School of Public Health

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Infant Feeding Practices and Maternal Factors in Vietnam: A Prospective Cohort Study

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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.

Human Ethics (For projects involving human participants/tissue, etc) 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 approvals from the Curtin University Human Research Ethics Committee (EC00262), Approval Number HR32/2015 and from the Hai Phong University of Medicine and Pharmacy Human Research Ethics Committee, Approval number 05/PHUMPRB.

Signature

Phung Thi Hoang Nguyen

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Abstract

Introduction

Breastfeeding is known to establish a strong foundation for infant's health and development. However, the benefits of breastfeeding are still underestimated by the majority of Vietnamese people, despite the Infant and Young Child Feeding Indicators published by World Health Organization (WHO) being incorporated into the national nutrition surveillance system since 2010. While more than 98% of Vietnamese mothers initiate breastfeeding, the 'exclusive' breastfeeding rate to six months in Vietnam (24%) is lower than other Southeast Asian countries. Similarly, 80% of mothers continue their breastfeeding until twelve months, yet the number drops dramatically to less than one quarter at 24 months. Only half of the newborns receive breastmilk one hour after birth, and 73% of Vietnamese newborns are giving something other than breastmilk, mostly formula milk (99%), as their first feed.

Breastfeeding-related factors that have been documented in previous research include socio-demographics variables, work and family support, the healthcare setting, mother's and family breastfeeding intention, knowledge and attitudes. However, the associations between breastfeeding and maternal factors such as gestational diabetes mellitus (GDM), pregnancy physical activity, and caesarean section have not been well examined. Therefore, this thesis aims to investigate Vietnamese infant feeding practices (including early breastfeeding initiation, the use of prelacteal feeds, early formula feeding, breastfeeding rates, and breastfeeding cessation) as well as maternal factors (GDM, physical activity during pregnancy, and caesarean birth) influencing

breastfeeding practices at specific time points from delivery to twelve months postpartum. Another objective of the study is to examine prelacteal feeding and early formula feeding in relation to infant hospitalisation, diarrhoea and lower respiratory tract infection during the first year of life.

Methods

This study was part of a multi-centre prospective cohort study conducted at six Vietnamese hospitals in three cities, namely Ha Noi (capital city), Hai Phong and Ho Chi Minh City. Data collection was conducted from August 2015 to December 2017. Ethics approvals were obtained from Curtin University (HR32/2015) and Hai Phong University (No.05/PHUMPRB) Human Research Ethics Committees.

The eligibility criteria for the study were: permanent residence in the recruitment areas; ≥18 years of age; at 24 to 28 weeks of gestation; had a singleton pregnancy; did not have any serious pre-existing health conditions (as indicated in medical records); and were able to read the information sheet and sign the consent form. A total of 2030 pregnant women were enrolled, interviewed after delivery at hospital, then visited at home at one, three, six and twelve months postpartum. Medical records retrieval and face-to-face interviews using structured questionnaires were undertaken during the data collection.

At baseline interview, the 2-hour 75-gram oral glucose tolerance test (three blood samples at fasting, one and two hours) was used to determine GDM status. Following the criteria from the WHO 2013 and the International Association of Diabetes and

Pregnancy Study Group, GDM was diagnosed if at least one glucose value was above the thresholds: fasting plasma glucose ≥5.1 mmol/L, 1-h plasma glucose ≥10.0 mmol/L, 2-h plasma glucose ≥8.5 mmol/L.

The Pregnancy Physical Activity Questionnaire (PPAQ), validated for Vietnamese pregnant women, was chosen to assess the habitual physical activity levels and sedentary behavior at baseline. It recorded the duration, frequency, and intensity of physical activity in 32 activities across four domains namely housework/caregiving, occupational, sports/exercise, and transportation for the past three months.

During the data collection phase, 25 women were excluded according to the adopted selection criteria, and 296 women refused to participate. As a result, 1709 mothers remained in the cohort at the end of the study period with a participation rate of about 85%.

Data was entered using Epidata 3.1, and statistical analyses were performed using the SPSS 22. Descriptive statistics were conducted to describe participants characteristic. Group comparisons were undertaken using chi-square tests (or Fisher's exact tests) for categorical variables, and independent samples t-tests/ANOVA (or Mann-Whitney U-tests and Kruskal–Wallis tests) for continuous variables. Kaplan–Meier estimates, log-rank tests, logistic and Cox proportional hazard regression models were used to examine the association between maternal risk factors and breastfeeding outcomes and duration.

Results

In this study, 99.4% (n=1698) of women reported ever breastfeeding their baby. The rate of 'any' breastfeeding at discharge was high at 91.4%, and declined to 87% and 72.9% at six and twelve months postpartum, respectively. The mean (± standard deviation) duration of 'any' breastfeeding was 44.4±14.1 weeks. In contrast, only 18.9% of women 'exclusively' breastfed, and 20.9% of women 'predominantly' breastfed at discharge. Rates of 'exclusive' and 'predominant' breastfeeding at six months decreased substantially to 2.0% and 2.5%, respectively. Only one third of infants received breastmilk within one hour after birth (early initiation of breastfeeding), but more than half of the infants received prelacteal feed (56.5%), most of which was formula milk (99%), as their first feed.

The prevalence of GDM was 21.8% (n=373). Our study found no significant differences in breastfeeding at discharge (early initiation, prelacteal feeding, and 'any' breastfeeding) between GDM and non-GDM groups. However, the rate of 'any' breastfeeding at twelve months was lower [adjusted odds ratio (aOR) 0.66; 95% confident interval (CI) 0.51-0.85], and breastfeeding duration was also shorter [hazard ratio (HR) 1.38; 95% CI 1.12-1.70] among GDM women. The rates of 'exclusive' and 'predominant' breastfeeding from discharge to six months were also lower among GDM women but not significantly different comparing to those of their non-GDM counterparts.

Similarly, the rate of breastfeeding at twelve months was lower, and the risk of breastfeeding cessation was higher among physically inactive women. Pregnant

women engaging in higher levels (3rd and 2nd tertiles) of physical activity appeared to incur a lower risk of breastfeeding cessation [HR 0.59; 95% CI 0.47-0.74, and HR 0.74; 95% CI 0.60-0.92, respectively] when compared to those in the lowest tertile. Likewise, pregnant women with higher levels (3rd and 2nd tertiles) of physical activity tended to breastfeed at twelve months postpartum, when compared to others with the lowest level of physical activity (aOR 1.71; 95% CI 1.29-2.25 and aOR 1.38; 95% CI 1.06-1.79; respectively). There were no significant differences in breastfeeding cessation in terms of vigorous-intensity and the occupation domain.

The caesarean rate in this study was more than 38% (n=653). Mothers who experienced caesarean section sustained a lower rate of early breastfeeding initiation (aOR 0.04; 95% CI 0.02-0.05) and more likely practiced prelacteal feeding (aOR 13.91; 95% CI 10.52-18.39) than mothers who delivered vaginally. Undergoing a caesarean section was significantly associated with decreased rates of 'any', 'predominant' and 'exclusive' breastfeeding from discharge to one, three, and six months postpartum. At one year, the 'any' breastfeeding rate was lower in the caesarean group (70.2%) than the vaginal delivery group (72.9%), even though the difference was not statistically significant (p=0.232).

During the 12-month period, approximately one-quarter of infants had been admitted to hospital (24.8%); one-quarter experienced diarrhoea (25.5%) while almost half (47.6%) contracted lower respiratory tract infection with at least one episode. Prelacteal feeds (56.5%) as well as early formula feeds during hospital stay (79.5%) were common in our cohort of Vietnamese infants. When compared to infants who

were exclusively breastfed, those who were given prelacteal food and those who were early fed infant formula were more likely to experience adverse health outcomes during their first year of life, for example their risk of hospital admission were increased by 1.43 (95% CI 1.09-1.88) and 1.48 (95% CI 1.07-2.05) times higher, respectively.

Conclusion

This thesis reported findings from the first multi-centre prospective cohort study in Vietnam investigating the associations between maternal factors and breastfeeding practices. The results suggested that GDM, physical inactivity during pregnancy and caesarean delivery are associated with lower breastfeeding rates. The results also indicated that prelacteal feeds and infant formula should only be given if clinically necessary, in order to reduce the risk of subsequent infant illness and hospital admissions.

Appropriate levels of physical activity should be recommended for pregnant women who have no complications. Extra support should be available to women with GDM, and those mothers experiencing difficulties to initiate breastfeeding after caesarean delivery, so as to minimise their use of infant formula in hospital and to maintain their long-term breastfeeding.

Statement of Contribution

Curtin's School of Public Health provided the environment which supported the PhD candidate to undertake this research. The candidate was the investigator of the project which involved designing methodology, undertaking recruitment, and processing data. The candidate was also responsible for writing all publications presented as parts of the thesis with input from other co-authors. Details are provided below:

Associate Professor Yun Zhao was the PhD main supervisor who contributed and supported the study, as well as suggested improvements and revised the thesis.

Professor Andy Lee was the PhD co-supervisor who participated in study design, data analysis, paper drafting, and suggested improvements for publications.

Professor Colin Binns was the PhD co-supervisor who provided his expertise on methodology as well as paper drafting and suggested improvements for publications.

Associate Professor Dung Van Do contributed as associate supervisor and provided advice on different steps of the research project, including designing the study, reading drafts and approving the articles for publications.

Dr Dat Van Duong contributed as associate supervisor, provided support on study design, recruitment, draft reading, and suggested improvements for publications.

Appendix A contains signed statements of contribution of all co-authors.

List of Publications

This thesis contains five publications. The statements of contribution of the co-authors and the permissions to include the published papers in the thesis are attached in Appendix A. I (the PhD candidate) warrant that I have obtained, where necessary, permission from the copyright owners to use any third-party copyright material reproduced in the thesis, or to use any of my own published work in which the copyright is held by another party. Copyright permissions are provided in Appendix B.

1. **Nguyen, P. T. H.,** C. W. Binns, C. L. Nguyen, A. V. V. Ha, T. K. Chu, D. V. Duong, D. V. Do, and A. H. Lee. "Gestational Diabetes Mellitus Reduces Breastfeeding Duration: A Prospective Cohort Study." *Breastfeed Med* 14, no. 1 (Jan/Feb 2019): 39-45. http://dx.doi.org/10.1089/bfm.2018.0112. [Impact factor: 1.521]

2. **Nguyen, P. T. H.,** N. M. Pham, K. T. Chu, D. Van Duong, and D. Van Do. "Gestational Diabetes and Breastfeeding Outcomes: A Systematic Review." *Asia Pac J Public Health* (Mar 4 2019): 1010539519833497. http://dx.doi.org/10.1177/1010539519833497. [Impact factor: 1.743]

3. **Nguyen, P. T. H.,** C. W. Binns, C. L. Nguyen, A. V. Van Ha, K. T. Chu, D. V. Duong, D. V. Do, and A. H. Lee. "Physical Activity During Pregnancy Is Associated with Improved Breastfeeding Outcomes: A Prospective Cohort Study." *Int J Environ Res Public Health* 16, no. 10 (May 16 2019). http://dx.doi.org/10.3390/ijerph16101740. [Impact factor: 2.468]

4. **Hoang Nguyen, P. T.,** C. W. Binns, A. Vo Van Ha, C. L. Nguyen, T. Khac Chu, D. V. Duong, D. V. Do, and A. H. Lee. "Caesarean Delivery Associated with Adverse Breastfeeding Practices: A Prospective Cohort Study." *J Obstet Gynaecol* (Sep 4 2019): 1-5. http://dx.doi.org/10.1080/01443615.2019.1647519. [Impact factor: 0.588]

5. **Nguyen**, **P**., C. W. Binns, A. V. V. Ha, T. K. Chu, L. C. Nguyen, D. V. Duong, D. V. Do, and A. H. Lee. "Prelacteal and Early Formula Feeding Increase Risk of Infant Hospitalisation: A Prospective Cohort Study." *Arch Dis Child* (Sep 15 2019). http://dx.doi.org/10.1136/archdischild-2019-316937. [Impact factor: 3.158]

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List of Abbreviations

CI	Confident Interval
DHS	Demographic and Health Surveys
EBF	Exclusive Breastfeeding
GDM	Gestational Diabetes Mellitus
GDP	Gross Domestic Product
GVA	Gross Value Added
HIV	Human Immunodeficiency Virus
HR	Hazard Ratio
MET	Metabolic Equivalent of Task
NCDs	Non-Communicable Diseases
OR	Odds Ratio
PPAQ	Pregnancy Physical Activity Questionnaire
RR	Relative Risk
UNICEF	United Nations Children's Fund
US	The United States
WHO	World Health Organisation

Definitions

Any breastfeeding: is defined as the child has received breastmilk (direct from the breast or expressed) with or without other drink, formula or other infant food (World Health Organization 2008a). **Any breastfeeding duration:** is the total length of time an infant received any breastmilk (World Health Organization 2008a).

Breastfeeding cessation: is completely stop breastfeeding, including suckling (World Health Organization 2008a).

Caesarean birth/caesarean section: is a surgical procedure to deliver a baby through a cut in the mother's abdomen (tummy) and uterus (womb) (Department of Health 2017).

Early initiation of breastfeeding: is the act of putting newborns to the breast within one hour of birth (World Health Organization 2008a).

Ever breastfeeding: is defined as infants received breastmilk or colostrum on at least on occasion (World Health Organization 2008a).

Exclusive breastfeeding: is breastfeeding while giving no other food or liquid, not even water, with the exception of drops or syrups consisting of vitamins, mineral supplements or medicines (World Health Organization 2008a)

Gestational diabetes mellitus (GDM): is carbohydrate intolerance resulting in hyperglycaemia of variable severity with onset or first recognition during pregnancy (World Health Organization 2013a).

Predominant breastfeeding: is defined when breastmilk is the infant's predominant source of nourishment. In addition, the infant may also have received water and water-based drinks (sweetened and flavoured water, teas, infusions, etc.), fruit juice, oral dehydration salts solution, drop and syrup forms of vitamins, minerals and medicines, and ritual fluids (in limited quantities). No food-based fluid is allowed under this definition (World Health Organization 2008a).

Prelacteal feeds: are any fluid or feed (such as infant formula, water, sugar-water, honey, tea, fruit juice, herbal drink) provided for the newborns before the initiation of breastfeeding (World Health Organization 2009). **Prelacteal feeding:** is the practice of giving prelacteal feeds. Plain water, infant formula, sugar water, honey, tea and other traditional feeds such as ghee or herbal tea are often used as prelacteal feed.

Physical activity: is defined as any bodily movement produced by skeletal muscles that requires energy expenditure (World Health Organization). The term 'physical activity' should not be mistaken with 'exercise'. Exercise is a part of physical activity together with other activities which involve bodily movement such as playing, working, active transportation, house chores, and recreational activities (World Health Organization).

Chapter 1: Introduction

The purpose of this chapter is to provide a brief outline of this study including the Vietnamese background, context of breastfeeding practices and related maternal factors. The key findings and limitations of previous studies, the importance of this study, aim and objectives are also addressed.

1.1. Background

The rate of obesity continues to rise, while at the same time the prevalence of under nutrition is not decreasing in Asia. Worldwide, including in East Asia, inappropriate maternal and infant nutrition practices are relatively widespread (Black et al. 2013). The WHO estimated that 44% of the 2.8 million neonatal deaths could be prevented by universal early breastfeeding; and that maternal and child under nutrition has contributed to over 10% of the burden of chronic and communicable diseases (World Health Organization 2010b). While the protective effects of breastfeeding for both infant and maternal health have been well documented, these benefits have not been enjoyed by all of the Vietnamese (Hajeebhoy et al. 2014; National Health and Medical Research Council 2012; Save The Children 2013; World Health Organization 2017; World Health Organization and United Nations Children's Fund 2003).

In Vietnam, breastfeeding is a key component of the national nutrition programme for the period 2011 - 2020 and the vision 2030. The ‘WHO standard comprehensive Infant and Young Child Feeding Indicators for international use’ had been incorporated into

the Vietnamese national nutrition surveillance system since 2010 (World Health Organization 2008a; Hajeebhoy et al. 2013). However, with the rate of 'exclusive' breastfeeding being less than 20% among infants under six months old, breastfeeding practices remain marginal in Vietnam (Nguyen et al. 2011; Hajeebhoy et al. 2013). The aim of the WHO to increase the 'exclusive' breastfeeding rate to 50% by 2025 for children under six months of age, is therefore, extremely challenging for Vietnam (World Health Organization 2014). It should be noted that neighbouring South East Asian countries have different cultures and languages. South East Asia's breastfeeding rates, economic development and promotion of infant formula are different from Vietnam's situation. As a result, findings from studies conducted in other regional countries may not be directly relevant to Vietnam.

This study investigated infant feeding practices including early breastfeeding initiation, prelacteal feeds, early formula feeding, breastfeeding rates at specific time points from delivery to one year after birth, and breastfeeding cessation, in relation to maternal factors such as GDM, physical inactivity during pregnancy, and caesarean delivery. Also, the impacts of early formula feeds before hospital discharge and prelacteal feeds on infant hospitalisation and infant illnesses, namely lower respiratory tract infection and diarrhoea during the first year, were also examined. The study will provide quality evidence for policy makers, programme planners, and health professionals to improve maternal and child health in Vietnam.

1.2. Background information of Vietnam

Vietnam, a developing country in South East Asia, borders China in the North, Laos and Cambodia in the West, and Oriental Sea in the East; see Figure 1.1. It is the world's 15th most populous country with a population of 96.5 million as of 2018 (World Bank 2019b). With a total area of 330,967 km^2, Vietnam's population density is approximately 311.2 people per km^2 (United Nations 2019). Vietnam has transformed from one of the poorest into one of the most dynamic countries in the region as a result of the economic reform since 1986 (World Bank 2019c).

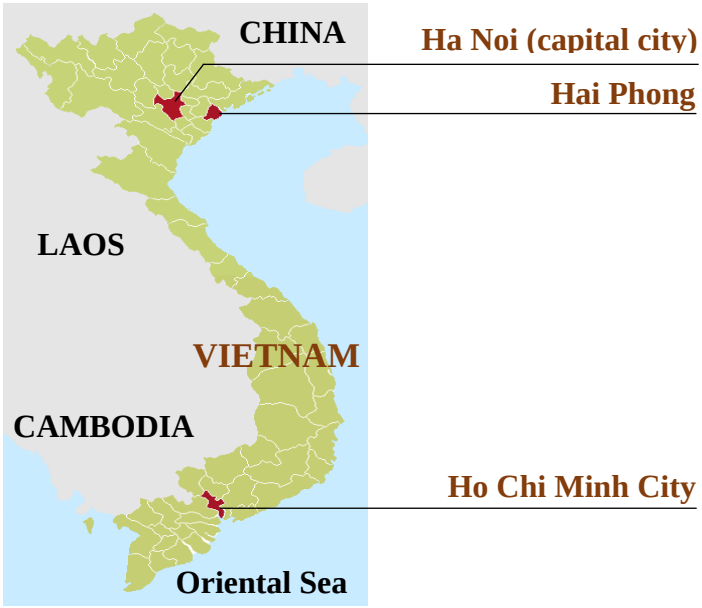

Figure 1.1: Location of Vietnam and the recruitment areas

The Gross National Income per capita in 2018 was US$2,400, which is classified as a low-middle income economy (US$1,000 to <$4,000) (World Bank 2019a). The country has a human development index of 0.694 which is in the medium range between 0.55 and 0.70 (United Nations Development Programme 2018). Vietnam offers an effective health system which places emphasis on primary health care

(Walters et al. 2016). While women aged 15 to 49 make up more than one fourth of the total population, children aged 0 to 4 account for 8.3% (General Statistics Office and United Nations Children's Fund 2015). Immunization coverage for children 12 to 23 months of age ranges from above 86% to 98% depending on the type of vaccination (General Statistics Office and United Nations Children's Fund 2015). Child mortality rates including post-neonatal, neonatal, infant, children under five as well as life expectancy have been improved significantly despite the limited expenditure and available resources (General Statistics Office and United Nations Children's Fund 2015; United Nations 2019). Table 1.1 presents some basic information on socio-economic development and health indicators of Vietnam in the year of 2018.

Table 1.1: Basic information of Vietnam

Category	**Value**
Gross domestic product per capita (current US$)	2171.0
Economy: Agriculture (% of GVA)	18.1
Economy: Industry (% of GVA)	36.4
Economy: Services and other activity (% of GVA)	45.5
Unemployment rate (% of labour force)	2.1
Population growth rate (average annual %)	1.1
Urban population (% of total population)	35.9
Urban population growth rate (average annual %)	3.2
Life expectancy at birth (females/males, years)	80.3/70.7

Infant mortality rate (per 1000 live births)	19.3
Health: Current expenditure (% of GDP)	5.7
Health: Physicians (per 1000 population)	0.8
Education: Government expenditure (% of GDP)	5.7
Research & Development expenditure (% of GDP)	0.4

Source: United Nation 2018: A world of information (United Nations 2019)

Abbreviation: GDP: Gross Domestic Product; GVA: Gross value added; US: The United States;

1.3. Breastfeeding in Vietnam

The latest report from the United Nations Children's Fund (UNICEF) showed that only 42% of infants worldwide were 'exclusively' breastfed during the first six months (United Nations Children's Fund 2019). The 'exclusive' breastfeeding rate at six months in Vietnam had been reported at 15.5% according to national data from 2000 to 2005. This figure increased to 24% (Vietnam Multiple Indicator Cluster Survey 2014) but was still lower than the rates of other South East Asian countries which varied between 30% and 40% (United Nations Children's Fund 2019; Dibley, Senarath, and Agho 2010). The national report in 2014 also found that while the average duration of 'any' breastfeeding amongst Vietnamese children aged under three years was long (15.8 months), the average durations for 'exclusive' and 'predominant' breastfeeding were as short as 0.6 month and 2.4 months respectively (General Statistics Office and United Nations Children's Fund 2015). In 2011, the reported rate of 'exclusive' breastfeeding for 0 to 6 months ranged from 17% to 20% (Hajeebhoy et al. 2013;

Mongensen and Frida 2009). However, in a prospective cohort study conducted in the north of Vietnam in 2005, Duong et al found that the 'exclusive' breastfeeding rate fell from 83.6% at first week to 43.6% at 16th week and no exclusive breastfeeding by the 24th week (Duong, Lee, and Binns 2005).

The rates of early initiation of breastfeeding remained low in Vietnam and other Asian developing countries (Dibley, Senarath, and Agho 2010; World Health Organization 2010a; Thu et al. 2012; Cai, Wardlaw, and Brown 2012). In 2011, this early breastfeeding rate was reported to range from 40% to 60% in Vietnam. It was considered a significant improvement from 2006, when the National Nutritional Survey found only 17% of Vietnamese infants received early breastfeeding within one hour of birth (Hajeebhoy et al. 2013). A hospital-based study of 223 women in Ho Chi Minh City in 2014 found that, of 83% breastfeeding women, only 14% initiated breastfeeding within one hour after delivery (Ramoo et al. 2014). The common practice of giving prelacteal feeds to newborns accounted for the low rates of early breastfeeding initiation and 'exclusive' breastfeeding (Hajeebhoy et al. 2014; Nguyen et al. 2013; United Nations Population Fund 2017; Tuan et al. 2014).

Many factors contributed to giving prelacteal feeds resulting in 'non-exclusive' breastfeeding (Duong, Lee, and Binns 2005; Duong, Binns, and Lee 2004; Nguyen et al. 2011; Tuan et al. 2014; Tang, Lee, and Binns 2015a; Lundberg and Ngoc Thu 2012; Thu et al. 2012; Morrow 1996; Almroth et al. 2008). Factors commonly mentioned in Vietnamese studies included early introduction of water and other milk based products, delivery method and settings, breastfeeding difficulties (e.g. breast problems, milk

insufficiency), intention of formula feeding at birth, and mass media advertisement of infant formula (Ramoo et al. 2014; Tuan et al. 2014; Duong, Binns, and Lee 2004; Nguyen et al. 2013). A study in 2011 found that 21% of Vietnamese mothers intended to feed their infants with formula after birth (Tuan et al. 2014).

Breastfeeding support, follow-up care after birth, and attitudes of health professionals towards breastfeeding were also important elements for early initiation and maintenance of breastfeeding (Nguyen et al. 2011; Tuan et al. 2014; Almroth et al. 2008). Mothers often received insufficient information and support from healthcare professionals and were lacking in breastfeeding skills (Tuan et al. 2014; Nguyen et al. 2013). In Vietnam, infant formula and formula-milk coupons were commonly gifted to the newborns by friends and relatives. For women living with their extended families, they typically received advice from senior family members (e.g. mother, mother-in-law) who might not have sufficient and up-to-date knowledge about infant feeding (Nguyen et al. 2011; Tuan et al. 2014; Lundberg and Trieu 2011; Duong, Binns, and Lee 2004; Nguyen et al. 2013).

Research also showed that early solid foods introduction was associated with a duration of 'exclusive' breastfeeding shorter than the six months recommendation by the WHO (Inoue and Binns 2014). Socio-demographic and maternal factors also played a role in affecting the rate of breastfeeding. These factors include maternal age, education, occupation, parity, infant gender, prenatal care, guidance/education on breastfeeding, public breastfeeding comfortability, and social support (Duong, Binns,

and Lee 2004; Duong, Lee, and Binns 2005; Tang, Lee, and Binns 2015a; Nguyen et al. 2011; Thu et al. 2012).

1.4. Significances of the study

The practice of breastfeeding is known to be the most effective and cost-effective disease prevention for both mothers and infants (World Health Organization 2017). Due to lifestyle changes in modern society, it is indispensable to update the existing knowledge and broaden our understanding about breastfeeding practices and their determinants. Mode of delivery (caesarean section or vaginal delivery) was briefly mentioned in several cross-sectional studies in Vietnam for its impacts on early initiation or breastfeeding practices before hospital discharge, but its effects on short or long-term breastfeeding had not been quantified. The effects of maternal type 1 and type 2 diabetes as well as physical activity during postpartum period on breastfeeding were mentioned in a few papers, most of which were studies undertaken in developed countries such as the United States, Australia, and European countries. However, the relationship between GDM status, physical activity during pregnancy and breastfeeding have rarely been examined, especially in developing countries. Details of the literature review will be reported in the next chapter.

This study will provide pertinent information for Vietnamese women on the three-abovementioned maternal factors (i.e., mode of delivery, GDM status, physical activity during pregnancy) influencing breastfeeding practices. Such information will assist in the planning of breastfeeding promotion programmes. Assessment of breastfeeding cessation and maternal factors during pregnancy also has important

implications for developing early interventions to potentially enhance breastfeeding self-efficacy and practice. Documenting prelacteal feeds and the early introduction of infant formula, as well as their effects on infant hospitalisation and infant health, can provide evidence-based guidelines to protect young children and enhance mothers' breastfeeding capacity. The present study was the first comprehensive cohort study of infant feeding practices in Vietnam, a country of over 96.5 million people and multiple cultural groups. Findings of this thesis will be useful for monitoring the breastfeeding trends, planning future research, and advocating the achievement of the millennium goal to improve maternal and child health in Vietnam.

1.5. Aim and objectives

Aim: To ascertain infant feeding practices in Vietnam, and to examine maternal factors, such as GDM, physical activity during pregnancy, and caesarean delivery, which could influence breastfeeding practices. In addition, the study aimed to assess the impacts of prelacteal feeds and early formula feeding on infant health in Vietnam.

Objectives

1. To conduct a systematic literature review of GDM and breastfeeding outcomes.
2. To assess the association between GDM and breastfeeding outcomes including early breastfeeding initiation, prelacteal feeding, 'any' breastfeeding at specific time points, and breastfeeding cessation.
3. To determine the rate of 'any' breastfeeding at twelve months postpartum, breastfeeding cessation, and their association with physical activity during pregnancy for Vietnamese women.

4. To determine the association between caesarean section and breastfeeding outcomes including early breastfeeding, prelacteal feeds, and ‘any’, ‘predominant’, and ‘exclusive’ breastfeeding at different time points from delivery to twelve months postpartum.
5. To determine the prevalence of prelacteal feeds and early formula feeding, and their associations with infant hospitalisation, diarrhoea and lower respiratory tract infection within twelve months postpartum.

Chapter 2: Literature Review

2.1. Breastfeeding

The World Health Organisation recommends that newborn infants should be breastfed within 30 to 60 minutes after birth, followed by exclusive breastfeeding for the first six months, and then breastfeeding should be sustained for the next two years or more (World Health Organization 2017). UNICEF and the WHO have described the importance of 'the first 1,000 days', from conception to around two years of age, during which the foundation of whole of life nutrition and health is established (United Nations Children's Fund 2015). During the first two years after birth, breastmilk provides nutrients for growth and development of the child's health and brain, but also includes antibodies, nonspecific anti microbiological agents, white cells and probiotics to protect against infant illnesses and diseases (United Nations Children's Fund 2015).

The 2025 global nutrition target set by WHO and UNICEF places emphasis on the consequences of sub-optimal breastfeeding, including 'non-exclusive' breastfeeding. It was estimated that adequate breastfeeding could prevent approximately 11.6% of mortality in children under five, which was equal to 804,000 deaths, in 2011 (World Health Organization and United Nations Children's Fund 2014). The promotion of breastfeeding was also regarded as an efficacious and cost-effective intervention in public health (Rollins et al. 2016; Victora et al. 2016; Binns, Lee, and Low 2016). For less developed settings, the role of breastfeeding in saving infant and child deaths has been emphasised by the WHO Collaborative Group (WHO Collaborative Group 2000). A cost analysis of seven Southeast Asian countries found that breastfeeding was able

to prevent over 12,400 child and maternal deaths annually and saved about $1.6 billion per year due to improvements in cognition, higher IQ and earnings. This study reported that the Vietnamese breastfeeding promotion program could avert 200 child deaths per year and yield a generous return of 139% on investment (Walters et al. 2016). These numbers are much lower than the estimates of Rollins and would seem to be in need of revision (Rollins et al. 2016).

The World Health Assembly has designated breastfeeding as a requisite for a achieving a number of health goals, including the improvement of maternal, infant, and young child nutrition and reducing overweight and related non-communicable diseases (NCDs) (United Nations System Standing Committee on Nutrition 2017). "Appropriate breastfeeding practices, including appropriate complementary feeding practices after six months of 'exclusive' breastfeeding, not only prevent malnutrition among young children, but are also associated with less susceptibility to overweight and NCDs later in life" (United Nations System Standing Committee on Nutrition 2017). The European draft policy for health encompasses several references that emphasise the significance of breastfeeding in maintaining public health. "The life of a mother and her baby are inextricably linked. Breastfeeding is an important aspect of caring for infants and young children. It leads to improved nutrition and physical growth, reduced susceptibility to common childhood illnesses and better resistance to cope with them, a reduced risk of certain non-communicable diseases in later life and stimulating bonding with the caregiver and psychosocial development" (World Health Organization European Regional Office 2019).

2.1.1. The short- and long-term benefits

The short- and long-term benefits of breastfeeding on physical and well-being health of infants and mothers have been assessed and documented (Horta, Loret de Mola, and Victora 2015; Victora et al. 2016; Binns, Lee, and Low 2016; Ip et al. 2007). The 2016 Breastfeeding Lancet series described the lifelong effects of breastfeeding for children and mothers (Victora et al. 2016). It has been estimated by Victora and colleagues that if breastfeeding is practised on a global scale, it can annually prevent the death of 823,000 children under five and 20,000 women with breast cancer (Victora et al. 2016). This would be considered as an underestimate if associations with a slightly lower level of evidence were comprehended. Victora stated that "our meta-analyses indicate protection against child infections and malocclusion, increases in intelligence, and probable reductions in overweight and diabetes" (Victora et al. 2016).

Additional reviews in recent years have substantiated the link between breastfeeding and reduced risks of specific conditions including obesity (Tambalis et al. 2018; Mihrshahi and Baur 2018; Matvienko-Sikar et al. 2018; Palou, Pico, and Palou 2018; McCallister, Medrano, and Wojcicki 2018), lower respiratory tract infection (McAllister et al. 2019), and cardiovascular disease, hypertension, metabolic syndrome (Heshmati et al. 2018; Faintuch and Faintuch 2018; Wisnieski et al. 2018; Bonifacino et al. 2018), SIDS (Moon and Hauck 2018; Young and Shipstone 2018), asthma (Moossavi et al. 2018) and necrotizing enterocolitis (Patel and Kim 2018). A systematic review indicated that infants who were breastfed had one-third the risk of developing type 2 diabetes compared to non-breastfed neonates (Horta, Loret de Mola, and Victora 2015). The beneficial effect of breastfeeding on hypertension is found to be proportional to breastfeeding duration (Qu et al. 2018). A recent re-analysis in

which possible genetic confounding was considered has confirmed an association between breastfeeding and adult intellectual capacity (Horta, Hartwig, and Victora 2018; Mortensen 2015). Other conditions including leukaemia, osteoporosis, coeliac disease, infant colic and Alzheimer's disease have also been reported to be related to breastfeeding, but the strength of these pieces of evidence is variable. Being breastfed within one hour after birth could reduce neonatal deaths, and breastfeeding from twelve months or more was associated with a decrease in nutrition risk as well as an increase in healthy eating and dietary intake at three to five years of age (Phukan, Ranjan, and Dwivedi 2018; Borkhoff et al. 2018).

Mothers also obtain health benefits from breastfeeding. The risks of developing breast (Sauter 2018; Collaboration for breast cancer 2002; Chowdhury et al. 2015) and ovarian cancers were reduced in mothers who breastfeed (Su et al. 2013; Binns, Lee, and Lee 2014; Zhang et al. 2004; Ali 2018; Unar-Munguia et al. 2017; Chowdhury et al. 2015). In a cohort study from Michigan, the United States, there was a link between breastfeeding for longer than six months and possessing smaller maternal waist circumference for as far as a decade after parturition (Snyder et al. 2019). In many societies non-alcoholic fatty liver disease is an increasing problem. A large cohort study from four megacities of the United States showed that mothers who breastfeed for longer than six months faced a lower risk, possibly related to lower rates of obesity after breastfeeding (Ajmera et al. 2019). A systematic review of breastfeeding and hypertension found a benefit from breastfeeding even for short periods such as one to four months. The decline in the risk for developing hypertension lasted for decades and the authors speculated that breastfeeding makes a permanent change to maternal metabolism (Bonifacino et al. 2018). In the Women's Health Initiative Study, a large

cohort study with the sample of 80,191 people, there were a dose-response association of breastfeeding with risk of stroke in postmenopausal women after adjustment of multiple stroke and lifestyle risk factors (Jacobson et al. 2018).

One of the most significant chronic diseases in terms of global disease burden is type 2 diabetes. Several meta-analyses have demonstrated that mothers who breastfed their infant have a lower risk of type 2 diabetes. For longer duration of breastfeeding this resulted in lower risk of developing type 2 diabetes by 32%, "in linear dose–response analyses, there was a 9% reduction in relative risk for each 12-month increase in lifetime duration of breastfeeding" (Chowdhury et al. 2015). Although, the authors noted that at least in part, this might have been related to the weight loss following breastfeeding (Chowdhury et al. 2015; Feng et al. 2018).

Breastfeeding also provides a significant public health benefit by increasing birth spacing. During the period of lactational amenorrhea the rate of pregnancy before six months of age was reduced to 2-3% (Duong 2012; Van der Wijden, Kleijnen, and Van den Berk 2003; Chowdhury et al. 2015). A review of six studies of osteoporosis found the studies were very heterogeneous and a narrative review concluded there was no apparent association between breastfeeding and maternal bone mineral density (Chowdhury et al. 2015). However a meta-analysis of twelve studies a few years later concluded that breastfeeding may well reduce the risk of osteoporotic fracture (Duan, Wang, and Jiang 2017). Reviews of the benefits of breastfeeding for infants and mothers compared to formula feeds are summarized in Table 2.1.

Table 2.1: Reviewed short- and long-term health benefits of breastfeeding compared to formula feeding for infants and mothers

Infant health outcomes	**Surgeon General[a]**	**Victora[b]**	**Lessen[c]**	**NHMRC[d]**	**Ip[e]**
Nonspecific gastrointestinal infections	++	++	++	+	++
Upper/lower respiratory tract infections		++	++		++
Otitis media	++	++	++		++
Cognitive development		++	+		
Type 1 diabetes mellitus		+	+		
SIDS	++		++	+	++
Necrotizing enterocolitis	++		++		
Asthma	+		+		+
Eczema	+		+		
Later overweight or obesity	+	+	+	++	+
Comorbidities of excess weight (type 2 diabetes, cardiovascular disease, heart	+	+	+	+	

disease, hypertension, high cholesterol)					
Maternal health outcomes					
Breast cancer prevention	+	++	+		+
Ovarian cancer prevention	+	+	+		+
Hypertension			+	+	
Diabetes		+	+	+	
Postpartum weight			+		
Postpartum depression			++		

Sources: [a] From Department of Health and Human Services Office of the Surgeon General (2011) (U.S. Department of Health and Human Services 2011); [b] From Victoria et al (Victora et al. 2016); [c] From Lessen and Kavanagh (Lessen and Kavanagh 2015); [d] From National Health and Medical Research Council (National Health and Medical Research Council 2012); [e] From Ip et al (Ip et al. 2007; Ip et al. 2009); + some evidences; ++ many evidences.

2.1.2. Breastfeeding definitions and assessment methods

There are several difficulties related to the interpretation of 'exclusive' breastfeeding studies as different definitions are often used in reports. The length of recall time may vary considerably. In some studies the feeding method is recorded contemporaneously, while in other studies it may be years later. Breastfeeding rates may be reported as incidence, point prevalence or period prevalence. 'Exclusive' breastfeeding is rarely

defined in compliance with the strict definition from WHO, recall time, incidence, point prevalence or period prevalence; and thus, comparing results between studies and surveys is difficult (Binns et al. 2012; Flores et al. 2018; Inoue et al. 2012). Definitions that do not adhere to WHO's standard are commonly used in published reports, for example, 'exclusive' breastfeeding which allows small amounts of non-nutritious drinks such as water, tea and water-based drinks (Hummel et al. 2008; Hummel et al. 2014). This should be described as 'full' or 'predominant' breastfeeding. Several studies in the literature did not include definitions of breastfeeding or how it was applied when collecting 'exclusive' breastfeeding data (Finkelstein et al. 2013; Haile et al. 2016). Some reports measured 'exclusive' breastfeeding as a period prevalence. For instance, infants under six months of age or from 0 to 5 months. It is preferable to present data as point prevalence (that is, the rate of 'exclusive' breastfeeding at an exact point of time i.e. at three months or at six months). Breastfeeding data is often derived from cross-sectional studies rather than longitudinal cohort studies, and the reported values depended on the age composition of the samples and the length of recall (Musmar and Qanadeelu 2012; Bui et al. 2016; Joshi et al. 2014; Tuan et al. 2014). For example a report of six month breastfeeding rates of 50% could be a period prevalence or a point prevalence. This could be 100% at birth and 0% at six months, averaging 50%. Alternatively, it could be 50% all the way through the first six months. Therefore, it creates a discrepancy in results. Moreover, 'exclusive' breastfeeding should only be measured from birth. However, data may have been collected using the last 24-hours or 48-hours food recall in which it is reported as 'exclusive' breastfeeding if only breastmilk has been given (Binns et al. 2012; Joshi et al. 2014; Aris et al. 2015; Chamberlain et al. 2017; Tuan et al. 2014). These differences in definitions are important because of the impact of breastfeeding

on the development of the microbiome and its importance in the prevention of infections (Lee and Binns 2019; Chong, Bloomfield, and O'Sullivan 2018).

Table 2.2 presents different rates of 'exclusive' breastfeeding in the Asia Pacific region summarized by Binns and Lee, in which a range of variation in definitions and measurements lead to discrepant results (Binns et al. 2012). Therefore, it is critical to consider the methodology in collecting breastfeeding data, especially for 'exclusive' breastfeeding (Binns and Lee 2014).

Table 2.2: Reported rates of exclusive breastfeeding in the Asia Pacific region

Country	**WHO Database EBF 6/12**	**UNICEF Database EBF 6/12**	**WHO/UNICEF Workshop 2007 EBF 6/12**	**Curtin Studies Asia EBF at 6/12**
Australia	46	-	22	2
Cambodia	60	12	62	20
China	56	31	65	6
Indonesia	-	40	45	-
Japan	41	-	38	15
Korea	14	-	0	-
Laos	17	23	5	-
Malaysia	29	29	30	-
Mongolia	79	51	57	-
Myanmar	-	15	-	-
New Zealand	-	-	13	2

Papua New Guinea	21-86	59	30	35
Philippines	34	34	33	-
Singapore	-	-	2	1
Thailand	4	15	-	-
Vietnam	12	15	12	1

Source: Reported breastfeeding in the Asia Pacific region (Binns et al. 2012); reported numbers in the table are breastfeeding proportions; EBF: Exclusive breastfeeding;

2.1.3. Global breastfeeding situation

The latest statistics by UNICEF on Infant and Young Child Feeding Indicators published in October 2019 stated that, globally, only two in five newborns were breastfed within one hour after birth (United Nations Children's Fund 2019). In 2016, the meta-analysis reported by Victoria et al from more than 90 publications and data sources worldwide found that the early breastfeeding rates were low at all levels of national income (Victora et al. 2016). In East Asia and the Pacific, the early initiation rate, within one hour of birth, was estimated to be the lowest among other regions, at 32%, in 2017(World Health Organization and United Nations Children's Fund 2018). Vietnam is one of the countries where early initiation rate has decreased from 44% (in 2005) to 26.5% (in 2017) (World Health Organization and United Nations Children's Fund 2018).

UNICEF also reported that the 'exclusive' breastfeeding rate of 0 to 5 months was 42% worldwide which was similar to the estimation of about 40% of infants 0 to 6 months

from the WHO (World Health Organization 2018b; United Nations Children's Fund 2019). As mentioned before, both organizations reported data on period prevalence instead of point prevalence. The 'exclusive' breastfeeding rate at 37% for low- and middle-income countries in the detailed meta-analysis was also collected as period prevalence for infants 0 to 5 months using 24-hour food recall (Victora et al. 2016).

The WHO has set a target of 'exclusive' breastfeeding rate of at least 50% globally (World Health Organization 2014). However, according to latest data of UNICEF published in 2019, for over a decade, 'exclusive' breastfeeding rates have increased gradually for most regions, especially East Asia and the Pacific region, with the prevalence of 'exclusive' breastfeeding between 2013-2018 only at 29% (United Nations Children's Fund 2019). Amongst countries in East Asia and the Pacific region which had the lowest rate of 'exclusive' breastfeeding, Vietnam's 'exclusive' breastfeeding rate was 24% (Vietnam 2013 Multiple Indicator Cluster Survey), lower than the region's rate (United Nations Children's Fund 2019). This reported rate however was increased slightly over years, from 15.7% in 1997 to 16.1% in 2006 and 17.0% in 2010 (United Nations Children's Fund 2019). The exclusive breastfeeding rates from 2000 to 2013 were significantly lower in urban compared to rural areas except the finding from Vietnam Demographic and Health Survey in 2002 (United Nations Children's Fund 2019). The rate of 'exclusive' breastfeeding at six months in Vietnam from Demographic and Health Survey data is measured from cross-sectional study and the result is dependent on the sample selected for interview and is higher than results using a strict definition which range 1% to 15%(see Table 2.2 by Binns and Lee 2012) (Binns et al. 2012). In low- and middle-income countries, 'exclusive'

breastfeeding rates are normally low due to the high prevalence of prelacteal feeding and formula feeding use which will be discussed in the next sections of this chapter.

The ever breastfeeding rates are reported to be as high as 90% or more for most regions, but this only describes the percentage of children received breastmilk or colostrum for at least one occasion (United Nations Children's Fund 2019). Detailed meta-analysis of available data worldwide indicated that most mothers initiated breastfeeding, except France, Spain, and the United States with the ever breastfeeding rates less than 80% (Victora et al. 2016). While the ever breastfeeding rates are usually high in most countries, mothers in low- and middle-income countries tend to breastfed for longer when compared to high-income countries (United Nations Children's Fund 2019; Victora et al. 2016). Continued breastfeeding or 'any' breastfeeding at twelve months and longer, even to more than two years of age, has positive public health benefits. The WHO report stated that 70% of children aged 12 to 15 months and 44% of children aged 20 to 23 months were breastfed (World Health Organization 2008a; United Nations Children's Fund 2019).

Vietnam, as a lower middle-income country, also has a high rate of ever breastfeeding (96.9%) and 65% of mothers continued breastfeeding at one year (United Nations Children's Fund 2019). However, rates of early breastfeeding initiation (26.5%) and continued breastfeeding to two years of age (21.8%) (see Table 2.3) are low in Vietnamese mothers (United Nations Children's Fund 2019). There have been several short-term studies of breastfeeding in Vietnam including trials and interventions (Bich, Long, and Hoa 2019; Granger 2018; Bui et al. 2016; Duong, Binns, and Lee 2004;

Duong, Lee, and Binns 2005; Hajeebhoy et al. 2013; Le et al. 2018; Lundberg and Ngoc Thu 2012; Lundberg and Trieu 2011; Mongensen and Frida 2009; Nguyen et al. 2013; Nguyen et al. 2011; Nguyen et al. 2016; Ramoo et al. 2014; Thu et al. 2012; Tuan et al. 2014). There is a need for long-term follow up studies to understand the factors associated with continued breastfeeding practices in Vietnam. Trials to maintain long-term breastfeeding should also be focused. Details on breastfeeding data by UNICEF region including Vietnam were summarized in Table 2.3 (United Nations Children's Fund 2019).

Table 2.3: Breastfeeding indicators by UNICEF region and Vietnam in 2018

Region	**Early initiation of breastfeeding (%)**	**Exclusive breast-feeding 0-5 months (%)**	**Breast-feeding at 1 year (%)**	**Breast-feeding at 2 years (%)**	**Ever breast-feeding (%)**
Eastern and Southern Africa	65	55	87	51	96
West and Central Africa	41	34	87	39	96
Middle East and North Africa	36	31	67	26	95

South Asia	40	54	84	70	96
East Asia and the Pacific	**38**	**29**	**43**	**22**	**-**
Eastern Europe and Central Asia	57	33	64	30	-
Latin America and Caribbean	54	38	57	32	96
North America	-	35	15	12	74
Global	**44**	**42**	**70**	**44**	**95**
Vietnam	**26.5**	**24**	**65.6**	**21.8**	**96.9**

Source: UNICEF global databases: Infant and young child feeding, based on Multiple Indicator Cluster Surveys, Demographic and Health Surveys, and other nationally representative sources from 2013 to 2018 (United Nations Children's Fund 2019)

Indicator definitions used by UNICEF (United Nations Children's Fund 2019)**:**

Early initiation of breastfeeding – Percentage of newborns put to the breast within one hour of birth: Children born in the last two years who were put to the breast within one hour of birth per total children born in the last two years

Exclusive breastfeeding 0 to 5 months – Percentage of infants 0 to 5 months of age who are fed exclusively with breast milk: Infants 0 to 5 months of age who received only breastmilk during the previous day per total infants 0 to 5 months.

Breastfeeding at one year – Percentage of children 12 to 15 months of age who are fed breastmilk: Children 12 to 15 months of age who received breast milk during the previous day per total children 12 to15 months of age.

Breastfeeding at two years – Percentage of children 20 to 23 months of age who are fed breast milk: Children 20 to 23 months of age who received breast milk during the previous day per total children 20 to 23 months of age.

Ever breastfed – Percentage of newborns ever breastfed: Children born in the last two years who were ever breastfed per total children born in the last two years.

2.2. Infant illness and hospitalisation in relation to prelacteal feeds and early formula feeds

2.2.1. Prelacteal feeds

The WHO states that any fluid or feed such as infant formula, water, sugar-water, honey, tea, fruit juice, herbal drink provided for the newborns before the initiation of breastfeeding is a prelacteal feed (World Health Organization 2009). Similarly, Neville and Morton define "prelacteal feeds as any feeds given before the onset of lactogenesis II, which is the onset of copious breastmilk secretion that occurs within four days of birth" (Neville and Morton 2001). The WHO also emphasizes that giving even small amounts of these feeds to the infants can lead to infection due to a high risk of contamination (World Health Organization 2009). The action of giving prelacteal food directly causes lower rates of 'exclusive' breastfeeding by reducing breast stimulation and prolactin release and delaying lactogeneis II (World Health Organization 2008a; Fok et al. 2019). Prelacteal feeds are associated with the delays in breastfeeding initiation and establishment as well as a shorter overall duration of breastfeeding (Scott et al. 2006; Liu et al. 2013; Hossain et al. 1992; Ahmed, Rahman, and Alam 1996;

Perez-Escamilla et al. 1996). The importance of avoiding prelacteal feeds has been emphasised by WHO as they should only be given for specific medically diagnosis indications (World Health Organization 2018b, 2009; World Health Organization and United Nations Children's Fund 2003).

Despite all of the risks, high rates of prelacteal feeds are continued to be reported worldwide. In West Africa, prelacteal feeding of infant formula was reported in five different settings in Benin City, Nigeria in 1985, and the negative association between early onset of bottle feeding and breastfeeding duration was also mentioned (Isenalumhe and Oviawe 1987). Later, prelacteal feed had been reported with 60% in a prospective cohort study conducted in rural Egypt in 1992 (Hossain et al. 1992). The multilevel-analysis of data from the Demographic and Health Survey programme between 2010-2014 from 22 countries in sub-Sahara Africa (n= 95,348) calculated that the prevalence of prelacteal feeds was 32.2 % in which Côte d'Ivoire, Nigeria and Guinea were ranked the highest with 67%, 60.5% and 59.8% respectively (Berde and Ozcebe 2017). In Northeast Africa, about 58% of newborns were provided prelacteal food in Egypt (El-Gilany and Abdel-Hady 2014). Another meta-analysis of 28 studies conducted in Ethiopia between 2012 and 2016 showed the pooled prevalence of prelacteal feeds at 25.3% (95% CI 17.43-33.15) (Temesgen et al. 2018). Some studies reported the prelacteal rates as high as 75.8% in Ethiopia (Egata, Berhane, and Worku 2013; Mekuria and Edris 2015).

In Central American, the Epidemiology and Family Health Survey from Honduras in 1992 (n=2380) concluded that there was an association of milk and water-based prelacteal feeds with adverse breastfeeding outcomes (Perez-Escamilla et al. 1996).

Data from National Demographic and Health Surveys (DHS) of seven Latin American and Caribbean countries between 2005 and 2010 found that for every three children, one of them was given prelacteal food with the highest rate of 55.2% in Dominican Republic (Boccolini et al. 2015).

In Southern Asia, a community-based study in rural Bangladesh found that 77% of newborns (n=420) were given prelacteal feeds, and honey was the common prelacteal food (72%), reflecting the cultural beliefs of Islamic countries (Ahmed, Rahman, and Alam 1996). A cross-sectional study conducted in Bihar, India between 2012 and 2013 found that amongst 10,392 newborns, 26% of them received prelacteal feeds (Das et al. 2019). Other studies in India published in 2012 and in 2014 indicated that 88% and 40% of mothers respectively provided prelacteal feeds to their baby, reflecting regional cultural differences (Roy et al. 2014; Raina, Mengi, and Singh 2012). In the Maldives, 23% of babies were given prelacteal feeds in which 4.1% of infants received infant formula, 10.6% and 7.4% received honey and dates, respectively, as prelacteal ritual feeds (Raheem et al. 2014). Studies in Nepal found 30.5% to 56.6% of infants received prelacteal foods (Pries et al. 2016; Khanal, Lee, Karkee, et al. 2016). A prospective cohort study from Shiraz, Iran in 2014-2015 also found 65.4% of the participants received prelacteal feeds as their first feed, including 40.8% receiving a traditional ritual prelacteal food (Zarshenas et al. 2019). In Sichuan Province and the city of Chengdu in China, prospective cohort studies found that, respectively, only 6.8% and 24% of infants received breastmilk as their first food (Tang et al. 2013; Yu, Binns, and Lee 2016). A birth cohort with 951 infants from Changsha in Hunan Province, China, reported that, only 17.4% of newborns were given prelacteal foods, mostly infant formula, one of the lowest rates reported from China (Wu et al. 2019).

In Vietnam, the use of prelacteal feeds, predominantly infant formula, has been described in several studies (Hajeebhoy et al. 2014; Nguyen et al. 2013; United Nations Population Fund 2017). In many of these studies, the same data source from the 'Alive and Thrive' baseline household survey was used for the publications (Nguyen et al. 2013; Tuan et al. 2014; Nguyen et al. 2016). Data was collected in 2011 in eleven provinces of Vietnam with a total sample of 10,834 Vietnamese infants aged 0 to 23 months in which 6,068 children were under six months of age. A high rate of prelacteal feeding was reported with 73.3% of newborns being given prelacteal feeds with 53.5% given formula milk and water to 44.1% (Nguyen et al. 2013). The prevalence of prelacteal feeding decreased when the mothers have more confidence, knowledge, and beliefs about 'exclusive' breastfeeding; in specific, women who had misapprehensions about breastfeeding had a twofold risk of prelacteal feeding (Nguyen et al. 2013). Caesarean section was a further risk factor for prelacteal feeding compared to vaginal delivery (OR 2.94; 95% CI 2.39-3.61) or episiotomy (OR 1.36; 95% CI 1.17-1.58) (Nguyen et al. 2013). Although professional support during pregnancy and after delivery reduced the use of infant formula, family support after delivery increased the risk of giving water to newborns (Nguyen et al. 2013). This study also reported 21% of mothers intended to feed infant formula at birth and 67% of mothers bringing infant formula from home, or purchasing it at or near hospitals (Tuan et al. 2014). Another prospective cohort with 6,706 infants from Ho Chi Minh City and Dong Thap province found that the any formula milk rates were higher in urban compared to rural areas, especially at birth, with more than 90% of newborns in urban areas being fed formula milk compared to 25% in rural areas (Le et al. 2018).

2.2.2. Infant formula

Human milk substitutes have existed throughout human history. When the mothers could not breastfed their infants directly, wet nurses were hired to replace the source of human milk. The other sources were milk from other mammals, typically cow, sheep, and goat (Fomon 1993). "Infant formulas are specialised products designed for the dietary management of infants" (Guo and Ahmad 2014). Infant formula can be in liquid or powder form. In 1867, the first generation of infant formula based on cow milk and included other ingredients such as wheat, malt, and potassium bicarbonate was introduced (US Institute of Medicine 2004). Infant formula is prescribed as an alternative for human milk in some medical circumstances in which the mothers are temporarily unable to breastfeed (for example, untreated brucellosis, positive *Human Immunodeficiency Virus* (HIV), active *Herpes Simplex Virus*, active tuberculosis, active varicella, under cancer chemotherapy), or the babies are unable to receive breastmilk (such as allergy to breastmilk compositions, abnormal metabolism, preterm birth) (U.S. Department of Health & Human Services 2018; World Health Organization and United Nations Children's Fund 2003).

Other cow-milk-based types of formula addressing specific nutritional requirements have been constantly introduced to the market. This led to the success of animal milk feeding (US Institute of Medicine 2004). Depending on the special needs of different infants, or the marketing needs of commercial companies, extra elements including vegetable oils, minerals and vitamins (iron, calcium), taurine, nucleotides, arachidonic acid, docosahexaenoic acid, and probiotics have been added to the milk. Some additives, including fat blends, have been removed and the ratio of calcium and phosphorus has been adjusted. The composition has been modified in an attempt to

make formula closer in composition of human milk and to enhance the infant health as well as to fulfil their special needs (US Institute of Medicine 2004). In the rare event that an infant becomes allergic to animal's milk proteins, non-milk-based formula is sometimes used. In 1929, for the first time, soya formula was commercially sold to the market, but until 1960s when soy protein was used, the milk free formula was more accepted (Abt and Garrison 1965). Soy milk formula now controls up to 40% of the United States formula sales as parents choose to feed their infants this to avoid cow-milk proteins (US Institute of Medicine 2004). However the rates of allergy to soy milk are higher than to cow milk, and the Australian National Health and Medical Research Council does not recommend soy milk for infants during the first twelve months, especially for preterm infants (National Health and Medical Research Council 2012). Even the best modern infant formula do not match the quality of protein in human milk and higher levels of protein are required to meet all nutritional requirements. Higher levels of protein increases the risk of obesity in formula fed infants (Koletzko et al. 2019).

Although the infant formula currently manufactured is an improvement on early formula, given the use of modern technology and the introduction of additional ingredients, breastmilk with living tissues is unique and cannot be replaced by any alternative or substitute (US Institute of Medicine 2004; Binns and Lee 2014). The unique composition of human milk is a key factor providing the formation of a healthy development of gastrointestinal microbiome which is associated with decreased risk of many diseases such as asthma, allergy, diabetes, depression, obesity and arthritis (Gilbert et al. 2018; Gaufin, Tobin, and Aldrovandi 2018; Chong, Bloomfield, and O'Sullivan 2018; Iozzo and Sanguinetti 2018; Stiemsma and Michels 2018). Within

the first year of the newborn, an estimated thousand or more species, colonise the gastrointestinal tract (Gilbert et al. 2018). Breastmilk also contains bacteria and prebiotics that promote the growth of those microbes. However, the establishment of a normal healthy microbiome is also disrupted by preterm birth, caesarean delivery and the use of antibiotics during the perinatal period (Chong, Bloomfield, and O'Sullivan 2018; Iozzo and Sanguinetti 2018; Stiemsma and Michels 2018).

As mentioned above, the use of infant formula, even one time only, means that by definitions, the infant can no longer be classified as 'exclusively' breastfed. The higher use of infant formula is, the lower 'exclusive' breastfeeding rate. A cost analysis of pediatric diseases (such as necrotizing enterocolitis, otitis media, gastroenteritis, hospitalisation for lower respiratory tract infection, atopic dermatitis, sudden infant death syndrome, childhood asthma, childhood leukemia, type 1 diabetes, and childhood obesity) in the United States estimated that US$13 billion would be saved per year if 90% of American families could exclusively breastfeed for six months, together with the prevention of an extra 911 deaths, mostly in infants (US$10.5 billion and 741 deaths at 80% compliance) (Bartick and Reinhold 2010). In 2014, while the infant formula industry globally made US$44.8 billion, an estimation of US$302 billion, representing 0.49% of the world's GNP, was charged to society (Rollins et al. 2016; Victora et al. 2016). Another comprehensive cost analysis compared the health outcomes and economic burdens between formula feeding and breastfeeding in the US, and it found that the number of excess deaths due to infant formula was about 3,340 cases per year, which was valued at US$14.2 billion, and about 80% of the excess deaths were accounted for maternal health such as myocardial infarction, breast cancer, and diabetes (Bartick et al. 2017). Data on infant deaths from 1970 to 2011 of 46 low-

and middle-income countries showed that infant formula increased infant mortality by 9.4 per 1000 births which was equal to 66,000 infant deaths in the 1980s at the peak of the infant formula debate (Anttila-Hughes et al. 2018). Despite the decline in health outcomes and the increase in breastfeeding policy and interventions, the infant formula market increased worldwide, in which from 2008 to 2013, the sales rapidly rised by 40.8 %, and it continued growing by 50% in 2018, with the largest consumption in East Asia, particularly China, Indonesia, Thailand and Vietnam (Baker et al. 2016). Likewise, the marketing report "Trends in the baby food and diaper markets around the world" from Nielsen 2015 mentioned the sale in baby formula was remarkable, with Latin America sale values grew by 37.3% and Africa and Middle East by 16% (Nielsen 2015). The largest consumer was Asia Pacific region contributing to 53% of the sale market (Nielsen 2015).

Epidemiology studies have reported high rates of early infant formula use during hospital stay after delivery. A prospective cohort study in Shiraz, Iran conducted in 2014-2015 found that 34.9% of newborns received formula during their hospital stay (Zarshenas et al. 2019). Another prospective cohort study in rural area of China reported that two in three newborns were given infant formula as their first feed (Tang et al. 2013). In Vietnam, data from a cross-sectional study with 10,681 mothers of children aged 0 to 23 months indicated that during the first three days after birth, infant formula was fed to 50% of newborns. The study also found a subsequent high rate of formula feeding after hospital discharge and early breastfeeding following with early formula feeding during hospital stay after birth (Nguyen et al. 2016).

In 1981, the World Health Assembly has adopted the International Code of Marketing of Breastmilk Substitutes ("the Code") in effort to control the marketing of formula in a way that undermined mothers' breastfeeding decisions (World Health Organization 1981). In the four decades that has passed since "the Code" was adopted, only 35 countries, out of 194 countries, have implemented "the Code" fully, while 58 countries have enacted no legal measures to enforce "the Code". Notably, the United States and the Republic of Korea have taken no action even in signing "the Code" (World Health Organization, United Nations Children's Fund, and International Baby Food Action network 2018). Global sales of breastmilk substitutes are still increasing, and despite "the Code", promotion of formula, often in subtle ways, remains widespread (Piwoz and Huffman 2015). Even in countries committed to "the Code", such as China, India and Vietnam, infant formula use continues to rise and new strategies for intervention are needed. These could include longer maternity leave, health promotion for mothers, more training about breastfeeding for health workers, and health system enhancement using the principles of the Baby Friendly Hospital Initiative (Robinson et al. 2018). In the few medical circumstances in which infant formula should be used, storage and preparation of formula must follow the guidelines from WHO and manufactures to minimise infection, especially in professional care settings involving in a large number of babies (World Health Organization and Food and Agriculture Organization 2007b; World Health Organization and Food and Agriculture Organization 2007a).

2.2.3. Infant illnesses and hospitalisation

In 2016, according to the WHO, there were 56.9 million deaths globally, over half (54%) of these belonged to the top ten causes (World Health Organization 2018d). While three of the leading deaths were caused by non-communicable diseases, namely

heart disease, stroke, and chronic obstructive pulmonary disease; lower respiratory infection was the most common communicable disease causing death, presenting in all income groups and causing three million deaths in 2016 (World Health Organization 2018d). The number of deaths by diarrhoeal diseases declined by nearly one million between 2000 and 2016, yet still claimed 1.4 million lives in 2016, the ninth rank in the top ten global death causes (World Health Organization 2018d). Importantly, poor hygiene in low- and lower-middle income countries exacerbates the negative impact of lower respiratory infection (ranked first place for low-income and third place for lower-middle income countries in 2016) and diarrhoeal diseases (ranked second place for low-income and sixth place for lower-middle income countries) on death rates (World Health Organization 2018d).

Lower respiratory tract infection symptoms are defined as "at least one specific lower respiratory tract sign (fast or difficulty breathing, chest wall indrawing) and/or abnormal auscultatory findings (crackles/crepitations or bronchial breath sounds)" (Roth et al. 2008). Pneumonia, a common type of acute respiratory infection which affects the lungs, is the most common infectious cause of death among children (World Health Organization 2019). As defined by the WHO, "the passage of three or more loose or liquid stools diurnally, or more frequently than is normal for the individual" is considered as diarrhoea (World Heatlh Organization 2017). By engendering dehydration and fluid loss, severe diarrhoea can increase the risks in young children, malnourished people, and people with impaired immune system (World Heatlh Organization 2017).

Respiratory infection and diarrhoea are also two most common death causes for children younger than five years old, particularly in low- and middle-income countries (United Nations Children's Fund 2016; G. B. D. Mortality Collaborators 2017; Kyu et al. 2016). In 2012, a report by WHO mentioned that respiratory infection caused 570,000 deaths in under five-year-old children, while diarrhoea was responsible for the demises of 361,000 children (World Health Organization). WHO reports that pneumonia and diarrhoea altogether are the causes of more than two million children deaths each year and account for 29% of all child deaths internationally (World Health Organization 2013b). Pneumonia by itself ended more than 800,000 lives under the age of five in 2017, accounting for a quarter of all deaths of under five-year-old children all over the world (World Health Organization 2019), and diarrhoeal disease followed in second place. Each year, around 525,000 children under five die from diarrhoeal diseases, from approximately 1.7 billion cases in children (World Heatlh Organization 2017). Diarrhoeal diseases are an important contributing factor to malnutrition in children of less than five years old (World Heatlh Organization 2017). WHO and UNICEF are advocateing for actions against these two diseases to lower the under-five death rate. One of the most effective interventions mentioned by these organisations is ‘exclusive’ breastfeeding during the first six months in conjunction with being vaccinnated, handwashing, drinking water and receiving appropriate treatment using oral rehydration therapy (World Health Organization 2013b).

In Vietnam, the greatest proportion of deaths among children under five were attributable to pneumonia (10-14%) and diarrhoeal disease (5-9%) (United Nations Children's Fund 2016; Nhung et al. 2014). Respiratory diseases were responsible for

the majority of hospital admissions (37.7%) amongst 199,827 admission of children 0 to 17 years old from Ha Noi, finding from the inpatient electronic database of the National Children's Hospital from 2007 to 2014 (Nguyen et al. 2017). Respiratory disearses were also the major reason for hospital admission for children-under-five, with 45.8% contribution in under one year of age, 36.4% in the group of 1 to 4 years of age. However, for the age group 5 to 17 years old, digestive diseases (20.8%) were the main reason for hospitalisation of Ha Noi children (Nguyen et al. 2017).

A prospective cohort study of 1049 infants conducted in a rural area of Northern Vietnam in 2010-2012 with a six-month follow up, found that 8.8% and 4% of infants required hospital inpatient care due to pneumonia or diarrhoeal illness respectively (Hanieh et al. 2015). Results from the cross-sectional study (sourced from the 'Alive and Thrive' baseline household survey) of 6,068 children 0 to 5 months from eleven provinces in 2011 indicated that the prevalences of diarrhoea and acute respiratory infection during the last two weeks were 5.3% and 24.5% respectively (Hajeebhoy et al. 2014).

2.2.4. The association between feeding practices and infant health

There is an important link between infant feeding and hospital admission for infectious diseases including respiratory infection and diarrhoea (Hengstermann et al. 2010; Bahl et al. 2005; Oddy et al. 2008; Fisk et al. 2011; Raheem, Binns, and Chih 2017; Payne and Quigley 2017; Yamakawa et al. 2015). The situation in Vietnam is similar, and in 2011, a cross-sectional study conducted in eleven provinces by 'Alive and Thrive' with 6,068 infants from 0 to 5 months reported that early initiation and 'exclusive' breastfeeding were inversely associated with the prevalence of diarrhoea and acute

respiratory infection (Hajeebhoy et al. 2014). However, for infant health, this cross-sectional study recalled the symptoms only in the past two weeks, while 'exclusive' breastfeeding was defined based on 24- hour food intake prior to the survey (Hajeebhoy et al. 2014). The literature suggests that the 24-hour recall of breastfeeding which is used by WHO and UNICEF may overestimate the prevalence of 'exclusive' breastfeeding since birth (Khanal, Lee, Scott, et al. 2016). Maternal recall of child illness is routinely used in epidemiological studies and is regarded as valid over long period of recall. In the study by Hajeebhoy et al, they used a much shorter recall of two weeks compared to longer studies in the literature (McCormick and Brooks-Gunn 1999; Perret et al. 2020).

In 2012, a prospective cohort study of 1049 infants from rural province of Northern Vietnam concluded that 'exclusive' breastfeeding at six weeks reduced the odds of inpatient admission for suspected pneumonia and diarrheal illnesses (Hanieh et al. 2015). However, this cohort was a part of a control trial in which the mothers received antenatal micronutrient supplementation during their pregnancy and the infants were only followed for six months (Hanieh et al. 2015). In Vietnam, the relationships among prelacteal and early formula feeding, infant illnesses and hospitalisation have not been investigated in detail. The present prospective cohort study, therefore, aimed to ascertain specifically the risk of hospitalisation, lower respiratory infection and diarrhoea within one year of birth for infants who were given prelacteal or early formula feed.

2.3. Breastfeeding and gestational diabetes mellitus

Gestational diabetes mellitus, which is defined as carbohydrate intolerance resulting in hyperglycemia with onset or first recognition during pregnancy, is one of the most common complications in pregnancy (World Health Organization 2013a; American College of Obstetricians and Gynecologists 2011). A review in 2016 revealed that the prevalence of GDM is increasing worldwide, with the highest prevalence at 12.9% (8.3-24.5%) in the Middle East and North Africa region, followed by Southeast Asia at 11.7% (8.1-18.3%) (Zhu and Zhang 2016). A literature review and meta-analysis concluded that the GDM prevalence in East and Southeast Asia was 10.1%, and Vietnam had the highest prevalence of 20.1% (Nguyen, Pham, Binns, et al. 2018).

The diagnostic criteria for GDM were firstly developed by O'Sullivan and Mahan more than 50 years ago (O'Sullivan and Mahan 1964). In 1965, the WHO published a report on diabetes mellitus, including diagnostic criteria for GDM (World Health Organization 1965). Based on new evidence about the risks of adverse pregnancy outcomes rather than the previous focus on cardiovascular disease in mothers, the criteria have been updated many times by different organisations (Knights et al. 1999; World Health Organization 1999, 2006, 2013a; International Association of Diabetes Pregnancy Study Groups Consensus Panel et al. 2010; American Diabetes Association 2004, 2010; American College of Obstetricians and Gynecologists 2011). However, due to its simplicity and accuracy, most recommended method for diagnosing GDM is the one-step approach, using the 75g oral glucose tolerance test, taken at 24 to 28 weeks of pregnancy (Rani and Begum 2016). Plasma glucose levels are measured at three time points, including fasting, one hour and two hours later. The latest and widely

used diagnostic criteria were developed by the International Association of Diabetes and Pregnancy Study Groups, based on the results of the HAPO study with a sample size of 25,000 pregnant women (International Association of Diabetes Pregnancy Study Groups Consensus Panel et al. 2010). Since 2013, the WHO has advocated for criteria in which GDM is defined comprising of at least one value meeting the threshold: fasting plasma glucose ≥5.1 mmol/L,1-h plasma glucose ≥10.0 mmol/L, 2-h plasma glucose ≥8.5 mmol/L) (World Health Organization 2013a).

In addition to the general benefits of breastfeeding, women with GDM who breastfeed their infants have a lower risk of adverse health outcomes (Kim, Newton, and Knopp 2002; Taylor et al. 2005; Much et al. 2014; Gunderson 2014; Yasuhi et al. 2017; Corrado et al. 2017; Aune et al. 2014). Women with GDM who breastfed for at least three months had the lowest postpartum diabetes risk (Ziegler et al. 2012; Much et al. 2014; Gunderson 2014). Breastfeeding can also reduce the risk of neonatal hypoglycaemia and obesity for infants born from GDM women (Cordero et al. 2013; Yan et al. 2014). Similarly, results from a meta-analysis indicated that infants who were breastfed are less likely to develop type 2 diabetes later in life when compared to the non-breastfed babies (Horta, Loret de Mola, and Victora 2015).

Despite these benefits, studies have found that mothers with type 2 diabetes had shorter duration and lower rates of ‘any’ and ‘exclusive’ breastfeeding compared to those with GDM or without type 2 diabetes (Finkelstein et al. 2013; Oza-Frank, Chertok, and Bartley 2015; Taylor et al. 2005). GDM mothers also experienced more lactation difficulties including pain after caesarean section, breast engorgement, obstetric

complications, and delayed onset of lactogenesis II (De Bortoli and Amir 2016; Gunderson 2007; Trout, Averbuch, and Barowski 2011; Taylor et al. 2005; Sudasinghe, Wijeyaratne, and Ginige 2018). Moreover, infants born from GDM mothers are at higher risk of having neonatal complications such as preterm birth, low birthweight, and being admitted to intensive care unit which results in delaying breastfeeding after birth (Cakmak and Kuguoglu 2007; Hallowell et al. 2016). Therefore, rates of 'exclusive' and 'predominant' breastfeeding are lower for mothers with GDM at hospital discharge (Chamberlain et al. 2017; Haile et al. 2016; Finkelstein et al. 2013). However, associations between GDM and breastfeeding rates at longer term after birth, and/or duration have been studied less often. Our systematic review found that rates of breastfeeding initiation, 'any' breastfeeding at discharge, or 'any' breastfeeding duration were not significantly associated with GDM. Conversely, 'exclusive/predominant' breastfeeding rates at discharge were lower, and 'exclusive/predominant' breastfeeding duration was shorter in women with GDM compared to those without. This study has suggested that mothers with GDM need extra supports and education for continuing breastfeeding. Results of this work, which is also the first objective of this thesis, has been published on the Asia Pacific Journal of Public Health in 2019, and are stated below:

Objective 1: To conduct a systematic literature review of gestational diabetes and breastfeeding outcomes.

Citation:

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Gestational Diabetes and Breastfeeding Outcomes: A Systematic Review

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Abstract

Studies of gestational diabetes mellitus in relation to breastfeeding are limited, while their findings are inconsistent. This systematic review was conducted to assess the associations between gestational diabetes and breastfeeding outcomes. An initial search of PubMed, Web of Science, and ProQuest identified 518 studies, and after applying the inclusion criteria, 16 studies were finally included in the review. Four studies reported that "exclusive/predominant/full breastfeeding" rates at discharge were lower in mothers with gestational diabetes than in those without gestational diabetes, and 2 studies showed a shorter duration of "exclusive/predominant breastfeeding" in the former than in the latter. However, most studies found no apparent difference in the rate of "breastfeeding initiation", "any breastfeeding" duration, or "any breastfeeding" in hospital and at discharge between mothers with and without gestational diabetes. In summary, mothers with gestational diabetes were less likely to exclusively breastfeed their infants and may have a shorter breastfeeding duration than other mothers.

Keywords

breastfeeding, gestational diabetes, systematic review

Introduction

The prevalence of diabetes in general diabetes and gestational diabetes mellitus (GDM) are high and have been rising in the Asian Pacific region.[1,2] On the other hand, the beneficial effects of breastfeeding have been widely documented, including a lifetime reduction in the incidence of metabolic syndrome for children and mothers.[3,4] A systematic review by the World Health Organization (WHO) found that breastfed infants were 35% less likely to develop subsequent type

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2 diabetes, while a further systematic review estimated the reduction to be 32% as compared with their non-breastfed counterparts.[5,6] Women with GDM who breastfed for at least 3 months had the lowest postpartum diabetes risk.[7,8] However, previous studies have suggested that breastfeeding outcomes may be worse (shorter duration and less likely to be exclusively breastfed) in mothers with GDM compared with mothers without GDM.[9-17] The high rates of obesity and obstetric complications among women with GDM may account for some of the lactation difficulties.[9,18] Moreover, infants born to mothers with GDM are more likely to be delivered by cesarean, preterm birth, and suffer from low birth weight or macrosomia, and subsequent intensive care. As a result, breastfeeding rates in mothers with GDM are lower than those without GDM.[19,20]

Previous reviews have mainly considered breastfeeding as the exposure or a moderator of the associations and breastfeeding per se and maternal factors with resultant obesity and type 2 diabetes.[7-9,18,21-23] Two recent reviews addressed either the need for supportive breastfeeding practices for mothers with type 1 and type 2 diabetes[24] and mothers with GDM who had delayed onset of lactogenesis II (72 hours postpartum).[24,25] Few studies have specifically investigated the association between GDM and breastfeeding outcomes, leaving a gap in our understanding of the link between GDM and breastfeeding patterns. The purpose of this systematic review was to evaluate the association between GDM and breastfeeding at discharge and breastfeeding duration, namely, "any breastfeeding", "predominant breastfeeding", and "exclusive breastfeeding".

Methods

Search Strategy

We conducted a systematic literature search of PubMed, Web of Science, and ProQuest for observational studies that assessed the association between GDM and breastfeeding outcomes, following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines.[26] The following MeSH terms and key words were used: "breast feeding", "breastfeeding", "breast-feeding", "lactation", "lactating", and "gestational diabetes", "gestational diabetic", "diabetes in pregnancy", and abstracts and/or full texts published in English, without restriction of publication date.

Selection Criteria

Identified titles and abstracts were initially screened by 2 assessors after removal of duplicates. Relevant full-text articles were then independently evaluated. Original studies that reported data on breastfeeding by mothers with and without GDM were included. Studies were excluded if they did not compare breastfeeding outcomes between mothers with and without GDM, had small sample sizes ($n < 100$), or were classified as qualitative reports, review articles, intervention studies, conference and meeting abstracts, or comments.

Quality Assessment

The methodological quality of studies was assessed using a recently developed checklist,[27] which was derived from the criteria of Strengthening the Reporting of Observational Studies in Epidemiology (STROBE),[28] and another checklist proposed by Tooth et al.[29] This checklist has a score between 0 and 18, and it is classified as high (score >14), medium (score >11 and <14), or low (score <11). It contains 9 criteria, namely, design of the study, percentage of loss to follow-up, sample size, description of recruitment period, participant selection, measurements of exposures and outcomes, proper statistical analysis with confounding adjustment, and reporting of key results.

Definitions

To promote the benefits of breastfeeding, the WHO has recommended infants be breastfed within 1 hour after birth (early initiation of breastfeeding) and then exclusively breastfed for the first 6 months.[30] Exclusive breastfeeding is defined as "breastfeeding while giving no other food or liquid, not even water, with the exception of drops or syrups consisting of vitamins, mineral supplements, or medicines". Predominant breastfeeding is defined as "babies receiving breast milk (including milk expressed or from a wet nurse) as the predominant source of nourishment with some types of liquids (water and water-based drinks, fruit juice), ritual fluids, and oral rehydration salts, drops, or syrups (vitamins, minerals, medicines) but not anything else (in particular, nonhuman milk, food-based fluids)". Any breastfeeding is considered when "a child has received breast milk (direct from the breast or expressed) with or without other drink, formula, or other infant food".[30]

GDM is impaired carbohydrate tolerance that results in hyperglycemia of variable severity with onset or first recognition during pregnancy.[31] The diagnostic criteria for GDM were first published by WHO in 1965 and have been updated several times.[32-38] The commonly used diagnostic test for GDM involves a 75-g oral glucose tolerance test done at 24 to 28 weeks of pregnancy, following the guidelines developed by WHO, the International Association of Diabetes Pregnancy Study Groups, and American Diabetes Association.[34,37,38]

Ethics Approval

The ethical review of this study was not required because it solely used data published in journals and books.

Results

The initial database search in December 2017 yielded 891 articles. After the removal of 373 duplicate records and 467 irrelevant studies, 51 articles remained. Thirty-five studies that reported unsuitable or irrelevant data (eg, monitoring glucose blood levels during lactation period, breastfeeding interventions for mothers with GDM) were thereafter excluded (Figure 1). Finally, 16 articles remained for further assessment. Table 1 presents characteristics and the quality assessment of the included studies according to geographical location (Asia, Europe, United States of America, and Australia) and study design (cohort and cross-sectional studies). Table 2 shows specific information about breastfeeding assessment and statistical results for each study of breastfeeding in relation to GDM. Table 3 summarizes the association between GDM and breastfeeding outcomes.

Characteristics of the Studies

There were 16 eligible articles, with the earliest reported study being conducted in 1985.[39] It is noteworthy that 6 were not designed to evaluate the effect of GDM on breastfeeding, but rather to consider breastfeeding as an effect modifier or a confounder of associations between other factors (eg, postpartum weight retention, child obesity, and chronic conditions) and GDM[39-44] (Table 1). Eleven studies were undertaken in the United States, 1 in Canada, 1 in Australia, 2 in Europe, and 2 in Asia. Of the 16 articles, 15 were assessed to be of medium quality (11-14 score), and one as low quality ($<$11 score; Table 1). Different methods were used to collect the data. For example, in the largest study, from Ohio, data were extracted from birth certificates, which contains the question, "Is the infant being breastfed at discharge?"[10] This dataset was collected over 6 years at various locations.

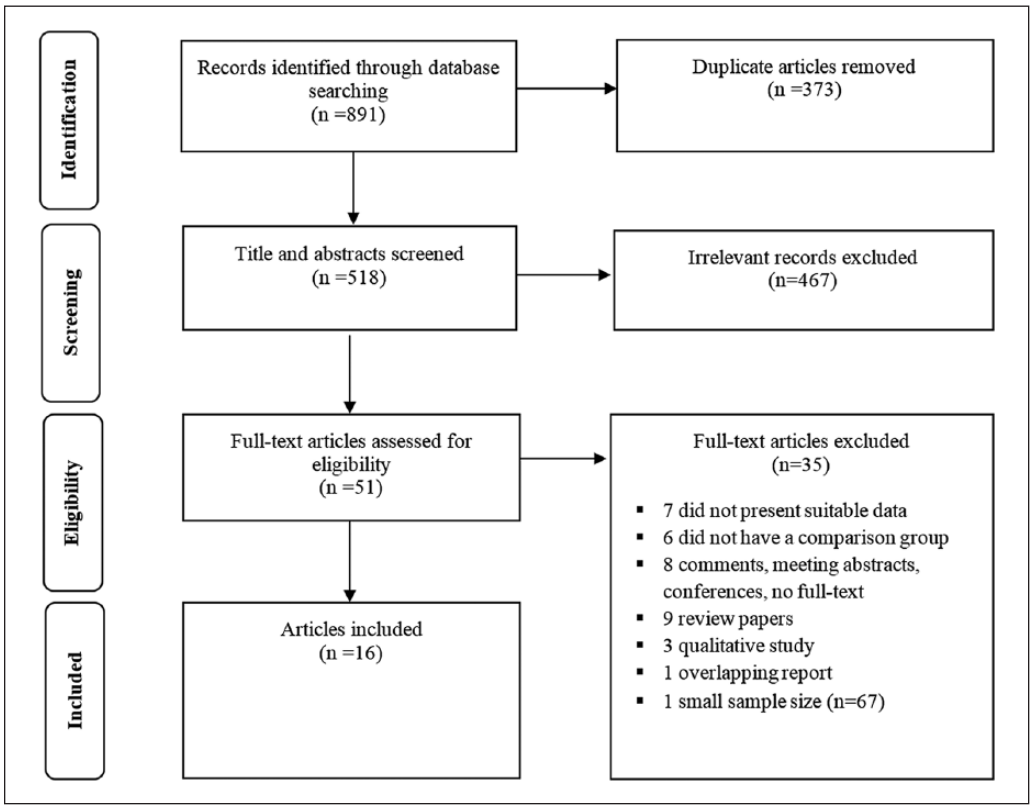

Figure 1. PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) systematic search flow chart.

Several subgroups of diabetes were also categorized to compare breastfeeding outcomes such as women with prepregnancy diabetes, GDM, and infants born with and without family history of diabetes. Therefore, the sample sizes were recalculated for 4 studies, using only 2 groups, mother with and without GDM (Table 1). In some studies, participants were selected based on the availability of information on both exposure and outcome from medical records. This could lead to the variations in the reported proportions of GDM within certain studies; for example, in Germany, the GDM proportion varied from 8.7% to 32.8%.[11,45] Hence, the GDM data presented in Table 1 are by proportion rather than prevalence.

Breastfeeding Assessment and the Impact of GDM

It is noted that several different breastfeeding definitions and categories were used to assess breastfeeding outcomes. For studies where the primary aim was not to examine the effect of GDM on breastfeeding, data on GDM and breastfeeding were extracted and/or calculated, then included in the findings (Tables 2 and 3).[39,42] Likewise, information on multivariable analysis or confounding factors of the association between GDM and breastfeeding was not included in Table 2.[39-44]

Five studies had breastfeeding outcomes measured at discharge[10,13,46-48] (Tables 2 and 3). The results showed that "exclusive breastfeeding" at discharge was lower than in mothers with GDM in the 4 studies where the data were reported. However, the rates of "any breastfeeding" were similar between mothers with and without GDM. In the studies with long-term follow-up, "any breastfeeding" duration was measured as a continuous variable in 4 studies.[11,44,45,49] Another 7

Table 1. Characteristics of the Included Studies.

Reference	Study Aim	Location	Study Design	Conducted Year	Sample Size	GDM Diagnosis Method	GDM Proportion	Quality Score
Veena et al[43]	To examine whether longer duration of breastfeeding and later introduction of complementary foods are associated with lower glucose concentrations and insulin resistance in Indian children	India	Prospective cohort	1997-2007	518	Test: 100-g 3-hour OGTT at 30 ± 2 weeks with ⩾2 plasma glucose concentrations fasting ⩾5.3, 1-hour ⩾10.0, 2-hour ⩾8.7, 3-hour ⩾7.8 mmol/L	5.9%	12
Aris et al[40]	To examine the association between infant milk feeding and postnatal growth from birth to 36 months in the offspring of mothers with GDM	Singapore	Prospective cohort	2009-2010	1016	75-g 2-hour OGTT at 26 to 28 weeks of gestation, WHO criteria fasting or 2-hour plasma glucose >7.0 or 7.8 mmol/L, respectively	17.8%	14
Hummel et al[45]	To document breastfeeding habits of women with GDM and to identify factors associated with BF habits	Germany	Prospective cohort	1989-2000	784	Not mentioned	32.8%	12
Hummel et al[11]	To assess the association between family history of diabetes and infant feeding patterns	USA, Germany, Sweden, and Finland	Prospective cohort	2004-2011	6270[a]	Not mentioned	USA 6.1%, Finland 11.9%, Germany 8.7%, and Sweden 2.8%	12
Gunderson et al[39]	To assess the association between lactation duration and incidence of metabolic syndrome among women of reproductive age	Four geographic areas of USA	Prospective cohort	1985-2006	704	75-g 2-hour OGTT fasting, 2-hour glucose levels, medical history, and self-report	11.9%	14
Wallenborn et al[56]	To investigate the direct effect of GDM on breastfeeding duration and the indirect effect of GDM on breastfeeding duration through perceived benefits of breastfeeding	USA	Prospective cohort	2005-2007	4444	Self-reported	7.0%	14
Weisband et al[44]	To assess the associations between GDM and exclusive breastfeeding intentions, hospital supplementation, and breastfeeding duration, including whether hospital supplementation mediates the association between exclusive breastfeeding intentions and breastfeeding duration	USA	Prospective cohort	2005-2007	2299	Self-reported	7.0%	12
Kachoria and Oza-Frank[13]	To examine breastfeeding trends at discharge from 2006 to 2011 by diabetes status and to determine associations between diabetes status and breastfeeding	Ohio, USA	Cross-sectional study	2006-2011	792730[a]	Birth certificate	5.3%	12

(continued)

Table 1. (continued)

Reference	Study Aim	Location	Study Design	Conducted Year	Sample Size	GDM Diagnosis Method	GDM Proportion	Quality Score
Oza-Frank et al[15]	To examine prevalence of and associations between breastfeeding initiation and continuation by maternal diabetes status and reasons for not initiating and/or continuing breastfeeding by maternal diabetes	37 states of USA	Cross-sectional study	2009-2011	71354[a]	Self-reported	8.8%	14
Shearrer et al[42]	To examine the association between breastfeeding duration stratified by GDM status and the prevalence of obesity in offspring	Los Angeles, USA	Cross-sectional study	2011	2287	Self-reported	10.1%	11
Oza-Frank et al[49]	To examine breastfeeding patterns during 12 months postpartum by GDM	Ohio, USA	Cross-sectional study	2011-2012	432	Medical record	7.9%	14
Haile et al[47]	To examine the association between GDM and exclusive breastfeeding at hospital discharge	USA	Cross-sectional study	2005-2007	2038	Self-reported	5.8%	10
Oza-Frank and Gunderson[48]	To determine changes in the prevalence of hospital breastfeeding experiences between 2004 and 2008, and 2009 and 2011 among women with GDM and women without diabetes	16 states and New York City, USA	Cross-sectional study	2004-2011	157187	Self-reported	8.8%	14
Bider-Canfield et al[41]	To assess interplay among 4 factors, maternal obesity, excessive gestational weight gain, GDM, and breastfeeding, and their independent contributions to childhood overweight	South California, USA	Retrospective cohort	2011	15710	50-g 1-hour OGTT plasma glucose ⩾11.1 mmol/L or 100 g or 75 g; OGTT: having at least 2 plasma glucose values: fasting ⩾5.3; 1-hour ⩾10.0; 2-hour ⩾8.6; and 3-hour ⩾7.8mmol/L	11.0%	11
Finkelstein et al[10]	To explore intention to breastfeed and breastfeeding rates in hospital and on discharge in women with pregestational diabetes or GDM, or no diabetes	Canada	Retrospective cohort	2008-2010	24582[a]	Medical record	5.3%	13
Chamberlain et al[46]	To investigate rates of "any" and "predominant" breastfeeding in hospital among Indigenous and non-Indigenous women with and without GDM	Australia	Retrospective cohort	2007-2010	8512	Medical record	7.3%	14

Abbreviations: GDM, gestational diabetes mellitus; OGTT, oral glucose tolerance test; WHO, World Health Organization.
[a]Sample size recalculated with only 2 groups of GDM and women without GDM.

Table 2. Assessment of Breastfeeding Outcomes and Their Associations With Gestational Diabetes Mellitus.

Reference	Breastfeeding Assessment	Definition of Exclusive Breastfeeding	Breastfeeding Measured	Other Variables Adjusted	Main Findings	Other Comments
Veena et al[43]	BF initiation Any BF duration (<3 months, 3-5, 6-8, 9-11, 12-17, ⩾18 months)	Not applicable	At 1, 2, 3 years	Not applicable	All were breastfed Mothers with GDM any breastfed longer than mothers without GDM, albeit there was no significant difference ($P = .05$)	
Aris et al[40]	Exclusive/predominant BF duration (no BF, full BF <4, ⩾4 months) Any BF duration (no BF, BF <4 month, ⩾4 months)	WHO guidelines	At 3, 6, 9, 12 months	Not applicable	No differences in any BF ($P = .352$) and exclusive/predominant BF ($P = .061$)	BF included directly or expressed
Hummel et al[45]	Ever BF Full BF duration Any BF duration	Exclusive BF included small amounts of nonnutritious drinks such as tea, water and water-based drinks, and nutritional supplements	At 9 months, 2 years	Age, parity, gestational age, year of birth	Fewer children of mother with GDM were ever breastfed ($P < .0001$) Duration of BF significantly differed between GDM and without GDM (HR = 1.4; $P < .05$ for full BF; HR = 1.5; $P < .0001$ for any BF)	Full-text was in German GDM treatment independently correlated with reduced BF duration (HR 1.7; $P < .001$), shorter in insulin-dependent than in diet-controlled
Hummel et al[11]	BF initiation Age of any BF Age of exclusive BF	Exclusive BF included small amounts of nonnutritious drinks such as tea, water and water-based drinks, and nutritional supplements	Diary was given from birth and reviewed at 3, 6, 9, 12, 18, 24 months	Mother's smoking, BMI, gestational weight gain, child gender, age, birth order, country, education, mode of birth, gestational age, Apgar, birth weight	No difference in initiation, and any BF duration Association between age at exclusive BF end and GDM (HR = 1.13; 95% CI = 1.01-1.26)	BF included own and banked breast milk Father/sibling with type 1 diabetes could affect BF Country-specific analyzed revealed differences, Sweden showing the strongest, Finland showing no association
Gunderson et al[39]	Time-dependent lactation (0-1, >1-5, 6-9, >9 months)	Not applicable	7, 10, 15, 20 years	Not applicable	No difference in any BF[a]	
Wallenborn et al[56]	Any BF duration (no BF, <6, ⩾6 months)	Not applicable	3 times over 1 year postpartum	Marital status, race, education, income, insurance, age, and prepregnancy BMI	GDM was not associated with any breastfeeding duration ($P = .398$)	GDM did not have an indirect effect on BF duration through perceived benefits of breastfeeding

(continued)

Table 2. (continued)

Reference	Breastfeeding Assessment	Definition of Exclusive Breastfeeding	Breastfeeding Measured	Other Variables Adjusted	Main Findings	Other Comments
Weisband et al[44]	Any BF duration	Not applicable	10 times over 1 year postpartum	Not applicable	Any BF duration was shorter for GDM compared with women without GDM (21.4 vs 24.6 weeks, $P = .04$)	GDM was associated with lower the intention to exclusively breastfeed and more likely to supplement compared with without GDM
Kachoria and Oza-Frank[13]	Any BF at discharge	Not applicable	At discharge	Gestational age, BMI, education, marital status, mode of birth, parity, NICU, Medicare, nutrition program participation during pregnancy, prenatal care index, race	Any BF rates were frequently highest in GDM, and lowest in prepregnancy diabetes women, but 1% difference between mother with and without GDM was not clinically considered	2006 to 2011, a significant, increasing trend of BF ($P < .0001$) existed among women with GDM (63% to 70%) and without GDM (62% to 69%)
Oza-Frank et al[15]	BF initiation BF continuation (<2, ⩾2 months)	Not applicable	At 2 to 4 months	Age, race, marital status, BMI, education, previous live births, preterm birth, intention to become pregnant, smoking, participation in the Special Supplemental Nutrition Program, insurance at delivery, NICU, discussed BF with a health care worker, mode of birth	Breastfeeding initiation was similar among GDM and no diabetes women (80.8% vs 82.2%, aOR = 0.93 [95% CI = 0.81-1.06]), but any breastfeeding continuation was lower among GDM (65.7% vs 68.8%; $P = .01$; aOR = 0.89 [95% CI = 0.79-1.00])	Data from 37 states (including Ohio), during 2009-2011 BF included breastfeed or pumped Current smoking was a significant effect modifier for initiation, not for continuation
Shearrer et al[42]	Any BF duration (no BF, 1 day <3 months, 3 to <6, 6-12, ⩾12 months)	WHO guidelines	Recalled at 2 to 4 years	Not applicable	No difference in any BF duration[a]	

(continued)

Table 2. (continued)

Reference	Breastfeeding Assessment	Definition of Exclusive Breastfeeding	Breastfeeding Measured	Other Variables Adjusted	Main Findings	Other Comments
Oza-Frank et al[49]	BF initiation Any BF duration	Not applicable	At 12 months	Age, insurance, parity, race, education	GDM initiated BF (97.1% vs 98.0%, respectively), feeding at-the-breast (93.9% vs 96.7%), and pumping (90.9% vs 91.4%) as often as without GDM Mean durations of any BF and pumping did not differ by GDM Women with GDM engaged in at-the-breast feeding for fewer days than without GDM (152.2 ± 136.7 vs 209.4 ± 137.6 days, $P < .05$), but not significant after adjustment Women with GDM initiated pumping significantly sooner than women without GDM	Breast milk intake directly from breast and pumped, not considering stored breast milk Women stating an intention to exclusively bottle feed (n = 303) were excluded
Haile et al[47]	Exclusive BF at discharge	Not mentioned	At 1 month	Age, marital status, race, education, income, BMI, gestational weight gain, prenatal smoking, NICU, intention to exclusive BF, GDM history	Exclusive BF were lower among women with GDM (aOR = 0.59; 95% CI = 0.39-0.92) Exclusive BF at discharge was 62.2% among GDM, compared with 75.4% of women without GDM	2003-2004 American Diabetes Association criteria of either 3-hour, 100 g OGTT or 2-hour, 75 g OGTT were used at the moment
Oza-Frank and Gunderson[48]	Any BF in hospital Feeding only breast milk in hospital (predominant breastfeeding according WHO definition)	Not mentioned	At discharge	Maternal age, race, maternal education, Medicaid, prepregnancy BMI, parity, mode of birth, gestational age, intended pregnancy, NICU admission, multiples, year	Any BF in hospital was similar between GDM and women without GDM, aOR = 0.93 (95% CI = 0.82-1.04) Women with GDM were less likely to report feeding only breast milk (predominant BF) in the hospital (aOR = 0.73, 95% CI = 0.65-0.82), with restricted to women who reported ever breastfeeding	Not include pumped breast milk Rate of early initiation was lower in women with GDM (aOR = 0.83, 95% CI = 0.73-0.94)

(continued)

Table 2. (continued)

Reference	Breastfeeding Assessment	Definition of Exclusive Breastfeeding	Breastfeeding Measured	Other Variables Adjusted	Main Findings	Other Comments
Bider-Canfield[41]	Never breastfed Any BF (<6, ⩾6 months)	Not applicable	4 weeks, 2, 4, 6, 9, and 12 months	Not applicable	Mothers with GDM had similar BF initiation rates compared with mothers without GDM No difference in rates of any BF ⩾6 months	
Finkelstein et al[10]	Intention to breastfed Exclusive BF in hospital Exclusive BF at discharge	Not mentioned	At discharge	Age, income, education, area of residence, parity, first trimester visit, antenatal classes, health care provider and small for gestational age, mode of birth, NICU	Intention to BF of GDM similar to women without (aOR = 0.98; 95% CI = 0.78-1.22) Exclusive BF in hospital of GDM less than without GDM (aOR = 0.77; 95% CI = 0.68-0.87) Exclusive BF at discharge of GDM less than without GDM (aOR = 0.75; 95% CI = 0.66-0.85)	Women with insulin-treat GDM were less likely to intend to BF, exclusive BF than others
Chamberlain et al[46]	Any BF in hospital Predominant BF in hospital	WHO guidelines	At discharge	Country of birth, Indigenous status, remoteness, age, parity, antenatal visits, smoking in pregnancy, complications, induction of labor, mode of birth, gestation, birth weight, admission to special care nursery, BMI, diabetes treatment	More than 90% women reported any BF at discharge, with no different by GDM status Any BF significant increased over time ($P < .0001$), but women with GDM were less likely to predominantly BF (OR = 0.32, 95% CI = 0.27-0.38)	Lower rates among Indigenous women compared with non-Indigenous; and having a cesarean or preterm

Abbreviations: aOR, adjusted odds ratio; BF, breastfeeding; BMI, body mass index; CI, confidence interval; GDM, gestational diabetes mellitus; HR, hazard ratio; NICU, neonatal intensive care unit; OR, odds ratio; WHO, World Health Organization.
[a]Self-calculation.

Table 3. Summary of Associations Between GDM and Breastfeeding.

Breastfeeding Outcome	Association	References
Rate of exclusive/predominant breastfeeding at discharge	Lower rate in women with GDM	10, 46-48
Rate of any breastfeeding at discharge	No difference	13, 46, 48
Exclusive/full/predominant breastfeeding duration (including category and continuous results)	No difference	40
	Shorter duration in women with GDM	11, 45
Any breastfeeding duration (including category and continuous results)	No difference	11, 39-43, 49, 56
	Shorter duration in women with GDM	15, 44, 45
Rate of breastfeeding initiation (ever breastfeeding)	No difference	11, 15, 41, 43, 49
	Lower rate in women with GDM	45

Abbreviation: GDM, gestational diabetes mellitus.

studies categorized "any breastfeeding" duration but used different categories (Table 2). Exclusive breastfeeding duration was found to be shorter in women with GDM. A larger number of studies indicate that GDM was not associated with "any breastfeeding" duration (Tables 2 and 3).

Considering large-scale studies, the study from Ohio, United States (n = 792,730), concluded that mothers with GDM and without GDM had "any breastfeeding" rates at discharge similar to the national breastfeeding rates.[13,50] In this study, the rates of breastfeeding at discharge overall increased over the period of the study, 2006 to 2011. However, the rates of "any breastfeeding" were slightly higher in women with GDM, but the difference of only 1% is not clinically important. For rates of any breastfeeding were 63% and 62% in 2006 for GDM and without GDM, respectively, increasing to 70% and 69% in 2011.[13] Similarly, another study from the United States (n = 157,187) found that "any breastfeeding" rates in hospital were not different between mothers with GDM and those without. However the "feeding only breastmilk" (ie, "predominant breastfeeding" in the WHO categorization) rate was lower than in the mothers with GDM.[48] In another study covering 37 states of the United States (n = 71,354), the initiation rates were similar between mothers with and without GDM, but the mothers with GDM tended to cease breastfeeding earlier (65.7% vs 68.8% at 2 months postpartum, respectively).[15] A Canadian retrospective cohort (n = 24,582) showed no difference in "any breastfeeding" rates, but the "exclusive breastfeeding" rate at discharge was lower than in mothers with GDM.[10]

A wide range of variables were considered as confounding factors of the associations between GDM and breastfeeding outcomes from studies included in the present review. They were demographic characteristics (maternal age, marital status, race, education, income, and residence), mother- and infant-related factors (prepregnancy body mass index, parity, gestational age, gestational weight gain, delivery mode, Apgar score, child's gender, birth weight, and infant admission to the intensive care unit), care of the mother during pregnancy, and delivery (first trimester visit, antenatal classes, and health care provider; Table 2).

Discussion

Despite 5 decades of recognizing and researching, most aspects of GDM screening, diagnosis, management, and follow-up remain controversial.[51-53] This lack of consensus causes challenges in addressing the prevalence, complications, prenatal treatment efficacy, and postpartum GDM monitoring. Moreover, although global criteria have been applied in some countries, it remains barriers from health care providers, health system, and client-related determinants to implement guidelines.[54,55] Especially, in low-resource setting such as Asian developing countries, the

feasibility, accessibility, and acceptability of GDM screening and management becomes more challenging. Therefore, it was suggested that local modifications should been implemented.[52] As a result, it becomes difficult to compare results between studies.

This review of epidemiological evidence indicates that mothers with GDM had lower rates of "exclusive/predominant breastfeeding" at discharge, and duration of "exclusive/predominant/full breastfeeding" was shorter, compared with mothers without this condition. There was no difference in the rates of "any breastfeeding" at discharge, or "any breastfeeding" duration between mothers with and without GDM (Table 3). While relative risks indicated some negatively and positively significant differences for breastfeeding initiation in mothers with GDM, the association was not strong.[11,15,41,43,45,49]

While most studies had large sample sizes, the study quality was of concern related to the assessment of exposures (Table 1). For example, GDM proportion was highest in Finland (11.9%) but lowest in Sweden (2.8%), although these countries are in the same geographical location.[11] Similarly, studies conducted in the United States within the same period of time showed that GDM proportion varied from 5.3% to 11.9%.[11,13,15,39,41,42,44,47,48,56] More than half of studies relied on self-reported GDM status or included no information on diagnostic criteria.[11,15,39,42,44,45,47,48,56] Differences in diagnostic criteria including timing of test, 1-/2-step testing, glucose load, threshold glucose values were mentioned in previous reviews where at least 6 criteria of GDM were reported.[22,52,57] In addition, a recent study in Spain showed the association between maternal glucose tolerance and exclusive breastfeeding cessation, but mildly impaired glucose tolerance was used for exposure definition instead of GDM definition.[14]

As with GDM, breastfeeding outcomes were assessed differently, which could lead to discrepant results (Table 2). For instance, exclusive breastfeeding refers that infants receive solely breast milk, whereas some studies in our review accounted also for small amounts of nonnutritious drinks (eg, tea, water and water-based drinks, and nutritional supplements).[11,45] Other studies applied the WHO definition, although some data may have been collected using the past 24 hours as a measure of since birth.[40,46,58] The variation of follow-up period also makes it difficult to compare data among studies. It is conceivable that the accuracy of recalled data on breastfeeding is questionable after 1 to 2 years.[15,39,42,43,45] Additionally, breast milk intake was also defined in different ways, such as direct and expressed, own breast milk, or stored/banked breast milk.[11,15,40,49] However, the effect of GDM on breastfeeding abilities could not be correctly evaluated because banked breast milk may come from other mothers.

A wide range of factors that commonly occur in women with GDM may independently contribute to poor lactating outcomes. Prepregnancy obesity has been suggested to preclude breast development during pregnancy, delay the onset of lactogenesis, and cause improper positioning and latching as well as early breastfeeding cessation.[9,18,21,23,59] Delivery services may affect the association between GDM and breastfeeding outcomes. Indeed, the use of formula has been associated with cesarean, obstetric and neonatal complications, lengthy separation between infants and mothers, and management of neonatal hypoglycemia.[9,22,25,60,61] In Sweden, for instance, infants of mothers with GDM tend to be provided with formula to avoid hypoglycemia, while banked breast milk was commonly given to mothers without breastfeeding abilities in Finland.[11]

The assessed studies have limitations and should be interpreted with caution. First, included studies are restricted to English language only. Therefore, relevant articles in other languages (if any) could not be analyzed. Second, the majority of the studies relied on self-reported data on GDM and/or recalled information on lactation. Third, the findings may be subject to bias due to lack or inadequacy of adjustment for confounding in the included studies. Fourth, variation in the definition of breastfeeding outcome and follow-up periods in the reviewed studies may have led to disparate results. A formal meta-analysis was not possible due to lack of homogeneity regarding the methodology, definitions, and measurement criteria used to ascertain the association

between GDM and breastfeeding outcomes. Finally, the relevant, reviewed studies predominantly involved Western nations as data from developing countries are limited, inaccessible, or nonexistent.

Given the insufficiency of the evidence on the association between GDM and breastfeeding outcomes in this review, it is important to conduct further prospective studies using rigorous design methodologies. These should include the use of standard definitions conducted in a number of different cultures, including in lower income countries.

Implications of This Review

Exclusive breastfeeding is less common in mothers with GDM compared with other mothers. This may be due to insulin resistance of mothers with GDM, inadequate β-cell function, hormonal changes, and genetic predisposition[21,23,62,63] together with the need for postpartum special care of the infants, which may lead to lower rates of exclusive breastfeeding.[46] Breastfeeding support and promotion remains a priority for the midwifery management of GDM.[64,65] International guidelines for neonatal hypoglycemia management give special emphasis on protecting and promoting exclusive breastfeeding[66] in order to minimize the rates of infection and hospitalization, to increase breast milk production, and to protect the microbiome.[67] In fact, midwifery interventions have been shown to improve breastfeeding outcomes, including exclusive breastfeeding duration for women with GDM.[60,68,69] Accumulating studies in the United States between 2006 and 2011, and Australia during 2007 to 2010, demonstrated that breastfeeding support over time effectively increased breastfeeding rates among mothers with GDM.[13,46] Given the well-recognized benefits of breastfeeding, midwifery nurses and medical staff should be aware of the link between GDM and reduced exclusive breastfeeding outcomes. It is also important to encourage early skin to skin contact, reduce the separation between mothers and newborns, and give extra support for women who are experiencing breastfeeding difficulties.

Conclusion

The studies in this review show that mothers with GDM are less likely to exclusively breastfeed their infants and will have a shorter breastfeeding duration than other mothers. The evidence is not strong, and further well-designed studies are needed in a variety of cultures and in countries with different income levels. Mothers with GDM require continuing support from professionals to preserve and improve breastfeeding initiation and duration. Breastfeeding for mothers with GDM should be more emphasized in care standard.

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2.4. Breastfeeding and physical activity

2.4.1. Physical activity: Definition

Physical activity is defined by the WHO as any bodily movement produced by skeletal muscles that requires energy expenditure, including activities undertaken while working, playing, carrying, travelling, and participating in recreational pursuits (World Health Organization 2018c). Conversely, exercise is a subcategory of physical activity, which is planned, structured and conducted during the leisure time, to improve and maintain the physical fitness (World Health Organization 2018c). Regular physical activity with moderate or vigorous intensity is believed to be beneficial to people at any stage of life, such as improving muscular and cardiorespiratory systems, bone and functional health, reducing the chance of having heart disease, hypertension, stroke, overweight, cancer and depression (World Health Organization 2018c).

Together with the evidence-based health benefits of physical activity for all ages, the benefits of physical activity for pregnant women have been examined over the past 50 years (Von Rutte 1951; Wasserbauer and Kratochvila 1953). Previously, there was concern about the impact of physical activity on pregnant women, particularly the potential negative impact of vigorously-intense exercise on mothers and foetal development (Snyder and Carruth 1984; Takito, Benicio, and Neri Lde 2009). A large sample size study of 2232 patients undergoing in vitro fertilization in Boston, the United States, concluded that regular exercise might have more adverse effects on the outcomes, including chance of having a live birth, experience cycle cancellation, and implantation failure or pregnancy loss compared to no exercise (Morris et al. 2006). This effect was more prominent in those who had more than four hours per week of exercise, for one to nine years, before the treatment. A safe level of physical activity

and exercise, including recommended duration, intensity, frequency, and type of sport/exercise for pregnant women was suggested with caution (Snyder and Carruth 1984; Lokey et al. 1991; Takito, Benicio, and Neri Lde 2009). Appropriate types of exercise and their effects on different stages of pregnancy (i.e. early pregnancy, second trimester, last trimester) together with the effects on the delivery outcomes were also highlighted in the research (Clapp et al. 2000; da Silva et al. 2019; Berntsen et al. 2014; Bao et al. 2018; Krzepota, Sadowska, and Biernat 2018; Sönmezer 2018).

2.4.2. Physical activity: Benefits for mothers

The benefits of physical activity for pregnancy and childbirth outweigh concerns about the side effects mentioned above. Reviews have emphasized the important role of physical activity to the health of mothers from preconception phase (infertility, assisted reproductive therapy, polycystic ovary syndrome, weight gain prevention and psychological well-being) through pregnancy and childbirth (prevention of excess gestational weight gain, GDM, preeclampsia, labour shortening, improving pregnancy and neonatal outcomes) and for postpartum health (lactation and breastfeeding, postpartum weight retention and depression) (Harrison et al. 2016; Ezmerli 2000; Aune 2003; Davies et al. 2003; Snyder and Carruth 1984; Lokey et al. 1991; Downs et al. 2012; Clapp 2000, 2008; Davies et al. 2018; Olson et al. 2009; Davies and Artal 2019; Di Biase et al. 2019; Piercy et al. 2018; American College of Obstetricians and Gynecologists 2015; Ferraro, Gaudet, and Adamo 2012).

2.4.3. Physical activity in pregnancy: Recommendations and guidelines

In 2002, the American College of Obstetricians and Gynaecologists published an updated set of guidelines about physical activity and exercise for women in pregnancy and postpartum stage, which was adapted from the recommendation released in 1995 (Committee on Obstetric 2002; Practice 2002; Pate et al. 1995). Warning signs for termination of exercising and contraindications to aerobic exercise during pregnancy were given in the guidelines, including the recommendation of 30 minutes or more of moderate exercise per day on most days of week for a healthy pregnancy (Committee on Obstetric 2002). A later version of the recommendations updated in 2008, also confirmed the safe levels of physical activity for pregnant women, with the first time mentioning about the safety of vigorous-intensity activity for pregnancy (US Department of Health and Human Services 2008). Since then, pregnant women without obstetric/medical complications have been recommended to undertake at least 150 minutes of moderate-intensity physical activity per week (American College of Obstetricians and Gynecologists 2015; Woodman, Reina-Fernandez, and Goldberg 2014; Piercy et al. 2018; US Department of Health and Human Services 2008). This suggested threshold had also been adopted internationally by other countries including Canada, England, Netherlands, and Australia (Wolfe et al. 2003; Royal College of Obstetricians and Gynaecologists 2017; Oostdam et al. 2009).

2.4.4. Measurement of physical activity during pregnancy

Physical activity measurement for pregnant women typically consists of two methods including self-report using a questionnaire or diary (Chasan-Taber et al. 2004; Ota et al. 2008; Evenson and Wen 2010). Other studies have tried to gather data more objectively by using activity tracking devices (heart rate monitor, pedometer, or

accelerometer) (Anjana et al. 2016; Smith, Foster, and Campbell 2011; Lemmens et al. 2018). There are advantages and disadvantages related to each method of measurement. Objective activity measures are considered as the gold standard approach for their precise estimations of physical activity volume, without bias in recalling, literacy or social-cultural differences (Downs et al. 2012). However, the participants must adhere to the instructions in order to provide accurate data, for example, time of wearing, position of wearing (e.g. waist-worn devices) (Connolly et al. 2011). Some monitors are not waterproof to be able to measure the aquatic and nautical activities. Most monitors can store a limited amount of data and do not have the ability to assess the long-term pattern. Monitors cannot point out the dimensions of activities involved (Downs et al. 2012). Importantly, monitors (accelerometers) require calibration data to interpret the physical activity intensity, but these types of studies for pregnant women during different trimesters have not been widely conducted (Downs et al. 2012). Lastly, the cost of devices may limit their use in epidemiology studies with large sample sizes (Chasan-Taber and Evenson 2019).

The second approach which is self-reporting using questionnaires was developed for use by pregnant women in 1988 (Eskenazi and Pearson 1988). Since then, several questionnaires have been developed and evaluated in terms of validity and reliability of results about pregnant women (Chasan-Taber et al. 2002; Chasan-Taber et al. 2004; Schmidt, Freedson, et al. 2006; Ota et al. 2008; Evenson and Wen 2010; Ainsworth, Sternfeld, et al. 2000). Both the Pregnancy Physical Activity Questionnaire (PPAQ) and the Kaiser Physical Activity Survey are self-administered questionnaires that include activities to assess the total physical activity during a trimester divided into four dimensions (Chasan-Taber et al. 2002; Chasan-Taber et al. 2004; Ota et al. 2008;

Schmidt, Freedson, et al. 2006; Ainsworth, Sternfeld, et al. 2000). Recently, to assess the moderate-to-vigorous intensity level and perceived intensity of each type of physical activity, a one-week-recall questionnaire the 'Pregnancy, Infection, and Nutrition 3 Physical Activity Questionnaire' (PIN-3) was developed (Evenson and Wen 2010). For all three questionnaires mentioned, the Metabolic Equivalent of Task (MET) was calculated based on modes of activities, duration of time and intensity using the instructions of scoring (Ainsworth et al. 2011).

2.4.5. The Pregnancy Physical Activity Questionnaire

Among the well-developed questionnaires, the PPAQ has been widely used to assess physical activity during pregnancy (Ota et al. 2008). The PPAQ has been translated, modified and validated to suit the social-cultural differences between countries (Ota et al. 2008; Matsuzaki et al. 2010; Cirak et al. 2015; Tosun et al. 2015; Xiang et al. 2016; Krzepota et al. 2017). It is a semi-quantitative questionnaire that assesses the total time spent in 32 different activities across four domains including housework/caregiving, occupational, sports/exercise, and transportation. Each activity is calculated into the Metabolic Equivalent of Task (MET-hours per week) based on the instructions of PPAQ scoring (duration of time, intensity) (Chasan-Taber et al. 2004) and the Compendium of Physical Activities (Ainsworth, Haskell, et al. 2000; Ainsworth et al. 2011). Overall total and sub-total energy expenditure is calculated by all activities and by sub-domain in the PPAQ. The intensity of activity is categorised as sedentary, light (1.5-<3.0 METs), moderate (3-6 METs), and vigorous (>6 METs) (Berntsen et al. 2014).

2.4.6. Physical activity levels in pregnant women

A review of pregnancy exercise patterns and determinants with data from 25 English studies published between 1986 and 2009 indicated that exercise decreased in both frequency and intensity, from pre-pregnancy to pregnancy (Gaston and Cramp 2011). Despite all benefits and published guidelines on physical activity in pregnancy, this review also found that only a small number of women met the exercise recommendation (Gaston and Cramp 2011). Housework/caregiving and occupational activities contributed a substantial proportion to total physical activity (Schmidt, Pekow, et al. 2006; Chasan-Taber et al. 2007). In Spain, a study of 1175 pregnant women found that nearly 70% did not meet the guideline for physical activity during pregnancy (>/=150 min moderate intensity exercise per week) (Amezcua-Prieto et al. 2013). Even among the pregnant adolescents in the United States, physical activity is also low, with only 45% meeting this guideline, while others spent more than half of the monitored time on sedentary activities (Steinl et al. 2019). It was reported that only 11% of the Chinese women achieved the exercise recommendation in pregnancy (Zhang et al. 2014). A recent study in China showed that the major contributors of physical activity during pregnancy were household and occupational activities (Xiang et al. 2019). Similarly, in Vietnam, a prospective cohort study of 2030 pregnant women showed that about 3% of pregnant women engaged in vigorous-intensity activity, and only 20% of them met the exercise recommendation (Nguyen, Pham, Lee, et al. 2018). This cohort also found that pregnant women were more active in doing household and occupational activities (Nguyen, Binns, et al. 2019).

2.4.7. The association of physical activity and lactation

While evidence of the benefits of physical activity on pregnancy outcomes is extensive, the effect of physical activity during pregnancy on breastfeeding outcomes has rarely been examined and is insufficient (Daley et al. 2012; Tucker and Fouts 2017). A study of 16 lactating women published in 1990 from California, US, by Lovelady et al was conducted to examine the effects of vigorous exercise on maternal metabolic indicators, lactation performance and body composition. It was found that no adverse effect of vigorous exercise on milk volume and breastmilk composition between well exercising and sedentary groups (Lovelady, Lonnerdal, and Dewey 1990). Later, in 1994, this group of researchers conducted a randomized control study of 33 mothers recruited at six to eight weeks postpartum to re-examine the effects of regular aerobic exercise during lactating period on breast-milk volume and composition, plasma lipids, metabolic responses and maternal body composition among exclusively breastfed mothers (Dewey et al. 1994; Lovelady et al. 1995). The study also reported no significant difference in the volume or composition of the breast milk, or maternal prolactin levels were found (Dewey et al. 1994). Similarly, the authors found that postpartum aerobic exercise improved the cardiovascular indicators, but did not affect the lactation (Lovelady et al. 1995). Another randomized control trial of 67 women was also conducted in the United States to compare the effects of weight loss, by dieting, and by dieting plus aerobic exercise, on lactation. There was no change in milk volume and composition between groups which also suggested that postnatal aerobic exercise was safe for breastfeeding (McCrory et al. 1999). Likewise, a birth cohort study of 587 mothers to twelve months postpartum in Western Australia indicated that postnatal exercise, regardless of levels of energy expenditure (MET-hours), had no association with the duration of 'full' breastfeeding to six months and the duration of

‘any’ breastfeeding to twelve months postpartum (Su et al. 2007). Also, the interactions between postpartum physical activity, diet and breastfeeding on maternal weight or infant growth had been examined (Garmendia et al. 2015; Lopez-Olmedo et al. 2016; Lovelady et al. 2000; Su et al. 2007). In 2011, one meta-analysis synthesised evidence of 160 infants from the four randomised controlled trials in the United States concluded that there was no adverse effect of maternal exercise on breastfeeding via the indirect measure of their infants’ growth (Daley et al. 2012; Lovelady et al. 2000; Dewey et al. 1994; McCrory et al. 1999; Lovelady et al. 2009).

A further study was conducted in the United States to understand how elite female distance runners managed their breastfeeding. Although the findings claimed that the runner breastfed at higher rates and for longer duration than the general public, it was a qualitative study of only 14 participants (Giles et al. 2016). Another qualitative study conducted in Tennessee, the United States, in 2014 consisting of 19 women to recall the factors influencing women's decisions to engage in prenatal physical activity and breastfeeding. There was an indirect association between prenatal physical activity and breastfeeding decisions as both factors were believed part of a healthy lifestyle (Tucker and Fouts 2017).

Recently, a pseudorandomized controlled trial of 47 participants was conducted in Spain to investigate the influence of an exercise intervention during pregnancy on colostrum and mature milk inflammatory. The results showed that mothers who followed the exercise program had lower the anti-inflammatory in colostrum and also in mature milk than those in the control group, and this could induce a greater

neurodevelopment and neuroprotection for their babies (Aparicio et al. 2018). The common features of many of these trials have been the small sample sizes, differing methodologies and problems with study designs. The present study will seek to overcome many of these problems.

Several professional committees such as the American College of Obstetricians and Gynaecologists and the Physical Activity Guidelines Advisory Committee have used available information, despite its shortcomings to state that maternal physical activity (postpartum and occasionally prenatal) is compatible with satisfactory lactation (Physical Activity Guidelines Advisory Committee 2018; American College of Obstetricians and Gynecologists 2015; Evenson et al. 2014). Published quantitative research of the association between pregnancy physical activity and breastfeeding could not be found. It is essential to conduct a study about the relationship between different domains and intensity of physical activity and breastfeeding outcomes.

2.5. Breastfeeding and caesarean section

2.5.1. Caesarean delivery: Definition and indications

Caesarean delivery is an operating procedure through an incision in the mother's abdomen and uterus in order to deliver the baby (American College of Obstetricians and Gynecologists 2018). Although named after the historical Roman Emperor, Julius Caesar, it seems unlikely that he was actually born by caesarean section and the true origin of the naming myth is lost in time (U.S. National Library of Medicine 2019). Circumstances when caesarean sections are performed include the failure of labour progression, concerns for the baby such as abnormal heart rate, multiple pregnancy,

problems with the placenta, very large baby, breech presentation, maternal infections such as *Human Immunodeficiency Virus* or *Herpes Virus*, and maternal medical complications such as diabetes or high blood pressure (American College of Obstetricians and Gynecologists 2018).

2.5.2. Caesarean section rates around the world and in Vietnam

The WHO has suggested as guidance that a caesarean section rate between 10% and 15% would be appropriate (World Health Organization 2015, 1985). However analyses from 194 countries suggest that 20% may be a more optimal global rate (Robson and de Costa 2017). Caesarean section rates have increased globally in the past few decades (Betran et al. 2016; Boatin et al. 2018). Data from 169 countries, equal to 98.4% of the world's births, concluded that the year 2015 had twice the amount of caesarean births (29.7 million; 21.1%) compared to the year 2000 (16.0 million; 12.1%) (Boerma et al. 2018). Asia was reported to be the region with the highest average annual rate of increase (Betran et al. 2016). As an example, caesarean section rates increased fourfold from 2000 to 2014 in Bangladesh (Haider et al. 2018). The rate of caesarean section among nine Asian nations was 27.3% between 2007 and 2008, with Vietnam ranked the second highest at 35.6% (Lumbiganon et al. 2010). This rate was reported to have doubled between 2009 and 2015, from 14% to 30%, according to the national statistics on Vietnamese women (United Nations Population Fund 2017). A study to examine factors related to 'exclusive' breastfeeding, a prospective cohort following 6,706 Vietnamese infants of Ho Chi Minh City and Dong Thap Province, Southern Vietnam was conducted between 2009 and 2013 (Le et al. 2018). The caesarean section rate was 28% in this study, and caesarean sections were more common in the urban (40%) than the semi-rural areas (7%) (Le et al. 2018).

Another study in Da Nang, the middle part of Vietnam, found that the caesarean delivery rate was as high as 57.9% for public, and 70.6% for private sectors (Giang et al. 2018).

2.5.3. The impact of non-essential caesarean sections

Caesarean sections are crucial in saving the lives of mothers and their baby only when it is required due to medical or obstetrical indications (World Health Organization 2015). Previous caesarean sections are the main reason for subsequent caesarean section (Boerma et al. 2018; Ming et al. 2019). Beside the medical reasons, non-medical factors leading to the overuse of caesarean sections were various including the fear of pain, the misconception about the baby's safety, concerns about genital modifications after vaginal delivery, fear of medical litigation, choosing the lucky date of delivery, or the convenience for health professionals, and health insurance coverage (Mi and Liu 2014; Long et al. 2012; Karlstrom et al. 2011; Tollanes 2009; Fenwick et al. 2010; Aref-Adib et al. 2018; Sharpe et al. 2015).

The immediate effects of caesarean section on maternal and paediatric outcomes include the risks of any surgery (blood loss, blood clots in organs, organs damage, reaction to medications) and the usage of antibiotics for prophylaxis against the high chance of wound infection, as well as the economic costs of healthcare due to the resources required have been broadly reported (Hyde et al. 2012; Ellwood and Oats 2016; American College of Obstetricians Gynecologists et al. 2014; United Nations Population Fund 2017; Sandall et al. 2018; World Health Organization 2015; American College of Obstetricians and Gynecologists 2018). Furthermore, caesarean

sections are believed to be associated with medium- and long-term physical and emotional health of the mothers, the infants' microbiome and immune system, as well as increased risks in subsequent pregnancies (Ellwood and Oats 2016; World Health Organization 2015). For women living in poor-resource settings or having limited access to health care, these risks to mothers and the newborns following caesarean births are greater than for those living in better social circumstances (World Health Organization 2015).

2.5.4. Impact of caesarean sections on breastfeeding

Besides the negative effects for mothers and babies mentioned above, caesarean sections may have an impact on breastfeeding outcomes. Although a caesarean section is major abdominal surgery, the best practice for both a vaginal birth and caesarean section is still early skin-to-skin contact following the initiation of breastfeeding within minutes after delivery. The infant can stay on the mother's chest when the caesarean section is being sutured though she may still under the effects of epidural/spinal anaesthesia (World Health Organization 2009). However, after a caesarean section, mothers may be confined to bed and restricted in movement in some cultures, be worried and stressed, be deprived of energy, and be separated from the baby, while the newborns might have breathing difficulties, suffer from maternal pain medications or have pain and discomfort at mouth and throat due to the suction of mucus (World Health Organization 2009). As a result, post-caesarean breastfeeding has become a challenge particularly in the early recovery period (Rowe-Murray and Fisher 2002; Spear 2006). In addition, anaesthesia and other pain relief prescriptions may affect breastfeeding adversely (Lim et al. 2018; Hestenes et al. 2008; Jones et al. 2012). Infants are sometimes separated from mothers after the procedure so that the mothers

can have postnatal “rest”, and this is common in Asia (Cohen et al. 2018; United Nations Population Fund 2017).

Caesarean birth has been reported as a persistent barrier to early initiation of breastfeeding, even in baby friendly hospitals (Rowe-Murray and Fisher 2002). Maternal body mass index, gestational weight gain, maternal complications such as diabetes in pregnancy are also important confounders which enhance the negative association between caesarean section and breastfeeding outcomes (Cohen et al. 2018; De Bortoli and Amir 2016; Haku 2007; Huang, Ouyang, and Redding 2019; Nguyen, Pham, et al. 2019). In 2012, a meta-analysis of 48 studies from 31 countries around the world found a significant negative association between caesarean section and early initiation of breastfeeding (pooled OR 0.57; 95% CI 0.50-0.64) (Prior et al. 2012). A cohort study in Hunan, China (n=954) found that mothers who had a caesarean section were more likely to delay breastfeeding initiation compare to vaginal delivery (OR 6.78; 95% CI 5.07-9.08) and breastfeeding duration was shorter (HR 1.40; 95% CI 1.06-1.84) (Chen et al. 2018). Low rates of early breastfeeding after caesarean section have also been reported for both rural and urban areas of Vietnam (Duong, Binns, and Lee 2004; Bui et al. 2016; Nguyen, Tran, et al. 2018; Thu et al. 2012). The difficulties in establishing breastfeeding experienced by Vietnamese mothers who had a caesarean section were documented in a small cross-sectional survey (n=286) while mothers were still in hospital in Da Nang, Vietnam (Nguyen, Tran, et al. 2018). In this survey, most of the mothers (90%) still managed to breastfeed within one hour of birth, and the majority indicated that they would try and fully breastfeed for six months (Nguyen, Tran, et al. 2018). Another small survey (n=223) from Ho Chi Minh City found a very high rate (79%) of formula use in infants born by caesarean section,

although in almost all cases the infants also received some breastmilk (Ramoo et al. 2014). This study also found factors that influenced the decision not to initiate breastfeeding included pain and fever after caesarean section (Ramoo et al. 2014). A cohort study (n=463) in a rural area of Vietnam found mothers might defer breastfeeding initiation to avoid the transmission of antibiotics from breastmilk to their newborns (Duong, Binns, and Lee 2004).

As mentioned above, caesarean section is often followed by a period of postnatal 'rest' together with the baby-mother separation during which newborns may receive replacement feeds (prelacteal feeds) such as water, infant formula, honey, traditional feeds or herbal drink (World Health Organization 2009; Chen et al. 2018; Cohen et al. 2018). A significant decrease in breastmilk transfer from mothers to babies for the first five days after caesarean section is barrier to 'exclusive' breastfeeding (Evans et al. 2003; Cohen et al. 2018). Consequently, the rate of 'exclusive' breastfeeding in hospital was lower for mothers who underwent a caesarean procedure. Planned caesarean sections have been reported to have even lower breastfeeding initiation rates and shorter durations compared to emergency caesarean sections (Cohen et al. 2018). Results from a meta-analysis of 27 studies in China, published between 1995 and 2015, indicated that, 'exclusive' breastfeeding during the early postpartum was lower in mothers who had a caesarean section compared to those having a vaginal delivery (pooled OR 0.53; 95% CI 0.41-0.68) (Zhao et al. 2017). In a birth cohort of 6,709 infants in Vietnam, there was a lower rate of 'exclusive' breastfeeding during hospital stay in caesarean births compared to vaginal births in both urban and semi-rural settings (OR 0.07; 95% CI 0.04-0.11 and OR 0.05; 95% CI 0.03-0.08, respectively) (Le et al. 2018). Similarly, a national cross-sectional study of 6,068 Vietnamese

mother-child dyads in 2011 showed that caesarean section increased almost three folds the chance of giving prelacteal feeds to newborns compared to vaginal delivery (OR 2.94; 95% CI 2.39-3.61) (Nguyen et al. 2013).

Since infants who are given of infant formula or other drinks, common after caesarean section, cannot be classified as 'exclusively' breastfed, the rates of 'exclusive' and 'full' breastfeeding subsequently reduce during postpartum period, according to the definitions of WHO (World Health Organization 2008a). However, it is believed that 'any' breastfeeding rates postpartum are also lower in mothers having an operative delivery. Results from a meta-analysis of Chinese studies showed that the 'any breastfeeding' rate at four months postpartum was lower in mothers having a caesarean section when compared to vaginal deliveries (pooled OR 0.61; 95% CI 0.53-0.71) (Zhao et al. 2017). In this study, data available on breastfeeding at six months was insufficient to conduct a pooled analysis (Zhao et al. 2017). However, an earlier meta-analysis of nine studies found a lower 'any' breastfeeding rate at six months in mothers having a caesarean section (pooled OR 0.91; 95% CI 0.86-0.97) (Prior et al. 2012). It was noteworthy that once the mothers initiated breastfeeding, the rate of 'any' breastfeeding at six months was not significantly different between caesarean and vaginal deliveries (pooled OR 0.95; 95% CI 0.89-1.01) (Prior et al. 2012). A recent six-month-cohort of 954 mothers in China also found that 'any' and 'exclusive' breastfeeding rates at one and three months were significantly lower for mothers having a caesarean section compared to a vaginal delivery, but not for 'any' and 'exclusive' breastfeeding rates at six months (Chen et al. 2018). The latest meta-analysis including 16 studies aimed to quantify factors related to breastfeeding initiation and continuation concluded that breastfeeding continuation was shorter for

caesarean deliveries (Risk ratio (RR) 1.23; 95% CI 1.15-1.32) (Cohen et al. 2018). However, most studies included in the analysis had a time limit of six months postpartum, except for a study in Hong Kong with one year follow up which found no association between breastfeeding continuation and mode of delivery (Cohen et al. 2018). Our literature search found only one Chinese prospective study (n=602 mother-infant dyads) which were followed for one year after birth. This Chinese study documented a shorter duration of breastfeeding for caesarean births compared to vaginal births (RR 1.21; 95% CI 1.10-1.33) (Wang et al. 2006). Overall the literature on the impact of caesarean section on breastfeeding beyond six months is deficient (Prior et al. 2012; Zhao et al. 2017; Cohen et al. 2018).

Interventions to promote breastfeeding after caesarean sections have rarely been conducted (Zhao et al. 2017; Prior et al. 2012). Recently, a systematic review found seven controlled trials focusing on caesarean section interventions including early skin-to-skin contact, breastfeeding education and support, sidecar bassinets and breast pump provision (Beake et al. 2017). The Baby Friendly Hospital Initiative and individual country policies promote early skin-to-skin contact, including in the post-caesarean section environment (Singh et al. 2017; World Health Organization 2018a). With the present high rate of caesarean sections, the low rate of 'exclusive' breastfeeding in Vietnam and the deficiency in long-term breastfeeding data, the need to conduct a prospective cohort study in Vietnam is evident. The purpose of this study is to determine the association between caesarean section and breastfeeding outcomes from discharge to twelve months postpartum.

Chapter 3: Methods

This chapter provides details on the methods for the present study including the location, design, sample size calculation and sampling method, data collection phases and instruments, together with data management, statistical analysis and ethical considerations.

3.1. Study location

Vietnam has 58 provinces and 5 municipalities, two of which are Ha Noi, the capital located in Northern region, and Ho Chi Minh City, the largest economic centre situated in Southern region. The country also has a long coastline of 3260 kilometres with multiple coastal cities, including Hai Phong. Located in Northern Vietnam, Hai Phong has an economy based on industry and agriculture. Ha Noi, Hai Phong and Ho Chi Minh City were chosen as the recruitment areas for the study. With a population of over 8,000,000 residents each, Ha Noi and Ho Chi Minh City are the two largest metropolitan areas, while the port city Hai Phong has about 3,000,000 people (General Statistics Office 2015). Although the three cities are major industrial cites of Vietnam, the Northern region retains most Asian traditional culture, while the Southern part typically follows modern and open lifestyles resulting from Western influences. As the capital, Ha Noi is the home of many government bodies. On the other hand, international and national enterprises prefer to open their main offices in Ho Chi Minh City. Both cities have a large number of immigrants from other provinces as well as foreigners coming to work and travel. In Hai Phong, although food processing and heavy industries dominate its economy, the city still reserves one-third of its land use for agriculture. Fishery is another major sector due to its coastal location. Together,

agriculture and fishery account for about one-third of the total employment in Hai Phong (General Statistics Office 2009).

One suburban district from Ha Noi and another from Hai Phong were selected, these were Dong Anh and Vinh Bao, respectively. Dong Anh has 23 communes and one town with a population of over 300,000 people living in an area of over 180 km^2. This district has developed a combination of industrial and agriculture zones as well as traditional handicraft trade villages (People's committee of Dong Anh District 2013). Vinh Bao, a coastal district with a similar total area of 180 km^2, comprises of 29 communes and one town with about 180,000 people. The economy of Vinh Bao is mainly based on agriculture, forestry and fishery sectors (People's committee of Vinh Bao District 2008).

In Ho Chi Minh City, immigrants from other provinces tend to live in close proximity to their relatives, which has created small communities within different districts. While the city contributes about 10% of the nation's population, it injects more than 20% of the gross domestic products, making business and finance the strength of the city (Ho Chi Minh City Statistical Office 2016). Among the five suburban districts whose total area (1600 km^2) accounts for more than 3/4 of the city (2100 km^2), Hoc Mon District was selected. Hoc Mon comprises of one town and eleven communes with a total population of approximately 422,000 people and an area of about 110 km^2 (Ho Chi Minh City Statistical Office 2016). The other two chosen from nineteen urban districts were Tan Phu District and District 2. Located on the west side of the city, Tan Phu has eleven wards with a total population of over 460,000 people. On the east side of the

city, District 2 which borders the Sai Gon River has about 150,000 people living in eleven wards. The area of District 2 (50 km^2) is three times larger than Tan Phu District (16 km^2) (Ho Chi Minh City Statistical Office 2016). By choosing different districts situated in various regions of Ho Chi Minh City, the diversity in socio-economic characteristics was accounted for in the present study.

Within every district of Vietnam, there is a public district-level hospital as the largest government healthcare provider offering multiple specialties for most of its citizens. Each hospital has a department of obstetrics and gynaecology, which provides adequate and affordable care, including caesarean section, for pregnant women. However, if any complication arises, the patients are then transferred to regional obstetric hospitals. For example, high-risk pregnancies from Tan Phu and Hoc Mon could be transferred to Hung Vuong Hospital, a leading provincial-level obstetric hospital situated in District 5 of Ho Chi Minh City. Consequently, Hung Vuong Hospital was also selected to fully capture all the cases with high risk and to avoid selection bias. If the recruitment took place only in district-level hospitals, it would be unable to include high-risk cases and the outcomes may have been severely affected.

It is noteworthy that Hung Vuong Hospital has some distinctive features compared to the other five hospitals selected for this study. First, it is accredited as a Baby Friendly Hospital. It has provincial status, so no transfers are required. Women feel much safer having both antenatal care and delivery services at the same hospital. In addition, mothers can choose between public or private services offered at the hospital depending on their financial capability. Any pregnant woman, including those from

Tan Phu, Hoc Mon and District 2, may directly book for appointments at Hung Vuong Hospital, regardless of health conditions or problems so low risk cases are captured as well.

In summary, the six hospitals chosen represented different areas and levels in order to minimise potential selection bias in the recruitment process. They were: Dong Anh District Hospital in Ha Noi; Vinh Bao District Hospital in Hai Phong; Tan Phu District Hospital, Hoc Mon District Hospital, District 2 Hospital, and Hung Vuong Hospital in Ho Chi Minh City.

3.2. Study design

A prospective cohort study of 2030 pregnant women was undertaken at the six hospitals in three cities of Vietnam from August 2015 to December 2017. Six surveys were conducted at baseline, hospital discharge and one, three, six and twelve months postpartum, in order to follow up the cohort and collect information on maternal variables and outcomes of interest including breastfeeding practices, infant health and hospitalisation. Details of this cohort profile was published and are attached in Appendix J.

3.3. Sample size calculation

The sample size calculation was based on the hypothesis testing that pregnant women with mild gestational hyperglycemia (primary exposure) had a lower rate of 'exclusive' breastfeeding before day 100 postpartum (primary outcome) (Verd et al. 2016). We assumed that 20% of participants would have gestational hyperglycemia diagnosed at

24 to 28 weeks of gestation(Hirst et al. 2012), and the rates of 'exclusive' breastfeeding before day 100 postpartum among mothers with mild gestational hyperglycemia and others without are 48% and 58%, respectively (Verd et al. 2016). At 5% level of significance, a minimum sample size of 1669 participants was required to attain 90% power to detect an expected odds ratio of 0.7 between the two groups. The estimated sample size was derived using the Kelsey formula (Kelsey JL et al. 1996).

A final sample size of 2020 pregnant women were adopted at baseline, after accounting for a 10% non-response rate and a further 10% attrition during the follow up period. Based on the population of the three recruitment cities (General Statistics Office 2015), the sub-sample sizes assigned to Ha Noi (total population over 8 million), Hai Phong and (about 3 millions) Ho Chi Minh City (more than 8 millions) were 900, 300, and 820, respectively. Participants were consecutively recruited from the three regions, which include the five district hospitals and one obstetric hospital, until the desired sampling quota was reached.

3.4. Data collection procedures

Recruitment of participants

During the antenatal care attendance in the second trimester (about 20 weeks), pregnant women were approached by trained research assistants to check for their eligibility before inviting them to participate in the cohort study.

The inclusion criteria were:

- permanent residents in one of the recruitment areas; have attended antenatal care and plan to deliver at one of the recruitment hospital;

- ≥ 18 years of age;
- at 24 to 28 weeks of gestation;
- with a singleton pregnancy;
- be able to read the information sheet and sign the consent form.

All eligible pregnant women who met the above inclusion criteria were invited to participate, given the information letter (Appendix H) and asked to sign the informed consent form (Appendix I). Women who had met the following exclusion criteria were excluded from the study:

- became pregnant after infertility treatment including in-vitro fertilization or intrauterine insemination;
- deemed ineligible due to illness or other health conditions following advice from their medical doctors;
- were advised not to breastfeed their infants for medical reasons of mother or infant;
- terminated her pregnancy; experienced a stillbirth or infant death during the following up period;

In total, 2248 pregnant women who met the inclusion criteria were invited, 218 (9.7%) refused participation, and 2030 consented to take part in the study. The response rate was 90.3%, and no significant difference in mean age was found between participants and non-participants (p-value 0.991).

Baseline interview

At the six hospitals, the participants who were at 24 to 28 weeks of gestation were face-to-face interviewed by research assistants via a structured questionnaire. Socio-demographic and personal characteristics, such as maternal age, education, occupation, parity, maternal smoking and physical activity during pregnancy, were solicited from the participants using validated instruments. Maternal anthropometric and GDM status were also assessed following appropriate guidelines. The recruitment process took about seven months to complete. The structured questionnaire at baseline took approximately 30 minutes to complete. A copy of this questionnaire is given in Appendix C.

Hospital discharge assessment

Mothers and their newborns were assessed before hospital discharge. Information on infant's and mother's health, including complications during pregnancy, preterm birth, mode of delivery, birthweight, infant gender and admission to neonatal intensive care, was extracted from medical records. Mothers were asked about timing of first feed, prelacteal feeds (if any), early formula feeding during hospital stay (if any) and breastfeeding practices at this time. The discharge questionnaire required about 30 minutes to complete; a copy of which is given in Appendix D. An appointment was then made for a subsequent home visit one month after hospital discharge.

Four follow up surveys

The mothers and their infants were visited at their residence at one, three, six and twelve months postpartum to assess the feeding practices, infant health and hospitalisation. After completing each survey, data enumerators set up for the next appointment time and sent an invitation letter to remind the participants. Another

reminder via telephone close to the interview date was made by the data enumerators. It took 25 to 30 minutes to complete each follow up survey. The follow up survey questionnaire is given in Appendix E.

Figure 3.1 summarizes the recruitment and follow up flowchart of participants, recording the number of women in each survey, as well as the reason for exclusion or loss of follow up. Nineteen mother-child dyads including 7 from Ha Noi, 5 from Hai Phong, and 7 from Ho Chi Minh City, were excluded due to serious maternal health problems such as having HIV, pregnancy termination, or stillbirth and infant deaths during the data collection phase. The drop-out rates of Ha Noi and Hai Phong were low at 7.2% and 9.9% respectively, but the rate was high at 24.8% in Ho Chi Minh City due to a variety of reasons such as delivery at another hospital in the city or in their hometown, return to work, change in contact details during the following-up period. Finally, the number of participants remained at the three sites was 1715, leading to a retention rate of 84.9% for the whole sample. There were six women with diabetes before pregnancy (1 mother from Ha Noi, and 5 mothers from Ho Chi Minh city) were further excluded, leaving n=1709 as the final sample size for data analysis.

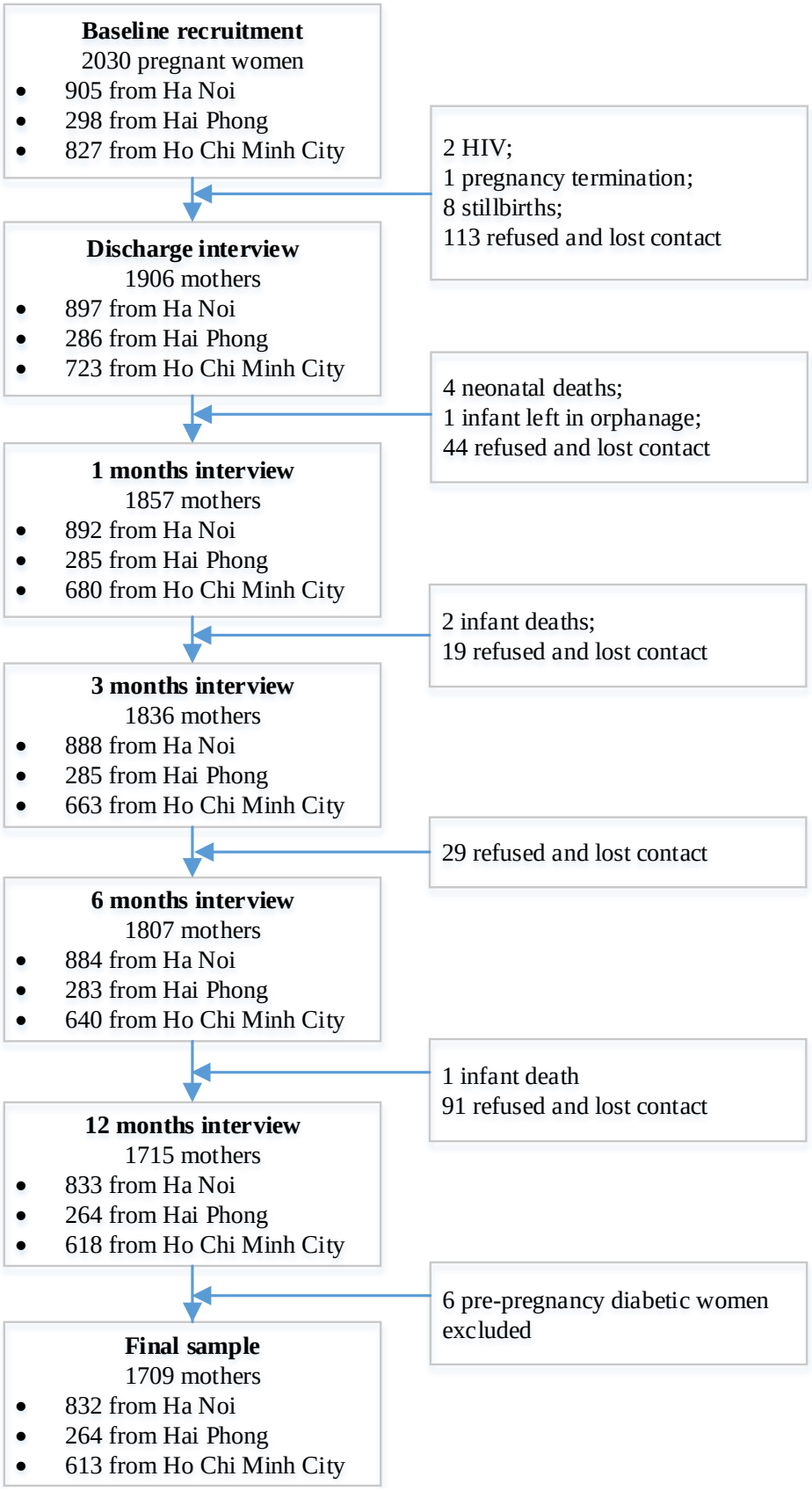

Figure 3.1: Recruitment and follow-up flow-chart of the participants

3.5. Data collection instruments

Participants were assessed using the instruments described in Table 3.1.

Table 3.1: Data collection instruments

Measures	**Instrument**	**Assessment**
Demographic and personal characteristics such as age, education level, occupation, and parity	Structured questionnaire	Baseline
Gestational diabetes mellitus	Clinical assessment	Baseline
Physical activity during pregnancy	Pregnancy Physical Activity Questionnaire	Baseline
Maternal anthropometric assessment: pre pregnancy body mass index (maternal height, pre-pregnancy weight); and gestational weight gain (pre-pregnancy weight, pre-delivery weight)	Anthropometric Assessment Medical records	Baseline Discharge
Maternal passive smoking status	Structured questionnaire	Baseline
Obstetric and birth outcomes: complications during pregnancy, preterm birth, still birth, mode of delivery, gestational weight gain, infant gender, birthweight, and admission to neonatal intensive care	Medical records	Discharge
Breastfeeding and prelacteal feeds: early initiation, prelacteal feeds, 'any/predominant/exclusive' breastfeeding at different time points and breastfeeding cessation	Breastfeeding questionnaire	Discharge, 1, 3, 6 and 12 months
Infant hospitalisation, diarrhoea and lower respiratory tract infection	Structured questionnaire	1, 3, 6 and 12 months

	Medical records	
Other infant's and mother's implications	Medical records	Discharge, 1, 3, 6 and 12 months

Demographic and personal characteristics: Information on age, education level, occupation, marital status, as well as contact details (address, phone numbers) were collected using a structured questionnaire.

Gestational diabetes mellitus: All pregnant women were invited to check their glucose-metabolic status using the 75-gram oral glucose tolerance test during the baseline interview, which was between 24 and 28 weeks of gestation. By collecting three blood samples at fasting, 60 and 120 minutes, GDM status was then confirmed positive, if at least one glucose value meets the thresholds: fasting plasma glucose ≥5.1 mmol/L, 1-hour plasma glucose ≥10.0 mmol/L, 2-hour plasma glucose ≥8.5 mmol/L, according to the 2013 diagnostic criteria of the WHO and the 2010 diagnostic criteria of the International Association of Diabetes and Pregnancy Study Groups (World Health Organization 2013a; International Association of Diabetes Pregnancy Study Groups Consensus Panel et al. 2010).

Pregnancy physical activity assessment: The validated Vietnamese version of the Pregnancy Physical Activity Questionnaire was used to assess the habitual physical activity and sedentary behaviour (Ota et al. 2008). The PPAQ measures the duration, frequency, and intensity of different domains and levels of physical activity during

pregnancy. It is a semi-quantitative questionnaire that solicited the time spent participating in 32 activities, including household/caregiving (13 activities), occupational (5 activities), sports/exercise (8 activities), transportation (3 activities) and inactivity (3 sedentary activities). For each activity/inactivity, respondents were asked to select a category with the nearest amount of time spent per day or per week. The possible duration ranged from 0 to 6 or more hours per day. An open-ended section was appended to allow listing of additional activities not covered by the PPAQ. Please refer to Appendix C for the questions and response categories.

Maternal anthropometric assessment: Height was measured at the baseline interview using a stadiometer to the nearest 1mm. Pre-pregnancy weight was retrieved from the first antenatal examination using medical records. Pre-pregnancy body mass index (kg/m^2) then was calculated using pre-pregnancy weight and height recorded. Total gestational weight gain (kg) was assessed by subtracting the pre-pregnancy weight (first examination) from the pre-delivery weight (last examination) taken from medical records at discharge interview.

Passive smoking assessment: At baseline assessment, information on cigarette passive smoking during pregnancy was acquired using the WHO-STEPS questions (World Health Organization 2008b).

Breastfeeding information: Definitions of the WHO were adopted for this study: see Table 3.2 (World Health Organization 2008a). The validated questionnaire was taken from those used in previous studies in Vietnam and China (Duong, Binns, and Lee 2004; Duong, Lee, and Binns 2005; Duong, Binns, and Lee 2005; Tang, Lee, and

Binns 2015b, 2015a). At discharge, one, three, six and twelve months postpartum, information on breastfeeding practices was collected (Tang et al. 2014).

Table 3.2: Definitions of breastfeeding

Category	**Requires that the child received**	**Permits the child to receive**	**Does not allow the child to receive**
Exclusive breastfeeding	Breastmilk (including direct or expressed mother milk, from wet nurse or banked breastmilk)	Prescribed drops or syrups (vitamins, mineral supplements or medicines)	Anything else
Predominant (Full) breastfeeding	Breastmilk (including direct or expressed mother milk, from wet nurse or banked breastmilk) as the predominant source of nourishment	Liquids (water and water-based drinks, fruit juice, oral rehydration solutions), ritual fluids (in limited quantities) and drops or syrups (vitamins, minerals, medicines)	Anything else (in particular non-human milk, solid foods, food-based fluids)
Any breastfeeding	Some breastmilk	Any food or liquid including non-human milk or other infant food	

Ever breastfeeding	Breastmilk or colostrum received on at least one occasion		

Source: Indicators for assessing infant and young child feeding practices: Part 1-Definition: Conclusions of a consensus meeting held 6–8 November 2007 in Washington D.C. (World Health Organization 2008a)

Infant hospitalisation, diarrhoea and lower respiratory tract infection: Information on hospital admission was collected at the one, three, six, and twelve-month follow-up interviews using the question "Has your baby had any inpatient admission since the last interview?" Details on length of hospital stay and health problems including diarrhoea and lower respiratory tract infection were also solicited from the mothers. Medical records were used to validate such illness outcomes and hospital admission whenever feasible. A diarrhoea episode was defined as "the passage of three or more loose or liquid stools per day, or more frequently than is normal for the individual'' (World Heatlh Organization 2017). Symptoms for a lower respiratory tract infection were "at least one specific lower respiratory tract sign (fast or difficulty breathing, chest wall indrawing) and/or abnormal auscultatory findings (crackles/crepitations or bronchial breath sounds)" (Roth et al. 2008).

Other infant's and mother's implications: Problems that happened with the foetus, infants and mothers during the following-up period, such as stillbirth, miscarriage, pregnancy termination, infant death were collected at discharge, one, three, six and twelve months. The structured questionnaire together with medical records were used to validate such information.

3.6. Data management and statistical analysis

Data was manually coded then entered to Epidata version 3.1 by research assistants who were also responsible for checking the missing information. The candidate was responsible for verification of data accuracy and data management, as well as data checking and correct transcription of information from paper records to an electronic database. Hard copies of all questionnaires were kept in a locked filing cabinet in an office accessible to the investigators only. Information was combined across the six hospital sites. The electronic data was stored in the candidate's laptop and backed up at the network R drive provided by Curtin University, both with password protection, and only accessible by the chief investigators. Data was de-identified prior to statistical analysis. Only aggregated data were reported.

After data cleaning, comparisons were undertaken between subgroups of interest via descriptive statistics, univariate parametric and non-parametric statistical methods, by using chi-square test (or Fisher's exact test) for categorical variables, and either independent t-test/ANOVA (or Mann-Whitney U-test and Kruskal–Wallis test) for continuous variables.

Logistic regression analyses were performed to determine maternal and other factors associated with binary outcomes such as early breastfeeding initiation, prelacteal feeds, early formula feeds, and types of breastfeeding at different time points, as well as infant hospitalisation and infant illness outcomes. The Kaplan-Meier method was used to estimate the distribution of breastfeeding duration, and log-rank test was used to compare the difference in breastfeeding cessation between groups. Bivariate Cox and

logistic models were used initially and followed by multivariable models. Variables for the multivariable regression models included maternal age, maternal education, employment status, parity, mother's passive smoking, pre pregnancy body mass index, GDM, gestational weight gain, delivery method, gestational age, infant gender, birthweight, physical activity levels, and admission to neonatal intensive care. Crude and adjusted estimates (odds ratios for logistic models; hazard ratios for Cox models) and associated 95% confidence intervals were reported. Different sets of confounding factors corresponding to each outcome variable of interest in the multivariable analyses were described and discussed in each publication. All statistical analyses were conducted using the SPSS package version 22 (IBM Corp 2013)

3.7. Ethics

This study was part of the large project "Maternal lifestyle and nutritional status in relation to pregnancy and child health outcomes: A multi-centre prospective cohort study in Vietnam", approved by the Curtin Human Research Ethics Committee (approval number HR32/2015) (Appendix F) and Hai Phong University of Medicine and Pharmacy Human Research Ethics Committee (No. 05/PHUMPRB) (Appendix G).

An information sheet, written in plain language, was distributed and verbally explained to potential participants (Appendix H). It provided information about the purposes and nature of the larger project, assessment procedure, and contact details of the chief investigators to seek further information and clarification if required. Participation was entirely voluntary and consented participants were free to withdraw at any time or

decline to answer any question without prejudice. The completed consent form was signed and witnessed before enrolment (Appendix I). Information provided by participants was treated as completely confidential and not released to the hospitals. Each participant was allocated a unique identity number before being de-identified. Their contact details such as name, address, and mobile phone numbers of themselves and one family members were kept in a separate electronic file. All identifiable information of participants was coded and securely stored, as addressed previously in the data management section. Data were summarized and reported in aggregated format only without releasing the identity of individual participants. Those participants who reported breastfeeding problems or difficulties were advised to consult their medical doctor. Study findings were disseminated to the public through publications in academic journals. See Appendix K for other details on poster and oral presentations on part of the study findings.

Chapter 4: Results and Discussion

This chapter presents results of the thesis, addressing the four objectives [2-5] which were stated in Chapter 1. Findings and the discussions had been published in four papers as listed below. The statement of primary contribution of the first author and the permissions to include the four publications in this thesis can be found in the Appendix A. The permissions to reproduce the material from the publishers can be found in the Appendix B.

4.1. Association between gestational diabetes and breastfeeding

Previous studies have reported that mothers with gestational diabetes mellitus have lower rates of 'exclusive breastfeeding', and had shorter 'exclusive breastfeeding' duration compared to those without gestational diabetes. However, the effects of gestational diabetes on 'any breastfeeding' rates and duration have been studied less often, especially in developing countries. This is the first study to examine the association of gestational diabetes mellitus and breastfeeding duration in Vietnam, using a prospective cohort. Our study found that the rate of 'any breastfeeding' at twelve months was lower, and the breastfeeding duration was also shorter in the gestational diabetes women compared to the other mothers. Rates of 'exclusive/predominant breastfeeding' were lower, but not significantly different due to the small numbers of 'exclusive/predominant breastfeeding' in Vietnamese women. We have suggested that mothers with gestational diabetes need extra support to maintain breastfeeding duration.

The content of this section is covered by the following published paper, which addresses the **Objective 2**, to assess the association between gestational diabetes and breastfeeding outcomes including early breastfeeding initiation, prelacteal feeding, 'any' breastfeeding at specific time points and breastfeeding cessation.

Citation:

Nguyen, P. T. H., C. W. Binns, C. L. Nguyen, A. V. V. Ha, T. K. Chu, D. V. Duong, D. V. Do, and A. H. Lee. "Gestational Diabetes Mellitus Reduces Breastfeeding Duration: A Prospective Cohort Study." *Breastfeed Med* 14, no. 1 (Jan/Feb 2019): 39-45. http://dx.doi.org/10.1089/bfm.2018.0112. [Impact factor: 1.521]

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Gestational Diabetes Mellitus Reduces Breastfeeding Duration: A Prospective Cohort Study

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Abstract

Background: Gestational diabetes mellitus (GDM) and its complications are major concerns because of the negative effects of GDM during antenatal period and on the future health of mothers and infants. Breastfeeding is beneficial for GDM mothers and their babies to reduce future health risks. Little is known about the link between GDM and the duration of ''any'' breastfeeding. Therefore, the aim of this study was to investigate the relationship between GDM and the duration for which Vietnamese women breastfeed their babies postpartum.
Materials and Methods: A prospective cohort of 2,030 pregnant women between 24 and 28 weeks of gestation was recruited. GDM status was determined using a 75 g oral glucose tolerance test. Included mothers were then followed up from discharge after childbirth until 12 months postpartum to determine their breastfeeding duration. Kaplan–Meier estimates, log-rank tests, logistic and Cox regression models were used to examine the association between GDM and breastfeeding outcomes.
Results: In our cohort, 94.4% of all women reported ''any'' breastfeeding at discharge and 72.9% of women were still breastfeeding at 12 months postpartum. The risk of early breastfeeding cessation was higher in GDM women than their non-GDM counterparts after adjustment for demographic factors (hazard ratios [HR] = 1.39, 95% confidence intervals [CI] = 1.13–1.71, $p = 0.002$), and all potential confounding factors (HR = 1.38, 95% CI = 1.12–1.70, $p = 0.002$). There were no significant differences in breastfeeding outcomes at discharge (early initiation, prelacteal feeding, and ''any'' breastfeeding rate) between GDM and non-GDM mothers.
Conclusions: GDM was associated with shorter breastfeeding duration. Women with GDM require ongoing support after hospital discharge to maintain long-term breastfeeding.

Keywords: breastfeeding, gestational diabetes mellitus, prospective cohort, Vietnam

Introduction

Gestational diabetes mellitus (GDM) is defined by the World Health Organization (WHO) as carbohydrate intolerance resulting in hyperglycemia with onset or first recognition during pregnancy.[1] The prevalence of GDM is increasing worldwide, which can have long-term effects on maternal health. In 2016, the reported prevalence of GDM was highest in the Middle East and North African region at 12.9% (8.3–24.5%), followed by Southeast Asia at 11.7% (8.1–18.3%).[2] However, a recent meta-analysis of the prevalence of GDM in Eastern and Southeastern Asia indicated that the pooled prevalence of GDM was 10%, and Vietnam had the highest prevalence at 20%.[3]

It is well documented that mothers with GDM have higher rates of gestational hypertension, preeclampsia, and later type 2 diabetes.[4,5] The health of infants may also be affected during the perinatal period with increased rates of macrosomia, neonatal hypoglycemia, as well as the future development of obesity and chronic diseases.[5,6] Previous studies have suggested that women with GDM who breastfeed their infants are associated with a lower risk of adverse health

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outcomes.[7–12] Similarly, results from a meta-analysis indicated that breastfed infants were less likely to develop type 2 diabetes later in life compared with their nonbreastfed counterparts.[13]

Infants born from GDM mothers are more likely to suffer from neonatal complications such as preterm birth, low birth weight, admission to intensive care unit, which result in delaying breastfeeding at discharge.[14] Besides, mothers with GDM are at higher risk of having lactation difficulties including pain after caesarean section, breast engorgement, obstetric complications, and delayed onset of lactogenesis II.[7,15–18] Therefore, rates of exclusive and predominant breastfeeding seemed to be lower for mothers with GDM at hospital discharge.[19–21] However, previous studies have shown inconsistent results concerning the impact of GDM on ''any'' breastfeeding duration.[22–26] There has also been a lack of studies in Asia, apart from two studies in Singapore and India, where the prevalence of GDM was rising.[25,27] The objective of this study was to investigate the association between GDM and ''any'' breastfeeding duration within 12 months postpartum in Vietnamese women.

Materials and Methods

Design

This study utilized data from a multicenter prospective cohort study on maternal lifestyle and diet in relation to pregnancy, postpartum, and infant health outcomes in Vietnam.[28] Data were collected from August 2015 to December 2017, at six hospitals across three cities of Vietnam. A total of 2,248 pregnant women were invited at their antenatal care visits between 24 and 28 gestational weeks; among them, 218 women refused (9.7%) and 2,030 (90.3%) agreed to participate in the study. No difference in mean age was found between participants and nonparticipants. Detailed information about the recruitment and the catchment area, including a flowchart of the cohort, was given elsewhere.[28] These women and their babies then were followed up at hospital discharge (after child birth), and at home at 1, 3, 6, and 12 months postpartum. The study protocol was approved by the Curtin University Human Research Ethics Committee (HR32/2015) and Hai Phong University of Medicine and Pharmacy Human Research Ethics Committee (No. 05/PHUMPRB).

Participants

Participants were pregnant women who (1) were permanent residents in the study locations, (2) ≥18 years of age, (3) at 24–28 weeks of gestation, (4) had a singleton pregnancy, (5) did not have any serious preexisting health conditions (as indicated in medical records), and (6) were able to read the information sheet and sign the consent form. However, during the course of the study, 25 women were removed from the analysis based on our exclusion criteria, as follows: (1) with serious maternal health problems or who did not otherwise allow their babies to be breastfeed ($n=2$ with human immunodeficiency virus, $n=1$ baby transferred to an orphanage); (2) who terminated their pregnancy because of intrauterine growth restriction ($n=1$), endured a still birth ($n=8$) or infant death within 12 months ($n=7$); and (3) mothers with prepregnancy type 1 or type 2 diabetes ($n=6$).

Main exposure

The 2-hour 75 gram oral glucose tolerance test (2 h 75 g OGTT) was used to determine the GDM status of participants. It is routine practice at the participating hospitals for all mothers to have the 2 h 75 g OGTT between 24 and 28 weeks of gestation. The test involves collecting three blood samples at fasting, at 60 and 120 minutes. As indicated by the criteria from the International Association of Diabetes and Pregnancy Study Groups for GDM, GDM is evident if at least one glucose value is above the thresholds. The thresholds are as follows: fasting plasma glucose ≥5.1 mmol/L, 1-hour plasma glucose ≥10.0 mmol/L, and 2-hour plasma glucose ≥8.5 mmol/L[29]

Outcome measures

In this study, breastfeeding practices were defined according to the WHO criteria. Reference to ''any'' breastfeeding meant ''when a child had received breastmilk (direct from the breast or expressed or stored breastmilk) with or without other drink, formula or other infant food.'' Early initiation of breastfeeding signified the situation where ''the mother puts her newborn to the breast within one hour of birth.'' Prelacteal feeds were categorized as any feeds given to the infants before the initiation of mother's breastfeeding.[30]

Infant feeding was assessed in five face-to-face interviews through the question *''How are you feeding your baby?''* at discharge, 1, 3, 6, and 12 months. Breastfeeding duration was recorded in weeks by asking *''How old was your baby when you stopped breastfeeding?''* Early initiation of breastfeeding and prelacteal feed were recorded at hospital discharge using the following questions *''What was your baby's first feed after he/she was born?''* and *''How long after delivery did you first breastfeed your baby?''*

Other variables

Factors to be considered as confounders were determined from the literature.[23,24,26,31] These included maternal demographic characteristics (age [years], occupation, education, and parity) collected at the baseline interview. Obstetric complications and birth outcomes were obtained from medical records at hospital discharge, including gestational age (weeks), birth weight (g), caesarean section (yes/no), and infant admission to neonatal intensive care unit (yes/no).

Statistical analysis

The main outcome measure was ''any'' breastfeeding duration and the primary exposure was GDM status. Data were analyzed using the IBM SPSS package version 22 (IBM, Armonk, NY). Group comparisons were made between women with and without GDM using the chi-square test for categorical variables and the *t* test for continuous variables. Kaplan–Meier curves were used to compare breastfeeding duration for subgroups of interest. Crude and adjusted hazard ratios (HR) and associated 95% confidence intervals (CI) were reported using Cox's regression model. Logistic regression with odds ratio was used for the multivariable analysis of breastfeeding rates. Covariates included in the regression models were maternal age, occupation, maternal education, parity, gestational age, birth weight, caesarean section, and infant admission to neonatal intensive care unit. The rationale

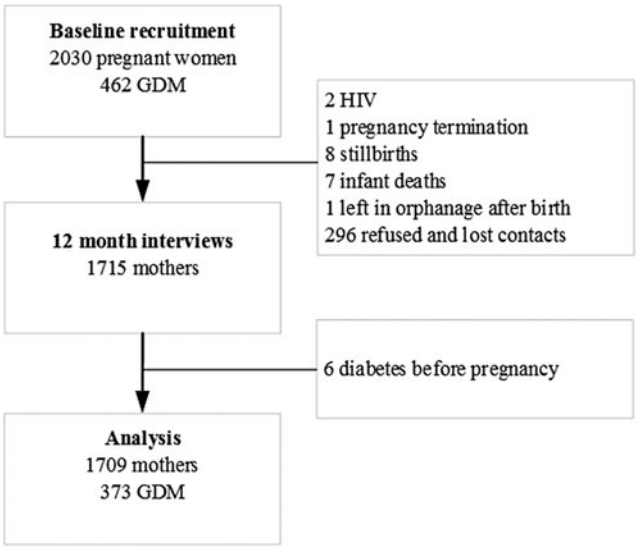

FIG. 1. Flowchart of included participants.

was to ascertain the association between GDM and breastfeeding outcomes accounting for the effects of such mediators and confounding factors.

Results

A total of 2,030 pregnant women (462 GDM, 1,561 non-GDM, and 7 prepregnancy diabetes) were recruited at baseline. In addition to the 25 women excluded based on the previously mentioned exclusion criteria, 296 women subsequently refused to participate or were unable to follow-up during the 12-month postnatal period. The final sample consisted of 1,709 women (Fig. 1). There were no differences in maternal age, parity, and other demographic characteristics between the loss to follow-up group and the completion group, except occupation and education level ($p < 0.05$).

Table 1 describes the demographic and perinatal characteristics of participants with GDM ($n = 373$) and without GDM ($n = 1{,}336$). In the GDM group (21.8% of the final sample), 17 women were diagnosed as having diabetes according to the diagnostic criteria of WHO 2013.[32] Women with GDM were significantly older, had shorter gestation, and were more likely to have caesarean section compared with those without GDM.

In Table 2, other breastfeeding outcomes namely rate of early breastfeeding (within 1 hour), rate of prelacteal feed, rates of ''any'' breastfeeding at discharge, at 1, 3, 6, and 12 months postpartum were compared between GDM and non-GDM women. About one in three women initiated breastfeeding within the first hour of delivery, and 56.6% of the infants received something other than breast milk within 24 hours of birth. The ''any'' breastfeeding rate at discharge was 91.4%, and nearly 73% of women still breastfed at 12 months. Breastfeeding rates at 1, 3, and 6 months were higher in the non-GDM group but no significant differences were found after adjustments for first demographic factors, and second for all confounders, with the exception at 12 months postpartum (Table 2).

Only 18.8% of women ''exclusively'' breastfed and 20.8% of women ''predominantly'' breastfed at discharge, and the rates of ''exclusive'' and ''predominant'' breastfeeding at 6 months were 2.0% and 2.5%, respectively. ''Exclusive'' and ''predominant'' breastfeeding rates at the various time points were lower among GDM women and for early initiation of breastfeeding, but not statistically different from those of the non-GDM group.

Assuming all women started breastfeeding at the same point after delivery (week 0), results from the rank-sum test showed a significant difference between the two groups of women ($p = 0.0008$). That is, women with GDM had shorter

Table 1. Characteristics of Participants With and Without Gestational Diabetes ($N = 1{,}709$)

Variables	*Total*	*GDM*[a]	*Non-GDM*	p
Total, *n* (%)	1,709 (100)	373 (21.8)	1,336 (78.2)	
Maternal age, mean ± SD	27.5 ± 5.3	29.2 ± 5.4	27.0 ± 5.1	<0.001
Occupation, *n* (%)				
Farmers	257 (15.0)	47 (12.6)	210 (15.7)	0.098
Workers	682 (39.9)	151 (40.5)	531 (39.8)	
Office and technical staff	401 (23.6)	103 (27.6)	298 (22.3)	
Sales worker	276 (16.1)	50 (13.4)	226 (16.9)	
Housewife/unemployed	93 (5.4)	22 (5.9)	71 (5.3)	
Maternal education, *n* (%)				
Secondary school or lower	574 (33.6)	133 (35.7)	441 (33.0)	0.627
High school	445 (26.0)	95 (25.5)	350 (26.2)	
College/university or above	690 (40.4)	145 (38.8)	545 (40.8)	
Parity, *n* (%)				
0	655 (38.3)	134 (35.9)	521 (39.0)	0.111
1	636 (37.2)	156 (41.8)	480 (35.9)	
≥2	418 (24.5)	83 (22.3)	335 (25.1)	
Gestational age, mean ± SD	38.9 ± 1.3	38.7 ± 1.3	38.9 ± 1.3	0.047
Birth weight, mean ± SD	3,146.2 ± 395.0	3,161.5 ± 416.4	3,141.9 ± 388.8	0.396
Caesarean section, *n* (%)	653 (38.2)	165 (44.2)	488 (36.5)	0.007
Infant admitted to NICU, *n* (%)	44 (2.6)	12 (3.2)	32 (2.4)	0.376

[a]GDM is confirmed based on criteria of the International Association of Diabetes and Pregnancy Study Groups criteria.[29]
GDM, gestational diabetes mellitus; SD, standard deviation; NICU, neonatal intensive care unit.

Table 2. Breastfeeding Outcomes for Mothers With and Without Gestational Diabetes (N = 1,709)

Variables	*Total,* n *(%)*	*GDM*[a]*,* n *(%)*	*Non-GDM,* n *(%)*	*OR (95% CI)*	*Adjusted*[b] *OR (95% CI)*	*Adjusted*[c] *OR (95% CI)*
Early breastfeeding[d]	603 (35.3)	122 (32.7)	481 (36.0)	0.86 (0.67–1.10)	0.88 (0.68–1.13)	0.97 (0.72–1.30)
Prelacteal feeding	966 (56.5)	223 (59.8)	743 (55.6)	1.19 (0.93–1.51)	1.18 (0.92–1.50)	1.09 (0.82–1.44)
Breastfeeding at discharge	1,562 (91.4)	344 (92.2)	1,218 (91.2)	1.15 (0.75–1.82)	1.07 (0.69–1.66)	1.18 (0.75–1.85)
Breastfeeding at 1 month	1,681 (98.4)	364 (97.6)	1,317 (98.6)	0.58 (0.25–1.48)	0.59 (0.26–1.34)	0.60 (0.25–1.43)
Breastfeeding at 3 months	1,596 (93.4)	340 (91.2)	1,256 (94.0)	0.66 (0.42–1.04)	0.68 (0.44–1.06)	0.68 (0.43–1.08)
Breastfeeding at 6 months	1,488 (87.1)	313 (83.9)	1,175 (88.0)	0.72 (0.51–1.00)	0.79 (0.56–1.11)	0.80 (0.57–1.13)
Breastfeeding at 12 months	1,228 (72.9)	243 (65.2)	985 (73.7)	0.67 (0.52–0.86)	0.65 (0.50–0.84)	0.66 (0.51–0.85)

[a]GDM is confirmed based on criteria of the International Association of the Diabetes and Pregnancy Study Groups criteria.[29]
[b]Adjusted for maternal age, occupation, maternal education, and parity.
[c]Adjusted for maternal age, occupation, maternal education, parity, gestational age, birth weight, caesarean section, and infant admission to Neonatal Intensive Care Unit.
[d]Breastfeeding within 1 hour after birth.
OR, odds ratio; CI, confident interval.

duration of breastfeeding than the non-GDM women. The Kaplan–Meier curves comparing the difference in any breastfeeding duration within 12 months between GDM and non-GDM women are given in Figure 2.

The crude model without covariates suggested that GDM was associated with early breastfeeding cessation (HR = 1.41, 95% CI = 1.15–1.73, $p = 0.001$). After adjusting for both demographic factors and all potential confounders, the inverse association between GDM and breastfeeding duration remained significant (Table 3). Moreover, maternal age, occupation (office staff and housewives), maternal education, and caesarean section were found to be influencing factors on the breastfeeding duration, as evident from their corresponding adjusted HR (95% CI) given in Table 3. We further investigated glucose intolerance using the blood glucose levels from the 2 h 75 g OGTT, which showed their significant association with the early cessation of any breastfeeding; details of the Cox regression results are not presented for brevity.

Discussion

This study indicates that mothers with GDM tend to have shorter breastfeeding duration. Our findings from Vietnam are consistent with the literature reports from western countries.[24,26,33] We also confirmed that glucose intolerance was significantly associated with early breastfeeding cessation.[34] However, the rate of ''any'' breastfeeding at discharge was the same for GDM and non-GDM mothers, similar to the results from the United States.[19,35,36] Other studies that examined ''any'' breastfeeding duration by predominantly dividing into categorical scales found no differences, including two Asian studies.[25,27,31,37,38]

Several studies have examined ''exclusive/predominant/full'' breastfeeding outcomes. In comparison, despite the finding of this study that ''exclusive'' and ''predominant'' rates were slightly lower among GDM women at different time points, no significant differences were evident because

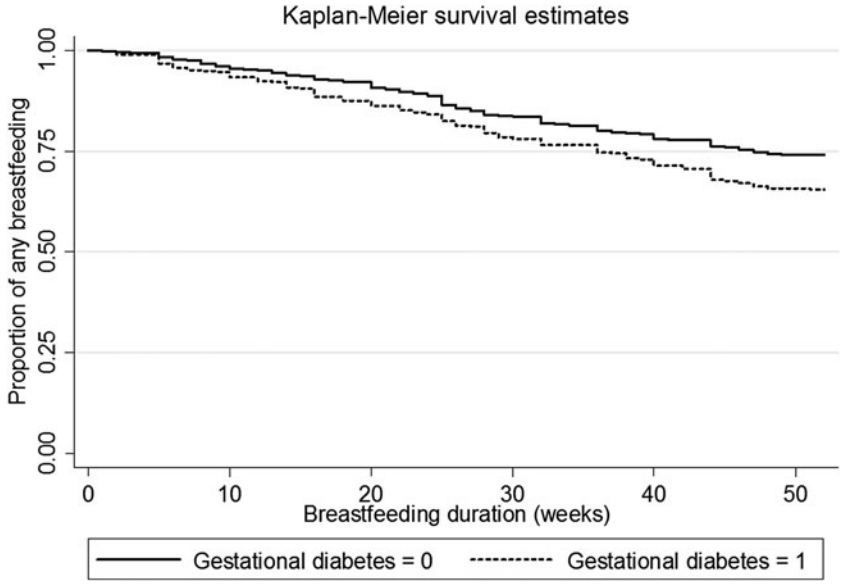

FIG. 2. Kaplan–Meier curves of any breastfeeding in the first 12 months postpartum for mothers with and without gestational diabetes.

Table 3. Adjusted Hazard Ratios of Gestational Diabetes Mellitus and Breastfeeding Duration Using Cox's Regression (N= 1,709)

Variables	*Adjusted*[a] *HR (95% CI)*	p	*Adjusted*[b] *HR (95% CI)*	p
Gestational diabetes mellitus	1.39 (1.13–1.71)	0.002	1.38 (1.12–1.70)	0.002
Maternal age (mean)	0.98 (0.96–1.00)	0.033	0.97 (0.95–0.99)	0.013
Occupation				
Farmers	1		1	
Workers	1.25 (0.93–1.67)	0.135	1.25 (0.93–1.67)	0.134
Office and technical staff	2.02 (1.38–2.95)	<0.001	2.00 (1.37–2.91)	<0.001
Sales worker	1.33 (0.95–1.87)	0.097	1.31 (0.93–1.84)	0.119
Housewife/unemployed	1.70 (1.10–2.63)	0.017	1.66 (1.07–2.56)	0.023
Maternal education				
Secondary school or lower	1		1	
High school	0.64 (0.51–0.81)	<0.001	0.65 (0.51–0.82)	<0.001
Post high school	0.40 (0.30–0.53)	<0.001	0.40 (0.30–0.53)	<0.001
Parity				
0	1		1	
1	0.98 (0.79–1.22)	0.840	0.98 (0.79–1.23)	0.888
≥2	0.78 (0.58–1.03)	0.079	0.79 (0.60–1.05)	0.110
Gestational age (mean)			0.93 (0.86–1.00)	0.050
Birth weight (mean)			1.00 (1.00–1.00)	0.470
Caesarean delivery			1.22 (1.01–1.47)	0.042
Infant admitted to NICU			0.93 (0.52–1.68)	0.815

[a]Adjusted for maternal age, occupation, maternal education, and parity.
[b]Adjusted for maternal age, occupation, education, parity, gestational age, birth weight, caesarean section, and infant admission to neonatal intensive care unit.
HR, hazard ratio.

of their very low rates in Vietnamese women.[18–21,35] Although two previous studies mentioned GDM and breastfeeding in Asia,[25,27] this is the first study in a developing country that examined the association between GDM and both short- and long-term breastfeeding outcomes. Strengths of this study are as follows: multicenter longitudinal study with a large sample size, involving prospective measurements of breastfeeding duration (weeks) with five times interviews from discharge to 12 months; standard definitions of WHO were applied for breastfeeding indicators; GDM status was assessed at baseline using the International Association of Diabetes and Pregnancy Study Groups criteria; and use of regression models adjusting for the effects of demographic and other plausible confounding factors.

The possible causes of adverse breastfeeding outcomes at discharge among GDM women in previous reviews include the following: the higher rates of obstetric and neonatal complications for both infants and GDM mothers, and delays in the onset of lactogenesis II.[7,15] Consequently, the suboptimal breastfeeding at hospital discharge lead to early breastfeeding cessation.[8] Women with insulin-treated GDM were less likely to breastfeed than other women.[21] Although the advantages of breastfeeding for GDM women had been documented, GDM status was not associated with the perceived benefits of breastfeeding and breastfeeding duration.[22] Recently, a study about breastfeeding knowledge, attitudes, and beliefs during pregnancy and hospital breastfeeding experiences found that women with GDM were less likely to say that ''breastfeeding is the best way to feed an infant,'' and more likely to say ''their physicians prefer formula.''[39] However, programs that aimed to educate and support them with breastfeeding showed effectiveness in terms of increasing breastfeeding duration.[40]

There are several limitations to be considered when interpreting the results of this study. Although participants were recruited from six hospitals of three cities, the sample might not necessarily be representative of the entire Vietnam. Moreover, the regression models focused on confounding factors related to maternal and birth outcomes, but not social, parental factors and professional supports. Information on any GDM treatment(s) was also not available that may affect a mother's decision to breastfeed.[21]

Conclusion

In this prospective cohort study of Vietnamese pregnant women, it was found that GDM was significantly associated with a shorter duration of any breastfeeding. Given the well-recognized benefits of breastfeeding for women and their infants, midwives and medical staff should be aware of the increased risk of early breastfeeding cessation among mothers with the condition. Extra support for these women to prolong and sustain their duration of breastfeeding after hospital discharge should be routinely provided.

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4.2. Association between physical activity during pregnancy and breastfeeding

Previous studies have reported that maternal exercise provides numerous benefits for both mothers and infants during the preconception phase, delivery and postnatal period. Some studies investigated the association between postnatal exercises and breastmilk composition and volume, as well as breastfeeding duration, but found no association with postnatal physical activity and lactation. However, the impact of prenatal physical activity on breastfeeding was rarely examined, except for one qualitative study about the link between physical activity and breastfeeding decision. This is the first study to examine the association of maternal physical activity during pregnancy and breastfeeding cessation together with breastfeeding rate at twelve months postpartum, using a prospective cohort in Vietnam. Our study found that the rate of breastfeeding at twelve months was lower, and the breastfeeding duration was also shorter in the inactive women compared to the other mothers. We have suggested that expecting mothers should be more active during pregnancy, to have better breastfeeding outcomes.

The content of this section is covered by the published paper below, which addresses the **Objective 3,** to determine the rate of 'any' breastfeeding at twelve months postpartum, breastfeeding cessation and the association with physical activity during pregnancy for Vietnamese women.

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Physical Activity During Pregnancy is Associated with Improved Breastfeeding Outcomes: A Prospective Cohort Study

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Abstract: Physical activity is important for health, but little is known about associations between physical activity during pregnancy and breastfeeding. The aim of this study was to investigate any association between antenatal physical activity and breastfeeding duration. A prospective cohort of 2030 Vietnamese women, recruited between 24 and 28 week-gestation was followed up to twelve months postpartum. Physical activity was determined using the pregnancy physical activity questionnaire at baseline interview. Data was available for 1715 participants at 12 months, a 15.5% attrition rate. At 12 months 71.8% of mothers were still breastfeeding. A total of 20.9% women met physical activity targets and those mothers undertaking higher levels of physical activity had a lower risk of breastfeeding cessation by twelve months [hazard ratios HR = 0.59 (95% CI 0.47–0.74), $p < 0.001$, and HR = 0.74 (0.60–0.92), $p = 0.006$; respectively] when compared to the lowest tertile. Similarly, women with increased levels of physical activity have higher rates of breastfeeding at twelve months, compared to the lowest level [odds ratio OR = 1.71 (95% CI 1.29–2.25) and 1.38 (1.06–1.79)]. Higher levels of physical activity by pregnant women are associated with improved breastfeeding outcomes.

Keywords: breastfeeding; breastfeeding duration; physical activity; pregnancy; prospective cohort; Vietnam

1. Introduction

Prenatal physical activity is associated with having a healthy pregnancy, and benefits obstetric and perinatal outcomes, including preventing excessive gestational weight gain, gestational diabetes, gestational hypertension, prenatal depression, and lower rates of instrument delivery [1–5]. The benefits of breastfeeding for both infant and maternal health have been well documented in numerous reviews [6–10].

The US Physical Activity Guidelines Advisory Committee has concluded that during pregnancy there is strong evidence that more physically active women are less likely to gain excessive weight during pregnancy, less likely to develop gestational diabetes or develop postpartum depression than

their less active peers [11]. This committee also stated that it was likely that physical activity had no effect on lactation.

As both breastfeeding and physical activity are beneficial it would be reasonable to expect that mothers might want to do both [12]. There is some evidence for associations between physical activity during pregnancy and longer-term postpartum weight loss, lower rates of depression, improved quality of life, and longer breastfeeding [13–15]. Although there has been extensive research on the independent benefits of physical activity and breastfeeding for both mothers and infants, the association between these important issues has only rarely been studied [12,15]. Studies have explored the impact of physical activity during lactation on breastfeeding performance or on infant health or growth, but as yet there are no published reports of the association between physical activity during pregnancy and breastfeeding outcomes, including breastfeeding duration [16–20]. During the postpartum period interactions between lactation and physical activity together with diet on maternal weight and/or infant growth have examined [21,22]. Exclusive breastfeeding to around six months results in greater weight reduction than mothers who stopped breastfeeding earlier [22]. There has been one qualitative report of an association between sports women and improved breastfeeding outcomes [23]. Several professional organisations have indicated that postpartum exercise, and occasionally antenatal exercise are compatible with satisfactory lactation, although these are based on expert consensus and not on additional studies [1,24–27]. We were unable to find published quantitative studies of an association between antenatal exercise and breastfeeding, which resulted in this study.

Vietnam has a population of 95 million and over the past three decades had made great progress in improving overall health, including in reducing infant and maternal mortality [28]. The health system is one of the most efficient in terms of value or the resources used. Almost all deliveries in Vietnam take place within the formal health care system at health centres or district hospitals with referral available to tertiary provincial hospitals [28]. Within the Vietnamese culture, during childbirth and the postpartum period, mothers usually have extensive peer support through her family and community [29]. Breastfeeding initiation is very high, with almost all mothers, (98%) leaving the health care facility breastfeeding their infant [29,30]. However high rates of prelacteal feeding, and the early introduction of complementary foods, results in low rates of exclusive breastfeeding [31,32]. Increasingly infant formula is advertised in Vietnam and its use is increasing, particularly in the cities [33,34]. Most Asian countries, including Vietnam, are experiencing a trend towards increased weight gain in pregnancy, which while still low by Western standards, is associated with increased rates of gestational diabetes [35–37]. The objective of this study was to examine associations between physical activity during pregnancy and breastfeeding prevalence at, and breastfeeding cessation before, twelve months postpartum in Vietnamese women.

2. Materials and Methods

2.1. Design

A multi-centre prospective cohort study was undertaken between August 2015 and December 2017 at six hospitals across three cities in Vietnam [38]. A total of 2030 pregnant women were recruited during their antenatal care visits between 24 and 28 weeks of gestation. The baseline questionnaire completed at recruitment included the Pregnancy Physical Activity Questionnaire. After delivery, participants were followed up at hospital discharge and then at 1, 3, 6 and 12 months postpartum. Detailed information about the recruitment and the catchment area has been presented elsewhere [38]. The study was approved by the Hai Phong University of Medicine and Pharmacy Human Research Ethics Committee (approval no. 05/PHUMPRB) and the Curtin University Human Research Ethics Committee (approval no. HR32/2015).

2.2. Participants

Participants were pregnant women who: (1) were permanent residents in the study locations; (2) ≥18 years of age; (3) at 24–28 weeks of gestation; (4) had a singleton pregnancy; (5) did not have

any serious pre-existing health conditions (as indicated in medical records); and (6) were able to read the information sheet and sign the consent form. During the course of the study, participants who had serious maternal health problems and, or who were advised not to breastfeed their infants for medical reasons, termination of pregnancy, a still birth, or infant death were excluded from the analysis.

2.3. Measurement

The Pregnancy Physical Activity Questionnaire (PPAQ) is a self-reported questionnaire to assess physical activity during pregnancy which has been widely used, including in the Vietnamese context [3,39]. It measures the physical activity of pregnant women during the past three months through 32 activities categorized in four domains including (1) housework/caregiving, (2) occupational, (3) sports/exercise, and (4) commuting. For each activity, duration, frequency and intensity were measured in Metabolic Equivalent Tasks; MET-hours per week [40]. Total physical activity was categorized into four intensity levels: (1) sedentary, (2) light (1.5–<3.0 METs), (3) moderate (3–6 METs), and (4) vigorous (>6 METs) [41]. Energy expenditure of the total physical activity and four domains and intensity levels were reported by tertiles. As few (n = 47) women participated in vigorous activity during pregnancy, this variable was categorized into two levels: 'yes' and 'no'.

During pregnancy, healthy women are encouraged to engage in moderate-intensity aerobic activity (at least 150 min per week) as advised by the Department of Health and Human Services (DHHS) and in other guidelines [2,4,11,42]. Physical activity was categorised as 'yes' (if they participated 7.5 MET-hours or more per week in sport/exercise activities of moderate-intensity), and 'no'. In this study the mothers completed the PPAQ at the baseline interview at 24–28 weeks of their pregnancy. After delivery the prevalence of 'any breastfeeding' at twelve months postpartum and breastfeeding cessation before twelve months were measured. 'Any breastfeeding' is defined as "when a child had received breastmilk (direct from the breast or expressed or stored breastmilk) with or without other drink, formula or other infant food" [43]. Infant feeding was assessed in face-to-face interviews through the question *"How are you feeding your baby?"* at hospital discharge and at 1, 3, 6 and 12 months. Breastfeeding duration was recorded in weeks by asking *"How old was your baby when you stopped breastfeeding?"*.

Factors to be considered as confounders were determined from the literature, predominantly from studies in Vietnam, Japan and in neighboring China [16,29,44–48]. These included maternal characteristics such as maternal age (years) (<25; 25–35; >35), occupation (currently working; currently not working), education level (secondary school or lower; high school; diploma/university or above), parity (0; 1; ≥2), pre-pregnancy body mass index (kg/m^2) (overweight ≥ 23; not overweight < 23), which were collected at the baseline interview. Gestational diabetes was diagnosed between 24 and 28 weeks of gestation following the criteria from the International Association of the Diabetes and Pregnancy Study Groups, with at least one glucose value equal or above the threshold: fasting plasma glucose ≥ 5.1 mmol/L, 1-h plasma glucose ≥ 10.0 mmol/L, 2-h plasma glucose ≥ 8.5 mmol/L [49]. Maternal and neonatal variables were obtained from medical records at hospital discharge including gestational age (preterm < 37 weeks; not preterm ≥ 37 weeks), caesarean section (yes; no), low birth weight (yes < 2500 g; no ≥ 2500 g), and admission to neonatal intensive care unit (yes; no).

2.4. Data Analysis

Descriptive statistics and group comparisons between participants' breastfeeding and not breastfeeding at twelve months were made, using chi-square test or Fisher exact test. Logistic regression analyses were then performed to determine the associations between physical activity and breastfeeding prevalence at twelve months, with adjusted odds ratio (OR) and associated 95% confidence intervals (CI) to account for the effects of plausible confounding factors. Cox's regression model with adjusted hazard ratios (HR) and associated 95% CIs were used to report the effect of physical activity on the risk of breastfeeding cessation. Covariates were maternal age, occupation, education level, parity, pre-pregnancy body mass index, gestational diabetes status, gestational age,

caesarean section, low birth weight, and admission to neonatal intensive care unit. All statistical analyses were undertaken using the SPSS package version 22 (IBM, Armonk, NY, USA).

3. Results

A total of 2030 pregnant women were recruited at baseline. Then 19 women were excluded; eight mothers endured a still birth, two had human immunodeficiency virus infection, one terminated her pregnancy due to intrauterine growth restriction, seven infants died within 12 months, and one infant was transferred to an orphanage. Another 296 women declined to participate or were lost to follow-up during the 12-month postnatal period. Therefore, 1715 participants remained at the 12-month survey, yielding a participation rate of 85%. There were no significant differences in age, parity and other demographic characteristics between the 'loss-to-follow-up' group and the completed group, except small differences in occupation and education level ($p < 0.05$).

Table 1 describes the demographic, maternal and neonatal characteristics of participants who were breastfeeding ($n = 1232$) and not breastfeeding at twelve months ($n = 483$), which makes a total of 1715 mother-infant dyads included in the analysis. Women who maintained breastfeeding to twelve months or more were likely to have a higher education level ($p < 0.001$), less overweight ($p < 0.001$), and less gestational diabetes ($p = 0.001$) compared to those who had already stopped breastfeeding.

Table 2 explores the association between the levels and types of physical activity intensity during pregnancy and breastfeeding status at twelve months. As can be seen from Table 2, those who had a higher level of physical activity were more likely to be breastfeeding at 12 months (p-value < 0.05). This finding was observed in all physical activity related variables including total physical activity, eight sub-groups of intensities and domains. However, after adjustments for all confounders, significant differences were not found for the 'vigorous' and 'occupational' activities. See detailed adjusted ORs in Table 2.

Table 1. Characteristics of participants by breastfeeding at 12 months ($N = 1715$).

Variables *N* (%)	Overall	Any Breastfeeding at 12 Months		p [a]
	N (%)	Yes	No	
Total	1715 (100)	1232 (71.8)	483 (28.2)	
Maternal age (years)				0.116
<25	548 (32.0)	380 (30.9)	168 (34.8)	
>35	1167 (68.0)	852 (69.1)	315 (65.2)	
Occupation				0.374
Currently not working	535 (31.2)	392 (31.8)	143 (29.6)	
Currently working	1180 (68.8)	840 (68.2)	340 (70.4)	
Education level				**<0.001**
Secondary school or lower	576 (33.6)	375 (30.4)	201 (41.6)	
High school	447 (26.1)	323 (26.2)	124 (25.7)	
Diploma/university or above	692 (40.3)	534 (43.4)	158 (32.7)	
Parity				0.059
0	658 (38.4)	464 (37.7)	194 (40.2)	
1	638 (37.2)	448 (36.3)	190 (39.3)	
≥2	419 (24.4)	320 (26.0)	99 (20.5)	
Pre-pregnancy body mass index [b]				**<0.001**
Overweight: ≥23	189 (11.0)	113 (9.2)	76 (15.7)	
Not overweight: <23	1526 (89.0)	1119 (90.8)	407 (84.3)	
Gestational diabetes [c]				**0.001**
Yes	373 (21.8)	243 (19.8)	130 (27.0)	
No	1336 (78.2)	985 (80.2)	651 (73.0)	
Gestational age (weeks)				0.281
Preterm: <37	71 (4.1)	47 (3.8)	24 (5.0)	
Not preterm: ≥37	1644 (95.9)	1185 (96.2)	459 (95.0)	
Caesarean section				0.232
Yes	654 (38.1)	459 (37.3)	195 (40.4)	
No	1061 (61.9)	773 (62.7)	288 (59.6)	

Table 1. *Cont.*

Variables N (%)	Overall	Any Breastfeeding at 12 Months		p [a]
	N (%)	Yes	No	
Low birth weight (g)				0.159
Yes: <2500	64 (3.7)	41 (3.3)	23 (4.8)	
No: ≥2500	1651 (96.3)	1191 (96.7)	460 (95.2)	
Admission to neonatal intensive care unit				0.376
Yes	44 (2.6)	29 (2.3)	15 (3.1)	
No	1671 (97.4)	1203 (97.7)	468 (96.9)	

[a] From Chi-square test or Fisher exact test; [b] Classified for Asian populations according to World Health Organization; [c] Based on International Association of the Diabetes and Pregnancy Study Groups criteria 2010 [49]. Bolded *p*-values are significant.

Table 2. Associations of levels of physical activity intensity and types during pregnancy with reported breastfeeding at 12 months among Vietnamese women (*N* = 1715).

Physical Activity Variables	Any Breastfeeding at 12 Months		Adjusted [a] OR 95% CI
	Yes	No	
Total PA (METs h/week)			
Mean, SD (125.0, 57.6)	129.7 (59.0)	112.9 (52.1)	
1st tertile (8.4–<94.3)	368 (64.3)	204 (35.7)	1.00
2nd tertile (94.3–<144.2)	419 (73.2)	153 (26.8)	**1.38 (1.06–1.79)**
3rd tertile (144.2–362.8)	445 (77.9)	126 (22.1)	**1.71 (1.29–2.25)**
Domain of activity			
Household/caregiving (METs h/week)			
Median, IQR (50.1, 52.0)	53.4 (55.3)	42.7 (42.7)	
1st tertile (0–<37.3)	369 (64.1)	207 (35.9)	1.00
2nd tertile (37.3–<68.4)	412 (72.5)	156 (27.5)	**1.42 (1.09–1.85)**
3rd tertile (68.4–231.0)	451 (79.0)	120 (21.0)	**1.85 (1.39–2.47)**
Occupational (METs h/week)			
Median, IQR (33.6, 45.1)	33.6 (46.2)	33.6 (45.1)	
1st tertile (0–<10.7)	409 (71.2)	165 (28.8)	1.00
2nd tertile (10.7–<41.2)	400 (70.0)	171 (30.0)	1.04 (0.78–1.39)
3rd tertile (41.2–176.2)	423 (74.2)	147 (25.8)	1.23 (0.91–1.66)
Sports/exercise (METs h/week)			
Median, IQR (5.6, 5.6)	5.6 (5.6)	0.0 (5.6)	
1st tertile (0–0)	524 (67.4)	253 (32.6)	1.00
2nd tertile (0–<5.6)	422 (73.1)	155 (26.9)	1.20 (0.94–1.54)
3rd tertile (5.6–81.4)	286 (79.2)	75 (20.8)	**1.76 (1.30–2.39)**
Commuting (METs h/week)			
Median, IQR (7.9, 13.1)	7.9 (13.1)	7.0 (11.4)	
1st tertile (0–<4.4)	377 (65.6)	198 (34.4)	1.00
2nd tertile (4.4–<12.3)	435 (73.6)	156 (26.4)	**1.35 (1.04–1.76)**
3rd tertile (12.3–170.6)	420 (76.5)	129 (23.5)	**1.59 (1.21–2.08)**
Sedentary (h/week)			
Median, IQR (38.0, 33.6)	38.0 (34.1)	39.4 (32.2)	
1st tertile (0–<23.1)	432 (75.4)	141 (24.6)	1.00
2nd tertile (23.1–<46.9)	395 (68.9)	178 (31.1)	**0.75 (0.58–0.99)**
3rd tertile (46.9–110.1)	405 (71.2)	164 (28.8)	**0.74 (0.55–0.99)**
Light (METs h/week)			
Median, IQR (52.0, 46.2)	53.9 (46.9)	47.3 (42.5)	
1st tertile (0–<38.9)	387 (67.5)	186 (32.5)	1.00
2nd tertile (38.9–<69.3)	403 (70.3)	170 (29.7)	1.03 (0.80–1.34)
3rd tertile (69.3–166.8)	442 (77.7)	127 (22.3)	**1.51 (1.14–2.00)**

Table 2. *Cont.*

Physical Activity Variables	Any Breastfeeding at 12 Months		Adjusted [a] OR 95% CI
	Yes	No	
Moderate (METs h/week)			
Median, IQR (18.2, 36.4)	23.1 (37.1)	12.3 (23.1)	
1st tertile (0–<10.9)	371 (61.4)	233 (38.6)	1.00
2nd tertile (10.9–<31.9)	405 (73.8)	144 (26.2)	**1.63 (1.25–2.11)**
3rd tertile (31.9–203.5)	456 (81.1)	106 (18.9)	**2.47 (1.86–3.27)**
Vigorous (METs h/week) (*n*; %)			
Yes (MET-h/week>0) (1668; 97.3)	34 (72.3)	13 (27.7)	1.16 (0.59–2.26)
No (47; 2.7)	1198 (71.8)	470 (28.2)	1.00
Met exercise guideline (*n*; %)			
Yes [b] (359; 20.9)	285 (79.4)	74 (20.6)	**1.65 (1.23–2.20)**
No (1356; 79.1)	947 (69.8)	409 (30.2)	1.00

[a] Adjusted for maternal age (<25; 25–35; >35), occupation (currently not working; currently working), education level (secondary school or lower; high school graduate; college/university or above), parity (0; 1; ≥2), pre-pregnancy body mass index (overweight; not overweight), gestational diabetes (yes; no), gestational age (preterm; not preterm), caesarean section (yes; no), low birth weight (yes; no), and admission to neonatal intensive care unit (yes; no); [b] Meeting Department of Health and Human Services guidelines of > 7.5 MET h/week in sports/exercise activities of moderate-intensity or greater [4]; Abbreviations: OR, Odds ratio; CI, Confident Interval; MET, Metabolic Equivalent of Task; SD, Standard Deviation; IQR, Interquartile Range. Bolded odds ratio values are significant.

An assumption of the models in Figures 1 and 2 and Table 3 is that all women starting breastfeeding at the same point after delivery (week zero) and the actual rate of breastfeeding within one week was very close to this at 98.4%. Results from the rank sum tests show significant differences in any breastfeeding duration between the two groups of women: those who had lower total physical activity during pregnancy, and who did not meet the physical activity guideline had a higher risk of stopping breastfeeding compared to active women ($p < 0.001$ and $p = 0.0005$ respectively). The Kaplan-Meier curves in Figures 1 and 2 represent the difference in breastfeeding duration between active and inactive women (by total physical activity, Figure 1, and by meeting the recommendations for physical activity Figure 2).

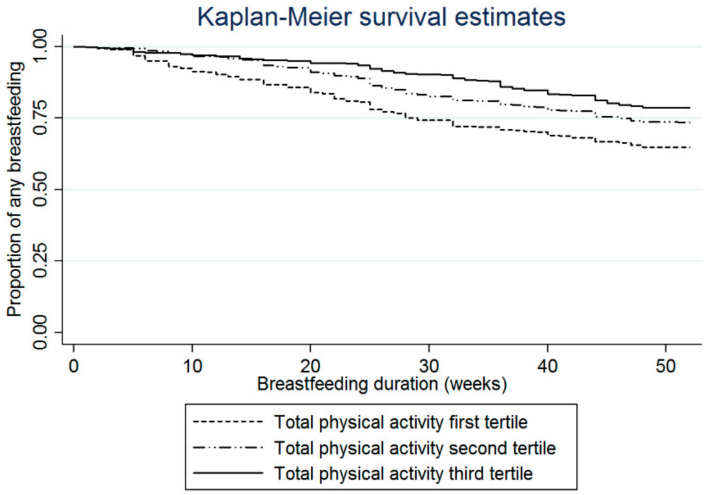

Figure 1. Kaplan-Meier curves of 'any breastfeeding' in the first twelve months postpartum for mothers with three different levels of physical activity (tertiles) during pregnancy (log-rank test $p < 0.001$).

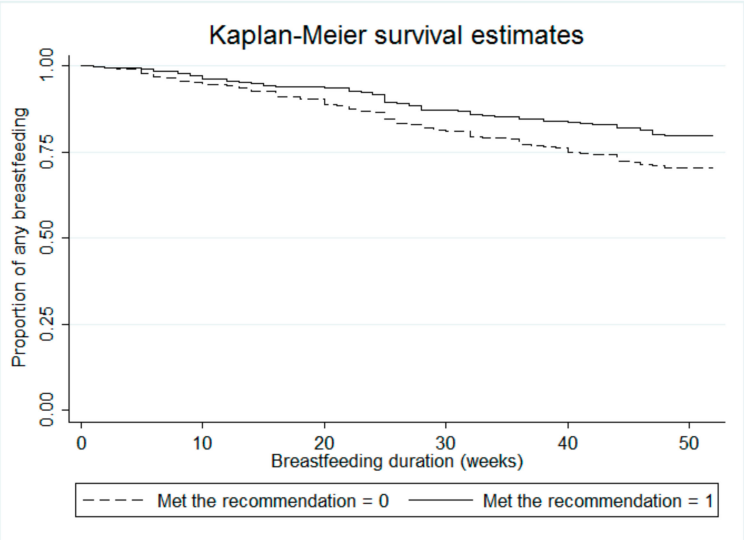

Figure 2. Kaplan-Meier curves of 'any breastfeeding' in the first twelve months postpartum for mothers who met and not meet the recommendation of physical activity during pregnancy (log-rank test $p = 0.0005$). The cutoff point for physical activity used the DHHS Guidelines [4].

The adjusted hazard ratios showing a significant association between prenatal physical activity on ceasing breastfeeding are presented in Table 3, also except for the vigorous and occupational activities.

Table 3. Cox regression models of any breastfeeding duration and physical activities among Vietnamese women ($N = 1715$).

Physical Activity Variables	Adjusted [a] HR 95% CI	*p*-Value
Total PA (METs h/week)		
1st tertile	1.00	
2nd tertile	0.74 (0.60–0.92)	**0.006**
3rd tertile	0.59 (0.47–0.75)	**<0.001**
Domain of activity		
Household/caregiving (METs h/week)		
1st tertile	1.00	
2nd tertile	0.73 (0.59–0.91)	**0.005**
3rd tertile	0.57 (0.43–0.73)	**<0.001**
Occupational (METs h/week)		
1st tertile	1.00	
2nd tertile	0.94 (0.74–1.19)	0.627
3rd tertile	0.80 (0.62–1.03)	0.082
Sports/exercise (METs h/week)		
1st tertile	1.00	
2nd tertile	0.85 (0.69–1.04)	0.116
3rd tertile	0.63 (0.48–0.82)	**0.001**
Commuting (METs h/week)		
1st tertile	1.00	
2nd tertile	0.77 (0.62–0.96)	**0.020**
3rd tertile	0.66 (0.53–0.83)	**<0.001**
Intensity		
Sedentary (h/week)		
1st tertile	1.00	
2nd tertile	1.27 (1.01–1.59)	**0.042**
3rd tertile	1.29 (1.01–1.64)	**0.044**

Table 3. *Cont.*

Physical Activity Variables	Adjusted [a] HR 95% CI	*p*-Value
Light (METs h/week)		
1st tertile	1.00	
2nd tertile	0.96 (0.77–1.19)	0.704
3rd tertile	0.68 (0.54–0.87)	**0.002**
Moderate (METs h/week)		
1st tertile	1.00	
2nd tertile	0.67 (0.54–0.83)	**<0.001**
3rd tertile	0.45 (0.35–0.57)	**<0.001**
Vigorous (METs h/week)		
Yes (MET-h/week > 0)	0.99 (0.57–1.74)	0.981
Met exercise guideline		
Yes [b]	0.67 (0.52–0.86)	**0.002**
No	1.00	

[a] Adjusted for maternal age (<25; 25–35; >35), occupation (currently not working; currently working), education level (secondary school or lower; high school graduate; college/university or above), parity (0; 1; ≥2), pre-pregnancy body mass index (overweight; not overweight), gestational diabetes (yes; no), gestational age (preterm; not preterm), caesarean section (yes; no), low birth weight (yes; no), and admission to neonatal intensive care unit (yes; no); [b] Meeting Department of Health and Human Services guideline of > 7.5 MET h/week in sports/exercise activities of moderate-intensity or greater [4]; Abbreviations: HR, Hazard Ratio; CI, Confident Interval; MET, Metabolic Equivalent Task. Bolded *p*-values are significant.

4. Discussion

The current findings indicate that women who undertake physical activity during pregnancy are less likely to terminate breastfeeding at any point up to twelve months, and have a higher rate of breastfeeding at twelve months. The rate of breastfeeding at 12 months was 71.8%, which is similar to or just above other reported rates in Asia [50]. In China and Japan breastfeeding rates for the first six months are similar to Vietnam, but between 6 and 12 months rates in Vietnam are maintained at higher rate [48,51–53] The findings from this study in Vietnam related to physical activity, provide further evidence to strengthen current guidelines showing that physical activity during pregnancy appears to have no adverse effects on breastfeeding [1,4,5,42].

A controlled trial of thirty-three mothers from six to eight weeks postpartum found aerobic exercise found no association between exercise and breastmilk volume and composition (and maternal prolactin levels), but improved oxygen uptake by the mothers [17]. A cohort study in Australia found that the intensity levels of postnatal exercise had no association with the duration of 'any breastfeeding' up to twelve months, and the duration of full breastfeeding to six months postpartum [16]. While several studies have examined the impact of physical activity after birth on breastfeeding, this is the first published study examining the association of all aspects (total physical activity, four sub-groups of intensity and four domains, and compliance to the guideline of DHHS) of prenatal physical activity and long-term breastfeeding. Previous studies have found no association between postnatal physical activity and lactation. However, this study suggests that prenatal physical activity is beneficial to breastfeeding outcomes. The possible causes of breastfeeding [15,17]. cessation among less active women include an unhealthy lifestyle, and a lack of knowledge and research about the benefits of both physical activity and breastfeeding.

Population lifestyles include patterns of health behaviours that cluster together, positive and negative are a well-known phenomenon in health promotion studies [54,55]. In intervention trials and subsequent programs it is best practice to address a number of lifestyle factors together, resulting in a greater improvement in health outcomes [56]. Many multiple risk factor interventions have demonstrated the efficiency of this approach [57]. However, the clustering of behaviours means that it is not always possible to adjust for all potential confounding factors and covariates. This is a limitation of cohort studies, including this one.

The strengths of this current study are that it is a multicenter longitudinal study with a large sample size, included prospective measurements of breastfeeding cessation (weeks) from discharge to twelve months and appropriate statistical methods were used to account for interactions between covariates. Physical activity guidelines and recommendations should not only be focused on perinatal period and delivery outcomes, but should also include breastfeeding benefits [1,4,5,42]. The main finding from this study is evidence for the beneficial role of physical activity during pregnancy and in the postpartum periods [4,5,58].

There are several limitations to be considered when interpreting the results of this study. Although participants were recruited from six hospitals of three cities, the sample may not be representative of the all parts of Vietnam. Although the physical activity was self-reported, the questionnaire has been widely used worldwide and has been validated for Vietnamese women [39]. Self-reported physical activity has been widely used in epidemiological studies with good results [13]. Only a few women reached high levels of physical activity and the results may not apply to these high levels, but very high levels of activity are not recommended in pregnancy [1]. This study only focused on confounding factors related to maternal and birth outcomes, but not social, parental factors, professional support as well as physical activity after postpartum which can affect the breastfeeding outcomes. Although postpartum physical activity could be a modifying factor for breastfeeding outcomes, the same physical activity questionnaire could not be used for the postnatal period and was not included in this study. Future studies should include measurement of antenatal and postnatal exercise in a longitudinal study.

5. Conclusions

Women who are physically active during the lactation period are known to have better breastfeeding outcomes. In this prospective cohort study of Vietnamese women, it was found that higher levels of physical activity during pregnancy are associated with an increased likelihood of breastfeeding at 12 months postpartum. Given the well-recognized benefits of breastfeeding and physical activity for both mother and child, midwifery nurses and medical staff should be aware that this association may enhance breastfeeding. A trial of health promotion to encourage physical activity for pregnant women may prove to be beneficial to mother and infant.

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4.3. Association between caesarean section and breastfeeding

This is the first study that aimed to examine the relationship between caesarean section and breastfeeding outcomes in Vietnam, using a large multi-centre prospective cohort design. The study found that the rates of breastfeeding from discharge to six months were lower in the caesarean delivery group when compared to the mothers who deliver vaginally. We recommend the provision of extra support to mothers with caesarean section to increase their breastfeeding rates and breastfeeding duration.

The content of this section is covered by the published paper below, which addresses the **Objective 4**, to determine the association between caesarean section and breastfeeding outcomes include early breastfeeding, prelacteal feeds, 'any', 'predominant' and 'exclusive' breastfeeding at different time points following childbirth to twelve months postpartum.

Citation:

Hoang Nguyen, P. T., C. W. Binns, A. Vo Van Ha, C. L. Nguyen, T. Khac Chu, D. V. Duong, D. V. Do, and A. H. Lee. "Caesarean Delivery Associated with Adverse Breastfeeding Practices: A Prospective Cohort Study." *J Obstet Gynaecol* (Sep 4 2019): 1-5. http://dx.doi.org/10.1080/01443615.2019.1647519. [Impact factor: 0.588]

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ORIGINAL ARTICLE

Caesarean delivery associated with adverse breastfeeding practices: a prospective cohort study

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ABSTRACT

Caesarean delivery rates are increasing in many Asian countries. This study investigated the effects of caesarean section on breastfeeding practices from delivery to twelve months postpartum. A prospective cohort study was conducted on 2030 pregnant women recruited from three cities in Vietnam during 2015–2017. The overall caesarean rate was 38.1%. Mothers who underwent caesarean section were more likely to give prelacteal feeds to their infants (adjusted odds ratio (OR) 13.91, 95% confidence interval (CI) 10.52–18.39) and as a result have lower rates of early initiation of breastfeeding (adjusted OR 0.04, 95%CI 0.02–0.05). Having a caesarean section reduced the likelihood of (any, predominant and exclusive) breastfeeding from discharge to 6 months postpartum. After 1 year, the any breastfeeding rate was still lower in the caesarean delivery (70.2%) compared with the vaginal delivery group (72.9%), $p = .232$. Vietnamese women who give birth by caesarean section need extra support to initiate and maintain breastfeeding.

IMPACT STATEMENT

- **What is already known on this subject?** Early initiation of breastfeeding, and 'exclusive' or 'predominant' breastfeeding rates at discharge are lower in mothers delivering by caesarean section compared to vaginal delivery. Prelacteal feeding rates are higher following caesarean section. However, the association between 'any' breastfeeding duration and caesarean delivery has not been established.
- **What the results of this study add?** This study showed that caesarean delivery reduced all breastfeeding rates from discharge to six months and any breastfeeding rate at 12 months postpartum in Vietnamese women.
- **What the implications are of these findings for clinical practice and/or further research?** Further breastfeeding interventions are needed during the postpartum period for mothers who deliver by caesarean section.

KEYWORDS
Caesarean delivery; breastfeeding; prelacteal feeding; Vietnam; prospective cohort

Introduction

The steady increase in caesarean deliveries worldwide has raised public health concerns (Betran et al. 2016; Boatin et al. 2018). The World Health Organisation (WHO) has historically suggested a caesarean section rate of 10–15%, although 20% may be optimum according to the latest findings (Robson and de Costa 2017). Global surveys showed that the overall caesarean section rate in nine Asian countries was 27.3% during 2007–2008, and Vietnam had the second highest in the region at 35.6% (Lumbiganon et al. 2010). National statistics on Vietnamese women also reported the increasing rate from 14% in 2009 to 30% in 2015 (United Nations Population Fund 2017). The caesarean delivery rate in Vietnam is continuing to increase and had risen to 58.5% in 2018 in the Da Nang Province (Giang et al. 2018).

The negative impacts of caesarean section on maternal and child health, as well as the increased costs of healthcare, have been widely documented (Hyde et al. 2012; American College of et al. 2014; Ellwood and Oats 2016; United Nations Population Fund 2017). Moreover, it may lead to adverse breastfeeding outcomes (Rowe-Murray and Fisher 2002; Qiu et al. 2008; Regan et al. 2013). A systematic review of data from 30 countries indicated a negative association between caesarean delivery and early breastfeeding (Prior et al. 2012). Results from a recent meta-analysis of Chinese studies showed that after caesarean section, the odds of 'exclusive'

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breastfeeding at discharge (pooled odds ratio (OR) 0.53, 95% confidence interval (CI) 0.41–0.68) and breastfeeding at four months postpartum (pooled OR 0.61, 95% CI 0.53–0.71) were lower when compared to vaginal delivery (Zhao et al. 2017). However, the effect of caesarean section on breastfeeding at 6 months postpartum was still inconclusive, while evidence is lacking beyond 6 months.

Long-term breastfeeding can protect infants against infections and dental malocclusion, reduce overweight and enhance their intelligence, while preventing certain chronic diseases such as diabetes, breast cancer and ovarian cancer for the mothers (Victora et al. 2016). In Vietnam, although lower early breastfeeding rates after caesarean section have been observed (Thu et al. 2012; Nguyen et al. 2013; Bui et al. 2016), published details are lacking concerning infant feeding practices in both short and long term. The aim of the present prospective cohort study was to determine the effects of caesarean section on breastfeeding outcomes for Vietnamese women from discharge to 12 months postpartum.

Materials and methods

This study utilised data from a multi-centre prospective cohort study in Vietnam (Nguyen et al. 2017). A total of 2030 pregnant women were recruited from six hospitals across three cities during their antenatal examination at 24–28 weeks of gestation commencing in August 2015. After delivery these mothers were followed up before hospital discharge, then at 1, 3, 6, and 12 months postpartum until December 2017. Ethics approval was obtained from both Curtin University (HR32/2015) and Hai Phong University (No. 05/PHUMPRB) Human Research Ethics Committees, and the study protocol was approved by all six hospitals.

Participants were pregnant women who (1) were permanent residents at the respective study locations; (2) aged 18 years or older; (3) had a singleton pregnancy; (4) not having any serious pre-existing health conditions (as indicated in medical records); and (5) able to read the information sheet and sign the consent form. Based on our selection criteria, 19 women were removed from subsequent analysis due to (1) serious maternal health problems and/or did not allow their babies to be breastfeed ($n = 2$ with human immunodeficiency virus, $n = 1$ baby transferred to an orphanage); (2) termination of pregnancy due to intrauterine growth restriction ($n = 1$), enduring a stillbirth ($n = 8$), or infant death within 12 months ($n = 7$).

Mode of delivery (vaginal or caesarean section) was confirmed using hospital medical records. Breastfeeding practices were classified according to WHO definitions (World Health Organization 2008a), as follows.

Early initiation of breastfeeding: putting newborns to the breast within one hour of birth.

Exclusive breastfeeding: babies receiving breastmilk only (including milk expressed or from a wet nurse) while giving no other food or liquid, not even water, with the exception of drops or syrups consisting of vitamins, mineral supplements or medicines.

Predominant breastfeeding: babies receiving breastmilk as the predominant source of nourishment with some types of liquids (water and water-based drinks, fruit juice), ritual fluids and oral rehydration salts, drops or syrups (supplements or medicine), but nothing else.

Any breastfeeding: when a child was receiving breastmilk with or without other drinks, formula or other infant food.

Prelacteal feeding: any foods given before the onset of lactogenesis II, which is the onset of copious breastmilk secretion occurring within four days of birth (Neville and Morton 2001).

Feeding practices were repeatedly assessed via five face-to-face interviews before hospital discharge, then at 1, 3, 6, and 12 months postpartum during home visits. Information on early breastfeeding initiation and prelacteal feeding was obtained using the respective question '*How long after birth before you put your baby to the breast?*' and '*What was your baby's first feed?*', whereas methods of exclusive, predominant or any breastfeeding were classified through the question '*How are you feeding your baby?*'

Other variables to be considered as plausible confounding factors were determined from the literature (Hobbs et al. 2016; Wallenborn and Masho 2016; Zhao et al. 2017; Doughty et al. 2018). These included maternal socio-demographic characteristics collected at the baseline interview, namely, age (years), education, occupation, parity, passive smoking, and gestational diabetes status. Passive smoking at home and workplace was obtained using the WHO STEPS questions (World Health Organization 2008b). The diagnosis of gestational diabetes followed the criteria from the International Association of Diabetes and Pregnancy Study Group (International Association of Diabetes Pregnancy Study Groups Consensus Panel et al. 2010). Further information on birth outcomes was retrieved from medical records, such as birthweight (g), admission to neonatal intensive care unit (yes/no), and preterm birth (defined as babies born alive before 37 weeks of gestation) (World Health Organization 2018b).

Comparisons between caesarean and vaginal delivery groups were made using Chi-square or Fisher exact tests. Multivariable logistic regression models were fitted to ascertain the association between mode of delivery and breastfeeding outcomes, accounting for the effects of the aforementioned covariates, with results reported in terms of OR and their corresponding 95% CI. All statistical analyses were performed using the SPSS package version 22 (IBM, Armonk, NY).

Results

During the 12 months postnatal period, 296 women were either lost to follow-up or withdrew from the study, resulting in $n = 1715$ participants (84.5%) remaining in the cohort. No differences in demographic characteristics were found between final participants and non-completers, except occupation and education ($p < .05$). The caesarean section rate was 38.1%. Table 1 compares the characteristics of participants by mode of delivery. Significant differences between caesarean and vaginal delivery groups were evident in age,

Table 1. Characteristics of participants by mode of delivery ($n = 1715$).

Characteristics	Total *N* (%)	Caesarean delivery	Vaginal delivery	p^a
	1715 (100)	654 (38.1)	1061 (61.9)	
Maternal age (years)				<.001
<25	548 (32.0)	170 (26.0)	378 (35.6)	
25–35	1029 (60.0)	407 (62.2)	622 (58.6)	
>35	138 (8.0)	77 (11.8)	61 (5.8)	
Occupation				.020
Farmers	257 (15.0)	103 (15.8)	154 (14.5)	
Workers	685 (39.9)	231 (35.3)	454 (42.8)	
Office/technical staff	401 (23.4)	172 (26.3)	229 (21.6)	
Sales worker	278 (16.2)	106 (16.2)	172 (16.2)	
Housewife/unemployed	94 (5.5)	42 (6.4)	52 (4.9)	
Educational level				.002
Less than high school	576 (33.6)	214 (32.7)	362 (34.1)	
High school graduate	447 (26.1)	145 (22.2)	302 (28.5)	
College/University	692 (40.3)	295 (45.1)	397 (37.4)	
Parity				.620
0	658 (38.4)	255 (39.0)	403 (38.0)	
1	638 (37.2)	234 (35.8)	404 (38.1)	
≥2	419 (24.4)	165 (25.2)	254 (23.9)	
Passive smoking	1132 (66.0)	432 (66.1)	700 (66.0)	.973
Gestational diabetes	373 (21.8)	165 (25.3)	208 (19.7)	.007
Birthweight (g)				.023
<2500	64 (3.7)	26 (4.0)	38 (3.6)	
2500–4000	1630 (95.1)	614 (93.9)	1016 (95.8)	
>4000	21 (1.2)	14 (2.1)	7 (0.6)	
Admission to neonatal intensive care unit	44 (2.6)	21 (3.2)	23 (2.2)	.184
Preterm birth (<37 weeks)	72 (4.2)	29 (4.4)	43 (4.1)	.702

[a]From Chi-square tests.

Table 2. Comparison of breastfeeding practices between caesarean and vaginal delivery groups ($n = 1715$).

Feeding practices	Total ($n = 1715$) *n* (%)	Caesarean delivery ($n = 654$) *n* (%)	Vaginal delivery ($n = 1061$) *n* (%)	p^a	Crude OR (95% CI)	Adjusted OR[b] (95% CI)
Early BF (within 1 hour)	607 (35.4)	29 (4.4)	578 (54.5)	<.001	0.04 (0.03–0.06)	0.04 (0.02–0.05)
Prelacteal feeding	967 (56.4)	578 (88.4)	389 (36.7)	<.001	13.14 (10.03–17.21)	13.91 (10.52–18.39)
Exclusive BF at discharge	324 (18.9)	44 (6.7)	280 (26.4)	<.001	0.20 (0.14–0.28)	0.20 (0.15–0.29)
Exclusive BF at 1 month	270 (15.7)	39 (6.0)	231 (21.8)	<.001	0.23 (0.16–0.32)	0.23 (0.16–0.33)
Exclusive BF at 3 months	225 (13.1)	32 (4.9)	193 (18.2)	<.001	0.23 (0.16–0.34)	0.23 (0.16–0.34)
Exclusive BF at 6 months	34 (2.0)	3 (0.5)	31 (2.9)	<.001	0.15 (0.05–0.50)	0.13 (0.04–0.44)
Predominant BF at discharge	358 (20.9)	47 (7.2)	311 (29.3)	<.001	0.19 (0.13–0.26)	0.19 (0.14–0.27)
Predominant BF at 1 month	310 (18.1)	43 (6.6)	267 (25.2)	<.001	0.21 (0.15–0.29)	0.21 (0.15–0.30)
Predominant BF at 3 months	261 (15.2)	37 (5.7)	224 (21.1)	<.001	0.22 (0.16–0.32)	0.23 (0.16–0.33)
Predominant BF at 6 months	42 (2.5)	3 (0.5)	39 (3.7)	<.001	0.12 (0.04–0.39)	0.11 (0.03–0.35)
Any BF at discharge	1568 (91.4)	557 (85.2)	1011 (95.3)	<.001	0.28 (0.20–0.41)	0.28 (0.19–0.40)
Any BF at 1 month	1686 (98.3)	638 (97.6)	1048 (98.8)	.057	0.49 (0.24–1.04)	0.43 (0.19–0.93)
Any BF at 3 months	1601 (93.4)	601 (91.9)	1000 (94.3)	.057	0.69 (0.47–1.01)	0.63 (0.42–0.94)
Any BF at 6 months	1492 (87.0)	553 (84.6)	939 (88.5)	.018	0.71 (0.54–0.94)	0.66 (0.49–0.89)
Any BF at 12 months	1232 (71.8)	459 (70.2)	773 (72.9)	.232	0.88 (0.71–1.09)	0.81 (0.65–1.01)

[a]From Chi-square tests or Fisher exact test.
[b]Adjusted for maternal age, occupation, education, parity, passive smoking, gestational diabetes, birthweight, admission to neonatal intensive care unit, and preterm birth.
BF: breastfeeding; CI: confidence interval; OR: odds ratio.

occupation, education, gestational diabetes, and birthweight. In particular, mothers who delivered by caesarean section appeared to be older (mean age 26.9 versus 28.5 years), more highly educated and had a higher prevalence of gestational diabetes than their vaginal delivery counterparts.

Although the great majority (> 90%) of the cohort had been breastfeeding their newborns before hospital discharge, the caesarean mothers experienced a significantly lower prevalence (85% versus 95%). Table 2 shows that only 4.4% of babies born by caesarean section received breastmilk within 1 hour after birth, compared to over half (54.5%) among those delivered vaginally. Their likelihood of early breastfeeding initiation was low, the adjusted OR being 0.04 (95% CI 0.02–0.05). Furthermore, these caesarean born infants were more likely to be given prelacteal foods (88.4% versus 36.7%; adjusted OR 13.91 (95% CI 10.52–18.39)), with formula milk commonly fed to them (92.8% versus 70.5%; $p < .001$) before hospital discharge.

The results in Table 2 also indicate that 'exclusive' and 'predominant' breastfeeding rates from discharge to 6 months were significantly lower in the caesarean section group than the vaginal delivery group. Similarly, 'any' breastfeeding rates were lower, especially at discharge ($p < .001$) and at 6 months postpartum ($p = .018$). After 1 year, the 'any' breastfeeding rate remained lower among mothers who delivered by caesarean section (70.2%) than those with vaginal delivery (72.9%), though the difference was not statistically significant ($p = .232$).

Discussion

The findings of this large prospective cohort study showed that caesarean delivery is associated with adverse breastfeeding outcomes, especially during the first 6 months postpartum. The rate of 'any' breastfeeding in the long term (12 months) was also lower among mothers who underwent caesarean section, albeit the difference of 2.7% did not attain statistically significance ($p = .232$).

The caesarean section rate of 38.1% was higher than the national average of 27.5% in 2010–2014 (Boatin et al. 2018) but lower than the 58.5% previously reported in the Da Nang province (Giang et al. 2018). It should be noted that the national rate in the 2018 WHO report was derived from the Demographic and Health Surveys and Multiple Indicator Cluster Surveys 2000-04 and 2010-14, while the annual increase in prevalence was expected to be 1.6% (Boatin et al. 2018).

Our findings are consistent with a meta-analyses of 42 studies, in which early-to-6-month breastfeeding rates were lower after caesarean section (Prior et al. 2012). The high prevalence of caesarean section was a main cause for delaying early breastfeeding initiation and giving prelacteal foods to the newborns. Similarly, the odds of prelacteal feeding increased three times for caesarean section infants according to a previous study in Vietnam (OR 2.94, 95% CI 2.39–3.61) (Nguyen et al. 2013). Due to the high rate of prelacteal feeding (56.4%) with mainly formula milk, the exclusive and predominant breastfeeding rates were low in Vietnamese infants.

Consequently, managing post-caesarean infant feeding has become a growing concern for maternal and child health professionals particularly in the early recovery period (Rowe-Murray and Fisher 2002; Spear 2006). Findings from a recent systematic review on interventions on breastfeeding after caesarean section suggested very few studies (seven control trials) have focussed on components such as early skin-to-skin contact, breastfeeding education and support, sidecar bassinets and breast pump provision (Beake et al. 2017), even though current breastfeeding policy of baby friendly hospitals specifically addresses post-caesarean delivery and promotes early skin-to-skin contact (Singh et al. 2017; World Health Organization 2018a).

It is a common practice to administer antibiotics after caesarean section, with two reports of 63% and 100% prescription rates in United States and Scotland, respectively (Denison et al. 2003; Brubaker et al. 2014). The use of prophylactic antibiotics is now above 90% in Vietnam (Morisaki et al. 2014). Following recent studies it may increase further (Knight et al. 2019). Mothers may delay breastfeeding to avoid transmission of antibiotics to their newborns (Duong et al. 2004). Such challenges to establish appropriate infant feeding practices have been documented for caesarean mothers residing in Da Nang province (Nguyen et al. 2018). In Vietnam, mothers are often separated from their babies after caesarean delivery (United Nations Population Fund 2017), and may experience more pain which result in lower rates of early initiation and exclusive breastfeeding at discharge (Duong et al. 2004; Bui et al. 2016). Limited milk volume for the first 5 days after caesarean section is also a barrier for exclusive breastfeeding (Evans et al. 2003; Cohen et al. 2018).

Strengths of this study include the following: a multicentre prospective cohort study design with a large sample size; longitudinal repeated measures of breastfeeding outcomes with five times data collection up to 12 months postpartum; application of WHO standard definitions of breastfeeding indicators; confirmation (particularly for mode of delivery) with medical records whenever feasible; and appropriate statistical methods to account for the effects of confounding factors. The findings are applicable to the general Vietnam population. However, several limitations should be considered. First, residual confounding may still persist, especially social, parental or professional factors, which may affect breastfeeding behaviour but such information was not collected in our study. Second, the majority of the participants (72%) were still breastfeeding at 12 months postpartum, making it difficult to determine the exact duration of 'any' breastfeeding for assessing the long-term effect of caesarean section. Third, information on elective or unplanned caesarean section was not available, which might also affect the mother's breastfeeding decision.

In conclusion, caesarean delivery was associated with adverse breastfeeding practices, from early stage after delivery to 6 months postpartum. Interventions are needed to encourage Vietnamese mothers to initiate and maintain breastfeeding and inhibit prelateal feeds soon after the operation. Assistance and support from community nurses are also important to further educate mothers before and after caesarean section given the established benefits of breastfeeding to both maternal and child health.

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4.4. Association between feeding practices and infant health outcomes

This is the first study that aimed to examine the relation between early formula feeding, together with prelacteal feed, and infant hospitalisation, lower respiratory tract infection and diarrheal illness, using a large multicentre prospective cohort design. The study found that the rates of hospitalisation, lower respiratory tract infection and diarrheal illness of infants from discharge to twelve months postpartum were lower in prelacteal-fed and early formula-fed groups when compared to the infants without prelacteal and early formula feeds. However, the association between early formula feeds and diarrhoea was not significant after adjustment of covariates or confounders (maternal socio-demographic characteristics and birth related factors). We recommend increasing awareness about these risks to nurses and midwives, who directly give breastfeeding counselling to mothers. Extra supports for mothers who having difficulties in initiating breastfeeding in hospital should be provided, to maintain 'full or exclusive' breastfeeding and to prevent infants from future illness and hospital admission.

The content of this section is covered by the published paper below, which addresses the **Objective 5**, to determine the prevalence of prelacteal feeds and early formula feeding, and their associations with infant hospitalisation, diarrhoea and lower respiratory tract infection within twelve months postpartum.

Citation:

Nguyen, **P.**, C. W. Binns, A. V. V. Ha, T. K. Chu, L. C. Nguyen, D. V. Duong, D. V. Do, and A. H. Lee. "Prelacteal and Early Formula Feeding Increase Risk of Infant

Hospitalisation: A Prospective Cohort Study." *Arch Dis Child* (Sep 15 2019). http://dx.doi.org/10.1136/archdischild-2019-316937. [Impact factor: 3.158]

Prelacteal and early formula feeding increase risk of infant hospitalisation: a prospective cohort study

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ABSTRACT

Objective To ascertain the relationship between prelacteal feeding, early formula feeding and adverse health outcomes, especially hospitalisation during the first year of life.

Design Multicentre prospective cohort study.

Setting Six hospitals across three cities in Vietnam.

Patients A total of 2030 pregnant women were recruited at 24–28 weeks of gestation and followed up at hospital discharge, 1, 3, 6 and 12 months post partum.

Main outcome measures Rates of infant hospitalisation, diarrhoea and lower respiratory tract infection during the first 12 months.

Results For the final complete sample (n=1709, 84%), about one-quarter of the infants experienced diarrhoea (25.5%) or were admitted to hospital with at least one episode (24.8%), and almost half (47.6%) the cohort contracted lower respiratory tract infection by 12 months. The prevalence of prelacteal feeding was high (56.5%) while formula feeding was common (79.5%) before hospital discharge, both of which increased the risks of adverse health outcomes particularly hospitalisation by approximately 1.5-fold, with adjusted OR (95% CI) 1.43 (1.09 to 1.88) and 1.48 (1.07 to 2.05), respectively for these infants by 12 months, when compared with others who were exclusively breast fed.

Conclusions Prelacteal feeding and early formula feeding before hospital discharge are associated with higher risks of infection and hospital admission in Vietnamese infants. Support for exclusive breast feeding should be provided to mothers to avoid the adverse consequences of giving formula milk and prelateal foods.

What is already known on this topic?

- Giving prelacteal foods and formula milk to infants soon after birth is a common practice in Vietnam.
- The effects of early feeding method on infant illnesses have been documented in cross-sectional surveys and birth cohort studies, but were mostly limited to 6 months after birth.

What this study adds?

- Prelacteal feeding and formula feeding before hospital discharge are associated with higher risks of infection and hospital admission during the first 12 months of life.
- Interventions to support exclusive breast feeding and to curtail the use of formula milk and prelacteal foods are needed to protect infants against infectious diseases.

INTRODUCTION

Respiratory infections and diarrhoea are the most common causes of death in children under 5 years of age, especially in low-income and middle-income countries.[1–3] In Vietnam, the proportion of deaths among children under 5 years attributable to pneumonia is 10%–14% and diarrhoea is 5%–9%.[1 4] Current evidence has shown a link between infant feeding types and hospitalisation for infectious diseases including respiratory infections and diarrhoea.[5–11] For example, a cross-sectional study of Vietnamese infants <5 months in 2011 reported that early initiation and exclusive breast feeding were inversely associated with the prevalence of diarrhoea and acute respiratory infections.[12] Another prospective cohort study of 1049 infants in 2015 concluded that exclusive breast feeding at 6 weeks of age reduced the odds of inpatient admission for suspected pneumonia and diarrhoeal illness.[13]

In Vietnam, high prevalence of prelacteal feeding and formula feeding has been reported in several studies.[12 14 15] However, the relationships between prelacteal and early formula feeding, infant illness and hospitalisation have not been investigated in detail. Therefore, the present prospective cohort study aimed to ascertain specifically the risk of hospitalisation within 1 year of birth for infants who were given prelacteal or early formula feeds. We hypothesise that infants fed with prelacteal foods or infant formula soon after birth experience higher rates of hospitalisation and childhood illnesses than their exclusively breastfed counterparts.

MATERIALS AND METHODS

Design

A multicentre prospective cohort study was undertaken between August 2015 and December 2017 at six hospitals across three cities of Vietnam.[16] A total of 2030 pregnant women were recruited during their antenatal care visits between 24 and 28 weeks of gestation. After childbirth, participants were followed up at hospital discharge, then at 1, 3, 6 and 12 months post partum.

Participants

We recruited pregnant women who (1) were permanent residents in the study locations; (2) ≥18 years of age; (3) at 24–28 weeks of gestation; (4) had a singleton pregnancy; (5) did not have any serious pre-existing health conditions according to medical records and (6) were able to read the information sheet and sign the consent form.

Main exposures

Breastfeeding practices were defined according to the WHO criteria.[17] Prelacteal feeds are any foods (such as water, honey, formula milk and fruit juice) given before the onset of lactogenesis II, that is, the onset of copious breastmilk secretion occurring within 4 days of birth.[18] Early formula feeding refers to a baby receiving any amount of any kind of reconstituted milk products or replacer after birth and before hospital discharge. In this study, prelacteal and early formula feeding were not mutually exclusive and recorded as binary variables (yes; no) at hospital discharge using the question "*What was your baby's first feed after birth?*" and "*How are you feeding your baby?*", respectively.

Outcome measures

The main outcomes were the presence (yes; no) of hospitalisation, diarrhoea and lower respiratory tract infection during the first 6 months and the first year of life. Hospitalisation refers to any inpatient admission of the infant due to illness or medical problems. Information on hospital admission (for any reason such as fever, jaundice, ear infection, diarrhoea and lower respiratory tract infection) was collected at the 1, 3, 6 and 12 months follow-up interviews using the question "*Has your baby had any inpatient admission since the last interview?*" Medical records were used to confirm such illness outcomes and hospital admission whenever feasible. All mothers were able to provide documentary evidence of admission to hospital and/or diagnosis from their medical invoices and infant health record books. A diarrhoea was defined as 'the passage of three or more loose or liquid stools per day, or more frequently than is normal for the individual'.[19] Symptoms for a lower respiratory tract infection were 'at least one specific lower respiratory tract sign (fast or difficulty breathing, chest wall indrawing) and/or abnormal auscultatory findings (crackles/crepitations or bronchial breath sounds)'.[20] Although these two outcomes might overlap with the hospitalisation outcome for some cases, specific information on each admission episode was not collected, so that subcategorisation of the hospitalisation outcome was not feasible.

Other variables

Information on confounding factors such as maternal and sociodemographic characteristics, as suggested in the literature,[8 9 11 21] was collected at the baseline interview. Gestational diabetes was diagnosed following the criteria from the International Association of the Diabetes and Pregnancy Study Groups, with at least one glucose value above the threshold: fasting plasma glucose ≥5.1 mmol/L, 1 hour plasma glucose ≥10.0 mmol/L, 2 hours plasma glucose ≥8.5 mmol/L[22]. Variables related to birth were retrieved from medical records at hospital discharge, which included gestational age, gestational weight gain, caesarean section, infant gender, birth weight and admission to neonatal intensive care unit. Infant feeding methods after discharge were assessed through the question "*How are you feeding your baby?*" at the postpartum interviews. Any breastfeeding duration (weeks) was recorded at the interviews by asking "*How old was your baby when you stopped breast feeding?*"

Statistical analysis

In addition to descriptive statistics, group comparisons were made between infants with and without hospital admission during the first year, using χ^2 test for categorical variables and t-test for continuous variables. Cumulative prevalence of the outcomes were computed at the four follow-up time points. Separate logistic regression analyses were then performed to determine the associations between prelacteal feeding, early formula feeding and the risks of hospitalisation, diarrhoea and lower respiratory tract infection during the first 6 months and the first year of life, with adjusted OR (AOR) and associated 95% CIs to account for the effects of plausible confounding factors. Covariates included in the 12 logistic regression models were maternal age (years), occupation (working; not working), education level (secondary school or lower; high school graduate; college, university or above), parity (0; 1; ≥2), prepregnancy body mass index (kg/m^2), gestational diabetes status (yes; no), gestational age (preterm <37 weeks; not preterm ≥37 weeks), gestational weight gain (kg), caesarean section (yes; no), birth weight (g), infant gender (boy; girl) and newborn admission to neonatal intensive care unit (yes; no). To accommodate the potential effect of feeding practice after discharge, an additional covariate 'any breast feeding at 6 months (yes; no)' was included in the models for 6 months, whereas adjustment for the continuous 'any breastfeeding duration (weeks)' was made in the models for 12 months. All statistical analyses were undertaken using the SPSS package V.22 (IBM, Armonk, New York, USA).

RESULTS

Of the total 2030 pregnant women recruited at baseline,[16] 297 were lost-to-follow up and 24 mothers who experienced serious medical problems (HIV positive, n=2; prepregnancy diabetes, n=6; stillbirth, n=8; termination of pregnancy, n=1; infant death, n=7) were subsequently excluded, leaving n=1709 for data analysis (retention rate 84%). No differences were found in maternal and sociodemographic characteristics between the final participants and the dropouts, except for maternal education ($p<0.05$).

Table 1 presents the characteristics of our cohort. Preterm births occurred in 4.2% of the sample, while over one-third (38.2%) experienced caesarean section, and only 44 newborns (2.6%) had been admitted to the neonatal intensive care unit. When comparing infants with and without hospitalisation during the first 12 months, the two groups were significantly different in terms of maternal education, infant gender and early feeding methods. In particular, the hospitalised infants had significantly higher rates of prelacteal feeding and formula feeding than their healthy counterparts (61% and 83% vs 55% and 78%, respectively) before hospital discharge. Overall, formula feeding was common (40% at 1 month, 43% at 3 months and 66% at 6 months), but usually in conjunction with breast feeding, even though very few mothers exclusively breast fed their infants (18.8% at discharge and <2% at 6 months).

Table 2 summarises the cumulative prevalence of hospitalisation, diarrhoea and lower respiratory tract infection from the four follow-ups of the cohort. About one-quarter of the infants experienced diarrhoea or were admitted to hospital with at least one episode during the first 12 months, while 14.6% of infants had admission(s) during their second 6 months of life. The prevalence of lower respiratory tract infection was very high, with almost half the cohort contracted the disease by 12 months.

Tables 3 and 4 present the associations between prelacteal feeding, early formula feeding and the adverse health outcomes

Table 1 Characteristics of participants by hospitalisation status

Variables	Overall	Hospitalisation during the first 12 months		P value*
		Yes	No	
Total, n (%)	**1709 (100)**	**423 (24.8)**	**1286 (75.2)**	
Maternal age (years), mean±SD	27.5±5.3	27.1±5.1	27.6±5.3	0.072
Occupation, n (%)				0.816
Currently not working	533 (31.2)	130 (30.7)	403 (31.3)	
Currently working	1176 (68.8)	293 (69.3)	883 (68.7)	
Education level, n (%)				0.031
Secondary school or lower	574 (33.6)	146 (34.5)	428 (33.3)	
High school graduate	445 (26.0)	127 (30.0)	318 (24.7)	
College/university or above	690 (40.4)	150 (35.5)	540 (42.0)	
Parity, n (%)				0.720
0	655 (38.3)	160 (37.8)	495 (38.5)	
1	636 (37.2)	164 (38.8)	472 (36.7)	
≥2	418 (24.5)	99 (23.4)	319 (24.8)	
Pre pregnancy BMI (kg/m^2), mean±SD	20.1±2.4	20.1±2.5	20.1±2.4	0.945
Gestational diabetes†, n (%)				0.391
Yes	373 (21.8)	86 (20.3)	287 (22.3)	
No	1336 (78.2)	337 (79.7)	999 (77.7)	
Gestational age (weeks), n (%)				0.214
Preterm: <37	71 (4.2)	22 (5.2)	49 (3.8)	
Not preterm: ≥37	1638 (95.8)	401 (94.8)	1237 (96.2)	
Gestational weight gain (kg), mean±SD	13.0±4.0	13.3±3.8	13.0±4.0	0.112
Caesarean section, n (%)				0.784
Yes	653 (38.2)	164 (38.8)	489 (38.0)	
No	1056 (61.8)	259 (61.2)	797 (62.0)	
Infant gender, n (%)				<0.001
Boy	875 (51.2)	249 (58.9)	626 (48.7)	
Girl	834 (48.8)	174 (41.1)	660 (51.3)	
Birth weight (g), mean±SD	3146.2±395.0	3120.3±427.7	3154.7±383.4	0.143
Admission to NICU, n (%)				0.078
Yes	44 (2.6)	16 (3.8)	28 (2.2)	
No	1665 (97.4)	407 (96.2)	1258 (97.8)	
Prelacteal feeding, n (%)	966 (56.5)	258 (61.0)	708 (55.0)	0.033
Early formula feeding, n (%)	1352 (79.1)	350 (82.7)	1002 (77.9)	0.034

*From χ^2 and t-tests.
†Based on International Association of the Diabetes and Pregnancy Study Groups criteria (2010).
BMI, body mass index; NICU, neonatal intensive care unit; SD, Standard deviation.

during the first 6 and 12 months, respectively, after adjusting for plausible confounding factors. The observed rates for all outcomes were higher among prelacteal-fed and early formula-fed infants. Both prelacteal and early formula feeding were apparently associated with hospitalisation and diarrhoea but not lower respiratory tract infection during the first 6 months of life (table 3). By 12 months, their risks of adverse health outcomes were almost 1.5 times higher than the exclusively breastfed infants, particularly for hospitalisation, with AOR (95% CI) 1.43 (1.09 to 1.88) and 1.48 (1.07 to 2.05), respectively (table 4). The online supplementary table shows the detailed results from fitting the 12 multivariable logistic regression models, each with a different set of significant factors and covariates.

Table 2 Cumulative prevalence of infant hospitalisation, diarrhoea and lower respiratory tract infection at 1, 3, 6 and 12 months

Adverse health outcome	Prevalence (one or more episodes)			
	≤1 month	≤3 months	≤6 months	≤12 months
Hospital admission, n (%)	55 (3.2)	125 (7.3)	241 (14.1)	423 (24.8)
Diarrhoea, n (%)	45 (2.6)	120 (7.0)	256 (15.0)	435 (25.5)
Lower respiratory tract infection, n (%)	92 (5.4)	242 (14.2)	434 (25.4)	814 (47.6)

DISCUSSION

This large prospective cohort study confirmed that both prelacteal feeds and early formula feeding before hospital discharge are associated with adverse infant health outcomes during their first year of life. The observed high prevalence of prelacteal feeding and early formula feeding before hospital discharge were consistent with previous cross-sectional studies in Vietnam which reported rates above 50%.[12 14 23] A recent quasi-experimental study indicated over half the infants received prelacteal feeds, and formula milk was used as the first feed by 65.5% of the control group and 50% overall.[24]

In Vietnam, respiratory diseases, bacterial and parasitic infections accounted for most hospital admissions in children.[25] Compared with the our observed hospitalisation rate of 14.8% for all causes during the first 6 months, a previous cohort study

Table 3 Association between prelacteal feeding, early formula feeding and adverse health outcomes during the first 6 months of life

Feeding method before hospital discharge	Hospitalisation (0–6 months)			Diarrhoea (0–6 months)			Lower respiratory tract infection (0–6 months)		
	Yes n (%)	No n (%)	AOR* (95% CI)	Yes n (%)	No n (%)	AOR* (95% CI)	Yes n (%)	No n (%)	AOR* (95% CI)
Prelacteal feeding									
Yes	148 (15.3)	818 (84.7)	1.44 (1.02 to 2.03)	166 (17.2)	800 (82.8)	1.73 (1.25 to 2.41)	246 (25.5)	720 (74.5)	0.85 (0.65 to 1.12)
No	93 (12.5)	650 (87.5)	1	90 (12.1)	653 (87.9)	1	188 (25.3)	555 (74.7)	1
Formula feeding									
Yes	197 (14.6)	1155 (85.4)	1.39 (0.92 to 2.10)	215 (15.9)	1137 (84.1)	1.50 (1.02 to 2.21)	350 (25.9)	1002 (74.1)	1.00 (0.74 to 1.37)
No	44 (12.3)	313 (87.7)	1	41 (11.5)	316 (88.5)	1	84 (23.5)	273 (76.5)	1

*Adjusted for maternal age (years), occupation (currently not working; currently working), education level (secondary school or lower; high school graduate; college/university or above), parity (0; 1; ≥2), prepregnancy body mass index (kg/m^2), gestational diabetes (yes; no), gestational age (preterm; not preterm), gestational weight gain (kg), caesarean section (yes; no), infant gender (boy; girl), birth weight (g), admission to neonatal intensive care unit (yes; no) and any breast feeding at 6 months (yes; no). The models only included those with complete follow-up data for 12 months (n=1709).
AOR, adjusted OR; CI, confidence interval.

with 6 months follow-up found 8.8% and 4% of infants required inpatient admission for suspected pneumonia and diarrhoeal illness, respectively.[13] The prevalence of diarrhoea and acute respiratory infection among infants 0–5 months (during the last 2 weeks) was 5.3% and 24.5%, respectively, from another cross-sectional study in Vietnam.[12] These rates appeared to be comparable to our cumulative data at the 6-month follow-up (15% and 25.4%; table 2). Finding from a cohort study in Maldives also showed a large proportion of infants (35.5%) had diarrhoea and acute respiratory tract infection (30.2%) 6 months after birth.[9]

The present study found prelacteal and early formula feeding before hospital discharge are associated with adverse infant health outcomes, especially hospitalisation and lower respiratory tract infection. Data from a cross-sectional study in Vietnam similarly suggested that babies fed with prelacteal foods are more susceptible to acute respiratory illness.[12] The observed marginal association between early formula feeding and diarrhoea was also consistent with the result from a nationwide longitudinal survey of Japanese children.[11] Moreover, formula feeding during the first 3 days after birth was found to be associated with increased infant formula feeding and early breastfeeding cessation.[23] Another study from Brazil concluded that hospitalisation contributed to the interruption of exclusive breast feeding and the introduction of infant formula during hospitalisation.[26] Breastmilk is known to have immunological protection against infection. On the other hand, provision of prelacteal foods and formula milk during the first few days of life can increase the infant's exposure to environmental contaminants from non-breastmilk supplements and change the microbiome as a result,[27 28] thereby increasing their risk of childhood illnesses.

A major strength of this study was the multicentre prospective cohort study design with a large sample size, which enabled the longitudinal repeated measures of infant health outcomes with follow-up interviews at 1, 3, 6 and 12 months after birth; unlike previous cross-sectional surveys or birth cohort studies in Vietnam with limited follow ups (typically 6 months). Moreover, the final retention rate was high at 84%, and data were collected from six hospitals in both north and south of the country, thus representative of the urban population in Vietnam. To overcome the limitation concerning the self-reported nature of the outcome variables, all reported illness symptoms by the mothers were confirmed with medical records whenever feasible, otherwise the diagnoses were reviewed and assigned by a paediatrician following the standard protocol. Consequently, the observed hospitalisation rates might likely overestimate the actual prevalence of childhood illnesses attributable to the adverse feeding methods, but the same magnitude of bias would also apply to the exclusively breastfed infants. Therefore, additional analyses were undertaken for diarrhoea and lower respiratory tract infection to confirm the effects of prelacteal and early formula feeding. The infant health outcomes were classified as binary variables which did not distinguish infants with single and multiple episodes of illness. The data were analysed using

Table 4 Association between prelacteal feeding, early formula feeding and adverse health outcomes during the first year of life

Feeding method before hospital discharge	Hospitalisation (0–12 months)			Diarrhoea (0–12 months)			Lower respiratory tract infection (0–12 months)		
	Yes n (%)	No n (%)	AOR* (95% CI)	Yes n (%)	No n (%)	AOR* (95% CI)	Yes n (%)	No n (%)	AOR* (95% CI)
Prelacteal feeding									
Yes	258 (26.7)	708 (73.3)	1.43 (1.09 to 1.88)	271 (28.0)	695 (71.9)	1.56 (1.19 to 2.05)	504 (52.2)	462 (47.8)	1.50 (1.18 to 1.90)
No	165 (22.2)	578 (77.8)	1	164 (22.1)	579 (77.9)	1	310 (41.7)	433 (58.3)	1
Formula feeding									
Yes	350 (25.9)	1002 (74.1)	1.48 (1.07 to 2.05)	357 (26.4)	995 (73.6)	1.37 (1.00 to 1.87)	672 (49.7)	680 (50.3)	1.41 (1.08 to 1.83)
No	73 (20.4)	284 (79.6)	1	78 (21.9)	279 (78.1)	1	142 (39.8)	215 (60.2)	1

*Adjusted for maternal age (years), occupation (currently not working; currently working), education level (secondary school or lower; high school graduate; college/university or above), parity (0; 1; ≥2), prepregnancy body mass index (kg/m^2), gestational diabetes (yes; no), gestational age (preterm; not preterm), gestational weight gain (kg), caesarean section (yes; no), infant gender (boy; girl), birth weight (g), admission to neonatal intensive care unit (yes; no) and any breastfeeding duration (weeks). The models only included those with complete follow-up data for 12 months (n=1709).
AOR, adjusted OR; CI, confidence Interval.

information from participants who completed the 12-month postpartum interview, instead of adjustment of follow-up time for the entire cohort. Information on non-inpatient admission was not recorded, even though it might be a confounding factor for a subsequent inpatient admission. Finally, details of formula milk feeding such as intensity and duration before hospital discharge were not collected to avoid subject burden, which posed as another limitation of our study.

In conclusion, prelacteal feeding and early formula feeding are associated with elevated risks of hospitalisation, diarrhoea and lower respiratory tract infection. Given that relationships have been identified between paediatricians and formula milk companies,[29] it is important to promote exclusive breast feeding and to educate women during their pregnancy about the adverse consequences of giving prelateal foods. Extra support should be available to mothers who have difficulties to initiate breast feeding, and to overcome their reliance on infant formula as a substitute for breastmilk.

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Contributors PN: recruited patients, analysed and interpreted data, drafted the manuscript. CWB and AHL: conceptualised and designed the study, supervised the overall study conduct and analysis. AVVH, TKC, LCN: enrolled patients and interpreted data. DaVD and DuVD: provided technical support, supervised the overall study conduct and analysis. All authors critically revised and approved the final manuscript.

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Competing interests None declared.

Patient consent for publication Not required.

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Chapter 5: Conclusion

This chapter provides a summary of the main findings from the study, together with the discussion of the strengths and limitations. Implications for future breastfeeding research are also presented in this chapter.

5.1. Key findings of the study

The present cohort study found that most Vietnamese mothers (91.4%) initiated breastfeeding in hospital then continued 'any' breastfeeding until six months (87%) and twelve months (72.9%) postpartum. However, only about one fifth of newborns were breastfed 'exclusively' or 'predominantly' from birth; and most infants were no longer 'exclusively' or 'predominantly' breastfed at six months postpartum (2.0% and 2.5% respectively). About one third of newborns received breastmilk within one hour after birth, while more than half were fed with prelacteal food (infant formula, water, honey, etc.) as their first feed. Formula milk was given to four out of five newborns before hospital discharge.

The GDM prevalence (21.8%) was high in Vietnamese pregnant women. Approximately four out of ten participants delivered by caesarean section. Only one in five pregnant women met the exercise recommendation for pregnancy (7.5 MET-hours or more per week in sport/exercise activities of moderate-intensity). Low birth weight (<2500gram) and preterm birth (<37 weeks) were not common as the rates were 3.7% and 4.2%, respectively.

Our systematic review of 'GDM and breastfeeding outcomes' indicated that the likelihood of 'exclusive' breastfeeding was lower and the duration shorter among mothers who experienced GDM during pregnancy, when compared to others without GDM. The association between GDM and 'any' breastfeeding rates and duration were not different between the two groups of mothers as there were related issues in terms of key variables' definitions and measurements.

This cohort study found that the rate of 'any breastfeeding' at twelve months was lower, and the breastfeeding duration was shorter among GDM women. Their rates of 'exclusive' and 'predominant' breastfeeding also appeared lower from hospital discharge to six months, but were not significantly different compared to that of non-GDM women, due to the small numbers of Vietnamese women practicing 'exclusive' and 'predominant' breastfeeding. In our study, caesarean section was a significant risk factor for giving prelacteal feeds (aOR 13.91; 95% CI 10.52-18.39) and delaying early breastfeeding initiation (aOR 0.04; 95% CI 0.02-0.05). Having a caesarean section also reduced 'any, predominant and exclusive' breastfeeding rates from birth to six months postpartum. By twelve months, the 'any' breastfeeding rate was still lower in the caesarean delivery group than the vaginal delivery group, though not statistically different.

Physical activity during pregnancy was found to be positively associated with breastfeeding duration. At twelve months postpartum, the rate of 'any' breastfeeding was higher in active pregnant women than others who were not active. Breastfeeding

outcomes were not affected by vigorous intensity of physical activity or occupational activities during pregnancy.

During the twelve-month follow up period, one out of four infants were admitted to hospital with at least one episode of illness. Almost half of infants contracted lower respiratory tract infection, while one-quarter of infants experienced diarrhoea by twelve months. We found that the rates of these adverse health outcomes were higher among the prelacteal-fed and early formula-fed infants, when compared to infants who were exclusively breastfed before hospital discharge. In specific, both the prelacteal feeds and in-hospital formula use increased the risk of infants' hospitalisation by almost 1.5 folds during the first year of life.

5.2. Strengths and limitations of the study

A major strength of the study was its multi-centre prospective cohort design with a relatively large sample size of over 2000 participants from six hospitals in Northern and Southern Vietnam. The long follow-up period from 24 to 28 weeks of pregnancy to one year postpartum with six face-to-face interviews was another strength of the study. Previously, few prospective cohort studies had been conducted in Vietnam, either with smaller sample size, shorter following up duration, or the sample was collected only in one region of Vietnam. This study also had high response (90%) at baseline and high retention rates during the follow up period (85%).

Our study represented the first cohort study in Vietnam focusing on the association between breastfeeding outcomes and maternal factors, especially factors related to

lifestyles during pregnancy such as GDM and physical activity. The participants were also interviewed for a variety of characteristics including social demographic factors, pregnancy outcomes and postpartum maternal and child health to adjust for plausible confounding variables. Investigation of the effects of infant feeding practice (prelacteal feeds and early formula feeds) on infant health was another strength to add into this study. Importantly, breastfeeding data and infant health were recorded prospectively at frequent time points to avoid bias. Standard definitions were adopted to define both exposures and outcome variables.

Although the study has a number of strengths, there are several weaknesses, which need to be considered when interpreting the results. Firstly, participants were recruited from hospitals only, which might introduce some degree of selection bias. There are other mountainous or remote areas with different backgrounds in Vietnam. Therefore, caution should be taken before generalizing our findings to the entire population, due to variations in GDM prevalence, rate of caesarean section, levels of physical activity during pregnancy, rates of hospitalisation and infant diseases. However, for the study objectives focusing on the relationships between maternal risk factors and infant feeding outcomes, such selection bias should be deemed negligible.

Secondly, the self-reporting of physical activities might lead to recall error, but for large sample epidemiological studies such as the present study, self-report questionnaire is still the best approach to assess the habitual physical activity levels during pregnancy. Moreover, the pregnancy physical activity questionnaire is widely used in the literature and had been validated for Vietnamese women. The instrument

was also administered by experienced data enumerators to reduce potential estimation errors.

Data collections were conducted postpartum before hospital discharge at one, three, six and twelve months. Nevertheless, it was not feasible to interview mothers between six and twelve months due to budget constraint, limited resources and the mothers returning to work after six-month maternity leave. Infant health outcomes were reported as "at least one episode since the last interview" (rather than the actual number of episodes), and breastfeeding cessation was the main outcome monitored during this six month period, in order to minimize recall bias.

Lastly, although the follow up period was long when compared to previous studies in the literature, 72% of women still breastfed their baby at twelve months postpartum. The outcome breastfeeding cessation was thus censored for most women. Moreover, due to the low 'exclusive/predominant' breastfeeding rates, the study might lack sufficient power to ascertain the association between maternal factors and the breastfeeding outcomes. However, within the scope of the doctoral study, a longer timeframe in conjunction with a large sample survey was not feasible.

5.3. Implications for future research and health practice

As Vietnam has 54 ethnic groups with more than 90 different dialects, breastfeeding practices might differ from one place to another. To determine the relationship between maternal factors and infant feeding practices, future studies should be conducted in different parts of Vietnam. Comparisons between rural and urban areas

should also be made to clarify the role of maternal factors on breastfeeding practices among different ethnic groups. A longer follow up period and more frequent interviews are required to accurately measure the breastfeeding cessation. To ensure sufficient statistical power for analysing 'exclusive/predominant' breastfeeding data, prospective cohort studies with a larger sample size are recommended.

Interventions on mothers who underwent caesarean section, who were physically inactive or experienced GDM during pregnancy should also be considered in future research. Evaluations of 'exclusive/predominant' breastfeeding education programs should be conducted at regular intervals to increase their prevalence. Finally, more research on GDM and physical activity during pregnancy are recommended as limited information has been available in developing countries. Such studies should adopt standard definitions and measurements for both exposure and outcome variables.

It should be noted that breastfeeding is still an important part of Vietnamese culture and its role in improving maternal and child health has been a focus of the health care system. Therefore, the breastfeeding initiation rate has been high and 'any' breastfeeding duration has been relatively long in Vietnam. However, the increase in early use of infant formula and prelacteal feed remain the causes of low 'exclusive' and 'predominant' breastfeeding rates at discharge. Following the WHO's strict definitions of 'exclusive' and 'predominant' breastfeeding, these rates at later stages could not be improved, even though many Vietnamese families prefer to breastfeed their baby 'exclusively' or 'predominantly' after hospital discharge. More importantly, the study findings suggested the negative impacts of prelacteal feed and early formula

use on longer term infant health and hospitalisation. Since formula milk advertisements are still widespread in the community, health professionals and expecting mothers should be educated concerning the adverse effects of these products. The traditional belief of giving prelacteal foods for newborn as the ritual food should be explained and its practice should be discouraged. Such information should also be a part of the breastfeeding education program. Infant formula should only be administered to newborns if clinically justified.

In addition, mothers usually experience difficulties initiating breastfeeding soon after delivery. Expecting mothers, especially first time mothers, should be encouraged and supported by midwives to establish a breastfeeding bond to the newborn. Low-milk-supply is the common reason for introducing infant formula. Therefore, further supports are important immediately after delivery, in terms of early skin-to-skin contact, breastfeeding initiation, no prelacteal feeds and formula milk, and rooming-in for mother and child. Such interventions might increase the likelihood of 'exclusively' or 'predominantly' breastfeeding since birth. Consequently, the rates of 'exclusively' or 'predominantly' breastfeeding after hospital discharge could be prolonged.

Lastly, given the notably high rates of GDM and caesarean section in Vietnam, policy makers and health professionals should be aware of GDM and caesarean section's implications. Lifestyle change during pregnancy, especially increasing physical activity levels, could be one primary intervention to prevent GDM, which might also improve the breastfeeding outcomes. The present study revealed the association between sedentary lifestyle during pregnancy and shorter breastfeeding duration,

whereas vigorous intensity or occupational activities have little impacts on the lactating outcomes. This is an important finding for Vietnam where the Asian culture of staying inactive during the gestational period still presides. Physical activity recommendations should be a part of the health education for pregnant women, especially those at high risk of developing adverse metabolic conditions such as GDM.

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APPENDICES

Appendix A: Statement of contribution

Statement of Contribution

To Whom It May Concern

This study was part of the large project ***"Maternal lifestyle and nutritional status in relation to pregnancy and child health outcomes: A multicenter prospective cohort study in Vietnam".***

I, **Phung Thi Hoang Nguyen**, contributed to the design of the study and was primarily responsible for managing recruitment and data collection in Ho Chi Minh City as well as cleaning data, entering data and analysing data related to the objectives of this thesis. Major tasks undertaken included:

- Planning the study, including study design, sampling strategy/techniques, data collection instruments
- Translating English version of the data collection instruments into Vietnamese, and validating the questionnaires;
- Pilot testing the instruments i.e. questionnaires, information sheets, measurement instruments, and data collection administrative process;
- Choosing four recruitment sites in Ho Chi Minh City for data collection;
- Obtaining permissions and accompanying documents from the four sites in Ho Chi Minh City for Vietnamese ethics application;
- Providing training to help local staff and research assistants in Ho Chi Minh City develop/improve skills on conducting interviews, recording data, performing measurements, and taking blood tests;
- Conducting interviews with mothers, ensuring the quality of the data and the timeliness of its collection process;
- Answering questions and concerns raised by participants in Ho Chi Minh City via phone or email;
- Entering and primarily cleaning data of Ho Chi Minh City to statistical software;
- Cleaning, double checking, and analysing data of the thesis

Phung Thi Hoang Nguyen Signature: _____ Date: 20/09/2020

By signing below, other contributors endorse that the level of contribution by the candidate indicated above is appropriate.

Yun Zhao Signature: _____ Date: 20/09/2020

Andy H. Lee Signature: _____ Date: 20/09/2020

Colin W. Binns Signature: _____ Date: 20/09/2020

Dat Van Duong Signature: [redacted] Date: 20/09/2020

Dung Van Do Signature: _____ Date: 20/09/2020

Cong Luat Nguyen Signature: _____ Date: 20/09/2020

Tan Khac Chu Signature: _____ Date: 20/09/2020

Anh Vo Van Ha Signature: _____ Date: 20/09/2020

20 November 2019

To Whom It May Concern

I, **Phung Thi Hoang Nguyen**, am the primary contributor for the study design, data collection, data cleaning, and data analysis as well as drafting, writing, and editing of the papers below which are parts of the thesis. The details of my publications are as follows:

1. **Nguyen, P. T. H.,** C. W. Binns, C. L. Nguyen, A. V. V. Ha, T. K. Chu, D. V. Duong, D. V. Do, and A. H. Lee. "Gestational Diabetes Mellitus Reduces Breastfeeding Duration: A Prospective Cohort Study." *Breastfeed Med* 14, no. 1 (Jan/Feb 2019): 39-45. http://dx.doi.org/10.1089/bfm.2018.0112.
2. **Nguyen, P. T. H.,** N. M. Pham, K. T. Chu, D. Van Duong, and D. Van Do. "Gestational Diabetes and Breastfeeding Outcomes: A Systematic Review." *Asia Pac J Public Health* (Mar 4 2019): 1010539519833497. http://dx.doi.org/10.1177/1010539519833497.
3. **Nguyen, P. T. H.,** C. W. Binns, C. L. Nguyen, A. V. Van Ha, K. T. Chu, D. V. Duong, D. V. Do, and A. H. Lee. "Physical Activity During Pregnancy Is Associated with Improved Breastfeeding Outcomes: A Prospective Cohort Study." *Int J Environ Res Public Health* 16, no. 10 (May 16 2019). http://dx.doi.org/10.3390/ijerph16101740.
4. **Hoang Nguyen, P. T.,** C. W. Binns, A. Vo Van Ha, C. L. Nguyen, T. Khac Chu, D. V. Duong, D. V. Do, and A. H. Lee. "Caesarean Delivery Associated with Adverse Breastfeeding Practices: A Prospective Cohort Study." *J Obstet Gynaecol* (Sep 4 2019): 1-5. http://dx.doi.org/10.1080/01443615.2019.1647519.
5. **Nguyen, P.**, C. W. Binns, A. V. V. Ha, T. K. Chu, L. C. Nguyen, D. V. Duong, D. V. Do, and A. H. Lee. "Prelacteal and Early Formula Feeding Increase Risk of Infant Hospitalisation: A Prospective Cohort Study." *Arch Dis Child* (Sep 15 2019). http://dx.doi.org/10.1136/archdischild-2019-316937.

Phung Thi Hoang Nguyen Signature: _____ Date: 20/11/2019

By signing below, the co-authors give their permission to include the aforementioned publications in this thesis and endorse that this level of contribution by the candidate indicated above is appropriate.

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Dat Van Duong	Signature:	Date: 20/11/2019
Dung Van Do	Signature:	Date: 20/11/2019
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I, **Tan Khac Chu**, provided advice on the study design and instruments, implemented data collection, and commented on the manuscripts of the following publications. Phung was responsible for all decisions related to the design and implementation of research, collection and analysis of data, drafting of manuscripts, and interpretation of findings.

Nguyen, P. T. H., C. W. Binns, C. L. Nguyen, A. V. V. Ha, T. K. Chu, D. V. Duong, D. V. Do, and A. H. Lee. "Gestational Diabetes Mellitus Reduces Breastfeeding Duration: A Prospective Cohort Study." *Breastfeed Med* 14, no. 1 (Jan/Feb 2019): 39-45. http://dx.doi.org/10.1089/bfm.2018.0112.

Nguyen, P. T. H., N. M. Pham, K. T. Chu, D. Van Duong, and D. Van Do. "Gestational Diabetes and Breastfeeding Outcomes: A Systematic Review." *Asia Pac J Public Health* (Mar 4 2019): 1010539519833497. http://dx.doi.org/10.1177/1010539519833497.

Nguyen, P. T. H., C. W. Binns, C. L. Nguyen, A. V. Van Ha, K. T. Chu, D. V. Duong, D. V. Do, and A. H. Lee. "Physical Activity During Pregnancy Is Associated with Improved Breastfeeding Outcomes: A Prospective Cohort Study." *Int J Environ Res Public Health* 16, no. 10 (May 16 2019). http://dx.doi.org/10.3390/ijerph16101740.

Hoang Nguyen, P. T., C. W. Binns, A. Vo Van Ha, C. L. Nguyen, T. Khac Chu, D. V. Duong, D. V. Do, and A. H. Lee. "Caesarean Delivery Associated with Adverse Breastfeeding Practices: A Prospective Cohort Study." *J Obstet Gynaecol* (Sep 4 2019): 1-5. http://dx.doi.org/10.1080/01443615.2019.1647519.

Nguyen, P., C. W. Binns, A. V. V. Ha, T. K. Chu, L. C. Nguyen, D. V. Duong, D. V. Do, and A. H. Lee. "Prelacteal and Early Formula Feeding Increase Risk of Infant Hospitalisation: A Prospective Cohort Study." *Arch Dis Child* (Sep 15 2019). http://dx.doi.org/10.1136/archdischild-2019-316937.

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Nguyen, P. T. H., C. W. Binns, C. L. Nguyen, A. V. V. Ha, T. K. Chu, D. V. Duong, D. V. Do, and A. H. Lee. "Gestational Diabetes Mellitus Reduces Breastfeeding Duration: A Prospective Cohort Study." *Breastfeed Med* 14, no. 1 (Jan/Feb 2019): 39-45. http://dx.doi.org/10.1089/bfm.2018.0112.

Nguyen, P. T. H., C. W. Binns, C. L. Nguyen, A. V. Van Ha, K. T. Chu, D. V. Duong, D. V. Do, and A. H. Lee. "Physical Activity During Pregnancy Is Associated with Improved Breastfeeding Outcomes: A Prospective Cohort Study." *Int J Environ Res Public Health* 16, no. 10 (May 16 2019). http://dx.doi.org/10.3390/ijerph16101740.

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Nguyen, P. T. H., C. W. Binns, C. L. Nguyen, A. V. V. Ha, T. K. Chu, D. V. Duong, D. V. Do, and A. H. Lee. "Gestational Diabetes Mellitus Reduces Breastfeeding Duration: A Prospective Cohort Study." *Breastfeed Med* 14, no. 1 (Jan/Feb 2019): 39-45. http://dx.doi.org/10.1089/bfm.2018.0112.

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Appendix C: Baseline questionnaire

Interview Date: _____/_____/_____(DD/MM/YYYY) Interviewer Code:

Hospital code: ☐ Mother identification number: ☐☐☐☐

Mother's name: _____

A. PHYSICAL ACTIVITY

It is very important you tell us about yourself honestly. There are no right or wrong answers. We just want to know about the things you are doing during last month.

During last month, when you are NOT at work, how much time do you usually spend：

A1. Preparing meals (cook, set table, wash dishes)

None.....1
Less than 1/2 hour per day.....2
1/2 to almost 1 hour per day.....3
1 to almost 2 hours per day.....4
2 to almost 3 hours per day.....5
3 or more hours per day..6

A2. Dressing, bathing, feeding children while you are sitting

None.....1
Less than 1/2 hour per day.....2
1/2 to almost 1 hour per day.....3
1 to almost 2 hours per day.....4
2 to almost 3 hours per day.....5
3 or more hours per day.....6

A3. Dressing, bathing, feeding children while you are standing

None....1
Less than 1/2 hour per day.....2
1/2 to almost 1 hour per day..3
1 to almost 2 hours per day 4
2 to almost 3 hours per day 5
3 or more hours per day.....6

A4. Playing with children while you are sitting or standing

None.....1
Less than 1/2 hour per day.....2
1/2 to almost 1 hour per day.....3
1 to almost 2 hours per day.....4
2 to almost 3 hours per day.....5
3 or more hours per day..6

A5. Playing with children while you are walking or running

None.....1
Less than 1/2 hour per day.....2
1/2 to almost 1 hour per day.....3
1 to almost 2 hours per day.....4
2 to almost 3 hours per day.....5
3 or more hours per day..6

A6. Carrying children

None.....1
Less than 1/2 hour per day.....2
1/2 to almost 1 hour per day..3
1 to almost 2 hours per day 4
2 to almost 3 hours per day 5
3 or more hours per day.....6

A7. Taking care of an old adult

None.....1
Less than 1/2 hour per day.....2

A8. Sitting and using a computer or writing, while not at work

None.....1
Less than 1/2 hour per day.....2

A9. Watching TV or a video

None....1
Less than 1/2 hour per day.....2

1/2 to almost 1 hour per day.....3
1 to almost 2 hours per day.....4
2 to almost 3 hours per day.....5
3 or more hours per day..6

1/2 to almost 1 hour per day.....3
1 to almost 2 hours per day.....4
2 to almost 3 hours per day.....5
3 or more hours per day..6

1/2 to almost 2 hour per day..3
2 to almost 4 hours per day 4
4 to almost 6 hours per day 5
6 or more hours per day.....6

A10. Sitting and reading, talking, or on the phone, while <u>not</u> at work
None.....1
Less than 1/2 hour per day.....2
1/2 to almost 2 hours per day.....3
2 to almost 4 hours per day.....4
4 to almost 6 hours per day.....5
6 or more hours per day..6

A11. Playing with pets
None.....1
Less than 1/2 hour per day.....2
1/2 to almost 1 hour per day.....3
1 to almost 2 hours per day.....4
2 to almost 3 hours per day.....5
3 or more hours per day..6

A12. Light cleaning (make beds, laundry, iron, put things away)
None....1
Less than 1/2 hour per day.....2
1/2 to almost 1 hour per day..3
1 to almost 2 hours per day 4
2 to almost 3 hours per day 5
3 or more hours per day.....6

A13. Shopping (for food, clothes, or other items)
None.....1
Less than 1/2 hour per day.....2
1/2 to almost 1 hour per day.....3
1 to almost 2 hours per day.....4
2 to almost 3 hours per day.....5
3 or more hours per day..6

A14. Heavier cleaning (vacuum, mop, sweep, wash windows)
None.....1
Less than 1/2 hour per week.....2
1/2 to almost 1 hour per week.....3
1 to almost 2 hours per week.....4
2 to almost 3 hours per week.....5
3 or more hours per week.....6

Going Places…

During last month, how much time do you usually spend：

A15. Walking <u>slowly</u> to go to places (such as to the bus, work, visiting) <u>Not</u> for fun or exercise
None....1
Less than 1/2 hour per day..2
1/2 to almost 1 hour per day..3
1 to almost 2 hours per day 4

A16. Walking <u>quickly</u> to go to places (such as to the bus, work, visiting) <u>Not</u> for fun or exercise
None.....1
Less than 1/2 hour per day.....2
1/2 to almost 1 hour per day.....3
1 to almost 2 hours per day.....4
2 to almost 3 hours per day.....5

A17. Riding a bicycle to go places (such as the bus, work, or school) <u>Not</u> for fun or exercise
None....1
Less than 1/2 hour per day..2
1/2 to almost 1 hour per day..3
1 to almost 2 hours per day 4

2 to almost 3 hours per day.....5
3 or more hours per day.....6

3 or more hours per day..6

2 to almost 3 hours per day.....5
3 or more hours per day.....6

A18. Driving or riding in a motorbike or bus
None....1
Less than 1/2 hour per day..2
1/2 to almost 1 hour per day..3
1 to almost 2 hours per day.....4
2 to almost 3 hours per day.....5
3 or more hours per day.....6

For Fun or Exercise…

During last month, how much time do you usually spend：

A19. Walking <u>slowly</u> for fun or exercise
None.....1
Less than 1/2 hour per week.....2
1/2 to almost 1 hour per week.....3
1 to almost 2 hours per week.....4
2 to almost 3 hours per week.....5
3 or more hours per week.....6

A20. Walking more <u>quickly</u> for fun or exercise
None.....1
Less than 1/2 hour per week.....2
1/2 to almost 1 hour per week.....3
1 to almost 2 hours per week.....4
2 to almost 3 hours per week.....5
3 or more hours per day..6

A21. Walking <u>quickly up hills</u> for fun or exercise
None....1
Less than 1/2 hour per day.....2
1/2 to almost 1 hour per day.....3
1 to almost 2 hours per day.....4
2 to almost 3 hours per day.....5
3 or more hours per day..6

A22. Jogging
None.....1
Less than 1/2 hour per day.....2
1/2 to almost 1 hour per day.....3
1 to almost 2 hours per day.....4
2 to almost 3 hours per day.....5
3 or more hours per day..6

A23. Prenatal exercise class
None.....1
Less than 1/2 hour per day.....2
1/2 to almost 1 hour per day.....3
1 to almost 2 hours per day.....4
2 to almost 3 hours per day.....5
3 or more hours per day..6

A24. Swimming
None....1
Less than 1/2 hour per day.....2
1/2 to almost 1 hour per day.....3
1 to almost 2 hours per day.....4
2 to almost 3 hours per day.....5
3 or more hours per day..6

Doing other things for fun or exercise? Please tell us what they are.

A25. Dancing

A26. _____
Name of Activity

A27. _____
Name of Activity

None.....1
Less than 1/2 hour per day.....2
1/2 to almost 1 hour per day.....3
1 to almost 2 hours per day.....4
2 to almost 3 hours per day.....5
3 or more hours per day..6

None.....1
Less than 1/2 hour per day.....2
1/2 to almost 1 hour per day.....3
1 to almost 2 hours per day.....4
2 to almost 3 hours per day.....5
3 or more hours per day..6

None....1
Less than 1/2 hour per day.....2
1/2 to almost 1 hour per day.....3
1 to almost 2 hours per day.....4
2 to almost 3 hours per day.....5
3 or more hours per day..6

Please fill out the next section if you work for wages, as a volunteer, or if you are a student. If you are a homemaker, out of work, or unable to work, you do not need to complete this last section.

At work……

During last months, how much time do you usually spend:

A28. Sitting at working or in class

None.....1
Less than 1/2 hour per day.....2
1/2 to almost 2 hours per day.....3
2 to almost 4 hours per day.....4
4 to almost 6 hours per day.....5
6 or more hours per day..6

A29. Standing or slowly walking at work while carrying things (heavier than a 1 gallon milk jug)

None.....1
Less than 1/2 hour per day..2
1/2 to almost 2 hours per day.....3
2 to almost 4 hours per day..4
4 to almost 6 hours per day..5
6 or more hours per day 6

A30. Standing or <u>slowly</u> walking at work <u>not</u> carrying anything

None....1
Less than 1/2 hour per day..2
1/2 to almost 2 hours per day 3
2 to almost 4 hours per day 4
4 to almost 6 hours per day 5
6 or more hours per day.....6

A31. Walking <u>quickly</u> at work while <u>carrying</u> things (heavier than a 1 gallon milk jug)

None.....1
Less than 1/2 hour per day.....2
1/2 to almost 2 hours per day.....3
2 to almost 4 hours per day.....4
4 to almost 6 hours per day.....5
6 or more hours per day..6

A32. Walking <u>quickly</u> at work <u>not</u> carrying anything

None.....1
Less than 1/2 hour per day..2
1/2 to almost 2 hours per day.....3
2 to almost 4 hours per day..4
4 to almost 6 hours per day..5
6 or more hours per day 6

B. EXPOSURE TO CIGARETTE SMOKING

B1.	**Before** you became pregnant, did you smoke?	0 [ ] No *GO TO C3* 1 [ ] Yes	
B2.	On average, how many of the following tobacco products did you smoke per day **before pregnancy**?	Manufactured cigarettes? Hand-roll cigarettes? Pipes full of tobacco? Cigars, cheroots or cigarillos? Number of water pipe sections? Any others? Specify……	……..... per day ……..... per day ……..... per day ……..... per day …… per day ……..... per day
B3.	**While** you are pregnant, do you smoke?	0 [ ] No *GO TO C5* 1 [ ] Yes	
B4.	On average, how many of the following tobacco products do you smoke per day **during pregnancy**?	Manufactured cigarettes? Hand-roll cigarettes? Pipes full of tobacco? Cigars, cheroots or cigarillos? Number of water pipe sections? Any others? Specify……	…… per day …….. . per day ……..... per day ……..... per day ……..... per day ……..... per day
B5.	Did your relatives/people living with you smoke at home **before** you were pregnant?	0 [ ] No 1 [ ] Yes	
B6.	Are your relatives/people living with you smoking at home **while** you are pregnant?	0 [ ] No 1 [ ] Yes	

C. DEMOGRAPHIC INFORMATION

C	Address	
	Number: ; Street: commune:	
	District: ; Province:	
C	Contact numbers (home phone/mobile)	You …...../..... Your husband ……..... Your mother ……... You mother-in-law …….
C	Date of Birth	_____/_____/ _____ (dd/mm/yyyy) …….....years
C	Marital status	0 [ ] Never married 1 [ ] Married/de facto 2 [ ] Widowers/divorced/separated
C	Parity	_____
C	Occupation (before pregnancy)	0 [ ] Farmer 1 [ ] Labour/Manual worker 2 [ ] Office clerk 3 [ ] Teacher 4 [ ] Housewife 5 [ ] Other:……..
C	What is the highest level of education you have completed?	0 [ ] No formal education 1 [ ] Primary school 2 [ ] Secondary school 3 [ ] High school 4 [ ] College/vocational school/University

D. ANTHROPOMETRIC MEASUREMENTS

D1.	Height	___ ___ ___.___	cm
D2.	Weight at first antenatal visit (_____ weeks gestation) [Check medical record]	___ ___ ___.___	kg

THANK YOU VERY MUCH FOR YOUR PARTICIPATION!

Appendix D: Discharge Questionnaire

Interview Date: _____/_____/_____(DD/MM/YYYY) Interviewer Code: ☐☐

Hospital code: ☐ Mother identification numbe ☐☐☐☐

Mother's name: _____

Please inspect the medical record for information in this section

Baby's Date of Birth: _____/_____/_____(DD/MM/YYYY)

Baby's gender: Male.....1 Female.....2 ☐

Baby's birthweight: ___ ___ ___ ___ gram

Gestation: _____weeks _____days

Weight at last examination (delivery day): ___ ___ ___. ___ kilogram

Delivery method: Vaginal delivery without forceps or suction.....1
Vaginal delivery with forceps or suction.....2 ☐
Caesarean section.....3

Did the baby stay at intensive care unit?
No.....0

Yes.....1 (_____days)

Did the baby have any health problems while at hospital? ☐
No.....0
Yes.....1 (Health problems:_____ _____)

Did the mother have any health problems during this pregnancy? ☐
No.....0
Yes.....1
(Complications: _____)

Did the mother have any complications during delivery? ☐
No.....0
Yes.....1
(Complications: _____)

A. BREASTFEEDING INFORMATION

A1. How are you feeding your baby?

Breastfeeding only GO TO QA6.....1
Breastfeeding + (sugar) water.....2 ☐
Mainly breastfeeding but "topping up" with bottle feeding (formula).....3
Mainly bottle feeding (formula) but also breastfeeding.....4
Bottle feeding infant formula or milk.....5
Other (please specify) _____

A2. If you are giving your baby any bottle feeds, how many bottles did your baby have yesterday (24 hours)?

Infant formula (write the brand name) _____ bottles (use 00 if none) brand _____

Other milk (write the brand name) _____ bottles (use 00 if none) brand _____

Glucose water _____ bottles (use 00 if none)

Others (please specify) _____ _____ bottles

A3. If you are only bottle feeding, did you try to breastfeed your baby?

No GO TO QA5 ..... 1 ☐

Yes 2

A4. Why did you change to bottle feeding? (unprompted)

Baby refuses breast ..... 1 ☐

Trouble attaching the baby to the breast 2

Breastfeeding is painful 3

Inverted nipple 4

Not enough breastmilk 5

Other (please specify) _____

A5. If you decided to bottle feed your baby from the start, what were the reasons for this choice? (**You can have more than one answer**)

	NO…0	YES…1
1. Formula is better for the baby		
2. Bottle feeding is easier		
3. I don't like breastfeeding		
4. I will go back to work soon after the birth		
5. Breastfeeding will make my breasts sag		
6. The baby's father prefers bottle feeding		
7. Formula is just as good as breastmilk		
8. The baby's father can help with bottle-feeding		
9. I want to know how much milk my baby has at each feed		
10. My mother or mother-in-law suggested bottle feeding		
11. Friend or relative suggested bottle feeding		
12. Health worker (e.g. doctor, nurse) suggested bottle feeding		
13. Other (please specify)		

A6. When did you **first** decide how you were going to feed your new baby?

Before I became pregnant 1

Early in my pregnancy (< 20weeks gestation) ..... 2 ☐

Late in my pregnancy (≥ 20weeks gestation) 3

During labour 4

After my baby was born 5

A7. Who helped you decide whether you would bottle feed or breastfeed? (**You can have more than one answer**)

	NO…0	YES…1
1. No one		
2. The baby's father		
3. My mother/mother-in-law		
4. Other relatives		
5. Friends		
6. My doctor		
7. Other health professionals e.g., nurse		
8. Midwife		
9. Other (please specify)		

A8. How often are you feeding your baby?

On demand i.e. whenever baby wants to be fed (e.g. cries out in hunger) 1 ☐
By the clock – about every 2 hours 2
By the clock – about every 3 hours 3
By the clock – about every 4 hours 4
Other (please specify) _____

A9. About how long does your baby spend at the breast for a feed?

Baby is bottle feeding 1 ☐
Less than 15 minutes 2
15 minutes to half an hour 3
Half an hour to an hour 4
Over an hour 5
Other (please specify) _____

A10. About how many times per day do you feed your baby? (in a 24 hour period)? …... times

A11. Have you been encouraged by hospital staff to 'demand feed'? ('demand feeding' is feeding whenever the baby wants to feed)?

No 1 ☐
Yes 2

A12. In general, do you think you have had enough help and information about feeding your baby from hospital staff?

Yes 1 ☐
No 2
Do not want to comment 3

A13. Since you have been in hospital, have you received any of the following from hospital staff? (**You may have more than one answer**)

	NO…0	YES…1
1. Pamphlets on breastfeeding baby		
2. Lectures or classes on breastfeeding baby		

3. Demonstrations on how to breastfeed baby		
4. Video (TV) or slides show on how to breastfeed baby		
5. Individual consultation or discussion with any of the staff about breastfeeding baby		
6. Samples of infant formula		
7. Booklets or other information about infant formula		
8. None of the above		
9. Other (please specify)		

A14. Does the baby's father have any preference for how you will feed your baby?

Yes, he prefers bottle feeding 1
Yes, he prefers breastfeeding 2
He doesn't mind how I feed my baby 3
Never really discussed the matter with him 4

A15. Does your mother have any preference for how you will feed your baby?

Yes, she prefers bottle feeding 1
Yes, she prefers breastfeeding 2
She doesn't mind how I feed my baby 3
Never really discussed the matter with her 4

A16. Did your mother breastfeed any of her children?

No 1
Yes 2
Don't know 3

A17. How have your friends fed their babies?

Most of them bottle fed 1
Most of them breastfed 2
Some breastfed and some bottle fed 3
Friends don't have babies 4
Don't know how they fed their babies 5

A18. What was your baby's **first** feed?

Formula 1
Breastmilk (or colostrum) 2
Cow's milk 3
Glucose water 4
Plain water 5
Other (please specify) _____

A19. Did any member of the hospital staff encourage you to put your baby to the breast right after the birth?

No GO TO QA21 1
Yes 2

A20. Who encouraged you to put your baby to the breast right after the birth? (**You can have more than one answer**)

	NO…0	YES…1
1. Doctor		
2. Midwife		
3. Nurse		
4. Other (please specify)		

A21. Since delivery of the baby, did any relatives and/or friends visit you and give you some sugar and formula as a gift?

No 1
Yes, sugar ..... 2 ☐
Yes, milk 3
Yes, formula 4

A22. Is this the first child you have given birth to?

No ..... 1 ☐
Yes GO TO QA24 2

A23. If not, please write how many weeks or months each child was breastfed, or please write bottle fed if bottle fed from birth.

Child	Weeks/months of breastfeeding
_____	_____
_____	_____

A24. When do you plan to first give your baby solids?

Before 2 months 1
Between 2 and 3 months ..... 2 ☐
Between 4 and 6 months 3
Between 7 and 9 months 4
Between 10 and 12 months 5
Over 12 months 6
When baby is ready 7
I don't know 8
Other (please specify)_____

A25. When you leave the hospital, who will you contact if you have problems with feeding your infant? (**You can have more than one answer**)

	NO…0	YES…1
1. Doctors at district/provincial hospitals		
2. Health workers at Commune Health Centre		
3. Village health workers		
4. Women Union activists		
5. Mother/mother-in-laws		
6. Other close relatives		
7. Friends		

8. Neighbours		
9. Other (please specify)		

A26. Have any of the following people supported or encouraged you with breastfeeding? (**You can have more than one answer**)

	NO…0	YES…1
1. Your friends		
2. The baby's father		
3. Other members of your family		
4. Your clinic sister		
5. Your doctor		
6. Nursing Mother's Association		
7. Your mother		
8. Your mother-in-law		
9. Other (please specify)		

The following questions are for mothers who are breastfeeding. If the woman is not breastfeeding at all, please go to Section B.

A27. How long after birth was it before you put your new baby to the breast?

Immediately after birth, cord still attached 1
Within 15 minutes 2
Between 15 and 30 minutes 3
Between 30 minutes and 1 hour 4
Within a few hours 5
The next day 6
Baby was given a bottle instead 7
Other (please specify) _____ ☐

A28. How long was it before your milk came in?

Within one day of the birth 1
The second day after the birth 2
The third day after the birth 3
Still waiting for milk to come in 4
Other (please specify) _____ ☐

A29. Did any staff member check how your baby's mouth was attached to your breast when you first started feeding?

No 1
Yes 2
Didn't need to be checked ..... 3 ☐

A30. Did any staff member teach you how to position and attach your baby to the breast?

No 1
Yes 2
I didn't need to be taught ..... 3 ☐

A31. Why did you decide to breastfeed? (**You can have more than one answer**)

	NO…0	YES…1
1. The baby's father wanted me to breastfeed		
2. Breastmilk is better for the baby		
3. Breastfeeding is the right thing to do		
4. Breastfeeding is cheaper		
5. Breastfed babies are more intelligent		
6. Breastfeeding helps me lose weight		
7. Breastfeeding is fashionable		
8. My mother /mother-in-law advised me to breastfeed		
9. Other people advised me to breastfeed		
10. Breastfeeding helps prevent allergies		
11. Breastfeeding is more convenient		
12. Other (please specify)		

A32. At what age do you plan to stop breastfeeding your baby?

Before the baby is 6 weeks old 1
Between 6 weeks and 2 months 2
Between 2 and 3 months 3
Between 4 and 6 months 4
Between 7 and 9 months 5
Between 10 and 12 months 6
Over 12 months 7
Other (please specify) _____

A33. Are you planning to start giving your baby formula feeds?

No GO TO QA35 1
Yes 2
I have already started my baby on formula GO TO QA35 3

A34. At what age do you plan to start giving your baby formula feeds?

Before baby is 6 weeks old 1
Between 6 weeks and 2 months 2
Between 2 and 3 months 3
Between 4 and 6 months 4
Between 7 and 9 months 5
Between 10 and 12 months 6
Over 12 months 7
Other (please specify) _____

A35. Have you experienced any of the following since you started breastfeeding? **(You can have more than one answer)**

	NO…0	YES..1
1. Inverted nipples		
2. Cracked or sore nipples		
3. Baby gets too much milk		
4. Baby gets milk too fast		

5. Takes a long time before milk starts flowing at start of feed		
6. Baby too tired to feed		
7. Difficulty expressing milk		
8. Baby not gaining enough weight		
9. Baby has problems sucking		
10. Breast engorged (too full)		
11. Baby doesn't wake up for feeds		
12. Not enough milk or colostrum for baby		
13. Feeling that I'm not doing very well at breastfeeding		
14. Trouble positioning and/or attaching the baby to the breast		
15. Other (please specify)		

THANK YOU VERY MUCH FOR YOUR PARTICIPATION!

Contact numbers (home phone/mobile)	You …...../..... Your husband ……..... Your mother ……... Your mother-in-law...…….

Appendix E: Following-up Questionnaire (1, 3, 6, 12 months postpartum)

Interview Date: _____/_____/_____(DD/MM/YYYY) Interviewer Code:

Health institution code: ☐ Mother identification ☐☐☐

Mother's name: _____ Baby's Date of Birth: _____/_____/_____

A. BREASTFEEDING INFORMATION

A1. In the last interview, the feeding method I observed was: (**Interviewer fills this question**)

Breastfeeding only 1
Breastfeeding + (sugar) water 2
Breastfeeding + juice ..... 3 ☐
Mainly breastfeeding but "topping up" with bottle feeding (formula) 4
Mainly bottle feeding (formula) but also breastfeeding 5
Bottle feeding infant formula or milk 6
Other (please specify) _____

A2. How are you feeding your baby now?

Breastfeeding only 1
Breastfeeding + (sugar) water 2
Breastfeeding + juice ..... 3 ☐
Mainly breastfeeding but "topping up" with bottle feeding (formula) 4
Mainly bottle feeding (formula) but also breastfeeding 5
Bottle feeding infant formula or milk 6
Other (please specify) _____

A3. Is the way the mother feed the baby the same as that in last interview?

No 1
Yes GO TO QA5 ..... 2 ☐

a. If you have changed the feeding method, why? _____
b. How old was the baby when you changed? _____months_____weeks
c. What is/are the change(s)?

	NO…0	YES…1
1. Started solids		
2. Started formula		
3. Started other milk		
4. Others:		

A4. Did anyone help you decide to change in feeding practices? If yes, who?

	NO…1	YES…1
1. No one, I decided myself		
2. Yes, the baby's father		
3. Yes, my mother/mother-in-law		
4. Yes, other relatives		
5. Yes, friends		

6. Yes, commune Health workers		
7. Yes, hospital staff		
8. Yes, private health workers		
9. Yes, others:		

A5. Are you feeding by the clock or by demand?

Demand 1
Clock - ~ 2 hours ..... 2 ☐
Clock - ~ 3 hours 3
Clock - ~ 4 hours 4
Other (please specify) _____

A6. How many times per day on average do you feed your baby (24 hours) [If given range, average to one decimal place (0 or 5)] _____times

A7. How many times per day on average do you feed your baby between the hours of 10.pm and 6.00 am? [If given range, average to one decimal place (0 or 5)] _____times

A8. What is the average length of each feeding episode?

< 15 minutes 1
≥ 15 and but < 30 minutes ..... 2 ☐
≥ 30 minutes but < 1 hour 3
≥ 1 hour 4

A9. After you stop feeding, what is the average length of time before the baby wants another feed?

< 30 minutes 1
≥ 30 minutes but < 1 hour ..... 2 ☐
≥ 1 hour but < 2 hours 3
≥ 2 hours but < 3 hours 4
≥ 3 hours but < 4 hours 5
≥ 4 hours 6

A10. Has your baby used any of the following since last interview?

	NO…1	YES…1
1. Pacifier		
2. Bottle		
3. Feeding spoon		
4. None of the above		

The following questions are for mothers who are breastfeeding. If the woman is not breastfeeding at all, please go to Section B.

A11. What difficulties have you experienced since I spoke to you last time? **(unprompted, but probe for more than one answer)**

	NO…0	YES…1
Problems with breasts		
1. Cracked or sore nipples		

2. Breast engorged (too full)		
3. Inverted nipples		
4. Breastfeeding is painful		
Problems with baby feeding		
5. Baby not gaining enough weight		
6. Baby has difficulties sucking		
7. Baby gets too much milk or too fast		
8. Poor 'let-down'		
9. Baby refuses to breastfeed		
10. Baby too tired to feed i.e. falls asleep at breast		
11. Feeling that I'm not doing very well at breastfeeding		
12. Not enough milk for baby		
13. Other breastfeeding problems (please specify)		

A12. Have you experienced a painful, red and swollen area on breasts since last interview?

No GO TO QA17 ..... 1 ☐

Yes 2

A13. Have you had the following symptoms that **last at least 24 hours** while you were experiencing a painful, red, swollen area on breasts? (**You can have more than one answer**)

	NO…0	YES…1
1. An elevated temperature (either estimated or measured as being ≥ 38°C)		
2. Body aches		
3. Headaches		
4. Chills		
5. None of the above		

A14. Were you diagnosed with mastitis from a doctor while you were experiencing a painful, red, swollen area on breasts?

No GO TO QA17 ..... 1 ☐

Yes 2

A15. Have you received any advice from a health professional for mastitis management when diagnosed with mastitis?

No GO TO QA17 ..... 1 ☐

Yes 2

A16. What advice did you receive from a health professional for the management of mastitis? (**You can have more than one answer**)

	NO…0	YES…1
1. Feed frequently from the affected breast		
2. Feed the affected breast first, then the other breast		
3. Express milk between feeds or when infant not interested in feeding		
4. Do NOT stop breastfeeding		
5. Discontinue feeding from the affected breast		

6. Stop breastfeeding		
7. Other (please specify)		

A17. Have you worn a tight bra since last interview?

No 1
Yes, occasionally / less often than weekly 2
Yes, at least weekly (not daily) 3
Yes, daily 4

A18. Have you felt tired or stressed since last interview?

Never ..... 1 Seldom 2
Sometimes ..... 3 Often 4

A19. Do you empty the breast regularly? (i.e. by feeding the baby or expressing the milk)

No ..... 1 Seldom 2
Sometimes ..... 3 Often 4

A20. Since last interview, what methods have you used to express your milk?

No, I do not express my milk ..... 1 Hand express 2
Manual pump ..... 3 Electric pump 4

A21. How many times, on average, do you breastfeed your baby or express your milk between the hours of 10.00 pm and 6.00 am? _____ times

B. TERMINATION OF BREASTFEEDING ONLY

If still breastfeeding or stopped breastfeeding before last interview, no need to complete this section

B1. How old was your baby when you stopped breastfeeding? _____ months _____ weeks

B2. Why did you decide to stop breastfeeding? _____

B3. Did anyone advise you to stop breastfeeding?

No ..... 0 Yes ..... 1 (Who? _____)

B4. Did you plan to stop breastfeeding when you did? No ..... 0 Yes 1

B5. Were you disappointed for not breastfeeding for longer? No ..... 0 Yes 1

B6. Do you feel guilty for not breastfeeding for longer? No ..... 0 Yes 1

B7. Have other people made you feel guilty for not breastfeeding longer?

No ..... 0 Yes 1

B8. Would you breastfeed another child if you had another baby?

No ..... 0 Yes ..... 1 Yes, if I could 2

Why? _____

C. HEALTH OF INFANT

C1. Has your baby experienced any hospital admission since I spoke to you last time?

No 0
Yes ..... 1 ☐

C2. Has your baby experienced any health problem since I spoke to you last time, what is/are the health problem(s)?

	NO…0	YES…1
1. Lower respiratory tract infection		
2. Diarrhoea		
3. Other infant health problems		

Lower respiratory tract infection: *at least one specific lower respiratory tract sign (fast or difficulty breathing, chest wall indrawing) and/or abnormal auscultatory findings (crackles/crepitations or bronchial breath sounds)*

Diarrhoea: *the passage of 3 or more loose or liquid stools per day, or more frequently than is normal for the individual*

C3. Did you take your baby to see any health professionals regarding this problem?

No GO TO QC7 0
Yes ..... 1 ☐

C4. If YES, who did you take your baby to?

	NO…0	YES…1
1. General practitioner in community health centre		
2. Doctor in hospital		
3. Private practitioner		
4. Other (Please specify)		

C5. Total number of visits to health professionals since last interview? _____ ___Times

C6. Total days of hospitalisation since last interview? _____Times

C7. How do you feel about your baby's weight change since last interview?

Satisfied/pleased 1
A little concerned ..... 2 ☐
Very concerned 3
Don't know 4

THANK YOU VERY MUCH FOR YOUR PARTICIPATION!

Contact numbers (home phone/mobile)	You …...../..... Your husband ……..... Your mother ……... Your mother-in-law...…….

Appendix F: Ethic Approval 1

MEMORANDUM

Curtin University

To:	Prof Andy H Lee Public Health
CC:	
From	Professor Peter O'Leary, Chair HREC
Subject	Ethics approval Approval number: HR32/2015
Date	16-Feb-15

Office of Research and Development
Human Research Ethics Office

TELEPHONE 9266 2784
FACSIMILE 9266 3793
EMAIL hrec@curtin.edu.au

Thank you for your application submitted to the Human Research Ethics Office for the project: 4873

Maternal lifestyle and nutritional status in relation to pregnancy and child health outcomes: A multi-centre prospective cohort study in Vietnam.

Your application was reviewed by Human Research Ethics Committee at Curtin University at their meeting on the 9/12/2014

Thankyou for providing the additional information requested by the Human Research Ethics Committee. The information you provided was satisfactory and your proposal is now approved.

Please note the following conditions of approval:

1. Approval is granted for a period of four years from **17-Feb-15** to **17-Feb-19**
2. Research must be conducted as stated in the approved protocol.
3. Any amendments to the approved protocol must be approved by the Ethics Office.
4. An annual progress report must be submitted to the Ethics Office annually, on the anniversary of approval.
5. All adverse events must be reported to the Ethics Office.
6. A completion report must be submitted to the Ethics Office on completion of the project.
7. Data must be stored in accordance with WAUSDA and Curtin University policy.
8. The Ethics Office may conduct a randomly identified audit of a proportion of research projects approved by the HREC.

Should you have any queries about the consideration of your project please contact the Ethics Support Officer for your faculty, or the Ethics Office at hrec@curtin.edu.au or on 9266 2784. All human research ethics forms and guidelines are available on the ethics website.

Yours sinc

Professor
Chair, Human Research Ethics Committee

Appendix G: Ethic Approval 2

MINISTRY OF HEALTH
HAIPHONG UNIVERSITY OF MEDICINE AND PHARMACY

SOCIALIST REPUBLIC OF VIETNAM
Independence-Freedom-Happiness

No: 05 /HPUMPRB
Issue: Approval of HPUMPRB

CERTIFICATE OF APPROVAL

Basing on the Decision No. 580A/QD-YHP on June 22nd 2012 by The Rector of Haiphong Medical University on the foundation of the HPMU Review Board and secretariat for reviewing the ethical issues in Bio-medical researches;

Basing on the Decision No. 2153/2013/QĐ-TTg on November 11th 2013 by Prime Minister on rename of Haiphong Medical University to Haiphong University of Medicine and Pharmacy.

Basing on the Agreed Minutes (enclosured) of the Haiphong University of Medicine and Pharmacy Review Board (HPUMPRB) and the ratification and assessment committee on August 20th 2015.

HAIPHONG UNIVERSITY OF MEDICINE AND PHARMACY
REVIEW BOARD (HPMURB)
IN BIO-MEDICAL RESEARCH

approves the ethical issues of the following research proposal:

- Research title: ***Maternal lifestyle and nutritional status in relation to pregancy and child health outcomes: A multi-centre prospective cohort study in Viet Nam***
- Principal Investigators: ***Prof. AnDy Lee***
  Chu Khac Tan, MD
  Nguyen Cong Luat, MD
  Nguyen Hoang Phung, MD
  Ha Vo Van Anh, MD
- Research Institution: ***Curtin University, Australiaa***
- Site for research: Vietnam
- Research Period: From August 2015 to December 2017

Date of approval: August 25th, 2015

IRB Chair
Haiphong University of Medicine and Pharmacy

Assoc.Prof. Tran Quang Phuc, M.D, PhD

Rector
Haiphong University

Prof. Pham Van Thuc, M.D, PhD

Appendix H: Information Letter

School of Public Health
GPO Box U 1987
Perth, WA 6845, Australia

Project title:

Infant Feeding Practices and Maternal Factors in Vietnam: A Prospective Cohort Study

A PhD student from the School of Public Health at Curtin University is conducting research into maternal and child health in Vietnam. The purpose of this study is to investigate infant feeding practices, and maternal factors affecting breastfeeding duration.

In this project, we interview pregnant women of last trimester gestation. We are interested to find out your lifestyle such as cigarette smoking and physical activity during pregnancy. We will also ask you several questions regarding your health status and demographic details. The initial interview will take about 30 minutes to complete. We would like to measure your weight, height to check your health status. We will collect your blood samples to examine your gestational diabetes status. We will also check your medical records to collect additional information about your health during pregnancy and after childbirth.

After your delivery, an assistant researcher will contact you to ask you some further questions about your health and your baby's health, as well as feeding methods used before hospital discharge. The weight and length of your infant will be measured at discharge from hospital. Similar follow up interviews will be conducted at 1 month, 3 months, 6 months, and 12 months after delivery.

Your participation in this research is completely voluntary. You can refuse any specific question that you are uncertain or find it difficult to answer. During the initial or follow up interviews, if you decide to withdraw from the study, please feel free to do so because there will be no negative consequences.

After you have signed the enclosed consent form, we will assume that you have agreed to participate, and you allow us to use your data in this research project. The information you provided will be kept strictly confidential, and your identity will remain anonymous. Only aggregated and de-identified data from all participants will be analysed and reported.

Please be assured that the information you provided will only be accessed by the chief investigators of this project, and not anyone else. In particular, it will not be released to the medical staff and authority of the maternity hospital. Your completed questionnaire and other documents will be kept in a locked cabinet at Curtin University for seven years before being destroyed.

This study has been approved by the Curtin University Human Research Ethics Committee (Approval Number HR32/2015). The Committee is comprised of members of the public, academics, lawyers, doctors and pastoral carers. 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, 6845 or by telephoning +61-8-9266 9223 or by emailing hrec@curtin.edu.au

If you have any concern or questions about this study, please contact the following project staff:

- Nguyen Thi Hoang Phung, Project officer and PhD student, on +84909358909 or phung.nguyen@postgrad.curtin.edu.au
- Professor Andy Lee, Main supervisor, on +61 8 92664180 or andy.lee@curtin.edu.au
- Professor Colin Binns, Co-supervisor, on +61 8 92662952 or c.binns@curtin.edu.au
- Associate Professor Do Van Dung, Associate supervisor, on +84918382253 or dovandzung@ump.edu.vn
- Dr. Dat Van Duong, Associate supervisor, on +84913204461 or dat@unfpa.org

Thank you very much for your cooperation.

Appendix I: Consent Form

Project title:

Infant Feeding Practices and Maternal factors in Vietnam: A Prospective Cohort Study

You have been invited to participate in this study because you are a pregnant woman in the last trimester of gestation and aged ≥ 18 years. Please read the information document carefully and ask any questions you wish. Do not sign this informed consent form unless you fully understand the nature of the study and the commitment you may need to make over the next two years.

I, ..., agree to participate in the above study. I have read and understood the Information Letter given to me. I understand the requirements for participation in this study. I have been given the opportunity to ask questions about the study. I fully understand that my participation is voluntary. I may withdraw from the study at any time without any negative consequences.

Signed ..... Date .....

Name of witness ……

Signature of witness ..... Date .....

Address and contact numbers (home phone/mobile)	Address: No.: …… Street/Hamlet: ……..…..…… Commune/Ward: ……..……..… Phone: You …..... Your husband …….... Your mother ……..…..... Your mother-in-law ...……...…….

Appendix J: Cohort Profile Paper

Open Access Cohort profile

BMJ Open

Cohort profile: maternal lifestyle and diet in relation to pregnancy, postpartum and infant health outcomes in Vietnam: A multicentre prospective cohort study

Cong Luat Nguyen,[1] Phung Thi Hoang Nguyen,[2] Tan Khac Chu,[3] Anh Vo Van Ha,[4] Ngoc Minh Pham,[5] Dat Van Duong,[6] Dung Van Do,[2] Hong Kim Tang,[4] Colin W Binns,[7] Andy H Lee[7]

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For numbered affiliations see end of article.

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ABSTRACT

Purpose To determine modifiable maternal risk factors for adverse pregnancy, postpartum maternal and child health outcomes in Vietnam.

Participants This prospective cohort study included pregnant women seeking prenatal care at six hospitals in three large cities in Vietnam. After enrolment, eligible participants who gave their consent to participate in the study were interviewed at 24–28 weeks' gestation. Glucose testing was conducted and blood pressure was measured during this period. Each participant will be assessed prospectively during their postnatal visits at delivery, 1, 3, 6, 12, 18 and 24 months, and will be followed up for 5 years.

Findings to date Of 2248 eligible pregnant women, 2030 were recruited (participation rate 90.3%) between August 2015 and July 2016. All participants completed the baseline assessment. Their mean (SD) age was 27.6 (5.3) years. The mean pre-pregnancy body mass index (BMI) was 20.2 (SD 2.6) kg/m^2, with nearly two-thirds of participants having a normal pre-pregnancy BMI (18.5 to <23.0 kg/m^2) and one-quarter being underweight (pre-pregnancy BMI <18.5 kg/m^2). Overweight or obese mothers (pre-pregnancy BMI ≥23.0 kg/m^2) accounted for 12.8%. No pregnant women reported smoking during their pregnancy while 13.4% of them had continued drinking. 22.8% of participants had hyperglycaemia. Their mean systolic blood pressure was 105.6 (SD 8.2) mm Hg, and diastolic blood pressure was 67.4 (SD 7.5) mm Hg.

Future plans The relationships of maternal lifestyle and nutritional status with the health outcomes of pregnancy, postpartum maternity and infants will be analysed. Meanwhile, participants will be closely tracked to minimise loss to follow-up.

Strengths and limitations of this study

- This is the first multicentre, prospective cohort study of maternal and child health in Vietnam, with a large sample size over a relatively long period of follow-up.
- The study investigates multiple modifiable maternal risk factors for adverse pregnancy, postpartum maternal and child health outcomes in Vietnam.
- All questionnaires used for data collection have been validated for Vietnamese people.
- Potentially high rates of loss to follow-up in more affluent settings.
- Lack of participants from rural and remote areas.

INTRODUCTION

Pregnancy and the first 2 years after giving birth are critical periods for mother and child health. Maternal lifestyle and dietary intake are known to be associated with metabolic disorders, such as gestational diabetes mellitus (GDM). These conditions increase the risk of adverse pregnancy and infant health outcomes.[1 2] In particular, overeating or sedentary behaviour during pregnancy has been positively associated with a risk of GDM.[3–6] Development of maternal GDM increases the risk of adverse health in mothers (gestational hypertension and pre-eclampsia, subsequent type 2 diabetes),[2] in infants (stillbirth, macrosomia, neonatal hypoglycaemia)[7] and in children (obesity, diabetes, hypertension and cardiovascular diseases).[8]

Vietnam is a middle-income country in Southeast Asia with a population of over 90 million.[9] It is undergoing epidemiological transition. A high burden of infectious diseases remains and the prevalence of chronic non-communicable diseases is increasing. The prevalence of overweight and obesity (BMI ≥23.0 kg/m^2) among Vietnamese adults has risen from 11.7% to 16.3% between 2000 and 2005.[10] The prevalence of GDM is reported to range from 6.1% to 20.3%, and women with GDM tend to deliver

preterm. Thus the newborns have a higher incidence of neonatal hypoglycaemia, and labour induction is more prevalent.[11] Although breastfeeding has significant benefits for infants and mothers,[12] many Vietnamese people underestimate its advantages. The rate of exclusive breastfeeding during the first 6 months of life is low and decreased from 25.0% in 2000 to 17.0% in 2011.[13] Notably, mothers with hyperglycaemia during pregnancy tend to have a high rate of exclusive breastfeeding cessation.[14]

Few prospective cohort studies of mothers and their infants have been conducted in Vietnam,[11 15–17] and the few which are underway are being carried out in single provinces with limited outcomes being investigated. Moreover, the available data on the relationship between maternal lifestyle, nutrition and adverse pregnancy, postpartum and child health outcomes are sparse. This research is the first multicentre prospective cohort study, representative of the Vietnamese population, which investigates broad aspects of modifiable maternal risk factors and their health consequences. The main objectives of this study are:

1. To investigate the lifestyle, nutritional and metabolic status of pregnant women in Vietnam, including physical activity, smoking, alcohol drinking, dietary intake, pre-pregnancy body mass index (BMI) and gestational weight gain.
2. To ascertain the impact of aforementioned maternal factors on (a) obstetric complications (eg, GDM, pre-eclampsia, pregnancy-induced hypertension); (b) pregnancy outcomes (eg, preterm delivery, caesarean section, low birth weight, macrosomia and postpartum haemorrhage) and (c) postpartum maternal and child health.
3. To examine the association between breastfeeding and (a) maternal metabolic conditions, including GDM; (b) postpartum maternal and infant health status.
4. To determine the relationship between antenatal and postnatal depressive symptoms and (a) pregnancy and birth outcomes; (b) breastfeeding intention and initiation; (c) the intensity and duration of breastfeeding; (d) infant care and adverse home events; (e) postpartum maternal and infant health status.

COHORT DESCRIPTION

Study settings

This ongoing prospective cohort study is conducted in three cities of Vietnam—namely, Ha Noi, Hai Phong and Ho Chi Minh cities. Ha Noi is the capital of Vietnam located in the north while Ho Chi Minh City is the largest and most industrialised city in the south. Hai Phong is a coastal city, located in the Red River delta. For Ha Noi and Hai Phong cities, one suburban district from each city was selected—the Dong Anh and Vinh Bao districts, respectively. Dong Anh has 23 communes and one town with a population of over 300 000 people.[18] Vinh Bao is a coastal district comprising 29 communes and one town with over 180 000 people.[19] For Ho Chi Minh City, two typical urban districts (Tan Phu district and District 2) and one typical suburban district (Hoc Mon district) were chosen. Tan Phu (16.1 km^2) has 11 wards with a population of over 464 000 people while District 2 (49.7 km^2) consists of 11 wards and about 147 000 people.[20] Hoc Mon (109.2 km^2) comprises one town and 11 communes with a population of approximately 422 000 people.[20] Each district has one district hospital that provides healthcare for the majority of its citizens in the catchment areas. Moreover, some pregnant women from Tan Phu, Hoc Mon and District 2 may directly visit Hung Vuong Hospital, a large provincial obstetric hospital, especially if their pregnancies have complications. Therefore, Hung Vuong Hospital was also selected to obtain details of participants from these three districts. A total of six hospitals participated in the study. Figure 1 shows the location of the centres and districts involved in the study.

Participants and eligibility criteria

Participants were pregnant women who satisfied the following criteria: (1) permanent residents in the study locations; (2) ≥18 years of age; (3) at 24–28 weeks' gestation; (4) singleton pregnancy; (5) not having a serious pre-existing health condition, such as cancer, ischaemic heart disease according to information from their medical doctors; (6) able to read the information sheet and sign the consent form.

Sample size

The sample size calculation was based on testing the hypothesis that mothers with gestational hyperglycaemia (primary exposure) have a lower rate of exclusive breastfeeding at 3 months post partum (primary outcome). Assuming that 20% of participants would have gestational hyperglycaemia diagnosed at 24–28 weeks of gestation,[21] and that the rates of exclusive breastfeeding at 3 months post partum among mothers with prior gestational hyperglycaemia and those without are 42% and 52%, respectively,[14] a minimum sample size of 1662 is required to attain 90% power to detect an expected OR of 0.7[14] between the two groups[22] at 5% level of significance. We assumed a further 20% attrition, owing to withdrawal or subsequent loss to follow-up, and thus 2000 pregnant women were targeted for recruitment. Based on the population of three centres,[23] the subsample sizes assigned to Ha Noi, Hai Phong and Ho Chi Minh City were 900, 300 and 800, respectively. Participants were consecutively recruited from the three centres until their desired sampling quotas were reached.

Data collection

Baseline and postpartum follow-ups of study participants are currently being implemented. The study procedure is summarised in figure 2.

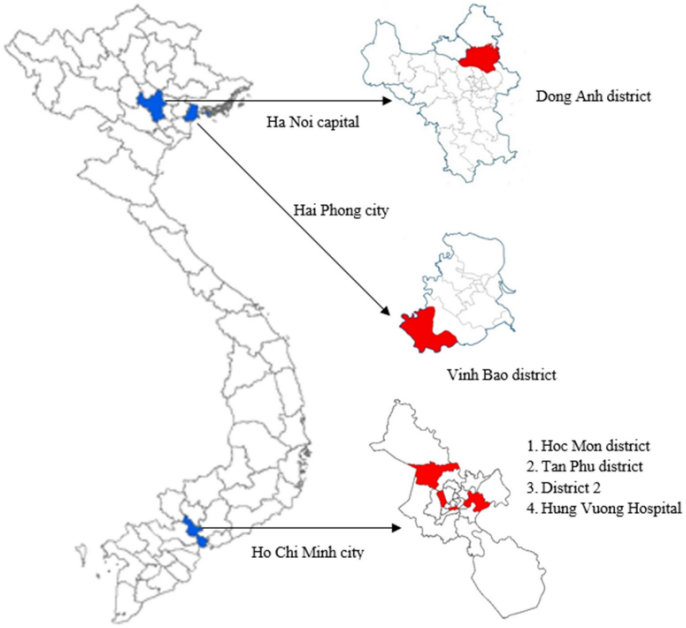

Figure 1 The location of study centres.

Recruitment

Recruitment began in August 2015 and ended in July 2016. During that period, all pregnant women from the participating hospitals were consecutively approached and invited to participate in the study if they met the eligible criteria. According to the Vietnam 2014 Multiple Indicator Cluster Survey, nearly 94% of the pregnant women delivered in hospitals.[24] Gestational age was determined using ultrasound during the first trimester and was available from medical records. A total of 2248 pregnant women who met the inclusion criteria were invited, 218 (9.7%) refused participation, and 2030 (90.3%) consented to take part in the study. No significant difference in mean age was found between participants and non-participants (p=0.991).

Baseline interview at 24–28 gestation weeks

After enrolment, pregnant women were interviewed face to face by trained personnel to obtain detailed information on demographic and personal characteristics, dietary intakes, lifestyle habits including physical activity, cigarette smoking and alcohol drinking, antenatal depressive symptoms and attitudes to breastfeeding. Standard or validated questionnaires for Vietnamese adults were used to collect information.

Dietary assessment

The Food Frequency Questionnaire for Vietnamese adults was applied to investigate habitual diet.[25] It consists of various food and beverage items grouped into categories, with frequencies and quantities consumed recorded in detail. The frequency recorded is either per day, per week, per month or never, with a standard portion or utensil defined for each food/beverage item listed.

Physical activity assessment

The Pregnancy Physical Activity Questionnaire (PPAQ) was used to examine physical activity.[26] The PPAQ measures the duration, frequency and intensity of physical activity during pregnancy. It is a semiquantitative questionnaire that asks about the time spent participating in 32 activities, including household/caregiving (13 activities), occupational (five activities), sports/exercise (eight activities), transportation (three activities) and inactivity (three sedentary activities). For each activity, respondents are asked to select a category with the closest amount of time spent per day or per week. The possible duration ranged from 0 to 6 or more hours a day. An open-ended section is appended to allow listing of additional activities not covered.

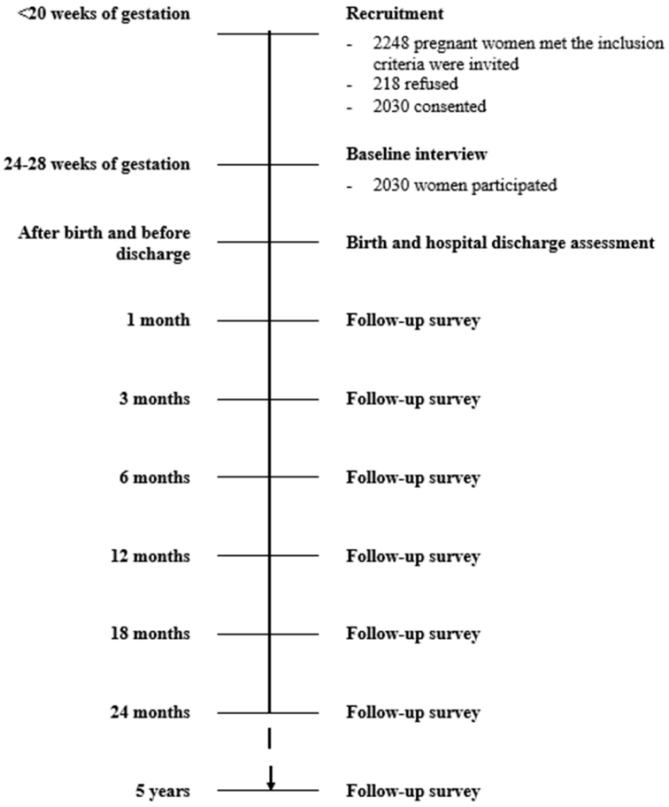

Figure 2 Recruitment and interview schedule planned.

Maternal depressive symptoms assessment

The Edinburgh Postnatal Depression Scale (EPDS) was used.[27] EPDS is a self-administered questionnaire widely used for research into antenatal and postnatal depressive symptoms to explore a woman's feelings within the past 7 days during the antenatal or postnatal period. It comprises 10 items rated on a four-point scale (from 0 to 3), reflecting the degree of agreement, with the total score ranging from 0 to 30.

Assessment of attitude to infant feeding

The Iowa Infant Feeding Attitude Scale was applied to study the breastfeeding attitudes of pregnant women.[28–30] It contains 17 items with a five-point Likert scale, ranging from 1 (strongly disagree) to 5 (strongly agree). Approximately half the items are worded favourably towards breastfeeding and the remaining items favour formula feeding. Items favouring formula feeding are reverse-scored and a total score is computed by summing all items. Total attitude scores range from 17 to 85, with higher scores reflecting attitudes more positive towards breastfeeding. Total scores are grouped into three categories: positive towards breastfeeding (70–85), neutral (49–69) and positive towards formula feeding (17–48).

Assessment of smoking and alcohol drinking

Information on cigarette smoking and consumption of alcohol was acquired using WHO STEPS questions.[31]

Anthropometric assessment

Anthropometric measurements were made during the baseline interview. A digital scale was used to record weight to the nearest 100 g. Height was measured using a stadiometer to the nearest 1 mm. Data on pre-pregnancy weight, retrieved from medical records, were likely to be self-reported. Total gestational weight gain was estimated by subtracting the early first trimester weight from the last measured weight before delivery. Maternal BMI was

calculated using weight and height recorded at baseline (kg/m^2).

Clinical assessment

To determine maternal glucose-metabolic status, all pregnant women were required by the participating hospitals to undergo a 75 g oral glucose tolerance test between 24 and 28 weeks of gestation; three blood samples were collected at fasting, 60 and 120 min. Confirmation of gestational diabetes mellitus was based on the 2013 diagnostic criteria of the World Health Ogarnization.[32] To determine gestational hypertension, blood pressure was measured at the same time as the glucose tolerance test by qualified nurses or physicians using an Omron M5-1 electronic sphygmomanometer according to the WHO procedure. Participants were required to take a short rest (15 min), sitting, feet supported on a flat surface and arm supported at heart level. Two consecutive measurements were taken 3 min apart and a mean value was obtained. WHO diagnostic criteria for gestational hypertension were used.[1] Information on pre-eclampsia was obtained from medical records. Details of obstetric complications during pregnancy were extracted from medical records.

Birth and hospital discharge assessment

At the time of delivery, details including obstetric and neonatal outcomes (eg, type of delivery, Apgar scores, problems/complications, intensive care treatment and length of hospital stay) will be recorded. Infants will be weighed to the nearest 10 g on an electronic scale immediately after birth. Length at birth will be measured on an infantometre. Other physical characteristics, such as head, abdominal and mid upper-arm circumference, will be measured within 72 hours after birth to the nearest 0.1 cm using a standardised measuring tape.

Mothers will be asked about breastfeeding initiation, prelacteal feeds (if any) and breastfeeding self-efficacy at this time using a standardised breastfeeding questionnaire[15 33] and the Breastfeeding Self-Efficacy Scale (BSES).[30] The BSES is a 33-item, self-report instrument developed to measure breastfeeding confidence. The items are preceded by the phrase 'I can always' and anchored with a five-point Likert scale, where 1=not at all confident and 5=always confident. All items are presented positively, and scores are summed to produce a range from 33 to 165. A higher score indicates a stronger confidence in breastfeeding. They will be also interviewed about depressive symptoms using the EPDS.

Follow-up surveys

All mothers will be assessed during their postnatal visits at delivery, 1, 3, 6, 12, 18 and 24 months post partum. Detailed information on infant feeding practices, infant illnesses, anthropometrics, maternal depressive symptoms, maternal diet and physical activity, and other health problems of both mothers and infants will be sought at subsequent follow-ups of the cohort. The follow-up interviews will be conducted at community health centres or at the mother's home. A 48-hour food diary will be used to record the consumption of breast milk, formula, foods and beverages by the infants at 1, 3, and 6 months of age. Symptoms of illness of the child such as fever, infection and diarrhoea, and length of hospitalisation will also be documented in detail based on both self-report and/or medical records.

A follow-up study on these children up to 5 years of age is planned and subject to funding availability.

Statistical analysis

Data will be pooled and combined across study sites. After data screening and cleaning, descriptive statistics will be used to characterise study participants. Group comparisons will be undertaken using X^2 tests for categorical variables, and either t tests/analysis of variance or Mann-Whitney U tests for continuous variables. Independent variables include demographic factors, medical history and maternal lifestyle such as dietary intake, physical activity, smoking and alcohol drinking. The main dependent variables of interest are gestational diabetes status, pregnancy outcomes (eg, stillbirth, pre-eclampsia), delivery outcomes (eg, low birth weight, macrosomia, preterm birth, caesarean section), breastfeeding duration, depressive symptom scores, gestational weight gain and postpartum weight retention, infant growth and child health conditions.

Logistic or Poisson regression models will be fitted to investigate the relationships between selected exposures and binary or discrete outcomes measured at a single point in time. Mixed regression analyses with random effects will be undertaken to assess the association between plausible risk factors and the longitudinal outcomes, such as depressive symptom scores and infant weight, while accounting for the repeated measures and clustering of subjects within study sites (hospitals). Kaplan-Meier test and Cox regression will be performed to determine the effects of influencing factors on the breastfeeding duration. Crude and adjusted coefficients or OR estimates and associated 95% confidence intervals will be reported for regression analyses, and adjusted hazard ratios for survival random-effects models.

Potential confounding variables will be selected with reference to the literature and modelling strategies.[34 35] For instance, to assess the association between gestational diabetes and rates of exclusive breastfeeding, possible confounders might be parity, delivery type, birth weight,[14] in addition to demographic factors, energy intake, energy expenditure and other covariates. Effect modification will also be taken into account in the statistical modelling. All statistical analyses will be performed using the SPSS package version 22 (IBM, Armonk, New York, USA).

Ethics and dissemination

The project has been approved by the Curtin University human research ethics committee (HR32/2015) and the Hai Phong University of Medicine and Pharmacy human research ethics committee (No 05/HPUMPRB/2015).

All participants have been provided with verbal and written information on the study describing its purpose and their requirements. Each participant has a unique ID number with basic information, including name, address, and phone numbers of themselves and partners so that they can be followed up later. Participants could withdraw from the study at any time without prejudice. All identifiable information of participants has been coded and securely stored. Study results will be published in academic journals.

FINDINGS TO DATE

Baseline characteristics of participants are summarised in table 1.

The 2030 pregnant women had a mean age of 27.6 (SD 5.3) years (range 18–48 years). The majority (60.6%) of women were in the age group 25–35 years in all locations. Almost all of the subjects were married (99.3%). Manual work and farming were the main occupations (54.9%) of the participants, followed by office and technical staff (22.5%). More than 60% of the mothers had completed high school and over one-third of them had a degree from college or university. Women in Ha Noi had the highest level of advanced educational level (50.9%) while Ho Chi Minh City had the highest rate of low educational level (18.5%). A majority (61.8%) of the participants had a normal pre-pregnancy BMI (18.5 to <23 kg/m^2) and mean BMI was 20.2 kg/m^2 (SD 2.6). The prevalence of normal BMI was similar among the three centres. However, Ho Chi Minh City had a substantially higher rate of overweight and obesity (20.8%) while Hai Phong city had a higher rate of underweight (31.7%). About one-quarter of the pregnant women were underweight. This rate was similar to a study in Ha Nam (26%)[36] and in Nha Trang (26.1%).[16] No pregnant women smoked during pregnancy but more than one-half were exposed to passive smoking at home. The overall prevalence of alcohol consumption during pregnancy was 13.4% and the highest proportion of women consuming alcohol was found in Ha Noi with 18.0%.

Very few participants had a history of hypertension or pre-eclampsia in each site. During their last pregnancy, the rate of GDM was 1.4%, birth defects (1.8%), macrosomia (3.6%) or preterm delivery (6.3%). The reported rates of stillbirth, abortion and caesarean section were 10.4%, 17.9%, and 21.5%, respectively.

Analysis of the blood test of 2023 participants (excluding seven patients with diabetes before pregnancy) showed that the prevalence of hyperglycaemia was 22.8%, slightly lower than found in a previous cohort study in southern Vietnam.[21] The hyperglycaemia rate was highest in Ho Chi Minh City (31.0%), followed by Hai Phong (19.9%) and Ha Noi (16.4%). The mean systolic blood pressure in all centres was 105.6 (SD 8.2) mm Hg, and the mean diastolic blood pressure was 67.4 (SD 7.5) mm Hg.

Data on physical activity, dietary pattern, breastfeeding and antenatal depressive symptoms are currently being analysed and results will be presented in subsequent articles.

STRENGTHS AND LIMITATIONS

One major strength of this multicentre, prospective cohort study in Vietnam is its large number of patients, followed up over a relatively long period; it is conducted in two principal regions of Vietnam, thus representing the urban Vietnam population. The few previous prospective cohort studies undertaken in Vietnam were either conducted in a single province,[11 15–17 37] or their sample sizes were small[15 17] or their follow-up times were short.[11 17]

Another strength is that it investigates a variety of modifiable maternal risk factors for adverse pregnancy, postpartum maternal and child health outcomes in Vietnam. Unlike previous prospective studies in Vietnam,[11 17 37] this project examines lifestyle, nutritional and metabolic status of pregnant women, including physical activity, smoking, alcohol drinking, dietary intake, pre-pregnancy BMI, gestational weight gain, antenatal and postnatal depressive symptoms and breastfeeding. It will also ascertain the impact of maternal factors (eg, pre-pregnancy BMI, dietary intake, physical activity, gestational weight gain) on obstetric complications (eg, gestational diabetes mellitus, pre-eclampsia, pregnancy-induced hypertension), pregnancy outcomes (eg, preterm delivery, caesarean section, low birth weight, macrosomia and postpartum haemorrhage), postpartum health status (eg, postnatal depressive symptoms, morbidity) and child health and growth for at least 2 years.

The results of our study will provide new evidence on the impact of diet and physical activity on delivery and postpartum health outcomes in Vietnamese women, which can be compared with findings from other developing and developed countries. The research findings will provide significant information for the development of guidelines, policy planning and advocacy, and can be used to formulate appropriate intervention programmes to improve maternal and child health in Vietnam. In addition, all questionnaires used for data collection have been validated for the Vietnamese people, thereby increasing the accuracy of the information.

This study has several weaknesses. First, pregnant women were recruited from hospitals, which may present some selection bias. However, the participation rate was high (90.3%) and thus selection bias should be negligible. Second, recall errors and bias in the assessments of physical activity and dietary intake cannot be ruled out. Nevertheless, we minimise these impacts by using validated questionnaires and experienced interviewers. Third, although contact information of participants and their partners, such as addresses and mobile phone numbers have been recorded, a high rate of attrition in an industrialised city like Ho Chi Minh City is expected. This limitation is reduced by maintaining a regular good relationship with participants during the follow-up. Finally, although farming respondents are recruited from

Table 1 Baseline characteristics of participants

Variables	Ha Noi (n_1=905) n (%)	Hai Phong (n_2=298) n (%)	Ho Chi Minh (n_3=827) n (%)	Total (n=2030) n (%)
Age (years)				
<25, (n (%)	346 (38.2)	97 (32.6)	194 (23.5)	637 (31.4)
25–35, n (%)	499 (55.1)	178 (59.7)	553 (66.9)	1230 (60.6)
>35, n (%)	60 (6.6)	23 (7.7)	80 (9.7)	163 (8.0)
Mean (SD)	26.6 (5.0)	27.4 (5.4)	28.6 (5.3)	27.6 (5.3)
Marital status (married)	902 (99.7)	294 (98.7)	819 (99.0)	2015 (99.3)
Occupation				
Famers	194 (21.4)	44 (14.8)	58 (7.0)	296 (14.6)
Workers	303 (33.5)	139 (46.6)	376 (45.5)	818 (40.3)
Office and technical staff	226 (25.0)	44 (14.8)	186 (22.5)	456 (22.5)
Sales worker	35 (3.9)	10 (3.4)	74 (8.9)	119 (5.9)
Housewife/unemployed	147 (16.2)	61 (20.5)	133 (16.1)	341 (16.8)
Educational level				
Under secondary	15 (1.7)	3 (1.0)	153 (18.5)	171 (8.4)
Secondary	164 (18.1)	98 (32.9)	289 (34.9)	551 (27.1)
High school	265 (29.3)	88 (29.5)	172 (20.8)	525 (25.9)
College/university	461 (50.9)	109 (36.6)	213 (25.8)	783 (38.6)
Parity				
0	361 (39.9)	105 (35.2)	323 (39.1)	789 (38.9)
1	306 (33.8)	110 (36.9)	340 (41.1)	756 (37.2)
≥2	238 (26.3)	83 (27.9)	164 (19.8)	485 (23.9)
Body mass index (BMI) before pregnancy (kg/m^2)* (n=2010)				
Low (<18.5)	244 (27.0)	88 (31.7)	177 (21.4)	509 (25.3)
Normal (18.5 -<23.0)	587 (64.9)	178 (64.0)	478 (57.8)	1243 (61.8)
High (≥23.0)	74 (8.2)	12 (4.3)	172 (20.8)	258 (12.8)
Mean (SD)	19.8 (2.3)	19.5 (2.2)	20.8 (2.8)	20.2 (2.6)
History of previous pregnancy (n=1241)				
GDM	1 (0.2)	1 (0.5)	15 (3.0)	17 (1.4)
Hypertension	0 (0.0)	0 (0.0)	4 (0.8)	4 (0.3)
Pre-eclampsia	4 (0.7)	0 (0.0)	3 (0.6)	7 (0.6)
Preterm birth	43 (7.9)	8 (4.1)	27 (5.4)	78 (6.3)
Macrosomia	29 (5.3)	4 (2.1)	12 (2.4)	45 (3.6)
Birth defects	13 (2.4)	3 (1.6)	6 (1.2)	22 (1.8)
Caesarean section	135 (24.8)	18 (9.3)	114 (22.6)	267 (21.5)
Stillbirth	100 (11.1)	37 (12.4)	75 (9.1)	212 (10.4)
Abortion	207 (22.9)	46 (15.4)	110 (13.3)	363 (17.9)
History of participant's family				
Diabetes	38 (4.2)	6 (2.0)	84 (10.2)	128 (6.3)
Hypertension	74 (8.2)	36 (12.1)	197 (23.8)	307 (15.1)
Smoking and drinking during pregnancy				
Active smoking	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
Passive smoking	481 (53.1)	150 (50.3)	439 (53.1)	1070 (52.7)
Drinking	163 (18.0)	29 (9.7)	80 (9.7)	272 (13.4)

Continued

Table 1 Continued

Variables	Ha Noi (n_1=905) n (%)	Hai Phong (n_2=298) n (%)	Ho Chi Minh (n_3=827) n (%)	Total (n=2030) n (%)
Blood glucose test (n=2023)				
Fasting (mean, SD)	4.4 (0.5)	4.4 (0.7)	4.5 (0.4)	4.5 (0.5)
1-Hour 75 g OGTT (mean, SD)	7.2 (1.8)	6.9 (1.6)	8.4 (1.8)	7.6 (1.9)
2-Hour 75 OGTT (mean, SD)	6.4 (1.5)	6.1 (1.3)	7.3 (1.5)	6.7 (1.6)
Hyperglycaemia†	148 (16.4)	59 (19.9)	255 (31.0)	462 (22.8)
Blood pressure				
Systolic, mm Hg (mean, SD)	105.0 (7.3)	107.0 (8.3)	105.8 (9.0)	105.6 (8.2)
Diastolic, mm Hg (mean, SD)	64.9 (6.4)	64.3 (6.1)	71.3 (7.3)	67.4 (7.5)
Pulse, bpm (mean, SD)	84.3 (9.3)	79.3 (6.0)	97.0 (9.9)	88.7 (11.5)

Results are shown as number (%) unless stated otherwise.
*BMI cut-off for Asian population was used.[38]
†Hyperglycaemia was classified by WHO 2013.[32]
GDM, gestational diabetes mellitus; OGTT, oral glucose tolerance test.

suburban districts, they may not represent rural women in the country.

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Collaborators There is room for future joint studies. This study will follow-up mothers and their babies until 2 years post partum. This duration can be extended to investigate the effects of maternal factors on the health problems of mothers and their children later in life. In addition, the study is currently performing in two regions (Red River Delta and Southeast), while Vietnam has six socioecological regions. It can be expanded into other regions to increase the sample size and representation. Therefore, the study welcomes all researchers who have the same objectives together with available funding. Study proposals must be submitted to the study research team for review and approval.

Contributors CLN, PTHN, TKC, and AWH participated in the study design and data collection. CLN wrote the draft and edited the manuscript. TKC performed the baseline analysis. NMP provided expert advice on the draft of the manuscript. DVDu, DVDo, HKT, AHL, and CWB were the study supervisors and involved in all aspects of the study. All the authors revised the article and approved the final version to be published.

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Competing interests None declared.

Patient consent Obtained.

Ethics approval The study was approved by the Curtin University human research ethics committee (approval number: HR32/2015) and the Hai Phong University of Medicine and Pharmacy human research ethics committee (approval number: 05/HPUMPRB/2015).

Provenance and peer review Not commissioned; externally peer reviewed.

Data sharing statement Researchers can access to the cohort data by sending us an applicationvia email () for discussion andapproval at the research team meeting.

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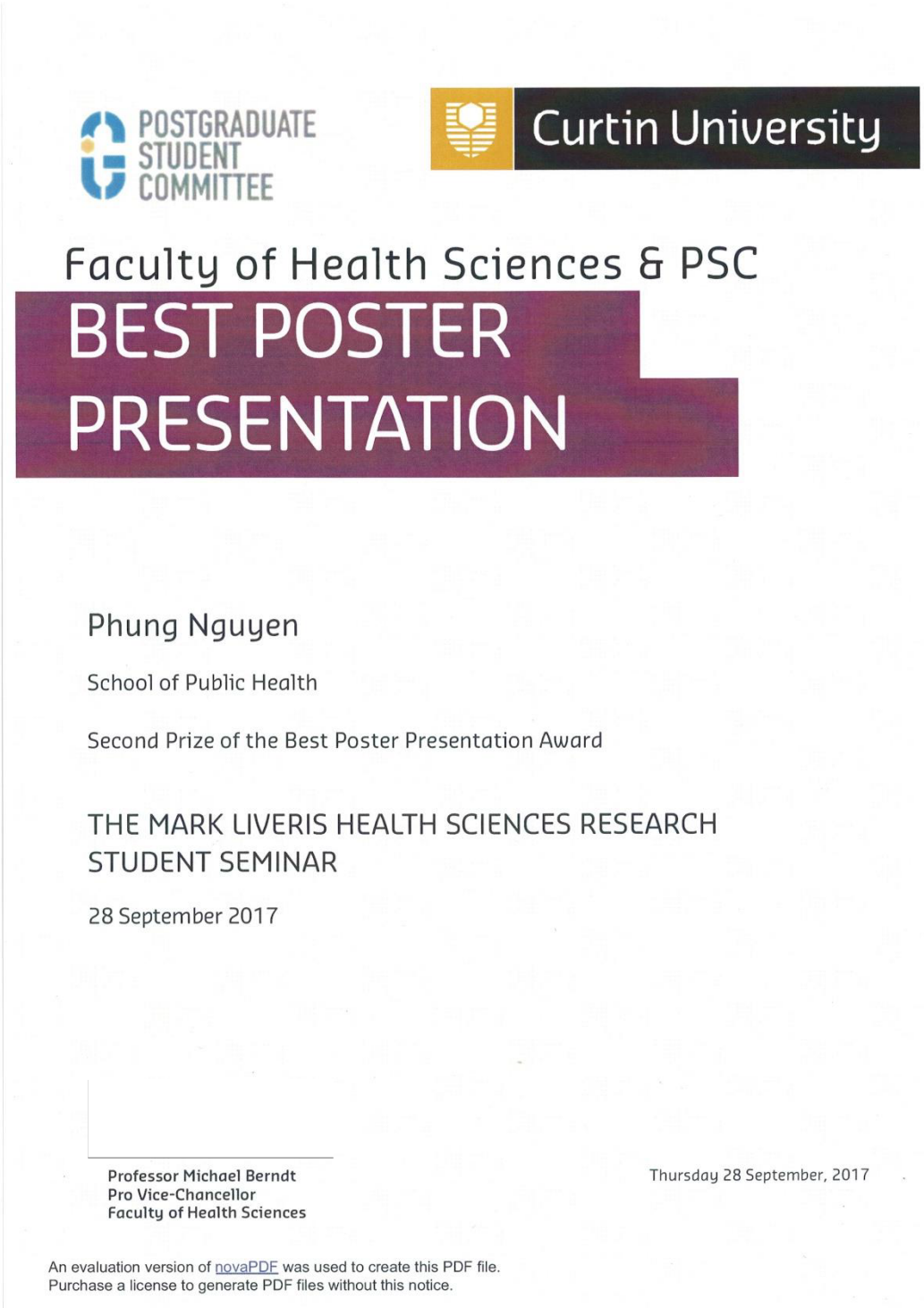
Appendix K: Oral and Poster Presentations from PhD project

Best Poster Presentation Award: Second Prize, the Mark Liveris Health Sciences Research Student Seminar, Faculty of Health Sciences, Curtin University, Sep 2017



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28 September 2017

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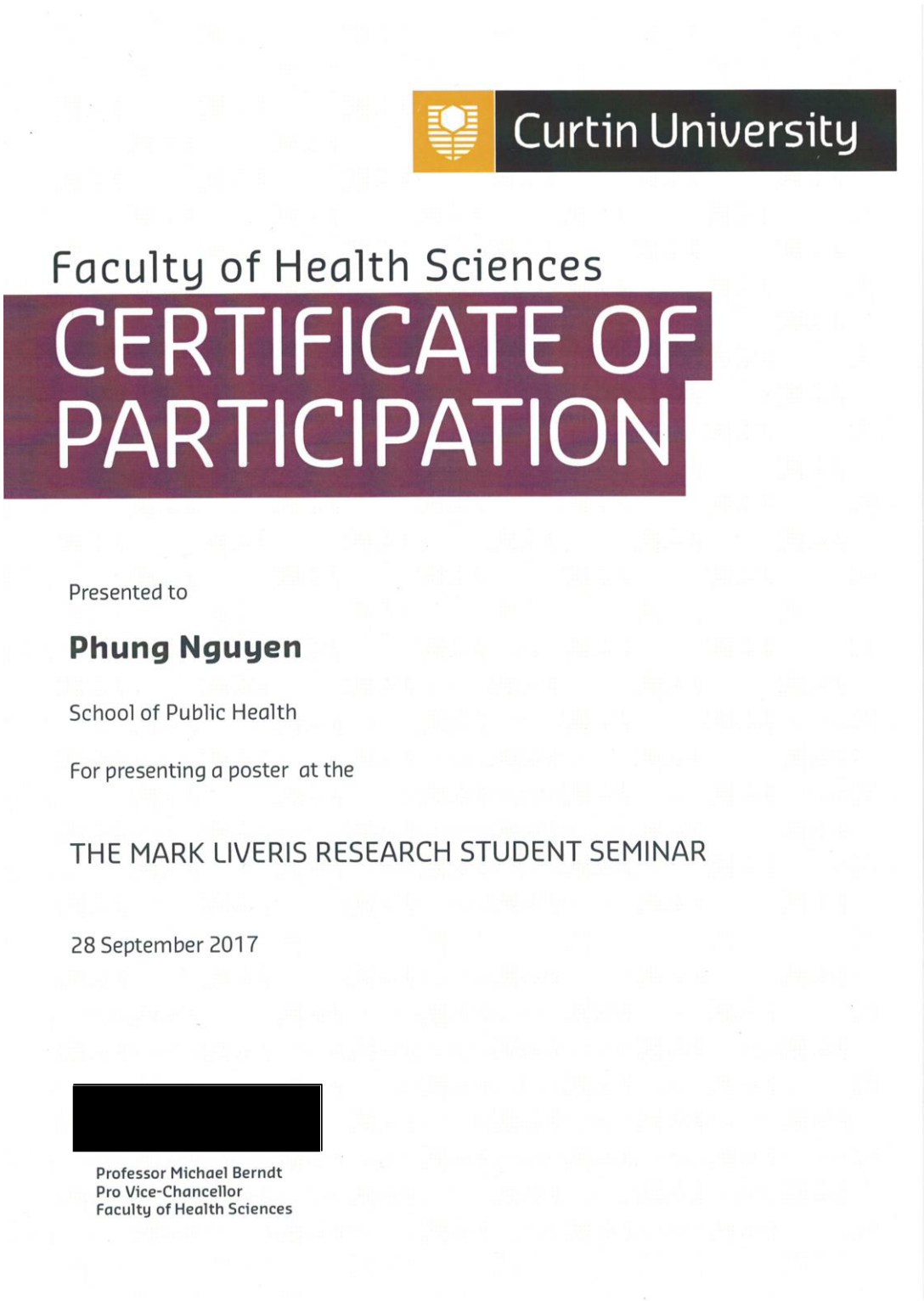
Faculty of Health Sciences

Thursday 28 September, 2017

Poster Presentation certificate: the Mark Liveris Health Sciences Research Student Seminar, Faculty of Health Sciences, Curtin University, Sep 28, 2017



Curtin University

Faculty of Health Sciences

CERTIFICATE OF PARTICIPATION

Presented to

Phung Nguyen

School of Public Health

For presenting a poster at the

THE MARK LIVERIS RESEARCH STUDENT SEMINAR

28 September 2017

[redacted]

Professor Michael Berndt
Pro Vice-Chancellor
Faculty of Health Sciences

Poster: Presented in the Mark Liveris Health Sciences Research Student Seminar, Faculty of Health Sciences, Curtin University, Sep 2017

Gestational Diabetes and Breastfeeding Outcomes: A Systematic Review

Phung T. H. Nguyen [a,b], Ngoc M. Pham [a], Colin W. Binns [a], Tan K. Chu [a], Dat V. Duong [c], Dung V. Do [b], Andy H. Lee [a]
[a] School of Public Health, Curtin University, Perth, Western Australia, Australia
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[c] United Nations Population Fund, Ha Noi, Vietnam

Background

Women with gestational diabetes mellitus (GDM) and their infants are at increased risk of developing metabolic syndrome [a], while breastfeeding can adjust blood glucose levels and lower diabetes risk [b]. Breastfeeding was solely considered as the exposure or moderator of the association between GDM and future risks for mothers and children (e.g. type 2 diabetes) in previous reviews[c]. However, the association between GDM and breastfeeding *per se* has yet to be reviewed.

Aim

To undertake a systematic review of the association between GDM and breastfeeding outcomes, namely **'any breastfeeding', 'predominant breastfeeding'** and **'exclusive breastfeeding'.**

Methods

Data sources: A search of PubMed, Web of Science, and Proquest for observational studies conducted through January 2017, using key words: **"breast feeding", "breastfeeding", "breast-feeding", "lactation", "lactating", and "gestational diabetes", "gestational diabetic", "diabetes in pregnancy".**
Inclusion criteria: Studies reported data on breastfeeding by mothers with and without GDM.
Exclusion criteria: Studies did not compare breastfeeding outcomes between GDM and non-GDM mothers, small sample sizes (n<100), qualitative reports, review papers, conference, meeting abstracts, or comments.

Results

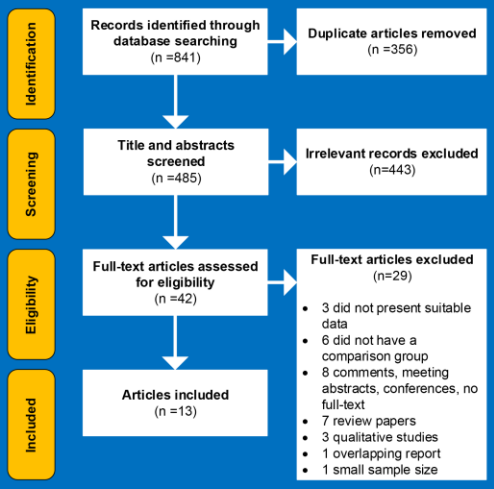

Figure 1: PRISMA systematic search flow chart

Table 1: Characteristics of included studies

Ref.	Study	Country	Design	Sample Size
1	Aris *et al.*, 2005	Singapore	Prospective cohort	1,016
2	Veena *et al.*, 2011	India	Prospective cohort	518
3	Hummel *et al.*, 2008	Germany	Prospective cohort	784
4	Hummel *et al.*, 2014	USA, Germany, Sweden, Finland	Prospective cohort	7,026
5	Gunderson *et al.*, 2010	USA	Prospective cohort	704
6	Haile *et al.*, 2016	USA	Cross-sectional	2,038
7	Kachoria *et al.*, 2014	USA	Cross-sectional	803,222
8	Oza-Frank *et al.*, 2015	USA	Cross-sectional	72,755
9	Shearrer *et al.*, 2015	USA	Cross-sectional	2,287
10	Oza-Frank *et al.*, 2016	USA	Cross-sectional	432
11	Bider-Canfield *et al.*, 2016	USA	Retrospective cohort	15,710
12	Finkelstein *et al.*, 2013	Canada	Retrospective cohort	24,755
13	Chamberlain *et al.*, 2017	Australia	Retrospective cohort	8,512

Table 2: Association between GDM and breastfeeding outcomes

Breastfeeding outcomes	Association	References
Rate of breastfeeding initiation (ever breastfeeding)	No differences	2, 4, 8, 10, 11
	Lower rate in GDM	3
Partial/any breastfeeding duration (including category and continuous results)	No differences	1, 2, 4, 5, 9, 10, 11
	Shorter duration in GDM	3, 8
Exclusive/full/predominant breastfeeding duration	No differences	1
	Shorter duration in GDM	3, 4
Rate of any breastfeeding at discharge	No differences	7, 13
Rate of exclusive/predominant breastfeeding at discharge	Lower rate in GDM	6, 12, 13

Conclusion

Rates of **'exclusive/predominant breastfeeding'** were **lower,** and **'duration of exclusive/predominant breastfeeding' was shorter** in women with GDM than those without. Mothers with GDM need care routines to increase exclusive breastfeeding rates and breastfeeding duration. Further research using standard definitions of GDM and breastfeeding is required.

[a] Aune, D., Norat, T., Romundstad, P., & Vatten, L. J. (2014). Breastfeeding and the maternal risk of type 2 diabetes: a systematic review and dose-response meta-analysis of cohort studies. *Nutr Metab Cardiovasc Dis, 24*, 107-115.
[b] Horta, B. L., Loret de Mola, C., & Victora, C. G. (2015). Long-term consequences of breastfeeding on cholesterol, obesity, systolic blood pressure and type 2 diabetes: a systematic review and meta-analysis. *Acta Paediatr, 104*, 30-37.
[c] Gunderson, E. P. (2014). Impact of breastfeeding on maternal metabolism: implications for women with gestational diabetes. *Curr Diab Rep, 14*, 460.

Request for full references can be sent to phung.nguyen@postgrad.curtin.edu.au

Best Poster Presentation certificate: Second Place, at the 19th Conference of International Society for Research in Human Milk and Lactation, Oct 2018

This certificate is awarded to

Phung Thi Hoang Nguyen

2nd Place, Best Poster Presentation

Gestational Diabetes Reduces Breastfeeding Duration:
A Prospective Cohort Study in Vietnam

At the 19th Conference of International Society for Research in Human Milk and Lactation

Shonan / Kanagawa / Japan

October 7-11, 2018

[redacted]

Nami Tanaka, MD, IBCLC, President of JALC
Japanese Association of Lactation Consultants

[redacted]

Sharon Donovan, PhD, RD
Chair of 19th ISRHML MEETING

Poster: Presented at the 19th Conference of International Society for Research in Human Milk and Lactation, Kanagawa, Japan, Oct 6-11, 2018

Gestational diabetes reduces breastfeeding duration
A prospective cohort study in Vietnam

PTH.Nguyen[1,2], CW. Binns[1], CL. Nguyen[1], HVV. Anh[1], TK.Chu[1], DV.Duong[3], DV. Do[2], AH. Lee[1]

[1] School of Public Health, Curtin University, Perth, Western Australia, Australia
[2] University of Medicine and Pharmacy at Ho Chi Minh City, Vietnam
[3] United Nations Population Fund, Ha Noi, Vietnam

Contact info: phung.nguyen@postgrad.curtin.edu.au

Background

Gestational diabetes mellitus (GDM) and its complications are major concerns due to the negative effects of GDM during antenatal period and on the future health of mothers and infants. Breastfeeding is beneficial for GDM mothers and their babies to reduce future health risks [a] [b]. Little is known about the link between GDM and 'any' breastfeeding duration.

Aim

To investigate association between GDM and 'any' breastfeeding duration within 12 months postpartum in Vietnamese women.

Results

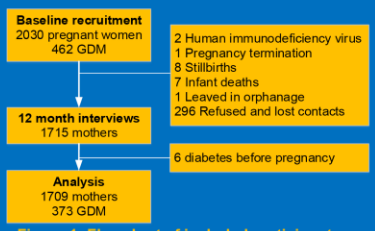

Figure 1: Flowchart of included participants

Table 1: Characteristics of participants with and without GDM

Variables	Total	GDM	Non-GDM	p-value
Total, n (%)	1709 (100)	373 (21.8)	1336 (78.2)	
Maternal age, mean±SD	27.5 ± 5.3	29.2 ± 5.4	27.0 ± 5.1	<0.001
Occupation, n (%)				
Farmers	257 (15.0)	47 (12.6)	210 (15.7)	
Workers	682 (39.9)	151 (40.5)	531 (39.8)	
Office and technical staff	401 (23.6)	103 (27.6)	298 (22.3)	0.098
Sales worker	276 (16.1)	50 (13.4)	226 (16.9)	
Housewife/Unemployed	93 (5.4)	22 (5.9)	71 (5.3)	
Maternal education, n (%)				
Secondary school or lower	574 (33.6)	133 (35.7)	441 (33.0)	
High school	445 (26.0)	95 (25.5)	350 (26.2)	0.627
College/university or above	690 (40.4)	145 (38.8)	545 (40.8)	
Parity, n (%)				
0	655 (38.3)	134 (35.9)	521 (39.0)	
1	636 (37.2)	156 (41.8)	480 (35.9)	0.111
≥2	418 (24.5)	83 (22.3)	335 (25.1)	
Gestational age, mean±SD	38.9 ± 1.3	38.7 ± 1.3	38.9 ± 1.3	0.047
Birth weight, mean±SD	3146.2 ± 395.0	3161.5 ± 416.4	3141.9 ± 388.8	0.396
Caesarean section, n (%)	653 (38.2)	165 (44.2)	488 (36.5)	0.007
Admission to NICU, n (%)	44 (2.6)	12 (3.2)	32 (2.4)	0.376

Methods

A prospective cohort of 2,030 pregnant women at 24-28 weeks gestation was recruited. GDM status was determined using 2-hour 75g OGTT, and confirmed based on the IADPSG criteria [c].

Included mothers were then followed up at discharge, 1, 3, 6 and 12 months postpartum to determine their breastfeeding duration, using WHO definition [d].

Kaplan-Meier estimates, log-rank tests, logistic and Cox regression models were used to examine the association of GDM and breastfeeding.

Table 2: Breastfeeding outcomes for mothers with and without GDM

Breastfeeding outcomes	Total (%)	GDM (%)	Non-GDM (%)	OR (95%CI)	AOR* (95%CI)
Early BF (1 hour)	603 (35.3)	122 (32.7)	481 (36.0)	0.86 (0.67-1.10)	0.97 (0.72-1.30)
Prelacteal feeds	966 (56.5)	223 (59.8)	743 (55.6)	1.19 (0.93-1.51)	1.09 (0.82-1.44)
BF at discharge	1562 (91.4)	344 (92.2)	1218 (91.2)	1.15 (0.75-1.82)	1.18 (0.75-1.85)
BF at 1 month	1681 (98.4)	364 (97.6)	1317 (98.6)	0.58 (0.25-1.48)	0.60 (0.25-1.43)
BF at 3 months	1596 (93.4)	340 (91.2)	1256 (94.0)	0.66 (0.42-1.04)	0.68 (0.43-1.08)
BF at 6 months	1488 (87.1)	313 (83.9)	1175 (88.0)	0.72 (0.51-1.00)	0.80 (0.57-1.13)
BF at 12 months	1228 (72.9)	243 (65.2)	985 (73.7)	**0.67 (0.52-0.86)**	**0.66 (0.51-0.85)**

*Adjusted for maternal age, occupation, education, parity, gestational age, birthweight, caesarean section, and admission to neonatal intensive care unit

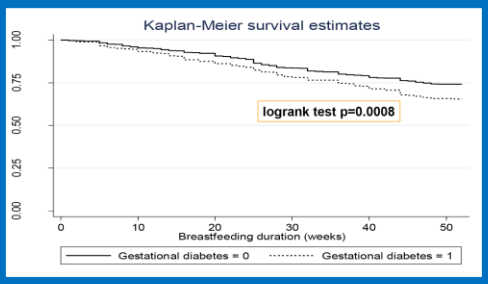

Figure 2: Kaplan-Meier curves of any breastfeeding in the first 12 months for mothers with and without GDM

Gestational diabetes mellitus was associated with early breastfeeding cessation HR=1.38, 95%CI 1.12-1.70, p=0.002, after adjusting for confounders.

Conclusion

GDM was associated with a shorter breastfeeding duration. Medical staff should be aware of the increased risk of early breastfeeding cessation. Extra support for these women after hospital discharge should be routinely provided.

[a] Horta, BL., Loret de Mola, C., & Victora, CG. (2015). Long-term consequences of breastfeeding on cholesterol, obesity, systolic blood pressure and type 2 diabetes: a systematic review & meta-analysis. *Acta Paediatr, 104*, 30-37.
[b] Gunderson, EP. (2014). Impact of breastfeeding on maternal metabolism: implications for women with gestational diabetes. *Curr Diab Rep, 14*, 460.
[c] International Association of Diabetes Pregnancy Study Groups Consensus Panel, Metzger BE, Gabbe SG, et al. International association of diabetes and pregnancy study groups recommendations on the diagnosis and classification of hyperglycemia in pregnancy. *Diabetes Care*. 2010;33(3):676-682.
[d] World Health Organization. Indicators for assessing infant and young child feeding practices: Part 1-Definition: Conclusions of a consensus meeting held 6–8 November 2007 in Washington D.C.

Oral and Poster Presentations: Presented at the 23rd Annual International Conference of the Academy of Breastfeeding Medicine, San Francisco, California, United States, Nov 14-17, 2018

Congratulations!

ABM <ABM@bfmed.org>

Wed 8/8/2018 1:46 AM

To: Phung Nguyen <phung.nguyen@postgrad.curtin.edu.au>;

ACADEMY OF Breastfeeding Medicine

Dear Ms. Nguyen,

As you know from an earlier email, your abstract was accepted to be part of our 23rd Annual International Meeting, and your poster will be on display throughout the conference. In addition, the Abstract Committee has selected seven to be featured as podium presentations during the conference. Your abstract, "Gestational diabetes reduces breastfeeding duration: A prospective cohort study in Vietnam" is one of these and is scheduled for presentation with two others on Friday, November 16, from 12:15pm to 12:30pm. You will each have 15 minutes for a brief presentation and questions.

By now we assume you have registered for the conference. All conference information is available on our website at www.bfmed.org.

Please make your hotel arrangements as early as possible since space is limited. If you are travelling internationally and need a letter of invitation for

your visa application, or if you have other questions, please email abm@bfmed.org.

We greatly appreciate your contribution to our 23rd Annual International Meeting and look forward to seeing you there.

With congratulations and best regards,

Rose St. Fleur, MD, FABM
Abstract Committee Chair

CC: Karla Shepard Rubinger
Executive Director

Academy of Breastfeeding Medicine
140 Huguenot Street
New Rochelle, New York 10801
914 740-2263
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www.bfmed.org

The Academy of Breastfeeding Medicine is affiliated with the United Nations Department of Public Information, the NGO Committee on UNICEF, and has consultative status with ECOSOC.

GESTATIONAL DIABETES REDUCES BREASTFEEDING DURATION A PROSPECTIVE COHORT STUDY IN VIETNAM

Phung TH.Nguyen[1,2], Colin W. Binns[1], Cong L. Nguyen[1], Ha VV. Anh[1], Tan K.Chu[1], Dat V.Duong[3], Dung V. Do[2], Andy H. Lee[1]

[1] School of Public Health, Curtin University, Perth, Western Australia, Australia
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[3] United Nations Population Fund, Ha Noi, Vietnam
Contact info: phung.nguyen@postgrad.curtin.edu.au

BACKGROUND

- GDM is defined as carbohydrate intolerance resulting in hyperglycemia with onset or first recognition during pregnancy. (WHO. 1999)
- GDM was highest in Middle East - North Africa (12.9%), Southeast Asia (11.7%). (Zhu and Zhang 2016)
- In East and Southeast Asia, meta analysis indicated pooled prevalence of GDM was 10%, Vietnam had highest prevalence (20%) (Nguyen, Pham et al. 2018)
- Women with GDM who breastfeed their infants are associated with a lower risk of adverse health outcomes
- A meta-analysis indicated breastfed infants were less likely to develop T2D when compared to non-breastfed infants (Horta, Loret de Mola et al. 2015).
- Infants born from GDM mothers are more likely to suffer from neonatal complications such as preterm birth, low birth weight, admission to intensive care unit, which result in delaying breastfeeding at discharge.
- Mothers with GDM ae at higher risk of having lactation difficulties including pain after caesarean section, breast engorgement, obstetric complications, and delayed onset of lactogenesis II. (Gunderson. 2007)
- Rates of exclusive/predominant breastfeeding appeared to be lower for mothers with GDM at hospital discharge. Previous studies have shown inconsistent results concerning the impact of GDM on 'any' breastfeeding duration.

AIM

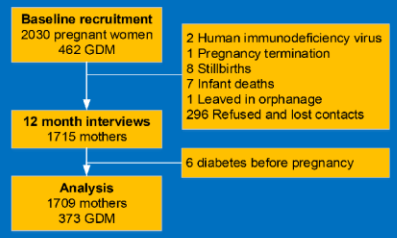
To investigate association between GDM and 'any' breastfeeding duration within 12 months postpartum in Vietnamese women.

METHODS

- A prospective cohort of 2,030 pregnant women at 24-28 weeks gestation was recruited. GDM status was determined using 2-hour 75g OGTT, and confirmed based on the IADPSG criteria (IADPSG. 2010)
- Included mothers were then followed up at discharge, 1, 3, 6 and 12 months postpartum to determine their breastfeeding duration, using WHO definition (WHO. 2007)
- Kaplan-Meier estimates, log-rank tests, logistic and Cox regression models were used to examine the association of GDM and breastfeeding.

RESULTS

Figure 1: Flowchart of included participants



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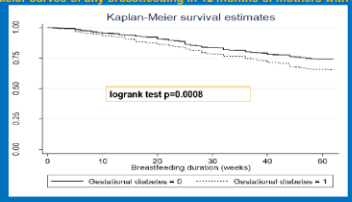
*Adjusted for maternal age, occupation, education, parity, gestational age, birthweight, caesarean section, and admission to neonatal intensive care unit

Figure 2: Kaplan-Meier curves of any breastfeeding in 12 months of mothers with and without GDM



Gestational diabetes mellitus was associated with early breastfeeding cessation HR=1.38, 95%CI 1.12-1.70, p=0.002, after adjusting for all confounders.

CONCLUSION

GDM was associated with a shorter breastfeeding duration. Medical staff should be aware of the increased risk of early breastfeeding cessation. Extra support for these women after hospital discharge should be routinely provided.

ABSTRACT

Background: Gestational diabetes mellitus (GDM) and its complications are major concerns due to the negative effects of GDM during antenatal period and on the future health of mothers and infants. Breastfeeding is beneficial for GDM mothers and their babies to reduce future health risks. Little is known about the link between GDM and the duration of 'any' breastfeeding. Therefore, the aim of this study was to investigate the relationship between GDM and the duration for which Vietnamese women breastfeed their babies postpartum.

Materials and Methods: A prospective cohort of 2,030 pregnant women between 24 and 28-weeks gestation was recruited. GDM status was determined using a 75g oral glucose tolerance test. Included mothers were then followed up from discharge after childbirth until twelve months postpartum to determine their breastfeeding duration. Kaplan-Meier estimates, log-rank tests, logistic and Cox regression models were used to examine the association between GDM and breastfeeding outcomes.

Results: In our cohort, 94.4% of all women reported 'any' breastfeeding at discharge, and 72.9% of women were still breastfeeding at twelve months postpartum. The risk of early breastfeeding cessation was higher in GDM women compared to their non-GDM counterparts after adjustment for potential confounding factors (HR 1.38, 95%CI 1.12-1.70, p=0.002). There were no significant differences in breastfeeding outcomes at discharge (early initiation, pre-lacteal feeding, and 'any' breastfeeding rate) between GDM and non-GDM mothers.

Conclusion: GDM was associated with a shorter breastfeeding duration. Women with GDM require ongoing support after hospital discharge to maintain long term breastfeeding.

References

World Health Organization (1999). Definition, diagnosis and classification of diabetes mellitus and its complications. Part 1: Diagnosis and classification of diabetes mellitus. Report of a WHO consultation.

Zhu, Y. and C. Zhang (2016). "Prevalence of Gestational Diabetes and Risk of Progression to Type 2 Diabetes: a Global Perspective." Curr Diab Rep **16**(1): 7.

Nguyen, C. L., N. M. Pham, C. W. Binns, D. V. Duong and A. H. Lee (2018). "Prevalence of Gestational Diabetes Mellitus in Eastern and Southeastern Asia: A Systematic Review and Meta-Analysis." J Diabetes Res **2018**: 6536974.

Horta, B. L., C. Loret de Mola and C. G. Victora (2015). "Long-term consequences of breastfeeding on cholesterol, obesity, systolic blood pressure and type 2 diabetes: a systematic review and meta-analysis." Acta Paediatr **104**(467): 30-37.

Gunderson, E. P. (2007). "Breastfeeding after gestational diabetes pregnancy." Diabetes Care **30**: S161-S168.

International Association of Diabetes Pregnancy Study Groups Consensus Panel, B. E. Metzger, S. G. Gabbe, B. Persson, T. A. Buchanan, P. A. Catalano, P. Damm, A. R. Dyer, A. Leiva, M. Hod, J. L. Kitzmiler, L. P. Lowe, H. D. McIntyre, J. J. Oats, Y. Omori and M. I. Schmidt (2010). "International association of diabetes and pregnancy study groups recommendations on the diagnosis and classification of hyperglycemia in pregnancy." Diabetes Care **33**(3): 676-682.

World Health Organization. (2006). "Indicators for assessing infant and young child feeding practices. Part 1-Definition: Conclusions of a consensus meeting held 6–8 November 2007 in Washington D.C.