

School of Public Health

**Development and evaluation of a socially connected mobile application
to increase fish consumption**

James A White

**This thesis is presented for the Degree of
Doctor of Philosophy
of
Curtin University**

August 2015

Declaration

To the best of my knowledge and belief this thesis contains no material previously published by any other person except where due acknowledgment has been made.

This thesis contains no material which has been accepted for the award of any other degree or diploma in any university.

The research presented and reported in this thesis was conducted in accordance with the National Health and Medical Research Council National Statement on Ethical Conduct in Human Research (2007) – updated March 2014. The proposed research study received human research ethics approval from the Curtin University Human Research Ethics Committee (EC00262), Approval Number RD-45-12.

Signature: 

Date: 13 August 2015

To Becky, Annabel and Molly, whose fingerprints are all over this.
In some cases, literally.

Acknowledgements

I would have had no idea an endeavour like this would have been possible for me, had it not been for the prompting of Professor Alexandra McManus, my supervisor and friend. Her advice, support, wisdom, advocacy and trust are the reason this project began, continued, and reached an end.

Professor Moyez Jiwa held me to account throughout, forcing me to leave no decision unconsidered and unjustified.

My colleagues at the Centre of Excellence for Science, Seafood and Health continue to do good and important work in the community promotion of seafood, and I thank them for finding a place for my ideas.

More broadly, I am indebted to the staff of Curtin University's School of Public Health, Faculty of Health Sciences, and Office of Research and Development for making so many opportunities available to me over this time.

Finally many talented developers were extraordinarily generous with their time, advice and pseudocode, in helping me to develop the app that was central to this study. My deep gratitude goes to the administrators and members of the Apple University Consortium, the Perth iOS Developers Meetup, and in particular my good friend Adam Shaw. Without their support this app, and by extension this study, would have been much the poorer.

Table of Contents

1.0	Abstract, objectives and thesis structure.....	2
1.1	Abstract.....	2
1.2	Objectives.....	3
1.3	Thesis structure	4
2.0	Fish consumption and health: review of literature	7
2.1	Fish consumption and health.....	7
2.1.1	Specific health benefits	7
2.1.2	Omega-3 fatty acids, oily and non-oily fish, and nutritional supplementation.....	18
2.1.3	Consumption recommendations.....	19
2.2	The fish consumer	22
2.2.1	Fish consumption: overview of drivers and barriers	22
2.2.2	Taste preferences.....	23
2.2.3	Availability, quality and convenience	24
2.2.4	Confidence.....	26
2.2.5	Cost.....	29
2.2.6	Perceptions of health benefits and risks	30
2.2.7	Environmental issues.....	33
2.2.8	Information sources	34
3.0	Mobile technology and health interventions: review of literature.....	37
3.1	What is mobile technology?	37
3.2	eHealth and mHealth: definitions	41
3.3	Technologies	42
3.3.1	Personal digital assistants and other early mobile devices	42
3.3.2	Short message service (SMS).....	42
3.3.3	The mobile web	44
3.3.4	Native mobile applications	45
3.3.5	Cameras.....	47
3.4	Benefits of mobile technology in delivering health interventions.....	50
3.4.1	Expanded reach	50
3.4.2	Anonymity	52
3.4.3	Notifications and “pushing” information	54
3.4.4	Ubiquity of mobile devices	56
3.4.5	Near-constant connectivity	60
3.4.6	Non-textual data entry	62
3.4.7	Tracking health behaviour	65
3.4.8	Gamification	67
3.4.9	Large scale medical data collection	69
3.5	Social networking and health promotion	72
3.5.1	Virtual communities	72

3.5.2	Social support and connectivity	75
3.5.3	Effectiveness of social media health interventions	78
3.6	Precedence for the use of mobile technology and social media in encouraging fish consumption	80
3.6.1	Fish is the Dish	80
3.6.2	How Much Fish?	81
3.6.3	Queensland prawns.....	82
3.7	Conclusion.....	83
4.0	Development of a complex intervention	86
4.1	Complex interventions in health promotion	86
4.2	Evaluation of studies using social media or mobile technology	87
4.3	A framework for complex interventions	91
4.4	The present study as a complex intervention.....	95
4.5	Study design.....	96
4.5.1	Theoretical phase	96
4.5.2	Phase I: Modelling	96
4.5.3	Phase II: Exploratory trial	97
5.0	Theoretical framework	100
5.1	Cognitive perspectives on food choice	102
5.1.1	Theory of planned behaviour	103
5.1.2	Health belief model	104
5.1.3	The transtheoretical model	106
5.2	Towards a behavioural understanding of consumer choice.....	108
5.2.1	Operant conditioning	109
5.2.2	Reinforcers and punishers.....	111
5.2.3	The behavioural perspective model	112
5.2.4	Classes of consumer behaviour	115
5.2.5	Open and closed settings	117
5.2.6	The interaction between behaviour setting and learning history	118
5.2.7	The BPM and fish consumption.....	120
5.2.8	Implications for the present study	121
6.0	Focus group study.....	124
6.1	Introduction and rationale.....	124
6.2	Methodology.....	126
6.2.1	Questions	128
6.3	Results	132
6.3.1	Themes	139
6.4	Discussion	152
6.4.1	BPM constructs	152
6.4.2	Fish and health	154
6.4.3	Sustainability	156

6.4.4	Early experiences with fish	158
6.4.5	Device and mobile application usage	158
6.4.6	Implications for the proposed intervention	159
7.0	Development of the experimental application	166
7.1	Introduction	166
7.2	Development and design	167
7.3	Platform and tools.....	169
7.3.1	The development methodologies spectrum	169
7.3.2	Advantages of native development.....	170
7.3.3	Other tools	173
7.4	Remote server	175
7.5	Design	179
7.6	Functions.....	184
7.6.1	Species guide	184
7.6.2	Fish finder	191
7.6.3	Health	194
7.6.4	Diary	196
7.6.5	Settings.....	199
7.7	Onboarding	202
7.8	Summary.....	204
8.0	Exploratory trial.....	206
8.1	Introduction	206
8.2	Objectives	208
8.2.1	Hypotheses.....	208
8.3	Methodology.....	209
8.3.1	General overview of trial design.....	209
8.3.2	Sample size	211
8.3.3	Recruitment, baseline questionnaire, and random assignment to groups 212	
8.3.4	Distribution of the experimental application	216
8.3.5	Data collection.....	219
8.3.6	Communication and participant feedback	222
8.4	Results	225
8.4.1	Participant’s reported estimate of consumption	225
8.4.2	Diary tool	225
8.4.3	Fortnightly newsletters	231
8.4.4	Intervention group application usage	232
8.4.5	H1: Association between use of the intervention application and increased consumption.....	239
8.4.6	H2: Association between time spent using the application and increased consumption	241
8.4.7	Demographic factors	243
8.5	Discussion	245

8.5.1	Effect on fish consumption behaviour	245
8.5.2	Contrasts between self-reported information and observed data	248
8.5.3	Summary of findings.....	250
8.5.4	Summary of limitations	251
8.5.5	Recommendations for a future RCT	252
9.0	Study discussion, recommendations and conclusion	263
9.1	Objectives	263
9.1.1	Planning.....	264
9.1.2	Development.....	266
9.1.3	Evaluation.....	269
9.2	Conclusion.....	272
	References.....	268
	Appendices.....	311

List of figures

Figure 1. Preferred sources of seafood information in a 2008 US survey	35
Figure 2. Volume of SMS and instant messages sent in the UK, 2004-2014	44
Figure 3. Individualised goal reminders in the RunKeeper application	47
Figure 4. Personalised setup and notification for <i>SmartQuit</i> , a smoking cessation application.	55
Figure 5. Step tracking, statistics and personal goals in the <i>iStepLog</i> application	61
Figure 6. Gamification elements in the fitness applications <i>Fitocracy</i> , <i>Health Mate</i> and <i>Zombies, Run!</i>	68
Figure 7. Screenshots from the <i>mPower</i> Parkinson’s Disease research application	71
Figure 8. Fish is the Dish homepage	81
Figure 9. Sequential phases of developing RCTs of complex interventions	93
Figure 10. Key elements of the development-evaluation-implementation process	94
Figure 11. Summary of the BPM.	113
Figure 12. Codes used in the thematic analysis of qualitative data.	134
Figure 13. Examples of excerpt coding.....	134
Figure 14. Species database entry.	174
Figure 15. <i>Parse</i> database table for seafood outlets.	175
Figure 16. The data synchronisation model used in the <i>Pier 2 Peer</i> application..	178
Figure 17. Screenshots from first-party iOS Applications showing common design idioms from iOS 6 and flatter, less-ornamented interfaces in iOS 7+	180
Figure 18. Navigation bars in iOS 6 and iOS 7.	181

Figure 19. Screenshots and icons showing the design transition from iOS 6 to iOS 7+	183
Figure 20. Species guide “Others think” section (for viewing community ratings and comments) and “I think” section (for submitting ratings and comments)	186
Figure 21. Species guide dummy comments.	187
Figure 22. The species guide navigation structure: category view, list view and search feature	188
Figure 23. Configurable options for the species recommendations feature	189
Figure 24. Species recommendation results view: first iteration and revised layout	190
Figure 25. Fish finder tab: map view, outlet detail view and submission view	193
Figure 26. The Health tab list view and detail views	196
Figure 27. Diary tab: meal entry view, camera input and list view	197
Figure 28. Diary tab feedback: weekly serves and omega-3 from fish consumption	198
Figure 29. Log in view and sign-up view	201
Figure 30. Settings tab list view and detail views	202
Figure 31. Onboarding (instructional) screens.....	203
Figure 32. Targeted Facebook advertisement	213
Figure 33. Demographic and baseline fish consumption distribution between intervention and control groups	215
Figure 34. Secondary demographic information and other baseline data.	217
Figure 35. Withings email newsletter	224

List of tables

Table 1. The four quadrants of operant conditioning	111
Table 2. Operant classes of consumer behaviour, defined by patterns of reinforcement	116
Table 3. Demographic breakdown for focus group participants	127
Table 4. A sample of code co-occurrence data from thematic analysis of focus group transcripts	137
Table 5. Functionality suggested by focus group participants	160
Table 6. Diary tool ease of use	227
Table 7 Adding photos to the fish consumption tool: user perceptions	228
Table 8. Difficulties experienced while using the fish dairy tool.....	230
Table 9. Participants' perceptions of the species guide.....	232
Table 10. Participants' perceptions of the fish outlet finder	233
Table 11. Participants' perceptions of the health information.....	234
Table 12. Number of health articles opened by participants.....	235
Table 13. Total Number times each health article was opened	235
Table 14. Participants' level of trust in the information contained in the application sections.....	237
Table 15. Participants' perceptions of impact of the application sections	238

1

**Abstract,
introduction and
objectives**

1.0 Abstract, objectives and thesis structure

1.1 Abstract

Consumption of fish is well documented as being protective against a number of chronic diseases, and as having specific health benefits for many key groups such as children, pregnant or lactating mothers, and seniors. Yet in Australia many people do not eat fish sufficiently regularly to achieve these documented health benefits. A complex intervention approach was used to determine whether a socially connected mobile application could address these barriers to consumption and lead to increased consumption over time. Formative research was used to identify a number of barriers to fish consumption. This research guided the development of a mobile application that was then evaluated in an exploratory trial. Changes in fish consumption were measured and, while overall fish consumption did not differ significantly between intervention and control groups, some patterns of application use were associated with increased consumption. Implications are discussed for the use of socially connected applications in health promotion interventions, and for the effective evaluation of such interventions.

1.2 Objectives

This project sought to evaluate the use of a socially connected mobile application to address barriers to fish consumption, with a goal of increasing consumption levels. Consumption was measured in serves per week (with a minimum serve defined as 40 grams). The target group was defined as Australians aged 18 years and over who consume some fish. For the purpose of recruitment, this was defined as having eaten fish at least once in the previous three months. Participants were also required to possess a compatible smartphone or other mobile device. The project comprised three stages:

1. Formative research including a review of literature and a focus group study. **The objective of stage 1 was to understand which components of the proposed intervention were most likely to have a positive impact on fish consumption for Australian adults.**
2. Construction of a socially connected mobile application based on findings from stage 1. **The objective of stage 2 was to build an application which, due to its grounding in evidence from stage 1, had a reasonable probability of increasing the fish consumption of its users.**
3. An exploratory trial to evaluate the effectiveness of this intervention in increasing fish consumption. **The objective of stage 3 was to determine whether individuals exposed to this application were likely to increase their fish consumption over time. In other words, whether this intervention had a clinically meaningful effect size, to merit further study.**

1.3 Thesis structure

A complex intervention involving both a qualitative formative study and a quantitative intervention presents certain challenges in describing methodologies and results clearly to the reader. This thesis adopts the following structure:

Chapter 2 examines the literature surrounding the health benefits of fish consumption and fish consumer behaviour. It explains why increasing fish consumption is an important health goal, and delineates the barriers to consumption identified in previous studies.

Chapter 3 describes the use of mobile technology in health interventions. It discusses different approaches and technologies, and provides examples both from peer review literature and commercial contexts.

Chapter 4 examines the notion of a complex intervention, presenting different approaches to methodology and evaluation. This chapter places the current study within the context of a complex intervention, and defines the project scope as comprising the first three phases of the complex intervention methodology.

Chapter 5 presents a theoretical framework through which the literature might be understood, and from which guidance might be taken in developing and evaluating this intervention. This section relates to the first phase of a complex intervention, known as the theory phase.

Chapter 6 describes the formative study carried out in advance of the intervention. The chapter provides a detailed methodology, presents results, and discusses implications for the other components of the study. This forms the second phase of a complex intervention, called the modelling phase.

Chapter 7 describes the development of a mobile application designed in response to the findings outlined in Chapter 6, with guidance from the theoretical model discussed in Chapter 5. While this chapter omits in depth technical explanations, it provides descriptions of key decisions and design methodologies.

Chapter 8 presents the methodology, results and discussion of the exploratory trial, in which this mobile application was evaluated. This is the third phase of a complex intervention.

Chapter 9 discusses the findings of the study as a whole, and implications for further research.

2

Fish consumption and health: review of literature

2.0 Fish consumption and health: review of literature

2.1 Fish consumption and health

Around 1940 chronic disease overtook infectious disease as the leading cause of death globally.¹ This trend led to substantial changes in public health initiatives including a much greater awareness of the role that lifestyle, and in particular, diet plays in the health of individuals.

In 2010, Curtin University's Centre of Excellence for Science, Seafood and Health² (CESSH) conducted a review of literature relating to the health benefits of regular consumption of fish as part of a healthy diet. The review adopted the National Health and Medical Research Council's recommendations for rating evidence,³ assigning each finding a confidence level – from A (High – findings from several high-quality studies or one large multi-centre study, with future research deemed unlikely to change confidence in the estimate of effect) to D (Very low – findings based solely on expert opinion or on studies with significant limitations). Major findings designated as high (A) or moderate (B) are summarised in Section 0.

2.1.1 Specific health benefits

2.1.1.1 Cardiovascular disease

- A United States (US) cohort study of 1822 men found that for those who consumed more than 35 grams of fish per day (compared with those who had none) the relative risk (RR) of death from coronary heart disease (CHD) and from myocardial infarction were 0.62 and 0.56 respectively, with a graded relation between RR and the strata of fish consumption.⁴
- A meta-analysis of cohort studies examined the association between fish intake and CHD mortality. The researchers examined 11 studies, incorporating 13 cohorts and over 22 000 individuals. Fish consumption was found to be

inversely associated with fatal CHD, with the researchers concluding that eating fish at least once per week may reduce risk. The RR for CHD mortality was 0.89 for those who ate one to three serves per week, 0.85 for one serve per week, 0.77 for two to four serves per week and 0.62 for five or more serves per week. For every 20 gram per day increase in fish intake a 7% lower risk of CHD mortality was found.⁵

- A cohort study of 84 688 women found that higher consumption of fish and omega-3 fatty acids were associated with lower risk of CHD, and particularly with CHD deaths, during 16 years of follow-up. The authors argued that there is strong evidence to support recommending the consumption of two serves of fish per week for the prevention of CHD.⁶
- A Japanese cohort study (n = 41 578) investigated whether the association between low-to-moderate fish consumption and reduced risk of CHD, exhibited in western countries, was also apparent in a population where high levels of consumption are the norm. Compared with a modest fish intake of one serve per week, higher intake was associated with substantially reduced risk of CHD, and particularly nonfatal cardiac events. The risk of CHD was around 40% lower among people at the highest quintile of fish intake (eight serves per week or about 180 grams per day), than those at the lowest (once per week).⁷
- An Australian study took a different approach, looking for possible effects of fish consumption on microvascular structure. A cohort of 2683 men and women were measured for retinal arteriolar and venular diameter. Regular fish intake (more than two serves per week, especially of oily fish) was associated with slight widening of mean retinal arteriolar diameter and slight narrowing of mean retinal venular diameter. Both these metrics are associated with lower risk of cardiovascular and cerebrovascular diseases. The authors suggested that fish consumption might provide a protective effect by preventing pathological changes to microvascular structures.⁸
- A cohort study of 4738 older adults found an association between the consumption of tuna or other baked or broiled fish, but not fried fish, and lower incidence of congestive heart failure (CHF). Consumption of one to two

servings per week was associated with a 20% lower risk, compared with an intake of once per month. At three to four servings per week, a 31% lower risk was observed. Dietary long chain omega-3 fatty acid intake was inversely associated with CHF; a 37% lower risk was shown in the highest quintile of intake compared with the lowest.⁹

- A population-based case-control study measured dietary intake of omega-3 fatty acids from seafood, and found an association with reduced risk of primary cardiac arrest for intake as low as one serving of fatty fish per week. The study did not find further reduction in risk at higher consumption levels. The researchers speculated that the reduced risk may be due in part to the effect of dietary omega-3 fatty acid intake on cell membrane composition.¹⁰
- A cohort study of 3042 Greek men and women found an association between fish consumption and lower inflammatory marker levels. This association was pronounced in individuals with diabetes or hypertension. The researchers concluded that daily consumption of 0.6 g of omega-3 fatty acids seemed to be an optimal intake level associated with the maximum reduction in inflammatory marker levels.¹¹
- A population-based prospective cohort study (n = 3910) concluded that the cardiac benefits of fish consumption might depend on the type of fish meal consumed. The study found that modest consumption of tuna or other broiled or baked fish, but not fried fish, among adults aged over 65, was associated with lower risk of ischemic heart disease (IHD) death, especially arrhythmic IHD death. The authors supported the recommendation of one to two servings of fatty fish per week.¹²
- A cohort study of 4815 older adults found an inverse association between consumption of tuna or other broiled or baked fish and atrial fibrillation. An intake of one to four servings per week was associated with a 28% lower risk, and an intake of more than five servings per week with a 31% lower risk.¹³

Summary

On the basis of the literature it is almost beyond doubt that fish consumption can be protective against cardiovascular disease. Indeed this observation forms the basis of several national advisories by health authorities, which have focused on the role fish can play in heart health (see section 2.1.3). The Australian Heart foundation released a position statement encouraging seafood consumption in 2008.¹⁴

2.1.1.2 Arthritis

- A meta analysis of evidence relating to health benefits associated with the consumption of fish and omega-3 fatty acids found strong evidence of clinical benefit in rheumatoid arthritis (RA), pointing towards at least 14 randomised, placebo-controlled, double-blind studies. It found less compelling evidence for benefits relating to other inflammatory conditions, including asthma, cystic fibrosis and Crohn's disease.¹⁵
- A Danish prospective cohort study (n = 57 053) investigated associations between dietary factors and risk of RA. A relatively small proportion of the cohort developed RA (n = 69), reducing the generalisability of results. Nevertheless, results indicated that each 30 gram per day increase in intake fatty fish was associated with a 49% reduced risk of RA. Fish intake was the only dietary factor for which an association was found – there was no evidence of an effect from the intake of long chain fatty acids, olive oil, fruit, coffee, vitamins A, E, C and D, zinc, selenium, iron or meat.¹⁶

Summary

On the basis of their meta-analysis of studies of inflammatory conditions, Ruxton et al. concluded that:

Evidence for a clinical benefit of LC n-3 PUFA in rheumatoid arthritis is robust but this is not the case for other inflammatory conditions, for example, asthma, cystic fibrosis, Crohn's disease, where some studies show benefits but overall persuasive evidence is lacking.¹⁵

Recent studies have tended to confirm these conclusions, showing modest but encouraging benefits both in the prevention and treatment of rheumatoid arthritis.^{17, 18} However, it is important to note that most of these studies have investigated omega-3 consumption via supplementation. In most cases the level of supplementation required to detect an effect would not be realistically achievable solely via the consumption of fish and seafood. Supplementation is a complex issue discussed further in Section 2.1.2.

2.1.1.3 Asthma and allergies

- A prospective cohort study of 2531 Norwegian children found a consistent negative association between early introduction to fish and risk of asthma and allergic rhinitis. After adjustment for confounding variables, the odds ratios for asthma and allergic rhinitis were 0.84 and 0.45 respectively, for children who consumed fish in their first year of life.¹⁹
- An Australian cohort study (n = 574) found that children who consumed fresh, oily fish were less likely to develop asthma or airway hyperresponsiveness. After adjustment for confounding variables the odds ratio was 0.26, for those who consumed any oily fish, compared to those who consumed none. The study found no evidence for significant risk reduction for any other food group or nutrient.²⁰
- A nested case-control study (279 cases, 412 controls) examined the effect of maternal fish consumption during pregnancy, and risk of asthma before the

age of five years. For children born to mothers with a history of asthma the odds ratio for asthma was 0.2 when mothers ate oily fish at least once per month during pregnancy, compared with no consumption. Maternal consumption of oily fish did not appear to provide a benefit for children of mothers with no history of asthma.²¹

Summary

As noted in Section 2.1.1.2, evidence for the benefits of fish consumption in controlling inflammatory conditions other than rheumatoid arthritis has been somewhat less compelling. Nevertheless, the evidence published to date certainly merits further investigation, and judicious presentation to consumers is warranted. Noting the apparent diversity of impact for different kinds of fish and seafood, McManus et al. stated, "Clear delineations need to be made between those seafood products that have positive benefits [for asthma control] and any that do not."²

2.1.1.4 Stroke

- A cohort study of 43 671 men aged between 40 and 75 years, with a 12-year follow-up, found an association between consumption of fish and reduced risk of stroke even at relatively low levels of consumption. Compared with those who ate less than one serve of fish per month, the multivariate RR of stroke for men who ate one to three serves per month was 0.57. No further risk reduction was found for higher levels of intake.²²
- A metaanalysis of nine cohorts from eight studies found an inverse relationship between consumption of fish and risk of stroke, particularly ischemic stroke.²³
- A cohort study of 79 839 women, with 14-year follow-up, examined relationships between fish and omega-3 fatty acid intake, and risk of specific categories of stroke. For all strokes, after adjusting for age, smoking and other cardiovascular risk factors, the researchers calculated a multivariate RR of 0.93

for consumption of one to three serves per month, compared with less than one. The RR was 0.78 for one serve per week, 0.73 for two to four times per week, and 0.48 for more than five serves per week. Higher consumption of fish and omega-3 fatty acids was associated with a reduced risk of thrombotic infarction, especially among women who did not take aspirin regularly. No relationship was observed with the risk of haemorrhagic stroke.⁷

- A cohort study of 4775 adults aged 65 years or over found an inverse association between fish consumption and both total stroke and ischaemic stroke. A 27% lower risk of ischaemic stroke was observed with an intake of one to four serves per week. In contrast, regular consumption of fried fish or fish sandwiches (burgers) was associated with increased risk of all forms of stroke studied. No association was found between fish consumption in general and haemorrhagic stroke.²⁴
- A United Kingdom (UK) cohort study of 24 312 adults found inconsistent associations between fish consumption and apparent health benefits. While consumption of oily fish was significantly lower among women who subsequently had a stroke, no significant relationships were found between total fish or shellfish consumption, and risk of stroke, after adjustment for confounding variables. The authors remarked, "Inconsistencies in the observed health effects of fish consumption in different populations may reflect different patterns and type of fish consumed and preparation methods."²⁵

Summary

The evidence showing that fish consumption is protective against stroke is quite robust. This is perhaps unsurprising given the weight of evidence relating to fish consumption and cardiovascular disease, and the many risk factors shared by these two conditions.

2.1.1.5 Cancer

- A prospective cohort study of 6272 Danish men found, at 30 year follow-up, that men who ate no fish had a two- to three-fold higher frequency of prostate cancer than those who ate moderate or high amounts of fish.²⁶
- A cohort study of 47 882 men found, during 12 years of follow-up, that eating more than three serves of fish per week was associated with a reduced risk of prostate cancer, with the strongest association being for metastatic prostate cancer (multivariate RR = 0.56, compared with intake of less than two serves per month). A similar but weaker association was found for intake of marine fatty acids from food, leading the authors to speculate that this reduction in risk might be associated to some extent with marine fatty acids from food, but that there might be a role played by other factors related to fish.²⁷
- A study examined population data for 36 countries over ten time periods. After adjusting for smoking and other confounding variables the authors found a significant inverse correlation between fish consumption and lung cancer mortality in all ten periods. Additional statistical analyses showed varying levels of association in different countries (especially when cigarette smoking was taken into consideration), and between men and women. The authors concluded, "Fish consumption is associated with a reduced risk from [lung cancer mortality], but this possible protective effect is clear-cut only in men and in countries with high levels of cigarette smoking or animal fat consumption."²⁸
- Researchers conducted a meta-analysis of cohort studies that had examined associations between fish consumption, omega-3 fatty acid intake, and colorectal cancer incidence or mortality. After pooling results from 19 studies, fish consumption was found to slightly reduce risk of colorectal cancer, with a more pronounced effect in women.²⁹

Summary

Fish consumption appears to be related to reduced risk of some forms of cancer, particularly those for which there is an established nutritional dynamic. However the extent of this association, and the mechanisms by which any protective effect occur, remain unclear. Presentation of this evidence to consumers should be judicious, and placed within the context of overall diet and lifestyle considerations.

2.1.1.6 Diabetes

- A longitudinal observational study observed 1770 children defined as being of high genetic risk of type 1 diabetes. Dietary intake of omega-3 fatty acids was found to be associated with a decreased risk of islet autoimmunity, a precursor to type 1 diabetes.³⁰
- Comorbidity of diabetes and CHD is common.³¹ A study looked for incidences of CHD in a cohort of 5103 women with type 2 diabetes, at 17-year follow-up. Compared with women who consumed less than one serve of fish per month, the RR of CHD (after adjustment for confounding variables) was 0.7 for fish consumption one to three times per month, 0.6 for once per week, 0.64 for two to four times per week, and 0.36 for five or more times per week. A significant association was also found between higher consumption of fish and reduced risk of total mortality for women with type 2 diabetes.³²

Summary

Further research is needed to understand the impact of fish consumption on diabetes risk, and the role it can play in effective diabetes management. However, a number of studies have highlighted the benefits of a Mediterranean diet in reducing the risk of type 2 diabetes.³³⁻³⁵ This dietary pattern is characterised by higher intake of fruit, vegetables, fresh fish and low glycaemic index carbohydrates,² and should be encouraged for the prevention and management of diabetes, as well as a number of other conditions.

2.1.1.7 Maternal fish consumption and child development

- A cohort study of 8729 pregnant Danish women found that among those who consumed fish at least once per week, occurrence of preterm delivery was 1.9%. This was significantly lower than the 7.1% occurrence in a group who consumed no fish. Low consumption of fish was a strong risk factor for both preterm delivery and low birth weight.³⁶
- A higher blood concentration of omega-6 fatty acids and/or trans fatty acids, relative to blood concentration of omega-3 fatty acids found at high levels in fish and seafood, has been shown to be associated with a number of health risks.³⁷ A cohort study of 12 371 pregnant women in the Netherlands found that an adverse fatty acid profile in early pregnancy was associated with lower birth weight.³⁸
- A cohort study of 25 446 Danish children found that higher maternal fish consumption during pregnancy was associated with attainment of developmental milestones at 6 and 18 months. The odds ratio was 1.29 for the highest quintile of fish consumption, compared with the lowest.³⁹
- A cohort study of 11 875 pregnant women found that maternal seafood intake greater than 340 grams per week was associated with better child cognitive development, including communication, fine motor skills and social development.⁴⁰

Summary

There is a robust body of evidence warranting the promotion of fish consumption for pregnant women. However, the increased implications of potential fish contaminants such as mercury mean that further consumption guidelines should be presented to this group. Weighing the relative importance of consumption recommendations and protective advice is a complex issue addressed in depth in Sections 2.1.3 and 2.2.6.

2.1.1.8 Mental health

- A review of evidence found that omega-3 fatty acids might be of therapeutic value in the treatment of depression. Furthermore, evidence was found for associations between fish and seafood consumption and reduced risk of post-partum depression, bipolar disorder and seasonal affective disorder.⁴¹
- A cohort study of 3204 Finnish adults found that, after adjustment for confounding variables, the incidence of depressive symptoms was significantly higher among infrequent fish consumers than frequent consumers.⁴²
- A cross sectional survey of 4644 New Zealand adults found a significant association between fish consumption and higher self-reporting of mental health status.⁴³

Summary

The evidence for mental health benefits accruing from fish consumption may best be described as emerging at this time.

2.1.1.9 All cause mortality

- A US cohort study of 20 551 men, with an 11-year follow-up, found that fish intake was associated with significantly reduced risk of total mortality. For men who consumed fish at least once per week the multivariate RR of sudden death was 0.48 compared with men who consumed fish less than once a month.⁴⁴
- A metaanalysis of evidence found that modest consumption of fish (one to two serves per week), especially species higher in omega-3 fatty acids, reduced the risk of total mortality by 17%.⁴⁵
- A cohort study of 18 244 Chinese men found that weekly fish or shellfish intake was associated with approximately 20% reduction in total mortality.⁴⁶

Summary

Impact on all cause mortality would be expected to reflect the range of health impacts found for specific conditions. This appears to be the case; given the strong evidence of impact on cardiovascular health, and emerging evidence of impact in a wide range of other areas, it is unsurprising that studies have found links between fish consumption and reduced total mortality. This should be a prominent message in consumer communications.

2.1.2 Omega-3 fatty acids, oily and non-oily fish, and nutritional supplementation

Much of the evidence for health benefit from fish consumption is associated with ingestion of omega-3 fatty acids, particularly in the case of CHD and adverse cardiac events.^{9, 45, 47-50} These essential polyunsaturated fatty acids are not produced by the human body, so must be ingested from food. Of the three long-chain omega-3 fatty acids found in food, evidence for health benefit is most strongly related to eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA), both of which are predominately marine-sourced. The third, alpha-linoleic acid (ALA), is mainly found in seed crops such as soybean, canola and linseed.⁵¹ It should be noted that while the body readily absorbs the majority of EPA and DHA ingested, only 3-8% of ALA ingested is converted into beneficial fatty acids.⁵²

As the evidence of health benefits from omega-3 fatty acid consumption has disseminated publicly, the market for nutritional supplements and fortified foods has increased. Researchers have examined the efficacy of these alternative sources of omega-3 fatty acids, finding that bioavailability can vary markedly depending on concentration, formulation, ingestion circumstances (e.g. during a meal or in isolation) and, for some forms of supplement, method of encapsulation.^{53, 54}

Clearly the regular selection of oily fish species should be emphasised in order to maximise the potential for health benefit. It is important for consumers to understand that all fish are not nutritionally equal, and neither are all methods of fish preparation. However, a sole focus on oily fish would be unrealistic, and omega-3 fatty acids are by no means the only explanation suggested in the literature for favourable health outcomes. Many fish and seafood species contain significant levels of other important nutrients such as iron, selenium, iodine, folate, calcium and vitamins A, E, D and B12, and are lower in fat, cholesterol and overall calorie count than red meats or poultry.⁵⁵ Individuals increasing their habitual fish consumption will in most cases be substituting fish for other forms of protein, including red meat and poultry. All other factors being equal, this is likely to reduce those individuals' fat and cholesterol intake, with well-documented health benefits.^{2, 14}

2.1.3 Consumption recommendations

There is no definitive agreement on the optimal level of fish consumption. Some studies have reported benefits from as little as a single serve per month, while others have found evidence that benefits magnify as consumption increases, up to and beyond five serves per week. How, then, should this or any other intervention assess an appropriate level of fish consumption to advise or target?

As with any food category it is important to consider both the risks and benefits of advocacy. Fish and seafood are in many cases the primary vectors for human exposure to a number of environmental contaminants, including methylmercury, arsenic and other organic pollutants.⁵⁶ When determining optimal consumption levels for public advisory campaigns it is vital to take a risk-benefit approach. Failing to do so can lead to contradictory, confusing public messages. This may lead some groups of individuals – for example, pregnant or lactating women – to err on the side of caution and omit fish from their diet. In doing so they may miss the opportunity for health benefits for themselves, and developmental benefits for their children.⁵⁷⁻⁵⁹

A number of government agencies and other groups have undertaken just such an analysis. The World Health Organization stopped short of making specific, numerical recommendations, but was clear in advocating for the promotion of fish consumption, and of the relative importance of benefits over potential risks:

Among the general adult population, consumption of fish, particularly fatty fish, lowers the risk of mortality from coronary heart disease. There is an absence of probable or convincing evidence of risk of coronary heart disease associated with methylmercury. Potential cancer risks associated with dioxins are well below established coronary heart disease benefits from fish consumption.⁶⁰

Similarly, a US Food and Drug Administration report found that, on balance, fish consumption should be recommended, primarily on the grounds of strong evidence for improved cardiovascular outcomes and neurodevelopmental factors.⁶¹ In relation to the latter, the report suggested that limiting maternal fish consumption might be inadvisable. The 2010 Dietary Guidelines for Americans advised the consumption of eight ounces (227 grams) of seafood per week, while noting that average consumption at the time of writing was only around half this level.⁶²

The French Food Safety Agency took a comprehensive, structured approach to comparing risks and benefits, examining a number of species commonly consumed in France. It made the following recommendation:

AFSSA...recommends, for the entire population and as part of a balanced diet, consuming 2 servings of fish per week, including one with high EPA and DHA levels, and varying the species and source (wild, farmed, fishing location, etc.). This consumption optimally meets nutritional requirements while limiting the risk of over-exposure to chemical contaminants.⁶³

Food Standards Australia New Zealand looked at common species available in the two countries in its jurisdiction and concluded that two to three serves per week of most common species could be safely consumed.⁶⁴ It recommended limiting the consumption of some species containing higher levels of mercury (including orange roughy, catfish, shark and billfish), particularly for children or pregnant women. This was also reflected in a 2008 Australian Heart Foundation position statement, which recommended that Australians consume two or three serves of fish per week.¹⁴

In line with this advice, and with reference to the body of evidence suggesting benefits from higher levels of weekly consumption, **the present study adopted the goal of supporting individuals to consume at least two serves of fish per week.**

2.2 The fish consumer

2.2.1 Fish consumption: overview of drivers and barriers

Given the clear evidence of associations between fish consumption and health benefits, and the fact that in many countries people do not consume enough fish to fully realise these benefits,⁶⁵ there has been considerable research into factors limiting consumption. Much of this investigation has taken place in Europe,⁶⁶⁻⁷⁶ with particularly strong focus in Scandinavia.⁷⁷⁻⁸⁷ A number of fish consumption studies have also been conducted in the US,^{57-59, 65, 88-95} Australia⁹⁶⁻¹⁰⁴ and Asia.¹⁰⁵⁻¹⁰⁸

The literature is consistent in identifying factors such as price, taste preferences, and lack of confidence in selecting and preparing fish.^{65, 75, 76, 104} However, despite these common misgivings, there is a very high level of awareness of the health benefits of fish consumption. The literature suggests that people generally know that fish is good for them, they feel good when they eat it, and many would like to eat it more regularly.^{75, 109} For example, one Australian study (n = 899) reported that 56% of respondents intended to eat more fish than they currently did, that 95% ate fish because they saw it as a healthy option, and that 50% felt morally obliged to serve it to their families.¹¹⁰

Given the subjectivity of the issues involved it is perhaps unsurprising that no clear consensus has emerged about the most important factors in determining an individual's fish consumption. However many studies have highlighted factors directly related to the process of purchasing and consuming fish, including taste, convenience, availability, quality, and cost, as being important determinants of consumption. Some studies have also pointed towards less direct cognitive or social factors such as knowledge of health benefits and risks, social norms, moral obligation (e.g. to serve fish to family members) or environmental issues. These studies, and several of the most commonly cited consumption determinants, are discussed in detail below.

2.2.2 Taste preferences

Taste is a highly subjective experience. What one person views as a delicacy may be seen as quite unpalatable by someone else. This is particularly true of foods with a strong or distinctive flavour; these foods are often either loved or loathed. Fish and seafood may be seen as belonging to this category of strong or distinctively flavoured foods, although the many species and varieties encompass a wide spectrum of flavours, textures and other sensory qualities.

Almost all studies of fish consumption behaviour cite taste preferences as a key determinant of consumption, with some suggesting that this is the most important factor.^{78, 111, 112} A recent Australian survey (n = 262) found that taste preferences were the second most important influence among those who ate fish (behind health benefits) and, conversely, were an important barrier among those who did not.¹¹³

Of course most adults do not eat in isolation; the taste preferences of family members such as partners and children may have a large bearing on the food an individual consumes. Verbeke and Vackier⁷⁶ found that the presence of children under the age of 18 years was associated with significantly less fish consumption in a family. Their theory of planned behaviour (TPB) study examined the impact of the external social norm, including the perceived opinions of friends, doctors and nutritionists, and the impact of advertising. They found that the impact of this social norm was significantly lower in families with children. Another study of 9407 Norwegian women found that the presence of teenagers in a household was associated with a negative response to the question "Do you eat enough fish". The authors speculated that "women with teenage sons or daughters feel dominated by their youngsters' tastes, and—unlike in households with younger children—do not feel confident enough to enact their own personal preferences."⁷⁹ A qualitative Australian study found further anecdotal evidence of the impact of partners and children on fish consumption, reporting that when the father or dominant male in a family did not eat seafood, it was seldom prepared.¹⁰⁴

So why do some people like the taste of fish, while others strongly dislike it, and is this distaste something that can be overcome? One possible explanation is the role of childhood experience and early exposure. Fischer and Frewer⁷² found that a low level of fish consumption during childhood was strongly associated with lower adult consumption, and with measures of food neophobia in relation to fish. This association between childhood and adult consumption was also reported by Trondsen et al.⁷⁹ Strong food neophobia may be difficult to overcome, given its apparent roots in evolutionary self-protective instinct.^{114, 115} However the relative diversity of fish species, encompassing those with both mild and strong flavours, may mean that it is possible to educate individuals to find fish species that are acceptable both to them and to their family members.¹⁰⁰

2.2.3 Availability, quality and convenience

People can only eat food that is available to them, and many studies have found that the availability of good quality fish has a significant impact on individuals' consumption.^{71, 76, 79, 80, 116} Of course, availability can be a subjective construct. Different people may have different levels of tolerance for inconvenience, and different thresholds for deciding that fish is simply too hard to obtain. This threshold may depend a great deal on the degree to which a person wants to eat fish, meaning that this issue is compounding. Those who are predisposed to eating fish will try harder to source it, including going further out of their way. Those who are less inclined may give up more easily, or look no further than the seafood counter at their local supermarket. If this counter only supplies a limited range of fish, or if the freshness or overall quality is low, this will further exacerbate the problem.

An Australian survey (n = 899) investigated what the researchers called the "perceived mental availability" of seafood.⁹⁸ Over half of respondents (57.1%) said that they would eat more fish, were it more readily available, with nearly half (45.8%) saying that it was more difficult to find good fish at the place where they did their regularly weekly shop, compared with other meats and poultry. The

study also showed that perceived lack of availability was higher among light consumers than those who ate fish regularly.

Improving the actual availability and quality of fish is important, but well beyond the scope of the present study. However there is some evidence that education campaigns may be able to improve perceptions of the availability of fish. Between 1996 and 1999 a large-scale advertising campaign was undertaken in Denmark, coordinated by the Danish fish sector and jointly funded by the European Union and Danish state.⁸⁰ An evaluation was carried out before and after the campaign to determine its effectiveness, using the TPB to analyze various factors determined to have a bearing on consumption. At baseline, prior to the campaign, perceived availability of fish in local shops was found to have a significant impact on the purchase of fresh fish. After the campaign, perceived availability no longer had a significant impact on either intention to purchase, or actual consumption frequency.

It is interesting to note that many studies, when asking participants about the availability of fish, asked them about “fresh” fish. For example, “Fresh quality fish is not readily available where I shop”⁹⁸ or “Perceived barriers: lack of fresh fish”.⁷⁹ A recent Australian survey (n = 239) reported significant confusion among consumers with regard to the meaning of the term “fresh”, as applied to fish and seafood.⁹⁷ Only around 15% recognised the generally accepted definition of indicating that the product had never been frozen. In any case, it seems likely that this was not the intended definition in many of these consumption studies. In most cases these researchers appeared to be using fresh either as a synonym for good quality, or to differentiate from canned or otherwise processed fish. It is highly probable that participants in these studies were thinking of many different things when asked about the availability of fresh fish. For example, local supermarkets in most Australian cities stock a variety of chilled fish fillets and seafood such as prawns and shellfish. However much of this fare will have been frozen shortly after capture and subsequently thawed for presentation. It may be beneficial for consumption studies to tighten the language used in these questions to gain a clearer insight into both real and perceived fish availability.

Convenience does not only relate to the ease with which fish can be obtained, but also the relative ease with which it can be stored, prepared and served. Several studies have found that fish is perceived to be a less convenient meal option than other meats and poultry, and that this perceived inconvenience can be a significant barrier to consumption.^{82, 87, 117} In particular, a large study (n = 4786) carried out across five European countries in 2006 found that fish was commonly considered to be a relatively inconvenient food.¹¹⁷ This was particularly true for strongly convenience-oriented individuals (as measured on a separate scale), with such individuals appearing to amplify the inconveniences associated with fish consumption. The authors did note that many people in all five countries surveyed considered fish to be a convenient food, and speculated that this may have related closely to individuals' level of experience and confidence with fish.

2.2.4 Confidence

Fish and seafood are quite unlike any other protein source, in terms of diversity. By way of comparison, consider chicken: consumers might differentiate between sources (for example, caged or free-range, local or imported), and may have a taste preference for certain products. However, despite the fact that many different chicken breeds are commercially available, this information is neither offered by producers nor sought by consumers; chicken breed simply does not have an impact on cooking or eating characteristics discernable to the average consumer.

Beef breeds are somewhat better known. Premium breeds such as wagyu and Angus fetch higher prices because many consumers can discern differences in their culinary characteristics, including fat profile, tenderness and flavour. However, outside of these premium breeds, most consumers are unlikely to discern between different cattle breeds, tending to rely more on the type of cut as an indicator of quality. Even when a consumer buys a premium beef breed, they do not generally anticipate needing to cook it fundamentally differently to less expensive breeds; the cooking methods are the same, but the expected outcome is different.

Fish and seafood are entirely different. There are hundreds of species commercially available in Australia, and each is marketed explicitly by name. No one would buy fresh fillets of a product simply called “fish”. Many consumers are happy to buy generic processed fish products, such as fish fingers or fish cakes, but even in these cases the type of fish used will be stated somewhere on the packaging.

There is a fundamental biological difference at play. In the case of chicken and beef we are dealing with different breeds of the same species - *Gallus gallus domesticus* and *Bos taurus* respectively – created over time via selective husbandry. With fish, we have entirely different species, some biologically close and others not. Although humans have proved adept at the use of selective breeding to create very distinct breeds (witness the difference between a Chihuahua and a great Dane, for example), they have not yet approached the effectiveness of nature in generating biological diversity. While we usually speak about different *species* of fish and seafood, humans in fact consume aquatic creatures from different species, genera, families, orders, classes and even phyla. It is hardly surprising that flavours, textures and cooking techniques vary so widely.

Put simply, selecting and cooking fish and seafood requires more knowledge than other meats. Where people do not have such knowledge, they are more likely to make mistakes, such as choosing inappropriate species or cooking methods. A chosen fish may be too strong in taste for the consumer or their family. It may fall apart in an undesirable way, be too tough or rubbery after cooking, or contain too many bones.^{67, 118, 119}

Studies of fish consumption behaviour have commonly reported that lack of confidence selecting, storing and preparing fish has been a significant barrier to consumption for many people.^{71, 76, 103, 104, 120} This is a multifaceted issue, contributed to by many ways in which fish differs from other meats and poultry. As well as this broad biological diversity, fish is also sourced in many more ways than other meats – it may be wild caught or farmed, from fresh or salt water, and consumers may perceive differences.⁷³ Safety concerns may also play a role, with

fish and seafood commonly perceived as potential sources of food poisoning. As such, people may consider that there are high stakes at play when determining the freshness of fish they are purchasing, when storing, refrigerating or freezing fish, or when ensuring that fish is eaten within an appropriate time period.¹⁰¹

An Australian study (n = 899) reported that half of respondents (51.1%) thought that fish was more difficult to assess for freshness and quality than other meats, with almost a third (29.3%) admitting that they did not know how to select fish, and around a quarter (23.1%) saying that they did not know how long they should keep fish before cooking it.⁹⁸ This general lack of confidence in quality assessment has been reported in a number of studies from different countries.^{65, 71, 104, 120}

In many cases the authors of these studies have recommended the use of education initiatives to improve consumer confidence. A survey of 1062 US consumers found a large gulf between the perceived importance of various seafood purchase factors and consumers' confidence assessing those factors.⁶⁵ For example, 75% of respondents thought that seafood quality was an important purchase consideration, but only 29% were confident or very confident in assessing this. Furthermore 62% of respondents were concerned about contaminants, but only 14% felt confident in making educated decisions. The authors concluded:

While consumers feel seafood quality and handling are important factors in making their seafood purchasing decisions, they do not have the knowledge/confidence to buy and prepare seafood products. Outreach education, targeting these key seafood topics, could help consumer confidence in purchasing and preparing seafood at home for the moderate and more infrequent seafood consumers.⁶⁵

2.2.5 Cost

Fish tends to be perceived as a somewhat expensive protein source in many western countries.^{71, 73, 121, 122} Australia, while surrounded by largely temperate seas, is faced with high labour costs, relatively restrictive catch limits and complex transportation logistics that place upward pressure on the price of locally sourced fish and seafood products.¹²³ Around three quarters of the fish and seafood consumed in Australia is imported, primarily from Thailand, New Zealand, Vietnam and China.¹²³ A 2010 survey of Australian seafood outlets found that seafood prices were much higher than equivalently sized portions of beef or chicken; premium skinless and boneless chicken fillet was typically priced around AU\$15 per kilo, while premium fish fillets usually retailed at two to three times this price.¹²⁴ In addition highly economical cuts such as boneless chicken thighs were found to retail between AU\$4-6 per kilo, a price that was not matched by any fish or seafood product, local or imported. Whilst seasonal, local whole fish was sometimes offered at an economic price, this required more preparation work on the part of the consumer, as retailers were generally unwilling to put labour costs into less expensive fish.

Portion sizes may play a role in consumer price perceptions. Many consumers may try to match fish serving sizes to those of other protein sources, such as beef, chicken, lamb or pork, and be deterred by cost comparisons. However in most cases they may be able to obtain a similar amount of protein from a smaller serve of fish. A 100 gram serve of fish may contain 2-3 times as much protein as beef. Furthermore, the amount of protein in a given species of fish is relatively stable compared to other sources of animal protein, as the flesh undergoes much less modification related to age and diet, particularly for wild-caught fish.⁶³

The perceived high cost of fish has often been cited as a barrier to consumption, both in Australia and elsewhere.^{65, 70, 101, 103, 104} As one forthright participant in an Australian focus group put it, "You actually need to take out a second mortgage if you intend to buy seafood. It is not cheap."¹⁰³ Australian retailers have been encouraged to focus on value proposition, the presentation of smaller, more

affordable portions, and educating consumers about the possibility of constructing good family meals from smaller quantities of fish and seafood, such as stir fries, salads or pasta dishes.^{110, 124}

There is conflicting evidence about the relationship between price, perceptions of affordability, consumer income and fish consumption. A large US study (n = 15 407) found that people with lower income ate significantly less fish and seafood than those in higher income brackets.⁹¹ This apparent link between higher income and higher fish consumption has been reported in a number of studies.^{65, 69, 90, 92} Other studies, however, have found either no association between income and fish consumption,^{79, 84} or an association only with intention to consume, rather than actual consumption.⁷⁶ Even where consumers believe fish is relatively expensive, this does not appear to always act as a deterrent to consumption. A study in the UK⁷⁵ and another in Finland⁷⁷ found no association between perceived price and consumption. Issues of price, affordability and consumption are clearly complex, and defy simple causal explanations.

2.2.6 Perceptions of health benefits and risks

It is almost unequivocal that a large majority of people believe that fish is a healthy food, with this finding reported in studies from Europe,^{69-71, 73, 83} Australia^{101, 125} and the US^{65, 92} In these studies, where reported, the overall perception of fish as a healthy food ranged from 77-93%. However it has been observed that this high level of recognition of the healthful properties of fish means that it is difficult to see this as a significant differentiator for consumption; if most people know that fish is healthy, why do some people eat it regularly while others do not?⁸³ Indeed, at least two studies have found no correlation between a high level of food health awareness and individuals' actual or intended fish consumption frequency.^{68, 76}

In some cases the perception that fish is a healthy food may be counterbalanced by the notion that it can contain harmful contaminants, such as mercury and other heavy metals. As discussed in Section 2.1.3, many health advisories have taken the approach of presenting balanced cost-benefits messaging and, while in

almost all cases these advisories have on balance recommended consumption,^{60, 62-64} the relative risk/benefit message may have been perceived differently by different individuals. These advisories have often recommended limiting the consumption of certain species of fish more likely to contain heavy metals (such as shark and swordfish), particularly for children, seniors and women who are pregnant or breastfeeding.^{62, 64} In some jurisdictions members of these groups have also been advised to limit or omit some species of tuna from their diet.^{56, 60, 126} This advice may have had a more significant impact on overall consumption, given the fact that in many places canned tuna makes up a considerable component of overall fish consumption,^{102, 121, 125, 127} and that it is sometimes difficult to know the exact species of tuna in any given canned product.

In some cases these warnings, or other information sources, may have caused people to limit their consumption of all fish, perhaps seeing this as the safest option. At least two studies have found that women in advisory target groups over-limited their fish consumption in response to advisories,^{57, 59} and a further two observed this effect even among non-targeted individuals.^{88, 89} Evaluation of the advisory used in the US state of Maine concluded that carefully-considered messages that emphasised low-mercury species substitutions could effectively minimise risk for pregnant women while avoiding the reduced overall consumption that had occurred after the issue of some other advisories.⁵⁸

Different studies have reported conflicting results with respect to the relative awareness of the benefits of fish consumption, and the risks (for example, of contaminants). One 2005 study of Belgian consumers (n = 429) concluded that participants were more aware of the effect of potentially harmful substances in fish than they were of its specific nutrients (although this did not necessarily prevent them from eating fish or viewing it as, on balance, a healthy food).⁶⁹ A somewhat contemporaneous US study (n = 329) found that almost all respondents (94%) were aware of the health benefits of eating fish, with significantly fewer being aware of its potential risks (70%).⁹⁴

One study found significant differences in knowledge of the nutritional composition of fish and seafood between younger and older participants. Younger people (under 25 years) were generally better informed about the nutrients found in fish, particularly omega-3 fatty acids, but were also more aware of the potential effects of contaminants. On average younger participants ate fish less often than older participants, who were less well informed yet tended to hold a stronger belief that fish was, on balance, a healthy food. The authors observed:

It should be noted that today's consumers in the >40 years age group have typically been educated with product-based nutrition information like 'eating fish is healthy', whereas today's adolescents have rather been educated with nutrient-based messages like 'fish contains omega-3 fatty acids, which is beneficial for human health'. The findings of our study suggest that this difference in the scope of public health and nutrition education is reflected in consumers' beliefs about fish.⁶⁹

The study further found that, when consumers thought they had a good understanding of the nutritional composition of fish and seafood, they were not always correct. For example 46% of participants believed that fish was a good source of dietary fibre, which is not the case. This belief was stronger among females. Less than a third of participants (31.8%) believed fish contained omega-3 fatty acids.

It seems clear that people are more likely to think of fish as being a generally healthy food, than they are to be able to name its specific nutrients or benefits. One study found that, despite almost universal recognition of the generally healthful properties of fish, less than half of participants (45%) said that fish was high in omega-3 oils, only 15% believed that these oils were healthy, and only 5% were aware that eating fish can lower cholesterol.⁹⁴ This common awareness of the general, but not specific, health benefits of fish consumption has been reported in several other studies.^{65, 69, 93}

2.2.7 Environmental issues

A qualitative Australian study conducted 1005 face-to-face interviews with consumers, asking a wide range of questions about fish consumption and attitudes.⁹⁶ The researchers noted that unprompted discussion of sustainability and other environmental issues was rare. Where discussions of environmental issues occurred they tended to focus on the sustainability of certain species (primarily orange roughy), on the use of antibiotics in feedstuffs for aquaculture, and on the possibility of genetically modified organisms escaping from fish farms and breeding with wild stock. When prompted about these issues, most participants told the researchers that they had not previously given much attention to sustainability issues, but that they supported the management of fishing and aquaculture in ways that would minimise impact on stock levels, and on the environment more generally. This study was conducted between late 2004 and early 2005; it may be the case that consumer awareness of these issues has heightened over the subsequent decade.^{92, 119}

A more recent US survey (n = 202) assigned participants to one of two groups based on their responses to questions about fish and ecological sustainability: those who were generally concerned about such issues and those who were largely indifferent.⁹² Ecologically sensitive respondents tended to be male and to reside in urban areas of the West Coast and Southern US. The authors also reported a number of differences in consumption behaviour between these two groups. Respondents who were ecologically sensitive ate fish more often when eating out than those who were not, although the latter group ate fish more often at home. Ecologically sensitive respondents tended to eat fish because they viewed it as healthier and more environmentally friendly than other meats while, for less ecologically minded respondents, taste was the primary reason for eating fish.

These findings somewhat contrasted with those of a Spanish study (n = 450) where females were found more likely to be environmentally conscious fish consumers than males (although the authors cautioned that their sample was

disproportionately female).¹²⁸ This study drew attention to the complex nature of environmental concern, as it relates to fish consumption. Some individuals are concerned about the sustainability of wild-caught fisheries, and regard aquaculture (fish farming) as a good, environmentally conscious alternative. For others this is reversed – aquaculture is seen as a concern, due to overharvest of species used as food sources, animal welfare or degradation of water quality, while wild fishing is viewed as a more sustainable or healthy option. Others view both options as concerning, while others still are concerned about neither wild nor farmed fish.

2.2.8 Information sources

A US survey of 1062 adults categorised respondents as current seafood eaters (CSE), former seafood eaters (FSE) or non-seafood eaters (NSE).⁶⁵ Among FSE and NSE respondents, the most common reason given for not eating seafood or changing consumption habits was taste preference (46%). For current seafood eaters the most common reason was affordability (45%). The survey also asked respondents about sources of seafood information, both positive and negative, that they had encountered, and about sources from which respondents would prefer to receive seafood information. The media topped both the list of positive information sources (51% of respondents recalled encountering positive media information about seafood) and the list of negative sources (46%). Also commonly mentioned were family and friends (34% positive, 20% negative) and the Internet (27% positive, 16% negative). The media (30%) and the Internet (14%) were the two most preferred information sources overall, as shown in **Figure 1**.

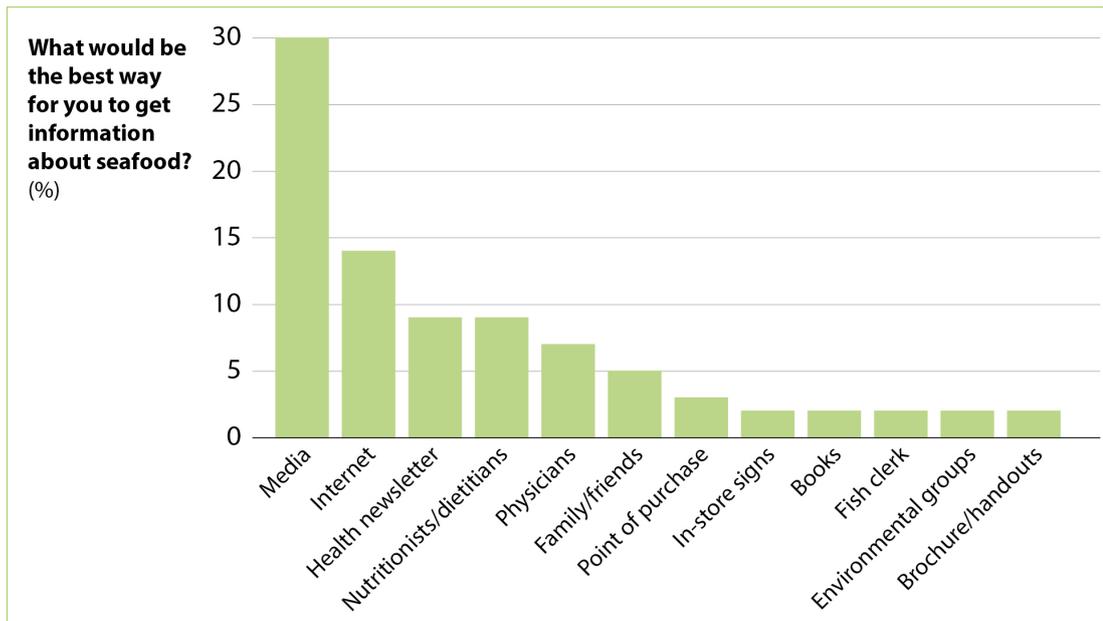


Figure 1. Preferred sources of seafood information in a 2008 US survey.⁶⁵

A 2009 review of literature and media messaging around fish consumption concluded:

There are many credible organisations, institutions and educational bodies promoting the healthy benefits of seafood as part of a healthy diet. The most pressing issue at hand is to provide these drivers with appropriate messages that are based on the highest level of evidence available...Proven marketing and communication techniques used to effectively promote other foods should be considered as a basic framework for the communication of regular seafood consumption...The framework should be well founded in behaviour change communication models in order to effect changes in behaviour within specific target groups chosen.²

Addressing consumer concerns, equipping people to be more confident in selecting and preparing fish, and debunking some of the common myths surrounding fish consumption are keys to increasing consumption and seeing more people achieve related health benefits over time.¹⁰⁹

3

Mobile technology and health interventions: review of literature

3.0 Mobile technology and health interventions: review of literature

3.1 What is mobile technology?

Terms such as mobile *technology*, *mobile device* and *smartphone* have evolved in meaning over the last decade. While all three terms were in earlier use, the technologies they refer to have changed significantly. Broadly speaking the term *mobile technology* refers to the use of cellular data transmission for wireless communication. Such communication was limited initially to voice calling, with the first handheld mobile telephones being developed in the early 1970s, before rapidly miniaturising and growing in popularity over the following 30 years. Short messaging service (SMS) was added in the early 1990s, enabling the transmission of messages containing up to 160 characters of text between compatible devices.¹²⁹

The development of second-generation (2G) digital cellular networks created opportunities for the transfer of larger quantities of data at higher speeds, and led to the creation of protocols for Internet access via mobile phones, including wireless application protocol (WAP). This enabled limited access to certain types of websites and web services designed to communicate via these protocols. The highly limited nature of these protocols, and limited development of user-friendly interfaces by mobile phone manufacturers, resulted in limited uptake of these technologies; although many mobile phone users through the 1990s and early 2000s had some level of mobile Internet access, relatively few opted to take advantage of these capabilities, or even knew of their existence.¹³⁰

Early smartphones, popular in Japan from the early 2000s and achieving some level of success outside of Japan from the mid 2000s onwards,¹³¹ typically had larger screens and incorporated a range of additional functionality including email access, calendars, limited support for third party applications and improved

Internet accessibility, albeit still via limited protocols like WAP. The mid-2000s also saw the introduction of the multimedia messaging service (MMS) protocol, which enabled the transmission of richer messages than were possible using SMS – messages containing, for example, images, videos and longer blocks of text.¹²⁹

In 2007 Apple Inc. released the first iPhone. While this device featured much of the same functionality as existing smartphones, such as email and Internet access, it introduced a new method for accessing these features: a large touch-sensitive screen, capable of detecting and acting on multiple simultaneous touches and gestures, a technology known as *multi-touch*. This technology had been in development since the early 1980s but had yet to be used as part of a portable, mass-market device.¹³² The iPhone also adopted modern Internet access protocols, making this one of the first mass-market mobile devices capable of accessing the majority of Internet content with no special requirements on the part of web developers.

The original iPhone, and its subsequent iterations, were highly commercially successful and heralded a sea change in the design of smartphones; within eight years virtually all smartphones sold around the world used the same full-screen, multi-touch paradigm.¹³³ This also led to a significant increase in adoption. In 2006, prior to the launch of the iPhone, an estimated 3.8% of US residents owned a smartphone.¹³⁴ By 2014 this had grown to 71%,¹³⁵ with a similar figure reported in Australia, where households had on average five connected devices.¹³⁶

The success of modern touch-screen smartphones led to renewed development in another segment of mobile computing, the tablet computer. Tablets – flat computing devices receiving stylus or touch input, and incorporating virtual keyboards – began appearing in the early 1990s and, despite some degree of iteration and improvement over the next two decades, never received wide adoption.¹³⁷ These early products generally featured pared-down versions of desktop operating systems, which were optimised for receiving mouse pointer input, and were never entirely suitable for stylus or touch input. Multi-touch technology, and mobile operating systems and applications built specifically for

receiving this input, were transitioned very successfully to the tablet form factor, with Apple's iPad, Microsoft's Surface, and numerous tablet computers based on the Android operating system seeing broad uptake from 2010 onwards.

Mobile device operating systems include applications for accessing the key functionality of those devices, for example phone diallers, calendars, email clients, and web browsers. These are known as "first-party" applications, meaning that they were developed by the creators and stewards of the platform itself. However a significant component of the success of modern mobile devices has been the rise of third-party application ecosystems (that is, applications built by external developers).¹³⁸ A mobile application, or app, is a small piece of software, tailored to the specifications of one or more mobile devices, with a specific and limited feature set. They can exist as standalone services, or can add value to a broader Internet service by making it easy for a user to access information or services without having to search for them at each use, and without having to navigate through complex websites to find the information required. They can also provide a positive user experience through a high level of device optimisation – for example, by accommodating the smaller screens that are a feature of mobile devices, and tailoring functionality to suit the form factor and data access speeds generally found on these devices. Developers may also design their applications so that some or all functionality is available without an Internet connection, making them suitable for use on devices that may not always be connected.

The large and growing user base for mobile devices and applications has resulted in significant interest in developing mobile applications that cover a wide range of interests and activities, including health and fitness. This category in particular has seen significant growth in recent years. Mobile analytics firm Flurry estimated that between December 2013 and June 2014, while use of mobile applications in general increased by 33%, use of health and fitness mobile applications increased at nearly twice that rate (62%).¹³⁹ Consumer research company Nielsen reported that nearly one third of smartphone owners in the US (approximately 46 million people) accessed health and fitness applications in January 2014. This represented an 18% increase over the same month a year earlier.¹⁴⁰

While the development of third-party mobile applications has been seen as commercially lucrative for a diverse range of content areas, it has also been seen as promising for the development of public health interventions for many of the same reasons. Mobile devices are increasingly ubiquitous, increasingly powerful, and increasingly capable of using a wide range of sensors to deliver data that is useful to those seeking understand and modify health behaviour.

3.2 eHealth and mHealth: definitions

Gunther Eysenbach, editor of the Journal of Medical Internet Research, proposed the following definition for eHealth (or e-health, to use his punctuation) in 2001:

e-health is an emerging field in the intersection of medical informatics, public health and business, referring to health services and information delivered or enhanced through the Internet and related technologies. In a broader sense, the term characterizes not only a technical development, but also a state-of-mind, a way of thinking, an attitude, and a commitment for networked, global thinking, to improve health care locally, regionally, and worldwide by using information and communication technology.¹⁴¹

More recently the term mHealth has emerged as a way of referring to health initiatives that make primary use of mobile technology. The World Health Organization proposed this definition in 2011:

mHealth or mobile health [refers to] medical and public health practice supported by mobile devices, such as mobile phones, patient monitoring devices, personal digital assistants (PDAs), and other wireless devices.¹⁴²

While there are no universally accepted definitions for these two terms, in essence eHealth is generally used to refer to health initiatives and interventions that make primary use of information and communication technologies. mHealth is used as a subset of eHealth, for initiatives that make primary use of mobile technology.

It is worth noting that neither term is used in this thesis with great regularity, except to differentiate between different approaches. As technology permeates healthcare, health data and public health more and more deeply, it is possible that these terms will become less useful as differentiators; the majority of health initiatives may eventually have at least some eHealth or mHealth component.¹⁴²

3.3 Technologies

3.3.1 Personal digital assistants and other early mobile devices

Health researchers began seeing the potential for mobile computing devices to improve the collection of data, with pilot studies into the use of personal digital assistants (PDAs) and other early mobile computers appearing in the early- to mid-2000s.¹⁴³⁻¹⁴⁵ For example nutritionists saw the potential to eventually replace traditional pen-and-paper data collection methods such as food frequency questionnaires¹⁴⁶ or 24-hour recall interviews.¹⁴⁷ Such methods had been problematic due to memory effects and the tendency of subjects to backfill data in the former method, and the relatively high cost and time burden in the latter. Data validation was a commonly cited concern.¹⁴⁸ These early pilot studies of the use of PDAs presented a mixed picture of the efficacy of this approach, often finding that these electronic methods were no more reliable than pen-and-paper methods.^{145, 147, 149} However the many apparent benefits of this approach, and the fact that mobile technology was clearly still in its infancy, led many of these researchers to remain positive about the approach in the long term.

3.3.2 Short message service (SMS)

SMS has often been leveraged in marketing campaigns and other circumstances calling for a simple, inexpensive means of delivering short messages, with a very high level of compatibility with user handsets. This approach has not been limited to commercial endeavours; many health promoters and researchers have sought to leverage SMS as a means of communication and information transfer. A 2009 systematic review identified 33 SMS-based health interventions between 1990 and 2008, with 14 of those studies meeting stricter criteria for inclusion in the review (for example, on the basis of study design). These included interventions in smoking cessation, chronic disease self-management, outpatient care and medication compliance.¹⁵⁰

An Australian study (n = 994) found that an SMS-based program increased knowledge of sexually transmitted infections among young people recruited at a music festival. The intervention also increased sexual health testing among young women, but did not increase condom use.¹⁵¹ A UK intervention (n = 2800) used a SMS-based smoking cessation tool called *text2stop*, and found significantly improved rates of cessation after six months, compared to a control group.¹⁵² SMS has been particularly popular in sub-Saharan Africa as a health intervention tool, due to its low cost and high uptake.¹⁵³⁻¹⁵⁵

It may be the case that SMS use (and, by extension, the use of SMS for health interventions) has reached its peak. After increasing in usage every year since the first SMS was sent in 1992, global SMS use plateaued in 2012 before declining in 2013.¹⁵⁶ It should be noted that this represents a decline only in the number of messages being sent using the SMS protocol. Recent years have seen a proliferation of new ways to send instant messages, mostly proprietary systems such as *iMessage*,¹⁵⁷ *BlackBerry Messenger*¹⁵⁸ and *WhatsApp*.¹⁵⁹ When these new systems are considered the picture becomes very different; global messaging has increased significantly over the last five years.¹⁵⁶ It can be difficult to identify overall global trends, given different usage patterns in different regions, but data available in the UK from Ofcom and Deloitte show a clear trend in growth of instant messaging at the expense of SMS, as illustrated in **Figure 2**.

In addition to exploring the use of SMS-alternatives, those planning health interventions have also been able to leverage the emergence of new, richer means of mobile communication, offering many of the benefits of SMS whilst adding many additional advantages: specifically, the mobile web, and native mobile applications.

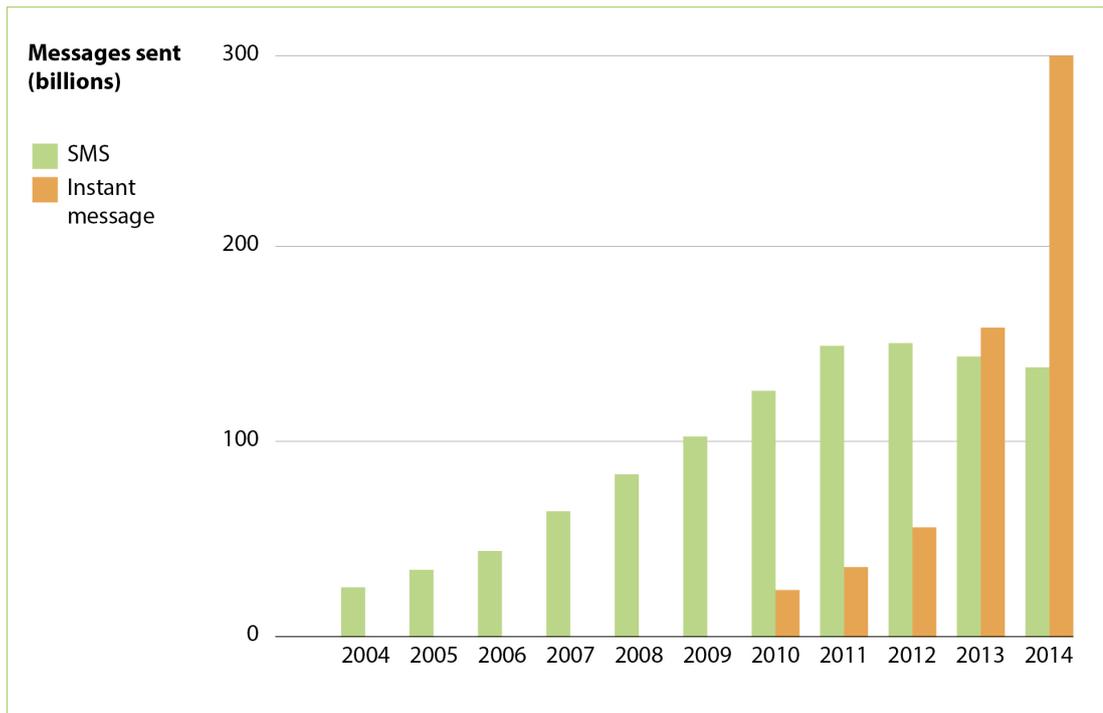


Figure 2. Volume of SMS and instant messages sent in the UK, 2004-2014.¹⁶⁰

3.3.3 The mobile web

As noted in Section 3.1 advances in fast mobile data networks, combined with the development of more capable, user-friendly mobile web browsers, led to an unprecedented level of Internet access from mobile devices. Nielsen estimated that in August 2014 58% of all Australian web browsing occurred on mobile devices.¹⁶¹ It should be noted that this statistic only included Internet activity that occurred in a web browser. When taking into account that fact that much Internet activity occurs within native applications rather than browsers - perhaps as much as 86%, according to another Nielsen report¹⁶² – the picture is one of overwhelming movement towards mobile Internet access.

In broad terms the mobile web refers to the access of websites and other web services (including web applications) via browsers on mobile devices. This is in contrast to the use of native mobile applications, installed on devices, described in Section 3.3.4. Web developers are increasingly optimising sites for mobile traffic. They can do this by serving alternate, mobile-optimised sites when the server

detects a visitor is browsing on a mobile device. Or, increasingly commonly, they may design *responsive* websites – sites that adapt intelligently to the size of the device they are being viewed on by resizing, moving, hiding or revealing content accordingly.

Analytics services, including *Google Analytics*¹⁶³ and *Go Squared*¹⁶⁴ can easily be added to websites to enable the collection of usage and basic demographic data which may be valuable in evaluating the reach and impact of an intervention. It should be noted, however, that information provided by standard analytics services only provides aggregate, depersonalised data. It can be used, for example, to measure the number of visitors to a site, their geographic location, the source of the traffic (i.e. whether from a direct link, from search, or from social media referral), and some technical details about visitors, including device types and operating systems. It cannot be used, for example, to track individual users' engagement with a service. This level of analysis, which may be required for some kinds of evaluation, necessitates the development of a custom analytics framework and some form of user authentication. This level of individual analysis is typically facilitated by the use of a third technology: native mobile applications.

3.3.4 Native mobile applications

Major mobile operating systems, including iOS, Android, Windows and Blackberry, provide software development kits (SDKs) that enable the development of applications. These applications are distributed via dedicated application stores accessed either on a desktop computer (with downloaded applications then synchronised with devices) or directly on the devices themselves. Applications built and distributed by these means are known as *native* applications; this means that they are written in a development language that is specific to the platform, and they can take advantage of vast libraries of existing framework code.

Since the launch of the iOS App Store in 2008, and the Android Market the following year (later renamed Google Play), the process of downloading mobile applications has become a familiar one to most mobile device owners. With the

fast growing popularity of mobile applications came an explosion of interest in developing for these platforms. At launch, in March 2009, the Android Market boasted around two thousand applications.¹⁶⁵ Just four years later this figure had grown to over one million applications, with more than fifty billion downloads globally.^{165, 166}

The proliferation of software developers, along with the advance of tools facilitating application development, has greatly reduced the barriers preventing health professionals from developing custom software to carry out their research or interventions. They need no longer rely on commercially available software which may or may not be a good fit for their purposes, or with which they may not have full control over the data they are collecting. A custom application may guide a participant through the informed consent process, eliminating the need for an additional paper-based process. Researchers using earlier commercial PDA software generally needed to meet with participants beforehand to provide the equipment, deliver any training that might have been needed, and have the participant read study information and sign consent forms.¹⁶⁷⁻¹⁶⁹ Now, in many cases, researchers need only send study recruits a link to an application, with the remainder of the process taking place automatically and, if desired, anonymously.

As noted above, while some analytics information may be obtainable from other kinds of electronic intervention (for example, through the use of an analytics-enabled website), a custom-built native application may facilitate much more individualised tracking of a participant throughout a study. A custom analytics framework may provide a precise picture of each user's engagement, and enable the examination of certain patterns of engagement, and health behaviour, or behaviour change. Furthermore, this information may facilitate the sending of precisely targeted messages and other intervention materials. For example an application may report on a user's activity level, and send individualised feedback and suggestions throughout the course of an intervention. Many commercial applications do precisely this. The *RunKeeper* application¹⁷⁰ encourages users to set exercise goals, then reminds them if they have not exercised in line with the expected schedule (see **Figure 3**).

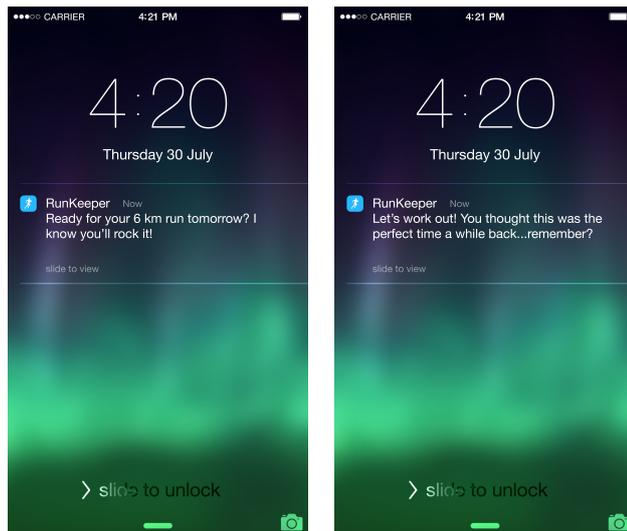


Figure 3. Individualised goal reminders in the RunKeeper application.¹⁷⁰

The proliferation of mobile application developers and development methodologies has meant that it is no longer inconceivable that a health intervention may choose to develop its own custom application for the purpose of an intervention. Rather than relying on out-of-the-box software, researchers may opt to develop bespoke software entirely for their own use, and then deploy that software solely to their research participants. This may reduce or eliminate the possibility of certain confounding variables that may be associated with publicly available software, such as contaminated data from users outside of the study group, or control group participants finding and downloading the software themselves. Custom applications have been developed and deployed to participants' personal mobile devices, for interventions in physical activity,^{171,172} smoking cessation,¹⁷³ mental health¹⁷⁴ and fatigue.¹⁷⁵

3.3.5 Cameras

Health researchers have used digital photography in a number of ways. The range of possibilities has increased with advances in digital photography made possible on mobile devices. Even ten years ago, health researchers could not assume that participants would have access to a digital camera and, even if they did, that they would have access to this camera at all times throughout the day. Furthermore,

the process of extracting a photo from a digital camera, reducing it to a size suitable for electronic transmission, and actually completing that transmission, was a technical challenge for many people even in a run-of-the-mill home situation, not to mention with added requirements implicit in a study.

Virtually all modern mobile devices are equipped with at least one camera. Many devices have both front and rear-facing cameras, at least one of which may be capable of taking very high-resolution photographs. As described in Section 3.4.4, the majority of people now have access to a mobile device (and, therefore, that device's cameras) at all times. Transmission of images may be as simple as tapping a single button and entering an email address; indeed, in a custom application, images taken may be automatically transmitted to the researcher with no direct action on the part of the participant. In this case, it will be incumbent on the researcher to ensure that participants are aware of the data that is being transmitted, as part of the informed consent process.

A common use of digital photography is to supplement or replace traditional means of journaling health behaviours. This is perhaps most prevalent in nutrition studies, in which a lot of information can be conveyed by a photograph of meals being consumed (for example, nutritional content and serving size).^{147, 176} The *My Meal Mate* nutrition intervention employed mobile device photographs to act as an *aide memoire* to assist participants in recording their food consumption at a later date.¹⁷⁷ A diabetes management application called *MAHI (Mobile Access to Health Information)* enabled users to keep a record of their meals using digital photographs and found positive signs of increased self-management efficacy in a pilot study (n = 49).¹⁷⁸ This use of photographs may provide some measure of data validation, compared with pen-and-paper or digital text entry methods. It may also serve to reduce the burden of entering large amounts of textual information.¹⁷⁹

Device cameras may also be used to facilitate the recording of complex information, for example about meals. Although the data may require more hands-on interpretation by a researcher, this may be an effective means of

capturing complex information whilst reducing the burden of data collection on the part of the research participant.^{147, 177} Use of device cameras has not been limited to nutritional studies. An intervention providing maternal, newborn and child health services in rural India used smartphone photographs of participants' health care cards and houses, along with time and location metadata, to verify that visits had occurred.¹⁸⁰ This overcame a reported problem with the use of village-based frontline health workers who had not always accurately represented their activities in previous interventions.

3.4 Benefits of mobile technology in delivering health interventions

3.4.1 Expanded reach

Accessibility of health information and representativeness of research samples are important concerns in the health sciences. This is particularly true in Australia, a large but sparsely populated country in which geographical remoteness and poor health outcomes are closely linked.^{181, 182}

Many health interventions are geographically limited for a range of reasons. The intervention strategy may call for face-to-face contact. For example, participants may need to attend a clinic or research centre, may need to participate in a group activity or discussion, or be visited by a clinician. Even where these practical considerations are absent, it may be financially prohibitive to include research participants in remote areas. In places like Australia, where some chronic diseases such as diabetes and heart disease are over-represented in remote populations, this may represent a serious flaw in the application of research findings.¹⁸³

Information communication technology has enabled some health interventions to achieve a broader geographic reach. However, until the last decade or so, very remote locations remained difficult to reach due to the need to build substantial infrastructure for delivering those communications services, and the relatively high cost of consumer hardware for accessing them.¹⁸⁴ The expanded reach of mobile technology has played a significant role in reducing this deficit. Modern smartphones, which may cost many hundreds of dollars, might be considered to be very expensive telephones, especially when compared to the very inexpensive feature phones available through the early 2000s. These devices often cost less than AU\$100, and were commonly given away for free as part of mobile service contracts. However, when seen as mobile computing devices capable of replacing much of the functionality of more expensive desktop and laptop computers, the value proposition may be seen very differently. Data appear to confirm this trend, with the rise in consumer uptake of mobile devices occurring concurrently with a similar fall in demand for traditional desktop or laptop computers.¹⁸⁵

The development of modern cellular networks capable of delivering data at fast speeds, along with the comparative affordability of mobile computing devices, has increased the level of access to Internet and other communication services in some remote areas, although infrastructure challenges remain in very remote areas of Australia.¹⁸⁴ This trend towards increased access has not been limited to geographically remote populations, but has also been observed in other groups of people who have traditionally had poor access to digital communication services for a range of reasons. A study of 95 Australian homelessness service clients found that 77% owned a smartphone, with the remainder owning more basic mobile phones.¹⁸⁶ The authors noted that this figure, whilst from a small sample, was higher than smartphone penetration in the general public. Similarly a 2011 study described Canadian homeless people as “surprisingly well connected”, in their use of mobile technology to access support services.¹⁸⁷ In 2012 the Australian Communications and Media Authority¹⁸⁸ reported that, while homeless people, older people, Aboriginal and Torres Strait Islander people, and people from culturally and linguistically diverse backgrounds used the Internet less than the general Australian population, there was evidence that smartphones and other mobile devices were helping to bridge the gap, with signs of increased access among those groups.

Aside from the social benefits inherent in wider access to communications technology, this also creates an opportunity to expand the reach of some kinds of health interventions. However it is important to realise that it is not simply a matter of taking traditional health interventions and expanding their reach through the use of mobile technology. These interventions introduce new complexities and potentially confounding variables. Larger samples may come at the cost of depth of data, and qualitative data may be more difficult to obtain. As ubiquitous as mobile devices may become, samples may still not be truly representative of the general population. Traditional theoretical frameworks and methodologies may or may not be suitable for use in these kinds of interventions; they may need to be adapted in significant ways, or replaced by new approaches more suited to these kinds of intervention.¹⁸⁹

3.4.2 Anonymity

One of the key differences between eHealth and mHealth interventions and traditional approaches is the possibility of a much greater degree of anonymity. This may be of significant advantage in research or interventions targeting certain population groups or certain kinds of sensitive behaviour. A meta-analysis of three studies found significantly higher levels of self-disclosure in computer-mediated discussions, compared to face-to-face discussions.¹⁹⁰

The developers of *NewBridger*, an Internet-based social support network for Chinese immigrants to Canada, cited anonymity as an important feature, as reported by their 2200 users.¹⁹¹ Similarly the developers of *Aurora*, a social mobile-phone-based mental health tool, conducted a small study (n = 65) and found evidence that users felt more comfortable discussing mental health issues with other anonymous users of the service, than they would have with people to whom they were known.¹⁹² Also in mental health, researchers investigating the attitudes and behaviour of young men (n = 486) found a strong preference for anonymous online support services.¹⁹³ Several studies have found that interventions targeting safe sexual health behaviour are more successful when anonymity and confidentiality can be assured, and that online forums can be an effective and trusted way to provide these assurances.¹⁹⁴⁻¹⁹⁶

As with any health research, those deploying mHealth interventions must be clear with participants about exactly what level of anonymity and confidentiality is being assured. Are participants anonymous both among other participants and to the researchers themselves? Or are their data personally identifiable by the research team? Many mobile applications authenticate users by way of a unique username, selected by the user; some participants will select a username that is a variation of their real name (e.g. johnsmith1972), while others will select something less identifiable. Researchers wishing to assure anonymity may opt to require randomised character strings as usernames.

The additional level of anonymity that is possible due to the reduced need for researchers to meet participants face-to-face may also introduce problems. Can researchers be sure that their participants are who they say they are? That they live in the places they say they do and are telling the truth about their age? Of course, it is perfectly possible for participants to mislead researchers even in a face-to-face context. However, it may be more difficult to falsify certain kinds of information and people may be less inclined to do so when they are engaged directly with a researcher, rather than perhaps seeing them as a faceless representative of a large university or hospital, with whom they have only communicated via email.

John Wilbanks is a noted data law expert and medical research advocate, and the founder of Consent to Research, a platform for people to donate health data for open source scientific research. In an informal interview about the potential for falsified data in a large-scale online study, he said:

We are less worried about fraud and...impersonation because there's a fair amount of work involved in being in this study, and doing it just for fraudulent purposes is kind of a strange behavior. People might do it [out of interest] for a week or two, but I can't see someone doing voice testing and gait testing for 52 weeks when there's no sort of public pay off.¹⁹⁷

In a personal communication with this author, Wilbanks expanded on his opinion. He said that fake research enrolment on an individual level is a confounding variable that can easily be controlled for in a study design, and that a more significant concern was the potential for *astrourfing*, in which an entity with a vested interest in the outcome of a study, could potentially influence those outcomes by way of organised, wholesale fraud. (Wilbanks J. pers. comm., May 7 2015). As large-scale, anonymous medical research becomes more prevalent, it will be important to establish new checks and balances to protect data integrity.

3.4.3 Notifications and “pushing” information

Mobile devices facilitate the “pushing” of information to users. Rather than hoping users will remember to check a website or other static information source, users can be notified of updated information, or prompted to take various actions or complete tasks. These notifications may be applied more widely than simply drawing users’ attention to digital information or the completion of digital tasks; research participants may be prompted to complete a real-world task, such as taking medication, measuring weight, or making a telephone call. The fact that many people have a mobile device within reach at most times of the day¹⁹⁸ can vastly improve the effectiveness of such reminders, compared with other methods of prompting. Core information and messaging may be combined with personal information stored on a device or in a back-end server to create messages that are personalised to individual users.¹⁷⁹

Mobile applications may, when permitted by the user, deliver various kinds of notifications to the user. These notifications may be scheduled by the application itself in response to specific events or data input from the user. For example, a task management application may notify the user when a certain task is due for completion. These are sometimes known as *local notifications*; they are managed automatically by a local instance of an application, without the need for action on a remote server. Other notifications may be scheduled on a remote server and delivered to devices either on a fixed or ad hoc schedule; these are usually referred to as *push notifications*.

The use of SMS and other messaging services may also be thought of as an information pushing approach. Tools exist to schedule and automate the process, although not to the extent of automation and customisation made possible by mobile applications, in which notifications may integrate tightly with the host application and may intelligently react to changing data. The use of SMS reminders has been particularly prevalent in the fields of medication adherence^{155, 199-202} and clinical care management.²⁰³⁻²⁰⁵

The ability to push information to users intelligently, in response to specific cues and circumstances, has been of great advantage to health application developers. Many health interventions using static digital media have found it difficult to sustain engagement with their content, or have commented on the difficulty of cutting through the vast array of online information and messages competing for users' attention.²⁰⁶⁻²⁰⁸ In these cases, engagement with the service required a conscious decision on the part of the participant, to look for information or otherwise use the application. Developers may find value in pushing information and timely notifications to users, to ensure that their content remains at front of mind. For example researchers evaluated the impact of a smartphone application for smoking cessation called *SmartQuit*, which utilised twice-daily push notifications to prompt users to complete activities and record information (see **Figure 4**). Use of the application during the study (n = 76) was found to be associated with smoking abstinence.¹⁷³ Another study (n = 50) evaluated an interactive web-based breastfeeding monitoring system, which featured notifications to mothers in the case of various lactation problems. The authors found that mothers appreciated the notifications and the tool was a promising mechanism for maintaining communication between breastfeeding mothers and lactation consultants.²⁰⁹

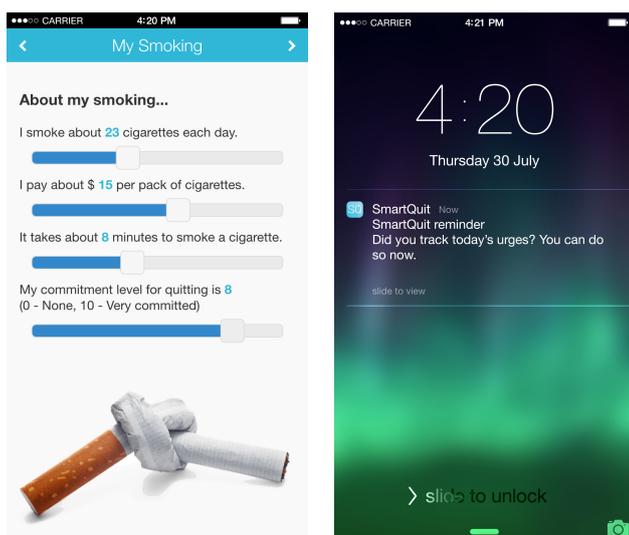


Figure 4. Personalised setup and notification for *SmartQuit*, a smoking cessation application.¹⁷³

Balance and restraint are critical. Mobile device operating systems are designed to offer users a high level of control over the way applications communicate with them; users who receive a large a number of notifications from an application, or messages they feel are inappropriate or overbearing, can and will disable notifications for that application. There may, however, be more leeway than might be expected. Consumer research firm IDC conducted a survey of 7446 US smartphone owners aged between 18 and 44 years, in 2013. The authors predicted: "Given most of these people use 7.4 [social or communications] applications on their phones, we may expect that many respondents would feel overwhelmed with the flurry of activity, alerts and notifications."¹⁹⁸ However, a relative sentiment index indicated that the most common sentiment users associated with this constant communication was one of connectedness. Negative feelings such as being overwhelmed, stressed or burdened by notifications or information were among the lowest reported sentiments on the scale. It should be noted that the sample comprised relatively young smartphone users; not all demographic groups may share the same positive sentiments towards this aspect of mobile technology.

3.4.4 Ubiquity of mobile devices

Another advantage of mobile devices, and in particular smartphones, is that they are typically close to users at most times through the day. This is very much in contrast with traditional computers, which tend only to be used in specific places, and at specific times. In the aforementioned IDC survey¹⁹⁸ 79% of respondents said that they had their smartphone within arm's reach for all but two hours of the day. One in four respondents could not recall a time that day when their smartphone was not either within reach, or in the same room. Four out of five respondents first checked their smartphone within 15 minutes of waking up.

The physical and mental health implications of this deep penetration of smartphones into everyday life is a matter of exigent discussion,²¹⁰⁻²¹² particularly so because of the rapid nature of its growth. Nevertheless, many professionals and researchers seeking to measure or influence health behaviour have seen the

opportunities afforded by the consistent presence of a mobile computing device. Even as early as 2004, researchers at the Massachusetts Institute of Technology recognised the potential of delivering “just in time” interventions that took advantage of emerging contextual awareness of mobile devices.²¹³ They flagged the emergence of applications capable of detecting declines in health, those that could detect more substantial health crises (for example, in conjunction with external biometric sensors, continuous monitoring for those with heart conditions) and systems for motivating healthy behaviour.

The near-constant presence of a mobile device, combined with those devices’ awareness of their physical location and other contextual information, makes it feasible for researchers to prompt participants to complete activities at certain times of the day, or in certain places. For example, researchers in the Netherlands trialled an application called *MORE Energy*, designed to reduce fatigue among airline pilots.¹⁷⁵ The application contained information about daylight exposure, sleep, physical activity and nutrition, and used *geofencing* (that is, continuous location awareness) to send tailored notifications when the application detected that the pilot had arrived somewhere outside of the Netherlands, and therefore was presumably working. The study (n = 502) found that pilots who used the application showed significant improvement in fatigue and sleep quality. Similarly the developers of an application called *Mobilettype*, which facilitated self-monitoring for people in the early stages of adolescent depression, prompted participants to complete tasks at random intervals throughout the day, with this randomness a key part of their study design.²¹⁴

3.4.5 Personal device ownership

For all the advantages mobile technology may have brought to the table, it brought at least one clear disadvantage for those pioneering its early use in health interventions: the necessity for researchers to procure and distribute expensive equipment to research participants. Researchers in the early 2000s were in no position to assume ownership of devices like this, except perhaps in targeting very specific subgroups of the population such as business or health professionals. In

2007, the peak of PDA sales, technology research company Gartner estimated shipment of 17.4 million PDAs globally.²¹⁵ To put this number in perspective, the same company estimated global smartphone shipments of 968 million in 2013.²¹⁶

Researchers in these early studies needed to obtain sufficient devices for the participants they were recruiting. To keep costs manageable, this meant either that samples were small,^{217, 218} or studies were conducted over extended periods of time, enabling a smaller number of devices to be used by successive participants.²¹⁹ In some cases participants were required to pay a security deposit.^{220, 221} The difficulties did not end there; participants generally needed to be trained to use these novel devices, which often required data input using unfamiliar methods, such as a stylus, and/or the use of a shorthand-like pseudo-alphabet.^{167, 169, 177, 219} Furthermore, appropriate software had to be identified, licensed and installed on the devices. In an age of diverse, readily-obtainable mobile applications it is perhaps hard to remember a time when software for mobile devices like PDAs was highly limited and costly, and in which any form of customisation would have been prohibitively expensive and time consuming for most research projects. Simply put, researchers had to make do with what was available. For example, early nutrition trials typically used off-the-shelf programs like *Handheld Diet Diary*¹⁴⁹ and *DietMatePro*.^{220, 222}

The rapid growth of smartphone and tablet computer sales has overcome many of these intervention barriers. It is now common for health interventions involving the use of a mobile application to require that research participants own, and agree to use, their own device for the purpose of the study. This has become a reasonable expectation, not just because of the growing ubiquity of mobile devices, but also because of considerable changes in the nature of mobile software. Installing a mobile application is now a very familiar task for most mobile device owners. A 2013 survey of 1000 Australian smartphone users found that they had an average of 33 applications installed, and had actively used 12 of those applications in the previous 30 days.²²³ The fact that applications on some platforms (for example, iOS) are *sandboxed* (that is, substantially cut off from other applications on a device, and from user data, except where authorised) has also

reduced safety and privacy concerns, and lessened the onus associated with asking individuals to install software on a personal device for the purpose of a study.²²⁴

The difference between asking individuals to participate in research using their own smartphone, and providing an unfamiliar device specifically for the purpose of research, cannot be overstated. In the former case, people are using a device with which they are already intimately familiar, and for which they need not make any special effort to remember to carry it with them or to keep it charged. Studies in which participants have been provided with devices have sometimes reported problems. At least two physical exercise studies reported that many of their participants were relative novices with the PDA devices given to them for the purpose of the intervention, and that this may have been detrimental to outcomes.^{168, 219} One study provided adolescent girls with mobile devices equipped with a custom application designed to influence physical activity and nutrition. The researchers, "In an attempt to discourage use of the program beyond the required goal-setting and self-monitoring components, [configured the intervention devices] without gaming, social media, or text messaging formats that could promote rather than diminish screen time."²²⁵ By the twelfth week of the study, participants were using the intervention device on average only every second day. Whilst acting with good intentions, the researchers may have rendered their intervention devices less attractive to these adolescents than their own personal devices.

Delivering an intervention via a participants' personal mobile device may also greatly reduce the need for face-to-face contact between researcher and participant.²²⁶ A study of 253 fathers from antenatal classes in Australia concluded that the relative lack of contact between fathers and health professionals was a strong limiting factor in their ability to effectively support their partners through pregnancy and the post-natal period.²²⁷ The authors strongly recommended the supplementation of face-to-face support with electronic information, tailored to fathers, and available via email or the Internet. However this reduced face-to-face contact may have drawbacks, as discussed in Section 3.4.2.

3.4.6 Near-constant connectivity

Not only do mobile devices tend to be always near, they are also typically always connected to the Internet, meaning that there are very few barriers to the collection of data. Early health studies involving computing devices required participants to synchronise data to a remote server or a connected computer, either periodically throughout a study, or at the conclusion of the research period.^{228, 229} As one example, a 2007 study of a mobile phone-based diabetes management application called *Diab-memory* required participants to measure their blood glucose level with a meter, then to manually enter this data into the application, along with other data including insulin dosage, carbohydrate intake and exercise times.²³⁰ Users were then required to manually synchronise this information to a server. In some cases where participants reported unsuccessful data transmission, the researchers had to ask participants to identify areas of their home or workplace with good cellular signal and to only attempt synchronisation in those areas. This meant one more task for which participants needed to be trained, and one more instance in which data loss could potentially occur.

Similarly, the 10,000 Steps project, a physical activity initiative at the University of Central Queensland, involved a mobile application called *iStepLog*,²³¹ screenshots from which are shown in **Figure 5**. This application required participants to record their daily steps using a pedometer, then to manually enter their step count each day, and manually synchronise this data to the project database. A case-control trial (n = 200) found that use of the smartphone application increased step logging rates compared with users of the desktop website.¹⁷¹ However, this approach to manually logging activity has almost certainly been superseded for most users by the inbuilt step counting functionality included in many smartphones released since about 2013, or by dedicated fitness trackers by companies like Fitbit and Jawbone, which automatically synchronise data with a web server.

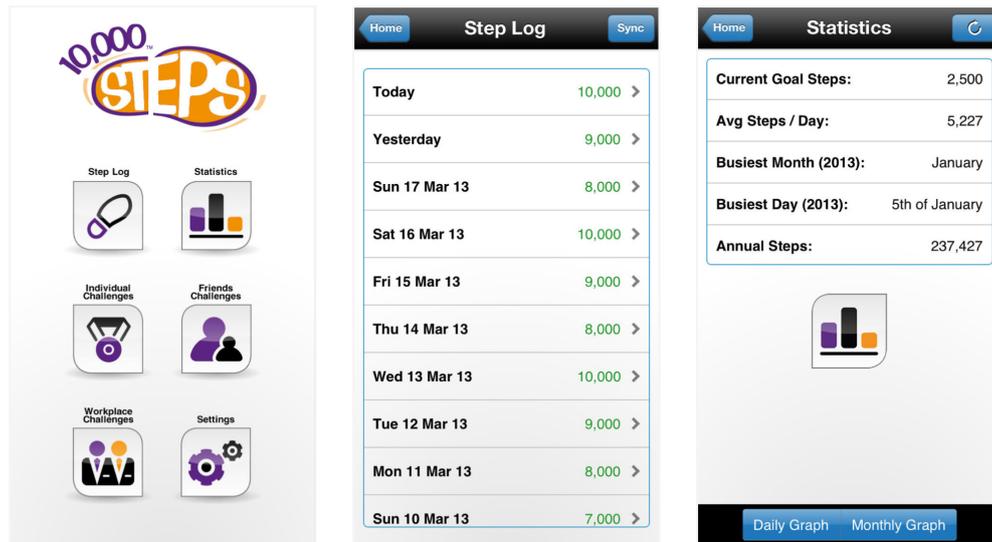


Figure 5. Step tracking, statistics and personal goals in the *iStepLog* application.²³¹

The always-connected nature of mobile devices means that it is possible to save and synchronise data immediately upon entry, to keep a full and accurate record of data as it is collected and, where permitted, make that data available to health researchers. This is in contrast to traditional means of data collection, such as food and exercise journals, which require direct maintenance by participants over a period of time, then manual submission at the end of a study, or at periodic intervals. Manual self-reported data may be subject to lost, incomplete or misremembered information,²³² and automation may assist with reducing memory effects. It may, however, introduce new issues or concerns, particularly with respect to privacy, data collection, and ongoing informed consent.¹⁹⁷

Modern mobile applications may synchronise data on an ongoing basis, even to the extent of event-by-event synchronicity (i.e. every user action is recorded and synchronised immediately after it occurs).²³³ This means that it is possible to gather data continuously throughout a study or intervention. It is also possible, if permitted by the study design, to make adjustments on the fly, or to contact a user if there appears to be a problem. For example, if a user's data is not appearing, there may be a problem with their application or device, they may not have granted necessary data sharing permissions, or they may have simply stopped participating, and this information may be very important to study

coordinators. In some circumstances it may even be possible to identify a potentially serious issue with the application being studied and to fix this via a software update.

For example, in 2014 Australian researchers trialled a mobile application designed to promote physical activity and reduce screen-time in adolescent boys deemed to be at risk of obesity.¹⁷² While it may seem counter-intuitive to use mobile devices to encourage reduced screen-time, the application, called *ATLAS* (Active Teen Leaders Avoiding Screen-time), comprised physical activity monitoring, fitness challenges, goal setting and personalised motivational messaging. After beginning the intervention the researchers discovered that this latter feature, implemented via push notifications to devices, was not functioning correctly. The researchers updated the application to fix this issue, meaning this functionality was available for the last 15 weeks of a 20-week intervention. It is important to recognise that taking an action like this may have important implications for data validity before and after the fix, depending on its magnitude and the stage of the study at which it takes place. However, issuing an update may be significantly better than waiting until the conclusion of a study and finding that no data has been collected, or the data collected is fundamentally flawed due to a software problem.

3.4.7 Non-textual data entry

Data entry has been problematic for applications seeking to facilitate self-monitoring of health and fitness activities. Manually entering the food one eats, or the exercise one engages in, is a significant burden, and one that only the most motivated of individuals will likely sustain for more than a short period. This has been a problem shared by both health interventionists and commercial application developers seeking to retain a large and highly engaged user base. The replacement of traditional pen-and-paper methods with simple text-entry applications for PDAs and early smartphones represented one step towards reducing this burden.^{168, 169, 218} However manually typing information into a device

is not significantly easier or less time-consuming than writing it down; indeed, some users may consider it more difficult.

Some modern mobile applications greatly reduce the burden of data entry via the use of non-textual data entry methods. Users may scan data using a device camera, speak into a device microphone, or use simple gestures such as swiping or pinching on a screen. These input methods may be augmented by access to online databases of information, offering predictive information or auto-completion functionality, and may facilitate the recording of significant amounts of information, requiring only a minor level of user interaction (for example to verify information or make selections to resolve data ambiguity). Indeed, mobile devices may facilitate the recording of health data with no direct input at all from the user, beyond initially consenting to that access. Modern devices, including wearable peripherals, contain sensors capable of automatically recording data such as steps taken, time spent sitting and standing, heart rate and sleep quality.

For example, an exercise monitoring application may use a device's GPS tracker to record the locations travelled through by a walker or jogger, its barometer to measure atmospheric pressure, and its system clock to record the time taken. This data, when combined with other inferred information, can provide a vast array of potentially useful information including distance, speed, elevation and calories burned. Pairing the application with a low-cost, commercially available peripheral can add additional biometric information, such as heart rate. Previously the recording of this information would require a number of pieces of equipment, the manual consultation of maps, and a number of different calculations. The recorded information would most likely have been less reliable; studies have shown that GPS is an accurate means of measuring distance travelled, although care must be taken in interpreting results in some sub-optimal circumstances.²³⁴⁻²³⁶

Interventions requiring the monitoring of dietary intake have similarly benefited from these advances. Traditional data entry methods, such as food diaries, 24-hour recalls and food frequency questionnaires rely on memory and can involve a lot of calculations on the part of the participant.^{146, 237} These methods commonly

introduce inaccuracy over time.²³⁸ Accurately recording the nutritional composition of meals is, quite simply, a difficult task. As one food scientist colourfully put it:

People are not one-armed bandits. If we drop in a coin and pull the handle, we may get truly random results or biased results. Few of us think of what we eat in terms of a shopping cart full of food. We cannot just look down and see how much milk, yoghurt, eggs or oil we consume. Our eating sessions are much too important to us, experiences associated with emotions of pleasure or pain, rather than with an inventory of items consumed.¹⁴⁸

Device cameras may also be used to scan barcodes or QR codes. For example a diet tracking application might enable a user to scan a barcode on product packaging to obtain a large amount of nutritional information about that product. There are also a number of inexpensive Bluetooth-enabled scales for recording the weight of food consumed and synchronising this information to a paired device. Thus, by placing food on a scale and using a device camera to scan a number of barcodes, a user could in seconds record a significant amount of information about the food they are eating, without the need to manually enter any information at all. In 2006, working with PDA devices, researchers developed a diet monitoring system for people with chronic kidney disease, which enabled users to enter their dietary information either by scanning barcodes or by speaking into a device.²³⁹

This, and other nutritional studies using emerging technology at the time (e.g. an evaluation of *HyperFit*, a nutrition and exercise tracking Internet service²⁴⁰) had some difficulty finding or creating sufficiently comprehensive databases of food barcodes. Siek et al.²³⁹ used an open source database of some 620 000 food products, and found that this only accounted for around 60% of participants' scanned barcodes. More recently, New Zealand researchers trialled a dietary modification tool called *SaltSwitch*, which incorporated a database of only around 13 000 food products.²⁴¹ Users of the application were encouraged to add food

products they found were missing from the database, by submitting photographs of the products' nutritional panels, for manual review and entry by the research team. Difficulties of this nature may be resolved by the emergence and success of comprehensive commercial nutrition-tracking applications, such as *MyFitnessPal*, which boasted a database of more than five million products, as of June 2015.²⁴² Researchers could potentially use this application directly as a data collection tool or, if they required a more tailored solution, could develop a custom application that incorporated the *MyFitnessPal* public application programming interface (API). An API is a set of protocols for accessing a data set or developing an application, explained further in Section 3.4.10.

3.4.8 Tracking health behaviour

In 2007 Gary Wolf and Kevin Kelly,²⁴³ editors of popular science and technology magazine *Wired* coined the term *the quantified self* to refer to the goal of applying data analysis techniques to a wide range of measurable information about the human body and mind. Since then many groups of enthusiasts have coalesced around the world to explore the potential for self-quantification both routine (for example, location tracking and mood journaling) and more extreme (for example, recording of chemical body load counts, personal genome sequencing, and the use of non-invasive sensors and probes).²⁴⁴ By one count, there are more than 110 such groups in more than 30 different countries, and a well-attended international conference has been held in San Francisco each year since 2009.²⁴⁵

Attending groups and conferences might be seen as the far end of a spectrum of engagement, but recent years have seen a growing public awareness of the principles of self-quantification, if not the term itself. There has been a surge of commercial and consumer interest in monitoring health and fitness activities, brought about by the development of inexpensive, user-friendly and relatively accurate devices to facilitate that monitoring. Technology industry analysis website Business Insider estimated growth in the US wearable fitness tracker market of around 500% per annum between 2011 and 2014.²⁴⁶ It was, however, acknowledged that this still only represented a comparatively small user base

when compared to more ubiquitous mobile devices such as smartphones, which increasingly include their own inbuilt activity tracking sensors.

Even without using dedicated activity trackers or other wearable devices, many people have been exposed to the principles of self-quantification via smartphone applications that adopt this strategy. These include movement trackers (e.g. *RunKeeper*,¹⁷⁰ *Strava*,²⁴⁷ *Nike+ Move*²⁴⁸), calorie counters (e.g. *MyFitnessPal*,²⁴² *Calorie King*²⁴⁹), lifeblogging/journaling applications (e.g. *Optimized*,²⁵⁰ *Happier*²⁵¹) and mood diaries (e.g. *MoodPanda*,²⁵² *iMood Journal*²⁵³).

A 2013 survey of 3014 US adults by the Pew Research Centre found that 69% of respondents tracked at least one health indicator such as weight, diet, exercise, sleep, or disease symptoms. However, only about one in five (21%) of those who tracked an indicator did so with the help of some form of technology.²⁵⁴ It is worth noting that it is by no means universally accepted that this growing interest in self-quantification is entirely positive. Some commentators have raised concerns about increased self-diagnosis and reliance on non-evidence-based information to interpret collected data,²⁵⁵ hypochondria or the phenomenon of the “worried well”,²⁵⁶ and the potential for breaches of privacy.²⁵⁷

Whether or not some individuals have taken their interest too far, health professionals have long been aware of these benefits of a moderate level of self-monitoring of health. Positive effects have been shown in studies of nutrition,^{147, 219, 222, 225, 258-260} physical activity,^{171, 172, 261} diabetes management²⁶²⁻²⁶⁵ and mental health.^{203, 214, 266, 267} Klasnja and Pratt¹⁷⁹ claimed that the effects of self-monitoring health behaviour may include increasing the frequency of desired behaviours or decreasing the frequency of undesirable behaviours, better understanding of individual’s own health and behaviour patterns, and opportunistic engagement in healthy behaviours. They further noted that, beyond these direct benefits, there might be additional advantages simply due to individuals being engaged in the monitoring process. Understanding one’s own health and patterns of behaviour has long been recognised a positive health trait, and a key component of health literacy.²⁶⁸

The fact that self-monitoring may improve people's health quite separately to the direct effects of a health intervention is positive from a health perspective. It may be less positive purely from a research perspective, because it may be difficult to separate the self-observation effect from the effect of the intervention itself. It is important to recognise the complex nature of these types of interventions and factor in this effect when designing studies with a self-monitoring component (see Chapter 4).

3.4.9 Gamification

The term *gamification* refers to the process of taking elements of games (both electronic and real-world) and applying them to non-game environments.²⁶⁹ Mobile applications using some form of gamification have proliferated, and in no field more so than in health. For example, a gamified fitness application might reward users who engage in physical activity with points or badges for assorted achievements. Users may be encouraged to compare their achievements with other users in their social group or to compete with other users, for example by issuing challenges or competing for position on a leader board. Many commercial health applications have adopted this approach, including activity-tracking applications (e.g. *Health Mate*,²⁷⁰ *The Walk*,²⁷¹ *Fitocracy*,²⁷² *Zombies, Run!*²⁷³), nutrition diaries (e.g. *MyFitnessPal*,²⁴² *WatchFit*²⁷⁴), goal setting and habit breaking applications (e.g. *HabitRPG*,²⁷⁵ *Superbetter*²⁷⁶) and mental health trackers (e.g. *Mindbloom*,²⁷⁷ *Personal Zen*²⁷⁸). A 2014 review of health and fitness applications on the iOS App Store identified 261 applications that met the selection criteria, with about half of these (52.5%, n = 137) including at least one gamification element.²⁷⁹ Examples of application gamification elements are shown in **Figure 6**.

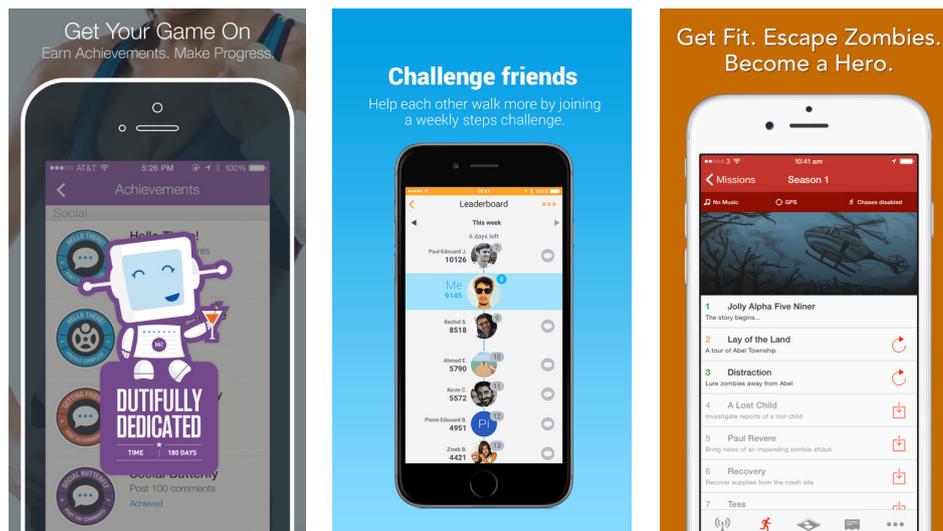


Figure 6. Gamification elements in the fitness applications *Fitocracy*²⁷² (left), *Health Mate*²⁷⁰ (centre) and *Zombies, Run!*²⁷³ (right).

The use of gamification in commercial weight loss applications has been somewhat controversial. Some have gone as far as enabling users to wager real money on their ability to lose weight, with winnings distributed among those who succeed in achieving their weight loss goals.^{280, 281} Perhaps not surprisingly, questions have been raised about the potential problems associated with this approach.²⁸² Emerging literature does appear to suggest that financial incentives can be effective in achieving weight loss, although not necessarily in maintaining that loss over time.^{283, 284} Quite aside from financial or other incentives, simply being part of a group competition may be an effective motivation for physical activity and weight loss. A state-wide Internet-based competition was implemented by the US state of Rhode Island in 2007, and evaluated in a large study (n = 4717).²⁸⁵ The authors reported modest, but statistically significant reduction in body mass index among participants.

Gamified applications have also been used for interventions in other health fields. Mental health researchers conducted a study (n = 78) of an attention-bias modification training application that incorporated gamification elements.²⁸⁶ Some (but not all) of the application treatment conditions showed improved perceptions of threat, as measured by a gold standard protocol. Another gamified

application was designed to assist adolescents with diabetes management. Participants received points for regularly self-administering blood glucose tests and real-world rewards (digital goods vouchers) for maintaining the correct testing regimen over a period of time. They could also share their progress and achievements with other users of the application. A pilot study (n = 20) found that participants showed improved monitoring regularity while using the application.²⁶²

When applied in a health intervention or education context, this approach is sometimes referred to as *serious gaming*.²⁸⁷ A subtle distinction between the two terms is that gamification usually refers to the addition of game-like elements to things that are not ostensibly games, while serious games are exactly that: genuine games that have a serious health or educational intent. The concept of serious gaming significantly pre-dates that of gamification, having been coined around 1970 (predominantly in reference to board and card games).²⁸⁸ There are at least three peer-reviewed journals dedicated to research relating to serious gaming and, more recently, gamification.²⁸⁹⁻²⁹¹

3.4.10 Large scale medical data collection

Until relatively recently many health interventions used the Internet as an effective means of carrying out an intervention, but may have collected study data via more traditional means, such as participant questionnaires.^{175, 206, 225, 292, 293} In some cases, this approach is necessitated by the fact that some control or comparison arms of the study are not engaged online.^{151, 201, 260, 294} It has become increasingly feasible to collect a wide range of data directly from participants' devices. For example researchers might collect analytics data about the extent to which participants used the application under investigation, and the ways in which it was used, or gather direct feedback from user interactions within the application.

These kinds of research activities were somewhat difficult to undertake using the standard facilities in place for the distribution of native mobile applications. For

example, it has been difficult to restrict the availability of an application to only certain users (for example, to ensure that an application is available only to intervention participants and not to members of a control group, or to facilitate a closed intervention that will not be contaminated with data from random members of the public). Researchers have needed to rely on methods of application distribution that are either technically difficult and expensive (for example, ad hoc distribution to devices via an enterprise agreement) or cumbersome for participants (for example, distribution via beta testing services, requiring participants to look up information about their device and install testing profiles).

In recent years there has been a profusion of services designed to facilitate health data collection and sharing. In some respects this has been the most significant growth area in mobile health; previously stand-alone applications are increasingly able to tap into large data repositories and share their data across entire families of applications. Three of the largest device operating system developers (Microsoft, Apple and Google) have their own proprietary health data repositories: *HealthVault*,²⁹⁵ *HealthKit*²⁹⁶ and *GoogleFit*²⁹⁷ respectively. Each of these systems facilitates the sharing of information between various first- and third-party health applications. Each also has a fine-grained permissions system that enables users to control the ways applications can read and write these data. Other smaller application vendors have created open APIs to enable authorised applications and devices to share data. For example, the popular cross-platform exercise tracking application *RunKeeper* has a proprietary API called *HealthGraph*, which enables other fitness applications to share this information (once permitted by the user).²⁹⁸ This has significantly reduced the friction of using multiple health applications to record similar data.

These proprietary APIs and data repositories been available for some time on an individual, local level to enable the monitoring of personal health information. However in March 2015, Apple announced a new framework called *ResearchKit*. Built in collaboration with a number of medical institutions and foundations including Stanford Medicine, Oxford University, Massachusetts Hospital and the

American Heart Foundation, the stated goal of *ResearchKit* was to make it easy for health and medical researchers to gather data on a scale never before possible, whilst upholding established best practice in ethics and informed consent.²⁹⁹ Critically, Apple announced that this framework would be open source, meaning that it can potentially be applied well beyond the Apple platform and device ecosystem.

At the time of launch, Apple had worked with medical research institutions to produce mobile applications designed to support research programs in diabetes, Parkinson's disease, diabetes, breast cancer and cardiovascular disease. In the first six hours of availability, researchers at the University of Rochester received more than 7000 individual volunteers for a Parkinson's disease study that had previously never obtained a sample larger than 1700.¹⁹⁷ Screenshots from *mPower*, the *ResearchKit*-powered application developed for this study are shown in **Figure 7**.

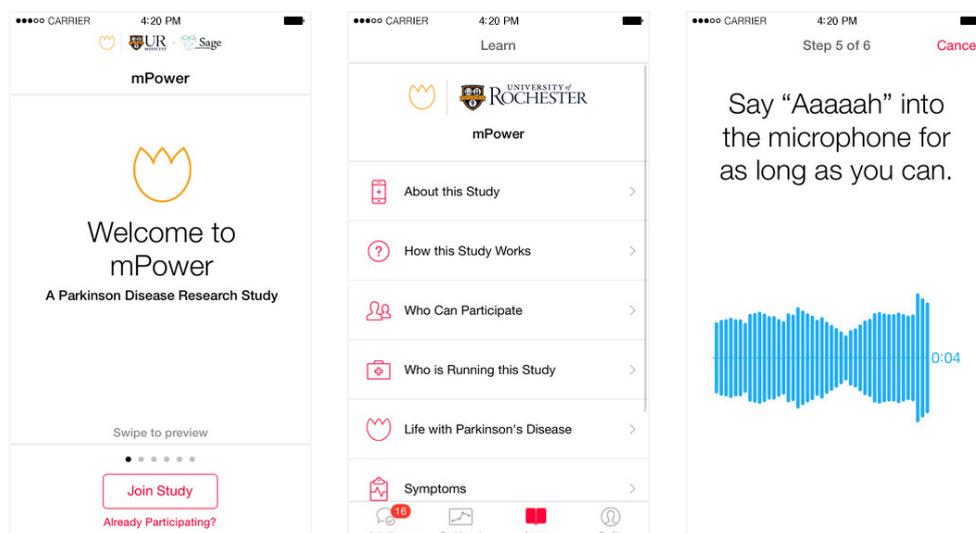


Figure 7. Screenshots from the *mPower* Parkinson's Disease research application.³⁰⁰

3.5 Social networking and health promotion

3.5.1 Virtual communities

Community health promotion is a discipline undergoing change. Never has the idea of community been as broad as it is today. Communication technology now enables communities to span enormous geographical distances and to overcome barriers of age, culture and even language. Naturally, as concepts of community evolve, so must the methods used to target those communities in promoting healthy behaviour.³⁰¹

The term *virtual community* sounds decidedly modern, but it is by no means a new concept. Jason Marcus³⁰² cites urban planner Melvin Webber observing four decades ago that developments in transportation and communication technology were beginning to have significant impacts on urban settlement, and that what he called “communities without propinquity” would necessitate new understanding of what it means to commune. In his seminal book on the subject, Howard Rheingold³⁰³ discussed the various ways in which pioneering Internet users were finding to communicate and form communities. While predating the World Wide Web, these early chat forums and electronic mail distribution lists were already forming communities that spanned previously unthinkable geographical barriers. Rheingold foresaw the potential psychological and social benefits of participation in these communities.

While the following two decades saw enormous growth in the uptake of these technologies, this growth was not without setbacks. The ‘burst of the dot com bubble’ in the early 2000s led to dramatic changes in Internet services – changes that have become retrospectively known as *Web 2.0*, a phrase coined by technology publisher Tim O’Reilly.³⁰⁴ Prior to this juncture the Internet comprised largely stand alone web pages that were mainly read-only; that is, they were typically maintained by a webmaster with a largely one-directional information flow. The term *Web 2.0* describes a range of technologies and Internet paradigms

that allow a multi-directional exchange of information and opinion from webmaster to user, from user to webmaster, and even from user to user.

3.5.2 Social marketing

Social marketing is an approach to health intervention that attempts to leverage many of the same principles used by commercial marketers to influence behaviour. This approach predates the advent of social media or social networking, in the modern sense, with early work in the field beginning in the late 1960s and early 1970s.³⁰⁵ The development of electronic communication and, more recently, widespread use of social networking, have had a dramatic impact on commercial marketing, with many companies finding it increasingly difficult to influence consumer behaviour through traditional marketing avenues, such as one-directional advertising.³⁰⁶ In one sense social marketing in health is a derivative activity, in that it adopts and adapts approaches from a different field (commercial marketing). Therefore, it is natural that changes in the one should take some time to filter into the other, and this has been true with the uptake of social networking in health promotion.

In their analysis of social marketing in public health, Grier and Bryant³⁰⁷ cited examples in such diverse fields as disease control, fruit and vegetable consumption, breastfeeding and the promotion of physical exercise, among many others. They warned that health professionals needed to have a deep understanding of the underlying principles, to avoid unwarranted assumptions, and to conduct effective evaluation of interventions to inform the development of the field.

While this is true of the general field of social marketing, it is particularly true of the use of social networking, where developments are especially fast-paced. Some projects have found that social media enables users to engage directly in the production and distribution of content, information and ideas, and to quickly disseminate information among very large audiences.³⁰⁸ Others have found this democratisation of information problematic, claiming that it is increasingly

difficult for users to make value judgements about the information they are presented with – for example, to separate information that is evidence-based or from expert sources, from that which may be non-credible and potentially incorrect.³⁰⁹ As promising as these new promotional avenues may appear, it is essential to understand the experience of users and the flows of information, and to evaluate the effect of these initiatives.³¹⁰

3.5.3 Participation and engagement

Interventions that draw on the benefits of community support, whilst also taking advantage of social networking or electronic media, may be able to minimise barriers to participation. People can join virtual communities freely and with no specific time or participation commitment. People can participate in multiple virtual communities with minimal disruption to their normal routines. Although in one sense, a person is automatically a member of the local community in which they live, active participation in that community requires both a conscious decision and the expenditure of time and effort. Furthermore, traditional communities of interest may require financial contributions and attendance at events or meetings. At least one study has found that testing virtual community participants for psychological sense of community yields results not dissimilar to participants of traditional communities. Of particular interest to the present study, it was found that health-oriented virtual communities showed the highest levels of ownership and sense of community.³¹¹

Although members of traditional communities are usually able to choose their level of participation, there are many factors bearing on this decision. Once joining, a person may feel compelled to participate to a certain degree, and having established a pattern of participation, may feel pressure (real or imagined) to continue, particularly if they feel that others are relying on them. This concern may be a factor in their decision to join a traditional community in the first place. In a virtual community, people may have the option of participating anonymously, and even where this option is not available or not taken, a participant is unlikely to

feel any compulsion to contribute beyond a level with which they are comfortable.¹⁸⁷

As easily as people can join virtual communities, they can also leave them. Although this presents a challenge, there is evidence that people can and do establish regular and long-term patterns of participation in virtual communities that interest, engage or are of use to them.³¹¹ Another factor at play is the possibility of passive participation in most virtual communities. It is often possible to observe discussions and examine resources both anonymously and invisibly, before deciding to become an active participant. This raises the question of whether such a passive participant is in fact a participant at all, but nevertheless there may be an easy and non-threatening path from non-engagement to full participation in a community. In many cases, once a person has made a connection (for example, by “liking” a page, or adding the content of a site to their Rich Site Summary (RSS) newsfeed), they will continue to be exposed to the content of that site until they elect to deliberately disconnect. Thus, a connection may be maintained over time even with no conscious effort on the part of the user.

Interactive communication applications have for some time been identified as being of high value in reaching large groups with a health message.³¹² In more recent times, social media has provided an ideal context in which to undertake such interventions – a fact attested to by the rapid increase in projects which operate in this medium.³⁰¹ The virtual communities created by social networking services are a fertile ground for the dissemination of all manner of messages, including health messages, and the explosive growth of mobile technology has only added to the potential avenues for health researchers to explore.

3.5.4 Social support and connectivity

The role of social support in health outcomes is well documented.³¹³⁻³¹⁷

Traditionally such support has been possible through the involvement of family and friends, health professionals, or participation in real-world groups or teams.

Interventions seeking to provide face-to-face support are often costly to administer both in financial terms, and in terms of burden to participants.

One significant innovation enabled by socially connected applications has been the possibility of much wider social support networks. An individual trying to run regularly, lose weight or quit smoking may now participate in global communities of thousands of people trying to achieve the same goals. Where desired, individuals may participate in these communities with partial or complete anonymity, something that is not possible with traditional real-world groups such as weight-loss support programs or Alcoholics Anonymous groups.^{193, 318} These technologies facilitate the establishment of social networks over large geographical areas, vastly increasing the potential scope for interventions seeking to leverage social support and connection.

The broad uptake of social media services such as Facebook and Twitter make these services attractive launching pads for many health interventions. Researchers have sought to leverage these networks, and the social connectivity they provide, for numerous interventions in nutrition and physical activity,^{207, 293, 319-322} smoking cessation^{173, 323} and sexual health.^{194, 324, 325} Not all researchers have found these existing networks to be entirely suitable to their needs or acceptable to their participants. The creators of *SitCoach*, a mobile application designed to reduce sedentary behaviour, found that a suggestion to share activity on Facebook or other social media platforms was not well-received by participants in a small pilot study (n = 8).³²⁶ The researchers were told by participants that they did not want to bother their broader networks with details of their participation in the program, an observation echoed by evaluators of another similar Facebook-powered health application called *3GT (Three Good Things)*.³²²

Researchers may feel that participants may be more likely to engage with social connectivity features of a project if that connectivity is solely within a social network specifically set up for that project, rather than within their more general networks. Their interventions may also require a greater degree of customisation, more control over the way content is presented and protected, or the ability to

collect more fine-grained information about the way participants are engaging, than what is afforded by the established social networks. In this case they may prefer to create custom mobile applications or web services that establish their own networks for sharing and social support. For example the *BecomeAnEx.org* smoking cessation intervention established a large online community of current and former smokers to provide support for those trying to quit. This community was facilitated by the organisation's own custom web and native applications, available across a wide range of platforms. A study of 1033 users found that overall number of visits to these applications significantly predicted both 7- and 30-day abstinence.³²³ Similarly, a physical activity intervention (n = 53) created a custom website providing, among other features, a forum in which participants could ask exercise- and health-related questions.³²⁷ All participants were able to view and answer questions, with the forum being monitored and moderated by research team members who also provided answers. When compared with other static information sources, the program proved more effective in increasing physical activity level, however this behaviour change was not maintained at six-month follow-up.

The support of relative strangers may be very different to the support of close friends and family.^{322, 328} Some health-focussed applications are able to facilitate more traditional close-network support; for example, some fitness tracking applications enable people to issue challenges to friends who also use the application, and to compare their progress over time. While friends and family members motivating each other to stay on track to complete health goals is not new, these applications facilitate this communication and simplify the recording and comparison of information, enabling some degree of objective comparison.³²⁹

While individuals may receive support from other people seeking to achieve the same health goals, they may also be supported by those who have previously succeeded in achieving those goals – for example, quitting smoking, managing diabetes, or successfully breastfeeding. This support is sometimes known as *peer modelling*, and some health applications (both in the research/intervention space, and commercial in nature) have sought to leverage this dynamic. For example the

aforementioned *BecomeAnEx.org* intervention drew on the support of people who had successfully quit smoking in supporting those who were trying to,³²³ and in a different study, German researchers found that web-based peer modelling intervention was successful in increasing physical activity.²⁹²

3.5.5 Effectiveness of social media health interventions

The efficacy of electronic social support in achieving lasting behaviour change is a question that is far from settled. Researchers at Australia's Commonwealth Scientific and Industrial Research Organisation (CSIRO) conducted an evaluation of the *Online CSIRO Total Wellbeing Diet* in 2012.³³⁰ This large study (n = 8112) incorporated a custom-built social networking platform as well as personalised information and advice on nutrition and meal planning. Studies of this nature are often unable to delineate the effect of various components of the intervention, and the researchers in this case wanted to isolate the effect of the social support component from other factors. In all, seven different websites were deployed, representing three main treatment categories: information-based, supportive, and personalised-supportive. Significant attrition was observed, with the study losing around 40% of its participants in the first week, and a further 20% of the remaining participants in each subsequent week throughout the 12-week study. Overall, relative to a control group, these supportive and personalised features did not have a significant effect on weight loss. However, their presence did increase the length of time users remained engaged with the system.

Similar findings resulted from a 2015 evaluation of a smartphone application for smoking cessation called *SmartQuit*. This application provided social support to those seeking to quit smoking by enabling them to share their progress with other users, friends and family. In a study of 78 users of the application, the researchers found that, while the support features were popular, their use was not associated with successful smoking cessation. Referring to the findings of a larger study of 1033 users of a web-based smoking cessation intervention,³²³ which reported similar results, the authors concluded:

[Even] those app features that follow evidence-based principles for in-person interventions (e.g. getting social support) may not be effective when translated into a mobile health intervention (e.g. getting social support by sharing via text, email, or social media).¹⁷³

The authors noted the existence of more than 400 smartphone applications for smoking cessation, with downloads of more than 780 000 per month. They claimed that most formal studies of these applications had evaluated them in terms of public health guidelines developed specifically for traditional face-to-face interventions. They further opined that these approaches might need to be re-evaluated as researchers seek to better understand user engagement with smoking cessation applications.

Equivocal outcomes in many of these studies may be as much about poor study design as innate limitations of the approach. A 2014 systematic review of social media interventions for dieting and exercise behaviours examined 22 randomised controlled trials that included social support components.³²¹ While pooled results from the studies showed a significant decrease in dietary fat consumption, the studies did not typically show significant differences between groups on other key outcomes. The authors commented that the methodologies of the reviewed studies were often lacking, and observed that it may be very difficult to determine the role that social media played in behaviour change, where engagement with the intervention was low, as it sometimes was.

3.6 Precedence for the use of mobile technology and social media in encouraging fish consumption

A small number of projects have attempted to use mobile technology and/or social media to promote the consumption of a particular fish or seafood product, or fish consumption in general. Some have achieved success, although formal evaluation of their impact has been limited.

3.6.1 Fish is the Dish

This UK initiative focused on showing mothers that fish is a healthy option for their families, which could be easier to prepare and less expensive than they might have thought.³³¹ The project recruited ambassadors ('fish fanatics') to cook fish for their families and write blog posts about their experiences. In November 2011 the project had 14 active bloggers, with an average of 3492 Twitter followers each (a total of 48 891 followers in all). In the same month, the Tots100 website (which provides a monthly ranking of UK blogs based on their impact on British parents) ranked Fish is the Dish 15th.³³² To put this in context, this was higher than Nintendo Wii (21st), Barbie (37th), Gap (42nd) and Toys R Us (50th). This might be taken as an indication that in the social media space, the quality of the execution is at least as important, if not more so, than the intrinsic appeal of what is being presented. The Fish is the Dish homepage is shown in **Figure 8**.

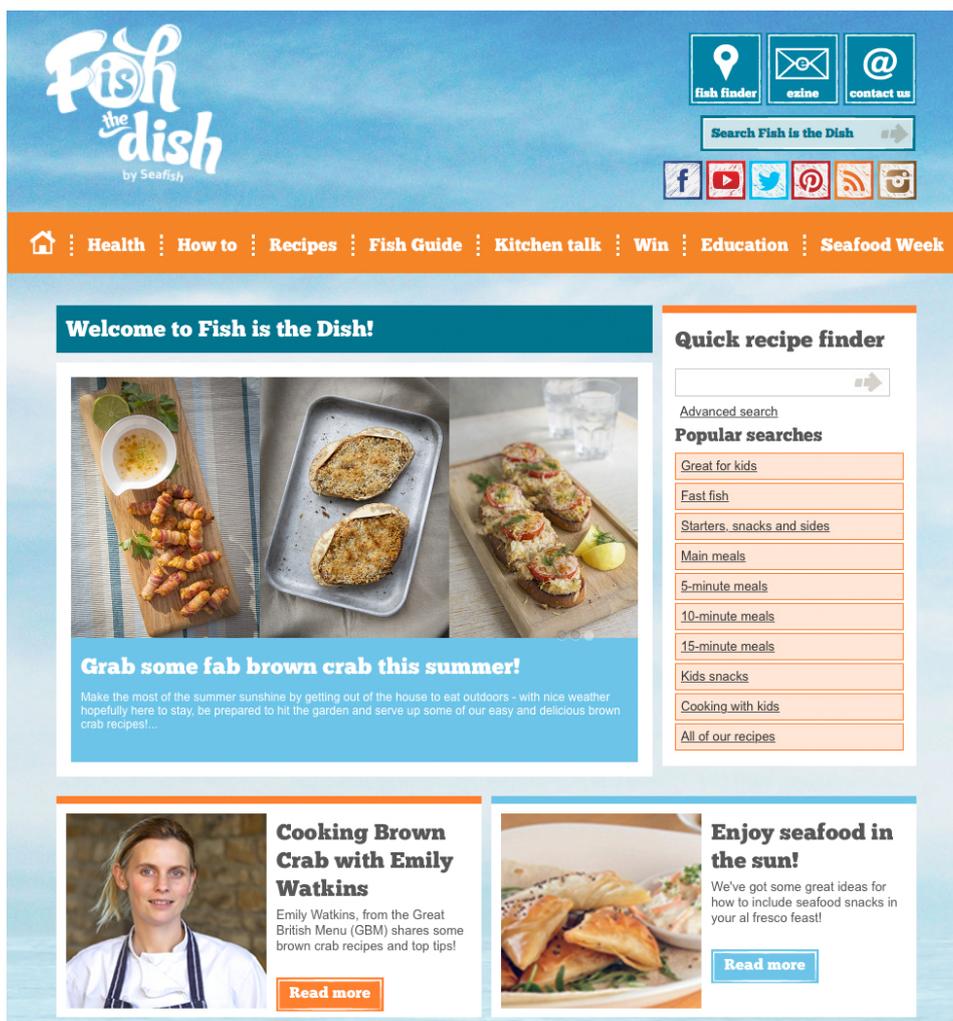


Figure 8. Fish is the Dish homepage.³³¹

3.6.2 How Much Fish?

How Much Fish was a US initiative that sought to counter the perception that fish is unsafe due to contaminants such as mercury.³³³ The source of this project, the Centre for Consumer Freedom (CCF), must be viewed with some degree of scepticism. It is an advocacy group that works to challenge many public health campaigns related to food safety, and has attracted criticism due to links with the tobacco, fast food and meat industries.³³⁴ Nevertheless, this initiative merits examination as an example of consumers' willingness to embrace a social media campaign to increase fish consumption.

The cornerstone of the How Much Fish project was a “seafood calculator”, available via both a website and a mobile application. This allowed users to select from a variety of popular fish species and to see how much could be safely consumed based on their weight, and on what the CCF claimed as the latest evidence. For all common species, this was presented as well above a realistic level of consumption. For example, it was claimed that an 80 kilogram person could safely eat 5.8 kilograms of cod per week.

In addition to this tool, the project maintained a Facebook page on which it highlighted seafood recipes and tips. This page was very active and well subscribed, until the end of 2011 (at which time it had more than 28 000 subscribers). These subscribers responded enthusiastically to posted content. In the month ending 14 December 2011, the page’s administrators had placed twelve posts, receiving an average of 3.3 comments and 14.8 ‘likes’ per post. They had also conducted two polls, receiving an average of 131.5 responses. This level of activity had been relatively consistent over more than two years previously. This project was discontinued without explanation in early 2012.

3.6.3 Queensland prawns

Seeking to establish Queensland Week as a third occasion for prawn consumption (alongside the established traditions of Easter and Christmas), this Australian project was successful in building a large and active community of people who were enthusiastic about the product.³³⁵ In December 2011, the two Facebook pages associated with this project (one for Queensland prawns in general, and one specifically for banana prawns) had a total of 22 428 subscribers. Both pages were very active, with regular well-commented posts about recipes, tips and special deals. The generic site in particular saw a considerable amount of user-generated content, particularly during Queensland Week itself.

3.7 Conclusion

There are clearly significant cost and convenience advantages in the use of mobile technology to deliver health interventions. Indeed, this technology enables new kinds of intervention that were previously difficult or impossible. However there may also be negative implications associated with reduced face-to-face contact in health contexts. Some meta-analyses of Internet-based interventions have questioned their efficacy compared with traditional face-to-face support mechanisms.^{336, 337} An early Cochrane review of telemedicine compared with face-to-face patient care alternatives, carried out in 2000, found good evidence for the feasibility of using telecommunications technology for health care, but limited evidence for efficacy or cost-effectiveness.³³⁸ More recently another Cochrane systematic review of 67 breastfeeding studies concluded that face-to-face support showed a larger treatment effect on breastfeeding duration than telephone support.³³⁹ In contrast, a meta-analysis of 21 studies found no significant differences between face-to-face psychotherapy and guided self-help in terms of mental health outcomes.³⁴⁰ It may very well prove to be the case that certain kinds of health behaviour are more easily targeted in a face-to-face context than others. The appropriateness of these approaches may also depend to some extent on the level of evidence being sought.

Ultimately, whether or not mHealth interventions are shown to be as effective in producing health behaviour change as traditional, face-to-face methods, they may still prove to be cost effective options. A review of economic evaluations of Internet interventions found that, while economic analysis was generally lacking, there were strong indications of cost-effectiveness for such interventions when all factors were considered. The authors suggested that "Even if Internet programs are found to be equally effective or even less effective than programs delivered via a traditional mode (e.g., face-to-face, phone), their relatively low delivery cost could result in Internet programs being more cost effective."³⁴¹

Evaluation, clearly, is critical. For mHealth interventions to warrant consideration in the expenditure of public health funds, they must be rigorously evaluated and have their effectiveness quantified. The present study, while focussed on the specific health issue of fish consumption, seeks to add to the evidence base for effective evaluation of mHealth interventions in general.

4

Development of a complex intervention

4.0 Development of a complex intervention

4.1 Complex interventions in health promotion

The methodologies to develop and evaluate pharmacological treatments are well established. Such treatments are subject to rigorous evaluation, ideally by way of randomised controlled trials (RCTs). Such trials are universally accepted as the gold standard for evaluation. There has been a growing move to introduce this kind of rigour to the fields of health promotion and public health. To find ways of evaluating the myriad activities of researchers in those fields – community trials, information campaigns, innovations in treatment and many other kinds of intervention, both qualitative and quantitative.

However it is seldom a simple matter to take the methodologies refined in simple pharmacological interventions, and apply them to other kinds of complex interventions. It should be noted that the word *simple*, in this context, is by no means pejorative. The development of a drug is a long and difficult process with a great deal of regulation and a very high burden of proof – *simple* here does not mean easy. Simple interventions are so called because the experimental variable can be isolated with relative ease, and the conventions for calculating statistical power can be easily applied.

An intervention is complex when it comprises a number of components and where it may be difficult to isolate the effect of each of those components. It is complex when confounding variables are expected to render results analysis problematic, or where there is limited scope to draw on existing research to inform the development of the intervention, selection of the sample, or estimation of the effect size.³⁴²

4.2 Evaluation of studies using social media or mobile technology

Chapter 3 outlined a number of interventions that have used socially connected electronic media to achieve promising results in health behaviour change. It was also shown that these media are increasingly acceptable to the public as avenues for information. In simple terms, when people are asked how they want to receive information, they often mention their smartphone.

Acceptability and appropriateness of the medium of delivery is by no means a new concern for those designing health promotion and public health initiatives; it has long been acknowledged that interventions must be designed and evaluated with reference to these dynamics.^{343, 344} Mobile technology appears to be a field with much potential for those practitioners. However the use of these technologies is relatively new in these disciplines. We are yet to develop validated methodologies for designing and evaluating these interventions.

Evaluation has been especially lacking. Take the field of sexual health promotion as an example. One systematic examination of social networking initiatives in this field found 178 projects, with only one of those projects reported in published scientific literature. The study concluded that "Future studies should examine the key factors for success among those [social networking] activities attracting a large and active user base, and how success might be measured, in order to guide the development of future health promotion activities in this emerging setting."³⁴⁵

The need for more rigorous evaluation of Internet-based health interventions was also highlighted by Ritterband and Kovatchev, who claimed that "Many...interventions have not been grounded in theory or developed from behaviour change models, and no overarching model to explain behaviour change in Internet interventions has yet been published."²²⁶

In the late nineties the US Department of Health and Human Services convened an independent panel to investigate the emerging use of the Internet and other forms of communication technologies in health. The Science Panel on Interactive

Communication and Health (SciPICH) comprised fourteen experts in the fields of medicine, computer science, education and health promotion, and consulted with Dr. David Satcher, the US Surgeon General. The panel carried out its investigation over two and a half years, and published a number of reports during this time.³⁴⁶⁻
³⁴⁹ It was tasked with making recommendations that might maximise the benefits, and minimise the risks, of the use of these new technologies in health.

SciPCH carried out its work a decade and a half ago. Needless to say this is a significant amount of time in technology. When the panel coined the term “interactive health communication applications”, it was talking about desktop software, databases, computer kiosks, email, online chatrooms, and health-related websites that were starting to emerge on the nascent Internet.

It might well be asked what can be learned from examining findings from so long ago, when technology has evolved so dramatically since that time. However, much of what the panel had to say is very relevant to developers of health-related technology today. In fact, readers of some of the panel’s statements could be forgiven for believing they had been written very recently. Take this, from Dr Satcher:

The rapid development of new technologies, coupled with the explosive growth of the Internet, brings opportunities for people to find interactive information, education, and support that is tailored to their needs and preferences. Equally important, the new connectivity creates links among individuals, public agencies, businesses and employers, community resources, health professionals, health plans, academic institutions, and other private organizations—all of which, together, are necessary to ensure health and well-being. To date, there has been little evaluation or quality control of interactive health communication because applications have been developed faster than theory and assessment tools.³¹²

The development of appropriate theory and evaluative tools was being outpaced by innovation even in 1999. It is worth considering whether much ground has been made up since then.

Or this, from the panel's paper *Introduction to Evaluation of Interactive Health Communication Applications*:

Concerns that the evaluation process may delay product release or increase development costs may be problematic because this is evolving to be a highly competitive field where time-to-market and development costs are important. Some developers believe that product marketing, rather than product evaluation results, is the key determinant of sales.³⁴⁶

These concerns ring true today, even though the landscape in which these innovations occur has changed dramatically since this was written. The panel identified a number of stakeholders in the development and uptake of these technologies, including consumers, health professionals, developers and healthcare purchasers. Of these groups, it could be said that this last group has seen the largest change in its role and prominence. In 1999 many innovations would need to be sold to healthcare purchasers, and these purchasing decisions would largely determine what was available to consumers. For example, a developer might conceive a new tool for diabetes management, then need to market that tool to health professionals for dissemination. The rise of the App Store and other consumer-facing application vendors, and the commoditisation of software led to more direct lines of communication between developers and consumers. Developers can now market their wares directly to consumers on an international scale. If the panel observed a tendency to focus more on marketing than evaluation as far back as 1999, it is not surprising that some developers might adopt a similar or greater focus in 2015, with much more direct paths to revenue available to them.

Narrowing the focus to electronic interventions to increase fish consumption (like those described in Section 3.6), when evaluation has been carried out at all, it has

typically been based on anecdotal evidence,³³¹ non-experimental measures such as activity on blogs or social media sites, or sales data.³³⁵ Although these measures might be taken as reasonable proxies for consumption, proxies are not proof. Sales data might suggest that someone is eating fish; they do not tell us who is eating it, under what circumstances, and due to what influences.

Ideally, evaluation should go to the heart of the behaviour being examined; if a researcher hopes to decrease the number of cigarettes smoked by a group of people, she should try to accurately count those cigarettes, either directly or by some clinical measure of consumption. If this is impossible, she might settle for asking those people about their intention to smoke, or recording attendance at a smoking cessation workshop, or perhaps tracking cigarette sales figures at nearby retailers. However, if she does this, her findings and recommendations will be, at best, educated guesses.

This point is equally relevant for the present study. Downloading a fish-related application or liking a blog post might be taken as positive behavioural sign. But if the final behaviour we are interested in is the consumption of the fish, then we should endeavour to measure that consumption as directly as possible.

4.3 A framework for complex interventions

The lack of empirically evaluated interventions in this area makes a full RCT unviable at this time. Ideal target populations are not established, the tools and resources required are as yet undeveloped and the likely effect size is difficult to predict. These issues are by no means unique to this intervention; while direct progression to a full trial is often acceptable for a simple intervention, it is seldom feasible for interventions where there are a number of factors at play.

Campbell et al.³⁴² identified a number of examples of complex interventions, including community or group interventions, interventions targeting the behaviour of health professionals, and health promotion interventions designed to reduce alcohol consumption or support dietary change. In all these examples, the authors identify a number of challenges faced by those wishing to evaluate their effectiveness. For example, it may be difficult to document the intervention accurately, making reproduction difficult. It may be necessary to collect both qualitative and quantitative data, with different means of analysis for each. It may also be difficult to isolate those aspects of the intervention which have the greatest impact – the “active ingredients”, to borrow a pharmacological term.

The Medical Research Council (MRC) of the UK has recommended a framework for development and evaluation of complex interventions.³⁵⁰ The MRC defines a complex intervention as one containing several interacting components, and several dimensions of complexity. This complexity may take a number of forms, including the range of possible outcomes, the variability of the population, or the number of elements in the intervention package. While standard experimental methods are often employed in the evaluation of such interventions, their application can present special problems that are not issues in the evaluation of straightforward pharmaceutical interventions. These issues include “... the difficulty of standardising the design and delivery of the interventions, their sensitivity to features of the local context, the organisational and logistical difficulty of applying experimental methods to service or policy change, and the length and complexity of the causal chains linking intervention with outcome.”³⁵⁰

Examining the subject of interest to this study, a wide range of individual, social, environmental and experiential factors are at play in an individual's decision to consume fish. One person may be a confident and enthusiastic cook, but does not know where to buy good quality fish, while another may be an eager recreational fisher, but tends to throw back their catch because they are less confident cooking fish, their family tends not to enjoy eating it, or they feel a moral imperative to do so. Clearly the input required in each case is very different. Furthermore, fish purchase and consumption, like the consumption of any good or service, has a context. The context in this case is complex and ever changing, and includes seasonally fluctuating price and supply issues, promotions, media messages and environmental sustainability campaigns.

It is important to take a systematic approach to building evidence for a proposed intervention, to understand the various factors at play, the participants themselves, and the mechanisms by which the intervention influences the desired behaviour. It is exactly this approach that is recommended by the MRC model, which takes the form of "An iterative, phased approach that harnesses qualitative and quantitative methods [leading to] improved study design, execution and generalisability of results."³⁴² The model (see **Figure 9**) works through stages of initial development (including understanding the existing evidence and identifying relevant theory) and piloting (including testing procedures and analysing recruitment and retention issues) before continuing to full evaluation and, where appropriate, public implementation.

The MRC's systematic approach helps to ensure that only those interventions with a reasonable likelihood of being effective proceed to full trial. With full RCTs being both expensive and time consuming, this approach maximises value for money by ensuring that full trials only occur when interventions have been shown to have a reasonable probability of having the desired impact on behaviour or health outcomes. It is much less expensive - in terms of time, money and opportunity costs - to discontinue an intervention at pilot stage, than it is after a full trial, or even a public implementation.

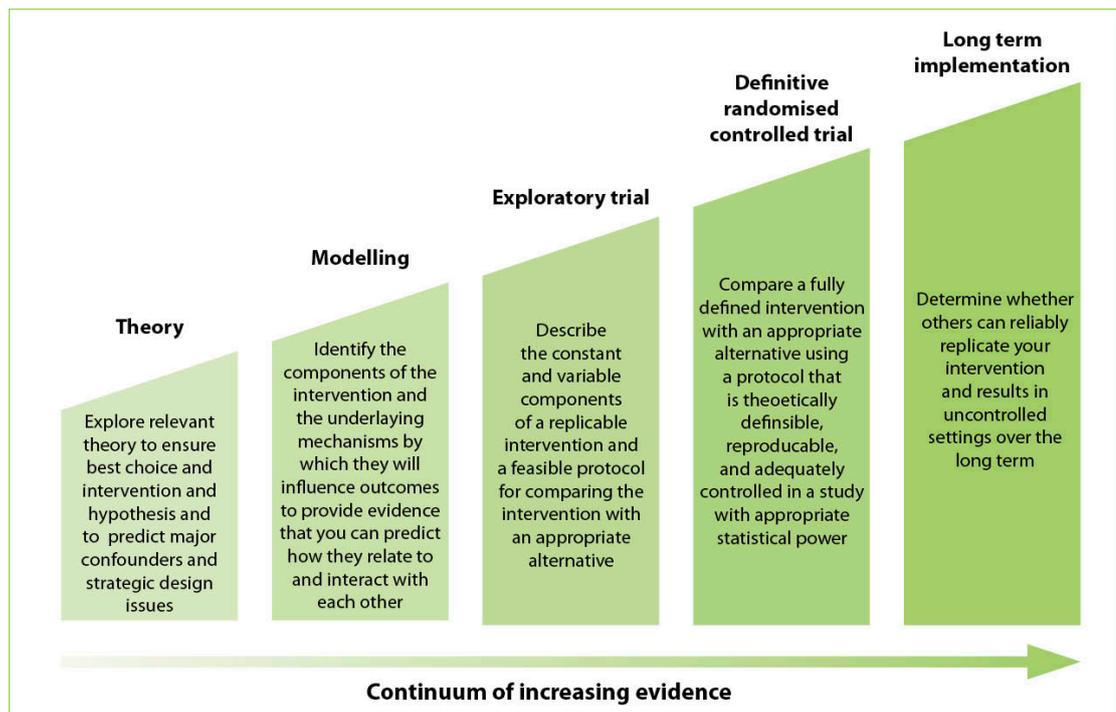


Figure 9. Sequential phases of developing RCTs of complex interventions.³⁴²

This piloting phase is critical in a complex intervention, particularly where the intervention is novel, with potential effect sizes unknown. In addition to providing information for sample size calculations, pilot studies inform future evaluation through an understanding of the mechanisms of change (which may be assessed via both qualitative and quantitative methods), the elements of the intervention that appear to have the greatest impact, and any potential issues that may have an impact on later evaluation.

4.3.1 Updated guidance

In 2008 the MRC updated their guidance for the development and evaluation of complex interventions.³⁵⁰ The authors acknowledged that, while the model recommended eight years earlier had been highly influential, a number of limitations had been highlighted in the interim. The model implied a linear development process which was common in clinical evaluations, but which was not always appropriate for complex interventions in public health. Furthermore it did not provide effective guidance for highly complex programs (for example,

programs comprising multiple complex interventions). Feedback further suggested that the model did not take into account the social, political or geographical contexts in which interventions took place, and that some of the recommendations were not, at the time, backed by a substantial evidence base

The authors sought to address some of these limitations by proposing a new, less linear model (see **Figure 10**), and providing examples of a range of different interventions carried out in different contexts. The updated model was not presented as a direct replacement for the 2000 model, but rather as an acknowledgment that “Although it is useful to think in terms of stages, often these will not follow a linear or even a cyclical sequence.”³⁵⁰

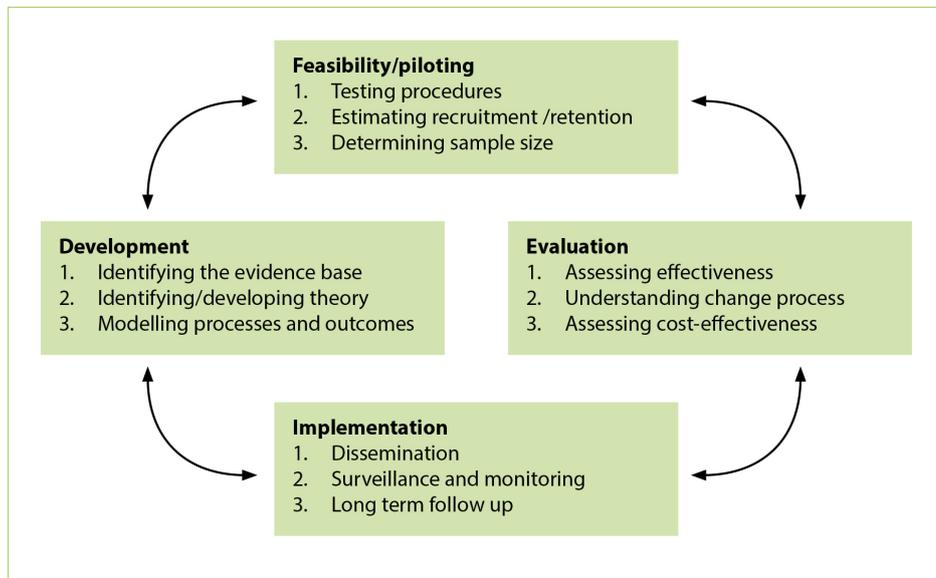


Figure 10. Key elements of the development-evaluation-implementation process.³⁵⁰

4.4 The present study as a complex intervention

Several aspects of the proposed intervention placed it squarely within the domain of complex interventions, as defined in both the 2000 and 2008 MRC papers.

- It comprised a number of components, which may have acted independently or inter-dependently. Whilst only a single application was developed, it included a number of different features designed to overcome the various barriers to consumption identified in the formative research. These features were expected to have different degrees of relevance, and potential impact, for different users.
- It was not easy to define the “active ingredients” of the intervention – which components made what relative contribution to the overall impact of the application. This was especially true for some highly subjective components, such as visual design and interface layout.
- There was no viable way to control the “dosage” to which research participants were exposed – i.e. the amount of time they used the application, or the degree of engagement with the community of users.
- Simply developing an application and proceeding directly to full trial, without first conducting formative research, basing the application on behavioural theory, or subjecting it to a smaller trial or pilot study, would make it very difficult draw direct conclusions, or to extrapolate the findings to other similar settings.
- Replication of the study would prove difficult, without detailed documentation of the development process and early evaluations.

These complexities made it important to conceive a systematic approach to both designing and evaluating the experimental application. The MRC model provided effective guidance in this respect. Use of this model was expected to make possible a number of study goals, primarily identification of an approximate effect size and refinement of the intervention itself as described in Section 4.5.3.

4.5 Study design

A cyclical development process, like the one shown in **Figure 10** is particularly appropriate in software development. There is great value in the process of releasing a product for widespread use, obtaining user feedback and iterating the product in response.^{351, 352} However, the scope of the present study did not allow for a fully iterative process, which might be implemented over many years. A more linear process was deemed appropriate, with the present study encompassing the first three phases of the original MRC model: theory, modelling and an exploratory trial. Recommendations are presented, in Chapter 9, for a potential definitive trial and for long-term implementation.

4.5.1 Theoretical phase

The first part of the MRC's framework for complex interventions is a theoretical, or pre-clinical phase. Any intervention begins with an idea, but these ideas should grow from existing literature, ideally in the field of interest or, if the evidence is lacking, in similar fields.³⁴²

This study began with an identification of themes in the existing literature concerning the health benefits of fish consumption, fish consumer behaviour, and the use of mobile technology. These themes are detailed in Chapters 2 and 3. Having identified a number of potential avenues for intervention, a theoretical framework was chosen to guide the development of the intervention, and the means through which it would be evaluated. The selection of an appropriate theoretical framework is described in Chapter 5.

4.5.2 Phase I: Modelling

The MRC describes Phase I in the development of a complex intervention as one in which the components of the proposed intervention are defined. This phase often employs qualitative testing via focus groups, surveys or case studies to help

identify which parts of a proposed intervention are most likely to be both acceptable and effective.

Phase I of this study involved a series of focus groups examining fish consumption behaviour and mobile technology use. These groups were used to explore the themes identified in the theoretical phase, both in terms of fish consumption and the use of mobile technology. Thematic analysis allowed the wide range of reported barriers to, and drivers of, fish consumption to be narrowed down to those that might be most effectively influenced by a socially connected mobile application. This qualitative study is described in Chapter 6.

4.5.3 Phase II: Exploratory trial

The next phase of the framework takes the information uncovered in the modelling phase and applies it to the development of an optimal intervention and methodology for evaluation. A comparative arm of the study, or control group, is established, as are protocols for randomisation and delivery of the intervention.

The purpose of this trial was twofold. Firstly, it was carried out to determine an approximate effect size. This would be needed to guide sample size and power calculations for a full trial. Secondly it helped to refine the intervention, to identify problems in recruitment, attrition or participant burden, and to determine whether data could be effectively collected.

Campbell et al. identified an important decision to be made at this stage of a trial: whether or not to directly assess health outcomes. This decision depends on the nature and scope of the study.

For studies such as those evaluating strategies to change professional behaviour, it may be sufficient to show that the intervention changed behaviour, provided that clear evidence exists that the changed behaviour – for example, prescribing particular treatments – is effective.³⁴²

For many of the health benefits associated with regular fish consumption, assessment of health outcomes would require years of observation. Given the strong evidence of positive associations between regular fish consumption, and benefits in a range of health areas, health outcomes were not directly assessed in this study.

The information gathered in the modelling phase was used to guide the development of a new mobile application, referred to hereafter as “the experimental application”, or by its application name, *Pier 2 Peer*. This was designed to be used both as the medium for delivery of the support and information hypothesised to be of benefit in increasing fish consumption, and also the mechanism by which consumption data was collected.

Application development is a time consuming process; great care was taken to ensure that each part of the application was designed to address a theme identified in the formative research, and to ensure that the overall balance of time expended on each section reflected a realistic expectation of effect on behaviour. These decisions, and the development process as a whole, are described in Chapter 7.

This application was used as the basis of an exploratory trial involving 100 participants. These participants were assigned to either a test or control group, and were given one of two different versions of the application. This trial served primarily to determine whether exposure to the experimental application appeared to lead to increased fish consumption. It also assisted in a detailed analysis of the application and identification of practical and methodological problems with the study, which would need to be addressed before a full trial could take place. This trial is described in Chapter 8.

5

Theoretical framework

5.0 Theoretical framework

5.1 Introduction

Although the proliferation of electronic health interventions has in recent years seen an increased emphasis on the adoption of relevant theory, these interventions have not always displayed such grounding. A meta-analysis of mobile phone based health interventions using SMS and MMS messages concluded that “...many researchers fail to consider behavioural theory in the deployment of SMS or MMS behavioural interventions. The frequent lack of theory may represent a significant current flaw, as theory is critical in health behaviour research because it aids investigators in understanding how and why individuals, groups, and organizations behave and change.”³⁵³

This study was grounded in the behavioural perspective model proposed by Gordon Foxall, a consumer psychology theorist, in the late 1980s. This model is based on the principles of operant reinforcement and seeks to explain consumer behaviour as an outcome of an individual’s learning history coming to bear on specific behavioural settings.

The selection of this model reflects the nature of the behaviour under investigation: fish purchase and consumption. As discussed in Section 2.2, the reasons people consume fish are complex, and most people probably do not do so primarily as a health exercise. However most people are aware of some benefits of fish consumption, and this is an influencing factor for many people. Furthermore, the present study is premised on the health arguments for increasing fish consumption; this is a health intervention. Accordingly, a number of theoretical models common in the health sciences were considered, with guidance taken both from the models themselves and from previous studies that have been based on them.

This chapter begins by briefly outlining these models - specifically the theory of planned behaviour, the health belief model and the transtheoretical model – describing the guidance taken from each, and explaining why each was not considered a sufficient match for the present study to warrant being used as the primary framework. All three of these models are cognitive in nature, and therefore contrast with the BPM, a model in the behavioural tradition. The difference between these two approaches is also discussed. This chapter then describes the BPM in detail and explains its application to the present study, with reference to its use in previous food studies in general, and a study of fish consumption specifically.

5.2 Cognitive perspectives on food choice

Cognitive behavioural models are concerned with the role of beliefs and attitudes in shaping behaviour, and these constructs have underpinned a great deal of consumer marketing research.³⁵⁴ While these terms are commonly used and understood in the general lexicon, they are much harder to define as empirically measurable constructs. The relationship between attitudes and behaviour is far from clear – see, for example contrasting recent findings in studies of blood donation behaviour,³⁵⁵ sexual attitudes and religiosity³⁵⁶ and recycling behaviour.^{30, 357} In each of these examples, research participants' self-reported attitudes, beliefs and intentions differed markedly from their observed behaviour. In simple terms what people believe, what they intend to do, and what they actually do are not always the same.

Similarly difficult to define is the idea of habit. Can we use habits to explain repeated behaviour, or is the repeated behaviour *itself* the habit? For example, one might observe the repeated purchase of certain kinds of fish, perhaps from the same store, and explain that purchase in terms of habits acquired over time. In making this claim we are saying that the habit explains, at least in part, the repeated behaviour. But what exactly is the habit, if it is not the actual act of repeatedly buying fish?

To the extent that we use the notion of habit to help predict or modify future behaviour, we are essentially examining past behaviour. Indeed, the predictive power of many cognitive behavioural models has increased with the introduction of measures of past behaviour^{76, 358} or situational influences.^{359, 360} The observation of the apparent predictive power of past behaviour and situational influence in consumer choice forms the basis of the behavioural model ultimately chosen for this study, as discussed in Section 5.3.3. That said, cognitive perspectives were by no means discounted in this case. Three cognitive models are now discussed, with potential applications to, and limitations in, the area of food choice in general, and fish consumption in particular.

5.2.1 Theory of planned behaviour

The theory of planned behaviour (TPB), like the theory of reasoned action (TRA) that preceded it, models behaviour with reference to the cognitive constructs of intention, attitudes and subjective norms. Where the TRA was primarily concerned with behaviour that was under the control of the individual,³⁶¹ the TPB broadened the scope to include other non-volitional behaviours, introducing the construct of perceived behavioural control.^{362, 363} The TPB in particular has had a long-lasting impact on the various fields of science in which human behaviour is a focus.

The predictive power of this model has varied widely between applications, particularly when applied to the prediction of food choices, where evidence has been mixed. Armitage and Connor's comprehensive meta-analysis of 185 TPB studies found that the theory accounted for 27% of the observed variance in behaviour, and 39% of the variance in intention.³⁶⁴ Some more recent studies have had better success in using the TPB to predict specific food choices – for example in the intention to consume fruit and vegetables³⁶⁵ and organic foods.³⁶⁶ However, in many cases these studies have modified the TPB by adding additional variables – for example, measures of affect were added to the model in a study of motives for purchasing sustainably sourced food, which reported a 61% explanation of variance in intention to consume.³⁶⁷

A number of food choice researchers have concluded the TPB is most effectively predictive when combined with some direct measure of past behaviour. In other words, that past behaviour is a more effective predictor of future food choice behaviour than either attitudes or subjective norms. This has been found to apply to meat consumption,³⁶⁸ fast food consumption³⁶⁹ and in a general behavioural study meta-analysis.³⁵⁸

Findings have been equally mixed when the TPB has been applied to the consumption of fish and seafood. One study found attitudes were weakly related to intention to consume,⁸⁰ while another found effects only for certain types of seafood.¹¹¹ Where additional measures of past behaviour were accounted for, the

effect of attitudes alone was generally lower.^{76,87} Verbeke and Vackier's study found the TPB to be generally assistive in explaining fish consumption, but noted that "including habit as a separate regressor in the TPB renders insignificant the impact of attitude and perceived behavioural control (past experience and facilitating conditions) on behavioural intention."⁷⁶ They also acknowledged that their study was of a non-probability sample of Belgian consumers, and that certain idiosyncrasies of this group might make it difficult to generalise their findings beyond the immediate study context.

5.2.2 Health belief model

The health belief model (HBM) attempts to explain an individual's decision to take action on a given health issue – and by extrapolation, the likelihood of a given health intervention having the desired effect.³⁷⁰ The model explains these choices as a factor of two sets of beliefs or perceptions – the individual's perception of threat (including their susceptibility to a health problem, and the seriousness of any consequences) and their outcome expectations (including perceptions of barriers to action, and potential benefits).

Proposed interventions may be evaluated against these dynamics. An intervention offering minimal benefit, with high barriers to participation, may be predicted to fail. On the other hand, one that offers large, quantifiable benefits with minimal barriers would be considered of high value. Seen this way, health interventions based on individuals taking preventative action may be difficult to implement successfully, unless the link between the preventative behaviour and improved outcomes is particularly well established and understood by members of the target group. Taking the example of coronary heart disease, a person may be far more motivated to act when they have experienced a significant health incident, such as a cardiac event. Their perception of the seriousness of consequences and their likelihood of benefit may very well outweigh the burden of action.³⁷¹⁻³⁷³ Those running a weight loss program for men recovering from cardiac events will face very different issues to those working with overweight teens; the latter researchers may need to employ youth specific strategies (such as

family inclusion) to overcome the difference in long-term outlook and risk perception among younger people.³⁷⁴

This is a pivotal issue in public health, with preventative interventions being shown to repay their costs many times over. The New South Wales Health Department has attempted to quantify these savings – ranging from AU\$2 for every dollar spent reducing tobacco consumption, to AU\$51.20 for every dollar spent on needle and syringe programs.³⁷⁵ These are examples of preventative interventions with the advantage of a high level of recognition of the health dangers, and of the individual's direct risk. But what of a whole range of interventions with a strong case for health benefit, but where the causal chain may be less apparent to the average person, or where the health benefits (no matter how well-documented) may be far in the future? Fish consumption appears to fit in this category.

The HBM has effectively guided interventions over a long period of time, and for good reason: many researchers and interventionists have found success in applying its premises in preventative health, for health behaviours such as cancer screening and immunisation. Indeed, the model was developed initially with these kinds of behaviours in mind.^{370,376} It has been less successful in explaining behaviours with a more complex mix of determinants, for example in safe sex practices³⁷⁷ tobacco use³⁷⁸ and alcohol use.³⁷⁹ In their paper *The health belief model: A decade later*, Janz and Becker³⁸⁰ reviewed 46 HBM studies, finding substantial empirical support for the model. They noted, however, that the model appeared to have less predictive power when the behaviour being studied was influenced by a wide range of factors, and where some of those factors were not specifically health-related. For example some behaviours such as cigarette smoking had a clear habitual component that appeared to circumvent the health decision-making process to some extent. Other behaviours were curtailed to some extent by economic and other restraints; individuals with a particular health belief were not always in a position to enact those beliefs. Perhaps most importantly, the authors noted that health behaviours were sometimes undertaken for non-health

reasons (for example, dieting to appear more attractive or stopping smoking for social approval).

Some of these limitations were addressed in additions to the model proposed in the late 1980s.³⁸¹ However it remains the case that the HBM, as its name suggests, is concerned with behaviours undertaken primarily as a result of an individual's health beliefs. The specific behaviour of fish consumption appears to hit all three of Janz and Becker's reservations: it is a behaviour commonly influenced by economic and other restraints (perceived or real),^{65, 91, 92} one which the cognitive tradition would see as having a significant habitual component,^{87, 92, 99} and one which is frequently undertaken for range of non-health reasons.^{76, 94}

5.2.3 The transtheoretical model

The transtheoretical model (TTM)³⁸² attempts to explain the drivers behind behaviour with reference to five stages of change, beginning with precontemplation (where individuals may not even be aware of the health benefits of change, and have not actively considered changing), through contemplation, determination, and eventual action. After having taking action, they may then maintain the health behaviour or relapse. The value of this model is in providing the opportunity to understand the various needs of a population, and to tailor an intervention to meet those needs. An intervention may be focussed on individuals at one discrete stage (for example, a health promotion campaign to increase the awareness of the dangers of a particular activity, such as the Royal Life Saving WA *Don't Drink and Drown* campaign,³⁸³ which included a social media component), or may assist individuals as they move through the stages of change.

The intervention undertaken as part of the present study took the latter approach, in providing support to individuals who ate very little fish, as well as those who ate it relatively regularly, but at lower than advised levels. These different consumption levels might be defined in TTM terms as different stages of change, particularly if those in the latter category are aware of the health benefits of fish consumption and have to some extent increased their consumption as a result.

Different kinds of support are needed in each case. Information about the health benefits of fish consumption might assist those who may not have considered fish as a healthy nutritional option. Those who are aware of its health benefits, yet still do not eat it sufficiently to achieve health benefits, might be supported by the provision of other support and resources, including species information, buying guides, and guidance on selection, storage and preparation. In both cases the ultimate goal would be a third stage in which the individual achieves the on-going, habitual consumption of at least two serves per week which is most likely to lead to health benefits (see Section 2.1.3).

As with the HBM, the TTM is most effective in explaining behaviours that are seen by the individual as primarily health-related. It is therefore limited in the same way by the variation in motivations for fish consumption. The theory might provide effective guidance for an intervention to encourage fish consumption by people with rheumatoid arthritis, or those at high risk of heart disease. It is probably less instructive for one targeted at the general population. Nevertheless, the recognition that individuals all come to an intervention at different cognitive stages, with different needs, is an important one.

5.3 Towards a behavioural understanding of consumer choice

Gordon Foxall, a consumer behaviour researcher and theorist at Cardiff University, proposed the behavioural perspective model (BPM) in a series of papers and monographs through the early 1990s.^{359,384} He and others have continued to expand on this model and test its constructs in a number of different consumer contexts including retail brand choice,³⁸⁵ fruit and vegetable purchase,³⁸⁶ environmentally conservative behaviour,³⁸⁷ supply and demand curves and pricing³⁸⁸ and, of relevance to the present context, fish consumption.⁷⁵

The BPM was positioned, at least partially, as a counter to what Foxall saw as heavy focus on cognitive psychological perspectives in the social sciences and, more specifically, in marketing research.³⁵⁴ Cognitive behaviour models, including the three discussed in Section 5.2 generally define *attitudes* as internal, mental variables which act as precursors to behaviour or, more precisely, as intervening variables between a stimulus and a response. This approach is in contrast to the psychological behaviourism of John Watson,³⁸⁹ who regarded mental phenomena as outside the scope of science and posited the well-known stimulus (S) response (R) pattern:

S -> R

Cognitive psychology places intervening variables (I) between the stimulus and response, in the pattern:

S -> I -> R

These intervening variables may include such factors as previous experience, learning, or other social influences. These intervening variables are not directly observable, and must be inferred from other data – most commonly verbal or written responses to attitudinal surveys. Of course these responses are themselves examples of behaviour; they are responses to stimuli (for example, a questionnaire), which are subject to the same (or other) intervening variables.

The BPM draws on the principles of radical behaviourism and, more specifically, those of operant conditioning proposed by B.F. Skinner.³⁹⁰ To provide a background to the core principles of the BPM, relevant components of operant psychology are now summarised.

5.3.1 Operant conditioning

Skinner summarised his position in simple terms: "Behaviour is shaped and maintained by its consequences."³⁹¹ This new paradigm in behavioural psychology contrasted with the earlier classical conditioning of Pavlov, who examined the mechanisms by which *preceding* stimuli influenced behaviour.³⁹² In Pavlov's model, repeated pairings with an unconditioned stimulus (food) could lead to a conditioned stimulus (a bell) producing a conditioned response (salivation). This model is still used, at least obliquely, in consumer marketing; a company sponsoring a sports team hopes to associate their logo (initially a neutral stimulus) with the feelings of excitement and euphoria a spectator might experience in watching a sports event. In so doing they hope to create a situation in which that logo becomes a conditioned stimulus, provoking similar positive feelings even outside of the sporting context.³⁵⁴

Where Pavlov sought to understand behaviour by examining its antecedent stimuli, Skinner examined rates of behaviour in relation to past consequences when performing similar behaviour – in other words, to post-behavioural effects. He observed that some consequences acted as reinforcers, making repetitions of the behaviour more likely, while others acted as punishers, making them less likely. By measuring previous rates and ratios of both positive and negative consequences, Skinner found that he could reliably predict the behaviour of his animal subjects. By manipulating these *schedules of reinforcement*, he found he could equally reliably influence behaviour.

Skinner summarised this relationship as follows, where R (rate of response) depends on the nature of positive, or appetitive, consequences (S^+) and aversive consequences (S^a) it generates.

$$R \rightarrow S^{r/a}$$

Like Pavlov, Skinner was also interested in prebehavioural stimuli that might signal to the individual what consequences were likely to occur after a given behaviour. The individual uses these *discriminative stimuli* (S^d) to discriminate their behaviour, effectively optimising their performance to maximise their chances of receiving positive reinforcement. Known in operant psychology as the *three-term contingency*, the construct is expressed:

$$S^d \rightarrow R \rightarrow S^{r/a}$$

In this formulation, the term *response* refers to *approach* behaviours – for example, in the consumer context, making a purchase. An individual may not engage in approach behaviour; they may elect not to make a purchase. In this case they are said to have engaged in *escape* behaviour. When an individual does not perform the approach behaviour (R), but rather an alternative escape response (R^E), the formulation becomes:

$$S^d \rightarrow R^E \rightarrow S^{r/a}$$

It may seem odd to use the word *escape* to describe a consumer opting against a purchase, but it is important to remember that the language of operant psychology originated in the animal laboratory, where the subjects of the research, typically rats, had a very limited range of behaviours available to them. This is more than a semantic point; the differences between animal and human behaviour, particularly with respect to the range of behavioural possibilities, must be considered when applying operant principles to human behaviour. The BPM addresses these issues by including notions of open and closed behavioural settings (see Section 5.3.5).

5.3.2 Reinforcers and punishers

In order to use an operant conditioning model to predict the rate of response (in the present context, the regularity of fish consumption) and ultimately to influence it, it is vital to understand both these antecedent discriminative stimuli and the schedules of reinforcement that follow the behaviour under examination. As well as distinguishing between positive and aversive stimuli, Skinner also categorised behavioural outcomes in terms of whether they involved the adding of a stimulus, or the removal of one. These distinctions led to the four-fold categorisation of stimulus outcomes shown in Table 1.

Table 1. The four quadrants of operant conditioning.

Stimulus type	Effect: Increase behaviour	Effect: decrease behaviour
Appetitive stimulus	Add appetitive stimulus: <i>Positive reinforcer (R+)</i>	Remove appetitive stimulus: <i>Negative punisher (P-)</i>
Aversive stimulus	Remove aversive stimulus: <i>Negative reinforcer (R-)</i>	Add aversive stimulus: <i>Positive punisher (P+)</i>

Positive reinforcers increase the likelihood that behaviour will be repeated by adding a positive stimulus – for example, a person might eat a well-prepared fish meal and enjoy it. Negative reinforcers also increase behaviour, but by removing negative stimuli. For example, a mother might feel a sense of guilt when she learns that children’s health can benefit from fish consumption, and that guilt might be assuaged when she prepares fish for them.

Punishers decrease the rate of the punished behaviour. Positive punishers do this by adding a negative stimulus; an extreme example is a person who becomes ill after eating a meal. A number of people who strongly dislike fish describe an aversion to it, or a fear of food poisoning.^{393, 394} Negative punishers reduce repeat behaviour by removing a positive stimulus. The surrender of money that takes place any time something is purchased is a negative punisher. The individual who complains that fish is expensive is effectively saying that the loss of money (a

negative punisher) has to some extent outweighed the benefits associated with the purchase of fish. It is important not to confuse negative reinforcement with punishment; the former increases response rate while the latter decreases it.

5.3.3 The behavioural perspective model

Based directly on these principles of operant reinforcement, the BPM was proposed as a model for interpretation and prediction of behaviour based on two primary measures: the environmental situation of the consumer and their previous learning history. Put differently:

The argument of the BPM research programme is that to explain consumer behaviour requires that it be located spatially (i.e. with respect to the scope of the behaviour settings in which it occurs) and temporally (i.e. within the stream of the consumer's learning history).³⁶⁰

Many models of behaviour begin by seeking to understand, explain and predict human behaviour and, having done so with some degree of effectiveness, are then used by social scientists to inform and guide efforts to modify behaviour. The degree to which they are effective in doing so is particularly important in public health and health promotion. Unfortunately some theoretical frameworks have, over time, proved more effective at predicting behaviour than changing it. For example, a systematic review of behaviour change interventions based on the TPB found that it was more often used to measure process and outcome variables and to predict behavioural intentions, rather than to inform the development of the intervention itself. It also found generally small effect sizes and limited evidence or description of the mediation of effects on behaviour change by the various components of the theory.³⁹⁵ As a model directed primarily at consumer marketing researchers, the BPM is strongly focused on providing practical guidance to those wishing to change behaviour. The applied goal for the BPM was to "understand how marketing strategies increase approach and, where ethically acceptable, reduce escape and avoidance."³⁵⁹

The BPM places all consumer behaviour within a context. Specifically, choices are said to be made in a specific behaviour setting, and to be influenced by a specific history of past learning. It is this learning history that determines which cues in the behaviour setting will act as triggers for certain behaviour and, more importantly in a consumer context, which cues will increase the likelihood of consumption and which will decrease it. The primary components of the BPM are illustrated in

Figure 11. Consequences of behaviour are grouped in three ways, summarised in Sections 5.3.3.1 - 5.3.3.3.

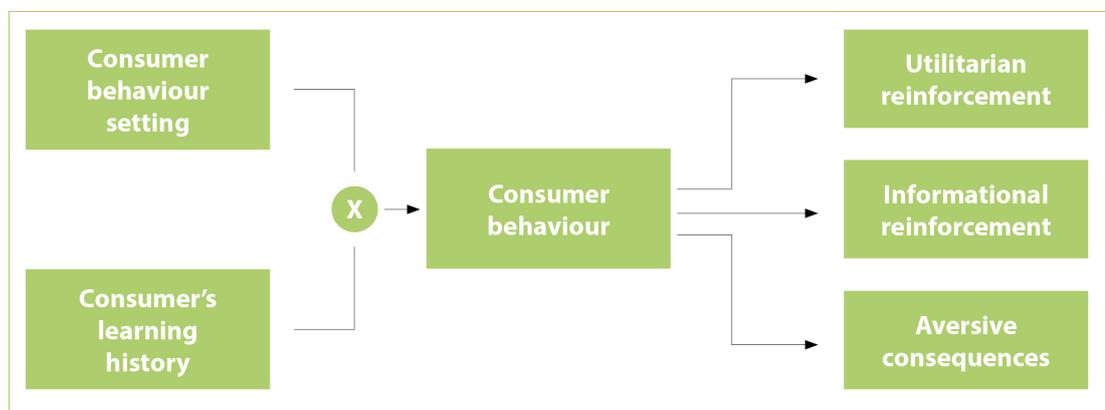


Figure 11. Summary of the BPM.

5.3.3.1 Utilitarian reinforcement

Utilitarian reinforcement, as the name suggests, is derived from the utility an individual gains from consuming a product or service. These are tangible benefits associated with purchasing something, owning it, or consuming it. For example, a car enables a person to get quickly from A to B, and a dishwasher saves a person time when cleaning up after a meal. Like all foods, the purchase and consumption of fish provides a certain amount of nourishment and may result in a pleasurable eating experience. It should be noted that, while utilitarian reinforcement is said to be concrete, it is not always a physically observable phenomenon; it includes positive feelings that arise from the consumption act. Indeed it could be argued that all utilitarian reinforcement falls into this category – it is not the actual washing of the dishes that acts as a reinforcement for the purchase of a

dishwasher, but rather the positive emotions that arise from feeling that one has saved time, or from the activities made possible during that saved time.

Utilitarian reinforcements are directly associated with the specific characteristics of the consumed goods. We may estimate these effects relatively easily by examining the goods themselves. Furthermore these reinforcements are likely to be relatively stable and consistent between different social systems.³⁹⁶

5.3.3.2 Informational reinforcement

Also referred to as symbolic reinforcement, informational reinforcement refers to positive feedback on the purchase act either received directly from other people, or assumed by the purchaser. So while two different cars, or two different dishwashers, may provide broadly similar utilitarian benefits, they may differ widely in the kinds of symbolic feedback they may attract - more prestigious brands might be seen to confer greater status, and the purchaser may receive more favourable feedback on their purchase choice. In one sense, these outcomes act as a kind of performance feedback. Consumers reflect on their own "purchasing performance" and those of others, a continuous non-verbal process whereby individuals reflect on how well they are exchanging their time, effort and money in acquiring goods.³⁵⁴

Informational reinforcers may be much more difficult to delineate than utilitarian reinforcers, particularly with respect to their relative influence any particular consumer. One consumer may be more susceptible to informational feedback than another. Informational reinforcers are likely to be different between different social systems (a given brand may be prestigious in one part of the world, but relatively unknown in another).³⁹⁶ They are also likely to change over time. The utilitarian consequences of smoking a cigarette have changed very little in the last fifty years, but the social feedback and prestige associated with doing so have changed a great deal.

5.3.3.3 Aversive consequences (punishers)

Not all purchase or consumption experiences are positive. A purchased good may be unfit for purpose, its properties may be different than expected, or it may not last as long as the consumer would like. The expected social feedback may not be forthcoming. A consumer, having decided to spend extra money to acquire a prestigious brand, or a more premium food product may decide on reflection that it was not worth the extra expense – that the cheaper brand or product would have provided similar benefits.

Negative experiences that occur after the purchase or consumption of goods naturally reduce the likelihood of that behaviour being repeated; in operant terms, the rate of response is reduced. The degree of the impact will depend on many factors, including the severity of the consequence, the consumer's previous history of reinforcement, and the mix of other reinforcers available. Foxall³⁵⁹ makes the point that all economic activity is simultaneously reinforced and punished, due to the fact that, at its core, it always involves the transfer of rights. In buying goods from a vendor, the purchaser is rewarded with ownership of the goods (a reinforcer) whilst simultaneously surrendering ownership of a certain amount of money to that vendor (a punisher). It is the relative mix of these stimuli, and of the subsequent consequences, which determine whether a repeat purchase is more or less likely.

5.3.4 Classes of consumer behaviour

The BPM describes four quadrants of consumer behaviour, contingent on the relative levels of reinforcement that typically accrue from it. These behaviour classes are illustrated in **Table 2**.

Table 2. Operant classes of consumer behaviour, defined by patterns of reinforcement.³⁹⁶

	High utilitarian reinforcement	Low utilitarian reinforcement
High informational reinforcement	<i>Accomplishment</i>	<i>Accumulation</i>
Low informational reinforcement	<i>Hedonism</i>	<i>Maintenance</i>

Accomplishment consumption refers to the acquisition of goods that are of both high utility and high status, such as luxury cars. *Accumulation* includes behaviours such as collecting and saving, behaviours that are of limited utility in and of themselves, but may collectively lead to greater utility at a later date. Loyalty cards, laybys and frequent flyer programs are based on this kind of behaviour. *Hedonism* refers to behaviour that is reinforced mainly by its practical benefits (such as less-prestigious household appliances) or the good feelings it engenders (such as watching movies). Finally, *maintenance* refers to behaviours that need little reinforcement because they are seen by the individual as necessary or mandatory – purchase of weekly groceries, including staple goods, or the payment of rates and taxes.

The consumption of fish might represent either hedonistic or maintenance behaviour, depending on the context of the purchase, and the traits of individual consumers. Eating a fish meal (or indeed, any meal) at a restaurant might be seen as a hedonistic purchase, as might the special purchase of relatively expensive fresh fillets, whole fish, or seafood for a special occasion. On the other hand, the regular purchase of categories like frozen fillets or canned fish as part of weekly grocery shopping looks more like maintenance behaviour. Some behaviours may represent different categories of consumption for different consumers. Taking the example of purchasing fresh fish fillets, one person may do this every time they shop, with no specific occasion in mind, while another may only do so only occasionally, seeing it as a luxury purchase.

5.3.5 Open and closed settings

The BPM also differentiates between relatively open, and relatively closed, behaviour settings.³⁶⁰ A setting is said to be open when a consumer has a large number of options from which to choose, and when they may easily choose to make no purchase at all. Shopping for clothing at a mall is an example of an open consumer setting. In contrast, closed settings provide relatively few options, and a consumer may have little choice but to select from one of those options. Choosing an electricity provider and paying taxes are examples of closed consumer settings, with the latter being extremely closed.

Closed consumer settings tend to be characterised by relatively few reinforcers, which may be quite easy to identify. The consumer selecting an electricity provider will likely be choosing from only a small number of candidates, will have relatively little comparative information on which to make their choice, and in most cases will make their decision based on a small number of factors, such as price. In contrast, open settings provide a much wider array of potential reinforcements, which may themselves be at least somewhat ambiguous. It may be much harder to delineate the specific stimuli that have impacted on a consumer's purchase; if asked, they may not themselves be able to articulate why they selected one brand, or store, over another.

Those seeking to predict behaviour, whether they be marketers or researchers undertaking a health intervention, must seek to understand the settings in which the target behaviours are performed, and to be aware of where those settings fall on the open-closed spectrum. Specifically, they must consider the availability of reinforcement, as discussed above. They may ask questions like:

- How many different reinforcers are available? (e.g. How many different aspects of the fish purchase and consumption experience are likely to make an individual feel good?)

- How many different ways are there to obtain those reinforcers? (e.g. Are the reinforcers available for the consumption of fish substantially different to those available for eating other meats?)
- Is the availability of those reinforcers dependent on certain skills, or the completion of specific tasks? (e.g. To what extent do cooking skills impact on the receipt of reinforcement? Naturally this will depend a great deal on whether the fish purchaser is also the person who will cook it, and the relative importance of this factor will be very different when fish is purchased for home consumption, as compared with fish ordered at a restaurant.)

If they are also interested in modifying behaviour, marketers or researchers must further ask themselves to what extent those factors are under their control or, at a minimum, within their sphere of reasonable influence. Foxall³⁵⁹ identifies three primary opportunities for behaviour change: enhancing the effectiveness of reinforcers, controlling schedules of reinforcement and increasing the quality and quantity of reinforcement. Herein lies the opportunity for health promotion, when the promoted behaviour requires making an impact on consumer choice. The present study aimed to identify ways to take advantage of these three opportunities.

5.3.6 The interaction between behaviour setting and learning history

To illustrate how behaviour setting and learning history interact, consider two different shoppers passing the fish counter in the same supermarket. The setting is identical for both individuals, including visual stimuli (signage, branding, point of sale materials such as recipe cards and, perhaps most importantly, the fish itself), other sensory stimuli (perhaps most pertinently, smell), and additional factors (the price of the fish, special deals that may be available, the cleanliness or otherwise of the store, the information that might be obtained by asking questions of the store staff). Both individuals have the same range of behaviours available to them, including both *approach* behaviours (examining the products available, asking questions, taking recipe cards and, ultimately, purchasing the fish) and *escape* behaviours (passing by the counter, and perhaps purchasing

alternative protein sources). And, yet, one consumer buys fish and the other doesn't. How is it that the same stimuli provoke different responses in these two individuals?

The BPM posits that each individual discriminates these stimuli differently, depending on their specific *learning history* – in other words, their experience with those stimuli on past occasions. In operant terms, consumers have experienced a particular mix of positive and negative consequences after having purchased fish in the past, and these environmental cues act as different discriminative stimuli for each individual. According to the BPM, we must understand the individual's learning history in order to predict their behaviour in a given context.

What a consumer lacks in direct consumption history, they will often try to make up by seeking advice from other consumers or salespeople, or by sampling the product. This represents an opportunity for those seeking to encourage a given consumption behaviour, so long as they can effectively position themselves as trustworthy sources of product information. They must also understand that they will be required to provide different information for different kinds of consumers, with different histories of consumption.³⁵⁴

An intervention to increase fish consumption might encounter consumers who have little experience with fish, and little understanding of how to incorporate fish into their diet. They may not have had any particularly negative experience; they simply lack consumption experience. In this case, the challenge is to create a desire to increase consumption (perhaps by identifying the health benefits associated with doing so), and to intervene in a way that might increase the chances of positive reinforcement arising from that consumption. For example, they might be shown how to select better quality fish, how to store or cook fish more effectively, or how to prepare fish in a way that might be appealing to their family members.

That intervention might also encounter individuals who have experienced mainly aversive consequences from consuming fish – perhaps they have tried fish they

did not like the taste of, or stored it in a way that it went bad, or cooked it in a way that was unpalatable for themselves or their family. Whilst the triggers to increase consumption might be similar to the first category of consumers, the balance of endeavours must be very different; these consumers may need more convincing to reconsider fish consumption, and may need very specific interventions to improve their outcomes. If, say, a consumer has experienced problems with the bones in fish, they will need specific help with either removing bones or identifying species and cuts that are less likely to contain bones.

5.3.7 The BPM and fish consumption

Leek et al.⁷⁵ applied the BPM to understanding the situational determinants of fish consumption. Working with a random sample of British shoppers (n = 311), they found that both fish consumers and non-consumers had a generally positive attitude toward fish. They sought to understand what other situational variables might explain the decision to purchase fish or not.

The researchers asked respondents about their beliefs regarding the potential consequences of fish consumption. This enabled an analysis of the discriminative stimuli that might have a bearing on purchase decisions for different consumers. They identified five categories of consumer belief regarding fish consumption, which were:

1. versatility (positive utility/technical criteria/product attributes);
2. appropriateness (symbolic rewards/integrative criteria/ branding);
3. negative (negative utility/product attributes/ technical criteria);
4. economic (costs/economic criteria/price); and
5. availability (setting/legal criteria/accessibility).

Fish consumers and non-consumers were found to differ in all five categories. For example, fish consumers were less deterred by unpleasant characteristics of fish, and more likely to see it as a versatile product from which easy meals could be prepared. Further differences were found between the three classes of fish

product investigated (fresh, frozen and canned), with regular consumers being more likely to opt for fresh fish.

That fish consumers are more likely to view the positive attributes of fish as outweighing its negative attributes should hardly be surprising. More important in the present context is that this study showed that a systematic analysis of the situational determinants of fish consumption is possible, within the framework of the BPM. This study showed that testable relationships between the constructs of behavioural setting and learning history *do* have predictive power when examining the choice to eat fish, as has been demonstrated in a number of other consumer contexts.

5.3.8 Implications for the present study

The present study sought to conduct formative research designed to understand the drivers and barriers to Australian fish consumption and to use these findings to design an effective intervention. Basing this work on the BPM required that the formative research investigated participants' learning history as well as the settings in which purchase and consumption took place.

Whilst these factors can be complex in any consumer behaviour, there are some specific properties of fish consumption that deserve special consideration. As discussed in Section 2.2 many people have had mixed experiences with seafood consumption, meaning that the experiential history of individual consumers is both complex and highly variable. Compare this with other foods. If an individual has had a negative experience with beef, they may have a good idea why. Perhaps it was overcooked, or a cheaper cut, or purchased from an inferior outlet. This experience may not have an effect on the individual's overall perspective on the product class.³⁹⁷ More likely, it may change some specific aspect of their future consumption behaviour – they may not choose that cut in future, or purchase from that outlet.

Experiences with seafood may be more likely to have a complex, unpredictable impact on consumption behaviour. A generally lower level of confidence and product knowledge¹⁰⁴ means that individuals are more likely to generalise negative experiences to the product class as a whole. When combined with the common perception of fish being somewhat expensive (a punisher, according to the BPM, although one which may be counterbalanced by perceptions of quality or social desirability), this creates a complex nest of factors counting against the establishment of regular, long-term patterns of consumption.

Consider also the variation in species of fish and seafood, and the wide diversity of appearance and other physical attributes – scales, bones and, in the case of certain kinds of seafood, claws, shells and carapaces. Some species have non-edible parts, requiring special knowledge to identify those parts and skills to remove them. For example, soft-shell crabs must be prepared by first removing the face, gills and apron (a tail-like appendage on the underside of the shell). Failure to do so would have a significant impact on the quality of the eating experience, and many species of fish and seafood have similar requirements. A consumer who has made a storage or preparation error, and subsequently not enjoyed the meal, may or may not be aware of their mistake, may have a general sense that the meal did not work, or may decide that this and similar species are “more trouble than they are worth”. The punishers associated with this experience are unlikely to be quarantined to the precise species involved. Studies in operant conditioning have shown that individuals tend to generalise their experiences to other similar stimuli.³⁹⁸ The individual is likely to apply their learning to other similar species or, in extreme cases, to fish and seafood as a whole.

Finally it was important to look not just for examples of behaviour that fitted well with the BPM but also for observations that were difficult to explain in the terms of this model. For example, cases where consumption was difficult to explain with reference to learning history or behaviour setting. Consumers who had easy access to affordable fish, and could not identify any specific negative experiences, yet still did not consume it. Or conversely, individuals who consumed fish despite having had experiences which might be expected to discourage consumption.

6

Focus group study

6.0 Focus group study

6.1 Introduction and rationale

As described in Chapter 2 an examination of existing fish consumption literature revealed a number of potential barriers to consumption. These factors included cost, access to high quality product, taste preferences, preferences of family members, early experiences and exposure to health information. Chapter 3 discussed the increasing use of mobile technology in health interventions, and explored the efficacy of this approach for addressing some of the reported barriers to fish consumption. Positioning this endeavour within the constructs of the MRC framework for complex interventions required first that an appropriate theoretical framework be applied, a process described in Chapter 5. The next step, a modelling phase, is described by the MRC as follows:

The second step in evaluating a complex intervention is to develop an understanding of [the] intervention and its possible effects. This involves delineating an intervention's components and how they inter-relate and how active components of a complex package may relate to either surrogate or final outcomes...It may also include qualitative testing through focus groups, preliminary surveys, case studies, or small observational studies.³⁹⁹

Undertaking formative research of this nature was considered particularly important due to the fact that many of the fish consumption studies reviewed were somewhat dated; the bulk of peer-reviewed fish consumption research occurred in Europe in the early to mid 2000s.^{59, 76, 78, 79, 84, 85, 87, 122} It was considered important to examine consumer perceptions within the immediate context of the current study – Australia, in 2013-2014. Conducting new qualitative formative research would also provide the opportunity to seek information about mobile device use, and to explore potential users' thoughts about the potential relevance

of this technology to fish consumption; in other words, to ask whether consumers would consider using an application like the one being proposed.

With these goals in mind a focus group study was designed in which participants would be asked about their consumption of fish, their perceptions of what drove or inhibited their fish consumption, the ways they accessed health and nutrition information, and their use of mobile technology including smartphones, tablets and mobile applications.

6.2 Methodology

Participants were recruited from two sources with different demographic profiles: the Curtin University student and staff pool and the Wanneroo Playgroup Association. In 2014 Curtin University had 53 617 students and 4020 staff.⁴⁰⁰ Participants were recruited via social media, email invitation and promotion on the university's radio station, Curtin FM. The Wanneroo Playgroup Association is a non-profit group providing play facilities for parents of young children, and in 2014 had an enrolment of 135 children from 90 families (pers. comm. Wanneroo Playgroup Association Enrolment Officer). The Australian Bureau of Statistics Socioeconomic Index for Australia (SEIFA) places the Suburb of Wanneroo in the fourth decile of socioeconomic disadvantage.⁴⁰¹

Participants were required to be aged 18 years or older. The only other requirement for inclusion was that participants were at least light fish consumers; individuals who ate no fish because of a vegetarian diet or other strong aversion were excluded. This ensured that the focus groups were broadly representative of the target population for the proposed intervention. A small incentive of an AU\$30 supermarket voucher was offered to thank volunteers for their participation.

Basic demographic information including gender, age and number of children at home was collected from prospective participants and used to organise them into groups that were broadly similar in demographic terms. For example, one group was planned to comprise volunteers with no children at home, while another was to be made up solely of students. Some changes to groups were required to accommodate preferred meeting times and late change requests, however, so the final groups were not fully homogenous with respect to age and family situation.

Recruitment was progressive; a basic thematic analysis was conducted after each group and used to determine future groups, with a view to conducting groups until saturation of themes was achieved (that is, until no new themes were forthcoming). In all, seven group sessions were conducted, comprising a total of

37 participants. Recruitment via the university channels was significantly more successful, contributing 32 participants, compared with 5 from the Playgroup Association.

A summary of the demographic information for the 37 selected group participants is shown in **Table 3**.

Table 3. Demographic breakdown for focus group participants.

Gender	
Female	26
Male	11
Age in years	
18-29	11
30-39	13
40-49	8
50-59	5
Children at home	
0	19
1	8
2	9
3	1
Total	37

Groups were conducted in a semi-structured manner to encourage free discussion, with the same facilitator conducting all groups. Each group lasted between 45 and 60 minutes. Active consent was gained from all participants prior to the commencement of each focus group; participants were provided with an information sheet and asked to sign a consent form (both reproduced in Appendix 1).

6.2.1 Questions

The main constructs of the behavioural perspective model (BPM) were used to frame focus group questions. These constructs were:

- behaviour setting – typical situations in which individuals purchased or consumed fish
- utilitarian reinforcers – positive experiential factors associated with purchasing and consuming fish
- informational reinforcers – positive feedback about fish consumption, including health messages
- punishers – negative aspects of fish purchase and consumption, including both experiential factors and negative feedback, such as environmental or contaminant concerns.

Questions covered both the purchase and consumption of fish and the use of mobile technology, particularly for health and nutrition information. Questions relating directly to fish consumption were guided by the questionnaire developed and validated in a previous BPM study of fish consumer behaviour.⁷⁵ This UK study, published in 2000, grouped questions into the following categories:

- health
- taste
- availability
- versatility
- the components of a good family meal
- value for money
- alternatives to red meat.

Taking the form of a quantitative survey, this study presented a series of attitudinal statements encompassing both positive and negative aspects of fish consumption. Respondents were asked to indicate a degree of agreement with statements like “fish is a healthy food”, “fish makes a good family meal”, “fish goes

off quickly”, “the bones in fish are off-putting”, and “I like to serve fish when I have guests”. For the purposes of the semi-structured discussions conducted in the present study, more open-ended questions were framed to encourage discussion of similar topics. Questions were phrased colloquially, to put participants at ease and encourage free conversation.

The full set of questions used in the focus groups is now presented, grouped according to the main BPM categories. In the focus group discussions, questions were ordered thematically (questions about buying fish, questions about cooking fish, etc.), rather than in the order presented here.

6.2.1.1 Behaviour setting

- What do the terms “fish” and “seafood” mean to you?
- Roughly how often do you eat any kind of fish?
- Do you tend to eat fish more often at home (cooked by you, or someone in your family) or when you are eating out?
- If you don’t cook fish especially regularly, in what circumstances do you?
- When you cook fish, do you find a recipe first, then go out and find the right fish, or do you tend to buy the fish first (perhaps by choosing something that’s on special), then figure out what to do with it?
- If there were one thing you could change about the places that sell fish, what would it be?
- Do you use a mobile device such as a smartphone or a tablet computer?
- Do you ever use your device, or the apps on it, while you’re food shopping, to help you make decisions?

6.2.1.2 Utilitarian reinforcers

- Roughly what proportion of the time would you say that cooking fish is successful for you (that is, the meal works out, and most of the people eating it enjoy it)?

- Are you interested in trying new products, ranges, or species of fish, or do you tend to buy kinds of fish that you have tried before?
- What do you think it would take to encourage you to try new kinds of fish?
- Do you think you would use an app that claimed to make it easier to eat more fish, by helping to find and share recipes, choose the right fish for different uses, and find good quality fish in your local area?
- If so, what would be the most important things you would be looking for in such an app?

6.2.1.3 Informational reinforcers

- How often do you think you should eat fish? Why do you think you should eat it this much?
- Do you think that eating fish is good for you?
- Do you feel any kind of obligation to serve fish to your family? If so, why?
- Let's say you wanted some information about fish, other than recipes. What would you do to find this?
- When it comes to fish, which information sources are you most likely to trust?
- Do you use apps on your device that have anything to do with food, nutrition and health? Are there any you use particularly regularly?
- If you use any of these kinds of apps, how did you find out about them?
- Have you ever used social media to find out something to do with food, nutrition or health?
- How likely would you be to trust food, nutrition or health information you found on a social media site, compared with the information sources we talked about earlier?
- Let's say an app was designed in such a way that most of the information was sourced from other consumers (for example, it showed places to buy fish that had been recommended by other consumers, or recipes that other people had tried). Would you be more or less likely to trust this information than if it was from sources such as government agencies, universities, or the seafood industry?

6.2.1.4 Punishers

- If you eat fish less often than you think you should, why do you think this is?
- How hard is it to cook fish, compared with other meats?
- How do you feel about the price of fish?
- If there were one thing you could change about fish, what would it be?

It should be noted that, in the context of an open-ended discussion, these categories were permeable and contained significant overlap. For example, a discussion of people's degree of success cooking fish could as easily encompass positive (reinforcing) aspects as negative (punishing) ones. Similarly, obtaining information could lead to informational reinforcement, utilitarian reinforcement (if, for example, the information improves an individual's ability to cook fish effectively), or even punishment (for example, if the information discourages consumption on health or environmental grounds).

6.3 Results

Immediately following each focus group session, audio recordings were transcribed and written notes incorporated. After all transcriptions were completed, the results were collated and organised thematically. Data management of full transcripts and other relevant text was facilitated by the *Dedoose* qualitative data analysis tool.⁴⁰²

Semantic content analysis was carried out to identify themes. Two specific sub-categories of this approach were used: designation analysis, which determines the frequency with which certain concepts are mentioned, and assertions analysis, in which the relative frequency of positive and negative mentions of those concepts is examined.⁴⁰³ Given that a central component of the BPM is the notion of a consumer's learning history, and the relative proportion of positive and negative experiences that history comprises, this latter approach was particularly relevant.

A cascading coding system was designed, in which excerpts were assigned first to a top-level category (e.g. cooking fish, fish and health, fish characteristics), then to any relevant sub-categories (e.g., for the cooking fish category, recipes, ease of cooking compared with other meats, and confidence experimenting). For some sub-categories, a third level of codes was appropriate. Most excerpts were also assigned one or more codes relating to the main constructs of the BPM. Codes were developed inductively from the transcript data, with close reference to the BPM constructs.

The categorised coding taxonomy is shown in full in **Figure 12**.

Fish consumption

Cooking fish

- Confidence experimenting
- Cooking confidence cf. other meats
- Ease of cooking cf. other meats
- Recipes
 - Finding fish to suit recipe cf. finding recipe to suit fish
 - Recipe sources - books
 - Recipe sources - online
 - Recipe sources - other people
 - Recipe sources - TV shows
 - Recipe sources - point of sale
- Success in cooking cf. other meats

Differences between Australian states

Cultural/international factors

Eating fish

- Consumption frequency - actual
- Consumption frequency - ideal
- Consumption occasions
- Dining out
- Early experiences
- Species preferences
 - Participant's species preferences
 - Participant's children's species preferences
 - Participant's partner's species preferences
- Specific negative experiences
- Taste preferences
 - Mildness
 - Participant's taste preferences
 - Participant's children's taste preferences
 - Participant's partner's taste preferences

Environmental issues

- Sustainability

Fish and health

- Allergies
- Contaminants
- Known health benefits
- Moral obligation to serve to family
- Negative health aspects of fish consumption
- Omega-3s
- Personal health condition as a consumption deterrent
- Personal health condition as a consumption incentive
- Pregnancy
- Supplements

Fish characteristics

- Bones, scales, shells etc.
- Firmness
- Freshness
- Odour
- Seasonality
- Wild/farmed

Fish information

- Government
- Online
- Other consumers
- Retailers
- Seafood industry
- Social media
- Universities (research)

Fishing - commercial

Fishing - recreational

Food and nutritional information (general; not specifically fish)

- Government
- Industry
- Media
- Online
- Social media
 - Social media: trustworthiness cf. other sources
- Recipes (not fish)
- Food labelling

Purchasing fish

- Availability
- Fish formats
- Fish labelling
- Fish outlets
 - Convenience
 - Fish shops cf. generic food outlets
 - Negative aspects
 - Quality variation
 - Specific outlets
- Fresh cf. frozen
- Judging freshness
- Local cf. imported
- Price
 - Price cf. other meats
- Providence
- Spoilage
- Storage

Species

- Confidence selecting species

Terms of reference (fish cf. seafood)

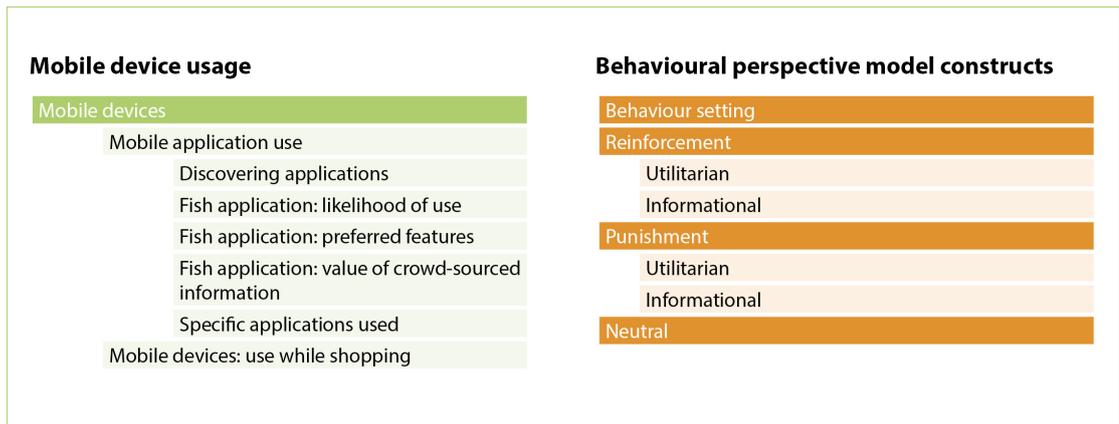


Figure 12. Codes used in the thematic analysis of qualitative data.

Two examples of the use of this coding taxonomy are shown in **Figure 13**.

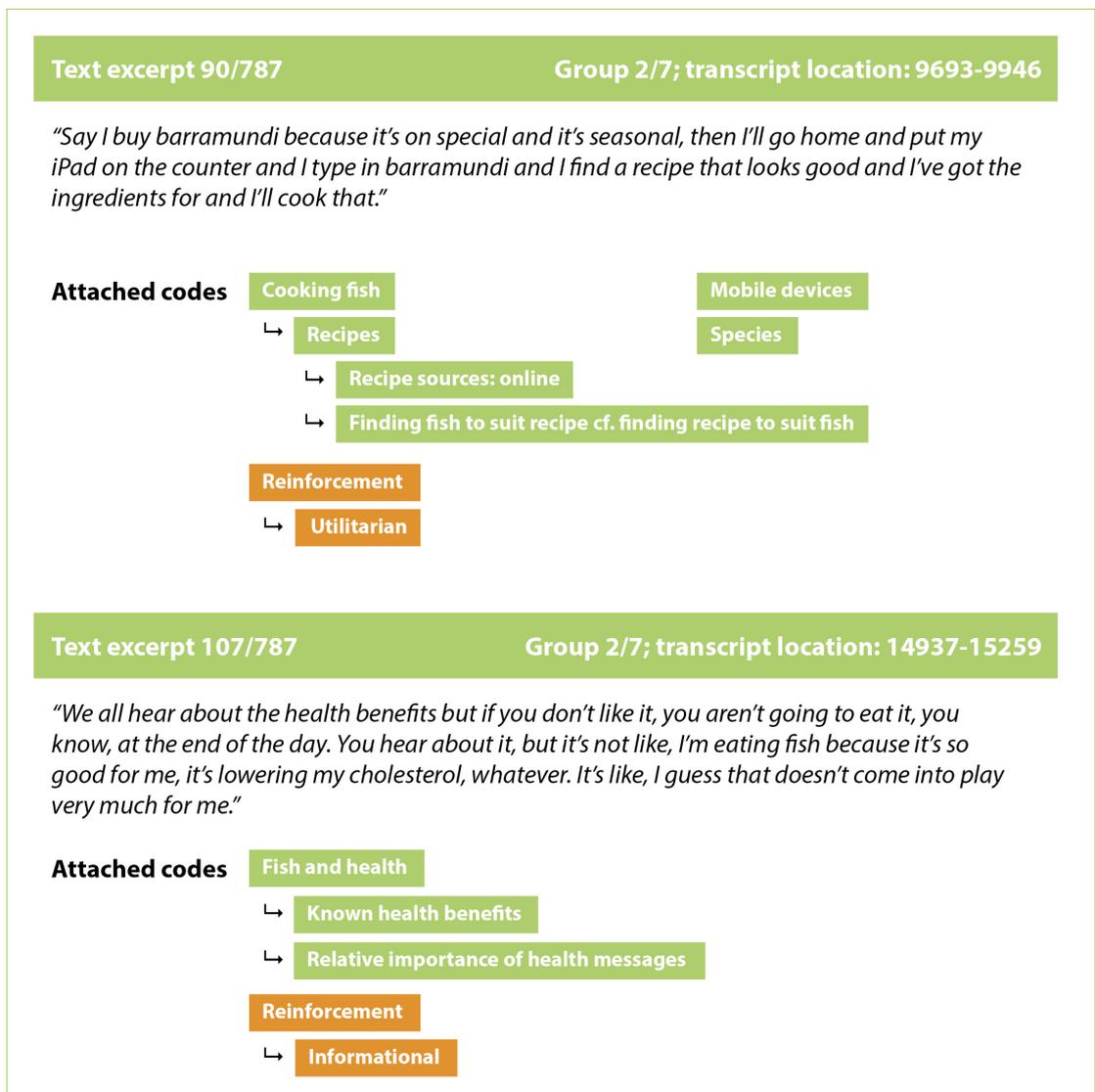


Figure 13. Examples of excerpt coding.

Two researchers independently coded excerpts from all seven transcripts. Differences in code applications were flagged, discussed and resolved either by retaining codes from both researchers or removing code applications agreed to be in error. In all, 787 excerpts were analysed and 3357 code applications made, comprising 107 discrete codes.

Code co-occurrence analysis assisted with the identification of key themes. The relative co-occurrence of positive and negative BPM constructs with various components of fish consumption behaviour created a broad-stroke picture of the degree to which these components had contributed to participants' learning history. This analysis enabled the following general observations:

- Physical characteristics of fish were mentioned in a negative (punishing) context five times more often than in a positive (reinforcing) context. (negative n = 44; positive n = 8)
- Combining all aspects of health, including benefits, contaminants and allergies, discussion was strongly positive. (positive n = 37; negative n = 7)
- Positive and negative mentions of issues relating to the cooking of fish occurred quite evenly. (positive n = 26; negative n = 24)
- Fish purchasing experiences were described in a negative context twice as often as in a positive one. (negative n = 62; positive n = 31)
- There was a somewhat more even incidence of positive and negative mentions of fish outlets themselves. (negative n = 25; positive n = 16)
- Price was mentioned in a negative context four times as often as in a positive one. (negative n = 31; positive n = 8)
- Cultural issues were more likely to be described as having a positive impact on consumption than a negative one. (positive n = 18; negative n = 10)
- Early experiences with fish were described as positive slightly more often than negative (positive n = 9; negative n = 6)
- Overall the discussion that occurred across the seven groups was very evenly divided between positive and negative factors, based on application of the BPM codes. (negative n = 803; positive n = 792)

Aside from BPM considerations, other observations were made possible by the analysis of code co-occurrence.

- Cultural and international factors more often related to purchasing fish (n = 16) than to cooking it (n = 2) or to its characteristics (n = 4).
- Taste preferences were discussed relatively evenly with respect to the preferences of the participant (n = 12), their partners (n = 13) and their children (n = 9).
- The most commonly mentioned physical characteristics of fish and seafood were bones, scales and claws (n = 36). Odour (n = 14) and freshness (n = 14) were other regularly mentioned factors.
- Recreational fishing (n = 47) was mentioned twice as often as commercial fishing (n = 24).

A sample of the code co-occurrence data is shown in **Table 4**.

Table 4. A sample of code co-occurrence data from thematic analysis of focus group transcripts. (Codes with fewer than 15 co-occurrences with any other code are omitted.)

	Behaviour setting	Informational	Punishment	Reinforcement	Utilitarian	Cooking fish	Confidence experimenting	Recipes	Finding fish to suit recipe...	Recipe sources - online	Success in cooking...	Cultural/international factors	Eating fish	Consumption frequency - actual	Consumption frequency - ideal	Early experiences	Taste preferences	Fish and health	Known health benefits	Fish characteristics	
Behaviour setting		11	28	19	37	8	4	2	1		1	6	12			3	2				9
Informational	11		32	87	16	16	4	13	2	11		20	48	10	24	6	10	44	16	15	
Punishment	28	32		9	106	24	6	2	1		11	10	27	2	3	6	13	7	1	44	
Reinforcement	19	87	9		59	26	4	11	4	4	8	18	48	9	22	9	10	37	17	8	
Utilitarian	37	16	106	59		46	7	8	3		25	11	38	2	2	13	17	7	1	48	
Cooking fish	8	16	24	26	46		20	74	21	42	31	2	10			1	4	1		6	
Confidence experimenting	4	4	6	4	7	20		3			1	1	4				1			2	
Recipes	2	13	2	11	8	74	3		20	46	1	1	3			1	1			1	
Finding fish to suit recipe...	1	2	1	4	3	21		20		3			3			1	1				
Recipe sources - online		11		4		42		46	3			1									
Success in cooking cf. other meats	1		11	8	25	31	1	1					1				1			1	
Cultural/international factors	6	20	10	18	11	2	1	1		1			14	3	4	3	7	9	3	4	
Eating fish	12	48	27	48	38	10	4	3	3		1	14		25	30	18	32	16	5	10	
Consumption frequency - actual		10	2	9	2							3	25		3		1				
Consumption frequency - ideal		24	3	22	2							4	30	3		1		7	4		
Early experiences	3	6	6	9	13	1		1	1			3	18	1			3	2		3	
Taste preferences	2	10	13	10	17	4	1	1	1		1	7	32	1		3		7	1	5	
Fish and health		44	7	37	7	1						9	16		7	2	7		16	2	
Known health benefits		16	1	17	1							3	5		4		1	16			
Fish characteristics	9	15	44	8	48	6	2	1			1	4	10			3	5	2			
Bones, scales, shells etc	6	1	26	3	29	4					1	2	4			1	1			36	
Fish information	6	35	6	7	1	1		1				1	1			1		1		1	
Fish information - online	1	10	1	1		1		1				1						1		1	
Fish information - other consumers		8		1																	
Fish information - retailer	5	14	5	5	1							1	1			1		1			
Nutrition information		15	1	2		1		1		1		1						1			
Nutrition information - social media		12		1		1		1		1											
Mobile devices		58	2	9	1	2		2	2	2		1	1			1		1		6	
Apps		57	2	9	1	1		1				1	1			1		1		6	
Fish app - likelihood of use		13		4		1		1					1			1					
Fish app - preferred features		31	1	2	1	1		1				1						1		5	
Specific apps		4	1	2																	
Mobile devices - use while shopping		2		1		2		2	2	2											
Purchasing fish	43	27	62	31	73	5		2	1		2	16	17	2	2	4	7	2		19	
Fish formats	4	4	8	7	12	1						3	3		2	1	1			4	
Fish outlets	33	11	25	16	31	2		1			1	7	5	1		1	1			5	
Fish outlets - fish shops...	13	5	12	7	15							3	1							2	
Specific outlets	16	7	7	12	11	1		1				3	3			1	1			3	
Price	5	7	31	8	32	3		2	2		1	5	9	1		1	4			4	
Species	6	22	23	19	30	12	6	4	3	1	2	8	24	8	3	1	7	6	2	13	

	Bones, scales, shells etc	Fish information	Fish information - online	Fish information - other consumers	Fish information - retailer	Nutrition information	Nutrition information - social media	Mobile devices	Apps	Fish app - likelihood of use	Fish app - preferred features	Specific apps	Mobile devices - use while shopping	Purchasing fish	Fish formats	Fish outlets	Fish outlets - fish shops...	Specific outlets	Price	Species
Behaviour setting	6	6	1		5									43	4	33	13	16	5	6
Informational	1	35	10	8	14	15	12	58	57	13	31	4	2	27	4	11	5	7	7	22
Punishment	26	6	1		5	1		2	2		1	1		62	8	25	12	7	31	23
Reinforcement	3	7	1	1	5	2	1	9	9	4	2	2	1	31	7	16	7	12	8	19
Utilitarian	29	1			1			1	1		1			73	12	31	15	11	32	30
Cooking fish	4	1	1			1	1	2	1	1	1		2	5	1	2		1	3	12
Confidence experimenting																				6
Recipes		1	1			1	1	2	1	1	1		2	2		1		1	2	4
Finding fish to suit recipe...								2					2	1					2	3
Recipe sources - online						1	1	2					2							1
Success in cooking cf. other meats	1													2		1			1	2
Cultural/international factors	2	1	1		1	1		1	1		1			16	3	7	3	3	5	8
Eating fish	4	1			1			1	1	1				17	3	5	1	3	9	24
Consumption frequency - actual														2		1			1	8
Consumption frequency - ideal														2	2					3
Early experiences	1	1			1			1	1	1				4	1	1		1	1	1
Taste preferences	1													7	1	1		1	4	7
Fish and health		1	1		1	1		1	1		1			2						6
Known health benefits																				2
Fish characteristics	36	1	1					6	6		5			19	4	5	2	3	4	13
Bones, scales, shells etc								1	1		1			4	1	3	2	2	2	6
Fish information			30	23	33	1		1	1			1		11		8	4	6	2	1
Fish information - online		30		3	1									2		1		1		1
Fish information - other consumers		23	3		1	1														
Fish information - retailer		33	1	1										9		7	4	5	2	1
Nutrition information		1		1			28	3	3					1						1
Nutrition information - social media						28														
Mobile devices	1	1				3			120	24	38	28	15	4					5	5
Apps	1	1				3			120	25	39	29	5	4					5	4
Fish app - likelihood of use								24	25		3			1					1	
Fish app - preferred features	1							38	39	3				3					4	3
Specific apps		1						28	29				5							
Mobile devices - use while shopping								15	5			5								1
Purchasing fish	4	11	2		9	1		4	4	1	3				20	46	21	20	57	19
Fish formats	1													20		4	2	1	4	3
Fish outlets	3	8	1		7									46	4		22	19	5	5
Fish outlets - fish shops...	2	4			4									21	2	22		6	2	2
Specific outlets	2	6	1		5									20	1	19	6		2	3
Price	2	2			2			5	5	1	4			57	4	5	2	2		8
Species	6	1	1		1	1		5	4		3		1	19	3	5	2	3	8	

It is important to note that this quantitative analysis of the transcript data was only used as a guide in the identification of themes. The semi-structured nature of the group sessions meant that any inferences from the data needed to be both measured and interpreted in the context of the discussions from which the

excerpts were taken. For example, some individuals spoke at length on a given topic, returning to the same themes throughout their session. A purely quantitative analysis of the data would have been of limited objective value.

6.3.1 Themes

6.3.1.1 Barriers to consumption

Reported barriers to consumption were in line with those reported by the literature (see Section 2.2). Participants cited high cost, the presence of bones, inconvenience, variable quality, and difficulty finding fish that suited their taste preferences, or those of their partners or children.

The BPM does not explicitly segregate punishers using the two categories it uses for reinforcers, namely *utilitarian* and *informational*. However in this case a distinction was made to assist with a deeper understanding of the reported barriers to consumption. Utilitarian punishers were considered to be factors expected to decrease fish consumption, specifically related to fish itself, or the experience of purchasing, preparing and eating it. Informational punishers were factors not related to the immediate act of purchasing or eating fish – for example, the opinions of other people, friends, family or health professionals, or information participants had been exposed to. This decision was not at odds with the terms of the BPM, which certainly examines both forms of punishment without usually making an explicit distinction in diagrammatic representations of the model.

Utilitarian punishers were nearly twice as likely to be reported by participants than informational punishers. (Utilitarian punishers $n = 106$, informational punishers $n = 59$) In other words, the barriers participants cited were more commonly related to the experience of purchasing and eating fish (cost, bones, smell, difficulty cooking), than they were to negative informational consequences or feedback about fish consumption. This is in keeping with the literature, which suggests a

high level of awareness of the health benefits of fish, and generally positive disposition towards its consumption.^{75, 109, 110}

Where informational punishers were reported, they appeared to have a minimal impact on the participant's consumption levels, to have had an impact only during a specific time period (for example, during pregnancy), or on consumption of specific fish species. These factors included sustainability issues, an awareness of contaminants such as mercury, and specific health issues for which the participant believed they should limit consumption of certain species. There was some level of perception that larger fish species were more likely to contain contaminants, with tuna, swordfish and salmon being mentioned specifically. In some cases participants had some awareness of official guidelines on this issue. For example:

There's advice that you shouldn't eat certain types of fish if you're, for example, pregnant or breastfeeding. Then there's certain types of fish that even if you're healthy, you should eat more than a certain amount. I'm not sure what the guidelines are but, I think its two or three times a week.

(University group 4, participant 3)

Some participants expressed the view that any concerns they had were outweighed by taste considerations and an awareness of counter-balancing health benefits. For example:

I know that in regards to the larger fish, there's a higher mercury content due to the pollution and everything so I do try to keep away from the larger fish if I can. But taste overtakes and I'll have a nice salmon steak every now and again. I don't know, I seem to be eating a lot more smaller fish these days, like sardines, pilchards, just because of the health benefit as well. I know they're higher in the omega-3s and all the other oils as well.

(University group 3, participant 3)

6.3.1.2 Drivers for consumption

Like barriers, the drivers to consumption were also analysed in line with the core BPM constructs, which organises reinforcing factors into the same two categories. People who have a positive experience buying and eating fish have received utilitarian reinforcement. Those who hear positive things about fish from friends, doctors or the media, have been exposed to informational reinforcement.

Conversely to punishers, participants more often reported informational reinforcement than utilitarian reinforcement, although the difference was smaller (Informational reinforcers $n = 87$, utilitarian punishers $n = 59$). Utilitarian, or experience-based reinforcers included good taste, convenience, relief from joint pain, success when cooking and positive experiences of recreational fishing. Informational, or feedback-based reinforcers mainly comprised knowledge of the health benefits of fish consumption.

Many participants said that taste – a strong utilitarian reinforcer - was the single biggest reason for their decision to consume fish regularly. In many cases those participants added that the health benefits of fish consumption were more of an “added bonus” than a direct reason for consumption. This interaction between hedonistic qualities of fish and health perceptions is discussed in more detail in Section 6.3.1.3.

6.3.1.3 Fish and health

Not surprisingly, people with a specific health condition, or with particular health needs, reported that health factors related to fish consumption were important. This was true both in terms of incentives for fish consumption (such as those with arthritis or joint complaints), and of deterrents (in a number of cases, for women while pregnant). Interestingly, one health condition (elevated cholesterol) was cited as a consumption incentive by some participants, and as a deterrent by others, pointing towards inconsistent information about the nutritional composition of fish and seafood and the impact of their consumption.

For those without specific health needs there was a range of views about the health benefits of fish consumption, and the relative importance of these factors in influencing participants' food choices. Many participants could name a number of specific benefits, and in most cases these named benefits aligned with those reported in scientific literature: for example, relief from inflammatory conditions and positive impact on heart health and brain function. However, many participants made it very clear that the health benefits of fish consumption played little or no role in their decision to eat fish, or the frequency with which they ate it. A number of participants, across several groups, stated that they ate fish solely because they liked it, not because of any health benefits they were aware of. For example:

[Some] people eat fish because they think it's going to be healthy for them. For me I eat fish just because I like it, and so I don't think if it's good or not good. I think it's healthy but I don't think of the content of it...it's just because it tastes good.

(University group 6, participant 4)

When my kids were younger, but even now for me, for my husband, there is...the nutritious quality, but for me...[it] is the pleasure, first and foremost is the pleasure. If you can mix up the pleasure with the variety with the nutritious value - perfect!

(University group 2, participant 2)

We all hear about the health benefits but if you don't like it, you aren't going to eat it, you know, at the end of the day. You hear about it, but it's not like, I'm eating fish because it's so good for me, it's lowering my cholesterol, whatever...I guess that doesn't come into play very much for me.

(University group 3, participant 3)

It would be more taste but health benefits are just a benefit really, a nice little perk on the side.

(University group 2, participant 1)

This attitude to health messages was also manifest among participants who ate relatively little fish, who did not believe that additional information, including health information, could influence their consumption. One participant observed:

If I love to eat something, be it fish or something else no app or no website would be able to stop me if that thing is not good for me...And if I don't like something, no amount of information on the apps or website will make me eat it...I used to get scolded, but no amount of scolding or whacking would ever make me if I never wanted to eat it. So that was like parents and friends, so what parents' influence couldn't do, certainly an app couldn't.

(University group 1, participant 1)

In some cases participants indicated a general confusion over the role of supplements, and their efficacy as compared with fresh seafood.

It's meant to be good for the joints...and I've been told it's great brain food so its supposed to be very good for your reflexes and things and because I come from the point where I don't like eating a lot of fish I've come across to thinking I should be taking fish oil capsules instead...I've got a big thing about taking pills even though they're vitamin pills, I know I should be having the fresh stuff...For arthritis and joints and things and the latest thing I've noticed in the shops is the krill oil tablets...so whether that's different or not, I don't know.

(Mothers' group, participant 3)

While most discussion of the health impact of fish consumption was strongly positive, one participant mentioned the cholesterol impact of seafood as a consumption barrier.

I like shellfish but I'm married to a man who has cholesterol problems so we don't have shellfish very often.

(Mothers' group, participant 3)

Although many participants indicated that health was not the primary factor influencing their consumption decisions, many participants reported that they thought they should eat more fish than they actually did. When questioned about this, they often said that this was primarily due to expected health benefits. It is noteworthy that, in many cases, the same participants reported both ambivalence towards the health benefits of fish consumption, and a general desire to eat more fish because of its benefits.

Only one participant mentioned allergies as a barrier to consumption, and only in the context of concerns about potential allergies for their children, rather than actual experience:

My kids have never had prawns or mussels or scallops. We've avoided giving them to them...they both tend to have allergies so we've avoided those sorts of crustaceans and things.

(University group 4, participant 1)

6.3.1.4 Fish and children

Mixed feelings about the health benefits of fish consumption, in terms of acting as a driver for consumption, did not prevent many participants reporting that they felt some kind of moral obligation to serve fish to their families – particularly their children:

They need that, they need fish and, so yeah, I do feel an obligation.

(Mothers' group, participant 5)

We do feel as though we should eat fish a few times a week. I do feel as though it's a duty to do that. Whereas I don't feel the same way with chicken or beef.

(Mothers' group, participant 3)

Some studies have found that the presence of young children or teenagers has a negative impact on a family's fish consumption.^{84, 404, 405} There did not appear to be

a strong trend of this kind among these focus group participants. Some reported that their children were happy to eat fish, while others found they needed to disguise fish, to call it chicken, to limit themselves to processed products like fish fingers, or to prepare it in a limited number a simple ways. Few participants felt that their children had a significant negative impact on their fish consumption.

6.3.1.5 Early experiences with fish and seafood

A number of participants described early experiences eating fish and seafood and speculated on the ways these early experiences had impacted on their later consumption. These early experiences were described in positive terms slightly more often than negative terms (positive = 9; negative n = 6).

Positive experiences included being in a family that ate a lot of fish, belonging to a culture for which fish was an important staple, living near the coast, and having a parent who regularly fished, either recreationally or commercially. Negative experiences included eating unpleasant fish at a young age and being very mindful of bones. Some participants reported that they simply were not exposed to a lot of fish and seafood beyond simple preparations such as fish and chips or fish fingers.

Where participants reported differences between their current home (Perth, Western Australia) and other cities they had lived in or visited in Australia or elsewhere, comparisons were generally negative. For example:

I've been to Tasmania, I've been to NZ, Sydney, Melbourne. You have proper fish markets with the proper fishmonger with the proper display and the proper conditioning of the fresh fish. Western Australia...when you got a [fish section]...you've got to choose [from] a small section. The fish are very "sad".
(University group 2, participant 2)

I come from Melbourne...It's a lot cheaper. I used to go Saturday morning, Vic Market, twelve dollars or eleven dollars a kilo and get a big portion of salmon,

but here, you don't get it.

(University group 5, participant 1)

We try and get at least two or three [serves of fish] in if we can get to the shops and get it, just depends...the availability in Perth is mostly the problem. When we were living in Sydney we had the fish market down the road...so we could get a lot more.

(University group 6, participant 1)

Conversely one participant reported that they felt availability was better in Perth than on the eastern seaboard.

When I'm here in Perth, I definitely eat more fish than when I was living in Sydney. I think it's the availability of the freshness for myself...Definitely more than on the east coast.

(University group 6, participant 2)

Although these experiences did not seem to have had an overly negative impact on their attitude to fish consumption, some of these participants said they felt it had reduced their likelihood of experimenting with different fish and seafood, and their adult tendency to eat it regularly.

6.3.1.6 Cultural factors

Some participants indicated a traditional, religious dynamic in their fish consumption behaviour. For example,

Christmas and Easter always seafood for those and, being Catholic, during Lent. Fridays we don't eat meat definitely and Ash Wednesday you don't eat meat and stuff like that so certain times of the year and we have tried to like keep the Friday fish thing going for dinner as often as possible.

(Mothers' group, participant 2)

Others indicated that, even through they were not themselves religious, they tended to observe at least some of these traditions.

It's interesting because we, my husband is not a churchgoer at all but we've always had fish on Good Friday and I think that's just out of respect.

(Mothers' group, participant 3)

Many participants of Asian descent reported a high level of confidence cooking and eating fish, often referring to a selection of traditional preparations they had learned from their parents. In some cases where individuals had emigrated relatively recently to Australia, they reported having difficulty finding the species and ingredients necessary for those recipes. For example:

Before I moved to Australia [I ate fish] two days a week. But when I came here, the types of fish, I'm not familiar with them...and I don't think I'm brave enough to try, 'cos I don't know how are they going to taste. If I can get someone who can tell me where I can get fish with good taste, or even just what they are then I will be able to explore more, so this is a factor that actually influences how many times we consume fish in Australia.

(University group 1, participant 2)

These participants often talked about the high regard with which fish was held in their home countries, or the home countries of their parents. Fish was said to be an important staple in Asian cuisine, with a high level of recognition of its healthful properties.

[In Asia] they reckon it has more nutrition in fish, and it's kind of our culture too because we are...really close to the ocean, so it kind of become our diet, we eat at least twice, lunch and dinner...We eat everything of fish...here is different you know, you have fillet and that's it...I think it may also be to do with the big population we have. We have to minimize the mass, the mass usage of our resources.

(University group 6, participant 5)

Some suggested a degree of discrimination between fish regarded as healthy and less healthy.

[We eat] oily fish like salmon, they're good. There's a different type of fish which are trevally and things which are not good for the heart, they are high in cholesterol...In Asia we differentiate those high cholesterol fish. Good oil omega-3 fish like salmon and cod and other very neutral fish like snapper, we differentiate that. So depending on whether we want to lose weight or we want to do this, or do that, we go according to the seafood. Like a lot of us, we stay away from crabs and prawns, because they are very high in cholesterol level.
(University group 5, participant 6)

This participant later added the opinion that, in Asian cultures, people tended to have greater awareness of the properties of high-quality fish.

Because I'm raised in North Borneo and we live near the sea we are spoilt for our choices of seafood...we learned to choose freshness and all that at a young age. Lift the gills, poke the eyes, all sorts at a young age...The moment you smell it you know the freshness. You press your finger in, you know the freshness. So basically we gauge like that, I try to stay away from the fillets, because it doesn't indicate, they're all frozen.
(University group 5, participant 6)

A smaller number of participants were recent emigrants from continental Europe, or had spent significant amounts of time there. These individuals spoke of a market culture, and of the habit of buying cheaper, less processed products, which they found somewhat lacking in Australia, and particularly in Western Australia.

6.3.1.7 Cooking fish

There appeared to be a stark contrast between participants who felt confident cooking fish and those who lacked such confidence, with most participants clearly defining themselves one way or the other. The latter group tended to use a relatively small number of simple preparations, such as barbequing or grilling, with the use of simple seasonings such as salt, lemon and butter. Although some more confident individuals enjoyed experimenting with different species of fish and with relatively complex recipes, many tended towards similarly simple preparations, preferring to rely on fresh high-quality product to produce appetising meals.

With fresh fish I tend to not to mix it up with a lot of stuff. I just cook fish with flour and enjoy it like that, because otherwise if you're spending a lot of money on it I don't really want it all mixed up with tomatoes and whatever else you might cook with it, because you don't take full advantage of the nice fish.

(University group 2, participant 3)

I haven't really looked up recipes for fish. I think because it [has] more subtle flavours you just kind of stick to the basics. I think other meats or desserts there's lots more different styles for cooking obviously. I cook a lot, as in fish as well, but I've never thought [to look for] a recipe for fish.

(University group 1, participant 5)

Many participants reported that they felt less confident, and experienced less success, cooking fish than they did with meats such as beef or chicken. A common complaint was that there was more that could go wrong cooking fish, with even confident individuals reporting some degree of failure. For example:

Sometimes we get it wrong as far as the texture, one fish falls apart... You go to flip it over and it falls apart, or something is a bit thicker than you imagined so it's hard to get the centre cooked... We never throw anything away but sometimes it goes back in the pan for a little bit more. And then some fish we don't know it but there are lots of little bones in there, and that becomes an issue for the kids and also for me because I don't do well with little bones getting stuck in my throat.

(University group 5, participant 2)

Just worrying about the bones when you're doing a full fish... My kids eat anything, so I worry that they're... not gonna go through it as carefully, and... where you just sort of panic, and especially sitting there with the tweezers... trying to get the bones out, just to be sure.

(Mothers' group, participant 4)

6.3.1.8 Mobile device and application usage

All participants had at least one mobile device, defined as either a smartphone or tablet computer. One third (n = 13) used at least one mobile application with a health, food or nutrition emphasis. These applications included those for fitness tracking (such as pedometer-based run and walk trackers), weight-management, recipes, food pairings, grocery shopping (for example, applications released by the major Australian supermarkets), restaurant recommendations, and calorie tracking. The most commonly mentioned application was *MyFitnessPal*,²⁴² a weight-management tool based on calorie tracking, using a combination of crowdsourced and officially-released nutritional information. About one in five participants (n = 7) used, or had used, this application. Two participants referred to applications containing information about seafood sustainability.

When asked how they found applications in this category, no clear trend emerged. Some participants actively searched for such applications, and chose which to download on the basis of positive reviews and price, while others tended to rely on recommendations by friends and family.

Participants were also asked if they used mobile devices or applications to assist them at any stage in the process of food shopping, planning or cooking meals. Again, there was no clear trend. Some participants used these technologies in planning meals – for example, to find recipes or prepare a shopping list. Others used them at point of sale, to find out more about food products, nutritional information, substitutes, or for price comparisons. Still others used them during cooking, mainly for recipe guidance (in lieu of traditional printed recipes or cooking books).

6.4 Discussion

6.4.1 BPM constructs

An important distinction must be made between informational reinforcers (and punishers), as described in the BPM, and sources of information, as reported by focus group participants. Informational reinforcers are not so-called because they are related to the receipt of “information” (in the lay sense) about a purchase. In fact, if such information is received *before* a purchase, then it does not constitute an operant reinforcement at all, because in operant conditioning reinforcers and punishers always occur *after* the behaviour. Informational stimuli take the form of positive or negative feedback the consumer receives about their purchase. For some kinds of purchases this may take the form of prestige or other “feel good” factors – other people have fed back to the consumer in such a way that they feel they have made a good, wise, or valuable purchase. For some purchases, these stimuli are very easy to discern. For example, John purchases a luxury car and receives praise; people comment favourably about the car. The praise is directly linked to the *specific* purchase of the car, and John’s purchase is thus reinforced.³⁵⁴

In the case of food purchases, specific stimuli can be difficult to determine and separate. Unlike one-off purchases, food is purchased regularly, and the rate at which certain foods or brands are purchased may vary over time. Food is purchased against a constantly evolving backdrop of reinforcement and punishment, and researchers may have difficulty connecting any given stimulus to a specific purchase, as it may very well occur after one purchase, but before another. Furthermore, the actual consumption of the food product may be somewhat removed from the purchase event. The primary utilitarian punisher (payment of money) may have taken place days or (in the case of canned or frozen products) weeks or months before the actual consumption of the product, and any antecedent stimuli. Leek et al.⁷⁵ cite evidence that the factors influencing food consumption tend to be environmental (i.e. situational) rather than intrapersonal, and make the case that situational determinants are more important in food choices than in other consumer contexts.

Consider, for example, exposure to media presenting a negative image of fish and sustainability. If a person has recently purchased fish, or regularly does so, this exposure might act as an informational punisher in the sense described in the BPM. It does this by eliciting a feeling of guilt, and the consumer may be somewhat less likely to buy the fish species in question, or even fish in general, in future. Now consider exposure to health information – the consumer comes across or is shown information about the health benefits of fish consumption. The consumer has not directly been praised for their purchase – the health information is not “feedback”, in the normal sense (except in the case of, say, a patient telling a doctor how much of a certain food group they eat, and being told that they have made a good, healthy decision). The information does not relate directly to any specific purchase the consumer has made. However, this information acts as informational reinforcement in contributing to the learning history of the individual.

Finally, consider the process of obtaining information about the purchase, storage and preparation of fish. This was discussed at length in all focus groups, with participants assigning differing levels of importance to such information gathering, reporting a range of ways to obtain this information, and expressing varying levels of satisfaction with the information available at the places they bought fish. This information sits somewhat awkwardly with notions of informational reinforcement, as described in the BPM. Exposure to this information does not constitute any kind of feedback on the consumer’s purchase. It is often obtained immediately before a specific purchase, rather than after it. The receipt of this information does not necessarily increase the likelihood of future consumption – this will depend on the mix of positive and aversive stimuli experienced after the act of consumption. In other words, a fishmonger telling you that crimson snapper is a tasty fish will only make you more likely to buy that species if you do in fact find it tasty. Either way, it is the utilitarian stimuli that follow consumption of the fish (e.g. good taste) that reinforce consumption, not the information gathered prior to its purchase.

However, this kind of pre-purchase information *does* make it more likely that utilitarian reinforcement will occur – by incorporating expert advice into their decision-making, the consumer is more likely to make choices that lead to reinforcement. This interaction is acknowledged in the BPM literature. Leek, Maddock and Foxall make the point that “what the consumer lacks in a direct consumption history he or she is likely to make up by seeking advice from other consumers, salespersons, or by sampling the product.”⁷⁵ As with health information, it is important to consider this information gathering in constructing a full picture of a given consumer’s learning history.

For the purposes of this study, items of information to which the participant was exposed, which actively encouraged increased fish consumption, were considered to be informational reinforcers. The most prevalent of these was health information. More general information about the use of fish was not considered to provide direct informational reinforcement, but rather to contribute to the greater picture of behavioural setting, particularly when the information was obtained at point of sale.

6.4.2 Fish and health

The discussion of matters relating to fish and health appeared to point towards a complex interaction between health knowledge, awareness of the health benefits of fish consumption, and intention to eat fish. While there was generally a high level of awareness of the benefits of consumption, this did not appear to directly link with consumption in a predictable fashion – for example, that people with more knowledge ate fish more often, and those with less ate it less.

Some foods have a well-known healthy nutritional profile, yet are less desirable to many consumers on hedonic grounds – in other words, many people do not like them. These people may still choose to consume such foods, if they are readily available and if the health benefits are well known. What might be called the “eat it up, it’s good for you” effect is supported in the literature, with some studies suggesting that some form of cost-benefit analysis influences the decision to

consume less hedonically attractive foods, such as vegetables.^{406, 407} This decision-making process is certainly complex, with many studies suggesting a wide range of influences, including health self-efficacy,^{408, 409} socio-economic status⁴¹⁰ and geographic location.⁴¹¹

Fish appears to differ somewhat as a food with well-known healthful properties, in that many studies have found that the majority of adult consumers report that they enjoy eating it.^{76, 103, 109, 110} Compare this to foods that are known to have a healthy nutritional profile, yet are less desirable for many consumers. Many people will choose to consume these foods, and to serve them to their families, largely because of the expected health benefits.^{412, 413} In the case of fish, it appears on the basis of these data to be influenced to a greater extent by other factors, including price, availability, and confidence (as outlined in Section 2.2). Notably, some studies have found families that try to adhere to fruit and vegetable intake recommendations also tend to report regular fish consumption.^{79, 414}

These findings had an important bearing on the nature of the experimental application being developed. Whilst reinforcing the nutritional benefits of regular fish consumption would certainly do no harm, the weight of evidence suggested that a strong focus on health (i.e., the creation of a “fish and health” application) would have less impact than focussing on improving the experiential (in BPM terms, the *utilitarian*) aspects of fish consumption. The importance of improving consumers’ experience of these non-health aspects of fish consumption has also been stressed in the literature. For example, an online survey of Australian consumers (n = 899) concluded:

While key drivers of seafood consumption including taste, convenience, variety and perceived health benefits should be leveraged to strengthen their facilitating effects, further strategies aimed at reducing perceived risks and attenuating inhibitory effects, in particular for lighter consumers, require further investigation.¹⁰¹

The relative balance of health and non-health foci in the experimental application is discussed further in Section 6.4.6.

6.4.3 Sustainability

Some discussion of the environmental impact of commercial fishing, and resulting implications for consumption, was expected. This expectation was based to some degree on contemporaneous media attention on these issues, including debate on the presence of the super trawlers *Margiris* and *Abel Tasman* in Australian waters,^{415, 416} similarly controversial debate on the Australian Government's proposed expansion of marine parks,⁴¹⁷ and moves by major Australian supermarket chains to introduce new sustainability standards and certifications for stocked seafood products.^{418, 419}

In fact, discussion of these topics was minimal. Analysis of the transcripts revealed six mentions of environmental issues throughout the seven focus groups. One participant expressed a strong interest in the subject, describing a mobile application that helped to make decisions about species to purchase. Another mentioned some awareness of sustainability issues for salmon, towards which they were quite partial, but admitted that this did not prevent them eating it regularly. A third expressed the importance of weighing environmental concerns with economic issues. Other mentions were in the context of places the participant would look for fish information, including sustainability information.

A few points should be made here. Firstly, the facilitator did not directly prompt the groups to discuss sustainability or other environmental factors. Most discussion of these issues occurred in response to questions about where participants looked for information about fish, including nutritional, health, environmental and sustainability information. It stands to reason that, if participants had been prompted more directly, there would have been greater discussion of these issues, and participants may have expressed a greater level of concern. However, the open-ended structure of the group discussions encouraged a flow of ideas beyond the direct questions, and there were certainly

instances where participants brought up topics that were not directly prompted by the facilitator.

It is also important to note that participants in the study all ate *some* fish (with the exception of one participant, who nominated himself in error). While many people who eat no fish at all do so due to taste preferences, others do so because of a vegetarian diet, or due to specific concerns about fish and/or fishing.^{65, 73} It is possible that focus groups more representative of the dietary diversity in the general population may have had more to say on these issues.

Danenberg and Remaud¹⁰⁹ also reported a complex relationship between consumers' environmental sensibilities and their intention to purchase fish. Drawing on a large Australian sample (n = 2643), they found that the majority of participants said they would be prepared to pay an extra 10% for certified sustainable seafood products. However, when shown products with a range of label combinations, an invented Federal Government sustainability certification appeared to have practically no effect on consumers' preferences. The authors acknowledged that this result might be partly attributed to the fact that the environmental certification label was by necessity invented, and therefore not known to respondents.

Sustainability is certainly an important issue for the commercial fishing and aquaculture industries, and one which will only become more important as the protein requirements of the growing Asian middle class increase.⁴²⁰ However addressing these issues in the proposed application would have added extra layers of complexity, necessary consultation and collaboration, and potential controversy; there are many definitions of the term *sustainability*, and many different criteria on which it might be judged. On the basis of both the literature review of consumer attitudes and the findings of these focus groups, environmental and sustainability information was not included in the experimental application.

6.4.4 Early experiences with fish

Participants reported a range of early experiences with fish and seafood. On the whole, those who had early exposure appeared to be more likely to consume it as an adult, particularly where their early experiences were positive. This seemed to hold true even when participants said they faced challenges in consuming fish. One possible interpretation is that early exposure to fish and seafood may create a kind of resistance to later consumption barriers. That is, when faced with issues such as rising prices, reduced availability or perceived inconvenience, people with positive early experiences of fish seemed more likely to continue consumption - to "find a way" to eat fish. Even those with neutral early experiences were more likely to write fish off as a significant part of their diet or to view it as an occasional delicacy, or something to be eaten only when dining out.

One participant described this theme succinctly. They had previously described very positive early experiences with fish, based on exposure to fish markets growing up in Europe, and a strong adult preference for eating fish. They then spoke of the difficulty of obtaining fish in Western Australia, citing high prices and poor quality in regular retail stores. They described their routine for obtaining good quality fish: rising early, driving some distance to a fish market, buying large amounts of semi-processed fish, and preparing and freezing that fish themselves. They concluded with the statement: "And if you want to have, to buy fish...my God! You really need to say 'I *want* to eat fish!'"

6.4.5 Device and mobile application usage

These discussions reflected the upward trend of mobile device usage in a wide range of circumstances described in Section 3.4.4. Although only a third had used health- or nutrition-focused mobile applications, most participants indicated a general openness to the concept. Only a small number of participants indicated a general mistrust of health-related applications, or a strong preference towards other means of accessing the same information (including other non-mobile digital sources, such as websites accessed via a desktop browser).

The same upward trajectory was apparent in the range of circumstances in which participants used mobile devices and applications. Many participants who did not personally use their devices while food shopping noted that they were observing this behaviour more and more frequently, and that it was becoming increasingly normal and acceptable to, for example, use a smartphone to scan barcodes in a supermarket.

Whilst apparently on the increase, the role of mobile devices in the overall experience of planning meals, shopping for ingredients, and cooking clearly differed greatly from individual to individual. Some individuals used this technology primarily as tools to replace existing offline or paper-based solutions to common needs – for example, to create shopping lists or to store known recipes. Others used it to supplement their knowledge or skills – to obtain information such as recipes or storage tips, or to gain advice.

A range of different users, and potential use-cases, is a common experience for mobile application developers, who must walk a fine line between accommodating the needs of a sufficiently large group of people to create a viable user base, and maintaining focus on a core set of tightly-defined features. These considerations are addressed in Section 6.4.6.

6.4.6 Implications for the proposed intervention

6.4.6.1 Application features

One of the primary goals of this formative study was to obtain guidance for the development of the application to be evaluated during the trial intervention. Which aspects of the fish consumption experience might best be influenced by the introduction of a mobile application, and from what sources should information be obtained and presented?

As well as deducing individuals' needs from discussions of their consumption experiences, focus group participants were also asked directly about the

likelihood of them using an application like the one being proposed, and about the features they believed it should include. A summary of the functionality and characteristics suggested by participants is shown in **Table 5**.

Table 5. Functionality suggested by focus group participants.

Functionality	Number of participants suggesting this functionality / characteristic
Assistance finding fish outlets and restaurants selling good quality fish	8
Assistance with the best ways to cook fish (including provision of recipes)	8
Assistance with selecting appropriate species	3
Assistance with understanding seasonality and obtaining seasonal products	5
Recommended serving sizes	1
Local specials / catch of the day promotions	2
Reminder to eat fish	1
Current prices	4
Daily availability	2
Delivery services	1
Assistance with feeding fish to children (e.g. child friendly recipes)	2
Nutritional information	1
Assistance with avoiding preparing fish and avoiding bones	3
Characteristic	
Localised (information relevant to the location of the user)	4
Information personalised to the user	2
Multiple levels of information	1
Information that is timely (e.g. daily specials or promotions) and/or regularly updated	5

Selection of appropriate species was an issue for many participants. Mentions of species, both in terms of specific species and more general observations about different kinds of fish and seafood, were quite evenly distributed between positive

and negative sentiments (positive n = 19, negative n = 23). This suggests that species selection can both aid and deter continued consumption, depending on the success of the selection.

Of course, selecting species appropriate to the preferences of the individual and their family does not guarantee a positive experience. The fish must be stored, prepared and served in an appropriate way, with techniques differing from species to species. Participants reported a wide range of experiences, positive and negative, and a range of ways of obtaining the necessary information and skills.

Finding sources of high quality fish and seafood, at reasonable prices, was another significant issue for many participants, and one that many indicated would be something a mobile application could assist with. Mentions of fish outlets, restaurants, and other more general aspects of the fish purchase experience were strongly negative (negative n = 62, positive n = 31), and many participants indicated that they would find it very difficult to find good fish without significant inconvenience. For example:

For me it is more convenience, you know you are used to going to the supermarket and I've got three kids so I'm used to pushing the trolley like that and so, I mean with fish, its not conveniently packed or stored so I have to go out of my way. I want to go out of my way but when I'm in the shops I'm just like... I feel like when the kids are older and I can leave them at home or something I can browse and select my fish.

(University group 1, participant 2)

A repeated theme was the perceived quality difference between products bought from dedicated fish shops, and those from supermarkets.

I find there's a big difference. I find it depends where you buy your fish from. I mean, I usually shop at the supermarket and buy fish that looks delicious, fresh from Australia or whatever, and I just do it in a pan in the oven and I find it can be a big rubbery mess. And it's completely unpalatable and in fact, no one will eat it. And I think damn, I should have gone to that fish shop, what have I done wrong, why is it like that?

(University group 3, participant 4)

6.4.6.2 Core purpose

As with any mobile application, or indeed any software, it was important to be very clear at the outset about the core purpose of the application being developed. How would a user perceive the application; in what way would its main purpose be expressed? The application could have been designed and communicated primarily as a “fish and health application”, intended to help users improve their health by eating fish regularly. Such an application would give prominent placement to health and nutritional information. On the basis of these focus groups, and of the literature described in Section 2.2, the decision was made to position the experimental application primarily as a service to help users to have a better experience finding, purchasing, cooking and eating fish. In other words, to improve the experiential, hedonistic aspects of the fish consumption experience: finding recommended fish outlets, choosing appropriate species and preparing them in an appropriate way.

In BPM terms, this meant that the application would focus predominantly on increasing utilitarian reinforcement and decreasing utilitarian punishment, rather than attempting to change the balance of informational reinforcement the individuals were receiving. Rather than primarily trying to persuade people that they should eat fish because it was good for them, the application would try to improve people's experiences, to increase the likelihood of continued consumption. This is not to say that health information would be absent from the application; it would simply not be the primary focus.

Only one participant stated that she believed such an application should include information about the health benefits of fish consumption, and even in that case, the participant did not believe the information would be of personal benefit:

I think an app like that would be useful for people who had specific dietary requirements and it could explain a bit more about the health benefits because I don't think personally I would find an app like that useful. Maybe having an Asian background, I think I have enough fish dishes and recipes. But I think in Australia, most people do eat fish and chicken and if they go for fish there would be a reason like a health reason, or maybe, not being a big red meat eater.

(University group 3, participant 5)

It was also important to consider the sources of information being presented. Participants were generally amenable to the idea of receiving information from a range of sources, including retail outlets, the seafood industry and other consumers, but many stated that the level of trust they afforded to different information sources depended largely on the kind of information being sought. For example:

[For] information [about] health benefits I'll get from...the university website. If that is readily accessible... that's fine but in terms of the regulations of fish industry, I would trust more government agencies. But in terms of how I go about cooking it, I trust my friends or other consumers or rather if I'm checking a certain shop, like how they store their product and so on, I'll trust maybe other consumers.

(University group 1, participant 3)

As discussed in Section 3.5 social information gathering (sometimes called crowdsourcing) is an increasingly effective and trusted means of gathering information, particularly consumer information. Discussions of this subject appeared to offer support for crowdsourcing at least some of the information presented in the experimental application, although not information related directly to health and nutrition.

One of the final questions asked of participants was whether, on balance, they would consider using a mobile application to assist with consuming fish regularly. Nine participants unequivocally stated that they would do so. A further five added the caveat that they would only do so if it were available for free, in which case there was “nothing to lose” – they could easily delete it if it did not provide the information they were looking for. Five participants said that they would have no interest in using such an application; they felt they already knew enough about fish, or had no strong desire to increase their consumption. In all, 32 of the 37 participants said that they would either certainly use the application, or would consider doing so if contained features they thought would be useful, and if it was well recommended or from a known, trusted information source.

7

Development of the experimental application

7.0 Development of the experimental application

7.1 Introduction

Software development shares many characteristics with intervention design. Neither is a deterministic activity; each begins with an end goal and applies human intelligence, experience and creativity towards achieving that goal. In both cases there is no single approach to tackling a given problem and, critically, no guarantee of a successful outcome.

This makes scientific description of software development difficult. When reporting on a study it is important to do so in a way that facilitates replication of that study. Study design is broken down into steps that can be followed by other researchers wishing to verify results or make changes to test some other variable. These later researchers should not need to have the same experience or background as the original researchers, or to go through the same creative process, just as we do not need to be culinary experts to follow a recipe. The creative work has been done; following the recipe closely should produce the same results (or not, in which case the original findings might be questioned).

When the centrepiece of a study is a complex software application, custom-made for that study, exact replication may be very difficult. Even a highly detailed description of the design of that application may not guarantee the same output. Difficulties notwithstanding, it is important to outline the design and development of the experimental application used in this study. This chapter will focus on the following aspects of the application development process:

- user features - what the application did
- database - how the application stored data, both content and user information
- research data collection functions
- key design decisions.

7.2 Objectives

The primary objective of the development phase of this study was to use the findings of the focus group study described in Chapter 6, and of the review of fish consumer literature outlined in Section 2.2, to construct an application aimed at increasing fish consumption. The experimental application was aimed at addressing the themes identified in this formative research. Specifically, it was designed to:

- assist users in identifying appropriate species for different purposes
- increase positive experiences of fish selection and consumption and reduce negative experiences
- share information about the locations where users purchased good quality fish
- provide information about the health benefits of fish consumption
- provide feedback on fish consumption, and the contribution that consumption might be making to the participant's health.

As discussed in Section 6.4.5, the focus groups were also intended to gauge participants' mobile device and application usage, and to test assumptions about the efficacy of using a mobile application to address barriers to fish consumption. While not all participants indicated an interest in such an application, many did, and participant feedback was used to tailor the feature set that was moved into the development phase.

7.3 Development and design

The *Pier 2 Peer* application was designed and built by the author, who has experience both as a graphic designer and mobile application developer. Compared with outsourcing to contractors, this approach provided many advantages, besides the obvious financial one. Full control of the development process was retained, making it possible for the application to evolve over time in a way that would not have been possible had development been outsourced. Substantial changes could be made in response to testing and early user feedback; in an outsourcing situation such changes would have been prohibitively expensive.

Most importantly the feature set could be determined with full knowledge of the time and complexity costs of various desired functions. This is a common problem experienced when outsourcing software development: it is necessary to clearly explain the required features to the developers, and for the developers to clearly explain everything that is required to implement those features. This communication does not always happen effectively, leading to problems once the application moves into production.

Although the application was designed and built by a single person, it was not constructed in isolation. The author consulted with a number of developers, designers and health professionals throughout the development process, and made a number of changes in response to feedback. Notably, the database structure and analytics system (described in Section 7.5) were designed after extensive consultation with experienced developers who had built applications with similar requirements.

Before being used in the exploratory trial, the application was provided to a group of eight beta testers, including both developers and non-technical people. This group identified a number of issues, all of which were addressed before the trial.

7.4 Platform and tools

Pier 2 Peer was developed for mobile devices using the iOS operating system – iPhone, iPad and iPod Touch devices. Developing for a single operating system allowed a degree of control over potential confounding variables; the more operating systems catered for, the greater the potential for variability in experience from one user to another. This decision also reduced the time required to build, test and deploy the application.

Pier 2 Peer was a native mobile application, written in the Objective-C programming language, using the *Xcode* integrated development environment. Native development was chosen over a number of alternative methodologies; to understand this decision and its implications, some explanation of these options is necessary.

7.4.1 The development methodologies spectrum

As discussed briefly in Section 3.3.4 the term *native* refers to applications built for a specific operating system – for example iOS, Android or Windows. Each of these operating systems requires that native applications be built using a particular programming language - Objective-C or Swift for iOS, Java for Android, and typically C++ or C# for Windows.

They also provide a set of protocols for accessing the various interface objects, functions, utilities, aerials and sensors of modern mobile devices. These are known as application programming interfaces (APIs), and they give developers access to extensive frameworks and tools that are written by the platform curators, specifically for that platform. APIs enable developers to build applications that can directly access device features such as cameras, global positioning system (GPS) features, accelerometers (sensors that detect which way the device is being held), and microphones. Non-native applications may be able to access some of these features, such as the camera or user location, but they do so using non-optimal methods.

Native applications are distributed directly by the companies that manage the operating systems, such as Apple, Google and Microsoft, via application stores on the device, or on desktop computers. Upgrades and bug fixes are also managed in this way. Developers who wish to modify their applications must do so via a submission to the relevant application store, and wait some length of time for approval.

Native applications can be seen as one end of a spectrum of development methodologies. At the other end of the spectrum are non-native web applications, designed to work across many devices and operating systems. They use common languages that are accessible on all devices, including HyperText Markup Language (HTML) and Javascript, languages long-used for general web development. These applications are essentially websites that have been optimised for smaller screens although optimisation is a challenge when the developer is trying to support literally hundreds of different devices, all with different screen sizes, resolutions, central processing units (CPUs) and graphics processing units (GPUs). Users are given a web address, just as they would for a standard website, and navigate to it using the browser on their device. The operating system and device manufacturers have no control over content or functionality of these applications – developers may make changes at any time, with immediate effect.

7.4.2 Advantages of native development

The main advantage of native applications is that they are built according to a set of specifications provided by the operating system manufacturer. These manufacturers provide vast libraries of code that can be used by developers, and this helps to ensure some level of consistency across applications. Buttons, indicators, item choosers and navigation structures all work consistently from application to application, because they are using the same code base, developed by the stewards of the platform, and refined over time. In contrast, an interface object in a web application may have been designed and programmed by anyone, and will vary greatly between applications.

As a simple example, a developer may require a button that when tapped, executes a software function. While this may seem like a trivial matter, a significant amount of code is required to achieve this. The button must be drawn on screen, in a given location, and the location may be dynamic, depending on the size or orientation of the device. It may have a particular visual style, comprising colours, gradients, lighting effects, images and typefaces. It must be capable of detecting taps that occur inside its bounds, and perhaps identifying different kinds of tap (for example, multiple sequential taps, or taps which begin inside the button's bounds, and end outside of them). Finally, it must be capable of communicating the fact that it was tapped to the wider system, along with any other relevant data (for example, the type of tap, or the identity of the button itself, to differentiate itself from other buttons performing similar but non-identical functions). In a native application, a developer need not create such a button from scratch, implementing all of this functionality. She may use an existing framework, built by the operating system developers. Beyond the time saving implications, this also provides a level of consistency between first party and third party applications. First party applications are those built by the operating system developers, providing essential functionality such as telephone dialling, messaging, music and video playback, and access to device settings. Third party applications are those built by any other developers.

The consequences of these factors should not be underestimated. As discussed in Section 3.4.4, mobile devices have deeply penetrated the daily lives of many individuals. Many people use such devices regularly through the day, for all manner of tasks, and as a consequence the interface of the device itself has become very familiar to users. In short, users expect applications to behave in particular ways, and there is an immediate disconnect when they do not. For example, many native mobile applications use a standard navigation structure to move from one screen to another. The device animates smoothly between the views and, because the content is usually embedded in the application, it appears almost instantaneously. Furthermore, the device presents various standard

controls for navigating backwards and forwards through content. Users recognize these controls, and know what to expect when they tap them.

The means of loading content creates another advantage of native development – all things being equal, a native application will consume far less data than a non-native, web-based equivalent. This is not to say that native applications consume no data – most modern applications, no matter how they are built, will have some function that requires access to the Internet. The critical difference is that, in a web application, everything seen on screen has been downloaded after launch. By contrast a native application will include a great deal, and in some cases all, of the data it needs to function at the time it is first downloaded from the distributor. Some distributors place an arbitrary limit on the size an application can be, if it is to be downloaded over a cellular connection; large applications can only be downloaded over a WI-FI connection. This prevents an application from consuming an unduly large amount of a user's cellular data allowance at the time it is first downloaded. There are no such safeguards with web applications, and this can impact on both performance and cost to the user. It should be noted, however, that experienced developers will attempt to design web applications with this in mind, and it is possible to develop efficient, fast, data-economic web applications.

Another consequence of the contrasting ways that native and web applications use data is that with most native applications it is possible to use some, most, or even all of the application's functionality without an Internet connection. The application's content and programming code are contained in the application when it is first downloaded. It may also be programmed to detect the presence or absence of an Internet connection, and modify itself accordingly. If there are parts of the application that require a connection, but the user is currently offline, it may hide or modify those functions, or present the user with a notification that they need to be online to use that part of the application. No such niceties exist for web applications; they simply will not work.

Specifically, building *Pier 2 Peer* as a native application enabled the following advantages:

- User data could be synchronised with the remote database at any time. If the user's device did not have an Internet connection at a given time, the data could be stored on the device until a connection was re-established (see Section 7.5).
- High quality images of fish species could be included with the application, and did not need to be downloaded on demand. This reduced on-going data consumption by the application, and sped up navigation considerably.
- Mapping and location functionality could be provided using the Apple Maps API (see Section 7.7.2).
- The application was able to access the device's camera, which was used in the diary tool for data collection (see Section 7.7.4).
- Despite being a relatively complex application, it could operate quickly and intuitively, using interface idioms that would be immediately familiar to users of iOS applications.

7.4.3 Other tools

Mock-ups of the application interface, and finished visual assets, were created using *Adobe Creative Suite* software – primarily *Photoshop*, *Illustrator* and *InDesign*.

A database of fish and seafood species commercially available in Australia was created using *Filemaker Pro*, a relational database application. Species were primarily taken from the Codes for Australian Aquatic Biota (CAAG) database,⁴²¹ maintained by the Australian Commonwealth Scientific and Industrial Research Organisation (CSIRO), with the addition of a number of common imported species. The final list comprised 208 species of fish and seafood; these are listed in full in Appendix 2. Data on the characteristics of each species were compiled from two authoritative sources: the Australian Seafood Users' Manual⁴²² and the Nutrient Tables for Use in Australia (NUTTAB) 2010 database.⁴²³ An entry from this

database is shown in **Figure 14**. The application was deployed to beta testers using *TestFlight*,⁴²⁴ a testing service for mobile applications.

Barramundi

Primary marketing name:

Secondary marketing name:

Scientific Name:

Type:

ASUM wild : farmed Wild Farmed

ASUM habitat saltwater estuarine freshwater

ASUM flavour:

ASUM oiliness:

ASUM moisture:

ASUM texture:

ASUM price:

ASUM taste:

ASUM versatility:

ASUM value:

NUTTAB n3:

ASUM Cooking methods (text):

ASUM Cooking methods: Steam or microwave Bake
 Poach Grill or BBQ
 Deep fry Smoke
 Shallow fry Raw

ASUM alternatives:

ASUM suitable whole: Yes

ASUM suitable fillet: Yes

image types:

Obsolete names:

Notes:

Figure 14. Species database entry.

7.5 Remote server

7.5.1 Server platform

A remote server, or backend, was required to serve data for the application, manage user profiles, and collect user-generated data. This database was created and managed using *Parse*. *Parse* is a mobile *backend as a service* (BaaS), which means it offers a framework for developers to create remote databases for their mobile applications, without needing to handle complex backend code. *Classes*, or database tables, were created for the following data types:

- users
- species
- facts (items of information about each species)
- species contributions (ratings and comments submitted by users)
- meals (serves of seafood consumed and recorded by users)
- outlets (user-recommended fish retailers)
- log events (for tracking user behaviour)

A database table from the *Parse* backend is displayed in **Figure 15**.

objectid	name	address	city	geoPoint	phone	url
Cdbt6FjWPI	A Fish Called Coogee	229 Coogee Bay Roa...	sydney	-33.920759999999999...	(02)96647700	(undefined)
Eg0TW0VJre	Anchors Seafood Centre	129 Lambton Road Br...	newcastle	-32.92369, 151.72584	(02)49571543	http://www.anchorse...
IFY6G5IGso	Angelakis Bros	30 Field St Adelaide S...	adelaide	-34.931159999999999...	(08)84001350	http://www.angelakis...
u67K87RWeU	Aptus Seafood	25 Market St, South ...	melbourne	-37.82946, 144.96023	(03)96997189	(undefined)
ntDrD6HLLm	Aqua Fresh Fish and ...	734 Glenferrie Rd, Ha...	melbourne	-37.81932, 145.0361	(03)98151028	http://www.aquanas.c...
uFYZDjQ5U	Aristos Waterfront	Unit 2/15 Bonnefoi Bo...	bunbury	-33.31787000000001...	(08)97916477	http://www.aristosbu...
gi1FUUVm7	Balgownie Fish Shop	166 Balgownie Road ...	woolongong	-34.388479999999999...	(02)42844252	(undefined)
9zZEiFjG6	Bay City Fisheries	138 Malop Street Gee...	geelong	-38.148, 144.36377	(02)52291886	(undefined)
nrfzB0FryQ	Bottom of the Harbou...	The Esplanade Balmo...	sydney	-33.8251, 151.25088	(02)99697911	http://www.bottomof...
CnoYfIMiIS	Brickworks Seafood	36 South Road Torren...	adelaide	-34.91363, 138.56438	(08)83524822	http://www.brickwork...
hFXy2gANTm	Burleigh Heads Fishm...	7/9 James Street Burl...	gold coast	-28.08922, 153.45148	(07)55352927	(undefined)
5nRYM7JTaC	Burswood Seafood	96 Burswood Road B...	perth	-31.96766, 115.8951	(08)94701389	http://www.burswood...
f9JVJZnQai	Charis Seafoods	371 Marine Parade La...	gold coast	-27.94152, 153.4083	(07)55271100	http://www.charisseaf...
LzDAcG4Z3L	Cicerello's	44 Mews Road Frema...	perth	-32.05829, 115.743	(08)93351911	http://www.cicerellos...
cn2lB3VjXB	Cicerello's	Unit 2/73 Mandurah T...	mandurah	-32.529, 115.7205	(08)95359777	http://www.cicerellos...

Figure 15. *Parse* database table for seafood outlets.

7.5.2 Data synchronisation methodology

Data synchronisation between a mobile application on a device and a remote server is a complex undertaking. There are a number of philosophies and methodologies, each with advantages and disadvantages in important areas such as speed, data consumption, server conservation, error handling and conflict resolution (i.e., the way in which a data model handles and merges conflicting data from two locations). Developers must prioritise these and other concerns in selecting a synchronisation methodology that is appropriate for a given application.

To understand this, consider two hypothetical applications. Application A is a news feed service. Upon opening the application, the user is shown an activity indicator (spinner) while the software establishes a connection with a remote server, fetches new news items, and then displays them to the user. The application also allows users to add comments on news items. Upon writing a comment and tapping “submit”, the user is shown another spinner while the comment is pushed to the remote server. Once the data is successfully transmitted, the spinner is removed, the user is shown a message indicating that their comment was submitted, and can immediately see her comment displayed among the others.

Application B shows user ratings for movies. Each time the user selects a movie the latest rating is pulled from the server and cached (saved) on the device. If the user looks at that movie at a later time, the application immediately shows the cached rating, without needing to display a spinner to the user. At the same time, it queries the server for the latest data and updates the display if necessary. If the user submits a movie rating, no spinner is shown; the rating is added to a queue for uploading and, when successful, it updates the remote data accordingly.

Application A has prioritised up-to-date data and user feedback, over a fast, immediate user experience. The user of this application may often be presented with an activity indicator and a delay while the application downloads or uploads

data but, in return, they always know that they are viewing up-to-date data, and that the things they have taken time to write have been successfully transmitted. In contrast, application B seldom interrupts its users, but does not guarantee that the current rating being shown for a movie reflects an up-to-the-minute value. Perhaps a number of recent negative reviews have pushed the rating from 90% down to 89%? Furthermore, the user never explicitly knows when her own review has been factored into the overall public rating.

The decision between these two approaches, or any number of variations, will depend largely on the goals for the application and the type of data being handled. For some data types it is of utmost importance that the latest data be shown at all times – a stock price application, for example. In other cases it may be perfectly acceptable to temporarily show older downloaded data, if it allows a better user experience. This is equally true for uploaded data. In some cases it is very important to confirm to a user that their data has been successfully transmitted. For example, if a user changes their password, they need to know if the change has been made, so they can begin using the correct password. It would be inappropriate to hold that change for completion at some indeterminate future time. Likewise, if the data being transmitted is particularly important or hard to replicate (for example, a lengthy note), the user will need to know that it has been saved. In contrast, data like a movie review may not be time critical.

In the case of the *Pier 2 Peer* application, priority was given to creating an application experience that would be fast and responsive for the user, avoiding delays and interruptions wherever possible. To this end, the full remote database was replicated on the user's device and synchronised each time the application was launched. When users entered data – for example, when they rated a species (see Section 7.7.1) or recommended a fish outlet (see Section 7.7.2) – this data was sent to a transmission queue, an approach known as *save eventually*. In most cases this data would be transmitted to the server within seconds, and therefore be virtually immediately available to other application users. However, if the synchronization engine did not detect a network connection or if the upload

failed for some other reason, it would back off and try again at a later time. The user interface was not blocked, creating an impression for the user that the data had been submitted instantaneously. This was appropriate due to the nature of the data; it was not essential that the user be aware of the precise moment at which, say, their recommendation of a fish outlet had been made available to other users, and it was not critical if a user viewed a fish outlet as having been recommended by three other users, when in fact a fourth had recommended it seconds or minutes earlier.

This synchronization methodology is referred to by the term *eventually consistent*; at any given time a data point may be different on the remote server than on one or more clients (i.e., instances of an application on a device), but inconsistencies are resolved over time according to defined rules for merging. This methodology is common in applications where the data is not highly sensitive, arduous to enter, or time sensitive, and is even used in some instances where this is not the case, in order to improve responsiveness and assist with scalability.⁴²⁵

This synchronisation methodology, as applied to the *Pier 2 Peer* application, is shown diagrammatically in **Figure 16**.

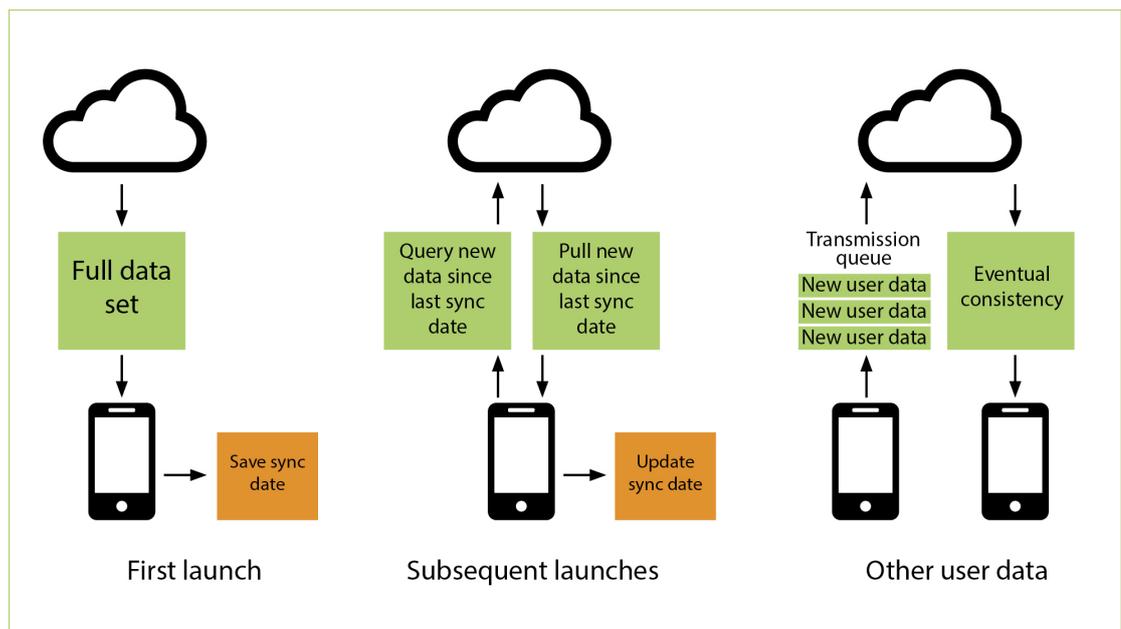


Figure 16. The data synchronisation model used in the *Pier 2 Peer* application.

7.6 Design

In application development the term “design” has a number of meanings. It can refer to the development methodology (as discussed in Section 7.4.1), to the features and interface of the application (what the application *does*, discussed in Section 7.7), or to the visual styling of an application – what it looks like. This section discusses design in the latter sense; *design* here means graphic design.

As noted in Section 7.1, replication of studies involving application or web development can be problematic. Design can be a significant confounder, as it is a critical component of successful applications, yet it is largely subjective. A particular design might be effective and appropriate for one application, yet be entirely inappropriate for another. Furthermore design trends change considerably over time – what was considered a well-designed application would likely appear dated and unfashionable just five years later, if it were not updated.

A significant change in design trends occurred during the period in which *Pier 2 Peer* was developed, with application designers and users growing to prefer *flat* interfaces and design motifs, stripped of unnecessary ornamentation such as textures and faux lighting effects. This ornamentation had been a feature of mobile application design since the beginning of the modern smartphone era, when adding three-dimensional lighting effects to buttons, icons and other interface objects was thought to enhance obviousness and usability, as users became familiar with new touch-based interfaces.

The move towards flatter interface design was a gradual one, heralded by small visual tweaks in mobile operating systems, by the work of innovative third-party designers creating increasingly distinct application interfaces, and by more dramatic system-wide overhauls, such as those made in Microsoft’s *Windows 8* operating system. One of the more significant milestones in this process was the release of the seventh major revision of Apple’s mobile operating system, *iOS 7*, in September 2013. This update represented a complete visual overhaul of the operating system, with an emphasis on simplified interfaces, flat iconography and

stark visual styling. Example screenshots from first-party Apple applications are shown in **Figure 17**.

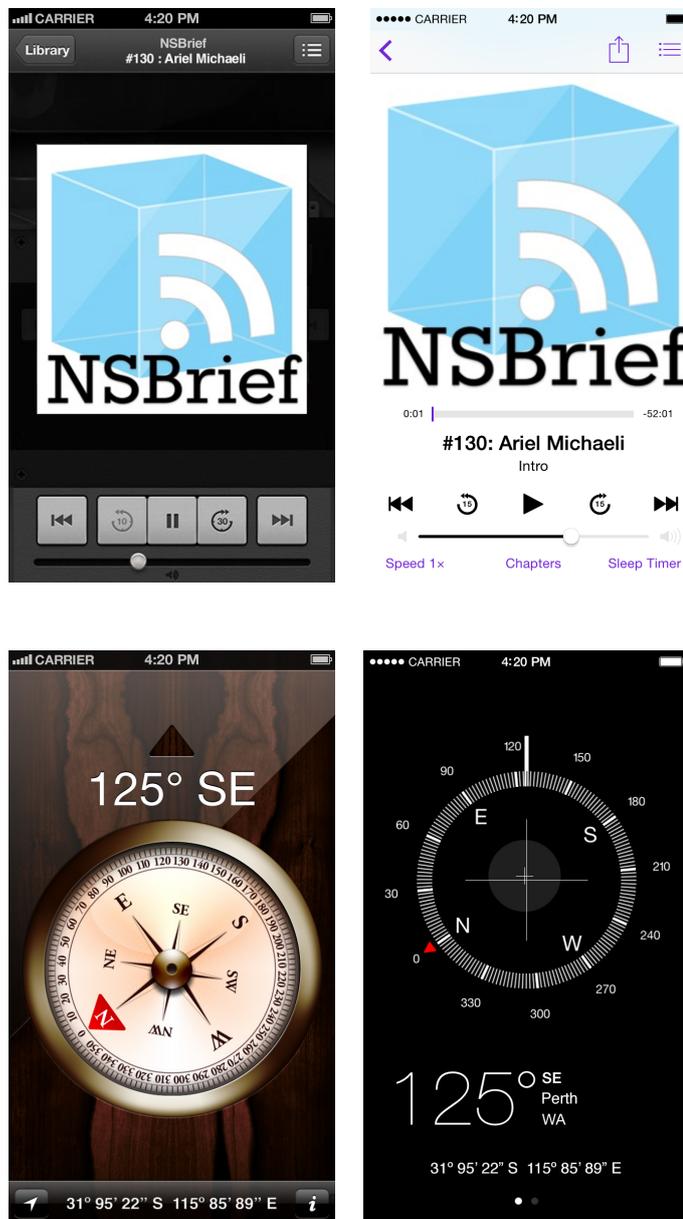


Figure 17. Screenshots from first-party iOS Applications showing common design idioms from iOS 6 (left) and flatter, less-ornamented interfaces in iOS 7+ (right).

Apple's operating system revisions are typically met with industry-leading rates of customer uptake, and iOS 7 was no exception: within three months of its release, the system was estimated to have been installed on three quarters of all active iOS devices.⁴²⁶ The revision was not without critics, however, with many users,

developers and industry analysts believing that it sacrificed usability for the sake of trendy design.^{427, 428} Criticisms notwithstanding, most third party developers were quick to adopt iOS 7 design motifs in their own applications.

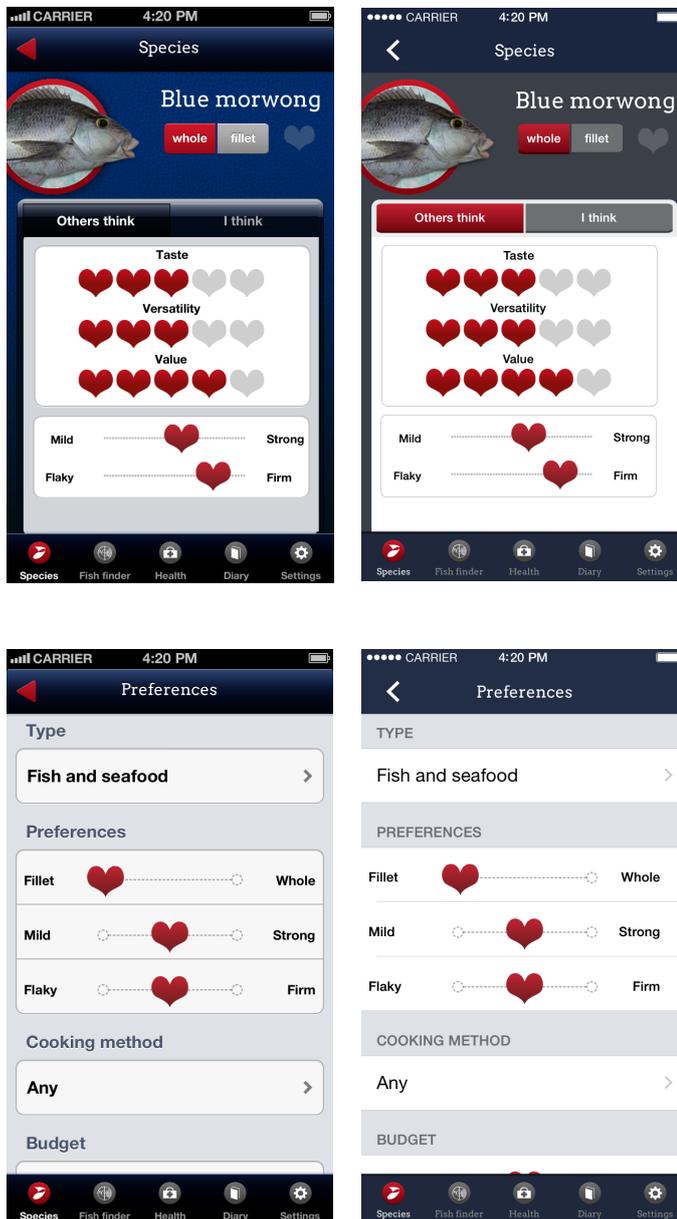
iOS 7 and its radically different design language presented a conundrum, with its arrival occurring approximately halfway through the development cycle of the experimental application. *Pier 2 Peer* had been initially designed in line with the design language of iOS 6. Should the new interface trends be adopted, bringing with them potential usability issues, or should the original design and interface be retained, at the risk of the application appearing dated and unappealing? This was not a trivial decision to make. Application designers walk a fine line between usability and visual appeal, and users have quickly come to expect a very high standard of both. In order for users to have their fish consumption behaviour influenced by their use of the application, they would need to *want* to use it, and their desire to use the application would be determined by many factors, including its content, usability and visual appeal. This was a clear message from participants in this study's focus groups, as discussed in Section 6.4.6.

A compromise was sought. The application was redesigned with flatter iconography and interface objects, but some of the more controversial aspects of the iOS 7 interface were avoided. For example, iOS 7 introduced the concept of borderless buttons. All earlier versions on the operating system used clearly demarcated buttons, with three-dimensional lighting effects such as bevelling and drop shadows. iOS 7 introduced a new "text-only" button style, with developers encouraged to use colour to designate tappable interface elements. This was possibly the most controversial of all the changes, with critics complaining it made tappable buttons difficult to distinguish from non-tappable text labels. The difference between button styles is shown in **Figure 18**.



Figure 18. Navigation bars in iOS 6 (left) and iOS 7 (right).

For *Pier 2 Peer*, most buttons retained outlines and subtle three-dimensional effects. However the application was largely stripped of unnecessary textures, glosses, gradients and other lighting effects. Examples of the changes made to the application interface are shown in **Figure 19**.



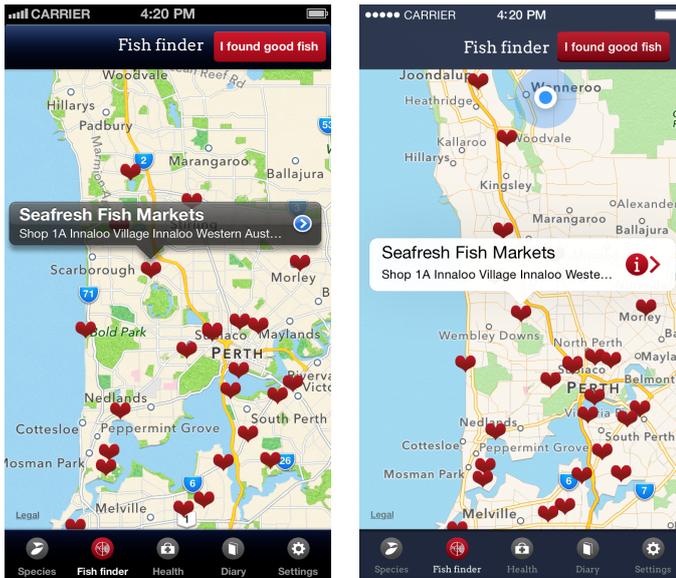


Figure 19. Screenshots and icons showing the design transition from iOS 6 (left) to iOS 7+ (right). Note the removal of textures, gloss and lighting effects, such as shadows and etching.

7.7 Functions

The experimental application comprised five sections:

1. a species guide containing both expert and crowdsourced content
2. a crowdsourced guide to outlets, such as fishmongers, markets and restaurants, selling good quality fish
3. a guide to the health benefits of fish consumption
4. a tool for recording fish consumption and providing health feedback to the user
5. a section in which users could manage their information.

7.7.1 Species guide

One barrier to fish consumption noted in the literature is the lack of confidence selecting appropriate species.^{80, 83, 110} This was also apparent from the experiences reported by focus group participants during the formative phase of this study (see Section 6.3.1.1). The *Pier 2 Peer* species guide was intended to address this knowledge gap by facilitating the transfer of knowledge from people who were confident selecting and cooking fish, to those who needed additional help. Peer to peer knowledge transfer (and therein lies the pun of the application's name) can be an effective means of disseminating information.⁴²⁹⁻⁴³¹ The term *crowdsourcing* refers to a process whereby "an organization communicates a problem or challenge to participants in an online community [and] members of this community then provide solutions to the problem, which the crowdsourcing organization processes and consolidates into a unified product."⁴²⁹ The ideas, opinions or experiences of a group of people are solicited, organised and analysed, and may be provided back to the group for collective use.

7.7.1.1 Species detail view

The main screen, or "detail view", of the species guide tab was a dual-purpose interface element that allowed users to either view crowdsourced information

about a chosen species (by tapping the “Others think” button) or to make their own contribution to this information (by tapping the “I think” button). These screens are shown in **Figure 20**. When making a contribution, users could enter any or all of the following information on a per species basis (users were not required to complete all fields):

- taste, versatility and value (each ranked from 0 – 5, in increments of 0.5)
- mildness (ranked on a continuous slider from “mild” to “strong”)
- firmness (ranked on a continuous slider from “flaky” to “firm”)
- good cooking methods (one or more of bake, deep fry, grill/BBQ, poach, raw, shallow fry, smoke and steam)
- a comment.

Entries were automatically uploaded to the remote server and used to update the data stored against each species. For example, if a user provided a “versatility” rating for Atlantic salmon, this rating would be averaged with all other users’ ratings for that species. User comments were moderated for inappropriate content, requiring manual approval by the administrator before appearing for other users. During the study no submitted comments were deemed inappropriate.

These averaged ratings were displayed when users tapped the “Others think” button. In this way, users could see how other users had rated various species of interest. Approved user comments were displayed in random order, in a horizontal slider.

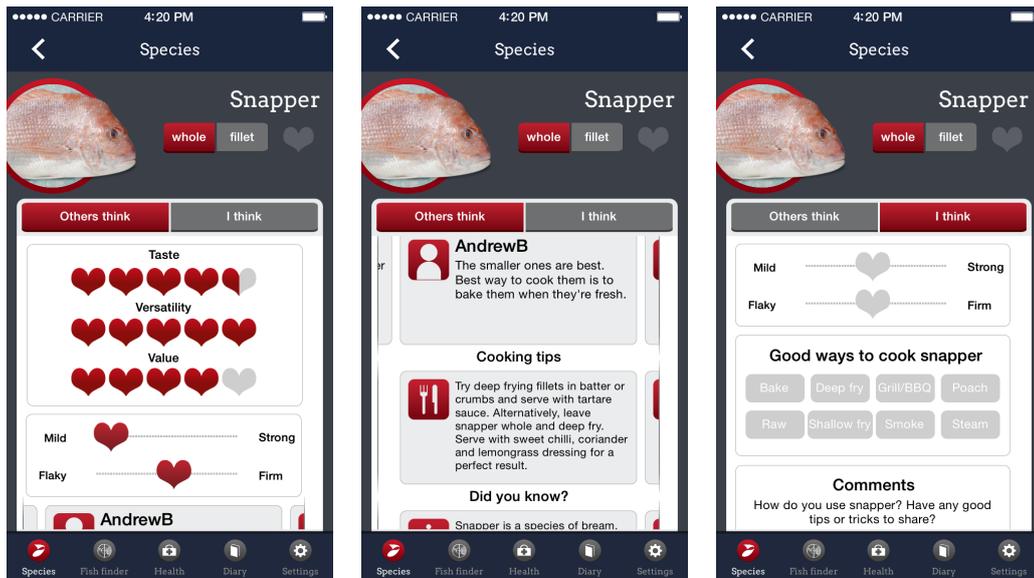


Figure 20. Species guide “Others think” section (for viewing community ratings and comments) and “I think” section (for submitting ratings and comments).

Any application that relies on crowdsourced information has an immediate problem in engaging its first users – that information does not yet exist. It was considered important for study participants to experience the application as it would appear once established, with at least some user-generated content. For the purposes of the study, a number of dummy user accounts were created, and species comments were added from these accounts. In order to provide a realistic approximation of a real community, these comments included both positive and negative content. Dummy comments were sourced from a range of individuals with different levels of experience and confidence with fish; examples of this dummy content are shown in **Figure 21**.

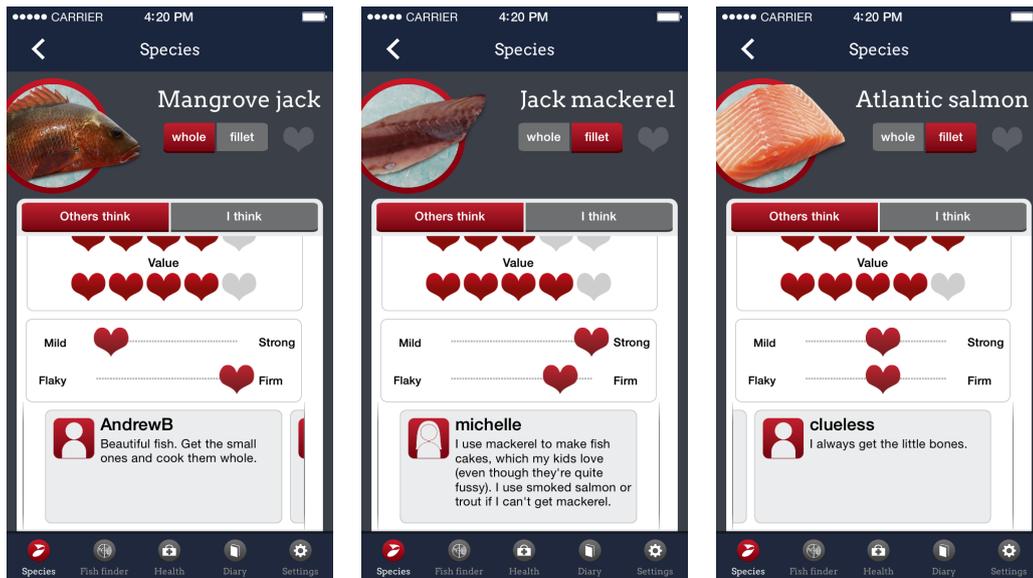


Figure 21. Species guide dummy comments.

In addition to comments, this screen also showed a selection of cooking tips and species facts, including alternative names, similar species and seasonality. Content was sourced from the Australian Seafood Users' Manual⁴²² and a number of Australian cooking books.⁴³²⁻⁴³⁴

This main screen also allowed users to mark a species as a favourite and to view images of the selected species (whole and, where appropriate, as a fillet, steak or cutlet). Images were sourced from the Atlas of Living Australia,⁴³⁵ which includes images from the CSIRO Australian National Fish Collection, made available under a Creative Commons license.

7.7.1.2 Species guide navigation

The species guide used a navigation controller structure. This is a common iOS application design pattern, where screens of content (known as views) are "pushed" onto a stack, and users can move backwards and forwards through the stack using navigation buttons in a toolbar at the top of the screen. Users began by choosing from a list of categories – all species, all fish, all seafood, or favourites

– and were then shown a second view containing a list of species filtered according to their selection. A search bar enabled the user to find specific species on this list by name. Selecting a species from this list took the user to the detail view described above. The navigation structure is illustrated in **Figure 22**.

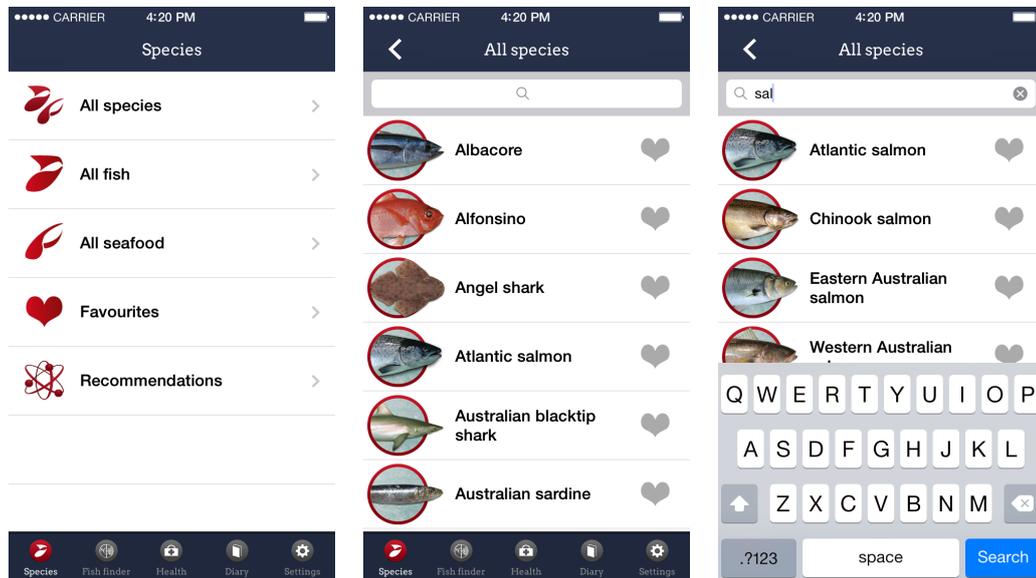


Figure 22. The species guide navigation structure: category view (left), list view (centre) and search feature (right).

7.7.1.3 Species recommendations

An additional layer of filtering was provided via a “recommendations” feature. The user could define a set of preferences, and then be shown a filtered list of species, ordered by how closely they matched those preferences (according to the accumulated crowdsourced data). Preference options were:

- species type (fish, seafood or both)
- fillet or whole
- mildness
- firmness
- cooking method
- budget (from “value” to “premium”).

A toggle also allowed the user to select whether they were “feeling adventurous” – whether the search should include all species, or only those commonly available. These preference options are illustrated in **Figure 23**.

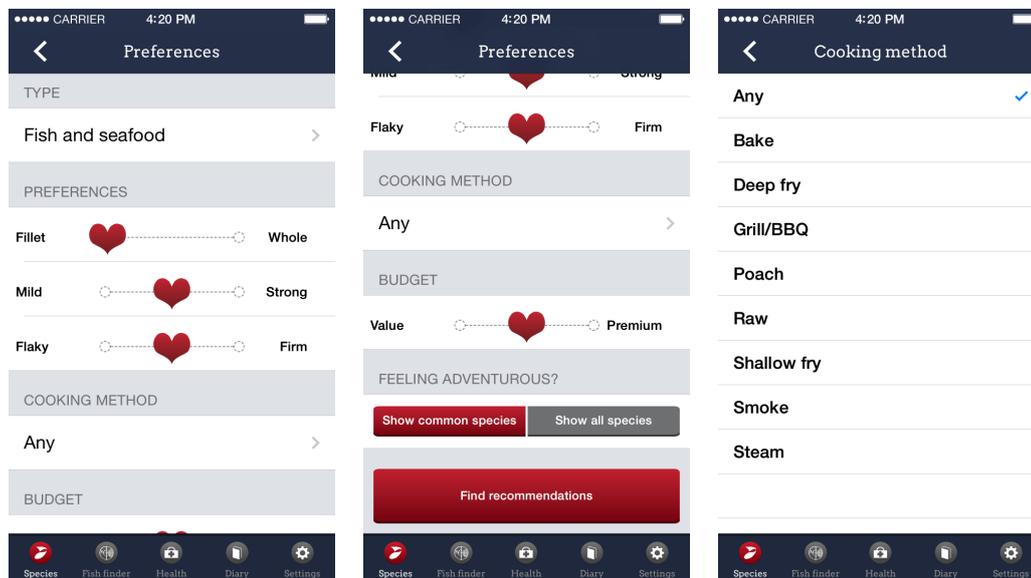


Figure 23. Configurable options for the species recommendations feature.

The filtering algorithm required a fine balance between showing species that were a good match for the preferences entered, and showing enough species to be useful. Overly strict preference matching might result in the user only being shown a small number of species, none of which might be available for them to purchase. Overly permissive matching would show a much larger list of candidates, many of which might not be especially suitable for what the user had in mind.

The matching algorithm worked by successively iterating over the full list of species, for each of the defined parameters. For binary parameters such as species type, where a given species could either be fish or seafood, and therefore could either be correct or not, species were filtered either in or out. For continuous parameters such as mildness, a score was assigned to each species, based on how close the species' community-aggregated score was to the user's defined

parameter. These scores were added together and all remaining species were then ordered by score (the lower the score, the closer the match to the user's preferences).

An early prototype of this feature set two cut-off scores. Species with a very low aggregate score were deemed "close matches"; those with a slightly higher score were deemed "reasonable matches". These were then shown in a second screen, in two sections. However, feedback from early beta testers indicated that certain combinations of preferences produced few close matches, and the user was given no feedback as to how close each match was to their preferences.

In response to this feedback an alternative interface was designed, which ordered species by score, then presented them in a table with a set of incremental bars (similar to a cellular signal indicator) to indicate the closeness of the match. This put the decision in the hands of the user: they could scroll down the list, find available species, and make their own judgment about how close was close enough. Both iterations of this feature are shown in **Figure 24**.

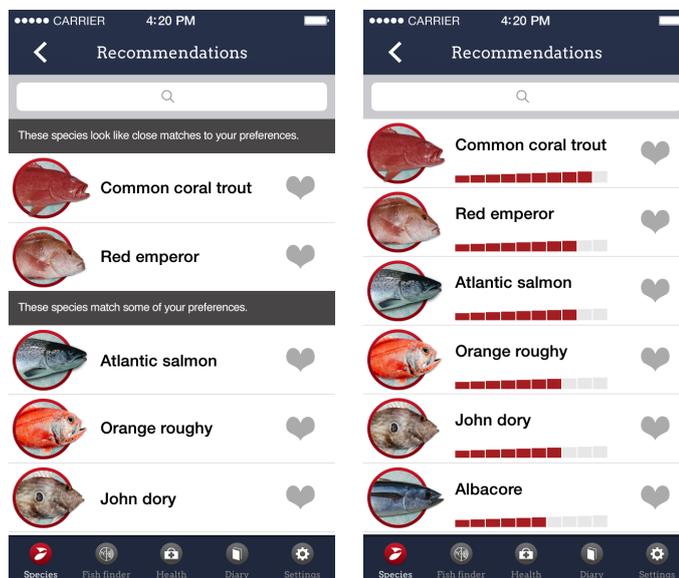


Figure 24. Species recommendation results view: first iteration (left) and revised layout (right).

7.7.2 Fish finder

Availability and quality of fish was another barrier to consumption reported in the literature^{65, 80, 104} and echoed by focus group participants (see Section 6.4.4). Some participants reported that the fish sold in the supermarkets where they did their grocery shopping was of poor quality, but that specialty outlets were unsuitable for them for a number of reasons. They were either too far away, were inconvenient in other ways (for example, they did not sell fish in formats that suited them), or they simply did not know of the location of such outlets. Some participants reported that, even in such specialty outlets, the product quality was mixed.

Pier 2 Peer sought to provide assistance for individuals who found it difficult to find high quality fish. As with the species guide, the application used crowdsourced data – in this case, recommendations of outlets where users had found good quality fish. One of the features of the Web 2.0 paradigm (see Section 3.5.1) is the prominence of community ratings and reviews which are built into many web services including those for shopping (e.g. Amazon and eBay) and software delivery (e.g. the App Store and Google Play). Indeed, entire businesses have been built around providing platforms for such community review, including *TripAdvisor*, *Urban Spoon* and *Air BnB*, which have very quickly grown in importance in their respective fields of travel, dining and accommodation.

7.7.2.1 Fish finder structure

The “Fish finder” tab of the experimental application served two purposes: to allow users to view the details of outlets that had been recommended by other users, and to make their own recommendations. The main screen consisted of a map view, powered by Apple’s *MapKit* API. This view showed markers (known as map annotations) showing the location of outlets that had been recommended by other users. Tapping an annotation showed a callout containing the name and address of the outlet. Tapping the action button at the right of the callout

presented a detail view containing full information about the selected outlet, including:

- full name
- full address
- a satellite map showing the location of the outlet, with nearby street names and landmarks overlaid
- a 'phone' button which, when tapped, initiated a phone call to the outlet
- a "visit website" button which, when tapped, took the user to the outlet's website. This button was only shown when the outlet had a public website.

This view also showed the number of users who had recommended the displayed outlet, and allowed users to recommend it themselves.

The fish finder tab also contained a mechanism for users to submit new recommendations - outlets that had not previously been recommended by other users. Users accessed this feature by tapping a button titled "I found good fish", which presented a view for inputting information about the outlet. Users were required to enter the name of the outlet and to either manually enter the outlet's address, or tap a button titled "I'm there now". In the later case, *Pier 2 Peer* accessed the user's location using their device's GPS sensor and used this as the outlet location.

Screenshots of the Fish Finder tab are shown in **Figure 25**.

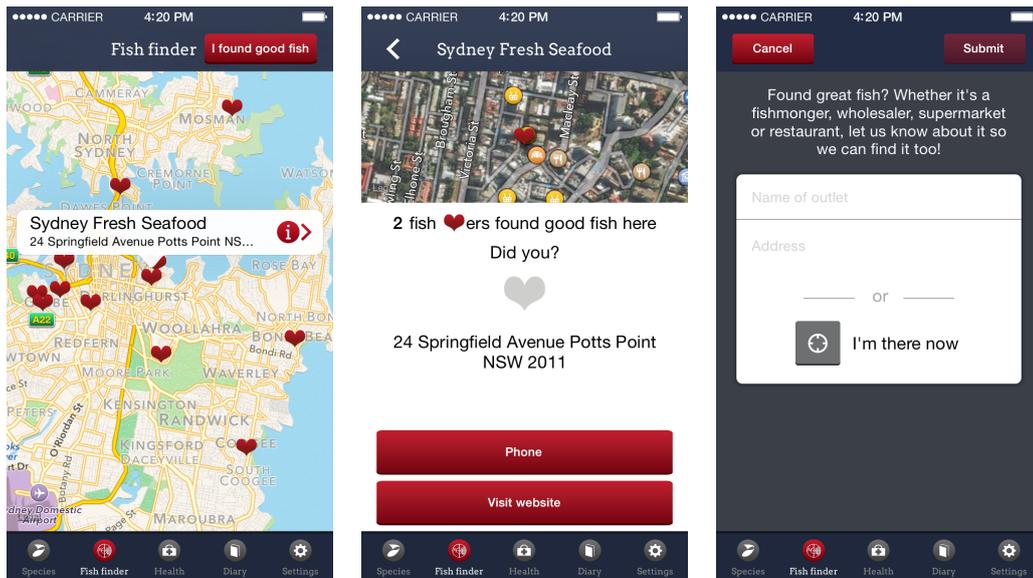


Figure 25. Fish finder tab: map view (left), outlet detail view (centre) and submission view (right).

In a production application (that is, one that is released for public use), a function like this would usually be fully automated. A user would submit data about an outlet, then the server would validate the name and location by comparing it with information with a database of places, and make the new outlet immediately available for other users. This automation requires access to large, regularly maintained database of places with a suitable API for mobile applications to access. One such database is *Google Places*, an API which can be used to provide retail place names and contact information for a given geolocation, or vice versa.

In this case, it was considered that this approach would add unnecessary complication to the application, both in terms of development, and burden on the user. Use of the *Google Places* API would require further validation steps on the part of the user (“Did you mean this place...?”). In order to reduce complexity, improve accuracy of locations, and avoid possible duplication of outlets, user submissions during the study were handled manually. Upon receiving a new outlet submission, the administrator conducted a search for the outlet by the provided name, obtained accurate geolocation and contact information, checked

that the outlet wasn't already in the application database, and then manually entered it.

As with species ratings, it was considered important for study participants to use the application in broadly realistic circumstances, where it already contained recommended outlets. To simulate this, outlets in major Australian cities were added on the basis of positive reviews from the *Yelp* local business review service.⁴³⁶

7.7.3 Health

The literature, like the formative research conducted in this study, is mixed about the potential for health information to impact on fish consumption. As noted in Section 2.2.6, most individuals are already aware of the healthful properties of fish, even if they are not aware of specific health benefits, or of optimal levels of consumption. Some researchers believe that a focus on the health benefits of fish consumption is not effective in increasing consumption – that it is more productive to focus on hedonic aspects such as quality and taste, and to improve people's experiences at the time of purchase and consumption.^{68, 85, 100} As Brunso et al. piquantly put it, "Taste of food has always been of high importance to most consumers – food is a matter of pleasure, and few people eat things they do not like the taste of."⁷¹ However, others have found evidence of a positive relationship between health involvement and seafood consumption.⁸³

Participants in the focus group component of this study appeared to have mixed thoughts on the subject of fish consumption and health (see Section 6.3.1.3). This exploratory trial provided an opportunity to examine these ideas. Would users spend time reading about the health benefits of fish consumption? If so, would this have an impact on their consumption?

The third tab in the *Pier 2 Peer* application contained seven articles about the health benefits of fish consumption. These articles were:

- **The super food:** a general article about the nutrients found in fish and seafood
- **Omega-3s:** an article about the benefits of omega-3 consumption, recommended intake, and a comparison of marine, whole-food sourced omega-3 and those from supplements or fortified food
- **Arthritis**
- **Heart health:** an article referencing cardiovascular disease, coronary mortality and blood pressure
- **Diabetes**
- **Cancer**
- **The best start:** an article about health benefits for expecting mothers and their babies, including a mention of contaminants and safe eating guidelines from Food Standards Australia New Zealand⁶⁴

These articles were based on research conducted by the Centre of Excellence for Science, Seafood and Health, and specifically on a number of consumer resources produced by that organisation, including the “Seafood and your health” series⁴³⁷ and commercial point-of-sale fliers.⁴³⁸ The articles were written in a brief (100-250 words), conversational style.

During the focus groups, it was clear that people wanted to know where this kind of information had been sourced, in order to judge its value. In line with this feedback each article carried the following byline: “Health information is provided by the Centre of Excellence for Science, Seafood and Health Curtin University, Western Australia”.

Screenshots from the health tab are shown in **Figure 26**. The full articles are reproduced in Appendix 3.

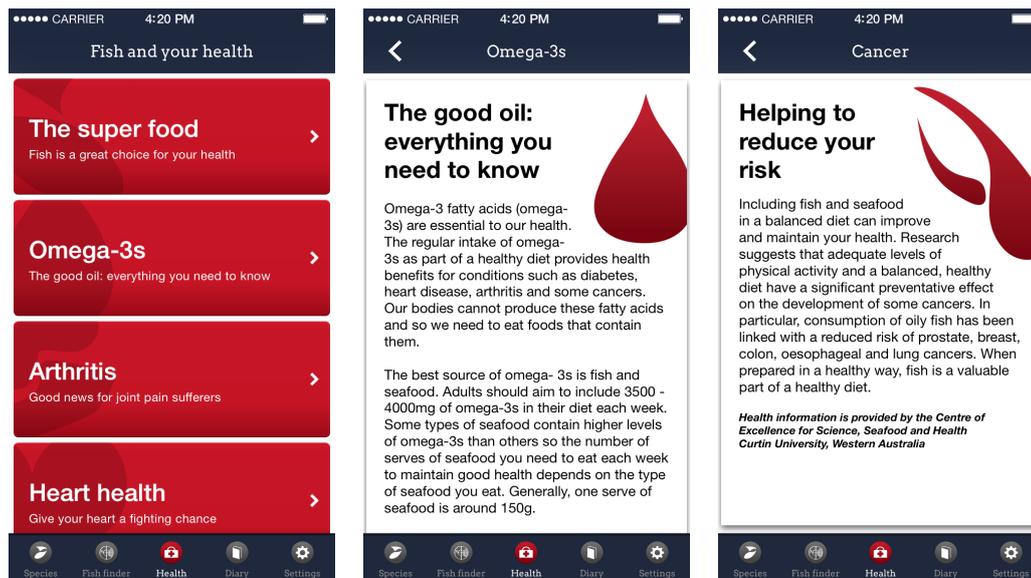


Figure 26. The Health tab list view (left) and detail views (centre and right).

It is acknowledged that the health section was less fully developed, and less interactive, than the application's other sections. Information was provided in a traditional top-down manner, by providing static articles. It may have been possible to develop a more innovative means of delivering health information, perhaps including some form of user interaction. Any application soliciting users' opinions or health experiences requires cautious navigation of the line between providing reliable, evidence-based information, and providing insight into the experiences of real people. On the basis of focus group feedback, the *Pier 2 Peer* application was limited to static, evidence-based health information, leaving crowdsourcing for species and outlet recommendations, areas in which people indicated they were more comfortable receiving advice from other consumers.

7.7.4 Diary

The fourth section of the experimental application enabled users to keep a log of the fish they had eaten, and receive feedback on their omega-3 consumption. This tool was also the primary data collection mechanism, with information uploaded automatically to the remote server. Users were asked to make an entry in this electronic diary each time they ate fish or seafood. The data fields were:

- the date the meal was eaten
- the species (chosen from a list including the 208 species in the database, plus nine other generic categories, including canned tuna, fish cakes and takeaway battered fish (see Appendix 2)
- the cooking method, chosen from a list (bake, burger, BBQ, deep fry, grill, pan fry, pie, poach, sandwich, steam, stir fry or other)
- the meal (either breakfast, lunch, dinner or snack)
- the estimated quantity, in grams.

Users were also able to add a photo of the meal, using their device's camera. This was for the purpose of data validation and encouraging contemporaneous data entry, as described in Section 8.3.5.

Meals were displayed in a table in reverse chronological order. Users could tap on an entry to edit or delete it; however, on first use of this feature, a message was shown asking users to only do this in the event of making an incorrect entry. Screens from the diary tab are shown in **Figure 27**.

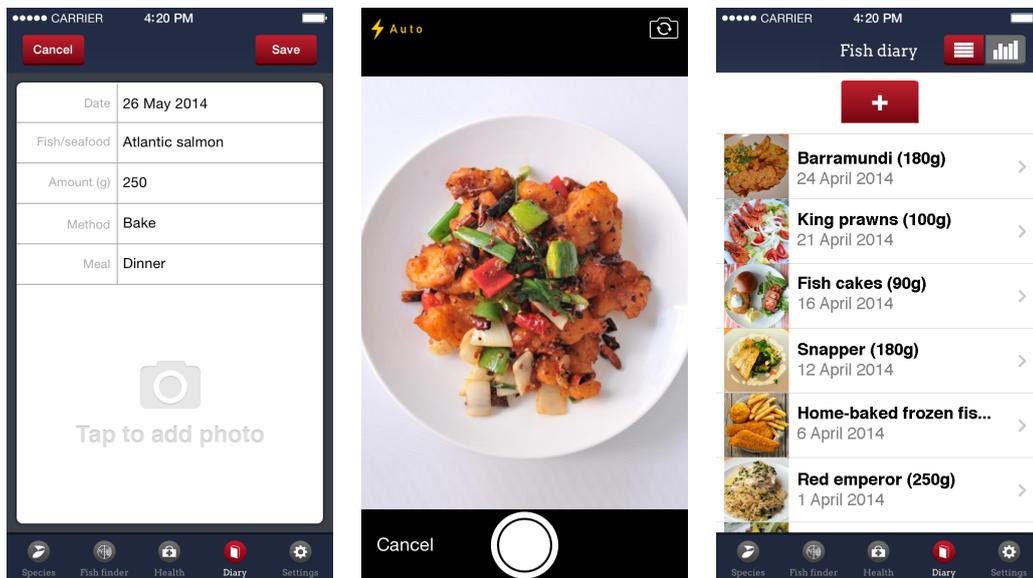


Figure 27. Diary tab: meal entry view (left), camera input (centre) and list view (right).

Users could also access a view providing feedback on their consumption over time. They could toggle between viewing the number of serves consumed per week and the total omega-3s obtained from their fish and seafood consumption. This latter view also displayed the recommended consumption level, based on their gender, and their average consumption level during their use of the application. These feedback views are illustrated in **Figure 28**.



Figure 28. Diary tab feedback: weekly serves (left) and omega-3 from fish consumption (right).

Different information sources present varying omega-3 values for specific fish and seafood species. This is partially due to the fact that many variables play a role in observed levels, including the provenance of the fish (e.g. wild caught or farmed), the part of the fish examined, whether the product was cooked or raw when analysed and, if cooked, by what method.⁴³⁵ For consistency, the values used in the application were taken from two volumes of an authoritative CSIRO publication on the oil content and composition of Australian species.^{439, 440} This source was chosen due to the rigorousness of its methodology and the broad coverage of species that it offered. Where values for specific species were unavailable, values were averaged from similar species.

Omega-3 values were stored on the remote server for each species, and synchronised with the application on launch along with other species data. It is important to note that omega-3 feedback provided to the user was approximate – it did not take into account the cooking method employed by the user, as this degree of detailed data (oil breakdowns, by cooking method) is only available for a small proportion of the species included in the application. Furthermore, this feedback only took into account the omega-3 fatty acids contained in the reported fish consumption, and not from any other dietary source or supplements. These limitations were explained to the user on first use of the application (see Section 0).

7.7.5 Settings

Although it was the fifth and final tab of the *Pier 2 Peer* application, content from the settings tab was the first point of interaction for new users – this was where they first set up a user account.

Most socially connected mobile applications require some form of user authentication. User accounts are used to collect and display information about users, for example in a profile, to provide proper access control to user-provided content (for example, to allow a user to edit or delete a comment they have added, but prevent others from doing so). Accounts also allow effective control and moderation of social networks. Some mobile applications make use of existing social networking authentication – for example, both Facebook and Twitter provide an API that allows third party applications to authenticate users with those services' user profiles. Other applications create their own custom user account system, often using email addresses as a unique identifier.

A custom system was preferred in this case. This approach provided greater control over the profile, and avoided adding another requirement for study participants – that they have a Facebook or Twitter account. The system was based on the user account model of *Parse*, the web service used to provide the application backend (described in Section 7.5). *Parse* handles the storing of user

data and other complex but necessary functions, including encrypted password handling and password resets, although applications using this system must still decide on what user data to collect, and implement their own interface for entering this data.

Pier 2 Peer collected more user information than would be typical for a mobile application of this type, due to research requirements. The data fields were:

- username (a unique identifier, chosen by the user)
- password (encrypted and stored securely by *Parse*, and inaccessible by the application administrator)
- first name
- last name
- email address
- gender
- birthday
- Australian state or territory.

Users could also select one of three avatar images to represent themselves in submitted comments. An early iteration of the application allowed users to upload a photograph. However early beta feedback raised the question of whether users would be comfortable using real photos in a social service they were participating in for research purposes, rather than having personally chosen to join. Login and sign-up views are shown in **Figure 29**.

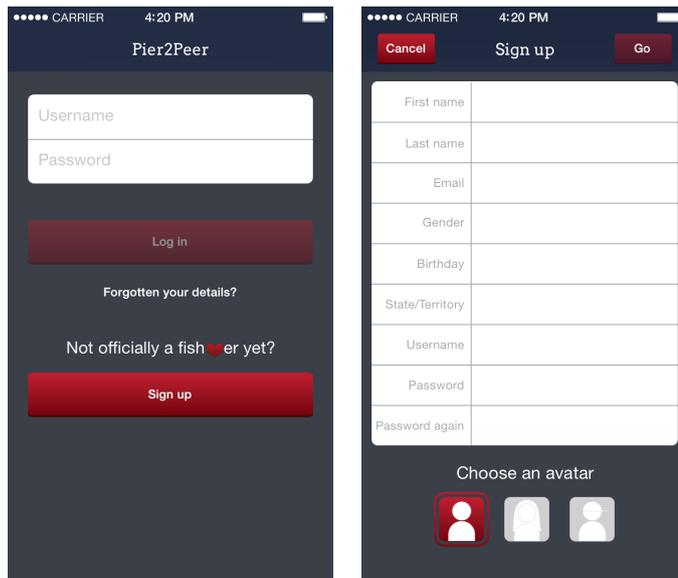


Figure 29. Log in view (left) and sign-up view (right).

In addition to user information management, the settings section of the experimental application also contained:

- a link enabling the user to communicate with the researcher via email
- a copy of the background information and consent form shown to the user on first launch of the application
- a link with which users could send all data stored in the application, to the researcher. This was added as a precaution; the application was designed to automatically upload data to the remote server throughout the study, but participants were asked to tap this button upon study completion, to enable this automatically collected data to be compared with a complete data set.

Screenshots from the Settings tab are shown in **Figure 30**. The full informed consent flow is reproduced in Appendix 4.

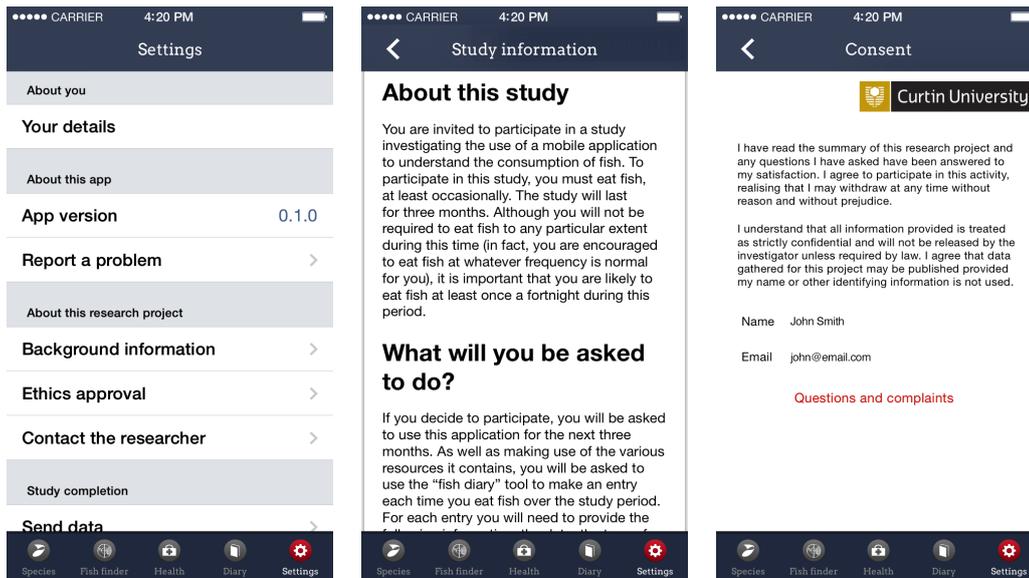


Figure 30. Settings tab list view (left) and detail views (centre and right).

It is important to note that the extent of data collection carried out in the experimental application is only reasonable and ethical in a research situation in which informed consent was obtained from participants. While many mobile applications collect aggregated, depersonalised analytics information, this application went well beyond this to enable detailed evaluation. While these data collection functions would likely be retained in a larger scale randomised controlled trial, if the application were to be deployed to public users, it would be necessary to scale back or remove these functions. The same applies to the personal information collected from users at the time of signup; it would not be appropriate to collect personal information not directly necessary for the use of the application.

7.8 Onboarding

The term *onboarding* refers to prompts or tutorials shown to a user to assist them in using a new application or discovering less-obvious features. These prompts are either shown all together, on first launch, or progressively as the user moves through the application.

In *Pier 2 Peer*, onboarding took place on the first occasion that users accessed the species, fish finder and diary tabs. The health tab was considered self-explanatory. On first launch, users were shown a series of screens containing screenshots and explanations of various key features for that tab. Examples of onboarding screens are shown in **Figure 31**.

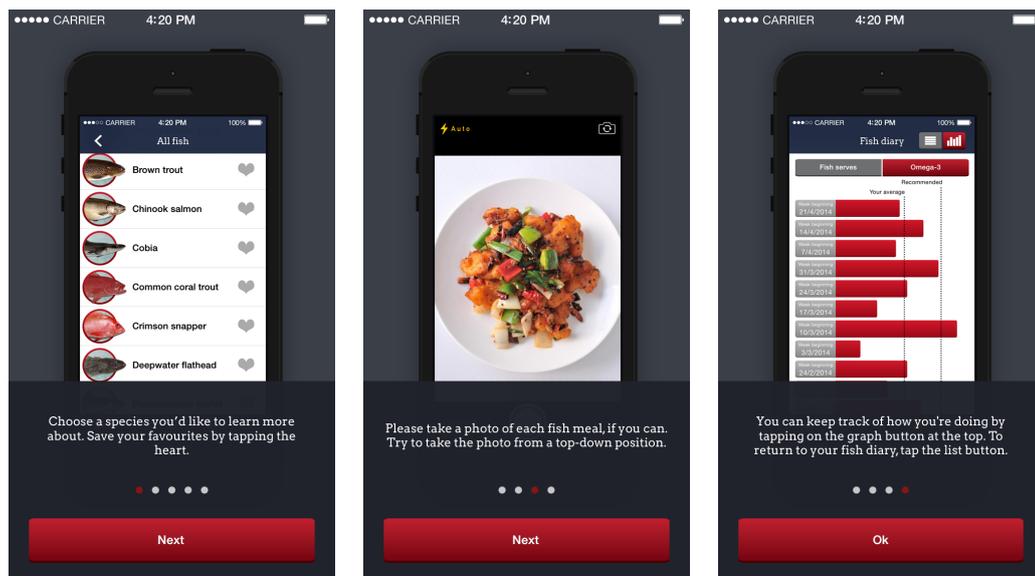


Figure 31. Onboarding (instructional) screens.

7.9 Summary

The experimental application was built carefully and methodically. It employed best-practice development methodologies, including the use of up-to-date APIs, a robust backend server, and modern visual design. Each of the tools in the application went through a number of rounds of development, testing and refinement, drawing on the feedback of experienced application developers.

As detailed in Sections 8.4 - 8.5, the application performed well during the trial evaluation. No errors or significant usability issues were reported, although some interface decisions were queried, most commonly by users of the control group application (see Section 8.5.6.3). Most importantly, the remote database and custom analytics engine performed as planned, delivering all the data needed to both evaluate the application's impact on a macro level, and to explore associations between consumption and various patterns of use and user engagement.

8

Exploratory trial

8.0 Exploratory trial

8.1 Introduction

As described in Section 4.5.3 an exploratory trial is the third phase of a complex intervention, as defined by the MRC.³⁹⁹ It is guided by theoretical considerations identified in phase one (described in Chapter 5) and by the formative modelling carried out in phase two (described in Chapter 6).

According to the MRC, an exploratory trial endeavours to “describe the constant and variable components of the replicable intervention and a feasible protocol for comparing the intervention with an appropriate alternative.”³⁹⁹ In simple terms, the trial is carried out to inform and guide a definitive randomized controlled trial.

Further guidance for the development of these trials, variously called pilot or feasibility studies, is offered from a number of other sources. In 2009 Bowen, Kreuter et al.⁴⁴¹ undertook a review of feasibility studies funded by the US National Cancer Institute. This was conducted to provide guidance for future funding applicants and to fill what was perceived as a gap in the literature in terms of standards for designing and evaluating such feasibility studies. The resulting report identified general areas of focus commonly addressed by feasibility studies, and a number of these were considered applicable to the present study. These were:

1. *Acceptability*. Feasibility studies sought to understand how research participants reacted to the intervention, and how likely they were to accept participation.
2. *Demand*. Related to acceptability, demand for an intervention was often estimated by examining patterns of use either for the intervention as a whole, or of selected parts of it.

3. *Implementation.* Researchers typically try to assess whether the proposed intervention can practically be implemented, or whether changes might need to be made for a full trial. The ease with which participants can be recruited and retained is usually examined.
4. *Limited efficacy testing.* Feasibility studies often attempted to test the effect of an intervention, but did so in a necessarily limited way. For example, convenience samples were often used, with shorter follow-up periods, and with limited statistical power.

8.2 Objectives

Based on this guidance, the following objectives were defined for this exploratory trial:

1. To estimate an effect size for this intervention, to assist with power and sample calculations for a future RCT.
2. To determine whether an intervention of this kind could be effectively delivered. In other words, if users found the tool to be user-friendly, of enough value and not overly burdensome, to make use of it for the duration of the intervention period. In terms of a later RCT, this information would serve to provide confidence that the intervention could be implemented on a larger scale, without unacceptable rates of attrition.
3. To collect data on usage of the intervention app, and to examine these data for associations between different usage patterns and increased fish consumption. These data would be of use in refining the intervention tool and possibly modifying or eliminating parts of the tool that did not appear to be effective in effecting behaviour.

8.2.1 Hypotheses

The following hypotheses were proposed:

H1. Exposure to the full experimental application, and the underlying virtual community, will be associated with increased fish consumption, measured in serves per week.

H2. There will be a positive association between increased consumption and time spent using the experimental application, measured in minutes.

8.3 Methodology

The methodology for this trial is presented in several sections. They are:

- 8.3.1 General overview of trial design
- 8.3.2 Sample size
- 8.3.3 Recruitment, baseline questionnaire, and random assignment to groups
- 8.3.4 Distribution of the experimental application
- 8.3.5 Data collection
- 8.3.6 Communication and participant feedback

8.3.1 General overview of trial design

Although it may have been possible to estimate the impact of the intervention in increasing fish consumption by deploying it to a single group and recording consumption trends over time, a controlled trial offered the best opportunity to estimate the size of the intervention effect. It also provided the opportunity to overcome the potential for observer effect.⁴⁴² Participants would be aware that they were engaged in a study of fish consumption. As shown in Section 2.2.6 most people are aware of at least some health benefits of fish consumption, and many want to increase their consumption. It was quite reasonable to expect that many participants would increase their consumption throughout the course of the study, and a single-group study design may have presented difficulties in attributing this effect to the intervention itself. To gain a better understanding of the likely impact of the intervention, it was important to compare the intervention group with a control group subjected to similar influences.³⁹⁹

Participants were recruited and randomly assigned to one of two groups. Recruitment and random assignment is discussed in detail in Section 8.3.3. Participants were then given one of two variants of the experimental application.

1. The intervention group received the full version of the experimental application. This included the species guide, fish outlet finder, health information, and diary tool for recording fish consumption.
2. The control group received a reduced version of the application, which only allowed the recording of fish consumption.

The control group version of the application contained only the diary and settings tabs from the primary application. The diary tab was modified, removing the feedback functionality to leave only the facility to add and edit fish meals. In this way, control group participants recorded their consumption during the study using the same mechanism as the experimental group, but received no support or feedback about their consumption.

All participants were asked to use the application for 12 weeks, and to make an entry in the diary each time they ate fish. These data were analysed to determine any significant differences in fish consumption between the intervention and control groups.

In addition to fish consumption data, usage data collected by the analytics engine in the intervention application were examined. These data were compared with consumption data, looking for associations between usage patterns and consumption trends.

After 12 weeks an exit questionnaire was administered to all participants. This sought qualitative data from participants, including their own assessment of changes in their knowledge, confidence and consumption patterns, and feedback both on the experimental application, and on the experience of participating in the trial.

8.3.2 Sample size

Appropriate sample sizes for pilot or feasibility studies can be difficult to determine, considering that standard power calculations are not usually possible.⁴⁴³ However it is important that studies seeking to estimate an effect size for use in later studies involve sufficient participants to make such estimations meaningful. Arain, Campbell et al. stated:

Feasibility studies for randomised controlled trials may not themselves be randomised... If a feasibility study is a small randomised controlled trial, it need not have a primary outcome and the usual sort of power calculation is not normally undertaken. Instead the sample size should be adequate to estimate the critical parameters (e.g. recruitment rate) to the necessary degree of precision.⁴⁴⁴

Bowen et al.⁴⁴¹ also suggested the use of small-scale RCT pilot studies (which they called Phase I or II clinical trials) to estimate the effect size, power and sample size for a future Phase III trial. Neither paper gave definitive guides for calculation of pilot study samples; rather, they indicated that the size be determined on a case-by-case basis to meet the objectives of the study.

In all such calculations it is important to consider not just statistical significance, but clinical significance. In other words, in the field of public health, what is the size of effect that might be expected to have a meaningful health impact, either in terms of disease prevention or improved quality of life?

For the purpose of this study it was determined that a clinically significant increase in fish consumption would be in the order of one additional serve per week; in lower-level consumers this could reflect a change from irregular consumption (less than 0.5 serves per week) to regular weekly consumption, or in moderate consumers (about one serve per week) approaching the recommended two to three serves per week. As shown in Section 2.1 many high-quality cohort

studies have found evidence of potential health benefits for those who consume between one and three serves of fish per week.

A sample of sufficient size was required to demonstrate this moderate effect size within sufficiently narrow confidence intervals. Guidance was taken from Hertzgog's paper *Considerations in determining sample size for pilot studies*,⁴⁴³ in which the author demonstrated the effect of various pilot study sample sizes on effect size confidence intervals. She argued that while pilot samples as small as 10 - 20 per group can be sufficient for determining usability and reliability, samples in the order of 30 - 40 per group are required to detect moderate effect sizes within tight confidence intervals.

With these considerations in mind, a sample size of 100 participants was chosen, comprising 50 participants for each of the groups (intervention and control). Although 30-40 may have been sufficient for the objectives of the trial, a larger sample was a conservative decision that allowed room for attrition.

8.3.3 Recruitment, baseline questionnaire, and random assignment to groups

8.3.3.1 Recruitment and selection criteria

A convenience sample was recruited comprising Australian residents aged 18 years and over. They were required to own a smartphone or tablet computer running the iOS operating system (specifically, iPhone, iPad and iPod Touch), this being the platform for which the experimental application was built. An AU\$25 iTunes voucher was offered as incentive for participation. This incentive was chosen as one that related to the intervention, which might be attractive to participants, and which could be easily provided – these vouchers can be purchased online and provided digitally as a redeemable code, avoiding the need for secure postage.

Participants were required to be at least occasional fish consumers. It was considered unlikely that this intervention would have an impact on those who never ate fish (for example, vegetarians or those with strong aversions or allergies). Potential volunteers were asked if they had eaten fish at least once in the previous three months. Individuals were excluded if they had not done so, on the grounds that in most cases this would indicate that the individual never ate fish, rarely ate it, or in some cases may have had strong reasons for not eating it. A similar criterion has been used in at least one other study seeking only potential fish consumers.¹⁰⁹

Facebook advertisements were purchased and displayed to Australian users aged 18 years and over, who used iOS devices. Advertisements were displayed both as sponsored news feed items (for desktop and mobile users) and as right-column advertisements for desktop users. An example of the advertisements is shown in **Figure 32**.

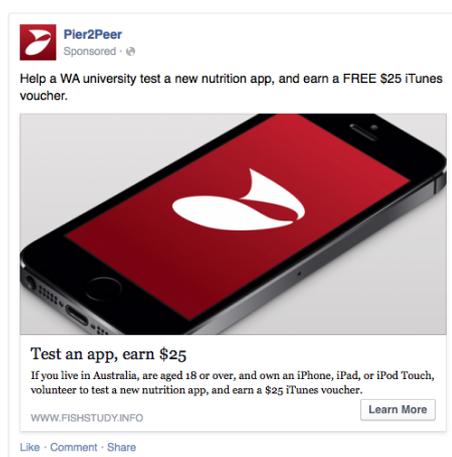


Figure 32. Targeted Facebook advertisement.

In all, these advertisements were shown to 15 350 users, resulting in 152 clicks or taps through to the information website. This represented a click-through rate of 0.99%. Although this may seem like a low return, it is in line with the average click-through rate for Facebook advertisements in Australia.⁴⁴⁵

In addition to these Australia-wide advertisements, university staff and students were targeted via Curtin University's social media channels, including Facebook, Twitter and Yammer, and via non-social channels including staff and student Internet noticeboards.

Recruitment was most successful in Western Australia, probably due to the more direct nature of the recruitment channels used in that state. It is also probable that the university staff and students targeted via these channels, being more familiar with the nature of research participation, were more willing to volunteer than the general population targeted by general Facebook advertising. Of the full sample, 64% (n = 64) were from Western Australia.

8.3.3.2 Baseline questionnaire and group allocation

In the first instance, interested individuals were directed to a website set up specifically to provide information about the study, and to screen out volunteers who did not meet the basic criteria (that they were aged over 18 years, lived in Australia, owned an iOS device, and had eaten fish in the last three months). Individuals who expressed interest in participating in the study were asked to answer "yes" on an electronic consent form, then to complete an entry questionnaire to determine basic demographic information, broad attitudes to both fish consumption and mobile application usage, and typical fish consumption frequency. This questionnaire was administered via the *SurveyMonkey* web application⁴⁴⁶ and is reproduced in Appendix 5.

Participants were paired as closely as possible in terms of typical consumption frequency, age, gender and location (Australian state). Then, from each pairing, one participant was randomly assigned to the intervention group, and the other to the control group. This pairing helped to ensure that the groups were as similar as possible at baseline. As shown in **Figure 33** this goal was largely achieved – participants were fairly evenly distributed between the two groups on all of these metrics.

In terms of these key demographic data, the sample was skewed towards females and individuals aged less than 40 years. The sample was 74% female (n = 74). Those aged between 18 and 39 years made up 76% of the sample (n = 76), with those aged between 40 and 59 years representing another 22% (n = 22). Just 2% of the sample (n = 2) were aged 60 years or over.

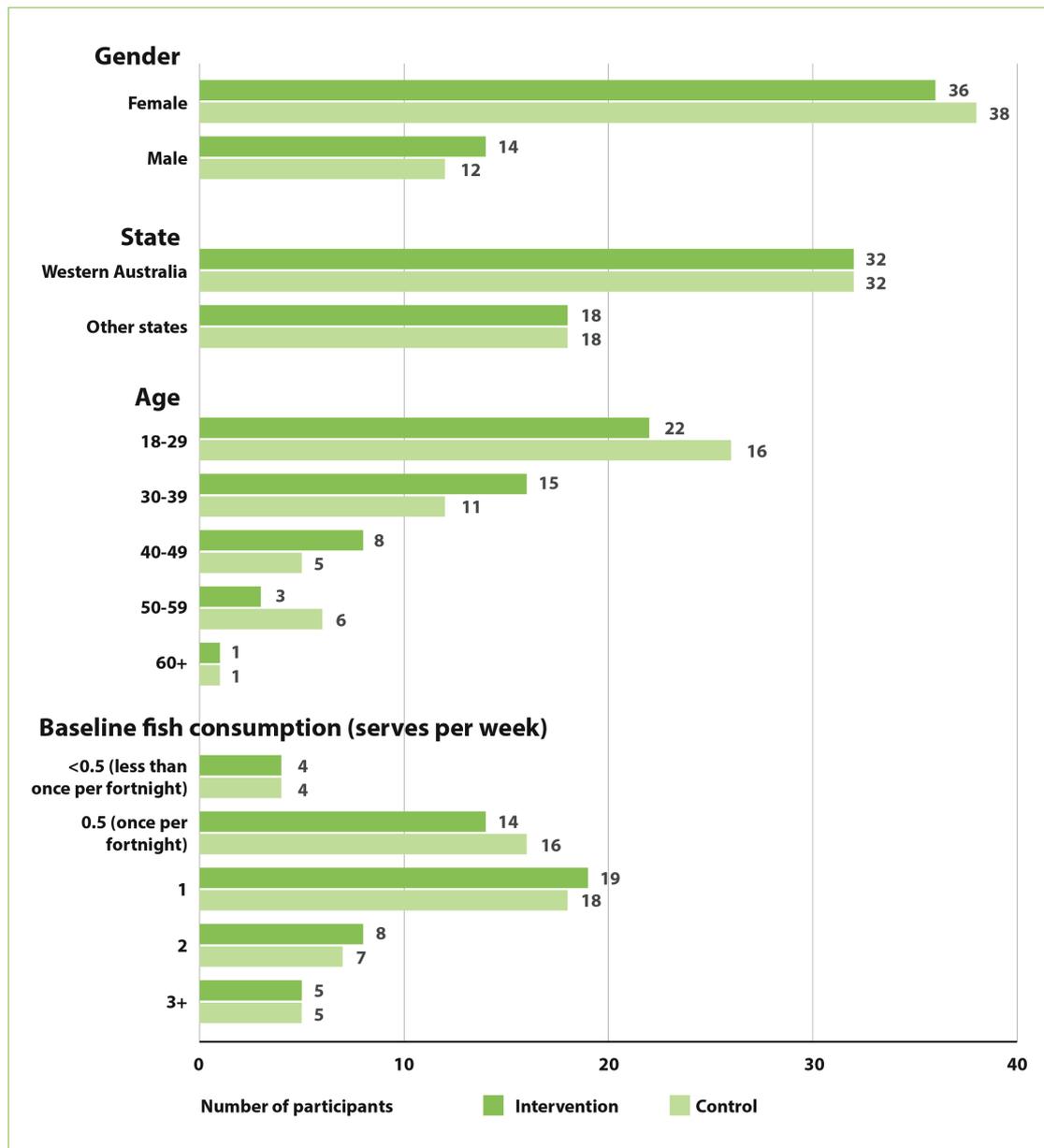


Figure 33. Demographic and baseline fish consumption distribution between intervention and control groups.

Estimated regular fish consumption was fairly normally distributed. The largest proportion of participants 37% (n = 37) reported a regular consumption of one serve per week.

Secondary information was also collected, including education, number of children and mobile device usage. Although it was not specifically used for the purpose of group assignment, this information was considered important in understanding as much as possible about the sample, including ways in which it might not be considered representative of the general population. Notably, the sample was highly educated, and those with children at home were under-represented. Three quarters of the sample were university educated (77%, n = 77), and only 8% (n = 8) had no post-high school qualifications. More than two thirds had no children at home (69%, n = 69). This secondary information is detailed in **Figure 34**.

8.3.4 Distribution of the experimental application

Having been randomly assigned to a group, participants were asked to download the appropriate version of the experimental application. This presented a technical challenge. Normally the only way for a mobile application to be installed on an iOS device is by submitting that application to Apple for approval and public release. This was unacceptable in this case. The intervention application allowed users to submit recommendations and other content, and having these submissions open to the public would have created an additional confounding variable. Furthermore, it would have presented the possibility of a member of the control group finding and downloading the full intervention app, either before or during the study period.

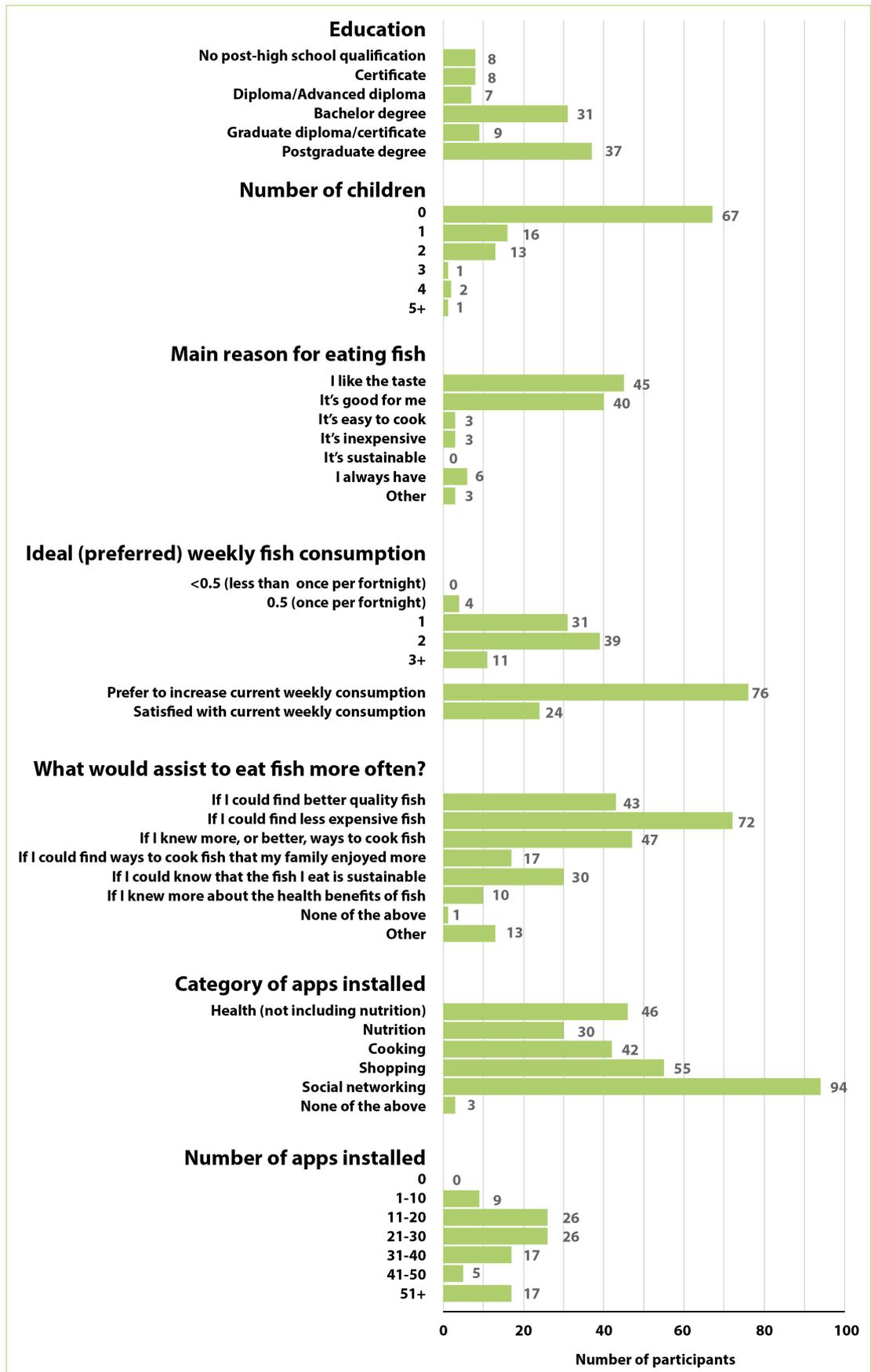


Figure 34. Secondary demographic information and other baseline data.

An alternative to public distribution involves registering test devices on a developer's account, and distributing applications using a service like *TestFlight*⁴²⁴ or *HockeyApp*.⁴⁴⁷ These services are commonly used by application developers and allow a small group of people to test applications for usability issues or errors before public release, a process known as beta testing. This was considered as an option for this project. However, the process of setting up a device and installing an application in this way is somewhat complicated, so this approach was deemed unfeasible for testers who could not be expected to have a high level of technical confidence.

A third option allowed for simple downloading, without the application being made available to the general public. The intervention and control applications were submitted for approval, but assigned a future release date. Once approved, these applications were hosted on the App Store, but not visible to the public. Developers are able to request promotional codes for accepted applications. These are typically used in cases where an application is a paid download, but the developer wishes to provide it to a reviewer for free. For the purpose of this study, promotional codes were requested and distributed to participants, along with simple instructions for completing the download.

It was desirable to have participants install the application and begin their 12-week trial as closely to each other as possible. To whatever extent possible, having all participants using the application during the same period of time would limit the introduction of confounding variables. Had this not been the case, some participants might have been engaged with the study during a period known to increase fish consumption, such as Easter, or during some media or commercial event, such as a seafood promotion by a supermarket chain, or a news report on the dangers of contaminants in seafood. Although these external events could not be controlled, their impact on the validity of data collected could be limited by ensuring that participants were exposed to similar events at the same time (although there could well be unavoidable regional differences in these events).

This goal notwithstanding, it was not possible to ensure that all participants installed the experimental application at exactly the same time. Participants had to complete the entry questionnaire, and install the application themselves, using the supplied codes. As might be expected, some participants took some time to complete each step, in some cases needing reminding. However, the full sample completed the various processes needed to begin the study within a satisfactorily narrow time frame. 76% of the sample (n = 76) began the study within a week, with a further 14% (n = 14) beginning the following week. A further 5% of the sample (n = 5) began in each of the third and fourth weeks, meaning the full sample was recruited within a month.

8.3.5 Data collection

For each participant, the 12-week data collection period began on the day they first installed the application and created a user profile. Those in the intervention group were not given specific instructions about how, or how often, to use the informative sections of the application, beyond the simple tutorials shown to them when they first accessed each tab (see Section 0). Participants in both groups were asked to make a record in the diary section of the experimental application each time they ate fish or seafood. The mechanism for data entry is described in detail in Section 7.7.4.

Although participants were not advised of a minimum quantity that constituted a serve, only those meals estimated to include more than 40 grams of fish or seafood were included in the data analysis. Although some studies have accepted any meal with a fish component in analysing fish consumption levels,^{65, 109} the health focus of this study and desire to only consider clinically meaningful results led to the decision to exclude meals with only a small quantity of fish or seafood. The 40 gram minimum allowed for the inclusion of meals like typical canned fish sandwiches, but the exclusion of trivial quantities of fish product – for example, fish paste on crackers, or anchovies on a pizza. In all, 81 of the 1087 reported serves (7.5%) were excluded from analysis due to being below this threshold.

Unreliability of self-reported consumption information is a commonly reported problem in nutritional studies.^{149, 232, 238, 448} Research participants have been observed waiting until the last moment (for example, before a clinical appointment) and then backfilling information, even when they have been instructed to record consumption activity on a regular basis. This commonly reported phenomenon is sometimes colourfully, but aptly, termed “parking lot compliance”.²³²

In order to encourage contemporaneous recording of fish consumption, and thereby reduce the potential for memory error, participants were asked to add a photo of each fish serve they ate, using their device’s camera. The application did not allow participants to upload a photo from their device’s camera roll, the store of photos saved previously on the device. Disallowing this meant that participants could not upload photos that they hadn’t taken themselves (photos can be saved to a device’s camera roll from the Internet, for example), and they could not use the same photo for multiple meals. Importantly they also could not take a photo of a fish meal with the intention of completing the entry at a later time. The tendency to make temporary “stub” diary entries, which may not ever be completed, has been observed by other researchers.⁴⁴⁸ During the study a number of participants contacted the researchers, asking whether it was possible to do this. This is discussed further in Section 8.5.6.3.

While it would have been possible to design the experimental application in such a way as to enforce the uploading of a photo (for example, by disallowing the saving of an entry which was not accompanied by an image), this approach was rejected. This would have made it impossible for a participant to make an entry even minutes after they had finished a meal, as it would be impossible to take the necessary photo. Therefore, although the application encouraged the addition of photos wherever possible, this was not enforced.

In addition to the date entered manually by the participant as the “date eaten”, the application automatically recorded the date and time at which the entry was

made. This made it possible to compare the date at which the meal was reported to have been eaten, and the date it was actually entered in the diary.

It was expected that the control group's consumption patterns would be affected to some extent by the fact that they were asked to record their fish consumption during the intervention period, and that observations effects may have had some bearing on the observed data.⁴⁴⁹ However, it was considered that this impact would be mitigated by the fact that both groups were required to record their consumption using the same mechanism. Therefore, there was no reason to assume that any observation effect would differ significantly between the test and control groups. This was an important consideration; even if it were possible (or ethically permissible) to observe control group participants' fish consumption without their knowledge, this approach would detract from, rather than enhance, the validity of statistical inferences made. It would be difficult, if not impossible, to separate the observation effect (the tendency for participants to increase their consumption as a result of being asked to record it) from the effect of the various resources they were exposed to during the measurement period.

In effect, the diary component of the application was sacrificed as a comparable independent variable, as it was common to both test and control groups. The trade-off was the ability to analyse the effect of all other features of the application, both in terms of overall (combined) impact on consumption, and associations between certain usage patterns and changes in consumption.

Finally, an exit questionnaire was administered to all participants in the test groups. This sought qualitative feedback about the user experience – effectiveness of the tools, level of burden, the degree to which the users feel their level of consumption was accurately reflected in the consumption diary, and any self-reported changes in skills, knowledge, attitudes or consumption intention. This questionnaire is reproduced in Appendix 6.

8.3.6 Communication and participant feedback

The experimental application included a function enabling participants to send feedback directly to the researchers. This allowed communication of any problems with the application, such as errors or crashes, and for providing feedback about the application's features or usability. Many mobile device users have become familiar with the process of providing feedback to application developers, and of seeing their feedback incorporated into later updates. This has been an interesting phenomenon in the mobile application age. Many users have begun to see software much more as a product made by real people who can be communicated with, than they did with the large-scale software products, made by large companies, they had used on desktop computers.⁴⁵⁰ It was possible that this feedback would have been offered by some participants, even had it not been solicited.

Although it was possible to update the application during the study, for example to correct an error or fix a problem, it was agreed that this would only be done in the case of serious issues which could affect data collection or render the application unusable for some users. It was not desirable to make non-essential changes to the application mid-study, as this could have introduced confounding variables. It would not have been possible to ensure that all users updated the application at the same time; different users could have had different versions of the application at different times in the study.

These contingencies proved unnecessary as no serious usability or functionality issues were identified during the study period. Several suggestions were offered regarding potential improvements that could be made to the application; these are described in Sections 8.4.4.6 and 8.5.6.3.

As part of their participation in the virtual community, intervention group members received a fortnightly newsletter. Newsletters are a common element of community membership, whether online or real world. They can be effective tools

in encouraging engagement, increasing trust, and establishing a brand as an authority on a given subject. As digital marketing researcher Laurent Flores put it:

Offering value-added newsletters through email...can place the brand in front of consumers on a monthly, weekly or even daily basis. As long as the customer experiences true value from the communication...the brand goes from being something consumers only think about periodically when shopping, to a trusted, daily source of category information.⁴⁵¹

A study found that website users who received a fortnightly newsletter were more likely to continue visiting that website, and showed more favourable attitudes to the brand being promoted.⁴⁵²

Many mobile application developers use electronic newsletters as a tool to encourage engagement with a new application, especially where there is a social networking aspect. These newsletters are typically used to introduce or explain features of the application, to provide a human face, or to encourage engagement. For example, the health and fitness brand Withings has developed an ecosystem of networked devices and socially connected mobile applications; an example of that company's electronic newsletters is reproduced in **Figure 35**.

Each of the fortnightly newsletters sent to the intervention group included two sections. One section highlighted a feature of the application, such as the facility of entering a user's preferences and receiving species recommendations, or of submitting favourite fish outlets to assist other users. The other section reminded the recipient that, if they had eaten fish or seafood, they should record this in the application. The newsletter did not specifically encourage users to eat fish, just to remember to record it if they had. The six newsletters used are reproduced in Appendix 7.

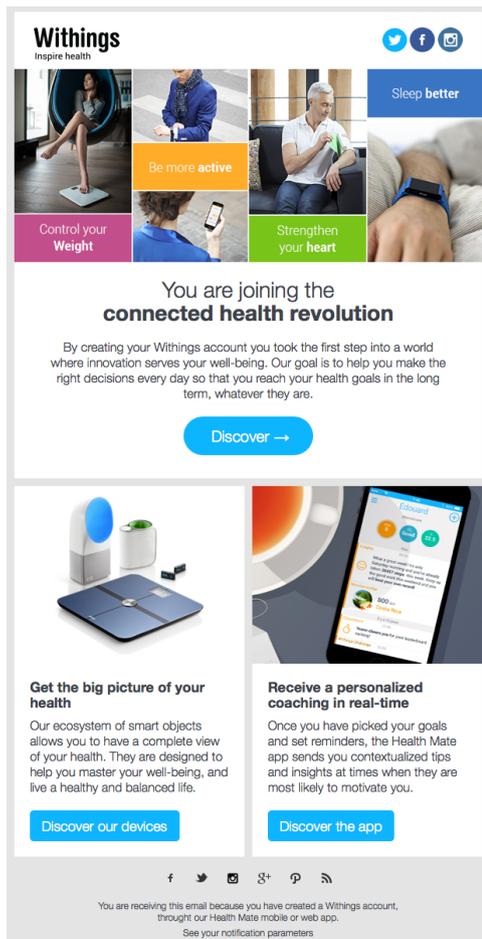


Figure 35. Withings²⁷⁰ email newsletter.

Insofar as these newsletters might act to reduce missed data, it was important that control group participants received the same reminders. Control group participants were sent a fortnightly newsletter containing the same reminder section from the intervention group newsletter. Newsletters were distributed using the *MailChimp* web application,⁴⁵³ with mail outs automatically scheduled for the Friday of the second week of a volunteer's participation, and every second Friday after that until the end of the study.

8.4 Results

One of the selection criteria for inclusion in the sample was that participants anticipated consuming fish at least occasionally during the study. Participants who did not record any instance of fish consumption during the study period were excluded from analysis. In all, 12 participants were excluded, leaving a sample of 88 (intervention = 45, control = 43). Of this sample, 78 participants completed the post-intervention questionnaire (intervention = 38, control = 40).

8.4.1 Participant's reported estimate of consumption

In the post-intervention questionnaire, participants were asked to say how they believed their consumption during the study period compared with what was normal for them. Most felt that their consumption had been about normal (67%, n = 52), while only 6 participants (8%) thought that their consumption had increased.

These participants' self-assessments were compared with consumption data recorded in the application, and participants' self-reported baseline estimates of normal consumption (as entered in the pre-intervention questionnaire). Half of participants' estimates (n = 39) closely matched the observed data (for example, the participant estimated that they ate about the same amount of fish as normal, and the consumption data recorded in the application matched their baseline estimate). In about a quarter of cases (n = 21), the recorded data suggested that the participant had increased their consumption more than they thought they had. In the remaining cases (n = 18), the recorded data suggested the participant's consumption had decreased more than they thought it had.

8.4.2 Diary tool

Given the importance of the diary tool in collecting fish consumption data, a number of questions were asked to both test and control group participants

about the usability of this tool and the effect (if any) they felt its use may have had on their consumption.

Participants were asked if they sometimes forgot to record fish they had eaten. Three quarters of all participants (test and control) either agreed or strongly agreed that they had (75.6%, n = 59). This may be partially explained by the circumstances in which participants recorded their consumption. Participants were asked to add photographs of their fish meals, as described in Section 7.7.4. They were restricted to doing this using the device camera, rather than from the device's photo library; one reason for this restriction was to encourage contemporaneous entry of the meal, ideally immediately before consuming it. However, nearly half of participants (46.1%, n = 36) said that they generally recorded their fish consumption after finishing the meal, with a quarter (26.9%, n = 21) admitting that it was typically not recorded until a later day.

Entry of a fish consumption occasion required the participant to record the species of fish, the date of consumption and meal (breakfast, lunch, dinner, or a snack), the means of cooking, and the approximate weight. This information was primarily used to provide nutritional feedback, such as omega-3 intake, although the weight estimation was also used to omit from analysis serves that fell below the 40 gram minimum.

The usability of the data entry tool was an important factor, and one that would require consideration in any further trial of this application, or in a different intervention seeking to use a similar method for data collection. Participants were asked to rate the ease with which they could enter this information. For example, how easy was it to know the species of fish being consumed, to find a matching species in the application list, to estimate the weight, and so on. The results are shown in **Table 6**.

Table 6. Diary tool ease of use.

Question	Agree or strongly agree	Disagree or strongly disagree	Mean score (1 = strongly disagree, 5 = strongly agree)
The diary tool was simple to use	87.2% (n = 68)	10.3% (n = 8)	4.18
The diary tool worked the way I expected it to	71.8% (n = 56)	10.3% (n = 8)	3.86
Entering the information into the app got in the way of preparing or enjoying my meal	6.4% (n = 5)	80.8% (n = 63)	1.96
	Somewhat easy or very easy	Somewhat difficult or very difficult	Mean score (1 = very difficult, 5 = very easy)
Knowing the kind of fish that I was eating	41% (n = 32)	47.4% (n = 37)	2.97
Finding a species in the list that matched what I was eating	23.1% (n = 18)	59% (n = 46)	2.54
Finding a cooking method in the application list that matched the way my fish was prepared	51.3% (n = 40)	32.1% (n = 25)	3.26
Estimating the amount (weight) of fish in each meal	17.9% (n = 14)	74.4% (n = 58)	2.28

Participants were also asked to add a photo of the meal, as a means of validating the consumption to some extent. It was equally important to understand the impact of this requirement on user behaviour; participants were asked a number of questions about this and results are shown in **Table 7**.

Table 7 Adding photos to the fish consumption tool: user perceptions.

Question	Agree or strongly agree	Disagree or strongly disagree	Mean score (1 = strongly disagree, 5 = strongly agree)
I didn't mind taking photos of my meals	66.7% (n = 52)	11.5% (n = 9)	3.71
Because I was taking photographs, I took extra care in presenting my meals	56.6% (n = 20)	48.7% (n = 38)	2.76
There were some situations when taking a photo of my meal was difficult	67.9% (n = 53)	20.5% (n = 16)	3.68
	Somewhat easy or very easy	Somewhat difficult or very difficult	Mean score (1 = very difficult, 5 = very easy)
Taking photos that showed the fish in my meals	42.3% (n = 33)	37.2% (n = 29)	3.12

It should be noted that, although the majority of participants said that they were happy to add photos, less than half of the 1006 fish meals recorded during the intervention included photos (n = 486). This was not surprising, given the high proportion of participants who said they usually recorded the information after having eaten the meal; adding a photo at this point was impossible. 15.9% of users (n = 14) did not include a photo with any recorded meal. Exactly the same proportion (15.9%, n = 14) added a photo for every recorded meal.

Participants were given the opportunity to provide open-ended, written feedback on difficulties they experienced using the fish diary component of the application. Although this question was optional, more than half of participants (57.7%, n = 45) provided feedback. The most common complaint was the requirement to add photos using the device camera, with 19 participants saying that they would have found it easier to enter all the information after completing the meal.

It would have been good to be able to add a photo from my camera roll for times when I remembered to take a photo but didn't want to complete the diary entry right away (e.g. when dining out).

(Control participant 42)

I took photos whilst preparing the food but was unable to use photos from my folders when entering the data. Often I didn't have time to do the data entry whilst cooking (I have children).

(Control participant 29)

Completed study on my iPad, which I didn't have with me at all times, meaning I was unable to take photos of all meals consumed. Had anticipated that the app would allow me to upload photos to meals eaten in the past (which I'd saved to camera roll from a different device) but this didn't seem possible.

(Control participant 36)

Another common issue was the difficulty in finding species. Ten participants said that they would have preferred a search function, or some other way to find species other than scrolling through a long list. While a search function existed in the species guide section of the application, it was not included in the fish diary.

I think the fish species "rolling" selection option was not very user friendly. Having to scroll through was sometimes tedious although I like the way some common options were presented at the start of the "roll". I would suggest a search option with predictive text would be helpful.

(Test participant 14)

Scrolling through the list took time, especially if I was looking for 'prawn' then found it didn't exist. Being able to type a letter, or words and search would have been better.

(Control participant 26)

A number of participants suggested either reducing the number of species displayed to broader categories (e.g. *prawn*, rather than *king prawn*, *tiger prawn* and *banana prawn*), or to order species by main category first (e.g. *prawn*, *tiger* rather than *tiger prawn*). The difficulties and implications of species selection, naming and categorisation are discussed in Section 8.5.6.3.

Feedback on the diary component of the application is summarised in **Table 8**. It should be noted that this question was framed negatively; participants were specifically asked about difficulties that had experienced with the fish diary tool. More general feedback on the application was sought elsewhere in the questionnaire.

Table 8. Difficulties experienced while using the fish dairy tool.

Difficulty experienced using the diary tool	Number of participants reporting this difficulty
Requirement to use device camera for photos (rather than importing from camera roll)	19
Some species were not listed, or listed under an unfamiliar name	14
Scrolling to find species was difficult; a search feature would have helped	10
Some cooking methods were not listed	5
It was difficult to estimate amounts	4
Species were overly specific; would prefer broader categories	4
Would prefer species to be listed by main category, before sub category (e.g. <i>prawn</i> , <i>tiger</i>)	3
It was difficult to know the species when eating out	3
The camera capture tool cropped some photos incorrectly	3
It was difficult to participate using an iPad, as the device was not always present	3
It was difficult to record meals containing more than one species	2

Participants in both groups were also asked whether they believed they had made a special effort to eat fish during the study period. Across both groups, 61.5% (n = 45) indicated that they had not, with only 11.5% (n = 9) saying that they had. A Mann-Whitney U test was run to determine if there were differences in median response to this question between the two groups. Distributions of the responses for both groups were similar, as assessed by visual inspection of the population pyramid. The median response score was not statistically significantly different between test and control groups, $U = 798$, $z = 0.406$, $p = .685$.

8.4.3 Fortnightly newsletters

Participants were asked about the fortnightly newsletters they had been sent: how many of these newsletters they opened, and what actions (if any) they took in response. A large majority (78.2%, n = 62) said that they opened and read all or most of the newsletters. The newsletter server automatically collected analytics information; it was possible to see which newsletters had been opened by individual participants and compare these data with participants' responses to this question. Notably, only half of participants (50%, n = 39) accurately reported their engagement with the newsletters (e.g. they said they opened all newsletters, and analytics data supported this claim). A further 29.5% (n = 23) over-reported their engagement (e.g. they said they opened all newsletters, but data suggested they only opened a few, or none at all). The remainder (20.5%, n = 16) under-represented their engagement (e.g. they said they opened only a few newsletters, but data suggested they opened all of them).

Both groups were asked how often the newsletter reminded them to record their fish consumption. Responses were evenly divided: half (50%, n = 39) said that the newsletter had prompted them to enter forgotten meals at least occasionally, with the other half saying this had never happened. The intervention group, whose newsletters included reminders about specific features of the application, were asked how often the newsletters promoted them to explore those features. 63% (n = 24) of the intervention group said that they had done so at least occasionally.

8.4.4 Intervention group application usage

8.4.4.1 Species guide

Participants were asked about the species guide and its impact on their behaviour. Results are tabulated in **Table 9**. Most participants said that the guide included the species they usually eat, and around half felt that it had helped them to understand more about different kinds of fish. Relatively few said that they tried new kinds of fish as a result of using the application.

Table 9. Participants' perceptions of the species guide.

Question	Agree or strongly agree	Disagree or strongly disagree	Mean score (1 = strongly disagree, 5 = strongly agree)
The species guide helped me to understand more about different kinds of fish	50.0% (n = 19)	2.6% (n = 1)	3.53
The species guide included most of the species I usually eat	81.6% (n = 31)	2.6% (n = 1)	3.89
The species in the guide seemed relevant to the area I live in	52.6% (n = 20)	5.3% (n = 2)	3.55
I tried new kinds of fish because of what I learned in the species guide	10.5% (n = 4)	63.2% (n = 24)	2.32
The information in the species guide was accurate	36.8% (n = 14)	0% (n = 0)	3.39

8.4.4.2 Fish outlet finder

Participants were asked about the fish outlet finder and its impact on their behaviour. Results are shown in **Table 10**. Around a third (31.6%, n = 12) said that

it had included a good selection of outlets in their local area, and around a quarter (23.7%, n = 9) said they found good fish as a result of using the tool.

Table 10. Participants' perceptions of the fish outlet finder.

Question	Agree or strongly agree	Disagree or strongly disagree	Mean score (1 = strongly disagree, 5 = strongly agree)
The fish finder tool helped me to find good fish in my local area	23.7% (n = 9)	15.8% (n = 6)	3.05
There were plenty of outlets in the fish finder tool that were near where I live	31.6% (n = 12)	18.4% (n = 7)	3.11
I found a good place, or places, to buy fish, as a result of using the fish finder tool	23.7% (n = 9)	23.7% (n = 9)	2.92

8.4.4.3 Health section

Participants were asked about the health section and its impact on their behaviour. They were also asked about the impact of the feedback on serves per week and omega-3 intake provided in the diary tool. Results for both sets of questions are shown in **Table 11**. Most participants said that the health information in the application made them want to eat more fish, although relatively few said that it had made them want to change the kinds of fish they ate.

Table 11. Participants' perceptions of the health information.

Question	Agree or strongly agree	Disagree or strongly disagree	Mean score (1 = strongly disagree, 5 = strongly agree)
I was interested in reading about the health benefits of eating fish	65.8% (n = 25)	10.5% (n = 4)	3.63
The information in this section made me want to eat more fish	60.5% (n = 23)	7.9% (n = 3)	3.61
The information in this section made me want members of my family to eat more fish	39.5% (n = 15)	21.1% (n = 8)	3.16
The information in this section made me change the kinds of fish I eat	15.8% (n = 6)	44.7% (n = 17)	2.58
The feedback on serves per week, and omega-3, made me want to eat more fish	36.8% (n = 14)	18.4% (n = 7)	3.21
The feedback on serves per week, and omega-3, discouraged me	7.9% (n = 3)	73.7% (n = 28)	2.07

Analytics data collected by the application itself provided a clear picture of user engagement with the health information provided by the application. Participants in the intervention group were able to use the diary tool to view information about the number of serves of fish they had consumed per week during the study period, and about the approximate dietary omega-3s provided by their fish consumption. Around three quarters of participants (73.3%, n = 33) viewed the serves-per-week information at least once, with around half (46.7%, n = 21) viewing this information three or more times. Engagement with the omega-3 information was somewhat lower; 60% (n = 27) viewed this information at least once, with 38.8% (n = 17) viewing it three or more times.

It was also possible to determine which participants had opened which of the seven health articles presented in the health section, and how often. Engagement was not high; two fifths of participants (40%, n = 18) opened none of the articles, with another quarter opening only one. These data are shown in **Table 12**.

Table 12. Number of health articles opened by participants.

Health articles opened	0	1	2	3	4	5
Proportion of participants	40.0% (n = 18)	26.7% (n = 12)	8.9% (n = 4)	11.1% (n = 5)	8.9% (n = 4)	4.4% (n = 2)

The most commonly opened articles were those containing general information about fish and health, or omega-3s. The least commonly opened were those about specific conditions such as cancer, diabetes or heart disease. The full data are shown in **Table 13**.

Table 13. Total Number times each health article was opened.

Health article title and subtitle	Number of times opened
Omega-3s The good oil: everything you need to know	17
The super food Fish is a great choice for your health	13
The best start The family dish, for when you're in the family way	10
Arthritis Good news for joint pain sufferers	8
Cancer Helping to reduce your risk	5
Diabetes A managed diet doesn't have to be dull	3
Heart health Give your heart a fighting chance	2
Total	58

It should be noted that these data refer to *opening* articles, rather than *reading* them; a user opening an article and skimming its content would have registered as an *open* as much as another user thoroughly reading one. Measuring real engagement is a difficult task faced by anyone delivering digital content.⁴⁵⁴

Notably, of the participants who said on the post-intervention questionnaire that the health information in the application had at least some impact on their fish consumption, more than a third (38.5%, n = 10) did not in fact open any health articles. Another third (30.8%, n = 8) opened only one article.

8.4.4.4 Trust

Participants were asked about the degree to which they trusted the information in the various sections of the application. For the health section, containing evidence-based health and nutrition information with a clear attribution to a university research centre, 84.6% of participants (n = 32) agreed or strongly agreed that they trusted this information. The species guide, containing a mix of expert information (such as cooking tips) and crowdsourced information (such as ratings) was attributed the same level of trust, with 84.6% of participants (n = 32) agreeing or strongly agreeing that they trusted this information. 44.7% of participants (n = 17) agreed or strongly agreed that they trusted the crowdsourced recommendations contained in the fish outlet finder section. It should be noted that only one participant said that they did not trust this information, with half of participants (50%, n = 19) neither agreeing nor disagreeing. Most participants simply did not frequently use this section. Responses to these questions are summarised in **Table 14**.

Table 14. Participants' level of trust in the information contained in the application sections.

Question	Agree or strongly agree	Disagree or strongly disagree	Mean score (1 = strongly disagree, 5 = strongly agree)
I trusted the information in the species guide	84.2% (n = 32)	2.6% (n = 1)	3.95
I trusted the information in the fish finder	44.7% (n = 17)	2.6% (n = 1)	3.47
I trusted the information in the health section	84.2% (n = 32)	0% (n = 0)	3.97

8.4.4.5 Self-reported impact on fish consumption

Participants were asked to what extent they felt that the various sections of the application had made an impact on their fish consumption. The health section was credited with the greatest impact, with 68.4% of participants (n = 26) saying that it had some impact or a big impact. The corresponding figures were 57.9% (n = 22) for the diary section, and 36.8% (n = 14) for both the species guide and fish outlet finder. It should be noted that few participants credited any section of the application as having had a *big* impact; most positive responses indicated *some* impact. A large majority of participants (86.8%, n = 33) said that the application as a whole, or one of its components, had at least some impact on their consumption.

Notably, of the 11 participants who said they did not think the application as a whole had an impact on their consumption, five had previously indicated that one of the application's components had had some impact, pointing towards a possible misunderstanding of the question (perhaps as referring to other aspects of the application not covered in previous questions). Responses to these questions are summarised in **Table 15**.

Table 15. Participants' perceptions of impact of the application sections.

Question: To what extent do you think the different sections of the application had an impact on your fish consumption?	No impact	Some impact	A big impact	Mean score (1 = no impact, 3 = a big impact)
The species section	63.2% (n = 24)	34.2% (n = 13)	2.6% (n = 1)	1.39
The fish finder section	63.2% (n = 24)	28.9% (n = 11)	7.9% (n = 3)	1.45
The health section	31.6% (n = 12)	55.3% (n = 21)	13.2% (n = 5)	1.82
The diary section	42.1% (n = 16)	44.7% (n = 17)	13.2% (n = 5)	1.71
The application as a whole	28.9% (n = 11)	65.8% (n = 25)	5.3% (n = 2)	1.76

8.4.4.6 Ideas for improvement

Members of the intervention group were given an open-ended opportunity to suggest ideas for improving the application. A number took the opportunity to reiterate the issues with the data entry tool discussed in Section 8.4.2, specifically the chore of scrolling through a long list, the preference for a search-based interface, and the inability to add a previously taken photo.

One participant suggested the use of local notifications to remind them to enter their fish consumption. Local notifications are a mechanism by which a user can receive a reminder, even when they are not currently using a given application.

Local notifications to remind ask if people have eaten fish today? Prompt as I forgot more often than not to enter the information.

(Test participant 16)

Another suggested that it may have been better to present information immediately after a user entered a fish meal, rather than requiring them to look for the information specifically.

When entering a meal - when saving - the next screen could show info about my meal, recipe ideas or health benefits. I wasn't proactive to go looking for additional info but if it flashed up before me I would have definitely read more info - which may have inspired me.

(Test participant 18)

A third made a more general observation about the balance of different kinds of information in the application, and what they perceived as an overly broad focus.

Too much information - I didn't really use the fish finder or species sections. There was too much to read and I'm already aware this information. It may be useful to people who are new to fish eating or a specific geographic area. But there are also other ways to find this information. Generally, the app was user friendly, but I think it tries to be too much to too many user groups. To really be effective, more focus is needed.

(Test participant 35)

8.4.5 H1: Association between use of the intervention application and increased consumption

This trial intervention had a mixed-factorial design; collection of data over the course of 12 weeks would allow within-subjects analysis of consumption over time, while the distribution of participants into intervention and control groups would provide the opportunity for a between-subjects comparison. In other words, the trial was designed to show whether use of the experimental application was associated with increased consumption over time and whether any increase in the intervention group differed significantly from the pattern observed in the control group.

However, issues with data collection rendered the within-subjects analysis highly problematic. Looking solely at the data collected in the fish diary tool, most participants appeared to display a *decrease* in consumption over the 12 weeks, rather than an increase or even a consistent level. When viewed in conjunction

with participants' self-reporting at the conclusion of the study, it was apparent that many, perhaps most, participants did not keep an accurate record of their fish consumption. Most participants admitted to forgetting to record fish consumption; in many cases participants appeared to begin the study enthusiastically recording their consumption, then to fall away during the course of the 12 weeks. These problems are discussed at length in Section 8.5.1, along with implications for future studies and potential improvements in study design to alleviate the issue.

Although it was not feasible to determine the impact of the trial intervention over time, a between-subjects analysis remained possible. Subjects were evenly distributed between the two groups in terms of self-reported baseline consumption, and attrition (that is, participants who consumed no fish during the study) was relatively even; the remaining 88 participants comprised 45 intervention group subjects (51.1%) and 43 control group subjects (48.9%).

Furthermore, an analysis of participants' self-reported estimates of consumption over the study period revealed no difference between the two groups. With the data being distinctly non-parametric, a Mann-Whitney U test was run to determine if there were differences in median response between the two groups, for the question asking if participants had forgotten to enter fish during the study. Distributions of the responses for both groups were similar, as assessed by visual inspection of the population pyramid. The median response score was not statistically significantly different between test and control groups, $U = 861$, $z = 1.13$, $p = .259$. In other words, there was no reason to assume a significant difference between the groups in the degree to which consumption was misrecorded over the study period. Weekly consumption records could be collapsed into a single value for the study as a whole, and used to determine if there was a significant difference between the two groups.

A Mann-Whitney U test was run to determine if there was a statistically significant difference between the total fish consumption of the two groups. Distributions of the responses for both groups were similar, as assessed by visual inspection of the

population pyramid. Total fish consumed was not statistically significantly different between test and control groups, $U = 999$, $z = 0.264$, $p = .792$.

8.4.6 H2: Association between time spent using the application and increased consumption

Analytics data provided a rich picture of intervention group participants' engagement with the application. The following parameters were either directly recorded in the application (and uploaded contemporaneously to the remote server), or deduced post hoc from other analytics data:

Overall application:

- Number of application launches
- Total time spent using the application
- Total time spent in each of the four main sections of the application (species guide, fish outlet finder, health section and diary tool)

Species guide

- Total species viewed
- Names of species viewed
- Route by which species were found (via categories, search, or recommendations)
- Number of time species recommendations were sought (and which preferences were entered)

Fish outlet finder

- Total outlets viewed
- Names of outlets viewed
- Number of times outlets were telephoned
- Number of times outlets' websites were viewed

Health section

- Number of health articles viewed
- Titles of health articles viewed

Diary tool

- Number of times serves-per-week information was viewed
- Number of times omega-3 intake was viewed

Although these data were of use in drawing a broad picture of the relative use of various components of the application, the lack of valid data for consumption over time limited the types of analysis that could be conducted. Whilst it was not possible to test H2 (the hypothesis that time spent using the application would be positively associated with increased fish consumption over time), it was possible to examine any correlation between time spent using the application and total aggregated consumption over the study period.

In order to test for this correlation, it was necessary to account for a number of outliers in both the fish consumption data, and in the application use time parameter. In terms of total fish consumption, two participants were deemed to be outliers, as assessed by inspection of a boxplot for values greater than 1.5 box-lengths from the edge of the box. These participants recorded 41 and 32 serves of fish respectively, significantly higher than the median 10.0 serves recorded by the intervention group as a whole. To avoid undue impact on the results of correlation tests, these cases were excluded from analysis.

Furthermore, fish consumption data were not normally distributed, as assessed by Shapiro-Wilk's test ($p < .05$). However, after the application of a square root transformation, these data were normally distributed ($p > .05$), and the transformed data were used for the purpose of the following analyses. It is acknowledged that some of the variation in the consumption data (and in the transformed analytics data outlined below) was lost by the use of this transformation.

Time spent using the application was considered to be time during which the application was in the foreground (note that, unlike desktop applications, only one iOS application can be fully active at a time), and the device screen was on.

The median minutes of application use throughout the course of the study was 23.0. One participant was a significant outlier in this respect, recording 246 minutes of use; the next highest value was 95 minutes. It is not clear how or why this participant may have recorded such an unusual value. Other analytics data for this participant showed it was unlikely that they were actively engaged with the application for this length of time. One possible explanation is that the participant had disengaged the *autolock* feature of their device (which automatically turns off the screen after a short period of non-use, much like the screensaver feature of a desktop computer), and left the experimental application open and unattended. Whatever the explanation, this participant's time data would have significantly distorted any correlation test, therefore they were excluded from this analysis.

The data for time spent using the application were not normally distributed, as assessed by Shapiro-Wilk's test ($p < .01$). However, after the application of a square root transformation, these data were normally distributed ($p > .05$), and the transformed data were used for the purpose of this analysis. Visual inspection of a scatterplot revealed that the relationship between time spent using the application (transformed) and average serves of fish consumed per week (transformed) was broadly linear.

A Pearson's correlation test showed a strong positive correlation between time spent using the application and average serves of fish consumed per week, $r = .713$. Time spent using the application explained 50% of the variability in fish consumption.

8.4.7 Demographic factors

The data for time spent using the application (with one outlier removed) were tested for differences between demographic subsets of participants.

There were 31 female and 12 male participants in the intervention group data set. The median time was higher for females (23.5 minutes) than males (17.5 minutes).

A Mann-Whitney U test determined that this was not a statistically significant difference, $U = 220.5$, $z = 1.129$, $p = .259$.

There were 24 participants from Western Australia and 18 participants from other Australian states in the intervention group data set. The median time was very similar for both groups – 23.5 minutes for Western Australian participants, and 22.5 for those from other states.

There were 19 participants under 30 years of age, and 23 participants aged 30 years or over, in the intervention group data set. The median time was very similar for both groups – 23.0 minutes for younger participants, and 24.0 for older.

There were 16 participants in the intervention group data set who had children for whom they were responsible (i.e. at home), and 26 who did not. The median time was very similar for both groups – 21.5 minutes for those with children, and 23.0 minutes for those without.

There were 36 participants in the intervention group data set who had a tertiary qualification, and 6 who did not. The median time was very similar for both groups – 23.0 minutes for those with a tertiary qualification, and 24.5 minutes for those without.

8.5 Discussion

This trial intervention had two main purposes: to quantify the impact that use of the experimental application had on fish consumption behaviour, and to make recommendations for a larger-scale RCT of this, or other similar applications. This section discusses these outcomes, but is limited to the trial intervention itself. A broader discussion of the implications of the full study, including its formative research, is undertaken in Chapter 9.

8.5.1 Effect on fish consumption behaviour

It was difficult, on the basis of the data collected during this trial intervention, to draw a clear picture of its impact on fish consumption behaviour. As discussed in Section 8.4.5, the study design made it difficult to separate participants who had practically, but informally, ceased participation in the study (by ceasing to use the experimental application) from those who simply ate very little fish.

This problem was born from the desire to study individuals' use of the application in as natural a setting as possible. A requirement could have been placed on participants that they use, or at least open, the application on some pre-defined regular basis. However, this would have created a decidedly *unnatural* set of circumstances; in the real world people are under no obligation whatsoever to use any given digital product or service on a regular basis, as much as the creators of those services might wish it otherwise. Adding a requirement like this would effectively have isolated the *content* of the application as the subject under investigation; the experimental question would have been something like "can exposure to certain information, mandated and regulated by the investigators, have an impact on the target behaviour?"

There is nothing inherently wrong with an experimental design like this – many health interventions take precisely this form.^{174, 177, 320} However, as some researchers acknowledge, exposure to information is not the same as

engagement with information.²⁰⁶ Researchers can ask participants to launch an application, visit a website, or attend a meeting, and measure the frequency with which they do so. It is much more difficult to measure their engagement with the information being presented. They may have visited the website on a daily or weekly basis, as instructed, but to what extent did they actually read and digest its content?

The decision to encourage, but not require, participants to engage with the application effectively meant that it was not just the information contained in the application that was under investigation, but the application itself. If individuals were given access to a fish-related mobile application, would its design, user experience and content sustain their interest and engagement, and to what extent would its use change their consumption behaviour?

It is fully acknowledged that this decision led to difficulties in identifying trends in the observed data. While it may have been highly instructive to examine participants' use of the application in a normal situation, any attempt to correlate that use with fish consumption would require accurate data on the fish consumed by participants throughout the study. Using the same mechanism (the application) both for delivery of the intervention and recording of the fish consumption data was attractive for reasons of simplicity and lower participant burden. However, it meant that those participants who dropped off in their use of the application also dropped off in the recording of their fish consumption, as many of them acknowledged when completing the post-study questionnaire.

8.5.2 Initial communication

Another contributing factor in intervention outcome may have been the manner in which the study was communicated to participants, who were told simply that they would be involved in a study of fish consumption. They were informed that the study would seek to understand the reasons why people do, and do not, eat fish. They were specifically *not* informed that the study was designed, at least for those of them in the intervention group, to increase their consumption. This

decision, made to reduce the chance that participants would feel they were required to deliberately eat fish during the study, may have had the unintended consequence of causing participants to believe that they *should not* increase their consumption – that they were expected to eat fish in a manner normal for them. Furthermore, it may not have been clear to participants that they were welcome to participate in the socially-connected components of the application – to rate fish, for example, or to share the location of favoured fish outlets. Intervention participants may have thought that they were primarily being asked to use the diary component of the application to record their fish consumption, and may have been confused about the expectation of engagement with other parts of the application.

Despite the difficulty in constructing a full picture of the impact of the intervention on fish consumption behaviour, a number of observations were made possible by analysis of some parts of the data set. There was a strong positive correlation between time spent using the application and overall fish consumption, among members of the intervention group. It is less clear in which direction the correlation ran; were people who liked to eat fish more likely to use the application more, or were those who used the application regularly more likely to eat more fish? The mixed study design used in this intervention was intended to enable such a judgment, however the issues experienced with between-subjects comparisons made this difficult. When comparing data from the intervention and control groups, no significant difference was found in overall consumption; there is no case to be made, on the basis of these data, that use of the application itself had a positive impact on fish consumption.

This intervention was based on the principles of the behavioural perspective model. In essence, the goal was to change individuals' experiences with fish consumption, to intervene in their learning history by increasing the chance of positive outcomes from eating fish. The impact of doing so may not manifest for some time afterward. Half of the intervention group participants said that the species guide component of the application had helped them to understand more about different species of fish. If a participant discovered a new kind of fish

that they, or their family members, enjoyed eating, or learned a new way to prepare fish, this might lead to an increase in consumption in the long-term. An increase might not be apparent in a few subsequent weeks. In short, behaviour change takes time, particularly when the habits being changed have been built up over many years, or even decades.

8.5.3 Contrasts between self-reported information and observed data

Participant self-reporting is a common technique in the health sciences. Although there are many potential problems associated with this approach to data collection, it is a necessary component of many kinds of study; there are many kinds of data that, in practical terms, cannot reasonably be collected directly and objectively.

Validity issues with self-reported data are sometimes grouped into two categories: those associated with the cognitive perspective of the individual being questioned, and those associated with individuals' situational perspective.⁴⁵⁵ The former category includes internal factors associated with the way people comprehend the questions they are being asked, how they retrieve the necessary information from short- or long-term memory, and how they sort and prioritise that information in generating responses to questions. The latter category includes external factors that may play a role in shaping individuals' responses: the place in which answering takes place, the presence of other people (including, potentially, the question-asker) and perceptions of privacy and anonymity. A commonly referenced situational factor is social desirability bias – the tendency for individuals to want to present a favourable image of themselves, and to (consciously or otherwise) modify their responses accordingly.^{456, 457}

A typical approach to validating self-reported data is to compare them with other data sets – either other self-reported data on the same subject (a process known as concurrent validation) or other objective data. In the case of this trial, several opportunities existed to compare participants' self-reported data with objective data collected directly from either the experimental application, or the other

online services used for various components of the trial. Furthermore, the nature of the collected data meant that individual participants' responses could be compared with their data on a case-by-case basis, rather than just in the aggregate.

In many cases participants reported a level of engagement with the application, or its ancillary components (such as the fortnightly newsletters) that did not appear to match with the objective data collected. For example, some participants said that the health information in the application had influenced their fish consumption, but no record was found of them having accessed any of that information during the study. Others reported that they had opened all, or most, of the weekly newsletters, while analytics data suggested that they had opened few, or none. Conversely, others reported they had opened few or none, while data showed they had opened several or all of the emails.

There are a number of possible explanations for these, and other, apparent discrepancies between self-reported and objective data. Firstly, participants may simply have misunderstood the questions they were being asked, a common cognitive perspective issue. Participants may have thought the health question related to other health information, either in the application or elsewhere. They may have thought they were being asked whether they had received the email newsletter (i.e., seen it appear in their inbox) rather than whether they had actually opened it.

A second explanation may be related to the validity of the objective data. Any time data is collected digitally, there is potential for that data to be incorrect due to software bugs or transmission errors. However, errors of this nature are often easy to identify by their repetitive patterns and the nature of the erroneous data; it is more typical to receive nonsense data in the case of errors like this, than it is to receive plausible but unexpected data. An inspection of all the data sets collected in the course of this study revealed no reasons for suspicion of technically erroneous data.

A third explanation is that at least some participants' answers were influenced to some extent by cognitive or situational factors. This may have included a desire to present a particular image of themselves that was consistent with their own personal self-image (for example, "I am somebody who believes health is important", "I am somebody who likes/does not likes fish", or "I am somebody who does/does not pay attention to marketing emails"). They may also have tended to avoid answers they may have seen as negative or critical of the application or project.

No conjecture is made here as to the relative likelihood of each of these possibilities, in this case. However, these observations are mentioned as a cautionary note to researchers undertaking evaluations of similar interventions. It is important not to rely solely on either objectively collected data or on self-reported measures of participant engagement and perception, but rather to collect both and to critically examine each data set in the light of the other.

8.5.4 Summary of findings

- Total fish consumed was not statistically significantly different between test and control groups.
- There was a strong positive correlation between time spent using the application and overall fish consumption, among members of the intervention group. Time spent using the application explained 50% of the variability in fish consumption.
- There were no statistically significant differences in application usage metrics based on any demographic factors - gender, age, education level, Australian location, or number of children.
- The majority of participants admitted that they did not record all the fish they had eaten and, in many cases, it appeared that the recorded data were a poor representation of participants' actual consumption.
- Participants generally found the experimental application easy to use and technically robust.

- Participants were mostly happy to record information about their meals, and did not find this task overly burdensome.
- Less than half of the fish meals recorded during the intervention included photographs, with many participants finding this task problematic.
- Most participants responded positively to the fortnightly newsletters.
- A large majority of participants said that they trusted both the health information and the species guide. Far fewer trusted the information in the fish outlet guide.
- Most participants said that the health information in the application made them want to eat more fish, although relatively few said that it had made them want to change the kinds of fish they ate.
- A large majority of participants felt that the application as a whole had an impact on their fish consumption

8.5.5 Summary of limitations

It is acknowledged that much of the potential value of consumption analyses is lost by the failure to capture valid time data to examine trends over the course of the study, as discussed in Section 8.4.5. It is perhaps not surprising that individuals who ate more fish tended to use the application more, look at information on more species, and so on. Indeed, even if any causation existed, it was by no means certain in which direction the causation occurred; did participants eat more fish because they used the application more, or vice versa?

A dataset providing a fuller picture of participants' consumption over the full 12 weeks would have enabled an analysis of changes over time. This may have shown, for example, whether those who used the application regularly tended to increase their consumption over time. That said, these analyses provided useful information about the way the application was used, and which parts of the application were commonly used by low, medium and high fish consumers.

As a trial or pilot intervention, this study did not endeavour to recruit a sample large enough to generalise findings to the wider population. It also did not attempt to recruit participants in a truly random fashion, but rather used a convenience sample. The resulting sample was by no means representative of any larger population. Females were over-represented, compared with the general population, as were those with higher levels of education. Parents were under-represented. Findings from this study should not be generalised beyond the study sample.

Finally, the 12-week duration of the study, while sufficient for the purposes of the trial intervention, was not long enough to capture a full picture of impact on this highly habitual behaviour. A considerably longer study would be necessary to understand the long-term effectiveness of this intervention in changing behaviour.

8.5.6 Recommendations for a future RCT

The analyses that were possible, from both direct trial data and the information obtained in the participant questionnaires, suggest that there are grounds for further examination of a tool like the experimental application, for use in behaviour change interventions. However any such investigation would require careful consideration of the lessons learned during this trial intervention, which are categorised and discussed below.

8.5.6.1 Recruitment

Providing participants with adequate information about the study they are engaging in is both ethically and practically important. However there must always be a balance between providing sufficient information (for example, to enable fully informed consent) and ensuring that the provision of this information does not itself confound any analysis of the study's results. A simple, common example: participants are not typically informed that they are in a control group. In one sense this might be seen as a mild deception. However it is one that is

almost universally seen as acceptable and necessary to enable many kinds of valid analysis.

In this case, participants were informed that they would be participating in a study of fish consumption behaviour. They were not told that the study would endeavour to influence their consumption and, critically, they were not asked to engage with the socially connected features of the application to any particular extent. It may have been advantageous to explain to intervention group participants that they were invited to participate in the discussions, and encouraged to explore the various tools in the application. Care would be required to ensure that undue influence was not brought to bear on participant behaviour.

A redefinition of the target population and, therefore, the sample selection criteria may also be appropriate. Among Australian adults, the only individuals excluded from participation in the trial intervention were those who ate no fish at all, and those without access to a compatible mobile device. Furthermore, a relatively low bar was set for identifying active fish consumers: anyone who had consumed fish at least once in the previous three months was eligible to participate. This meant that the study sample comprised individuals across the full spectrum of fish consumption: those who ate fish less than once per fortnight, to those who ate it more than three times per week. This was a deliberate decision; one of the goals of the intervention was to facilitate the support of less confident consumers by those with more experience.

Perhaps more importantly, the sample comprised individuals with a wide range of different attitudes to their own consumption. Many participants expressed a desire to increase their fish consumption (or, at least, said they thought they should ideally eat more fish than they currently did, which is not quite the same thing). However, around a quarter said that they were satisfied with their current consumption level. In retrospect, this created an unnatural application-use scenario: an individual who did not feel any desire to increase their fish

consumption would be unlikely to choose to download and use an application intended to do exactly that.

Given that such individuals would be unlikely to use and be influenced by this application, it is recommended that any future intervention consider limiting the target population to those individuals who wish to increase their fish consumption. This is perhaps a counter-intuitive recommendation. Why target only those individuals who want to increase their consumption, and what about those who do not? Firstly, on the basis of the formative data collected in this and other studies, a target population of individuals who wish to increase their fish consumption may still comprise a majority of the general population.^{75, 109, 110} Furthermore, many health interventions take this approach, acknowledging that different strategies are required to influence individuals at different stages in the behaviour change process. As discussed in Section 5.2.3, the transtheoretical model in particular is salient to this strategy. This recommendation does not imply that no intervention is appropriate to individuals who do not intend to increase their fish consumption, but rather that *this particular intervention* probably is not.

8.5.6.2 Collection of consumption data

Participants were asked to make a record in the application each time they ate fish, for the duration of the 12-week study. From the observed data, and participants' metaanalysis of their own behaviour in the post-study questionnaire, it was clear that many participants' record of their own consumption became erratic as the study progressed. If a given participant made a number of entries in the first four weeks, then none in the last eight, this may have been a correct record of their fish consumption (probably unlikely), or it may have indicated that the participant simply forgot or chose not to open the application. The design of the trial intervention did not make it possible to differentiate accurately between these two scenarios.

An alternative data collection strategy may have been to require participants to enter a small amount of information about each of their meals, for every day of

the study period. For example, they could have been asked to enter the main protein component of each meal (beef, chicken, pork, fish or vegetable). The requirement to consistently enter information for each meal, rather than just fish meals, would make it much easier to identify the true attrition rate for the study. This approach would have the added benefit of masking the true intent of the study. In this trial intervention, control group participants knew they were engaged in a study of fish consumption, and the act of recording their fish consumption almost certainly had an influence on their behaviour. Indeed, around a quarter of control group participants (27.5%, n = 11) said, in the post-questionnaire, that the act of recording their consumption had made them want to eat more fish. This proposed approach would mean that participants could be informed that they were participating in a more general study of nutrition, and it may have been possible to collect control data from a sample that was more likely to eat according to their regular habits, and less likely to be subject to observation effects.⁴⁴⁹ It is strongly recommended that a future study adopt these, or similar, modifications to the study design.

8.5.6.3 The experimental application

Participants were generally positive about the experimental application, in most cases saying that they found it intuitive and easy to use. Three in five intervention group participants (71.1%, n = 27) said that they believed the application had at least some impact on their fish consumption (although this was not always supported by the data collected).

Participants' criticism of the application was mostly focused on the mechanics of entering fish consumption information, and most of this was specifically about the requirement of adding photos of fish meals. As previously noted, this requirement was added as a means of validating the data entered. Furthermore, participants were only able to add a photo directly from the device camera; they were not able to add a previously taken photograph. This was a deliberate decision intended to encourage participants to enter information as closely as possible to the time at which they consumed the meal. In reality, it created a small window of

opportunity for participants to enter the information required. Entering all of the necessary information, including the photograph, was a task that took perhaps a minute or two. However, the moment to enter this information (after the meal was prepared and plated, but before eating it) is in most cases not an ideal time to stop and spend a minute or two engaging with a mobile phone application. It may be a time at which a parent is marshalling the family to the dinner table, while the food is getting cold. If the individual is eating out, for example at a restaurant, it may be socially awkward to complete this task before eating the meal. Furthermore, if the individual was participating in the study using a tablet computer, they did not always have the computer with them, making it impossible to enter the information at the time.

It is recommended that a future expanded study consider whether the added validation value of recording photographs of consumed meals justifies the additional participant burden. It is further recommended that, if the photograph requirement is retained, participants be enabled to add photographs either directly from the device camera, or from the device's photo library. Encouraging contemporaneous data entry is an important goal, in that it reduces the potential for memory effects and other issues associated with recording events after they occur.^{232, 238} However, if our efforts to this end result in participants being less likely to enter data at all, then those efforts are in vain. We can control for the problems associated with late data entry. We can do nothing to examine data that we were unable to collect in the first place.

A number of participants said that they found it difficult to navigate the fish diary component of the application, particularly with respect to entering the species of fish they had consumed. In developing the application, considerable attention was given to the presentation of information in the species guide tool. Users could filter species by type (fish or seafood), search for a species by name, and mark favourites for quick reference. However the diary component, in which users recorded their fish consumption, was effectively a standalone application housed within the main application. This was in many respects a pragmatic decision, based on the knowledge that this tool would need to be separated cleanly from

the main application, to enable control group users to be provided with a data entry tool that was identical to the one being used by the intervention group. If not for this consideration, several conveniences could have been added – for example, users may have been able to find a species in the species guide, using the filter or search functionality, tap a button to automatically populate the diary tool with a meal containing that species, then only have to complete the other data fields.

Consequently, the presentation of information in the data entry tool was limited. Users were required to find species names by scrolling in a long alphabetically ordered list, with no ability to search or quickly access previously used species. It is recommended that a future study incorporate added search, filtering or favouriting functionality in the diary tool. It is also recommended that consideration be given to a recommendation by some users to change the ordering of species names. The experimental application ordered species alphabetically by the first letter of their full marketing name. So, for example, species of prawn (banana prawn, king prawn and tiger prawn) would be placed at various points through the list. Grouping these species and ordering them by the common form of the taxon (prawn, banana; prawn, king; prawn, tiger) may make species selection simpler for participants.

A small number of participants went beyond identifying features or application components they believed could be improved, and offering more general feedback on the content and scope of the application as a whole. These participants opined that the application might have been too broad in scope, covering too many aspects of fish consumption information. One of the primary purposes of this trial intervention was to identify the most appropriate, and effective, information to present to users. An initial list of potential features and functionality was created on the basis of a review of literature described in Chapters 2 and 3 and the focus group study described in Chapter 6. This list, which included such diverse items as sustainability and other environmental information, seasonality guides, daily specials from fish outlets, and direct communication with fish suppliers, was reduced to a smaller feature set to be

included for testing in this trial intervention. Further reduction would be required to turn this experimental application into a tool that was appropriate for public release.

There is a tension in the use of experimental applications in trial interventions like the one described here, between what is best for a study and what is best for the application itself. Researchers may wish to include a larger subset of functionality for testing purposes, to identify which components are effective and should be retained. However, the inclusion of all this information may render the application itself less usable, impacting on the results of the trial. It is recommended that a future study investigate other options for testing expanded feature sets including A/B testing, where different users are presented with different configurations of the application. This approach, which is common in commercial application development⁴⁵⁸ may enable researchers to examine the effectiveness of a range of different features and information sets, while still ensuring that individual participants receive an application that is not overwhelming in its presentation of large amounts of information.

On the basis of the data collected in this trial, the two components of the application of most interest and benefit to participants were the species guide and the health section. Participants generally said that they trusted the information in these sections; in fact, the level of trust reported for these two sections was identical. This is noteworthy because of the different provenance of the information in these two sections: the species guide contained crowdsourced information and opinions, while the health section contained evidence-based information overtly attributed to a university research centre. While participants described a similar level of trust in these sections, twice as many felt that the health section had an impact on their consumption. Again, this was not always supported by the data: some participants who said the health information had an impact on their consumption did not, in fact, read very much of it. It is possible that some participants answered these questions on the basis of what seemed likely: "I care about my health, so of course health information would have an

impact on me.” This study is certainly not the first to suspect such a phenomenon, commonly known as confirmation bias.⁴⁵⁹

The section that appeared to be of least interest and benefit to participants was the outlet guide, or *Fish Finder* as it was called in the application. Most participants simply did not use this section, beyond initially looking at it when exploring the application after first installing it. Many focus group participants mentioned the lack of options for buying good quality fish in their local area. They also spoke of the difficulty of making extra trips to dedicated fish outlets, if they did not consider the quality to be sufficiently high at places where they did the bulk of their shopping. For many consumers the added inconvenience and (possibly) extra cost may mean that a dedicated fish retailer is never a realistic option. Working to improve the quality, variety and availability of fish and seafood at supermarkets may be more effective in encouraging regular, long-term consumption for large segments of the population, than highlighting the existence of well-regarded outlets, as this application endeavoured to do.

8.5.6.4 Gamification

As noted in Section 3.4.9, *gamification* refers to the addition of game-like elements into applications that are not games, to promote user engagement. This section further notes that there is a growing body of evidence for the efficacy of this approach in promoting health behaviour change. However at the time in which this experimental application was in development, both the term and the strategy were relatively new, and published studies into its use were still forthcoming. No explicit gamification elements were included in the experimental application used in this study, although the presentation of graphs showing users their consumption over time might be considered a simple form of gamification.

Given the increased popularity of this approach, and the growing evidence that it may be of value in health promotion, it may be worth considering including more explicit forms of gamification in a future version of *Pier 2 Peer*. This could take the form of achievements, such as badges, for consuming recommended serves of

fish or levels of omega-3. The application could also incorporate leaderboards, showing users who have managed to consume recommended levels of fish over time. While these examples are commonly used in a range of health, fitness and goal tracking applications, they may be considered somewhat contrived for the purpose of encouraging fish consumption, and it may be necessary to give further thought to innovative forms of gamification that make sense for this endeavour.

However, it is important to note that nothing in the data collected in this study, either directly in the application or via user surveys, directly indicates that gamification may be effective for encouraging fish consumption. This recommendation is made purely on the basis of its apparent efficacy in other health-related fields.

8.5.6.5 Features for parents

Some participants in the focus group study mentioned the difficulty of preparing fish that was acceptable to children, and some of the literature discussed in Section 2.2.2 suggests that these difficulties may play a significant role in overall consumption levels for parents and families. Some advice for parents was included in the experimental application, in the form of species information. For example, some species were marked as being typically free of bones when filleted, and therefore suitable for small children. However, this information was piecemeal; there was no single section of the application providing easy access to information targeted at parents and children.

It may be appropriate to address this in a future update to the application by providing more direct support for parents. The Centre of Excellence for Science, Seafood and Health has developed a number of resources for parents and children, including seafood-focused educational games⁴⁶⁰ and child-friendly recipes,⁴⁶¹ and these may be a useful starting point for such functionality.

8.5.6.6 Summary of recommendations

These recommendations are made for further evaluation of this intervention:

- Consider limiting the target population to those individuals who wish to increase their fish consumption.
- Inform intervention group participants at the outset of the study that they are involved in a study of a socially-connected application, and encouraged to participate in all the features of the application (not just to record their fish consumption).
- Rather than only requiring participants to enter information for fish meals, require a brief entry for every meal, noting the main protein component (beef, chicken, pork, fish or vegetable).
- Remove the requirement for participants to add photos of their fish meals.
- Alternatively if photographic validation is retained, enable uploading images from the device photo library, rather than solely from the camera.
- Incorporate search, filtering or favouriting functionality in the diary tool.
- Change the ordering of species names both in the diary tool and species guide, so that they are ordered first by the common form of the taxon (e.g. prawn, banana; prawn, king; prawn, tiger).
- Consider gamification as a means of encouraging engagement and social connectivity
- Consider the addition of functionality specifically targeted at parents
- Consider tightening the focus of the experimental application by removing the fish outlet guide (i.e. focus on species selection, cooking and health)
- Alternatively, retain all current application functionality and further explore differential effectiveness by more extensive A/B testing.

9

Study discussion, recommendations and conclusion

9.0 Study discussion, recommendations and conclusion

9.1 Objectives

This study was ambitious. At a time in which a great many health-related applications are being brought quickly to market, this study sought to add to the evidence base for effective evaluation of such applications. Can behaviour change associated with application use be measured, and can an application be dissected to identify which of its components have the greatest impact on behaviour? While it would have been possible to undertake an impact evaluation of existing applications, developing a novel application from the ground up provided the best opportunity for full control over the features and functionality of the application, and over the manner in which data could be collected. The subject of investigation further necessitated the decision to build an entirely new application: while there are myriad applications for fitness, disease management and general nutrition, none currently exist for promotion of fish consumption in the manner investigated here.

With so many facets and considerations, this study sought clarity of focus from the model for complex interventions developed by the MRC.^{350, 399} The study would comprise the first three phases of this model. A first, theoretical phase would examine the literature to provide guidance to the development of the application, and grounding within a theoretical framework. A second modelling phase would further refine the application and intervention, on the basis of qualitative data sought from focus groups. Finally, a trial intervention would seek to provide an estimate of the application's effectiveness in eliciting behaviour change, and practical guidance for a future RCT.

In very simple terms, the study sought to do three things:

1. To plan an application to encourage fish consumption, based on evidence from literature and focus group participants
2. To build that application
3. To test whether that application achieved its purpose

9.1.1 Planning

A great many factors *could* encourage individuals to eat fish more regularly. Some of these factors are entirely outside of the control of any researcher or, indeed, any person. For example, the cost of fish, or the possibility of encountering small bones when eating it. That said, most of these factors can at least be mitigated; individuals may be introduced to less expensive species and taught how to prepare them effectively, or to species that, when filleted, are less likely to contain small bones.

The specific barriers and drivers for fish consumption differ greatly from one individual to another. This is perhaps the most common observation in the fish consumption literature, and one that was supported by the qualitative data collected in the focus group component of this study. It would be practically impossible to create an application or, indeed any other kind of intervention, which addressed every conceivable barrier to consumption for every kind of person. As with so many public health initiatives, a utilitarian approach is called for, to find the most effective and efficient balance between the things an intervention might attempt to do, and what it might realistically achieve. In this case that utilitarian approach meant compiling a list of barriers to consumption, and determining which of those barriers might be effectively addressed by a mobile application.

Acknowledgement of the individual differences in fish consumption, and the complex interplay of factors which might influence that consumption, led to the grounding of this study in the behavioural perspective model.³⁹⁶ This consumer

psychology model sees behaviour as the result of the particular mix of positive and negative experiences the individual has experienced in relation to the target behaviour – their *learning history*. Those experiences are seen as either practical, tangible results of purchasing behaviour (for example, using a product one has bought, or being satiated by a food one has consumed), or less-tangible feedback, real or imagined, from other people (for example, admiration for having purchased a desirable brand, or censure for having purchased one that is bad for the environment). This framework enabled a further refinement of the list of potential avenues for investigation: in what ways could a mobile application, and the virtual community underlying it, play a role in changing an individual's learning history, in changing the proportion of reinforcement to punishment accruing from their fish consumption?

The BPM was a useful framework for summarising and categorising the data collecting during focus groups. Its constructs enabled a semi-quantitative analysis of barriers and drivers to fish consumption, based on relative occurrence of positive and negative experiences with fish. Concepts such as individual learning history and situational behavioural determinants seemed particularly well suited to the behaviour under investigation. The BPM categorises reinforcement into utilitarian and informational categories and, as discussed in Section 6.4.1, it was at times difficult to delineate the informational reinforcement that surrounds fish consumption. Recall that informational reinforcement does not pertain to the receipt of information *per se*, but rather the receipt of feedback on a purchase (say, from family members, or health professionals, or the media). The information that a consumer seeks about a product (for example, in this case, asking a fishmonger for advice) does not constitute reinforcement at all, given that it occurs before purchase and consumption – in operant conditioning reinforcement, by definition, occurs after behaviour. This advice and information acts as a kind of precursor to later utilitarian reinforcement (or punishment), in that it makes one more likely than the other, depending on the quality of the advice. The BPM does not explicitly consider these dynamics.

The MRC has this advice for researchers seeking to model complex interventions:

Modelling is concerned with unravelling and distinguishing the key components in a complex intervention...The most challenging part of evaluating a complex intervention - and the most frequent weakness in such trials - is defining the actual intervention, that is, standardising the content and the delivery of the intervention by determining the critical components of the intervention, and how they relate to, and impact on, each other. It is essential to clarify as far as possible the important components, partly in order to devise protocols for the trial itself and partly so that readers of eventual trial results can infer from results what elements were essential and what secondary or unimportant in producing a beneficial effect.³⁹⁹

In this instance, the modelling phase was highly instructive in taking a broad array of potential avenues for investigation, and defining a specific tool to take forward into development and evaluation. It could be argued, on the basis of the trial data and participant feedback, that the tool could have been scoped even more narrowly than it was. A future study would need to carefully consider whether to make use of the full experimental application trialled here, or to reduce its functionality. While there may be sufficient evidence here to warrant culling the least used and effective components of the application, there may also be value in subjecting the full application to a larger investigation, with modifications to the study design to better evaluate the impact of its various components.

9.1.2 Development

Having isolated the subset of fish consumption barriers and drivers to be targeted, a mobile application was designed and developed. The application was built, refined, tested and optimised over the course of 12 months, before being empirically evaluated. Shortly before the start of this trial, the application was overhauled visually to bring it into line with modern design trends. Feedback both from initial beta testers and trial participants suggested that the application was

visually appealing, intuitive and responsive. No significant usability issues were identified.

Application design is in many ways a subjective endeavour, particularly in terms of visual design and user experience (UX). It is also one that is subject to rapidly changing trends. Those seeking to make use of mobile applications in health interventions may not always realise the importance of these trends but, if they fail to heed them, they do so at their peril. The mobile application landscape has matured rapidly since its inception in 2007, and users now expect a high level of quality, even in free applications. A researcher may have something of an advantage in that their participants are to some extent required to use their application. However, if that application looks and operates very differently to other applications they use (and, particularly, if the experimental application appears dated, or is slow or unintuitive) this will almost certainly have a bearing on that individual's level of engagement.

Moreover it is not just visual design that changes quickly, but also the underlying mobile operating system (OS) of the various platforms, and their application programming interfaces (APIs). The two major mobile operating systems, Android and iOS, receive major updates on an annual basis. This presents both opportunities and challenges for developers and, by extension, for health researchers seeking to make use of mobile technology. Each update brings new functionality and opportunities to leverage new device components. Each year the APIs provided by OS stewards like Google and Apple give developers deeper access to the device system, and greater assistance in optimally accessing this system; each year developers are able to make their applications faster, more versatile, and more powerful. In most cases developers are not obliged to make use of the latest advances, or to optimise their applications for new OS versions. However, this is yet another way in which applications may quickly stagnate in comparison to others that are quicker to adapt. Furthermore, in some cases developers may have no choice but to adapt, as new OS releases may cause minor or major issues with older applications.

The rapidly changing state of the art in application design and development creates a significant issue, both for those implementing a further investigation of the experimental application discussed here, and for those evaluating any application over an extended period of time. An application cannot remain stagnant. Or, at least, an application's effectiveness is surely tied to the degree to which it is allowed to stagnate. Further evaluation of this experimental application would require at least some degree of redevelopment, and the extent of the redevelopment required would depend of the time gap between studies. These factors would also be an issue for researchers seeking to evaluate an application over an extended period (say, over a year or more).

However, while evolution and redevelopment may solve at least some problems with respect to user acceptability, they create others from a scientific perspective. Any modifications to an application mid-study would create confounding variables that would need to be accounted for in any statistical analyses. These factors are highly subjective; it is very hard to quantify the extent to which an application adheres to modern design trends, or makes best use of current APIs. Yet these variables cannot be accounted for if they cannot be properly quantified. While leaving an application unchanged for the duration of a study may seem at first glance to be the best option, scientifically, doing so creates another set of potentially confounding variables, if the study is long. Participants at the start of the study are (presumably) using an application that is modern, up-to-date, and compares well with other applications they are familiar with. As the study wears on, this may be less and less the case, particularly if one or more major OS updates occur mid-study.

The already fast pace of change will only become faster in the coming years, and these issues will become more and more important for health researchers using mobile technology. There would be great value in empirical investigations of the link between design, user experience, user acceptability and outcomes in health-related mobile applications, and between application stagnation and user engagement. A framework for measuring, quantifying and controlling for the

impact of changing an application, and guidelines for doing so with minimal experimental impact, would be of considerable benefit.

9.1.3 Evaluation

The outcomes of the trial evaluation, including its methodological problems, were documented thoroughly in Chapter 8. Recommendations for further study were outlined, with particular reference to modifications in recruitment, communication and data collection.

Empirical evaluation of mobile health applications has been lacking, particularly in those that are commercially available. This is a problem that grows in proportion to the popularity of such applications. A report on mHealth industry economics in 2014 estimated that there were 100 000 health and fitness mobile applications on the iOS and Android platforms, a market estimated to be worth US\$4 billion at the time, and predicted to rise to US\$26 billion by 2017.⁴⁶² As more and more health applications come to market, purporting to offer deeper insights into people's health, effective evaluation of the impact of health application usage will only become more important.

Testing a new application is very different to testing, say, a new pharmaceutical product. In many cases there may be a pressing human need to bring a drug to market, particularly if it is for a disease for which there are currently no effective treatments. However, if its testing takes many months or even years, the drug will not have become less effective in the interim. This is not the case with mobile applications, which may date and lose user acceptability in a short space of time. Researchers simply do not have the luxury of evaluating applications over extended periods of time. In the case of commercial health application developers, there are even stronger commercial imperatives associated with bringing products quickly to market.

Effective evaluation of mobile health applications will require innovation in study design. One strategy may be to adopt some of the testing practices of commercial

application developers. We may think of these developers as rushing products to market (at least in comparison with the rigorous peer review evaluation required in the health sciences). However with significant money at play, and increasingly strong competition, rigorous testing is still very important in a commercial context. One difference is the iterative approach used for testing, with no clear demarcation between testing an application and releasing it for public use. A typical application will be checked by a private group of testers for correct operation and user acceptability, for a limited period of time. It will then be released publicly with the full expectation that, once it is being used by a significant number of people in a wide range of environments, additional software bugs and usability issues will come to light. These are then resolved over subsequent updates, with the product being refined over time in response to user feedback.

Clearly this approach would not be suitable for all kinds of health applications. Developers of diagnostic tools, or applications that collect data for clinical use, must be as sure as possible that these application function correctly before they allow users to access them. In some cases there may even be regulatory considerations. However in many public health and health promotion cases, the efficacy of an application's content may be well established, and it may only be the mode of delivery that requires testing and refinement, to understand the most effective means of delivering that content. The experimental application developed in this study clearly falls into this category. In these cases an iterative approach to development, testing and public release may well be both appropriate and effective.

This is another example of the importance of health researchers, and those planning health interventions, working closely with application developers at all stages of the development process. It is all too common for applications to be planned thoroughly by researchers, who then contract developers for a limited period of time to build the product they (the researchers) have designed, within the specific scope they have set. These applications may then be evaluated and

eventually released publicly, as “finished products”. However, software is never a finished product, a reality that is not always clearly understood.

This kind of collaborative, ongoing working model does not fit well with the funding structures currently in place for health research. Researchers or project managers must typically prepare detailed grant applications, tightly defining the project deliverables and proposed budget. If the grant is approved, the project will proceed with many constraints already in place, and by this point it may be difficult or impossible to make significant changes to the nature or scope of the application being proposed. The kind of iterative development and testing process described above is very difficult to budget for; project managers are far more likely to attempt to scope and budget and application fully in advance, and to build it in one development cycle.

Innovation is called for, not just among those developing health applications, but among those who provide the funding that enables this development. Small exploratory grants may enable researchers to build working partnerships with developers to better plan applications at an early stage, with deliverables such as scoping plans or prototypes. More flexible funding arrangements that provide options for extension, renewal or modification in response to outcomes may enable evidence-based health applications to adopt the iterative practices used to good effect by their commercial counterparts.

9.2 Conclusion

I have written here about the role of mobile devices and applications in health interventions, and the need to refine the tools with which they are designed, developed and evaluated. These observations and recommendations encompass many kinds of intervention, across many fields of public health. In this discussion of health applications, however, it is important not to lose sight of the specific purpose of the study reported here: to increase fish consumption.

While this goal was driven by health considerations, it is unlikely that participants in the study considered that they were using a *health* application. Or, at least, one that bore much resemblance to other health applications they may have been familiar with, such as fitness trackers or calorie counters. Both the literature outlined in Section 2.2 and the data gathered in this study's focus group research, indicate a complex relationship between individuals' health knowledge and fish consumption; while most people recognise the healthful properties of fish, their decision to eat it or otherwise does not always relate closely to that recognition. A common theme in the focus group study was that people chose to eat fish because they liked its taste or versatility, and saw the health benefits as a sort of "added bonus". Similarly, when people did not eat fish, it was often due to personal preferences or experiences, rather than a lack of awareness that it was good for them. In recognition of this, the experimental application developed here focussed on improving the experiential aspects of fish consumption, rather than knowledge of the health benefits. It may, perhaps, be thought of as health application dressed in other clothes.

While other groups have sought to use social media and mobile technology to increase fish consumption, evaluation of these endeavours has been limited to analysis of webpage visits, social interaction (such as 'likes', comments, or sharing of posts) or application downloads. While these metrics can provide some insight into engagement levels, the current study sought to go further, in developing an effective methodology for evaluating the impact of such an intervention on *actual fish consumption*.

It must be said, in plain terms, that this study did not find evidence of increased fish consumption for intervention participants, in comparison to a control group. This does not mean that such an increase did not occur, and some data collected point towards some interaction between application use and consumption. Although a clear association was not found, the beginnings of a framework for effective data collection and evaluation of mobile health applications were outlined.

Mobile health, or mHealth interventions share many features of their offline counterparts. They must be grounded in theory, built on the back of earlier research, and developed in close consultation with end users to ensure they meet real needs in a user-acceptable way. However, they are also different in many important respects. Researchers developing and evaluating health applications may need to work on a time schedule that is entirely different to that which they are accustomed to, to meet the demands of a fast-moving consumer landscape. They may need to find new methodologies to quickly and iteratively evaluate their work, perhaps by blurring the lines between evaluation and implementation, where safe and appropriate.

Most importantly, health practitioners will need to work more closely and deeply with professionals from a range of disciplines with which they have not traditionally been involved. Health promoters and public health professionals have for decades contracted marketers and graphic designers to take their information and create attractive resources for public use. In many cases, to date, they have taken the same approach with application developers: consolidating their ideas in isolation, before contracting developers to “do the coding”. It is increasingly apparent that this is not sufficient. Multi-disciplinary teams including health professionals, data scientists, developers and human interaction designers, brought together as closely as possible to the inception of a project, stand the greatest chance of creating digital interventions that may truly change behaviour.

References

References

1. McLeroy KR, Crump CE. Health promotion and disease prevention: a historical perspective. *Generations*. 1994;18(1):9-17.
2. McManus A, Howieson J, Nicholson C. Review of literature and resources relating to the health benefit of regular consumption of seafood as part of a healthy diet. Perth, WA: Centre of Excellence for Science, Seafood and Health; 2009.
3. NHMRC. Levels of evidence and grades for recommendations for developers of guidelines. Canberra: NHMRC; 2009.
4. Daviglius ML, Stamler J, Orenca AJ, Dyer AR, Liu K, Greenland P, et al. Fish consumption and the 30-year risk of fatal myocardial infarction. *N. Engl. J. Med.* 1997;336:1046-53.
5. He K, Song Y, Daviglius M, Liu K, Van Horn L, Dyer A, et al. Accumulated evidence on fish consumption and coronary heart disease mortality: a meta-analysis of cohort studies. *Circulation*. 2004;109:2705-11.
6. Hu F, Bronner L, Willett W, Stampfer M, Rexrode K, Albert C, et al. Fish and omega-3 fatty acid intake and risk of coronary heart disease in women. *J. Am. Med. Assoc.* 2002;287(14):1815-21.
7. Iso H, Rexrode KM, Stampfer MJ, Manson JE, Colditz GA, Speizer FE, et al. Intake of fish and omega-3 fatty acids and risk of stroke in women. *J. Am. Med. Assoc.* 2001;285(3):304 - 12.
8. Kaushik S, Wang JJ, Flood V, Liew G, Smith W, Mitchell P. Frequency of fish consumption, retinal microvascular signs and vascular mortality. *Microcirculation*. 2008;15(1):27-36.
9. Mozaffarian D, Bryson CL, Lemaitre RN, Burke GL, Siscovick DS. Fish intake and risk of incident heart failure. *J. Am. Coll. Cardiol.* 2005;45(12):2015-21.
10. Siscovick D, Raghunathan TE, King I, Weinmann S, Bovbjerg VE, Kushi L, et al. Dietary intake of long-chain n-3 polyunsaturated fatty acids and the risk of primary cardiac arrest. *Am. J. Clin. Nutr.* 2000;71(suppl):208S-12S.
11. Zampelas A, Panagiotakos D, Pitsavos C, Das U, Chrysohoou C, Skoumas Y, et al. Fish consumption among healthy adults is associated with decreased

- levels of inflammatory markers related to cardiovascular disease. *J. Am. Coll. Cardiol.* 2005;46:120-24.
12. Mozaffarian D, Lemaitre R, Kuller L, Burke G, Tracy R, Siscovick D. Cardiac benefits of fish consumption may depend on the type of fish meal consumed: the Cardiovascular Health Study. *Circulation.* 2003;107:1372-77.
 13. Mozaffarian D, Psaty BM, Rimm EB, Lemaitre R, Burke GL, Lyles MF, et al. Fish intake and risk of incident atrial fibrillation. *Circulation.* 2004;110(4):368-73.
 14. Foundation H. Heart Foundation position statement: fish, fish oils, n-3 polyunsaturated fatty acids and cardiovascular health [Internet]. 2008 [cited 2015 May 26]. Available from: <http://www.heartfoundation.org.au/SiteCollectionDocuments/Fish-position-statement.pdf>
 15. Ruxton CHS, Calder PC, Reed SC, Simpson MJA. The impact of long-chain n-3 polyunsaturated fatty acids on human health. *Nutr. Res. Rev.* 2005;18(1):113-29.
 16. Pedersen M, Stripp C, Klarlund M, Olsen SF, Tjønneland AM, Frisch M. Diet and risk of rheumatoid arthritis in prospective cohort. *J. Rheumatol.* 2005;32(7):1249-52.
 17. Lee YH, Bae SC, Song GG. Omega-3 polyunsaturated fatty acids and the treatment of rheumatoid arthritis: a meta-analysis. *Arch. Med. Res.* 2012;43(5):356-62.
 18. Di Giuseppe D, Crippa A, Orsini N, Wolk A. Fish consumption and risk of rheumatoid arthritis: a dose-response meta-analysis. *Arthritis Res. Ther.* 2014;16(5).
 19. Nafstad P, Nystad W, Magnus P, Jaakkola JJK. Asthma and allergic rhinitis at 4 years of age in relation to fish consumption in infancy. *J. Asthma.* 2003;40(4):343-48.
 20. Hodge L, Salome CM, Peat JK, Haby MM, Xuan W, Woolcock AJ. Consumption of oily fish and childhood asthma risk. *Med. J. Aust.* 1996;164:137-40.

21. Salam M, Li Y, Langholz B, Gilliland F. Maternal fish consumption during pregnancy and risk of early childhood asthma. *J. Asthma*. 2005;42(6):513-18.
22. He K, Rimm EB, Merchant A, Rosner BA, Stampfer MJ, Willett WC, et al. Fish consumption and risk of stroke in men. *J. Am. Med. Assoc*. 2002;288(24):3130-36.
23. He K, Song Y, Daviglius ML, Liu K, Van Horn L, Dyer AR, et al. Fish consumption and incidence of stroke: a meta-analysis of cohort studies. *Stroke*. 2004;35:1538-42.
24. Mozaffarian D, Longstreth W, Lemaitre R, Manolio T, Kuller L, Burke G, et al. Fish consumption and stroke risk in elderly individuals. *Arch. Intern. Med*. 2005;165(2):200-06.
25. Myint PK, Welch AA, Bingham SA, Luben RN, Wareham NJ, Day NE, et al. Habitual fish consumption and risk of incident stroke: the European Prospective Investigation into Cancer (EPIC) - Norfolk prospective population study. *Public Health Nutr*. 2006;9(7):882-88.
26. Terry P, Lichtenstein P, Feychting M, Ahlbom A, Wolk A. Fatty fish consumption and risk of prostate cancer. *The Lancet*. 2001;357(9270):1764-66.
27. Augustsson K, Michaud DS, Rimm EB, Leitzmann MF, Stampfer MJ, Willett WC, et al. A prospective study of intake of fish and marine fatty acids and prostate cancer. *Cancer Epidemiol. Biomarkers Prev*. 2003;12:64-67.
28. Zhang J, Temme EHM, Kesteloot H. Fish consumption is inversely associated with male lung cancer mortality in countries with high levels of cigarette smoking or animal fat consumption. *Int. J. Epidemiol*. 2000;29:615-21.
29. Geelen A, Schouten JM, Kamphuis C, Stam BE, Burema J, Renkema JMS, et al. Fish consumption, n-3 fatty acids and colorectal cancer: a meta-analysis of prospective cohort studies. *Am. J. Epidemiol*. 2007;166(10):1116-25.
30. Norris J, Yin X, Lamb M, Barriga K, Seifert J, Hoffman M, et al. Omega-3 polyunsaturated fatty acid intake and islet autoimmunity in children at increased risk for type 1 diabetes. *J. Am. Med. Assoc*. 2007;298(12):1420-28.

31. Kannel WB, McGee DL. Diabetes and glucose tolerance as risk factors for cardiovascular disease: the Framingham Study. *Diabetes Care*. 1979;2(2):120-26.
32. Hu FB, Cho E, Rexrode KM, Albert CM, Manson J, E. Fish and long-chain n-3 fatty acid intake and risk of coronary heart disease and total mortality in diabetic women. *Circulation*. 2003;107:1852-57.
33. Biesalski H. Diabetes preventive components in the Mediterranean diet. *Eur. J. Nutr.* 2004;43(1):i26-i30.
34. Martínez-González MÁ, Fuente-Arrillaga CdL, Nunez-Cordoba JM, Basterra-Gortari FJ, Beunza JJ, Vazquez Z, et al. Adherence to Mediterranean diet and risk of developing diabetes: prospective cohort study. *Br. Med. J.* 2008;336(7657):1348.
35. Feskens EJM. Mediterranean diet and type 2 diabetes risk in the European Prospective Investigation into Cancer and Nutrition (EPIC) study: the InterAct project. *Diabetes Care*. 2011;34(9):1913-5992.
36. Olsen SF, Secher NJ. Low consumption of seafood in early pregnancy as a risk factor for preterm delivery: prospective cohort study. *Br. Med. J.* 2002;324(7335):447-50.
37. Nichols PD, Petrie J, Singh S. Long-chain omega-3 oils – an update on sustainable sources. *Nutrients*. 2010;2(6):572-85.
38. van Eijsden M, Hornstr G, van der Wal M, Vrijkotte T, Bonsel G. Maternal n-3, n-6, and trans fatty acid profile early in pregnancy and term birth weight: a prospective cohort study. *Am. J. Clin. Nutr.* 2008;87:887-95.
39. Oken E, Østerdal ML, Gillman MW, Knudsen VK, Halldorsson TI, Marin S, et al. Associations of maternal fish intake during pregnancy and breastfeeding duration with attainment of developmental milestones in early childhood: a study from the Danish National Birth Cohort. *Am. J. Clin. Nutr.* 2008;88:789–96.
40. Hibbeln JR, Davis JM, Steer C, Emmett P, Rogers I, Williams C, et al. Maternal seafood consumption in pregnancy and neurodevelopmental outcomes in childhood (ALSPAC study): an observational cohort study. *The Lancet*. 2007;369(9561):578-85.

41. Logan AC. Omega-3 fatty acids and major depression: a primer for the mental health professional. *Lipids Health Dis.* 2004;3(25):1-8.
42. Tanskanen A, Hibbeln JR, Tuomilehto J, Uutela A, Haukkala A, Viinamäki H, et al. Fish consumption and depressive symptoms in the general population in Finland. *Psychiatr. Serv.* 2001;52(4):529-31.
43. Silvers KM, Scott KM. Fish consumption and self-reported physical and mental health status. *Public Health Nutr.* 2002;5(03):427-31.
44. Albert CM, Hennekens CH, O'Donnell CJ, Ajani UA, Carey VJ, Willett WC, et al. Fish consumption and risk of sudden cardiac death. *J. Am. Med. Assoc.* 1998;279(1):23-28.
45. Mozaffarian D, Rimm EB. Fish intake, contaminants, and human health: evaluating the risks and the benefits. *J. Am. Med. Assoc.* 2006;296(15):1885-99.
46. Yuan J, Ross R, Gao Y, Yu M. Fish and shellfish consumption in relation to death from myocardial infarction among men in Shanghai, China. *Am. J. Epidemiol.* 2001;154:809-16.
47. Din JN, Newby DE, Flapan AD. Omega 3 fatty acids and cardiovascular disease—fishing for a natural treatment. *Br. Med. J.* 2004;328(7430):30-35.
48. Hu FB, Bronner L, Willett WC, Stampfer MJ, Rexrode KM, Albert CM, et al. Fish and omega-3 fatty acid intake and risk of coronary heart disease in women. *Journal of the American Medical Association.* 2002;287(14):1815-21.
49. Kris-Etherton PM, Harris WS, Appel LJ. Fish consumption, fish oil, omega-3 fatty acids, and cardiovascular disease. *Arterioscler. Thromb. Vasc. Biol.* 2003;23(2):e20-e30.
50. Mozaffarian D, Psaty BM, Rimm EB, Lemaitre RN, Burke GL, Lyles MF, et al. Fish intake and risk of incident atrial fibrillation. *Circulation.* 2004;110(4):368-73.
51. Holman RT. The slow discovery of the importance of ω 3 essential fatty acids in human health. *J. Nutr.* 1998;128(2):427S-33S.
52. McManus A, Merga M, Newton W. Omega-3 fatty acids. What consumers need to know. *Appetite.* 2011;57(1):80-83.

53. Dyerberg J, Madsen P, Møller JM, Aardestrup I, Schmidt EB. Bioavailability of marine n-3 fatty acid formulations. *Prostaglandins Leukot. Essent. Fatty Acids*. 2010;83(3):137-41.
54. Garg ML, Wood LG, Singh H, Moughan PJ. Means of Delivering Recommended Levels of Long Chain n - 3 Polyunsaturated Fatty Acids in Human Diets. 2006;71(5):R66-R71.
55. McManus A, Newton W. *Seafood, nutrition and human health: a synopsis of the nutritional benefits of consuming seafood*. Perth, WA: Centre of Excellence for Science, Seafood and Health; 2011.
56. Environmental Protection Agency. How people are exposed to mercury [Internet]. 2014 [cited 2015 May 27]. Available from: <http://epa.gov/hg/exposure.htm>
57. Lando AM, Fein SB, Choinière CJ. Awareness of methylmercury in fish and fish consumption among pregnant and postpartum women and women of childbearing age in the United States. *Environ. Res.* 2012;116:85-92.
58. Engelberth H, Teisl MF, Frohberg E, Butts K, Bell KP, Stableford S, et al. Can fish consumption advisories do better? Providing benefit and risk information to increase knowledge. *Environ. Res.* 2013;126(0):232-39.
59. Oken E, Kleinmn KP, Berland WE, Simon SR, Rich-Edwards JW, Gillman MW. Decline in fish consumption among pregnant women after a national mercury advisory. *Obstet. Gynecol.* 2003;102(2):346-51.
60. World Health Organization. Report of the Joint FAO / WHO expert consultation on the risks and benefits of fish consumption. Geneva: World Health Organization; 2011.
61. US Food and Drug Administration. Summary of published research on the beneficial effects of fish consumption and omega-3 fatty acids for certain neurodevelopmental and cardiovascular endpoints [Internet]. 2009 [cited 2014 Mar 31]. Available from: <http://www.fda.gov/Food/FoodbornIllnessContaminants/Metals/ucm153051.htm>

62. US Department of Agriculture, US Department of Health and Human Services. Dietary guidelines for Americans. Washington, DC: U.S. Government Printing Office; 2010.
63. French Food Safety Agency. Opinion of the French Food Safety Agency regarding the benefits/risks of fish consumption [Internet]. 2012 [cited 2014 Dec 5]. Available from: <https://www.anses.fr/en/content/opinion-french-food-safety-agency-regarding-benefitsrisks-fish-consumption-0>
64. Food Standards Australia New Zealand. Mercury in fish [Internet]. 2011 [cited 2011 Oct 29]. Available from: <http://www.foodstandards.gov.au/consumerinformation/mercuryinfish.cfm>
65. Hicks D, Pivarnik L, McDermott R. Consumer perceptions about seafood - an Internet survey. *J. Foodservice*. 2008;19(4):213-26.
66. Pieniak Z, Verbeke W, Olsen SO, Hansen KB, Brunsø K. Health-related attitudes as a basis for segmenting European fish consumers. *Food Policy*. 2010;35(5):448-55.
67. Pieniak Z, Verbeke W, Perez-Cueto F, Brunso K, De Henauw S. Fish consumption and its motives in households with versus without self-reported medical history of CVD: a consumer survey from five European countries. *BMC Public Health*. 2008;8:306-19.
68. Foxall G, Leek S, Maddock S. Cognitive antecedents of consumers' willingness to purchase fish rich in polyunsaturated fatty acids (PUFA). *Appetite*. 1998;31(3):391-402.
69. Verbeke W, Sioen I, Pieniak Z, Van Camp J, De Henauw S. Consumer perception versus scientific evidence about health benefits and safety risks from fish consumption. *Public Health Nutr*. 2005;8(4):422-29.
70. Verbeke W, Vanhonacker F, Frewer LJ, Sioen I, De Henauw S, Van Camp J. Communicating risks and benefits from fish consumption: impact on Belgian consumers' perception and intention to eat fish. *Risk Anal*. 2008;28(4):951-67.

71. Brunso K, Verbeke W, Olsen SO, Jeppesen LF. Motives, barriers and quality evaluation in fish consumption situations: exploring and comparing heavy and light users in Spain and Belgium. *Brit. Food J.* 2009;111(7):699-716.
72. Fischer ARH, Frewer LJ. Consumer familiarity with foods and the perception of risks and benefits. *Food Qual. Prefer.* 2009;20(8):576-85.
73. Moura APd, Cunha LM, Castro-Cunha M, Lima RC. A comparative evaluation of women's perceptions and importance of sustainability in fish consumption. *Manag. Environ. Qual.* 2012;23(4):451-61.
74. Verbeke W. Perceived importance of sustainability and ethics related to fish: a consumer behavior perspective. *Ambio.* 2007;36(7):580-85.
75. Leek S, Maddock S, Foxall G. Situational determinants of fish consumption. *Brit. Food J.* 2000;102(1):18-39.
76. Verbeke W, Vackier I. Individual determinants of fish consumption: application of the theory of planned behaviour. *Appetite.* 2005;44(1):67-82.
77. Honkanen A, Setälä J, Eerola E. Behavioural patterns related to Finnish fish consumption: an analysis of demographic characteristics. In: *Proceedings of the IIFET Conference; 1998 July 8-11; Tromso, Norway.*
78. Olsen SO. Consumer involvement in seafood as family meals in Norway: an application of the expectancy-value approach. *Appetite.* 2001;36(2):173-86.
79. Trondsen T, Scholderer J, Lund E, Eggen AE. Perceived barriers to consumption of fish among Norwegian women. *Appetite.* 2003;41(3):301-14.
80. Scholderer J, Grunert KG. Does generic advertising work? A systematic evaluation of the Danish campaign for fresh fish. *Aquaculture Econ. Manage.* 2001;5(5-6):253-71.
81. Rortveit AW, Olsen SO. Combining the role of convenience and consideration set size in explaining fish consumption in Norway. *Appetite.* 2009;52(2):313-17.
82. Rortveit AW, Olsen SO. The role of consideration set size in explaining fish consumption. *Appetite.* 2007;49(1):214-22.

83. Olsen SO. Understanding the relationship between age and seafood consumption: the mediating role of attitude, health involvement and convenience. *Food Qual. Prefer.* 2003;14(3):199-209.
84. Myrland Ø, Trondsen T, Johnston RS, Lund E. Determinants of seafood consumption in Norway: lifestyle, revealed preferences, and barriers to consumption. *Food Qual. Prefer.* 2000;11(3):169-88.
85. Juhl HJ, Poulsen CS. Antecedents and effects of consumer involvement in fish as a product group. *Appetite.* 2000;34(3):261-67.
86. Thorsdottir F, Sveinsdottir K, Jonsson FH, Einarsdottir G, Thorsd I, Martinsdottir E. A model of fish consumption among young consumers. *J. Consum. Market.* 2012;29(1):4-12.
87. Honkanen P, Olsen SO, Verplanken B. Intention to consume seafood - the importance of habit. *Appetite.* 2005;45(2):161-68.
88. Shimshack JP, Ward MB, Beatty TKM. Mercury advisories: information, education, and fish consumption. *J. Environ. Econ. Manage.* 2007;53(2):158-79.
89. Shimshack JP, Ward MB. Mercury advisories and household health trade-offs. *J. Health Econ.* 2010;29(5):674-85.
90. Cheng H, Capps O. Demand analysis of fresh and frozen finfish and shellfish in the United States. *Am. J. Agric. Econ.* 1988;70(3):543-52.
91. Jahns L, Raatz SK, Johnson LK, Kranz S, Silverstein JT, Picklo MJ. Intake of seafood in the US varies by age, income, and education level but not by race-ethnicity. *Nutrients.* 2014;6(12):6060-75.
92. Smith S, Varble S, Secchi S. Fish Consumers: environmental attitudes and purchasing behavior. *J. Food. Prod. Market.* 2015:1-17.
93. Herdt-Losavio ML, Lin S, Chen M, Luo M, Tang J, Hwang SA. Comparison of patterns and knowledge of benefits and warnings of fish consumption between parents and children. *Matern. Child Health J.* 2014;18(5):1258-64.
94. Burger J, Gochfeld M. Perceptions of the risks and benefits of fish consumption: individual choices to reduce risk and increase health benefits. *Environ. Res.* 2009;109(3):343-49.

95. Perez H, Sullivan ECMPH, Michael K, Harris R. Fish consumption and advisory awareness among the Philadelphia Asian community: a pilot study. *J. Environ. Health.* 2012;74(8):24-28.
96. Ruello and Associates Pty Ltd. The retail sale and consumption of seafood in Melbourne. Volume II. Consumer surveys and focus group findings. Melbourne, VIC: Fisheries Research and Development Corporation; 2005.
97. McManus A, Hunt W, Storey J, McManus J, Hilhorst S. Perceptions and preference for fresh seafood in an Australian context. *Int. J. Consum. Stud.* 2014;38(2):146-52.
98. Birch D, Lawley MA. The mental availability of seafood: an Australian consumer study. In: *Proceedings of the Academy of Marketing Conference; 2013 July 8-11; Cardiff, UK.*
99. Birch D, Lawley M. The role of habit, childhood consumption, familiarity, and attitudes across seafood consumption segments in Australia. *J. Food. Prod. Market.* 2013;20(1):98-113.
100. Lawley M, Birch D, Hamblin D. An exploratory study into the role and interplay of intrinsic and extrinsic cues in Australian consumers' evaluations of fish. *Australasian Marketing J.* 2012;20(4):260-67.
101. Birch D, Lawley M. Buying seafood: understanding barriers to purchase across consumption segments. *Food Qual. Prefer.* 2012;26(1):12-21.
102. Elizabeth PN, Amanda C, Yasmine CP, Marijka JB, Linda CT. Effectiveness of dietary advice to increase fish consumption over a 12-month period. *Food Nutr. Sci.* 2012;3(4):455-60.
103. Birch D, Lawley M, Hamblin D. Drivers and barriers to seafood consumption in Australia. *J. Consum. Market.* 2012;29(1):64-73.
104. McManus A, Burns SK, Howat PA, Cooper L, Fielder L. Factors influencing the consumption of seafood among young children in Perth: a qualitative study. *BMC Public Health.* 2007;7:119-26.
105. Wang F, Zhang J, Mu W, Fu Z, Zhang X. Consumers' perception toward quality and safety of fishery products, Beijing, China. *Food Control.* 2009;20(10):918-22.

106. Fabinyi M, Liu N. Seafood banquets in Beijing: consumer perspectives and implications for environmental sustainability. *Conservat. Soc.* 2014;12(2):218-28.
107. McKendree MGS, Ortega DL, Widmar NO, Wang HH. Consumer perceptions of seafood industries in the wake of the Deepwater Horizon oil spill and Fukushima Daiichi nuclear disaster. East Lansing, MI: Michigan State University; 2013.
108. Tuu HH, Olsen SO, Thao DT, Anh NTK. The role of norms in explaining attitudes, intention and consumption of a common food (fish) in Vietnam. *Appetite.* 2008;51(3):546-51.
109. Danenberg N, Remaud H. Omnibus consumer research findings. Adelaide, SA: University of South Australia; 2010.
110. Birch D, Lawley M. Repositioning Australian farmed barramundi: online consumer survey findings. Sunshine Coast, QLD: University of the Sunshine Coast; 2010.
111. Bredahl L, Grunert KG. Determinants of the consumption of fish and shellfish in Denmark: an application of the theory of planned behaviour. In: Luten JB, Børresen T, Oehlenschläger J, editors. *Seafood from producer to consumer: Integrated approach to quality.* Amsterdam: Elsevier; 1997. p. 21-30.
112. Gempe saw CM, Bacon, Jr., Wessells CR, Manalo A. Consumer perceptions of aquaculture products. *Am. J. Agric. Econ.* 1995;77(5):1306-12.
113. Rahmawaty S, Charlton K, Lyons - wall P, Meyer BJ. Factors that influence consumption of fish and omega-3 - enriched foods: a survey of Australian families with young children. *Nutr. Diet.* 2013;70(4):286-93.
114. Nordin S, Broman DA, Garvill J, Nyroos M. Gender differences in factors affecting rejection of food in healthy young Swedish adults. *Appetite.* 2004;43(3):295-301.
115. Siegrist M, Hartmann C, Keller C. Antecedents of food neophobia and its association with eating behavior and food choices. *Food Qual. Prefer.* 2013;30(2):293-98.

116. Spinks A, Bose S. Factors affecting households' seafood purchasing decisions in Auckland, New Zealand: an empirical analysis. *Int. J. Consum. Stud.* 2002;26(1):62-70.
117. Olsen SO, Scholderer J, Brunsø K, Verbeke W. Exploring the relationship between convenience and fish consumption: a cross-cultural study. *Appetite.* 2007;49(1):84-91.
118. Rahmawaty S, Lyons-Wall P, Batterham M, Charlton K, Meyer BJ. Food patterns of Australian children ages 9 to 13 y in relation to omega-3 long chain polyunsaturated intake. *Nutrition.* 2014;30(2):169-76.
119. Carlucci D, Nocella G, De Devitiis B, Viscecchia R, Bimbo F, Nardone G. Consumer purchasing behaviour towards fish and seafood products. Patterns and insights from a sample of international studies. *Appetite.* 2015;84:212-27.
120. Verbeke W, Vermeir I, Brunsø K. Consumer evaluation of fish quality as basis for fish market segmentation. *Food Qual. Prefer.* 2007;18(4):651-61.
121. Lawley MA, Birch D, Stanton J, Lang M, Laszlo V, editors. A Profile of the Australian Seafood Consumer. In: *Proceedings of the International Food Marketing Research Symposium; 2013 June 20-21; Budapest, Hungary*; p. 125-39.
122. Olsen SO. Antecedents of seafood consumption behavior. *J. Aquat. Food Prod. T.* 2004;13(3):79-91.
123. Fisheries Research and Development Corporation. Imported seafood in Australia [Internet]. 2011 [cited 27 May 2015]. Available from: http://frdc.com.au/knowledge/Factsheets/Factsheet_Imported_Seafood_in_Australia.pdf
124. Fisheries Research and Development Corporation. Fish prices and value: a marketing challenge [Internet]. 2010 [cited 2015 May 27]. Available from: <http://frdc.com.au/knowledge/Factsheets/Fact Sheet - Fish Prices and Value.pdf>
125. Grieger JA, Miller M, Cobiac L. Knowledge and barriers relating to fish consumption in older Australians. *Appetite.* 2012;59(2):456-63.

126. Council NRaD. Consumer guide to mercury in fish [Internet]. 2015 [cited 2015 May 27]. Available from:
<http://www.nrdc.org/health/effects/mercury/guide.asp>
127. Karagas MR, Mariën K, Rheinberger CM, Schoeny R, Oken E, Choi AL, et al. Which fish should I eat? Perspectives influencing fish consumption choices. *Environ. Health Perspect.* 2012;120(6):790-98.
128. Honkanen P, Olsen SO. Environmental and animal welfare issues in food choice. *Brit. Food J.* 2009;111(3):293-309.
129. Henry-Labordere A. SMS and MMS interworking in mobile networks. Norwood: Artech House; 2004.
130. Korhonen J. Deploying IPv6 in 3GPP networks: evolving mobile broadband from 2G to LTE and beyond. Chichester, UK: John Wiley & Sons; 2013.
131. Budmar P. Why Japanese smartphones never went global [Internet]. 2012 [cited 24 June 2015]. Available from:
http://www.pcworld.idg.com.au/article/430254/why_japanese_smartphones_never_went_global/
132. Walker G. A review of technologies for sensing contact location on the surface of a display. *J. Soc. Info. Disp.* 2012;20(8):413-40.
133. Amadeo R. The history of Android [Internet]. 2014 [cited 2015 Jun 24]. Available from: <http://arstechnica.com/gadgets/2014/06/building-android-a-40000-word-history-of-googles-mobile-os/>
134. Mobile Marketing Association. Americans lag behind Europeans in smartphone adoption [Internet]. 2006 [cited 15 May 2015]. Available from: <http://www.mmaglobal.com/articles/americans-lag-behind-europeans-smartphone-adoption-telephia>
135. Nielsen. Mobile millennials: over 85% of generation Y owns smartphones [Internet]. 2014 [cited 7 May 2015]. Available from: <http://www.nielsen.com/us/en/insights/news/2014/mobile-millennials-over-85-percent-of-generation-y-owns-smartphones.html>
136. Coyne B. Answering marketers' prayers? Smartphone penetration hits 75% [Internet]. 2014 [cited 2015 May 15]. Available from:

- <http://www.adnews.com.au/adnews/answering-marketers-prayers-smartphone-penetration-hits-75>
137. Lux A. Yesterday's tomorrows: the origins of the tablet [Internet]. 2015 [cited 2015 Jun 24]. Available from:
<http://www.computerhistory.org/atcm/yesterdays-tomorrows-the-origins-of-the-tablet/>
 138. Rowinski D. History of mobile app stores [Internet]. 2012 [cited 2015 Jun 24]. Available from:
http://readwrite.com/2012/02/07/infographic_history_of_mobile_app_stores
 139. Khalaf S. Health and fitness apps finally take off, fueled by fitness fanatics [Internet]. 2014 [cited 2015 Apr 24]. Available from:
<http://www.flurry.com/blog/flurry-insights/health-and-fitness-apps-finally-take-fueled-fitness-fanatics-.VTmID84xK2Q>
 140. Nielsen. Hacking health: how consumers use smartphones and wearable tech to track their health [Internet]. 2014 [cited 2015 May 7]. Available from: <http://www.nielsen.com/us/en/insights/news/2014/hacking-health-how-consumers-use-smartphones-and-wearable-tech-to-track-their-health.html>
 141. Eysenbach G. What is e-health? *J. Med. Internet Res.* 2001;3(2):e20.
 142. World Health Organization. mHealth: new horizons for health through mobile technologies [Internet]. 2011 [cited 22 May 2015]. Available from: http://www.who.int/goe/publications/goe_mhealth_web.pdf
 143. Tate DF, Wing RR, Winett RA. Using Internet technology to deliver a behavioral weight loss program. *J. Am. Med. Assoc.* 2001;285(9):1172-77.
 144. Weiss R, Fong AKH, Kretsch MJ. Adapting ProNutra to interactively track food weights from an electronic scale using ProNESSy. *J. Food Compost. Anal.* 2003;16(3):305-11.
 145. Beasley J, Riley WT, Jean-Mary J. Accuracy of a PDA-based dietary assessment program. *Nutrition.* 2005;21(6):672-77.

146. Kushi LH. Gaps in epidemiologic research methods: design considerations for studies that use food-frequency questionnaires. *Am. J. Clin. Nutr.* 1990;59(suppl. 1):180-84.
147. Fukuo W, Yoshiuchi K, Ohashi K, Togashi H, Sekine R, Kikuchi H, et al. Development of a hand-held personal digital assistant–based food diary with food photographs for Japanese subjects. *J. Am. Diet. Assoc.* 2009;109(7):1232-36.
148. Kohlmeier L. Gaps in dietary assessment methodology: meal- vs list-based methods. *Am. J. Clin. Nutr.* 1994;59(suppl. 1):175-79.
149. Ann Yon B, Johnson RK, Harvey-Berino J, Gold BC. The use of a personal digital assistant for dietary self-monitoring does not improve the validity of self-reports of energy intake. *J. Am. Diet. Assoc.* 2006;106(8):1256-59.
150. Fjeldsoe BS, Miller YD, Marshall AL. Behavior change interventions delivered by mobile telephone short-message service. *Am. J. Prev. Med.* 2009;36(2):165-73.
151. Lim MSC, Hocking JS, Aitken CK, Fairley CK, Jordan L, Lewis JA, et al. Impact of text and email messaging on the sexual health of young people: a randomised controlled trial. *J. Epidemiol. Community Health.* 2012;66(1):69-74.
152. Free C, Knight R, Robertson S, Edwards P, Zhou W, Cairns J, et al. Smoking cessation support delivered via mobile phone text messaging (txt2stop): a single-blind, randomised trial. *The Lancet.* 2011;378(9785):49-55.
153. Chang LW, Kagaayi J, Nakigozi G, Serwada D, Quinn TC, Gray RH, et al. Cost analyses of peer health worker and mHealth support interventions for improving AIDS care in Rakai, Uganda. *AIDS Care.* 2013;25(5):652-56.
154. Lemay NV, Sullivan T, Jumbe B, Perry CP. Reaching remote health workers in Malawi: baseline assessment of a pilot mHealth intervention. *J. Health. Commun.* 2012;17(suppl. 1):105-17.
155. Lester RT, Ritvo P, Mills EJ, Kariri A, Karanja S, Chung MH, et al. Effects of a mobile phone short message service on antiretroviral treatment adherence in Kenya (WeTel Kenya1): a randomised trial. *The Lancet.* 2010;376(9755):1838-45.

156. Deloitte. Technology, media and telecommunications predictions [Internet]. 2014 [cited 2015 Feb 10]. Available from: http://www2.deloitte.com/content/dam/Deloitte/global/Documents/Technology-Media-Telecommunications/dttl_TMT_Predictions-2014-lc2.pdf
157. Apple Inc. Messages: unlimited texting [Internet]. 2015 [cited 2015 Jul 30]. Available from: <https://www.apple.com/au/ios/messages/>
158. BlackBerry Inc. BBM: connect and collaborate [Internet]. 2015 [cited 2015 Jul 30]. Available from: <http://global.blackberry.com/en/bbm.html>
159. WhatsApp Inc. WhatsApp homepage. [Internet]. WhatsApp Inc.; [cited 2015 Jul 30]. Available from: <https://www.whatsapp.com>
160. Garside J. OMG! Number of UK text messages falls for first time. 2014 [cited 2015 Jul 22]. Available from: <http://www.theguardian.com/technology/2014/jan/13/number-text-messages-sent-britain-falls-first-time>
161. Nielsen. The Australian online landscape review [Internet]. 2014 [cited 2015 Feb 2]. Available from: <http://www.nielsen.com/content/dam/nielsen-global/au/docs/reports/online-landscape-review/nielsen-landscape-review-august-2014.pdf>
162. Nielsen. The digital consumer [Internet]. 2014 [cited 2015 Feb 2]. Available from: [http://www.nielsen.com/content/dam/corporate/us/en/reports-downloads/2014 Reports/the-digital-consumer-report-feb-2014.pdf](http://www.nielsen.com/content/dam/corporate/us/en/reports-downloads/2014%20Reports/the-digital-consumer-report-feb-2014.pdf)
163. Google Inc. Google analytics [Internet]. 2015 [cited 2015 Jul 14]. Available from: <http://www.google.com.au/analytics/>
164. Go Squared Ltd. Go Squared homepage. [Internet]. London, UK: Go Squared Ltd.; [cited 2015 Jul 14]. Available from: <https://www.gosquared.com>
165. Lawson S. Android Market needs more filters, T-Mobile says [Internet]. 2009 [cited 2015 Mar 30]. Available from: <http://www.pcworld.com/article/161410/article.html>
166. Warren C. Google Play hits 1 million apps [Internet]. 2013 [cited 2015 Mar 30]. Available from: <http://mashable.com/2013/07/24/google-play-1-million/>

167. DeVito Dabbs A, Dew MA, Myers B, Begey A, Hawkins R, Ren D, et al. Evaluation of a hand-held, computer-based intervention to promote early self-care behaviors after lung transplant. *Clin. Transpl.* 2009;23(4):537-45.
168. King AC, Ahn DK, Oliveira BM, Atienza AA, Castro CM, Gardner CD. Promoting physical activity through hand-held computer technology. *Am. J. Prev. Med.* 2008;34(2):138-42.
169. Walker I, Sigouin C, Sek J, Almonte T, Carruthers J, Chan A, et al. Comparing hand-held computers and paper diaries for haemophilia home therapy: a randomized trial. *Haemophilia.* 2004;10(6):698-704.
170. FitnessKeeper Inc. RunKeeper homepage. [Internet]. Boston, MA: FitnessKeeper Inc.; [cited 2015 Jul 14]. Available from: <http://runkeeper.com>
171. Kirwan M, Duncan MJ, Vandelanotte C, Mummery WK. Using smartphone technology to monitor physical activity in the 10,000 Steps program: a matched case-control trial. *J. Med. Internet Res.* 2012;14(2):e55.
172. Lubans DR, Smith JJ, Skinner G, Morgan PJ. Development and implementation of a smartphone application to promote physical activity and reduce screen-time in adolescent boys. *Front. Public Health.* 2014;2:e42.
173. Heffner JL, Vilaradaga R, Mercer LD, Kientz JA, Bricker JB. Feature-level analysis of a novel smartphone application for smoking cessation. *Am. J. Drug Alcohol Abuse.* 2015;41(1):68-73.
174. Watts S, Mackenzie A, Thomas C, Griskaitis A, Mewton L, Williams A, et al. CBT for depression: a pilot RCT comparing mobile phone vs. computer. *BMC Psychiatry.* 2013;13:49-58.
175. van Drongelen A, Boot CR, Hlobil H, Twisk JW, Smid T, van der Beek AJ. Evaluation of an mHealth intervention aiming to improve health-related behavior and sleep and reduce fatigue among airline pilots. *Scand. J. Work. Environ. Health.* 2014;40(6):557-68.
176. Wang DH, Kogashiwa M, Kira S. Development of a new instrument for evaluating individuals' dietary intakes. *J. Am. Diet. Assoc.* 2006;106(10):1588-93.

177. Carter MC, Burley VJ, Nykjaer C, Cade JE. 'My Meal Mate' (MMM): validation of the diet measures captured on a smartphone application to facilitate weight loss. *Br. J. Nutr.* 2013;109(3):539-46.
178. Mamykina L, Mynatt E, Davidson P, Greenblatt D. MAHI: investigation of social scaffolding for reflective thinking in diabetes management. In: *Proceedings of the CHI 2008 Conference on Human Factors in Computing Systems*; 2008 Apr 5-10; Florence, Italy: ACM; p. 477-86.
179. Klasnja P, Pratt W. Healthcare in the pocket: mapping the space of mobile-phone health interventions. *J. Biomed. Inform.* 2012;45(1):184-98.
180. Modi D, Gopalan R, Shah S, Venkatraman S, Desai G, Desai S, et al. Development and formative evaluation of an innovative mHealth intervention for improving coverage of community-based maternal, newborn and child health services in rural areas of India. *Glob. Health Action.* 2015;8:e26769.
181. Bourke L, Humphreys JS, Wakerman J, Taylor J. Understanding rural and remote health: a framework for analysis in Australia. *Health Place.* 2012;18(3):496-503.
182. Gregory A, Armstrong RM, Van Der Weyden MB. Rural and remote health in Australia: how to avert the deepening health care drought. *Med. J. Aust.* 2006;185(11-12):654-60.
183. Wise M, Angus S, Harris E, Parker S. Scoping study of health promotion tools for Aboriginal and Torres Strait Islander people. Sydney, NSW: The Lowitja Institute; 2012.
184. Broadband for the Bush Alliance. Better telecommunications for rural and remote Australians [Internet]. 2013 [cited 2015 May 7]. Available from: <http://broadbandforthebush.com.au/wp-content/uploads/2013/05/Broadband-for-the-Bush-Alliance-Policy-June-2013.pdf>
185. Gartner. Gartner says worldwide traditional PC, tablet, ultramobile and mobile phone shipments on pace to grow 7.6 percent in 2014 [press release]. 2014 May 7. Available from <http://www.gartner.com/newsroom/id/2645115>

186. Humphry J. Homeless and (mostly) connected: mobile phones and mobile Internet in the lives of youth, families and adults experiencing homelessness. *Parity*. 2014;27(8):76-77.
187. Taylor A. Social media as a tool for inclusion [Internet]. 2011 [cited 2015 May 24]. Available from: [http://www.homelesshub.ca/ResourceFiles/Taylor_Social_Media_feb2011\(1\)_1_2.pdf](http://www.homelesshub.ca/ResourceFiles/Taylor_Social_Media_feb2011(1)_1_2.pdf)
188. Lawder N. Homelessness and smartphones [Internet]. 2012 [cited 2015 Feb 2]. Available from: Thesis.docx
189. BinDhim NF, Hawkey A, Trevena L. A systematic review of quality assessment methods for smartphone health apps. *Telemed J. E Health*. 2015;21(2):97-104.
190. Joinson AN. Self - disclosure in computer - mediated communication: the role of self - awareness and visual anonymity. *Eur. J. Soc. Psychol*. 2001;31(2):177-92.
191. Lin JX. The role of Internet-based social support network in immigrant settlement [thesis]. Toronto, ON: Ryerson University; 2009.
192. Gay G, Pollak JP, Adams P, Leonard JP. Pilot study of Aurora, a social, mobile-phone-based emotion sharing and recording system. *J. Diabetes Sci. Technol*. 2011;5(2):325-32.
193. Ellis LA, Collin P, Hurley PJ, Davenport TA, Burns JM, Hickie IB. Young men's attitudes and behaviour in relation to mental health and technology: implications for the development of online mental health services. *BMC Psychiatry*. 2013;13:119-28.
194. Evers C, Albury K, Byron P, Crawford K. Young people, social media, social network sites and sexual health communication in Australia: "This is funny, you should watch it". *Int. J. Comm*. 2013;7:263-80.
195. Hillier L, Kurdas C, Horsley P. 'It's just easier': the Internet as a safety-net for same sex attracted young people. Melbourne: Australian Research Centre in Sex Health and Society; 2001.
196. Crowley MS. how r u??? Lesbian and bi-identified youth on MySpace. *J. Lesbian Stud*. 2010;14(1):52-60.

197. Duhaime-Ross A. Apple's new ResearchKit: 'ethics quagmire' or medical research aid? [Internet]. 2015 [cited 2015 May 7]. Available from: <http://www.theverge.com/2015/3/10/8177683/apple-research-kit-app-ethics-medical-research>
198. International Data Corporation. Always connected: how smartphones and social keep us engaged [Internet]. 2013 [cited 2015 Mar 24]. Available from: [http://www.nu.nl/files/IDC-Facebook Always Connected \(1\).pdf](http://www.nu.nl/files/IDC-Facebook%20Always%20Connected%20(1).pdf)
199. Ingersoll K, Dillingham R, Reynolds G, Hetteema J, Freeman J, Hosseinbor S, et al. Development of a personalized bidirectional text messaging tool for HIV adherence assessment and intervention among substance abusers. *J. Subst. Abuse Treat.* 2014;46(1):66-73.
200. Strandbygaard U, Thomsen SF, Backer V. A daily SMS reminder increases adherence to asthma treatment: a three-month follow-up study. *Respir. Med.* 2010;104(2):166-71.
201. Ollivier L, Romand O, Marimoutou C, Michel R, Pognant C, Todesco A, et al. Use of short message service (SMS) to improve malaria chemoprophylaxis compliance after returning from a malaria endemic area. *Malar. J.* 2009;8:236-43.
202. Miloh T, Annunziato R, Arnon R, Warshaw J, Parkar S, Suchy FJ, et al. Improved adherence and outcomes for pediatric liver transplant recipients by using text messaging. *Pediatrics.* 2009;124(5):E844-E50.
203. Shapiro JR, Bauer S, Andrews E, Pisetsky E, Bulik-Sullivan B, Hamer RM, et al. Mobile therapy: use of text-messaging in the treatment of bulimia nervosa. *Int. J. Eat. Disord.* 2010;43(6):513-19.
204. Pijnenborg GH, Withaar FK, Brouwer WH, Timmerman ME, van den Bosch RJ, Evans JJ. The efficacy of SMS text messages to compensate for the effects of cognitive impairments in schizophrenia. *Br. J. Clin. Psychol.* 2010;49(2):259-74.
205. Culley C, Evans JJ. SMS text messaging as a means of increasing recall of therapy goals in brain injury rehabilitation: a single-blind within-subjects trial. *Neuropsychol. Rehabil.* 2010;20(1):103-19.

206. Giglia R, Cox K, Zhao Y, Binns CW. Exclusive breastfeeding increased by an Internet intervention. *Breastfeed. Med.* 2015;10:20-25.
207. Lao L. Evaluation of a social networking based SNAP-Ed nutrition curriculum on behavior change [thesis]. Kingston, RI: University of Rhode Island; 2011.
208. Ferney SL, Marshall AL, Eakin EG, Owen N. Randomized trial of a neighborhood environment-focused physical activity website intervention. *Prev. Med.* 2009;48(2):144-50.
209. Ahmed A, Ouzzani M. Development and Assessment of an Interactive Web-Based Breastfeeding Monitoring System (LACTOR). *Matern. Child Health J.* 2013;17(5):809-15.
210. Kwon M, Lee J, Won W, Park J, Min J, Hahn C, et al. Development and validation of a smartphone addiction scale (SAS). *PLoS One.* 2013;8(2):e56936.
211. van Deursen AJAM, Bolle CL, Hegner SM, Kommers PAM. Modeling habitual and addictive smartphone behavior. *Comput. Human Behav.* 2015;45:411-20.
212. Roberts JA, Pullig C, Manolis C. I need my smartphone: a hierarchical model of personality and cell-phone addiction. *Pers. Individ. Dif.* 2015;79:13-19.
213. Intille SS. Ubiquitous computing technology for just-in-time motivation of behavior change. *Stud. Health Technol. Inform.* 2004;107(2):1434-38.
214. Kauer SD, Reid SC, Crooke AHD, Khor A, Hearps SJC, Patton G, et al. Self-monitoring using mobile phones in the early stages of adolescent depression: randomized controlled trial. *J. Med. Internet Res.* 2012;14(3):e67.
215. Gartner Inc. Gartner says worldwide PDA shipments top 17.7 million in 2006 [press release]. 2007 Feb 6. Available from <http://www.gartner.com/newsroom/id/500898>
216. Gartner. Gartner says annual smartphone sales surpassed sales of feature phones for the first time in 2013 [press release]. 2014 Feb 13. Available from <http://www.gartner.com/newsroom/id/2665715>

217. Holman RR, Smale AD, Pemberton E, Riefflin A, Nealon JL. Randomized controlled pilot trial of a hand-held patient-oriented, insulin regimen optimizer. *Inform. Health Soc. Care.* 1996;21(4):317-26.
218. Atienza AA, King AC, Oliveira BM, Ahn DK, Gardner CD. Using hand-held computer technologies to improve dietary intake. *Am. J. Prev. Med.* 2008;34(6):514-18.
219. Burke LE, Conroy MB, Sereika SM, Elci OU, Styn MA, Acharya SD, et al. The effect of electronic self-monitoring on weight loss and dietary intake: a randomized behavioral weight loss trial. *Obesity.* 2011;19(2):338-44.
220. Beasley JM, Riley WT, Davis A, Singh J. Evaluation of a PDA-based dietary assessment and intervention program: a randomized controlled trial. *J. Am. Coll. Nutr.* 2008;27(2):280-86.
221. Agras WS, Taylor CB, Feldman DE, Losch M, Burnett KF. Developing computer-assisted therapy for the treatment of obesity. *Behav. Ther.* 1990;21(1):99-109.
222. Acharya SD, Elci OU, Sereika SM, Styn MA, Burke LE. Using a personal digital assistant for self-monitoring influences diet quality in comparison to a standard paper record among overweight/obese adults. *J. Am. Diet. Assoc.* 2011;111(4):583-88.
223. Google Inc. Our mobile planet: Australia [Internet]. 2013 [cited 2013 Dec 4]. Available from: <http://services.google.com/fh/files/misc/omp-2013-au-en.pdf>
224. Kuehnhausen M, Frost VS. Trusting smartphone Apps? To install or not to install, that is the question. In: *Proceedings of the IEEE International Multi-Disciplinary Conference on Cognitive Methods in Situation Awareness and Decision Support*; 2013 Feb 25-28; San Diego, CA; p. 30-37.
225. Nollen NL, Mayo MS, Carlson SE, Rapoff MA, Goggins KJ, Ellerbeck EF. Mobile technology for obesity prevention: a randomized pilot study in racial- and ethnic-minority girls. *Am. J. Prev. Med.* 2014;46(4):404-08.
226. Ritterband LM, Thorndike FP, Cox DJ, Kovatchev BP, Gonder-Frederick LA. A behavior change model for Internet interventions. *Ann. Behav. Med.* 2009;38(1):18-27.

227. Fletcher R, Vimpani G, Russell G, Keatinge D. The evaluation of tailored and web-based information for new fathers. *Child Care Health Dev.* 2008;34(4):439-46.
228. Anderson I, Maitland J, Sherwood S, Barkhuus L, Chalmers M, Hall M, et al. Shakra: tracking and sharing daily activity levels with unaugmented mobile phones. *Mobile Networks and Applications.* 2007;12(2):185-99.
229. Consolvo S, McDonald DW, Toscos T, Chen MY, Froehlich J, Harrison B, et al. Activity sensing in the wild: a field trial of Ubifit Garden. In: *Proceedings of the CHI 2008 Conference on Human Factors in Computing Systems*; 2008 Apr 5-10; Florence, Italy: ACM; p. 1797-806.
230. Kollmann A, Kastner P, Schreier G, Riedl M, Ludvik B. Feasibility of a mobile phone-based data service for functional insulin treatment of type 1 diabetes mellitus patients. *J. Med. Internet Res.* 2007;9(5):e36.
231. Kirwan M, Duncan MJ, Vandelanotte C, Mummery WK. Design, development, and formative evaluation of a smartphone application for recording and monitoring physical activity levels: the 10,000 steps "iStepLog". *Health Educ. Behav.* 2013;40(2):140-51.
232. Hufford MR, Shiffman S. Methodological issues affecting the value of patient-reported outcomes data. *Expert Rev. Pharmacoecon. Outcomes Res.* 2002;2(2):119-28.
233. Jaspers MWM. A comparison of usability methods for testing interactive health technologies: methodological aspects and empirical evidence. *Int. J. Med. Inform.* 2009;78(5):340-53.
234. Yi T, Li H, Gu M. Recent research and applications of GPS-based monitoring technology for high-rise structures. *Struct. Control Health.* 2013;20(5):649-70.
235. Schipperijn J, Kerr J, Duncan S, Madsen T, Klinker CD, Troelsen J. Dynamic accuracy of GPS receivers for use in health research: a novel method to assess GPS accuracy in real-world settings. *Front. Public Health.* 2014;2:1-8.
236. Noury-Desvaux B, Abraham P, Mahe G, Sauvaget T, Leftheriotis G, Le Faucheur A. The accuracy of a simple, low-cost GPS data logger/receiver to study outdoor human walking in view of health and clinical studies. *PLoS One.* 2011;6(9):e23027.

237. Arab L. Epidemiological uses of food composition data in the European context. In: Rand W, Windham CT, Wyse BW, Young VR, editors. Food composition data: a user's perspective; 1987. p. 54-64.
238. Burke LE, Sereika SM, Music E, Warziski M, Styn MA, Stone A. Using instrumented paper diaries to document self-monitoring patterns in weight loss. *Contemp. Clin. Trials*. 2008;29(2):182-93.
239. Siek KA, Connelly KH, Rogers Y, Rohwer P, Lambert D, Welch JL. When Do We Eat? An Evaluation of Food Items Input into an Electronic Food Monitoring Application. In: Proceedings of the First International Conference on Pervasive Computing Technologies for Healthcare; 2006 Nov 29 - Dec 1; Innsbruck, Austria; p. 1-10.
240. Järvinen P, Järvinen TH, Lähteenmäki L, Södergård C. HyperFit: hybrid media in personal nutrition and exercise management. In: Proceedings of the Second International Conference on Pervasive Computing Technologies for Healthcare; 2008 Jan 30 - Feb 1; Tampere, Finland; p. 222-26.
241. Eyles H, McLean R, Neal B, Doughty R, Jiang Y, Mhurchu C. Using mobile technology to support lower-salt food choices for people with cardiovascular disease: protocol for the SaltSwitch randomized controlled trial. *BMC Public Health*. 2014;14(1):950-50.
242. MyFitnessPal Inc. MyFitnessPal homepage. [Internet]. San Francisco, CA: MyFitnessPal Inc.; [cited 2015 Jul 14]. Available from: <http://www.myfitnesspal.com>
243. Kelly K. What is the quantified self? [Internet]. 2007 [cited 2015 May 14]. Available from: <http://quantifiedself.com/2007/10/what-is-the-quantifiable-self/>
244. Prince JD. The quantified self: operationalizing the quotidien. *J. Elec. Res. Med. Libraries*. 2014;11(2):91-99.
245. Ramirez E. Announcing QS15: the quantified self conference & exposition [Internet]. 2014 [cited 2015 May 14]. Available from: <http://quantifiedself.com/2014/09/announcing-2015-quantified-self-global-conference-expo/>

246. Danova T. Just 3.3 million fitness trackers were sold in the US in the past year [Internet]. 2014 [cited 2015 May 24]. Available from: <http://www.businessinsider.com.au/33-million-fitness-trackers-were-sold-in-the-us-in-the-past-year-2014-5>
247. Strava Inc. Strava: unlock your potential homepage. [Internet]. San Francisco, CA: Strava Inc.; [cited 2015 Jul 14]. Available from: <https://www.strava.com>
248. Nike Inc. Nike+: your personal trainer. Anytime. Anywhere [Internet]. 2015 [cited 2015 May 14]. Available from: <https://secure-nikeplus.nike.com/plus/>
249. CalorieKing. Calorie King homepage. [Internet]. La Mesa, CA: CalorieKing; [cited 2015 May 15]. Available from: <http://www.calorieking.com>
250. GMBH O. Optimized homepage. Zurich, Switzerland: OptimizeMe GMBH; [cited 2015 Jul 14]. Available from: <http://optimized-app.com>
251. Happier Inc. Happier: join our positive community [Internet]. 2015 [cited 2015 May 15]. Available from: <https://www.happier.com/app/community>
252. Panda M. Mood Panda homepage. [Internet]. Bristol, UK: MoodPanda; [cited 2015 Jul 14]. Available from: <http://www.moodpanda.com>
253. Inexia Inc. iMoodJournal - mood tracking application for Android and iPhone [Internet]. 2015 [cited 2015 May 15]. Available from: <http://www.inexika.com/imood>
254. Fox S, Duggan M. Tracking for health [Internet]. 2013 [cited 2015 May 14]. Available from: <http://www.pewinternet.org/2013/01/28/tracking-for-health/>
255. Kuehn BM. More than one-third of us individuals use the Internet to self-diagnose. *Journal of the American Medical Association*. 2013;309(8):756-57.
256. Bates J. Worried well. *Nurs. Stand*. 2007;21(38):27.
257. Smith JT. Decrypted: caution in the age of the quantified self [Internet]. 2014 [cited 2015 May 15]. Available from: <http://gearpatrol.com/2014/09/19/caution-in-the-age-of-the-quantified-self/>

258. Azar KMJ, Lesser LI, Laing BY, Stephens J, Aurora MS, Burke LE, et al. Mobile applications for weight management theory-based content analysis. *Am. J. Prev. Med.* 2013;45(5):583-89.
259. Carter MC, Burley VJ, Cade JE. Development of 'My Meal Mate' - A smartphone intervention for weight loss. *Nutr. Bull.* 2013;38(1):80-84.
260. Haapala I, Barengo NC, Biggs S, Surakka L, Manninen P. Weight loss by mobile phone: a 1-year effectiveness study. *Public Health Nutr.* 2009;12(12):2382-91.
261. Hebden L, Cook A, van der Ploeg HP, Allman-Farinelli M. Development of smartphone applications for nutrition and physical activity behavior change. *JMIR Res. Protoc.* 2012;1(2):e9.
262. Cafazzo JA, Casselman M, Hamming N, Katzman DK, Palmert MR. Design of an mHealth app for the self-management of adolescent type 1 diabetes: a pilot study. *J. Med. Internet Res.* 2012;14(3):e70.
263. Krishna S, Boren SA. Diabetes self-management care via cell phone: a systematic review. *J. Diabetes Sci. Technol.* 2008;2(3):509-17.
264. Ribu L, Holmen H, Torbjørnsen A, Wahl AK, Grøttland A, Småstuen MC, et al. Low-intensity self-management intervention for persons with type 2 diabetes using a mobile phone-based diabetes diary, with and without health counseling and motivational interviewing: protocol for a randomized controlled trial. *JMIR Res. Protoc.* 2013;2(2):e34.
265. Yoon KH, Kim HS. A short message service by cellular phone in type 2 diabetic patients for 12 months. *Diabetes Res. Clin. Pract.* 2008;79(2):256-61.
266. Donker T, Petrie K, Proudfoot J, Clarke J, Birch M, Christensen H. Smartphones for smarter delivery of mental health programs: a systematic review. *J. Med. Internet Res.* 2013;15(11):e247.
267. Proudfoot J, Parker G, Hadzi Pavlovic D, Manicavasagar V, Adler E, Whitton A. Community attitudes to the appropriation of mobile phones for monitoring and managing depression, anxiety, and stress. *J. Med. Internet Res.* 2010;12(5):e64.

268. Chinn D. Critical health literacy: a review and critical analysis. *Soc. Sci. Med.* 2011;73(1):60-67.
269. Prince JD. Gamification. *J. Elec. Res. Med. Libraries.* 2013;10(3):162-69.
270. Withings Inc. Withings: Inspire Health homepage. [Internet]. Cambridge, MA: Withings Inc.; [cited 2015 Jul 23]. Available from: <http://www2.withings.com/us/en/>
271. Six to Start. The walk homepage. [Internet]. Six to Start; [cited 2015 May 20]. Available from: <https://www.thewalkgame.com>
272. Fitocracy. Fitocracy homepage. [Internet]. New York, NY: Fitocracy; [cited 2015 May 20]. Available from: <https://www.fitocracy.com>
273. Six to Start. Zombies, Run! homepage. [Internet]. London, UK: Six to Start; [cited 2015 Jul 23]. Available from: <https://zombiesrungame.com>
274. WatchFit. WatchFit homepage. [Internet]. London, UK: WatchFit; [cited 2015 Jul 14]. Available from: <http://watchfit.com>
275. HabitRPG. HabitRPG: motivate your team [Internet]. 2015 [cited 2015 May 20]. Available from: <https://habitrrpg.com/static/front>
276. Superbetter Labs Inc. About superbetter [Internet]. 2015 [cited 2015 May 20]. Available from: <https://www.superbetter.com/about>
277. Welltok Inc. Mindbloom homepage. [Internet]. Denver, CO: Welltok Inc.; [cited 2015 Jul 14]. Available from: <http://www.mindbloom.com>
278. Personal Zen LLC. Personal Zen: combining cutting edge neuroscience research with mobile technology to improve the world's health and well-being homepage. [Internet]. New York, NY: Personal Zen LLC.; [cited 2005 Jul 14]. Available from: <http://www.personalzen.com>
279. Lister C, West JH, Cannon B, Sax T, Brodegard D. Just a fad? Gamification in health and fitness apps. *JMIR Serious Games.* 2014;2(2):e9.
280. DietBet Inc. DietBet: no getters to goal getters [Internet]. 2015 [cited 2015 May 20]. Available from: <https://www.dietbet.com/about/mission>
281. Pact Inc. Pact homepage. [Internet]. San Francisco, CA: Pact Inc.; [cited 2015 Jul 14]. Available from: <http://www.gym-pact.com>
282. Bast M. The gamification of weight loss [Internet]. 2014 [cited 2015 May 20]. Available from: <http://blog.ted.com/the-gamification-of-weight-loss/>

283. Volpp KG, John LK, Troxel AB, Norton L, Fassbender J, Loewenstein G. Financial incentive-based approaches for weight loss: a randomized trial. *J. Am. Med. Assoc.* 2008;300(22):2631-7.
284. Kullgren JT, Troxel AB, Loewenstein G, Asch DA, Norton LA, Wesby L, et al. Individual versus group-based financial incentives for weight loss: a randomized, controlled trial. *Ann. Intern. Med.* 2013;158(7):505-14.
285. Wing RR, Pinto AM, Crane MM, Kumar R, Weinberg BM, Gorin AA. A statewide intervention reduces BMI in adults: Shape Up Rhode Island results. *Obesity.* 2009;17(5):991-95.
286. Dennis TA, O'Toole LJ. Mental health on the go: effects of a gamified attention-bias modification mobile application in trait-anxious adults. *Clin. Psychol. Sci.* 2014;2(5):576-90.
287. Bellotti F, Berta R, De Gloria A. Designing effective serious games: opportunities and challenges for research. *Int. J. Emerg. Tech. Learning.* 2010;5(SI3):22-35.
288. Abt C. *Serious games.* New York: Viking; 1970.
289. Sage Journals. *Simulation & Gaming* [Internet]. 2015 [cited 2015 May 20]. Available from: <http://sag.sagepub.com>
290. Journal of Medicinal Internet Research. *JMIR Serious Games* [Internet]. 2015 [cited 2015 May 20]. Available from: <http://games.jmir.org>
291. Serious Games Society. *International Journal of Serious Games* [Internet]. 2015 [cited 2015 May 20]. Available from: <http://journal.seriousgamesociety.org/index.php?journal=IJSG>
292. Schweier R, Richter C, Romppel M, Hoberg E, Hahmann H, Scherwinski I, et al. A web-based peer-modeling intervention aimed at lifestyle changes in patients with coronary heart disease and chronic back pain: sequential controlled trial. *J. Med. Internet Res.* 2014;16(7):e177.
293. Cavallo DN, Tate DF, Ries AV, Brown JD, DeVellis RF, Ammerman AS. A social media-based physical activity intervention: a randomized controlled trial. *Am. J. Prev. Med.* 2012;43(5):527-32.

294. Newton KH, Wiltshire EJ, Elley CR. Pedometers and text messaging to increase physical activity: randomized controlled trial of adolescents with type 1 diabetes. *Diabetes Care*. 2009;32(5):813-15.
295. Microsoft Corporation. HealthVault: take control of your health [Internet]. 2015 [cited 2015 May 20]. Available from: <https://www.healthvault.com/au/en>
296. Apple Inc. HealthKit [Internet]. 2015 [cited 2015 May 20]. Available from: <https://developer.apple.com/healthkit/>
297. Google Inc. GoogleFit [Internet]. 2015 [cited 2015 May 20]. Available from: <https://developers.google.com/fit/>
298. FitnessKeeper Inc. Health Graph: connect to the largest digital map of personal fitness and health [Internet]. 2015 [cited 2015 20 May]. Available from: <http://runkeeper.com/developer/healthgraph/>
299. Apple Inc. Introducing ResearchKit [Internet]. 2015 [cited 2015 May 20]. Available from: <http://researchkit.github.io>
300. Bionetworks S. mPower: mobile Parkinson disease study [Internet]. 2015 [cited 2015 Jul 23]. Available from: <http://parkinsonmpower.org>
301. Hanson C, Thackeray R, Barnes M, Neiger B, McIntyre E. Integrating web 2.0 in health education preparation and practice. *Am. J. Health Educ*. 2008;39(3):157-66.
302. Marcus J. The environmental and social impacts of telecommuting and teleactivities [Internet]. 1995 [cited 2011 Feb 13]. Available from: <http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.22.6955&rep=rep1&type=pdf>
303. Rheingold H. The virtual community: homesteading on the electronic frontier [Internet]. 1993 [cited 2011 May 8]. Available from: <http://www.rheingold.com/vc/book/>
304. O'Reilly T. What Is web 2.0? Design patterns and business models for the next generation of software [Internet]. 2005 [cited 2011 Dec 2]. Available from: <http://oreilly.com/web2/archive/what-is-web-20.html>
305. Anderson AR. The life trajectory of social marketing. *Market. Theory*. 2003;3:293-303.

306. The Conversation Group. The impact of social media on consumer behaviour [Internet]. 2012 [cited 2012 May 17]. Available from: <http://theconversationgroup.com/the-impact-of-social-media-on-consumer-behaviour-020512/>
307. Grier S, Bryant CA. Social marketing in public health. *Annu. Rev. Public Health.* 2005;26(1):319-39.
308. Thackeray R. Enhancing promotional strategies within social marketing programs: use of web 2.0 social media. *Health Promot. Pract.* 2008;9(4):338-43.
309. Chou WYS. Social media use in the United States: implications for health communication. *J. Med. Internet Res.* 2009;11(4):e48.
310. Bernhardt J. New communication channels: changing the nature of customer engagement. *Soc. Mar. Q.* 2009;15(suppl 1):7-15.
311. Forster P. Psychological sense of community in groups on the Internet. *Behav. Change.* 2004;21(2):141-46.
312. Science Panel on Interactive Communication and Health. *Wired for health and well-being: the emergence of interactive health communication.* Washington D.C.: U.S. Government Printing Office; 1999.
313. Grieve R, Indian M, Witteveen K, Tolan AG, Marrington J. Face-to-face or Facebook: can social connectedness be derived online? *Comput. Human Behav.* 2013;29(3):604-09.
314. Christakis N, Fowler J. The collective dynamics of smoking in a large social network. *N. Engl. J. Med.* 2008;358(21):2249-58.
315. van Dam HA, van der Horst FG, Knoop L, Ryckman RM, Crebolder HF, van den Borne BH. Social support in diabetes: a systematic review of controlled intervention studies. *Patient Educ. Couns.* 2005;59(1):1-12.
316. Moore SM, Dolansky MA, Ruland CM, Pashkow FJ, Blackburn GG. Predictors of women's exercise maintenance after cardiac rehabilitation. *J. Cardiopulm. Rehabil.* 2003;23(1):40-49.
317. Wang CY, Fenske MM. Self-care of adults with non-insulin-dependent diabetes mellitus: influence of family and friends. *Diabetes Educ.* 1996;22(5):465-70.

318. Bender JL, Jimenez-Marroquin MC, Jadad AR. Seeking support on Facebook: a content analysis of breast cancer groups. *J. Med. Internet Res.* 2011;13(1):e16.
319. Kernot J, Olds T, Lewis LK, Maher C. Usability testing and piloting of the Mums Step It Up program - A team-based social networking physical activity intervention for women with young children. *PLoS One.* 2014;9(10):e108842.
320. Turner-McGrievy G, Tate DF, Boyle A. Tweets, apps, and pods: results of a 6-month, mobile media, weight loss intervention. *J. Med. Internet Res.* 2011;13(4):e120.
321. Williams G, Hamm MP, Shulhan J, Vandermeer B, Hartling L. Social media interventions for diet and exercise behaviours: a systematic review and meta-analysis of randomised controlled trials. *BMJ Open.* 2014;4(2):e3926.
322. Munson S, Lauterbach D, Newman M, Resnick P. Happier Together: integrating a wellness application into a social network site. In: Ploug T, Hasle P, Oinas-Kukkonen H, editors. *Persuasive Technology.* Berlin: Springer Berlin Heidelberg; 2010. p. 27-39.
323. Richardson A, Graham AL, Cobb N, Xiao H, Mushro A, Abrams D, et al. Engagement promotes abstinence in a web-based cessation intervention: cohort study. *J. Med. Internet Res.* 2013;15(1):e14.
324. Gold J, Pedrana A, Sacks-Davis R, Hellard M, Chang S, Howard S, et al. A systematic examination of the use of online social networking sites for online sexual health promotion. *BMC Public Health.* 2011;11(1):583-91.
325. Gold J, Pedrana A, Stooze M, Chang M, Howard S, Asselin J, et al. Developing health promotion interventions on social networking sites: recommendations from the FaceSpace project. *J. Med. Internet Res.* 2012;14(1):e30.
326. Dantzig S, Geleijnse G, Halteren A. Toward a persuasive mobile application to reduce sedentary behavior. *Pers. Ubiquit. Comput.* 2013;17(6):1237-46.
327. Carr LJ, Dunsiger SI, Lewis B, Ciccolo JT, Hartman S, Bock B, et al. Randomized controlled trial testing an Internet physical activity intervention for sedentary adults. *Health Psychol.* 2013;32(3):328-36.

328. Wilson C, Boe B, Sala A, Puttaswamy KPN, Zhao BY. User interactions in social networks and their implications. In: Proceedings of the Fourth ACM European Conference on Computer systems; 2009 April 1-3; Nuremburg, Germany: ACM; p. 205-18.
329. Miller AS, Cafazzo JA, Seto E. A game plan: gamification design principles in mHealth applications for chronic disease management. *Health Informatics J.* 2014;1-10.
330. Brindal E, Noakes M, Freyne J, Berkovsky S, Smith G, Saunders I. Features predicting weight loss in overweight or obese participants in a web-based intervention: randomized trial. *J. Med. Internet Res.* 2012;14(6):e173.
331. Seafish. Fish is the dish homepage. [Internet]. Edinburgh, UK: Seafish; [updated 2015 Jul 9; cited 2015 Jul 14]. Available from: <http://www.fishisthedish.co.uk>
332. Tots 100. Tots 100 index of U.K. parent blogs homepage. [Internet]. [updated 2015 Jul 6; cited 2015 Jul 14]. Available from: <http://www.tots100.co.uk/>
333. Centre for Consumer Freedom. How much fish [Internet]. 2011 [cited 2011 Nov 14]. Available from: <http://www.howmuchfish.com>
334. Mayer CE, Joyce A. The Escalating Obesity Wars [Internet]. 2005 [cited 2015 May 22]. Available from: <http://www.washingtonpost.com/wp-dyn/content/article/2005/04/26/AR2005042601259.html>
335. Hale B. Case study: Queensland prawns [Internet]. 2011 [cited 2011 Dec 7]. Available from: http://www.adpower.com.au/profile/Curriculum_Vitae/Entries/2011/12/1_Seafood_Directions_2011_presentation.html
336. Norman GJ, Zabinski MF, Adams MA, Rosenberg DE, Yaroch AL, Atienza AA. A review of eHealth interventions for physical activity and dietary behavior change. *Am. J. Prev. Med.* 2007;33(4):336-45.
337. Weinstein PK. A review of weight loss programs delivered via the Internet. *J. Cardiovasc. Nurs.* 2006;21(4):251-58.
338. Currell R, Urquhart C, Wainwright P, Lewis R. Telemedicine versus face to face patient care: effects on professional practice and health care

- outcomes Cochrane Database Syst. Rev. [Internet]. 2000 [cited 2011 May 10]. Available from:
<http://onlinelibrary.wiley.com/doi/10.1002/14651858.CD002098/abstract>
339. Renfrew Mary J, McCormick Felicia M, Wade A, Quinn B, Dowswell T. Support for healthy breastfeeding mothers with healthy term babies Cochrane Database Syst. Rev. 2012 [cited 2015 Jun 2]. Available from:
<http://onlinelibrary.wiley.com/doi/10.1002/14651858.CD001141.pub4/abstract>
340. Cuijpers P, Donker T, van Straten A, Li J, Andersson G. Is guided self-help as effective as face-to-face psychotherapy for depression and anxiety disorders? A systematic review and meta-analysis of comparative outcome studies. *Psychol. Med.* 2010;40(12):1943-57.
341. Tate DF, Finkelstein EA, Khavjou O, Gustafson A. Cost effectiveness of Internet interventions: review and recommendations. *Ann. Behav. Med.* 2009;38(1):40-45.
342. Campbell M, Fitzpatrick R, Haines A, Kinmonth A, Sandercock P, Spiegelhalter D, et al. Framework for design and evaluation of complex interventions to improve health. *Br. Med. J.* 2000;321(7262):694-96.
343. Craig Lefebvre R, Flora JA. Social marketing and public health intervention. *Health Educ. Behav.* 1988;15(3):299-315.
344. Nastasi BK, Varjas K, Schensul SL, Silva KT, Schensul JJ, Ratnayake P. The participatory intervention model: a framework for conceptualizing and promoting intervention acceptability. *Sch. Psychol. Q.* 2000;15(2):207-32.
345. Gold J, Pedrana AE, Sacks-Davis R, Hellard ME, Chang S, Howard S, et al. A systematic examination of the use of online social networking sites for sexual health promotion. *BMC Public Health.* 2011;11(1):9.
346. Eng TR, Gustafson DH, Henderson J, Jimison H, Patrick K. Introduction to evaluation of interactive health communication applications. *Am. J. Prev. Med.* 1999;16(1):10-15.
347. Gustafson DH, Robinson TN, Ansley D, Adler L, Flatley Brennan P. Consumers and evaluation of interactive health communication applications. *Am. J. Prev. Med.* 1999;16(1):23-29.

348. Henderson J, Noell J, Reeves T, Robinson T, Strecher V. Developers and evaluation of interactive health communication applications. *Am. J. Prev. Med.* 1999;16(1):30-34.
349. Jimison H, Adler L, Coye M, Mulley Jr AL, Eng TR. Health care providers and purchasers and evaluation of interactive health communication applications. *Am. J. Prev. Med.* 1999;16(1):16-22.
350. Craig P, Dieppe P, Macintyre S, Michie S, Nazareth I, Petticrew M. Developing and evaluating complex interventions: new guidance [Internet]. 2008 [cited 2012 Jan 22]. Available from: <http://www.mrc.ac.uk/complexinterventionsguidance>
351. Larman C, Basili VR. Iterative and incremental development: a brief history. *Computer.* 2003;36(6):47-56.
352. Fulbright R. Incorporating innovation into iterative software development using the inventive problem solving methodology. *Int. J. Innov. Sci.* 2013;5(4):203-12.
353. Buhi ER, Trudnak TE, Martinasek MP, Oberne AB, Fuhrmann HJ, McDermott RJ. Mobile phone-based behavioural interventions for health: a systematic review. *Health Educ. J.* 2012;72(5):564-83.
354. Foxall GR. Understanding consumer choice. New York: Palgrave Macmillan; 2005.
355. Bednall TC, Bove LL, Cheetham A, Murray AL. A systematic review and meta-analysis of antecedents of blood donation behavior and intentions. *Soc. Sci. Med.* 2013;96:86-94.
356. Ahrold T, Farmer M, Trapnell P, Meston C. The relationship among sexual attitudes, sexual fantasy, and religiosity. *Arch. Sex. Behav.* 2011;40(3):619-30.
357. Iso H, Kobayashi M, Ishihara J, Sasaki S, Okada K, Kita Y, et al. Intake of fish and n3 fatty acids and risk of coronary heart disease among Japanese: the Japan public health center-based (JPHC) study cohort I. *Circulation.* 2006;113(2):195-202.

358. Ouellette JA, Wood W. Habit and intention in everyday life: the multiple processes by which past behavior predicts future behavior. *Psychol. Bull.* 1998;124(1):54-74.
359. Foxall G. The behavioral perspective model of purchase and consumption: from consumer theory to marketing practice. *J. Acad. Market. Sci.* 1992;20(2):189-98.
360. Foxall G. The behavioral perspective model: consensibility and consensuality. *Eur. J. Marketing.* 1999;33(5/6):570-96.
361. Fishbein M, Ajzen I. *Belief, attitude, intention, and behavior: an introduction to theory and research.* Reading, MA: Addison-Wesley; 1975.
362. Ajzen I. From intentions to actions: a theory of planned behavior. In: Kuhl J, Beckmann J, editors. *Action control : from cognition to behavior.* Berlin: Springer-Verlag; 1985. p. 11-39.
363. Ajzen I. *Attitudes, personality, and behavior.* Milton Keynes: Open University Press; 1988.
364. Armitage CJ, Conner M. Efficacy of the theory of planned behaviour: a meta-analytic review. *Br. J. Soc. Psychol.* 2001;40:471-99.
365. Murnaghan DA, Blanchard CM, Rodgers WM, LaRosa JN, MacQuarrie CR, MacLellan DL, et al. Predictors of physical activity, healthy eating and being smoke-free in teens: a theory of planned behaviour approach. *Psychol. Health.* 2010;25(8):925-41.
366. Dean M, Raats MM, Shepherd R. Moral concerns and consumer choice of fresh and processed organic foods. *J. Appl. Soc. Psychol.* 2008;38(8):2088-107.
367. Dowd K. *The theory of planned behaviour and motives for purchasing sustainably sourced food [thesis].* Rockhampton: Central Queensland University; 2011.
368. Saba A, Di Natale R. A study on the mediating role of intention in the impact of habit and attitude on meat consumption. *Food Qual. Prefer.* 1999;10(1):69-77.

369. Bagozzi RP, Wong N, Abe S, Bergami M. Cultural and situational contingencies and the theory of reasoned action: application to fast food restaurant consumption. *J. Consum. Psychol.* 2000;9(2):97-106.
370. Becker MH. *The health belief model and personal health behavior.* New Jersey: C.B. Slack; 1974.
371. Oldridge NB, Streiner DL. The health belief model: predicting compliance and dropout in cardiac rehabilitation. *Med. Sci. Sports Exerc.* 1990;22(5):678-83.
372. Horwood H, Williams MJ, Mandic S. Examining motivations and barriers for attending maintenance community-based cardiac rehabilitation using the health-belief model. *Heart Lung Circ.* 2015:1-8.
373. Shanks L. Usefulness of the health belief model in predicting cardiac rehabilitation initiation. *J. Theory Constr. Test.* 2009;13(1):33-36.
374. Straker LM, Smith KL, Fenner AA, Kerr DA, McManus A, Davis MC, et al. Rationale, design and methods for a staggered-entry, waitlist controlled clinical trial of the impact of a community-based, family-centred, multidisciplinary program focussed on activity, food and attitude habits (Curtin University's Activity, Food and Attitudes Program--CAFAP) among overweight adolescents. *BMC Public Health.* 2012;12:471-84.
375. NSW Department of Health. *Healthy people NSW: improving the health of the population.* Sydney, NSW: NSW Department of Health; 2007.
376. Rosenstock IM. Historical origins of the health belief model. *Health Educ. Behav.* 1974;2(4):328-35.
377. Montanaro EA, Bryan AD. Comparing theory-based condom interventions: health belief model versus theory of planned behavior. *Health Psychol.* 2013;33(10):1251-60.
378. Galvin KT. A critical review of the health belief model in relation to cigarette smoking behaviour. *J. Clin. Nurs.* 1992;1(1):13-18.
379. Minugh PA, Rice C, Young L. Gender, health beliefs, health behaviors, and alcohol consumption. *Am. J. Drug Alcohol Abuse.* 1998;24(3):483-97.
380. Janz N, Becker M. The health belief model: a decade later. *Health Educ. Behav.* 1984;11(1):1-47.

381. Rosenstock I, Strecher V, Becker M. Social learning theory and the health belief model. *Health Educ. Behav.* 1988;15(2):175-83.
382. Prochaska JO, DiClemente CC. Stages and processes of self-change of smoking: toward an integrative model of change. *J. Consult. Clin. Psychol.* 1983;51(3):390-95.
383. Royal Life Saving WA. Don't drink and drown [Internet]. 2011 [cited 23 May 2012]. Available from: <http://www.lifesavingwa.com.au/community/dont-drink-drown/>
384. Foxall GR. *Consumer psychology in behavioural perspective*. London: Routledge; 1990.
385. Foxall GR, Oliveira-Castro JM, Schrezenmaier TC. The behavioral economics of consumer brand choice: patterns of reinforcement and utility maximization. *Behav. Processes.* 2004;66(3):235-60.
386. Sigurdsson V, Larsen NM, Gunnarsson D. An in-store experimental analysis of consumers' selection of fruits and vegetables. *Service Indus. J.* 2011;31(15):2587-602.
387. Foxall G, Oliveira-Castro J, James V, Yani-de-Soriano M, Sigurdsson V. Consumer behavior analysis and social marketing: the case of environmental conservation. *Behav. Soc. Issues.* 2006;15(1):101-24.
388. Sigurdsson V, Larsen NM, Gunnarsson D. The behavioural economics of neutral and upward sloping demand curves in retailing. *Service Indus. J.* 2011;31(15):2543-58.
389. Watson JB. *Behaviorism*. New York: W. W. Norton; 1924.
390. Skinner BF. *Science and human behavior*. New York: Free Press; 1953.
391. Skinner BF. *Beyond freedom and dignity*. London: Cape; 1972.
392. Pavlov IP. *Conditioned reflexes*. London: Oxford University Press; 1927.
393. Vanhonacker F, Pieniak Z, Verbeke W. Fish market segmentation based on consumers' motives, barriers and risk perception in Belgium. *J. Food. Prod. Market.* 2010;16(2):166-83.
394. Pieniak Z, Verbeke W, Scholderer J, Brunsø K, Ottar Olsen S. Impact of consumers' health beliefs, health involvement and risk perception on fish consumption. *Brit. Food J.* 2008;110(9):898-915.

395. Hardeman W, Johnston M, Johnston D, Bonetti D, Wareham N, Kinmonth AL. Application of the theory of planned behaviour in behaviour change interventions: a systematic review. *Psychol. Health.* 2002;17(2):123-58.
396. Foxall GR. Putting consumer behaviour in its place: the behavioural perspective model research programme. *Int. J. Manag. Rev.* 1999;1(2):133-58.
397. Neely TR, Lorenzen CL, Miller RK, Tatum JD, Wise JW, Taylor JF, et al. Beef customer satisfaction: cooking method and degree of doneness effects on the top round steak. *J. Anim. Sci.* 1999;77(3):653-60.
398. Skinner BF. *About behaviorism.* New York: Vintage Books; 1976.
399. Medical Research Council. A framework for development and evaluation of RCTs for complex interventions to improve health [Internet]. 2000 [cited 2012 Jan 22]. Available from: <http://www.mrc.ac.uk/documents/pdf/rcts-for-complex-interventions-to-improve-health/>
400. Curtin University. Facts and figures [Internet]. 2015 [cited 2015 May 25]. Available from: <http://about.curtin.edu.au/welcome/facts-and-figures/>
401. Australian Bureau of Statistics. SEIFA [Internet]. 2011 [cited 2015 Jan 12]. Available from: <http://www.abs.gov.au/websitedbs/censushome.nsf/home/seifa2011?opendocument&navpos=260>
402. Dedoose. Dedoose qualitative and mixed methods mesearch homepage. [Internet]. Los Angeles, CA: Dedoose; [cited 2015 Jul 14]. Available from: <http://www.dedoose.com>
403. Stewart DW, Shamdasani PN, Rook DW. *Focus groups: theory and practice.* 2nd ed. London: SAGE; 2007.
404. Olsen SO, Heide M, Dopico DC, Toften K. Explaining intention to consume a new fish product: a cross-generational and cross-cultural comparison. *Food Qual. Prefer.* 2008;19(7):618-27.
405. Honkanen P, Olsen SO, Myrland Ø. Preference - based segmentation: a study of meal preferences among Norwegian teenagers. *J. Consum. Behav.* 2004;3(3):235-50.

406. Walsh EM, Kiviniemi MT. Changing how I feel about the food: experimentally manipulated affective associations with fruits change fruit choice behaviors. *J. Behav. Med.* 2014;37(2):322-31.
407. Kiviniemi MT, Duangdao KM. Affective associations mediate the influence of cost–benefit beliefs on fruit and vegetable consumption. *Appetite.* 2009;52(3):771-75.
408. Richert J, Reuter T, Wiedemann AU, Lippke S, Ziegelmann J, Schwarzer R. Differential effects of planning and self-efficacy on fruit and vegetable consumption. *Appetite.* 2010;54(3):611-14.
409. Kreausukon P, Gellert P, Schwarzer R, Lippke S. Planning and self-efficacy can increase fruit and vegetable consumption: a randomized controlled trial. *J. Behav. Med.* 2012;35(4):443-51.
410. Monsivais P, Aggarwal A, Drewnowski A. Are socio-economic disparities in diet quality explained by diet cost? *J. Epidemiol. Community Health.* 2012;66(6):530-35.
411. Lutfiyya M, Chang L, Lipsky M. A cross-sectional study of US rural adults' consumption of fruits and vegetables: do they consume at least five servings daily? *BMC Public Health.* 2012;12(1):280-80.
412. Kim K, Struempfer BJ, Parmer SM. Decision of SNAP recipients to consume more vegetables: an application of the theory of planned behavior. *J. Hunger Environ. Nutr.* 2011;6(3):294-311.
413. Allom V, Mullan B. Self-regulation versus habit: the influence of self-schema on fruit and vegetable consumption. *Psychol. Health.* 2012;27(2):7-24.
414. Turunen AW, Männistö S, Suominen AL, Tiittanen P, Verkasalo PK. Fish consumption in relation to other foods in the diet. *Br. J. Nutr.* 2011;106(10):1570-80.
415. Carney M. Super trawler steams into sea of controversy [Internet]. 2012 [cited 23 January 2015]. Available from: <http://www.abc.net.au/news/2012-08-30/margiris-conflict-of-interest/4231858>
416. Taylor L. Last-ditch bid to stop super trawler fishing [Internet]. 2012 [cited 2015 Jan 23]. Available from: <http://www.watoday.com.au/federal->

- politics/political-news/lastditch-bid-to-stop-super-trawler-fishing-20120910-25ohw.html
417. Duffy C. Government planning huge marine park expansion [Internet]. 2012 [cited 23 January 2015]. Available from: <http://www.abc.net.au/news/2012-06-11/government-planning-huge-marine-park-expansion/4063294>
 418. Coles Supermarkets Australia. Responsibly sourced seafood [Internet]. 2013 [cited 2013 Sep 18]. Available from: <http://www.coles.com.au/corporate-responsibility/responsible-sourcing-and-sustainability/responsibly-sourced-meat-and-seafood/responsibly-sourced-seafood>
 419. Woolworths Limited. Sustainable fish and seafood [Internet]. 2013 [cited 2013 Sep 20]. Available from: http://www.woolworthslimited.com.au/page/A_Trusted_Company/Responsible_Sourcing/Sustainable_Fish_and_Seafood/
 420. Deloitte. Positioning for prosperity? Catching the next wave [Internet]. 2014 [cited 2015 May 2]. Available from: <http://www2.deloitte.com/au/en/pages/building-lucky-country/articles/positioning-for-prosperity.html>
 421. CSIRO. Standard Fish Names in Australia (commercial species) [Internet]. 2014 [cited 2014 Aug 20]. Available from: http://www.marine.csiro.au/caabsearch/caab_search.fish_names_list
 422. Brown FK, Onley AC, Yearsley GK. Australian seafood users manual. Brisbane (Queensland): Queensland Government; 2000.
 423. Food Standards Australia New Zealand. Monitoring nutrients in our food supply [Internet]. 2013 [cited 2014 Aug 2]. Available from: <http://www.foodstandards.gov.au/science/monitoringnutrients/Pages/default.aspx>
 424. TestFlight. TestFlight homepage. [Internet]. Santa Monica, CA: Burstly; [cited 2014 Aug 13]. Available from: <http://www.testflightapp.com>
 425. Vogels W. Eventually consistent. Communications of the ACM. 2009;52(1):40-44.

426. Etherington D. Apple puts iOS 7 adoption at 74% based on App Store usage numbers [Internet]. 2013 [cited 2014 Aug 20]. Available from: <http://techcrunch.com/2013/12/05/ios-7-adoption-official-apple/>
427. Mrgan C. Why iOS 7's design is bold but flawed [Internet]. 2013 [cited 2014 Aug 20]. Available from: <http://www.macworld.com/article/2043265/why-ios-7s-design-is-bold-but-flawed.html>
428. Shaughnessy H. Is Apple facing a designer and developer revolt over iOS 7? [Internet]. 2013 [cited 2014 Aug 8]. Available from: <http://www.forbes.com/sites/haydnshaughnessy/2013/06/24/is-apple-facing-a-designer-and-developer-revolt-over-ios-7/>
429. Brabham DC, Ribisl KM, Kirchner TR, Bernhardt JM. Crowdsourcing applications for public health. *Am. J. Prev. Med.* 2014;46(2):179-87.
430. Bottles KMD, Kim JMDMPH. How physician leaders can use social media to crowdsource. *Physician Exec.* 2014;40(1):82-84.
431. American Association for Cancer Research. Games crowdsource cancer research. *Cancer Discov.* 2013;3:959-60.
432. O'Donoghue B. At home with Ben: great family food for every occasion. Prahran (Victoria): Hardie Grant; 2010.
433. O'Donoghue B. Ben's BBQ bible: the ultimate cook's companion. Prahran (Victoria): Hardie Grant; 2013.
434. McGlashan A. How to cook fish and eat it. Chatswood (NSW): New Holland; 2009.
435. CSIRO. Atlas of living Australia [Internet]. 2014 [cited 2014 Sep 17]. Available from: <http://www.ala.org.au>
436. Yelp. Yelp homepage. [Internet]. San Francisco, CA: Yelp; [cited 2015 Aug 5]. Available from: <http://www.yelp.com.au/perth>
437. Centre of Excellence for Science Seafood and Health. Seafood and your health [Internet]. 2010 [cited 2014 Aug 26]. Available from: <http://cessh.curtin.edu.au/resources/health.cfm>
438. Centre of Excellence for Science Seafood and Health. Point of sale flyers [Internet]. 2010 [cited 2014 Aug 26]. Available from: <http://cessh.curtin.edu.au/resources/industry.cfm>

439. Mooney BD, Nichols PD, Elliott NG. Seafood the good food II: oil profiles for further Australian seafoods, and influencing factors. Hobart (Tasmania): CSIRO / Fisheries Research & Development Corporation; 2001.
440. Nichols PD, Virtue P, Mooney BD, Elliott NG, Yearsley GK. Seafood the good food: the oil (fat) content and composition of Australian commercial fishes, shellfishes and crustaceans. Hobart (Tasmania): CSIRO / Fisheries Research & Development Corporation; 1998.
441. Bowen DJ, Kreuter M, Spring B, Cofta-Woerpel L, Linnan L, Weiner D, et al. How we design feasibility studies. *Am. J. Prev. Med.* 2009;36(5):452-57.
442. McCambridge J, Witton J, Elbourne DR. Systematic review of the Hawthorne effect: new concepts are needed to study research participation effects. *J. Clin. Epidemiol.* 2014;67(3):267-77.
443. Hertzog M. Considerations in determining sample size for pilot studies. *Res. Nurs. Health.* 2008;31(2):180-91.
444. Arain M, Campbell MJ, Cooper CL, Lancaster GA. What is a pilot or feasibility study? A review of current practice and editorial policy. *BMC Med. Res. Methodol.* 2010;10:61-68.
445. Salesforce Marketing Cloud. The Facebook ads benchmark report [Internet]. 2013 [cited 2014 Jul 13]. Available from: <https://www.salesforcemarketingcloud.com/wp-content/uploads/2013/06/The-Facebook-Ads-Benchmark-Report.pdf>
446. SurveyMonkey. SurveyMonkey homepage. [Internet]. Palo Alto, CA: SurveyMonkey; [cited 2014 Aug 12]. Available from: <http://www.surveymonkey.net>
447. Bit Stadium GMBH. HockeyApp homepage. [Internet]. Redmond, WA: HockeyApp; [updated 2014 Nov 12; cited 2015 Jul 14]. Available from: <http://www.hockeyapp.net>
448. Litt MD, Cooney NL, Morse P. Ecological momentary assessment (EMA) with treated alcoholics: methodological problems and potential solutions. *Health Psychol.* 1998;17(1):48-52.
449. Bandura A. Self-efficacy: toward a unifying theory of behavioral change. *Psychol. Rev.* 1977;84(2):191-215.

450. Kinsbruner E. Mobile users less tolerant, more demanding than desktop users [Internet]. 2013 [cited 2015 Jul 14]. Available from: <http://www.mobilemarketer.com/cms/opinion/columns/14609.html>
451. Flores L. 10 facts about the value of brand websites. *Admap* 2004(February):26-28.
452. Muller B, Flores L, Agrebi M, Chandon J-L. The branding impact of brand websites: do newsletters and consumer magazines have a moderating role? *J. Advert. Res.* 2008;48(3):465-72.
453. The Rocket Science Group. MailChimp homepage. [Internet]. Atlanta, GA: The Rocket Science Group,; [cited 2014 Aug 14]. Available from: <http://www.mailchimp.com>
454. O' Brien HL, Toms EG. The development and evaluation of a survey to measure user engagement. *J. Am. Soc. Inf. Sci. Technol.* 2010;61(1):50-69.
455. Brener ND, Billy JOG, Grady WR. Assessment of factors affecting the validity of self-reported health-risk behavior among adolescents: evidence from the scientific literature. *J. Adolesc. Health.* 2003;33(6):436-57.
456. Fisher RJ. Social desirability bias and the validity of indirect questioning. *J. Consum. Res.* 1993;20(2):303-15.
457. Fan X, Miller BC, Park K, Winward BW, Christensen M, Grotevant HD, et al. An exploratory study about inaccuracy and invalidity in adolescent self-report surveys. *Field Methods.* 2006;18(3):223-44.
458. Kohavi R, Longbotham R. Online controlled experiments and A/B tests. In: Sammut C, Webb G, editors. *Encyclopedia of machine learning and data mining*. New York: Springer; 2015.
459. Jonas E, Schulz-Hardt S, Frey D, Thelen N. Confirmation bias in sequential information search after preliminary decisions: an expansion of dissonance theoretical research on selective exposure to information. *J. Pers. Soc. Psychol.* 2001;80(4):557-71.
460. Centre of Excellence for Science Seafood and Health. Kidzone [Internet]. 2011 [cited 2015 Nov 17]. Available from: <http://cessh.curtin.edu.au/kidzone/index.cfm>

461. Centre of Excellence for Science Seafood and Health. Recipes for kids [Internet]. 2012 [cited 2015 Nov 17]. Available from: <http://cessh.curtin.edu.au/resources/0E423E5C52E04EB487326CE5578C2F0D.cfm>
462. Research2guidance. mHealth app developer economics: the state of the art of mHealth app publishing [Internet]. 2014 [cited 2015 Apr 10]. Available from: <http://research2guidance.com/r2g/research2guidance-mHealth-App-Developer-Economics-2014.pdf>

Every reasonable effort has been made to acknowledge the owners of copyright material. I would be pleased to hear from any copyright owner who has been omitted or incorrectly acknowledged.

Appendices

Focus group information sheet and consent form



Curtin University

CURTIN HEALTH INNOVATION
RESEARCH INSTITUTE

FOCUS GROUP INFORMATION SHEET

About the study

My name is James White. I am interested in understanding the experiences people have in selecting and eating fish, and in particular, the places people go to find information about fish. I am also interested in the way people use mobile technology (such as smart phones and tablet computers) and social media to find information about health and nutrition.

The aim of this study is to guide the development of a new mobile application to assist people to eat fish for health benefit.

What will you be asked to do?

If you would like to take part in this study, you can come along to a 45-minute group session that will include a maximum of 8 people. The group session will be held at xxxxxxxx on xxxxxxxxxxxxxx, from xxxxx to xxxxxx.

In recognition of your contribution to the study and to compensate you for your time and effort, you will be paid \$20 if you decide to take part in the study.

This session will be a focus group discussion centering around your perceptions and experiences of fish consumption and your use of mobile technology, including smartphones, tablet computers, and apps. This discussion will be recorded on audiotape, to enable the researchers to easily recall what was said.

If you agree to participate in the study you will be able to withdraw at any time, and you do not have to give a reason for doing so. If you withdraw from the study, all the information provided by you will be destroyed.

What will be done with this information?

The session will be recorded on an audiotape so that we do not miss any of the information you provide. The information collected during the study will be stored securely and kept confidential. All personal information will be kept only for as long as it is needed, and then will be destroyed. Information will not be reproduced in a manner that could lead to the identification of any of the participants. Once the study is completed, a summary of the findings will be available to all participants. The results of the study will also be circulated to the wider community. However, participants will not be named in any of the reports that are produced as part of the study.

How can you find out more information about this study?

If you are interested in taking part but would like to ask some questions about what is involved, please call me on 0405 761 580, or email me at james.white@curtin.edu.au. You may also contact my supervisor, Professor Alexandra McManus, on (08) 9266 2115, or at a.mcmanus@curtin.edu.au

This study has been approved by the Curtin University Human Research Ethics Committee (Approval Number RD-45-12). If needed, verification of approval can be obtained either by writing to the Curtin University Human Research Ethics Committee, c/- Office of Research and Development, Curtin University, GPO Box U1987, Perth WA 6845, or by telephoning 9266 2784 or by emailing hrec@curtin.edu.au.



FOCUS GROUP CONSENT FORM

I _____ (print your full name) have read the summary of this research project and any questions I have asked have been answered to my satisfaction. I agree to participate in this activity, realising that I may withdraw at any time without reason and without prejudice. I understand that all information provided is treated as strictly confidential and will not be released by the investigator unless required by law.

I agree that data gathered for this project may be published provided my name or other identifying information is not used.

Participant's Signature

Date

This study has been approved by the Curtin University Human Research Ethics Committee (Approval Number RD-45-12). If needed, verification of approval can be obtained either by writing to the Curtin University Human Research Ethics Committee, c/- Office of Research and Development, Curtin University, GPO Box U1987, Perth WA 6845, or by telephoning 9266 2784 or by emailing hrec@curtin.edu.au.

The Curtin University Human Research Ethics Committee requires that all participants are informed that, if they have any complaint regarding the manner, in which a research project is conducted, it may be given to the Project Manager (Telephone 9266 7021) or, alternatively to the Secretary, Human Research Ethics Committee, Office of Research and Development, Curtin University of Technology, PO Box U1987, Perth, WA 6845 (Telephone 9266 2784). All study participants will be provided with a copy of the Information Sheet and Consent Form for their personal records on request.

Species included in the experimental application

Bony fish

Marketing name	Scientific name	Marketing name	Scientific name
albacore	<i>Thunnus alalunga</i>	golden perch	<i>Macquaria ambigua</i>
alfonsino	<i>Beryx splendens</i>	golden pomfret	<i>Xenobrama microlepis</i>
Atlantic salmon	<i>Salmo salar</i>	golden trevally	<i>Gnathanodon speciosus</i>
Australian sardine	<i>Sardinops neopilchardus</i>	goldspotted rockcod	<i>Epinephelus coioides</i>
banded morwong	<i>Cheilodactylus spectabilis</i>	grass emperor	<i>Lethrinus laticaudis</i>
banded rockcod	<i>Epinephelus ergastularius</i>	green jobfish	<i>Aprion virescens</i>
barcheek coral trout	<i>Plectropomus maculatus</i>	greenback flounder	<i>Rhombosolea tapirina</i>
barramundi	<i>Lates calcarifer</i>	grey mackerel	<i>Scomberomorus semifasciatus</i>
bartail flathead	<i>Platycephalus indicus</i>	grey morwong	<i>Nemadactylus douglasii</i>
basa	<i>Pangasius bocourti</i>	hussar	<i>Lutjanus adetii</i>
bigeye trevally	<i>Caranx sexfasciatus</i>	imperador	<i>Beryx decadactylus</i>
bigeye tuna	<i>Thunnus obesus</i>	jack mackerel	<i>Trachurus declivis</i>
bight redfish	<i>Centroberyx gerrardi</i>	jackass morwong	<i>Nemadactylus macropterus</i>
bigscale pomfret	<i>Taractichthys longipinnis</i>	john dory	<i>Zeus faber</i>
black bream	<i>Acanthopagrus butcheri</i>	king dory	<i>Cyttus traversi</i>
black oreodory	<i>Allocyttus niger</i>	King George whiting	<i>Sillaginodes punctata</i>
black trevally	<i>Caranx lugubris</i>	king snapper	<i>Pristipomoides spp</i>
blacktip rockcod	<i>Epinephelus fasciatus</i>	king threadfin	<i>Polynemus sheridani</i>
blue grenadier	<i>Macruronus novaezelandiae</i>	largetooth flounder	<i>Pseudorhombus arsius</i>
blue morwong	<i>Nemadactylus valenciennesi</i>	lesser queenfish	<i>Scomberoides lysan</i>
blue threadfin	<i>Eleutheronema tetradactylum</i>	longfin eel	<i>Anguilla reinhardtii</i>
blue warehou	<i>Seriolella brama</i>	longfin rockcod	<i>Epinephelus quoyanus</i>
blue-eye trevalla	<i>Hyperoglyphe antarctica</i>	longnose emperor	<i>Lethrinus olivaceus</i>
bluefin trevally	<i>Caranx melampygus</i>	longsnout flounder	<i>Ammotretis rostratus</i>
bluespotted coral trout	<i>Plectropomus laevis</i>	longtail garfish	<i>Hyporhamphus quoyi</i>
bluespotted emperor	<i>Lethrinus sp.</i>	longtail tuna	<i>Thunnus tonggol</i>
bluespotted flathead	<i>Platycephalus caeruleopunctatus</i>	mackerel tuna	<i>Euthynnus affinis</i>
bluespotted trevally	<i>Caranx bucculentus</i>	mangrove jack	<i>Lutjanus argentimaculatus</i>
bluetail mullet	<i>Valamugil seheli</i>	Maori rockcod	<i>Epinephelus undulatostratus</i>
brown trout	<i>Salmo trutta</i>	mirror dory	<i>Zenopsis nebulosus</i>
chinook salmon	<i>Oncorhynchus tshawytscha</i>	Moses snapper	<i>Lutjanus russelli</i>
cobia	<i>Rachycentron canadum</i>	mulloway	<i>Argyrosomus hololepidotus</i>
common coral trout	<i>Plectropomus leopardus</i>	Murray cod	<i>Maccullochella spp</i>
crimson snapper	<i>Lutjanus erythropterus</i>	needleskin queenfish	<i>Scomberoides tol</i>
deepwater flathead	<i>Neoplatycephalus conatus</i>	northern pearl perch	<i>Glaucosoma buergeri</i>
diamondscale mullet	<i>Liza vaigiensis</i>	ocean blue-eye trevalla	<i>Schedophilus labyrinthica</i>
dusky flathead	<i>Platycephalus fuscus</i>	ocean jacket	<i>Nelusetta ayraudi</i>
Eastern Australian salmon	<i>Arripis trutta</i>	ocean perch	<i>Helicolenus barathri</i>
eastern sea garfish	<i>Hyporhamphus australis</i>	orange roughy	<i>Hoplostethus atlanticus</i>
european carp	<i>Cyprinus carpio</i>	pearl perch	<i>Glaucosoma scapulare</i>
frigate mackerel	<i>Auxis thazard</i>	pikey bream	<i>Acanthopagrus berda</i>
frypan bream	<i>Argyrops spinifer</i>	pink ling	<i>Genypterus blacodes</i>
gemfish	<i>Rexea solandri</i>	rainbow trout	<i>Oncorhynchus mykiss</i>
giant queenfish	<i>Scomberoides commersonianus</i>	rankin cod	<i>Epinephelus multinotatus</i>
giant trevally	<i>Caranx ignobilis</i>	Ray's bream	<i>Brama brama</i>
goldband snapper	<i>Pristipomoides multidens</i>	red emperor	<i>Lutjanus sebae</i>

Bony fish (contd.)

Marketing name	Scientific name
red morwong	<i>Cheilodactylus fuscus</i>
redfin	<i>Perca fluviatilis</i>
redfish	<i>Centroberyx affinis</i>
redspot emperor	<i>Lethrinus lentjan</i>
redthroat emperor	<i>Lethrinus miniatus</i>
reef leatherjacket	<i>Meuschenia freycineti</i>
reef ocean perch	<i>Helicolenus percoides</i>
river garfish	<i>Hyporhamphus regularis</i>
rock flathead	<i>Platycephalus laevigatus</i>
rock ling	<i>Genypterus tigerinus</i>
ruby snapper	<i>Etelis</i> sp.
saddletail snapper	<i>Lutjanus malabaricus</i>
samsonfish	<i>Seriola dumerili</i>
sand flathead	<i>Platycephalus bassensis</i>
sand whiting	<i>Sillago ciliata</i>
school mackerel	<i>Scomberomorus queenslandicus</i>
school whiting	<i>Sillago bassensis</i>
sea mullet	<i>Mugil cephalus</i>
shark mackerel	<i>Grammatorcynus bicarinatus</i>
sharptooth snapper	<i>Pristipomoides typus</i>
shortfin eel	<i>Anguilla australis</i>
silver dory	<i>Cyttus australis</i>
silver perch	<i>Bidyanus bidyanus</i>
silver trevally	<i>Pseudocaranx dentex</i>
silver warehou	<i>Seriolella punctata</i>
skipjack tuna	<i>Katsuwonus pelamis</i>
smooth oreodory	<i>Pseudocyttus maculatus</i>
snapper	<i>Pagrus auratus</i>
snubnose garfish	<i>Arrhamphus sclerolepis</i>
southern bluefin tuna	<i>Thunnus maccoyii</i>
southern flathead	<i>Platycephalus speculator</i>
southern garfish	<i>Hyporhamphus melanochir</i>
spangled emperor	<i>Lethrinus nebulosus</i>
Spanish mackerel	<i>Scomberomorus commerson</i>
spikey oreodory	<i>Neocyttus rhomboidalis</i>
spotted flounder	<i>Ammotretis lituratus</i>
spotted mackerel	<i>Scomberomorus munroi</i>
striped marlin	<i>Tetrapturus audax</i>
striped trumpeter	<i>Latris lineata</i>
stripey snapper	<i>Lutjanus carponotatus</i>
swordfish	<i>Xiphias gladius</i>
tailor	<i>Pomatomus saltatrix</i>
tarwhine	<i>Rhabdosargus sarba</i>
threadfin pearl perch	<i>Glaucosoma magnificum</i>
three-by-two garfish	<i>Hemiramphus robustus</i>
tiger flathead	<i>Neoplatycephalus richardsoni</i>
tilapia	<i>Oreochromis mossambica</i>
toothy flathead	<i>Neoplatycephalus aurimaculatus</i>
trumpeter whiting	<i>Sillago maculata</i>
turrum	<i>Carangoides fulvoguttatus</i>

Marketing name	Scientific name
velvet leatherjacket	<i>Meuschenia scaber</i>
warty oreodory	<i>Allocyttus verrucosus</i>
West Australian dhufish	<i>Glaucosoma hebraicum</i>
Western Australian salmon	<i>Arripis truttaceus</i>
white warehou	<i>Seriolella caerulea</i>
yellowedge coronation trout	<i>Variola louti</i>
yelloweye mullet	<i>Aldrichetta forsteri</i>
yelloweye redfish	<i>Centroberyx australis</i>
yellowfin bream	<i>Acanthopagrus australis</i>
yellowfin tuna	<i>Thunnus albacares</i>
yellowfin whiting	<i>Sillago schomburgkii</i>
yellowspotted rockcod	<i>Epinephelus areolatus</i>
yellowtail kingfish	<i>Seriola lalandi</i>

Cartilaginous fish

Marketing name	Scientific name
angel shark	<i>Squatina</i> sp.
Australian blacktip shark	<i>Carcharhinus tilstoni</i>
bronze whaler shark	<i>Carcharhinus brachyurus</i>
dusky whaler	<i>Carcharhinus obscurus</i>
gummy shark	<i>Mustelus</i> sp.
ray	<i>Trygonorrhina</i> sp.
sawshark	<i>Pristiophorus</i> spp
school shark	<i>Galeorhinus galeus</i>
whiskery shark	<i>Furgaleus macki</i>

Crustaceans

Marketing name	Scientific name
Balmain bug	<i>Ibacus peronii</i>
banana prawn	<i>Fenneropenaeus</i> sp.
bay prawn	<i>Metapenaeus</i> sp.
blue swimmer crab	<i>Portunus pelagicus</i>
eastern king prawn	<i>Melicertus plebejus</i>
eastern rocklobster	<i>Jasus verreauxi</i>
endeavour prawn	<i>Metapenaeus</i> sp.
king prawn	<i>Melicertus</i> sp.
marron	<i>Cherax cainii</i>
Moreton Bay bug	<i>Thenus orientalis</i>
mud crab	<i>Scylla serrata</i>
redclaw	<i>Cherax quadricarinatus</i>
school prawn	<i>Metapenaeus</i> sp.
southern rocklobster	<i>Jasus edwardsii</i>
spanner crab	<i>Ranina ranina</i>
tiger prawn	<i>Penaeus</i> sp.
tropical rocklobster	<i>Panulirus</i> sp.
vannamei prawn	<i>Penaeus vannamei</i>
western rocklobster	<i>Panulirus cygnus</i>
yabby	<i>Cherax destructor</i>

Molluscs

Marketing name	Scientific name
blacklip abalone	<i>Haliotis rubra</i>
blue mussel	<i>Mytilus edulis</i>
brownlip abalone	<i>Haliotis conicopora</i>
calamari	<i>Sepioteuthis</i> sp.
cockle	<i>Anadara trapezius</i>
commercial scallop	<i>Pecten fumatus</i>
cuttlefish	<i>Sepia</i> sp.
gould's squid	<i>Nototodarus gouldi</i>
green-lipped mussel	<i>Perna canalicula</i>
greenlip abalone	<i>Haliotis laevigata</i>
native oyster	<i>Ostrea angasi</i>
octopus	<i>Octopus</i> sp.
Pacific oyster	<i>Crassostrea gigas</i>
periwinkle	<i>Turbo undulatus</i>
pipi	<i>Donax deltoides</i>
roe's abalone	<i>Haliotis roei</i>
saucer scallop	<i>Amusium balloti</i>
squid	order Teuthoidea
surf clam	<i>Dosinia caerulea</i>
Sydney rock oyster	<i>Saccostrea glomerata</i>

Other

Marketing name	Scientific name
crocodile	<i>Crocodylus porosus</i>
sea cucumber	Holothuriidae sp.
sea urchin	Class Echinoidea sp.

Articles used in health section of experimental application

Good news for joint pain sufferers



A healthy diet high in oily fish can help reduce symptoms of rheumatoid arthritis and help you to manage your condition. These benefits include reduced joint tenderness, a reduction in morning stiffness and reduced use of analgesic anti-inflammatory drugs. Even if you do not yet suffer from arthritis, scientific studies have shown a link between regular seafood consumption and a reduced risk of developing arthritis. Rheumatoid arthritis may also increase your risk of heart disease, but research has shown that a diet high in oily fish can help to reduce this risk.

Fish and seafood rich in omega-3s is an important dietary investment in reducing the risk and the symptoms of arthritis. Seafood provides the best source of omega-3s, with the richest sources being oily fish such as salmon, mackerel and sardines.

If you are at risk of developing arthritis or have a mild form of the condition, you will start to feel the benefits of a healthier diet (coupled with mild exercise) within a few weeks. However, if you already have rheumatoid arthritis, you may not feel the full benefit for a month or two. Make oily fish a weekly habit!

Health information is provided by the Centre of Excellence for Science, Seafood and Health Curtin University, Western Australia

A managed diet doesn't have to be dull



For those at risk of diabetes, or those who have already been diagnosed, one of the biggest challenges can be making significant changes to their diet. Many people find it difficult to limit or eliminate foods that they enjoy, and report reduced enjoyment of meals. Fish and seafood provide the best of both worlds, helping people to retain taste and variety as they plan a nutritious, balanced diet.

A healthy diet can help you manage your weight and may help prevent type 2 diabetes. If you already have diabetes, a healthy diet can help you manage your condition.

People diagnosed with diabetes are more susceptible to coronary heart disease, making heart smart dietary decisions even more important.

Staying “heart healthy” is a key step to avoiding the onset of type 2 diabetes. Fish and seafood are much lower in saturated fat than other protein sources, such as red meat, and eating 2-3 serves a week can help to control cholesterol and blood pressure levels - both important considerations in avoiding type 2 diabetes.

Health information is provided by the Centre of Excellence for Science, Seafood and Health Curtin University, Western Australia

The family dish, for when you're in the family way



A healthy diet including high levels of oily fish during pregnancy has been shown to provide many benefits, including better brain development increased birth weight for the baby, and lower rates of hypertension for the mother. It has also been shown to reduce the chances of pre-term delivery. The benefits also continue after birth – fish consumption during pregnancy has been linked with better language, visual and motor development for children as they grow. If you are pregnant or planning pregnancy, a diet including seafood is a healthy food choice.

What about mercury?

You may have heard that pregnant women should be wary of the mercury content of fish and seafood. The good news is that most common fish species available in Australia are completely safe to consume while pregnant or planning pregnancy. However, there are some recommendations for pregnant women and children under six years (Note: a child's serving size is 75g, rather than the 150g recommended for adults).

2 – 3 serves/week of any fish/seafood

EXCEPT

orange roughy, catfish, shark or billfish
(swordfish/broadbill/marlin)

or

1 serve/week of orange roughy (sea perch)

OR
catfish
THEN

no other fish that week

or

1 serve/fortnight of shark (flake)

OR
billfish
THEN

no other fish that fortnight

*Recommendations from Food Standards Australia
New Zealand*

*Health information is provided by the Centre of
Excellence for Science, Seafood and Health
Curtin University, Western Australia*

The good oil: everything you need to know



Omega-3 fatty acids (omega-3s) are essential to our health. The regular intake of omega-3s as part of a healthy diet provides health benefits for conditions such as diabetes, heart disease, arthritis and some cancers. Our bodies cannot produce these fatty acids and so we need to eat foods that contain them.

The best source of omega-3s is fish and seafood. Adults should aim to include 3500 - 4000mg of omega-3s in their diet each week. Some types of seafood contain higher levels of omega-3s than others so the number of serves of seafood you need to eat each week to maintain good health depends on the type of seafood you eat. Generally, one serve of seafood is around 150g.

Can I just take fish oil supplements?

Although supplements may be of benefit for those with very high omega-3 requirements (for example, those suffering from rheumatoid arthritis), fish and seafood remains the very best source of these fatty acids. Recent research shows that there is great variability in the bioavailability of the omega-3s contained in supplements and other fortified foods, such as bread (in other words, the ease with which our bodies can make use of them). Besides being the best source of omega-3s, fish and seafood has many other benefits, making it a true super food.

Health information is provided by the Centre of Excellence for Science, Seafood and Health Curtin University, Western Australia

Give your heart a fighting chance



A healthy balanced diet including fish and seafood, along with regular physical activity, can help to reduce the risk of coronary heart disease. The benefits of eating fish and seafood include:

- protection against cardiovascular diseases
- protection against coronary mortality
- lowered blood pressure
- reduced heart rate
- protection for veins and arteries

Fish and seafood are also a smart choice for lowering cholesterol, and the omega-3 fatty acids in oily fish can actually help to prevent coronary heart disease.

Health information is provided by the Centre of Excellence for Science, Seafood and Health Curtin University, Western Australia

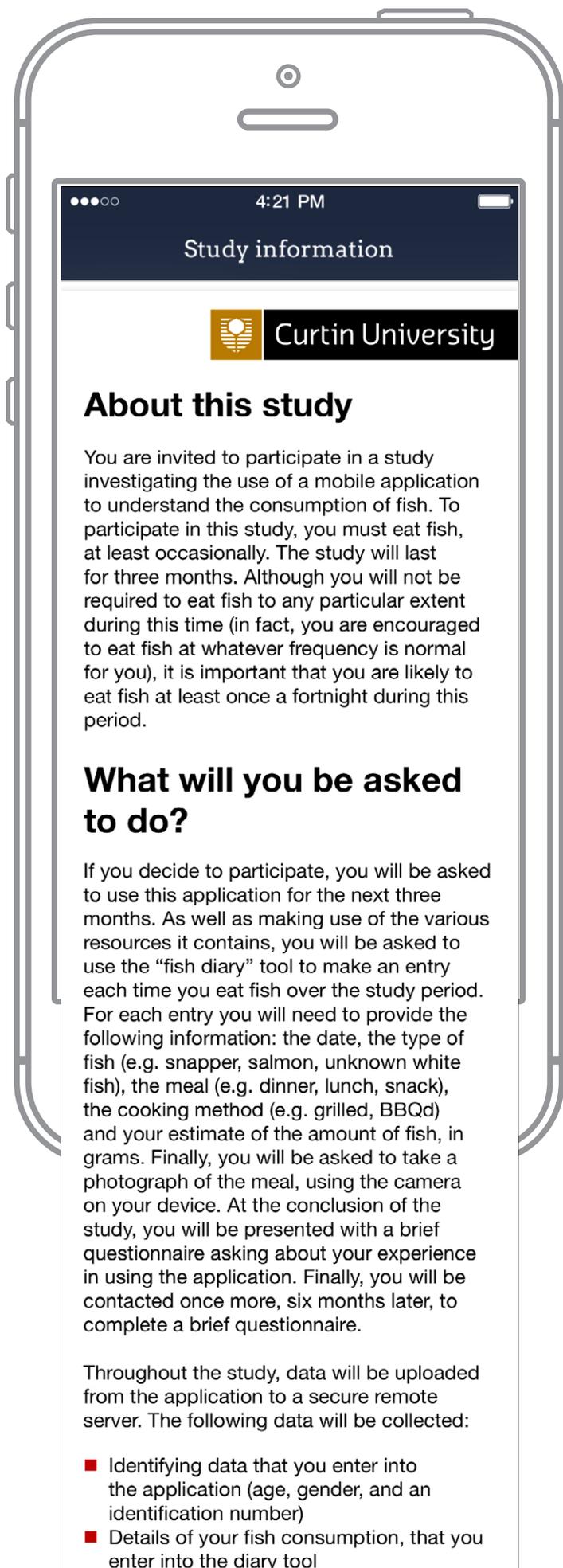
Helping to reduce your risk



Including fish and seafood in a balanced diet can improve and maintain your health. Research suggests that adequate levels of physical activity and a balanced, healthy diet have a significant preventative effect on the development of some cancers. In particular, consumption of oily fish has been linked with a reduced risk of prostate, breast, colon, oesophageal and lung cancers. When prepared in a healthy way, fish is a valuable part of a healthy diet.

Health information is provided by the Centre of Excellence for Science, Seafood and Health Curtin University, Western Australia

Intervention in-application information and consent screens



- Photographs that you take of your fish meals
- Information about the way you use the application - for example, which tools you use most often

Please note that, like all iPhone and iPad apps, this application is “sandboxed”. This means that it can only directly access its own data. The application can not, and will not, access your personal information or data from any other apps on your device.

If you agree to participate in the study you will be able to withdraw at any time, and you do not have to give a reason for doing so.

What will be done with this information?

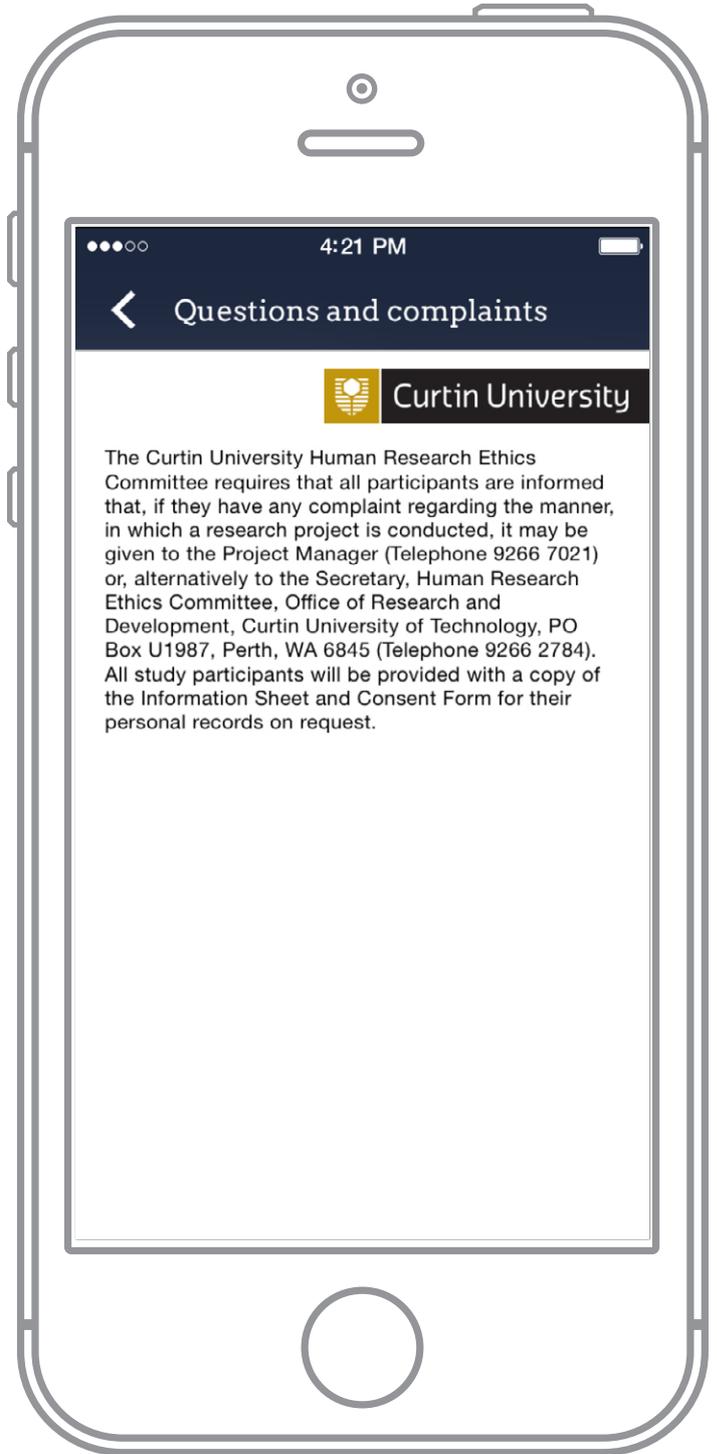
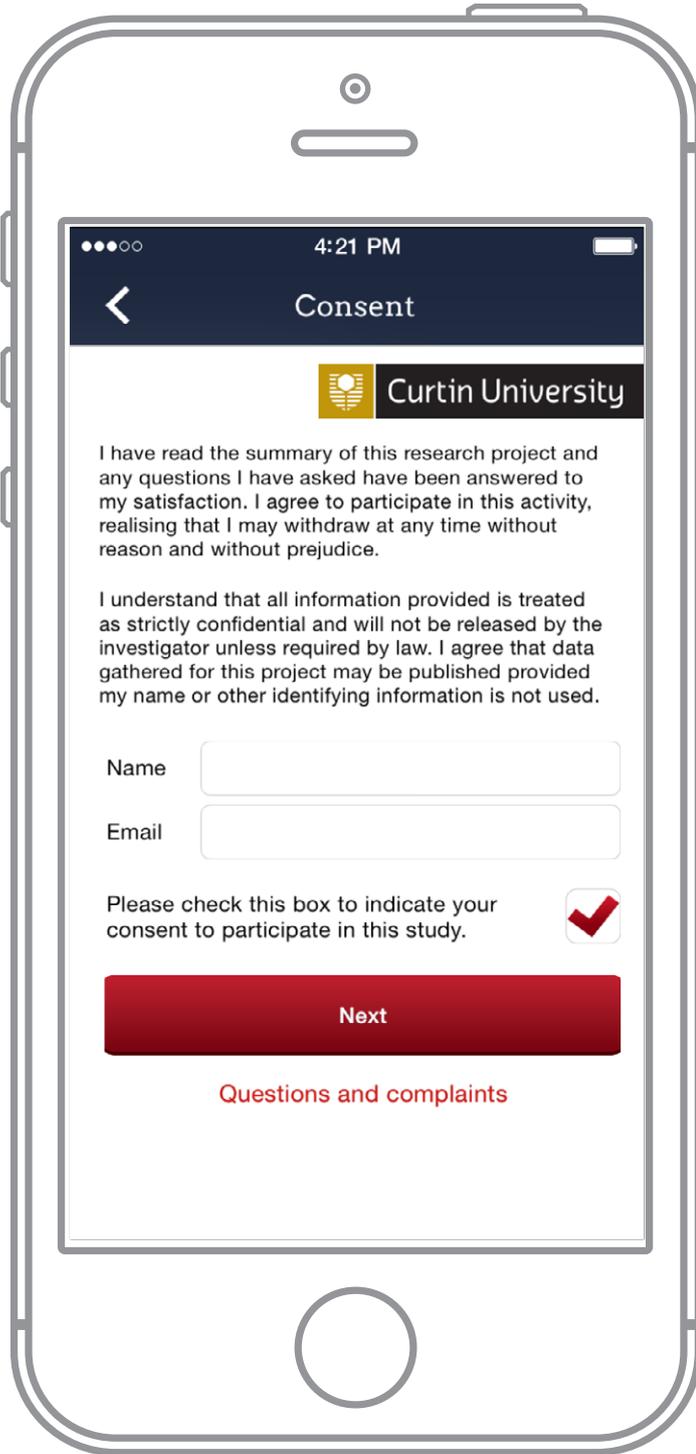
The information collected during the study will be stored securely and kept confidential. All personal information will be kept only for as long as it is needed, and then will be destroyed. Information will not be reproduced in a manner that could lead to the identification of any of the participants. Once the study is completed, a summary of the findings will be available to all participants. The results of the study will also be circulated to the wider community. However, participants will not be named in any of the reports that are produced as part of the study.

How can you find out more information about this study?

If you are interested in taking part but would like to ask some questions about what is involved, please call me on 0405 761 580, or email me at james.white@curtin.edu.au. You may also contact my supervisor, Professor Alexandra McManus, on (08) 9266 2115, or at a.mcmanus@curtin.edu.au

This study has been approved by the Curtin University Human Research Ethics Committee (Approval Number RD-45-12) If needed, verification of approval can be obtained either by writing to the Curtin University Human Research Ethics Committee, c/- Office of Research and Development, Curtin University, GPO Box U1987, Perth WA 6845, or by telephoning 9266 2784 or by emailing hrec@curtin.edu.au

Next



Entry questionnaire



FISH CONSUMPTION STUDY - PRE STUDY QUESTIONNAIRE

Thank you for participating in the Pier 2 Peer study, conducted by the Centre of Excellence for Science, Seafood and Health, at Curtin University. Your participation will help us to understand the reasons Australians do, and don't, eat fish and seafood.

About the study

You are invited to participate in a study investigating the use of a mobile app to understand the consumption of fish. To participate, you must be at least 18 years old, and live in Australia. You will also need to own an iPhone, iPad or iPod Touch, as you will need to install the app on your device.

To participate in this study, you must currently eat fish, at least occasionally. The study will last for three months. Although you will not be required to eat fish to any particular extent during this time, it is important that you think you are likely to eat fish at least occasionally during this period.

What will you be asked to do?

This brief questionnaire is the first component of participation in this study. After completing this questionnaire, you will be sent instructions for downloading a mobile application, which you will need to use for the next three months. During these three months, you may receive emails from time to time about the study. At the end of this time, you will be asked to complete a final questionnaire.

If you agree to participate in the study you will be able to withdraw at any time, and you do not have to give a reason for doing so.

What will be done with this information?

The information collected during the study will be stored securely and kept confidential. All personal information will be kept only for as long as it is needed, and then will be destroyed. Information will not be reproduced in a manner that could lead to the identification of any of the participants. Once the study is completed, a summary of the findings will be available to all participants. The results of the study will also be circulated to the wider community. However, participants will not be named in any of the reports that are produced as part of the study.

When will you receive the gift card?

You'll need to use the app throughout the three-month study period, making an entry each time you eat fish. Although you won't be expected to eat a particular amount of fish during the study, it's important that you eat it at least occasionally; you will need to have some entries in the fish diary by the end of the study. At the end of the three months you will be asked to complete a final questionnaire. After this, you'll be emailed a code which can be redeemed for \$25 of iTunes credit, as thanks for your participation.

How can you find out more information about this study?

You can obtain more information by contacting the researcher James White on 0405 761 580, or emailing james.white@curtin.edu.au. You may also contact the project supervisor, Professor Alexandra McManus, on (08) 9266 2115, or at a.mcmanus@curtin.edu.au

This study has been approved by the Curtin University Human Research Ethics Committee (Approval Number RD-45-12). If needed, verification of approval can be obtained either by writing to the Curtin University Human Research Ethics Committee, c/- Office of Research and Development, Curtin University, GPO Box U1987, Perth WA 6845, or by telephoning 9266 2784 or by emailing hrec@curtin.edu.au.

The Curtin University Human Research Ethics Committee requires that all participants are informed that, if they have any complaint regarding the manner, in which a research project is conducted, it may be given to the Project Manager (Telephone 9266 7021) or, alternatively to the Secretary, Human Research Ethics Committee, Office of Research and Development, Curtin University, PO Box U1987, Perth, WA 6845.

CONSENT

I have read the summary of this research project and any questions I have asked have been answered to my satisfaction. I agree to participate in this activity, realising that I may withdraw at any time without reason and without prejudice. I understand that all information provided is treated as strictly confidential and will not be released by the investigator unless required by law.

I agree that data gathered for this project may be published provided my name or other identifying information is not used.

1 I agree

QUESTIONS ABOUT YOU

2 What is your full name?

3 What is your email address?

4 What is your gender?

Male

Female

5 How old are you in years?

- 18-29
- 30-39
- 40-49
- 50-59
- 60+

6 What is the highest level of qualification you have received since you left school?

- Certificate
- Diploma/Advanced diploma
- Bachelor degree
- Graduate diploma/certificate
- Postgraduate degree
- None of the above

7 How many children are you responsible for? (i.e. people who are aged under 18 who live with you, and for whom you are the parent or caregiver)

- 0
- 1
- 2
- 3
- 4
- 5+

8 What state/territory do you live in?

- New South Wales / ACT
- Queensland
- Victoria
- Tasmania
- South Australia
- Northern Territory
- Western Australia

QUESTIONS ABOUT YOUR FISH CONSUMPTION

9 How many times have you eaten fish or seafood in the last seven days?

- 0
- 1
- 2
- 3
- 4 or more

10 How often do you usually eat fish or seafood?

- Less than once a fortnight
- Once a fortnight
- Once a week
- Twice a week
- Three times a week
- More than three times a week

11 How often would you ideally like to eat fish or seafood?

- Less than once a fortnight
- Once a fortnight
- Once a week
- Twice a week
- Three times a week
- More than three times a week

12 What would assist you to eat fish or seafood more often? (choose all that apply)

- If I could find better quality fish
- If I could find less expensive fish
- If I knew more, or better, ways to cook fish
- If I could find ways to cook fish that my family enjoyed more
- If I could know that the fish I eat is sustainable
- If I knew more about the health benefits of fish
- None of the above
- Other (please specify)

13 What is the main reason you eat fish? (choose the one main reason)

- I like the taste
- It's good for me
- It's easy to cook
- It's inexpensive
- It's sustainable
- I always have
- Other (please specify)

QUESTIONS ABOUT YOUR APP USAGE

14 On the smartphone or tablet computer you use most often, how many apps do you currently have installed? (for the purposes of this question, only count apps you have decided to download, not those which came already installed on your device)

- 0
- 1-10
- 11-20
- 21-30
- 31-40
- 41-50
- 51 or more

15 Which of the following kinds of smartphone or tablet apps do you use? (choose all that apply)

- Health (not including nutrition)
- Nutrition
- Cooking
- Shopping
- Social networking
- None of the above

Thank you for completing this questionnaire. You will be contacted shortly with instructions for downloading the study app.



FISH CONSUMPTION STUDY - EXIT QUESTIONNAIRE

Thank you for participating in the Pier 2 Peer study, conducted by the Centre of Excellence for Science, Seafood and Health, at Curtin University. Your participation will help us to understand the reasons Australians do, and don't, eat fish and seafood.

What will you need to do next?

This questionnaire is the final component of participation in this study. After completing this questionnaire, you will be sent a code which can be redeemed for \$25 iTunes credit, to thank you for your participation.

As always, your participation in this study is voluntary and you may withdraw at any time, without needing to give a reason for doing so.

What will be done with this information?

The information collected during the study will be stored securely and kept confidential. All personal information will be kept only for as long as it is needed, and then will be destroyed. Information will not be reproduced in a manner that could lead to the identification of any of the participants. Once the study is completed, a summary of the findings will be available to all participants. The results of the study will also be circulated to the wider community. However, participants will not be named in any of the reports that are produced as part of the study.

How can you find out more information about this study?

You can obtain more information by contacting the researcher James White on 0405 761 580, or emailing james.white@curtin.edu.au. You may also contact the project supervisor, Professor Alexandra McManus, on (08) 9266 2115, or at a.mcmanus@curtin.edu.au

This study has been approved by the Curtin University Human Research Ethics Committee (Approval Number RD-45-12). If needed, verification of approval can be obtained either by writing to the Curtin University Human Research Ethics Committee, c/- Office of Research and Development, Curtin University, GPO Box U1987, Perth WA 6845, or by telephoning 9266 2784 or by emailing hrec@curtin.edu.au.

The Curtin University Human Research Ethics Committee requires that all participants are informed that, if they have any complaint regarding the manner, in which a research project is conducted, it may be given to the Project Manager (Telephone 9266 7021) or, alternatively to the Secretary, Human Research Ethics Committee, Office of Research and Development, Curtin University, PO Box U1987, Perth, WA 6845.

CONSENT

I have read the summary of this research project and any questions I have asked have been answered to my satisfaction. I agree to participate in this activity, realising that I may withdraw at any time without reason and without prejudice. I understand that all information provided is treated as strictly confidential and will not be released by the investigator unless required by law.

I agree that data gathered for this project may be published provided my name or other identifying information is not used.

1 I agree

2 What is your full name?

FISH CONSUMPTION AND DIARY TOOL

These questions relate to your fish consumption during the last 12 weeks, and the “Diary” section of the application.

3 Compared to what is normal for you, do you think your fish consumption during the twelve-week study period was:

- Less than normal
- About normal
- More than normal

4 When did you generally enter your meal information into the application? (choose the one option you did most often)

- While you were preparing the meal
- Immediately prior to eating the meal
- While you were eating the meal
- After eating the meal, but on the same day
- After eating the meal, on a different day

5

Indicate the degree to which you agree with the following statements

	Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree
The diary tool was simple to use	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
The diary tool worked the way I expected it to	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
I didn't mind taking photos of my meals	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Because I was taking photographs, I took extra care in presenting my meals	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
There were some situations when taking a photo of my meal was difficult	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
I made a special effort to eat fish during this study	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Entering the information into the app got in the way of preparing or enjoying my meal	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
I sometimes forgot to use the application to record a fish meal	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
The feedback on serves per week, and omega-3, made me want to eat more fish	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
The feedback on serves per week, and Omega-3, discouraged me	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

6

How easy or difficult were the following tasks?

	Very difficult	Somewhat difficult	Neither difficult nor easy	Somewhat easy	Very easy
Remembering to enter the meals at the time I was eating them	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Estimating the amount (weight) of fish in each meal	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Taking photos that showed the fish in my meals	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Knowing the kind of fish that I was eating	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Finding a species in the list that matched what I was eating	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Finding a cooking method in the application list that matched the way my fish was prepared	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

7 Please tell us about any difficulties you experienced using the diary tool. (You may leave this section blank if you did not experience difficulties)

OTHER PARTS OF THE APPLICATION

These questions are about the other sections of the Pier 2 Peer application.

NOTE:
This section omitted from control group version of questionnaire

8 Indicate the degree to which you agree with the following statements about the SPECIES GUIDE section of the application

	Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree
The species guide helped me to understand more about different kinds of fish	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
The species guide included most of the species I usually eat	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
The species in the guide seemed relevant to the area I live in	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
I trusted the information in the species guide	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
I tried new kinds of fish because of what I learned in the species guide	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
The information in the species guide was quite accurate	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

9 Indicate the degree to which you agree with the following statements about the FISH FINDER section of the application

	Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree
The fish finder tool helped me to find good fish in my local area	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
There were plenty of outlets in the fish finder tool that were near where I live	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
I trusted the information in the fish finder	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
I found a good place, or places, to buy fish, as a result of using the fish finder tool	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

10 Indicate the degree to which you agree with the following statements about the HEALTH section of the application

	Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree
I was interested in reading about the health benefits of eating fish	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
The information in this section made me want to eat more fish	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
The information in this section made me want members of my family to eat more fish	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
The information in this section made me change the kinds of fish I eat	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
I trusted the information in this section	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

11 To what extent do you think the different sections of the application had an impact on your fish consumption?

	No impact	Some impact	A big impact
The species section	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
The fish finder section	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
The health section	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
The diary section	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
The application as a whole	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

12 Did you experience any technical problems while using the application - for example, crashes, errors, or things that didn't work the way you expected them to? Please tell us about these problems. (You may leave this section blank if you did not experience any technical problems)

13 Do you have any suggestions for ways that this application could be improved? (You may leave this section blank if you do not have any suggestions)

FORTNIGHTLY NEWSLETTERS

These questions are about the email newsletters you received every two weeks during the study..

14 How many of the email newsletters did you open and read?

- All of them
- Most of them
- A few of them
- None of them

15 Each email newsletter included a reminder to record any fish you had eaten that fortnight. How often did you enter fish meals you had eaten, but not yet recorded, after receiving this reminder?

- Frequently
- A few times
- Never

16 Each email newsletter included a reminder about a feature of the Pier 2 Peer application (for example, species recommendations, or finding fish outlets). How often did you explore features of the application, after receiving these reminders?

- Frequently
- A few times
- Never

THANK YOU

17

Would you like to hear about the outcomes of this study, at some time within the next year?

Yes

No

18

Would you like to know if and when Pier 2 Peer is made available publicly?

Yes

No

If you answered 'yes' to either of the two previous questions, your email address will be retained solely for the purpose of contacting you with that information.

Thank you for completing this questionnaire. You will shortly receive an iTunes voucher code as a token of our appreciation.

Fortnightly newsletters



Week 2 of 12



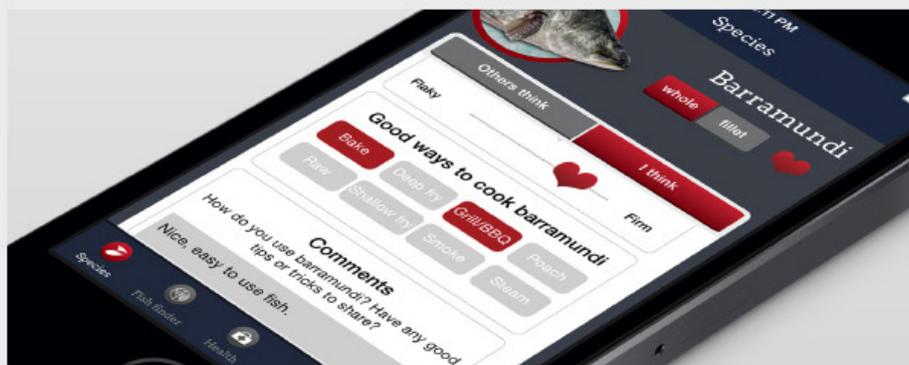
Thank you for your continued participation. If you've eaten fish or seafood this fortnight, please remember to enter it in the Pier2Peer app, and add a photo if you can.

Please [contact me](#) if you have any issues using the app.
James White

Share what you know!

Have you found a fish you love? Or one you've had trouble with? Help others by sharing what you know. Simply choose a species you've tried, and tap the "I think" tab. You can rate it, say how you cook it, and leave a brief comment. You don't even need to complete every field. Just tell us what you think, and you'll be helping others to improve their experiences with fish and seafood.

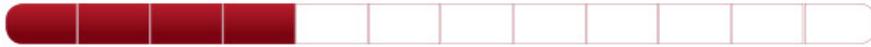
Adding "I think" information will also help you to remember fish you've enjoyed, and how you cooked it. Don't forget, you can also favourite a species by tapping the heart under its name.





Pier2Peer

Week 4 of 12



Thank you for your continued participation. If you've eaten fish or seafood this fortnight, please remember to enter it in the Pier2Peer app, and add a photo if you can.

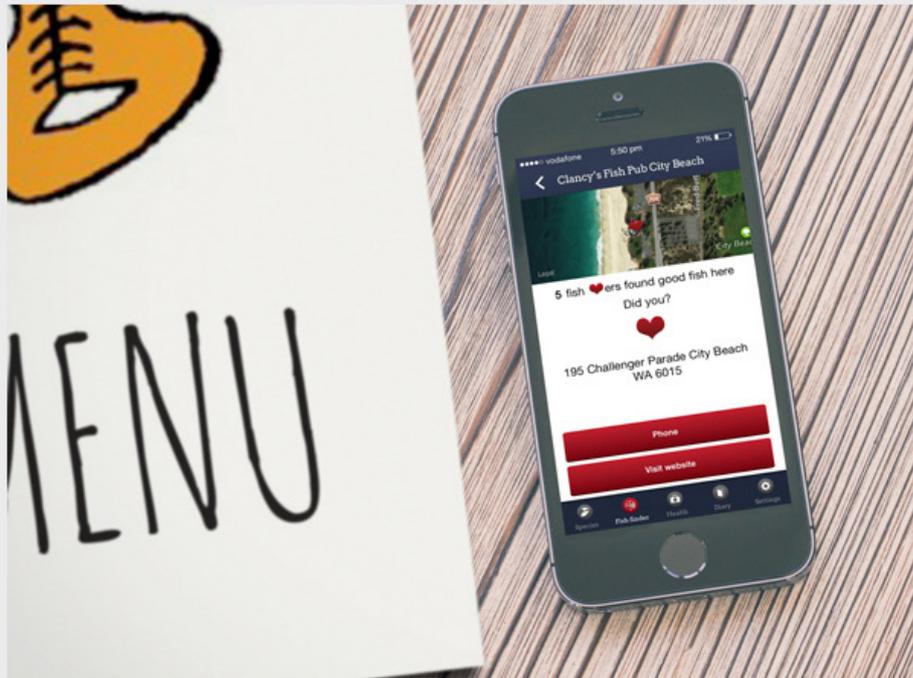
Please [contact me](#) if you have any issues using the app.

James White

Where do you get your fish?

Do you have a favourite place to get good fish? A fishmonger who always knows what's fresh? A restaurant that cooks a tuna steak just right? Even a supermarket or fish cafe that's a cut above the rest? Tell us about it, to help others find good fish too. Just go to the Pier2Peer fish finder, tap "I've found good fish", and let us know your favourite spots.

Don't forget to check out other fish fans' favourite places in your local area. Great fish might be just around the corner.





Pier2Peer

Week 6 of 12

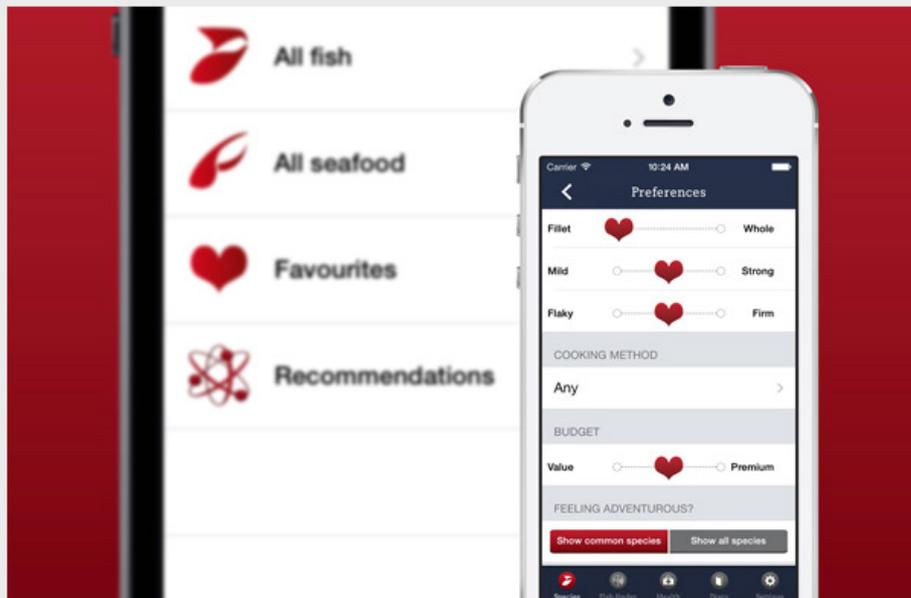


Thank you for your continued participation. If you've eaten fish or seafood this fortnight, please remember to enter it in the Pier2Peer app, and add a photo if you can.

Please [contact me](#) if you have any issues using the app.
James White

Need a hand?

Let's face it - fish can be tricky. With so many different kinds available, it can be hard to know what's best to use for what. Fortunately Pier2Peer includes a handy recommendations feature to help you find the perfect fish. You can say how firm you like your fish, how mild, and even how much you'd like to spend. Select the way you'd like to cook it, and whether you're feeling adventurous (go on, live on the edge!), and Pier2Peer will show you a list of species that match what you're looking for, based on what fish lovers around Australia have told us. Genius!





Week 8 of 12



Thank you for your continued participation. If you've eaten fish or seafood this fortnight, please remember to enter it in the Pier2Peer app, and add a photo if you can.

Please [contact me](#) if you have any issues using the app.
James White

Take a moment

You've been keeping track of all the fish you've eaten for eight weeks now. Have you taken a moment to check how it's benefitting you? Just tap the selector at the top of the diary tab to switch to the graph view. You can easily see how many serves of fish you've eaten each week, much omega-3 this has added to your diet, and how this compares with recommended levels.

If you're wondering exactly how all this omega-3 is helping you, be sure to check out the Good Oil article in the Health tab.





Pier2Peer

Week 10 of 12



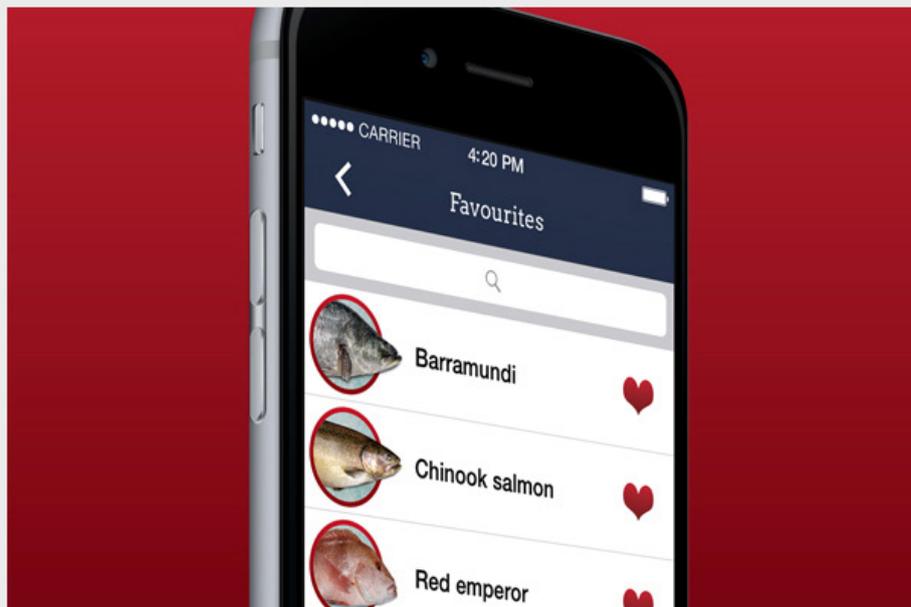
Thank you for your continued participation. If you've eaten fish or seafood this fortnight, please remember to enter it in the Pier2Peer app, and add a photo if you can.

Please [contact me](#) if you have any issues using the app.
James White

Save your faves

Keep track of the best fish by marking them as favourites. You can do this by tapping the heart either in the fish list, or at the top right when you're looking at a particular species. All your favourites can be conveniently accessed from the "Favourites" menu.

While you're at it, why not take a moment to tell other people about the fish you like best? Tap the "I think" button, add your ratings and even write a short comment about how you use it. Doing this will help other users to discover the fish that you already love.





Pier2Peer

Week 12 of 12



Thank you for your continued participation. If you've eaten fish or seafood this fortnight, please remember to enter it in the Pier2Peer app, and add a photo if you can.

Please [contact me](#) if you have any issues using the app.
James White

Good for you. And just plain good.

There aren't too many foods that are as tasty as they are good for you. By eating fish you're doing great things for your health, without having to feel like you're punishing yourself. Check out some of the health benefits that go along with eating fish, and some of the science behind those benefits, in the Pier 2 Peer health guide.

