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Brief Report

Brief Report: a Latent Class Analysis of Guideline Compliance Across Nine Health Behaviors

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Abstract

Background

Prevalence figures for health-related behaviors disguise the existence of behavioral clusters. A growing body of work indicates the potential effectiveness of using simultaneous (versus sequential) approaches to targeting health-related behaviors to make deeper inroads into addressing non-communicable diseases. To inform future interventions designed to simultaneously address multiple risk factors, the aim of the present study was to identify behavioral clusters including nine behaviors relating to smoking, alcohol consumption, nutrition, physical activity, and sleep.

Method

A latent class analysis was applied to a nationally representative sample of 1849 adult Australians.

Results

Of the four identified segments, one was characterized by a relatively healthy behavioral profile and another demonstrated poor results across multiple lifestyle domains. The other two groups comprised individuals who demonstrated healthy behaviors in some domains (e.g., substance use) but not in others (primarily physical inactivity and junk food consumption, respectively).

Conclusions

Results suggest the opportunity to encourage individuals in the latter two groups to build on existing positive behaviors to achieve greater overall

compliance with health recommendations. Particularly intensive interventions are likely needed for those in the unhealthiest group to address the potentially reinforcing effects of their multiple unhealthy behaviors.

Keywords

Healthy lifestyles
Health-related behavior
Guideline adherence
Latent class analysis

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1007/s12529-021-09988-8.

Introduction

Burden of disease figures highlight the particular importance of a range of unhealthy lifestyle behaviors as contributors to death and disability. These behaviors include smoking, alcohol consumption, poor diet, and physical inactivity, which in turn impact on other major risk factors such as high systolic blood pressure, high fasting plasma glucose, and high body mass index (BMI) [1]. As a consequence, nations around the world have established a series of recommendations across these behaviors to provide guidance for individuals and health practitioners. Compliance with these recommendations varies greatly within and between countries, and identifying effective means of encouraging individuals to improve their health-related behaviors by complying with guidelines remains challenging [2, 3].

In Australia, the context of the present study, there have been varying degrees of success in encouraging compliance with health recommendations. Tobacco control has been particularly successful, with smoking prevalence rates decreasing from 24% in 1991 to 12% in 2016 [4]. By comparison, efforts to increase vegetable consumption have been largely ineffective, with less than one in 10 adults meeting the minimum intake recommendation of 5 serves per day [5]. Across various lifestyle behaviors, there is a tendency for males and those experiencing disadvantage to exhibit poorer alignment with guidelines [6, 7].

Most previous research on health-related lifestyle behaviors has focused on the prevalence of individual behaviors and the development and implementation of interventions designed to modify these behaviors in isolation (for a review see Geller et al. [8]). However, there is increasing appreciation that prevalence figures can disguise the existence of behavioral clusters whereby the same individuals engage in multiple healthy or unhealthy lifestyle behaviors [6, 9, 10, 11]. There has also been a focus on the enactment of unhealthy behaviors, with less attention given to "positive deviants" who manage to overcome their social and/or physical environments to engage in recommended behaviors [12].

Individual behaviors are part of an overall lifestyle such that efforts to address single behaviors can be rendered ineffective by the broader contexts in which people live [13]. A modest but growing body of work indicates the potential effectiveness of efforts to simultaneously target multiple behaviors to make deeper inroads into disease prevention, but further research is needed to explicate the nature of the relationships between these behaviors to inform effective future interventions designed to concurrently address multiple risk factors [2, 8]. To contribute to this research area, the aim of this study was to identify behavioral clusters relating to compliance with a broad range of health recommendations. The results are interpreted in terms of implications for policy and practice.

Methods

A national web panel provider (Pureprofile) was commissioned to administer an online survey to a sample of 2000 Australian adults that was nationally representative according to age, gender, socioeconomic status (as per postcode classification), and location (metropolitan vs regional). The survey included items relating to demographic characteristics, self-rated health, and engagement in nine health-related behaviors. These behaviors and the associated health recommendations are as follows: (1) smoking (recommendation: nil intake), (2) consuming alcohol at levels associated with short-term harm (recommendation: no more than 4 standard drinks in a single sitting [14]), (3) consuming alcohol at levels associated with long-term harm (recommendation: an average of no more than 2 standard drinks/day [14]), (4) fruit intake (recommendation: 2 + serves/day [15]), (5) vegetable intake (recommendation: 5 + serves/day [15]), (6) fast food intake (recommendation: limit intake [15], operationalized as no more than once/week), (7) sugary drink intake (recommendation: limit intake [15],

operationalized as no more than twice/week), (8) physical activity (recommendation: minimum of 150 min/week [16]), and (9) sleep adequacy (no formal recommendation available, assessed as self-perceived adequacy of daily sleep duration).

Latent class analysis (LCA) was used to identify segments based on patterns of enactment of the assessed lifestyle behaviors. One- to five-class models were run using Stata 15.1. To ensure that the maximum likelihood solution was correctly identified, 500 iterations using randomly generated seed values were run for each model. Each respondent was assigned to a latent class (i.e., segment) based on the highest posterior probabilities. The best-fitting model was determined based on the following statistical fit indices: Akaike Information Criteria (AIC), Bayesian Information Criteria (BIC), and entropy values. The likelihood-ratio test statistics (G^2) and corresponding p values that test whether the model fits better than a saturated model were also examined. The smallest AIC and BIC, a relatively large entropy value, and a non-significant p value (> .05) of the likelihood-ratio test were used to identify the most suitable model [17, 18]. Parsimony and interpretability of a solution were also taken into consideration. To identify differences among those allocated to different classes, respondents' sociodemographic characteristics were compared across the derived classes using bivariate analyses in the form of one-way ANOVAs (for continuous variables) and chi-square tests (for categorical variables).

Results

The final sample comprised 2010 Australian adults, of whom 1849 provided complete data for the indicator variables and were therefore included in the analyses. The indicator variable of vegetable intake had 1% missing values, fruit intake 4%, and sleep adequacy 4%, totaling 8% of cases with any missing data and 1% with data missing for two or three variables. Little's MCAR test revealed a non-significant result (p value = 0.1457), indicating that missing values were missing completely at random (MCAR). Hence, a listwise deletion approach was taken in which cases with any missing data were not included in the LCA. Table S1 in the supplementary materials provides the sample profile compared to the Australian population. Compliance with relevant recommendations ranged from 93% reporting alcohol consumption below levels associated with risk of long-term harm to 11% meeting the minimum vegetable intake guideline. Table 1

shows the distribution of compliance across the nine assessed behaviors. Only 1% of respondents reported behavioral outcomes meeting the thresholds for all nine recommendations, 26% met seven or more, and 27% met four or fewer.

Table 1

Extent of co-enactment of multiple healthy lifestyle behaviors ($n = 1849$)

Number of health-related behaviors for which recommendations were met	Sample *n*	Sample %
0	2	< 1
1	8	< 1
2	63	3
3	147	8
4	271	15
5	439	24
6	429	23
7	320	17
8	150	8
9	20	1

In the LCA analyses, the AIC values continually decreased as the number of classes increased, but a four-class model was found to be most appropriate based on the other relevant statistical indices (the smallest BIC value relative to the other models, a non-significant difference from the saturated model, and ease of interpretation [17, 18]). The four-class model had an entropy value of .72 and average posterior probabilities (i.e., the likelihood of being allocated to each class) ranging between .75 and .79. The composition of the four classes is depicted in Figure S1 and the goodness of fit statistics results are provided in supplementary Table S2.

Table 2 provides segment size, item-response probabilities of the health behaviors, and respondent characteristics data for each of the four segments. Segment 1 was the largest, constituting 34% of the sample. This segment was distinguished by the highest probabilities of meeting minimum requirements for

most of the healthy lifestyle behaviors included in the model, and was therefore labeled the "healthiest" group. Respondents allocated to this group were more likely to be female, non-parents, and those with higher self-rated health.

Table 2

Latent class analysis results for the four-class model ($n = 1849$)[e]

	Segment 1—Healthiest (n = 638) 34% of sample	**Segment 2—inactive (*n* = 479) 26% of sample**	**Segment 3—high risk (*n* = 455) 25% of sample**	**Segment 4—treaters (*n* = 277) 15% of sample**
Indicator variables	Item-response probabilities			
No/low long-term alcohol risk (≤ 2 standard drinks/day)***	.98[a]	1.00[b]	.72[c]	.98[a]
Do not smoke regularly***	.93[a]	.87[b]	.73[c]	.78[c]
No/low fast food consumption (≤ 1 days/week)***	.93[a]	.87[b]	.72[c]	.17[d]
No/low soft-drink consumption (≤ 2 days/week)***	.95[a]	.79[b]	.68[c]	.26[d]
No/low short-term alcohol risk (≤ 4 standard drinks/day)***	.71[a]	.99[b]	.00[c]	.74[a]
Met fruit intake guideline (≥ 2 serves of fruit/day)***	.76[a]	.35[b]	.29[c]	.74[a]
Getting adequate sleep (≥ 4 days/week)***	.61[a]	.41[b]	.39[bc]	.33[c]

[e]Respondents reporting "unsure" to any of the indicator variables were excluded from the LCA, resulting in a final sample of 1849 from an original sample of 2010. Different lowercase letters within a row indicate significant differences in segment results using chi-square tests

***$p < .001$

	Segment 1—Healthiest (n = 638) 34% of sample	**Segment 2—inactive (*n* = 479) 26% of sample**	**Segment 3—high risk (*n* = 455) 25% of sample**	**Segment 4—treaters (*n* = 277) 15% of sample**
Met minimum physical activity guidelines (≥ 150 min/week)***	.66[a]	.15[b]	.42[c]	.46[c]
Met vegetable intake guideline (≥ 5 serves of vegetables/day)***	.21[a]	.03[b]	.03[b]	.18[a]
Average	0.75[a]	0.61[b]	0.44[c]	0.52[d]
Continuous predictor variables	M (SD)	M (SD)	M (SD)	M (SD)
Age***	50.42 (17.65)[a]	50.50 (16.90)[a]	43.48 (16.12) [b]	34.71 (13.28) [c]
Education***	4.31 (2.04)[ac]	3.96 (2.03)[bc]	4.14 (1.98)[c]	4.72 (1.98)[d]
Income***	7.77 (2.99)[a]	7.03 (2.97)[b]	8.02 (3.02)a	8.01 (3.26)[a]
BMI***	26.17 (5.65)[a]	28.03 (7.25)[b]	27.32 (6.53)[b]	26.52 (6.83)[ab]
Self-rated health***	3.30 (0.88)[a]	2.77 (0.88)[b]	2.88 (0.91)[b]	3.06 (0.96)[c]
Categorical predictor variables	*n* (%)	*n* (%)	*n* (%)	*n* (%)
Gender (female)***	333 (52)[a]	290 (61)[b]	205 (45)[c]	113 (41)[c]
Location (metro)***	404 (63)[a]	311 (65)[ab]	313 (69)[b]	218 (79)[c]
SES (mid/high)	409 (64)	291 (61)	313 (69)	180 (65)
Parent (yes)***	188 (29)[a]	188 (39)[b]	168 (37)[b]	139 (50)[c]

[e]Respondents reporting "unsure" to any of the indicator variables were excluded from the LCA, resulting in a final sample of 1849 from an original sample of 2010. Different lowercase letters within a row indicate significant differences in segment results using chi-square tests

***$p < .001$

AQ1

Segment 2 constituted 26% of the sample. Although exhibiting high levels of compliance for many of the behaviors (especially alcohol and tobacco use), this segment was characterized by low levels of physical activity and was therefore titled the “inactive” group. In addition, respondents allocated to this segment tended to report low fruit and vegetable intake. Distinguishing sociodemographic characteristics were female gender and lower income.

A quarter of the sample (25%) was allocated to Segment 3. Members of this group exhibited the lowest levels of recommendation compliance across five of the nine behaviors assessed in the study and the second lowest for the remaining four. As such, this segment was titled the “high risk” group. The most notable behavior was binge drinking, with all respondents in this segment reporting consuming alcohol at levels associated with risk of short-term harm. Fruit and vegetable intake levels were especially low. The only defining characteristic for this segment was that members were more likely to be male.

Segment 4 comprised 15% of the sample and was primarily differentiated from the other groups in terms of higher levels of fast food and soft drink consumption, despite relatively high intakes of fruit and vegetables. This segment was therefore titled the “treaters” group. Compared to the rest of the sample, members of this segment were more likely to be younger, male, based in the metropolitan area, and parents.

Discussion

Overall, the results showed very low proportions of respondents meeting minimum recommendations for all (1%) or nearly all (8%) of the nine assessed lifestyle behaviors. Around half of the sample met five or six of the nine recommendations. Given the importance of these behaviors for reducing risk of disease [1, 19] and increasing well-being [11], there is enormous need to implement effective interventions designed to encourage and facilitate healthy lifestyle behaviors.

Using a latent class analysis approach, four population segments were identified that exhibited varying combinations of health-related lifestyle behaviors. In terms of priority groups, the results indicate that members of the high risk group

are most in need of comprehensive interventions to address a broad spectrum of unhealthy lifestyle behaviors. The tendency for members of this group to exhibit higher smoking rates is consistent with prior research showing that smokers often engage in multiple unhealthy behaviors and should therefore be a particular focus of comprehensive health interventions [6]. The lack of identified defining characteristics for this group is in contrast to previous Australian research showing higher representation of younger and lower socioeconomic status respondents in high-risk behavioral segments [9]. This difference is likely to be a consequence of using a latent class approach to segmentation that allowed clusters to emerge from the data and the incorporation of a large number of health behaviors in the analyses. The lack of defining demographic characteristics for segment membership indicates that additional factors to those included in this study are likely to be influencing the clustering of unhealthy behaviors, and future research may thus need to include various psychosocial predictors (e.g., self-efficacy, self-esteem, and social provisions) to better understand the dynamics at play.

The results relating to the inactive and treaters groups suggest the opportunity to build on existing healthy lifestyle behaviors to encourage greater compliance with the identified problem areas [20]. These individuals may respond well to messages that acknowledge their positive behaviors in some domains while reinforcing the benefits that could be obtained by rounding out their lifestyles to include the “missing links”—more physical activity and less unhealthy food, respectively. Of interest would be how members of these groups account for their selective compliance with differing recommendations. This information would be useful to develop effective interventions that deliver useful information while avoiding the triggering of counter-arguments.

The very low levels of compliance with the minimum vegetable intake guideline across the entire sample highlight the need for substantial population-level efforts to increase vegetable consumption. The tendency for even those in the healthiest group to exhibit much lower compliance with this guideline relative to all the other behaviors indicates that major barriers exist to consuming adequate quantities of vegetables. This reflects the global situation where vegetable intake is inadequate in almost all countries around the world [21]. To date, interventions focusing on vegetable consumption have tended to be directed to children and have demonstrated limited success [22], suggesting a need for new approaches.

Considering vegetable intake in the context of individuals' broader lifestyles may represent a potential means of improving outcomes in this domain. For example, those in the healthiest group may be receptive to simple messages that highlight the role of vegetable consumption in a healthy lifestyle, while those in the high risk group may need more intensive interventions that include information and demonstrations on how to incorporate vegetables and other healthy behaviors into their currently unhealthy lifestyles [23]. Such interventions would need to consider the substantial socio-cultural determinants that are likely to be influencing the identified combination of behaviors.

Study Strengths and Limitations

Previous research has typically focused on analyzing the prevalence of lifestyle behaviors individually or in limited combinations, which constrains understanding of the ways in which unhealthy behaviors cluster and hinders the development of interventions that accommodate interactions between behaviors [2, 3, 8]. The primary strength of this study is the provision of unique insights into risk factor clustering across a large number of health-related lifestyle behaviors in a demographically representative sample. The results can be used to inform future efforts to simultaneously address multiple unhealthy lifestyle behaviors.

The primary limitations of this study were the use of a web panel and a reliance on self-reported behaviors. To extend this work, future research may use other recruitment methods and employ a combination of self-report and objectively assessed behaviors (and possibly health outcomes such as blood pressure and blood glucose levels). In addition, it would be of value to conduct comparable studies across multiple countries to assess the extent to which the identified behavioral clusters apply in other geographical and cultural contexts. International comparisons could permit deeper appreciation of the factors driving the clustering of specific healthy and unhealthy behaviors.

Future Research Directions

Some prior work has examined the effects of multi-behavior interventions among specific groups such as adolescents or young adults [24, 25] and those diagnosed with particular medical conditions [26]. Overall, this previous research indicates that addressing more than one risk factor at a time can be effective, but it is

recognized that substantial additional work is needed in this area [2, 3, 8]. The results of the present study indicate that across the adult population, it is especially important to explore potential methods of addressing the clusters of unhealthy behaviors identified in the high risk group. An important consideration in developing interventions targeting multiple risk factors will be the ability for any specific behaviors to constitute behavioral “wedges” that produce spill-over effects onto other behaviors. For example, reducing alcohol consumption may result in less smoking due to the situational co-occurrence of these behaviors, and increasing physical activity may reduce the consumption of unhealthy foods due to a desire to avoid “undoing the good work.” Further research is needed to explore these possible interactions to provide insights into the optimal priority order for targeting multiple behaviors. Such work would benefit from a particular focus on males and parents to better understand the barriers faced by these key groups.

Conclusion

This study applied latent class analysis procedures to a demographically representative sample of adult Australians and identified four distinct segments based on varying combinations of health-related behaviors. The results demonstrate the extent to which healthy and unhealthy lifestyle behaviors can cluster within population segments and highlight the importance of developing innovative approaches to address the needs of those with poor adherence to health guidelines across numerous lifestyle behavior domains.

Publisher's Note

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Declarations

Ethical Approval All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. Informed consent was

obtained from all individual participants included in the study.

Conflict of Interest The authors declare no competing interests.

Supplementary Information

Below is the link to the electronic supplementary material.

Supplementary file1 (DOCX 27 KB)

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