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Social inequalities in body weight trajectory among young women: The role of reproductive events

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Abstract

Background and aims: In 2014-15, 63% of Australian adults (27% of children) were overweight or obese. Reproduction is often implicated in explaining weight gain among women, with pregnancy influencing the offspring's body weight in the short and long term. Among women in high-income countries, low socioeconomic position (SEP) is associated with increased weight in early to mid-adulthood, with SEP differences in weight reportedly increasing among younger female cohorts. This thesis reports on social differences in body weight among women while accounting for reproductive history.

Methods: Two large data sources were used: The Australian Longitudinal Study on Women's Health (ALSWH) - a prospective cohort study of Australian citizens/permanent residents - and data from Swedish registers. The ALSWH cohort born 1973-78 were used; surveyed at baseline (1996; aged 18-23 years; n=14,247) and at three- to four-year intervals thereafter (up to Survey Five, 2009; 31-36 years; n=8,200: Survey Six, 2012; 34-39 years; n=8,010: and Survey Seven; 2015; n=6,901). Accurate and reliable information on pre-pregnancy BMI and gestational weight gain (GWG) are seldom available and were not collected from the ALSWH cohort. This data is important for investigating weight increases in relation to reproduction, and data from a nationally representative sample of 163,352 women from Swedish registers were used to investigate social patterning of these outcomes.

Education was the main measure of SEP used to investigate social patterning of i) body weight change over 13 years; ii) age at first birth, birth-to-pregnancy intervals, and parity; iii) initiation of and sustaining breastfeeding for at least six months; iv) pre-pregnancy BMI and GWG; and v) whether social differences in weight over 16 years persist after accounting for reproductive history. Traditional and advanced statistical methods were used, including: exploratory and novel graphical analysis, linear and logistic regression, linear mixed-effects models, and multiple imputation to account for missing data.

Main findings: ALSWH women with a high education (≥15 years) weighed 60.5kg at baseline and gained 10.4kg over the 13-year follow-up period, while women with a lower education (<15 years) were ~2.5kg heavier at baseline and gained an additional ~3.5kg. Compared to women who remained with a low education (≤12 years), those who went on

to achieve a high education had a similar weight trajectory to those highly educated at baseline.

Social differences were found in reproductive characteristics associated with body weight:

Timing of births

- While ~14% of parous women had their first birth <24 years of age, socially disadvantaged women were significantly more likely to do so; this included women with ≤12 years (OR 6.9) and <15 years (OR 3.7) education, women who did not know their parent's education level (OR 4.6), and women living in rural (OR 1.8) or remote (OR 2.1) areas
- Socially disadvantaged women were more likely to have a longer than recommended (18-27 months) birth-to-pregnancy interval

Breastfeeding

- Low educated women (≤12 years) had increased odds of not breastfeeding their first (OR 1.9) or subsequent children (second child OR 1.6, third child OR1.5) and to not sustain breastfeeding for at least six months (first child OR 2.2, second or third child OR 1.7)

Pre-pregnancy BMI and GWG

- Compared to women with >13 years education (post-secondary), Swedish women with a low/intermediate education were more likely to start the first or second pregnancy at an unhealthy weight status (underweight, overweight, or obese) (OR ranging from 1.1 to 2.5)
- Among women with a healthy weight status, having a low/intermediate education was associated with increased odds of excessive GWG in the first (OR 1.4/1.2) and second (OR 1.2/1.1) pregnancy
- Compared to post-secondary educated women, lower educated women had the largest BMI increase between pregnancies (an additional 0.5-0.11kg/m^2). These inequalities were greatest among women with excessive GWG in the first pregnancy ($p < 0.0001$)

Reproduction contributed to social inequalities in weight gain; despite reproductive history not have a large effect on body weight, and educational differences in body weight persisting:

- Having a first birth was associated with increased weight unattributed to other factors. This was most pronounced among those giving birth <26 years of age (2.1kg), compared to 26-32 years (1.2kg) or >32 years (0.7kg)
- Regardless of age at first birth, multiparous women were generally lighter than primiparous women at each follow-up

Conclusion: Reproduction contributes to social inequalities in weight among women; having a first birth <26 years of age was associated with increased weight, particularly among women who did not have additional children. Given the social differences in reproductive characteristics presented, assisting women to achieve optimal timing of reproduction, a healthy pre-pregnancy BMI, adequate GWG, and breastfeeding their children where possible, may assist in reducing future health risks. However, educational differences in body weight persisted after accounting for reproduction, suggesting a need to also explore alternative mechanisms generating social differences in weight, including early-life factors influencing both education and weight outcomes.

Declaration by author

This thesis is composed of my original work, and contains no material previously published or written by another person except where due reference has been made in the text. I have clearly stated the contribution by others to jointly-authored works that I have included in my thesis.

I have clearly stated the contribution of others to my thesis as a whole, including statistical assistance, survey design, data analysis, significant technical procedures, professional editorial advice, and any other original research work used or reported in my thesis. The content of my thesis is the result of work I have carried out since the commencement of my research higher degree candidature and does not include a substantial part of work that has been submitted to qualify for the award of any other degree or diploma in any university or other tertiary institution. I have clearly stated which parts of my thesis, if any, have been submitted to qualify for another award.

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Publications during candidature

Peer-reviewed papers

- **Holowko N**, Jones M, Tooth L, Koupil I, Mishra G. Combined effect of education and reproductive histories on weight trajectories of young Australian women: A longitudinal study. *Obesity (Silver Spring).* 2016. Oct 21 (10):2224-31. doi: 10.1002/oby.21610.

- **Holowko N**, Jones M, Tooth L, Koupil I, Mishra G. High education and increased parity are associated with breastfeeding initiation and duration among Australian women. *Public Health Nutrition.* 2016. Oct 19 (14):2551-61. doi 10.1014/S1368980016000367.

- **Holowko N,** Chaparro MP, Nilsson K, Ivarsson A, Mishra G, Koupil I, Goodman A. Social inequalities in body mass index and gestational weight gain in the first and second pregnancy among Swedish women. *Journal of Epidemiology and Community Health*. 2015; 69(12):1154-61

- **Holowko N,** Jones M, Tooth L, Koupil I, Mishra G. Educational mobility and weight gain over 13 years in a longitudinal study of young women. *BMC Public Health.* 2014 Nov 25; 14:1219

Published conference abstracts

- **Holowko N**, Chaparro MP, Nilsson K, Ivarsson A, Mishra G, Koupil I, Goodman A. OP06: Social inequality in BMI change and gestational weight gain in the first and second pregnancy among Swedish women (Abstract). *Acta Paediatrica.* 2015; 104 (suppl.266):2-4

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- NODE Nordic Doctoral Conference and Networking Event, June 9-10, 2016. Stockholm, Sweden. (Oral presentation)
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    - **Holowko N**, Jones M, Tooth L, Koupil I, Mishra G. 'The combined effect of education and reproductive history on weight trajectory of young women: an Australian longitudinal study'

- SIMSAM Lund workshop, April 18-19, 2016. Lund, Sweden. (Oral presentation)
    - **Holowko, N**. Thesis overview and results from the five studies included

- European Childhood Obesity Group (ECOG) 25th Annual Congress, October 12 -14, 2015. Stockholm, Sweden. (Oral presentation)
    - **Holowko N**, Chaparro MP, Nilsson K, Ivarsson A, Mishra G, Koupil I, Goodman A. 'Social inequality in BMI change and gestational weight gain in the first and second pregnancy among Swedish women'

- International Society of Behavioural Nutrition and Physical Activity (ISBNPA) Annual Conference, June 3-6, 2015. Edinburgh, Scotland. (Oral presentation)
    - **Holowko N**, Chaparro MP, Nilsson K, Ivarsson A, Mishra G, Koupil I, Goodman A. 'Social inequalities in body mass index and gestational weight gain in the first and second pregnancy among Swedish women'

- SIMSAM Lund workshop, November 6-7, 2014. Lund, Sweden. (Oral presentation)
    - **Holowko N**, Chaparro MP, Nilsson K, Ivarsson A, Mishra G, Koupil I, Goodman A. 2015. 'Social inequalities in body mass index and gestational weight gain in the first and second pregnancy among Swedish women'

- SIMSAM workshop, June 10, 2014. Stockholm, Sweden (organised by Prof. Koupil). (Oral presentation)
    - **Holowko N,** Jones M, Tooth L, Koupil I, Mishra G. 'The social patterning of body weight trajectory in young women'

- 'DaSwe Doctoral workshop', May 6, 2015. Copenhagen, Denmark. (Oral presentation)
    - **Holowko N,** Jones M, Tooth L, Koupil I, Mishra G. 'The social patterning of body weight trajectory in young women: the role of reproductive characteristics and lifestyle factors'

- Centre for Health Equity Studies (CHESS) mini-symposium: Overweight/Obesity from a life course perspective, December 13, 2013. CHESS, Stockholm University/Karolinska Institutet. Stockholm, Sweden. (Oral presentation)
    - **Holowko N,** Jones M, Tooth L, Koupil I, Mishra G. 'The social patterning of body weight trajectory in young women'

- Australian Epidemiological Association (AEA) Annual Scientific Meeting – Life Course Approach to Health and Wellbeing. October 20-22, 2013. Brisbane, Australia. (Oral presentation)
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Contributor	Statement of contribution
Natalie Holowko (Candidate)	Designed study (50%) Statistical analysis (60%) Wrote the paper (80%)
Mark Jones	Designed study (20%) Statistical analysis (15%) Interpretation and editing paper (5%)
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Ilona Koupil	Designed study (5%) Interpretation and editing paper (5%)
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- **Holowko N**, Chaparro MP, Nilsson K, Ivarsson A, Mishra G, Koupil I, Goodman A. Social inequalities in body mass index and gestational weight gain in the first and second pregnancy among Swedish women. *Journal of Epidemiology and Community Health.* 2015; 69(12):1154-61. (Incorporated as **Chapter 7**)

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Ilona Koupil	Designed study (25%) Interpretation and editing paper (10%)
Anna Goodman	Designed study (20%)

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Ilona Koupil	Interpretation and editing paper (5%)
Gita Mishra	Designed study (25%) Statistical analysis (15%) Interpretation and editing paper (5%)

- **Holowko N**, Jones M, Tooth L, Koupil I, Mishra G. Combined effect of education and reproductive history on weight trajectories of young Australian women: A longitudinal study. *Obesity (Silver Spring)*. 2016. Oct 21 (10): 224-31. Doi: 10.1002/oby.21610. (Incorporated as **Chapter 9**)

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Keywords

Socioeconomic position, social inequalities in health, overweight, obesity, body mass index, trajectory, gestational weight gain, age at first birth, birth interval, breastfeeding

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FoR code: 1117, Public Health and Health Services, 70%
FoR code: 1114, Paediatrics and Reproductive Medicine, 20%
FoR code: 1603, Demography, 10%

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List of Abbreviations

AIC	Akaike Information Criteria
ALSWH	The Australian Longitudinal Study on Women's Health
ANOVA	Analysis of variance
BWHS	The Black Women's Health Study
BMI	Body mass index
BMI1	Body mass index before the first pregnancy
BMI12	Body mass index before the second pregnancy
BTP	Birth-to-pregnancy interval
CARDIA	The Coronary and Artery Risk Development Study
CI	Confidence interval
GDP	Gross domestic product
GWG	Gestational weight gain
GWG1	Gestational weight gain in the first pregnancy
GWG2	Gestational weight gain in the second pregnancy
IOM	Institute of Medicine
LISA	Longitudinal integration database for health insurance and labour market studies
MAR	Missing at random
MHI-5	Mental Health Index
NHEFS	National Health and Nutrition Examination Survey I Epidemiological Follow-Up Study
NHMRC	The National Health and Medical Research Council
OR	Odds ratio
SEIFA	Socioeconomic indexes for areas
SEP	Socioeconomic position
SF-36	Medical Outcomes Study short form 36 health survey
SIMSAM	Swedish Initiative for Research on Microdata in the Social and Medical Sciences
SPAWN	The Stockholm Pregnancy and Weight Development Study
WHO	The World Health Organisation

Chapter 1. Thesis context and outline

While a trend of increasing body mass index (BMI) was found among Australian women and men from 1980-2007,[1] the prevalence of overweight and obesity in the Australian population has remained stable since 2011-12.[2] Despite this, 2014-15 estimates indicate that almost two-thirds of Australian adults (and one-third children) are overweight or obese.[2] This is of concern due to overweight and obesity exposing individuals to increased risk of certain cancers[3] and chronic diseases, such as type 2 diabetes and cardiovascular diseases, as well as their associated economic burden.[4] Overweight and obesity are also associated with excess obstetric risks for both mother and offspring,[5] and increased risk of childhood obesity,[6] including through the intergenerational transfer of adult metabolic risk via intrauterine growth and prenatal programming of adipose tissue.[7] Weight in early childhood is also associated with weight in later childhood, adolescence, and adulthood,[8] highlighting the importance of what happens early on in life for setting trajectories of weight into adulthood.

With a noted steady pattern of weight gain across the life course,[9,10] investigating determinants of patterns of long term weight change is of increasing priority. **Chapter 1** provides a short introduction to the thesis and a brief outline for each chapter. In **Chapter 2**, an overview of the existing literature relevant to the thesis is given, identifying gaps within the existing knowledge. Following this, **Chapter 3** outlines the rationale for and objectives of the thesis.

This thesis benefits from using two large data sources to address the research questions outlined in **Chapter 3**. The main source of data was the Australian Longitudinal Study on Women's Health (ALSWH), while data from a number of Swedish registers (Medical Birth Register, Education Register, LISA register) were also used; these registers contain large quantities of accurate and reliable information on pre-pregnancy BMI and gestational weight gain (GWG), two reproductive factors that are important for understanding weight increases in relation to reproduction and which are seldom available. **Chapter 4** describes and discusses the study methodology, including an overall description of these data sets.

In the following five chapters, results from analyses investigating socioeconomic differences in body weight and reproductive characteristics, which may influence body weight among women of reproductive age, are presented. Most of the studies use highest achieved education as a measure of socioeconomic position (SEP). This was done for a number of reasons: firstly, the literature details a well-established association between SEP and body weight when measured using education,[9-15] occupation,[9,15,16] and area level disadvantage,[17] while the association with income is less well established;[9] secondly, education is an important measure of SEP, since it precedes occupation and income; and thirdly, and most importantly, education is a more stable measure of SEP[18] particularly for women of childbearing age, since having children means an absence (albeit perhaps temporary) from the paid labour market and a reduction in income. Specifically, **Chapter 5** reports analyses of the association between SEP and body weight over 13 years (*Study 1*). **Chapter 6** introduces the importance of social patterning in reproductive characteristics, and begins by describing socioeconomic differences in age at birth of the first child and in the birth interval between the first and second child (*Study 2*). Both pre-pregnancy BMI and GWG have been associated with long term weight among women. **Chapter 7** explores the social patterning of these characteristics (*Study 3*), along with changes in BMI between pregnancies.

Since breastfeeding has been hypothesised to influence body weight in the postpartum period, **Chapter 8** presents socioeconomic differences in breastfeeding initiation and in sustaining breastfeeding for at least six months (*Study 4*). In **Chapter 9**, the role of reproductive factors in modifying the association between SEP and body weight over time is investigated (*Study 5*). A summary of the main findings from analyses included in the thesis is included in **Chapter 10**, together with an integration and discussion of results: including strengths and limitations, public health implications and directions for future research.

Chapter 2. Literature review

This chapter outlines the existing literature relevant to this thesis and identifies gaps in knowledge to be addressed. This literature review introduces the key terms used and highlights the importance of understanding social determinants of body weight across the life course, including the significance of reproduction as a potential catalyst for overweight and obesity development in women.

2.1 Social inequalities in health

Health inequality refers to the social patterning of morbidity and mortality, where individual health is a product of the social/environmental context. Social stratification exists through the structure of society and the distribution and allocation of power, goods, and resources within it; where factors such as age, sex, ethnicity, education, and social background define social positions and value, which accordingly influence individual susceptibility to disease/injury exposures and risks.[19] The complex interplay between these aspects of stratification, on both the macro level (for example, social institutions and welfare) and micro level (for example, social relationships between individuals and groups, psychosocial factors, including stress, and individual health behaviours), affects individual resources and health experiences. As such, individuals are subject to differential exposure and vulnerability to disease and the consequences of ill health.

Childhood circumstances, including parental economic and social capital (social networks and support), can modify or enhance future health opportunities by providing access to a greater range of resources.[20] On a macro level this includes institutions such as the education system, while on an individual level, advantages may come through greater financial resources, better nutrition, a safer neighbourhood environment, and the nurturing of social/communication skills most valued within society.[20] This clustering of advantageous and disadvantageous resources highlights the ease with which social class can be reproduced inter-generationally, as well as the critical role of social policies and the welfare state in buffering and reducing inequalities in health due to social stratification.

Countries have been grouped in many different ways with regard to the type of welfare state regime, reflecting the level of decommodification and the role of, and degree to which, the family, the state and the market influence individual livelihood.[21] These grouping began with Esping-Andersen's typologies (Liberal – Australia, New Zealand, Canada, U.K., USA; Conservative – Finland, France, German, Japan, Italy Switzerland; Social Democratic – Sweden, Norway, Denmark, The Netherlands, Belgium, Austria),[21] and progressed to other models that better reflect gender, politics, and service provision.[22] Later incarnations developed upon Esping-Andersen's original typologies include the additional categories of Southern European (Italy, Spain, Greece, Portugal), Eastern European (Poland, Hungary, Slovenia, Czech Republic), East Asian (Hong Kong, Japan, Republic of Korea, Singapore, Taiwan) and the ex-Soviet countries.[23]

While a focus on the type of welfare state has dominated the literature, this is now generally seen as less informative, due to large heterogeneity within each group;[24] current dialogue centres on specific aspects of the welfare state that are related to better health and which compensate for inequities generated within the market, such as the coverage and generosity of programmes (i.e. unemployment and sickness insurances, pensions), the availability and quality of services provided,[24] and wider public health indicators.[25] In the case of the more generous policies generalised by the Nordic welfare states, universal social insurance has been found to benefit the whole distribution of the population, and not just those who are most disadvantaged.[24] Despite this, there is a Nordic paradox, where a number of studies have not found the smallest health inequalities to be among the Nordic countries.[26-28] However, with regard to comparing health inequalities across countries, the choice of an absolute or relative measure is important; small relative differences are dependent upon how well more advantaged groups fair and may obscure the existence of large absolute differences between countries.[24] A recent study using a measure of total inequality (incorporating both between- and within-group variance) found that the smallest health inequalities were among the Nordic countries, however only among men and the younger population.[25]

A conceptual framework, created by Solar and Irwin for the World Health Organisation (WHO),[29] shows how the socioeconomic and political context affect aspects of social stratification that shape SEP; SEP then further influences the intermediary determinants of health, which affect health differentially based on individual susceptibility (Figure 2.1**)**. This framework[29] clearly differentiates between the social determinants of health inequities and the social determinants of health (Figure 2.1); a distinction that influences which social objectives and policies are addressed and how changes may be implemented. Given that there is a social gradient in health, policies should tackle health across the whole gradient, in order to ensure that the most vulnerable and disadvantaged are not further burdened and that they experience the same minimum standard for healthy living as all other members of society.[30] This can be achieved by influencing the distribution of, susceptibility to, and consequences of social determinants of health inequalities, and requires universal policies that are sensitive and proportionate to need.[30] A recent European study concludes that lower educational inequalities in health are associated with higher social spending, particularly for women,[31] and that greater social equality is associated with lower mortality and better health.[23]

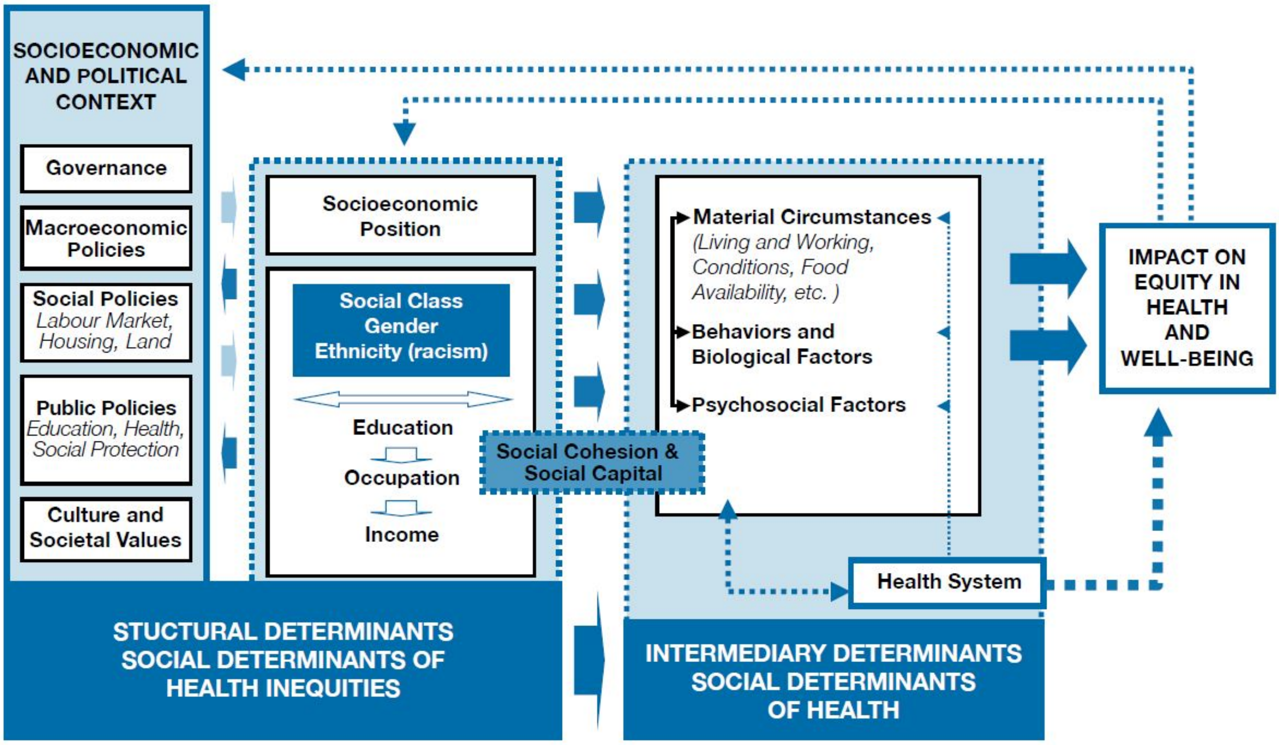


Figure 2.1: A conceptual framework of the social determinants of health, developed by The WHO Commission on the Social Determinants of Health

This figure, developed by Solar and Irwin,[29] clearly differentiates between the social determinants of health Inequities and the social determinants of health. This influences which social policies are addressed, at which time point and how. (With correct citation, no additional permission was required to use this figure).

As detailed in the WHO *Review of Social Determinants of Health*,[30] action is needed at various stages of the life course, as well as within the societal and macro-level contexts, in order to reduce existing health inequalities. Given that inequalities begin early in life, through focusing on women and children, particularly during pregnancy and early childhood, we can strive to provide all children with a 'fair start'. This includes universal provision of good quality child care and early childhood education,[30] improved education policies and investment in education in general,[32] and family-friendly policies that are gender equitable and encourage the same responsibilities of both women and men. Ensuring support in these early years provides a solid foundation and also the opportunity to modify, and hopefully mitigate, the intergenerational transfer of disadvantage.

Following on from early life conditions, the WHO report recommends addressing conditions of employment, as well as reducing unemployment, job stress, and social isolation.[30] This includes income redistribution, improved living conditions, and social protection policies.[32] A good example of the benefits of family policies and how income redistribution can reduce health inequalities is outlined in Fosse et al[33] where, despite differences in economic wealth, both Sweden and Slovenia (countries with universal family policies) have lower health inequalities than the U.K., where social policies are focused towards disadvantaged groups. The WHO report also emphasises the importance of social cohesion and mutual responsibility at the societal level, which can be achieved by building resilience and empowering individuals and communities through involving them in decisions that affect their lives.[30] At a macro level, the political context is also important for health and needs to be considered, including the effect of the recent economic crisis[30] and the displacement of large populations. This highlights the importance of universal access to health care and the idea of a minimum level of protection for all individuals, regardless of age, gender, ethnicity, education, or income. Other factors at a macro level which can have a positive influence on population health include changes to regulations and taxation, as in the example of tobacco control or the taxation of sugar-sweetened beverages.

2.1.1 A life course perspective

A life course perspective on health highlights how social inequalities in health and disease risk are influenced by biological, psychosocial and behavioural factors operating at various stages of the life course, both within and between generations.[34] Three main models are discussed within life course epidemiology which highlight the independent, cumulative, and interactive relationship between temporal circumstances and health in later life;[34] the critical period, sensitive period, and accumulation model.

The critical period in life course epidemiology proposes that disease later in life is directly influenced by exposures during a specific period, which is limited in time and influences the structure of the organism in an unmodifiable way.[34] While not exclusively so, critical periods are commonly related to exposures in utero[35] and the dynamic interaction between our genes and the environment, as presented in the developmental origins of health and disease theory,[36] where early life exposures shape foetal metabolism.[7] In contrast, the sensitive period refers to a time period in which an exposure has a stronger affect than it would at another time,[34] with the possibility of later modification. An example of this is a Swedish study[37] investigating the effect of SEP at different life stages on all-cause mortality in later life, in which although both childhood and adult SEP were associated with all-cause mortality, the effect was strongest for adult SEP. While critical periods are typically more related to the biological development of the organism, sensitive periods are more related to behavioural development.[35]

The accumulation model states that the health effects of exposures accumulate over the life course. These exposures can be positive and health enhancing, or negative and health damaging, with the greater number, frequency and duration of exposures increasing the cumulative damage.[35] This accumulation may be due to exposures that are independent, such as an accident, a death in the family, or job loss. Alternatively, they may be socially patterned or clustered, including poor nutrition, hygiene, and education as a result of an adverse childhood environment. Finally, the accumulation of exposures may be part of a chain of risk, where one exposure (positive or negative) is likely to lead to another such exposure. This could result in an additive effect of all exposures or a trigger effect, where the outcome is reliant on the final exposure within this chain.[35] Education is believed to speed up accumulations that benefit health and to slow down those with a damaging effect.[38]

These life course models can be applied to our understanding of social inequalities in body weight, linking childhood and adulthood SEP to body weight across the life course.

2.1.2 Measures of socioeconomic position

Within public health research, the social context is important for understanding social inequalities in health.[39] This means careful consideration is required when selecting the measure of SEP, to ensure that the causal pathway being evaluated is represented, particularly with regard to stages within the life course.[40] A number of different measures of SEP are used, each reflecting a different aspect of social stratification, being of a varying degree of usefulness depending on the research question, and with their own strengths and limitations to remain aware of (Table 2.1).

As outlined in Table 2.1 (based on summaries by Galobardes et al[18,41] and Shavers[42]), education is the most frequently used measure of SEP. Education is a relatively easy measure to capture and is especially useful for studies among women, particularly of reproductive age, as well as among others who may experience short or long spells out of paid employment, such as students and retired individuals. While this is an important consideration, above all it is clear that the choice of SEP measure needs to go beyond what is simply available within the data and must reflect the causal association being tested,[18,41,42] given that each measure may influence health in varying ways and at different stages of the life course.[43]

Table 2.1: Summary of the main indicators of socioeconomic position, including strengths and weaknesses[a]

Measure of SEP	Description	Strengths	Limitations
Main indicators			

Education	• Captures the knowledge-related assets
	  ○ Accessing health resources
	  ○ Navigating bureaucracies
	  ○ Communicating with health care providers
	  ○ Socialisation of health-promoting behaviours
	• Measured as a continuous (years of schooling) or categorical variable (representing level achieved, and opportunity for employment)
	• Most widely used measure of SEP
		• Inclusive of whole population
		• Easy to measure
		• High response rates
		• Basic indicator, influencing all other SEP measures
		• Relatively stable from early adult life onwards
		• Low reverse causality (compared with other SEP variables)
			• Meaning changes over time
			• Meaning is different based on
			  ○ Context
			  ○ Gender
			  ○ Race/ethnicity
			• The 'currency' of the education itself may vary – it does not necessarily translate into better economic circumstances

Income	• Measures material resources – ability to pay for
	  ○ Health care
	  ○ Good nutrition
	  ○ Housing
	  ○ Schools
	  ○ Recreation
	• Often measured as household income
	• Widely used in economic research
		• Give an indication of ability to purchase services required for good health
		• Strong indicator of material living standards
			• Low response rate - reluctance to share sensitive information
			• Poor reliability – inaccuracy in reporting and changes in meaning over time and between contexts
			• More unstable than education or occupation, particularly for women
			• Excludes assets
			• Possibility of reverse causality (with poor health)
			• Does not take into account in-kind transfers
			• Though more difficult to collect, disposable income is a more useful measures for considering services afforded
			• Household income assumes an even distribution according to needs

Occupation	• Positions individuals within the social structure
	• Represents access to resources and health exposures related to employment
	• Grouping of occupations based on:
	  ○ Prestige (The Registrar General's Social Classes)
	  ○ Characteristics of employment (Erikson & Goldthorpe; NS-SEC scheme)
	  ○ Relation to means of production (Wright's Social Class Scheme)
	  ○ Patterns of social interaction (Cambridge Social Interaction and Stratification Scale)
	  ○ Occupational based census classification
	• Widely used in the U.K.
		• Reflects working conditions and occupational exposures
		• Reflects social standing and hence privileges
		• More accurate than income
		• Can be used to represent SEP of people connected to an individual (for example, 'head of household')
		• Associated with income
		• Available in census data
			• More unstable than education, particularly for women
			• Meaning is different based on context, gender, and race/ethnicity
			• Can be imprecise/crude – categories may be outdated and not reflect the current work market
			• Original categories were based on male employment and may not reflect the stratification of women within the workforce
			• People not in paid employment are often excluded/misclassified (for example, women caring for children at home, unemployed, students, retired)
			• Possible reverse causality (with poor health)

Additional indicators			
Neighbourhood / area-level indicators	• Gives an indication of the context individuals live in, including local access to goods and services • Level of safety • Community social norms	• Good for multilevel analysis • Goes beyond the individual to look area-level factors that may influence health • Used as a proxy when individual factors are unavailable	• Low reliability, particularly for certain groups within society, and may be influenced by time period and area transience • Not highly correlated with individual level measures
Wealth	• Includes income and accumulated resources	• Account for assets and resources of market value, and which provide financial security	• Difficult to calculate

Housing tenure and conditions, household amenities	• Measures material aspect
	  ○ Owner occupied vs renting
	  ○ Access to hot/cold water
	  ○ Central heating
	  ○ Bathroom/toilet available (inside/outside)
	  ○ Amenities: fridge, television, washing machine
	  ○ Car access
	  ○ Housing conditions: damp/condensation, overcrowding
		• Gives an insight into the mechanisms associated with disease	• Context dependent – geographically and temporally specific
			• Can be difficult to interpret
			• Possibly more relevant in low-income countries

Composite indices	• Aggregating a number of SEP measures to create one index representing		

	○ Material and social deprivation (lack of goods and conveniences common within that society, as opposed to poverty); or ○ Social standing and prestige • At an individual or area level		

[a]Information compiled from summarises provided by Galobardes et al (2007) '*Measuring socioeconomic position in health research*',[18] **Shavers (2007)** '*Measurement of socioeconomic status in health disparities research*',[42] and Galobardes et al (2004) '*Glossary: Indicators of socioeconomic position (part 1)*'[41]

2.2 Overweight and obesity

It is well established that overweight and obesity are associated with increased disease risk, such as type 2 diabetes, cardiovascular disease, hypertension and certain cancers.[3] Globally, high BMI accounts for 3.4 million deaths and 3.8% of disability-adjusted life years, and is the leading risk of disease burden in Australia and other high income countries, as well as in Latin America, North Africa, Middle East, and Oceania.[44] Additionally, high BMI attributes to 23% of ischaemic heart disease disability-adjusted life years.[44]

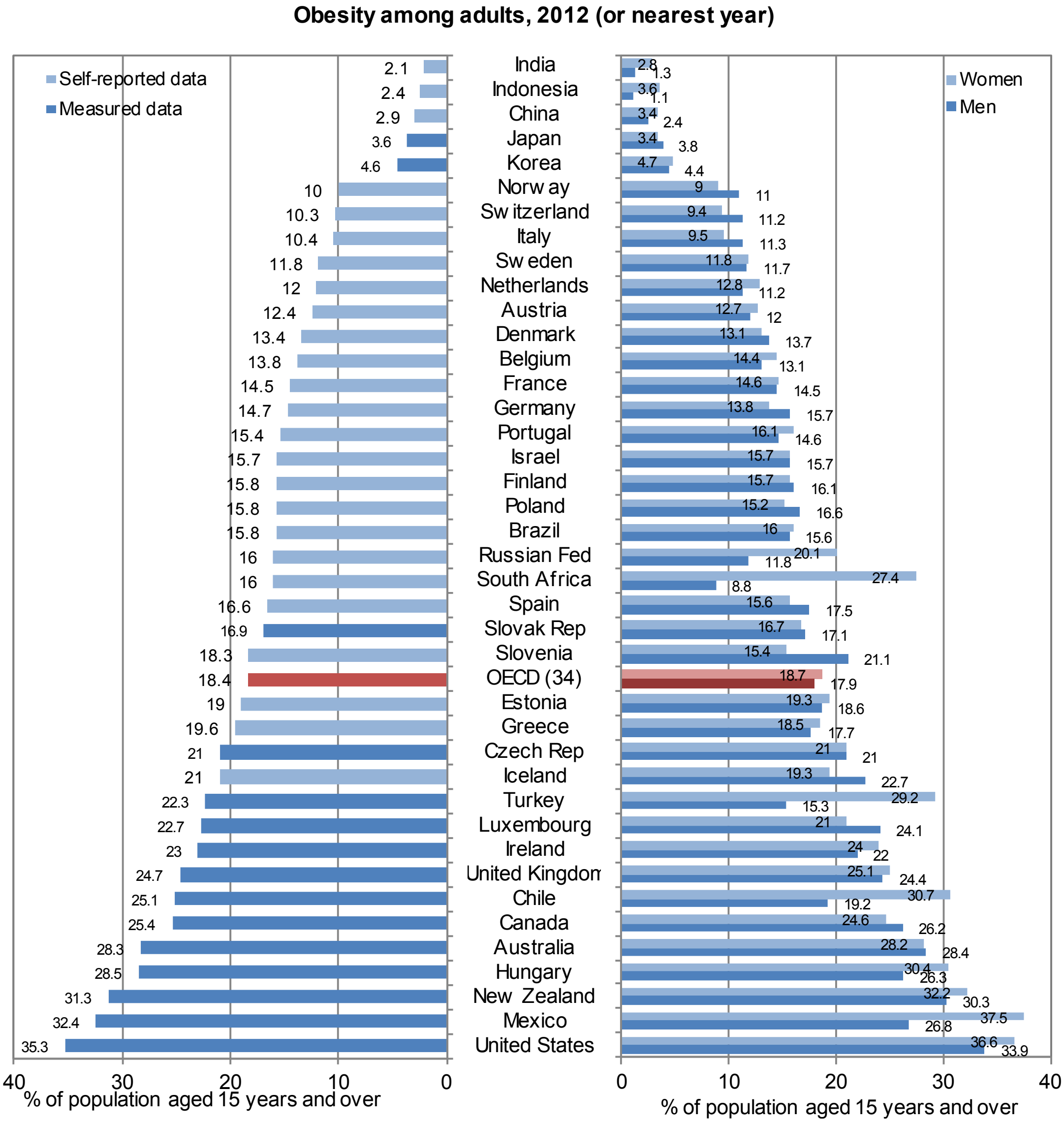


Figure 2.2: Total obesity (self-reported and measured), stratified by sex.

Figure available for download at http://www.oecd.org/health/obesity-update.htm (from the OECD report 'Obesity Update, June 2014')[45]

In high income countries, obesity first became of concern in the 1970s and 1980s,[46] and has alarmingly doubled in prevalence between 1980 and 2014;[47] in 2014, 39% of adults had an overweight weight status (38% of men, 40% of women) and 13% had an obese weight status (11% of men and 15% of women). Almost two-thirds of Australians were overweight or obese in 2014-15,[2] and while this prevalence has remained stable since 2011-12, results from a recent Australian study indicate a trend of increasing BMI among both men and women from 1980-2007.[1] Although a similar increasing trend in overweight or obesity is found in Sweden from 1992-2010,[48] the overall prevalence is lower than in many other high income countries (~40% of women aged 16-84 years).[49] An overview of the prevalence of obesity in a range of OECD and non-OECD countries is shown in Figure 2.2.

Understanding determinants of the high prevalence of obesity is important when considering how best to intervene, and is best illustrated by Swinburn et al[46] (Figure 2.3). This figure shows the influence of distal systemic and environmental drivers, as well as a modifying effect of environmental factors, on behavioural and physiological changes that influence obesity. These distal factors include systemic drivers, such as taxation systems, market regulations, and social policies, which then affect environmental drivers, such as the food supply/systems and marketing environments:[46,50] this includes making unhealthy foods more expensive and healthy foods more affordable,[46,51] restricting the marketing of unhealthy foods to children, revising agricultural policies, challenging dominant food lobbyists,[46] and holding governments and industry accountable for actions that work against good public health practice.[52] Between these distal factors and the behavioural patterns that influence energy balance are modifying environmental factors, which may explain some of the between- and within-country variation in obesity prevalence;[46] such as SEP, the built environment, transport systems, and food culture. Other mechanisms discussed in relation to weight gain include impaired sleep;[46] prolonged financial stress;[53] biological mechanisms, including variation in the FTO gene and increased leptin, which regulates appetite;[54] and early life growth patterns,[54] which will be discussed in detail later. Although met with greater political challenges, interventions targeted at the upstream level have a greater potential for large population affects (Figure 2.3). Overall, a systems approach to reducing obesity is needed in order to create long-term and sustained behaviour change: recognising the need to integrate (where possible) and to act simultaneously on the determinants of obesity on a number of levels and across the life course.[50] Additionally, improved systems for surveillance of overweight and obesity at a population level are required.[46,55]

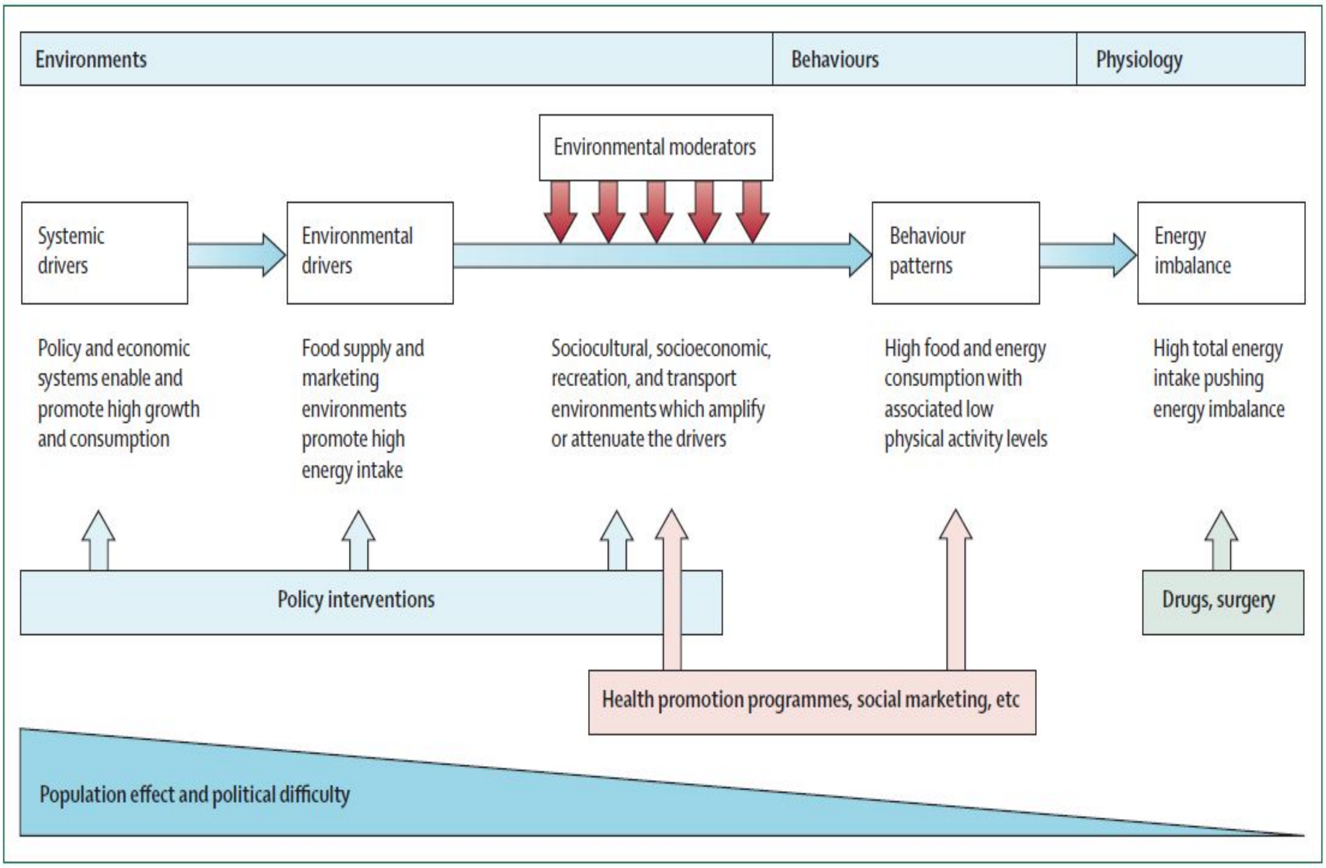


Figure 2.3: A framework to categorise obesity determinants and solutions.

The more distal drivers are to the left and the environmental moderators that have an attenuating or accentuating effect are shown, along with some examples. The usual interventions for environmental change are policy based, whereas health promotion programmes can affect environments and behaviours. Drugs and surgery operate at the physiological level. The framework shows that the more upstream interventions that target the systemic drivers might have larger effects, but their political implementation is more difficult than health promotion programmes and medical services. (Figure and label created by Swinburn et al.[46] The global obesity pandemic: shaped by global drivers and local environments. 2011. *The Lancet*, Aug 27; 378 (9793): 804-14. Reproduced with permission: license # 3831361097690)

2.2.1 Behavioural factors associated with body weight

As indicated in Figure 2.3, a number of behavioural factors are associated with body weight and change; including low physical activity, high fat and energy intake, and low energy balance[15] (particularly among women with overweight/obese baseline BMI);[56] increased sitting time and high BMI;[56] marital status (being married);[10] and neighbourhood characteristics that may be associated with a low level of safety (able to walk in the neighbourhood in the day/night, perception of violence, level of crime), which are inversely associated with BMI.[57]

Smoking is another behavioural factor commonly associated with body weight. Previously found within the ALSWH young cohort, higher weight gain is associated with quitting smoking,[58] and in the U.S., smokers are found to have lower body weight.[5] This is also the case in Sweden,[15] despite current smokers having a higher waist-to-hip ratio than non-smokers and ex-smokers, including after adjusting for BMI and age. Overall, better mental health has also been found among women with stable weight between their early twenties to mid-thirties,[58] although the possibility of reverse causality cannot be ruled out.

Among women in prospective studies, there are mixed results regarding the relationship between alcohol consumption and long term weight change. An inverse association has been found in U.S. studies over eight-year[59] and 10-year periods.[60] On the other hand, a Swedish study[15] among 25-53 year old women found higher weight gain over 20 years among those who did not consume alcohol, while other studies in the U.S. among women of similar ages have found no association at all.[61,62] Another prospective U.S. study found a u-shaped association between alcohol use and weight gain over an eight-year period among women aged 27-44 years,[61] while among mid- to older-aged women in the U.S.,[63] light to moderate drinking was associated with less weight gain and a lower risk of overweight/obesity over an approximate 13-year period, even after adjusting for diet and other potential confounding factors.

Another possible behavioural factor associated with BMI is sleep duration. Two systematic reviews have investigated this and conclude that there is an association between short sleep duration and increased BMI among children and adolescents.[64,65] Among adults, the results are mixed and complex; generally a u-shaped association is suggested, which remains after adjusting for the potential confounding effect of SEP.[64] Suggested mechanisms through which sleep may influence body weight include increased calorie intake, depression, fatigue, and reduced physical activity.[64]

2.2.2 Measuring body weight

By far, the most common measure of body weight is BMI. While easy to calculate and less prone to measurement error, BMI does not distinguish between lean and fat mass.[66] This can be calculated more accurately with specialised equipment (though this is expensive), or through alternative commonly used measures such as waist circumference, waist-to-hip ratio and waist-to-height ratio. These measures provide an indication of abdominal adiposity, however are prone to greater errors and inconsistencies due to precision being reliant on an accurate placement on the body.[66] Increasingly, research has questioned the best measure to use, in order to capture the true burden of disease associated with increasing body weight. While BMI and waist circumference are associated with both morbidity and mortality, measures of central adiposity, such as waist-to-hip ratio and in particular waist- to-height ratio, are argued to be a stronger early predictor of increased disease risk.[67-69] An Australian study did not find sex differences in obesity when using BMI as the measurement, while a greater incidence of obesity was found among women compared to men when using waist circumference.[70] In this study population, approximately 40% of individuals with a non-obese weight status had a waist circumference that was classified as 'high risk' (≥ 102cm for men, ≥ 88 cm for women).[70] This research was extended to calculate the number of deaths attributable to obesity (population attributable fraction) and found no additional benefit in using a combination of BMI and waist circumference, to using waist circumference alone;[71] in fact, the proportion of all-cause and cardiovascular disease mortality was higher when using waist circumference, compared to BMI. Given the comparative discriminate capability of the various measures of obesity in predicting disease,[72] and the ease in collecting BMI information, for now we are reminded to be cognisant of the potential underestimation of the effect of obesity when using the traditional measure of BMI.

2.3 Reproduction and body weight

Pregnancy is a critical period for weight development in the offspring, as indicated through the mechanisms discussed later in section 2.4.1.1. This includes epigenetics and the developmental origins of health and disease, where early life factors can have an impact on weight in later life. Pregnancy is also a critical period for both the mother and offspring in both the short and long term, due to a number of increased obstetric and neonatal risks/complications associated with excessive GWG. This includes increased risk of gestational diabetes mellitus, hypertension, preeclampsia, preterm birth, and delivery complications;[73] the effect of which varies according to pre-pregnancy BMI.[74] Among women of normal pre-pregnancy BMI, increased risk of adverse outcomes include gestational diabetes mellitus and caesarean section;[75] while women of overweight or obese pre-pregnancy BMI have additional increased risks of preeclampsia and failed induction.[75]

However, in addition to these risks, pregnancy may also be a sensitive period for obesity development in women.

2.3.1 The role of parity

Overall, the association between parity and long term weight varies from moderate[76,77] to strong;[10,78-80] while studies which have found no association[81] suggest that this may be due to low variation in the number of children per mother within their sample. While in the U.S.,[82,83] U.K.,[84,85] and Sweden,[15] the prevalence of obesity in mid-to-later life is positively associated with number of children, including after adjusting for SEP and other confounding factors,[82] some studies have suggested that the greatest gains in weight due to childbearing are mainly after the first and not subsequent births.[86,87]

Compared to nulliparous women, studies such as the National Health and Nutrition Examination Survey I Epidemiologic Follow-up study (NHEFS)[76] and the Stockholm Pregnancy and Weight Development Study (SPAWN)[88] have attributed only marginal higher 5-10-year weight gain to having had a child. Other studies suggest a greater effect of reproduction on long term body weight. The Coronary and Artery Risk Development in Young Adults study (CARDIA) found 10-year weight gain to be almost 5 kg higher among women who had a first birth or one or more short pregnancies within this period.[79] Another U.S. study found that over a 15-year period, women with children gained weight faster than those who did not, with higher education associated with more rapid weight gain over time.[80] Compared to women without a partner or children, a previous ALSWH study found that weight gain was 4 kg higher among women partnered with children and 1.8 kg higher among women partnered but without children.[10]

Among women of childbearing age, the results differ. In the Swedish SPAWN study of women of childbearing age, there was no difference between those who remained at a 'normal weight' and those who became overweight at 15-year follow-up, with regard to either parity or number of pregnancies before or after the index pregnancy;[81] although the authors note this could be due to low variation in parity within this sample, with most women having had two children. Additionally within the SPAWN study,[77] no association was found between parity, pre-pregnancy BMI, social class, occupation, or marital status with weight at one-year postpartum. In a U.K longitudinal study,[78] while women with three or more children had a higher BMI than women with less or no children, parity did not attenuate the association found between childhood SEP and adult BMI.

Results from longitudinal studies suggest that the first pregnancy may be particularly important for women with regard to overweight and obesity development. Within the U.S., the CARDIA study[79] found higher 10-year weight gain among women with an overweight status before their first pregnancy and not subsequent pregnancies. The BWHS (Black Women's Health Study)[89] also found higher weight gain during the four-year follow-up period among women who had their first birth during this period, compared to women who remained nulliparous or those who already had children. Among ALSWH young women,[10] a higher rate of weight gain over a 10-year period was found among primiparous women, compared to those with more than one child. Given these results, there is a suggestion that the greatest increases in weight associated with pregnancy occur in susceptible women after the first and not subsequent births. This may be due to an adiposity threshold being met in first pregnancy or to the greatest behavioural/lifestyle changes associated with weight change happening with the first birth.[10,79,89]

On the other hand, a U.S study of 4,015 women aged 14-21 years and nulliparous at baseline and followed up at 10 years, found a similar increase in BMI among primiparas and multiparas, which was greater than the increase among nulliparas.[90] This study also found that at 25-year follow-up, parity was only associated with increased BMI among black women with an overweight BMI at baseline.[90]

2.3.1.1 *Mechanisms through which parity may influence body weight*

Mechanisms through which pregnancy is believed to influence weight in later life include pre-pregnancy BMI, GWG and postpartum weight retention. While high pre-pregnancy BMI is one of the strongest predictors of GWG outside of the Institute of Medicine's guidelines,[86,91,92] an association between high BMI and risk of long term weight gain/retention has been found in many studies[10,79,83,86,93-95] but not all.[77,88,96,97] Within the literature there is a general consensus that high GWG is a strong risk factor for high postpartum weight retention at: up to nine months postpartum among Brazilian women;[96] up to 24 months postpartum among U.S. women;[98] both one-year and 15-year follow-ups among Swedish women;[88,99,100] 16 years postpartum among women in the U.K. AVON Longitudinal Study (ALSPAC);[93] 21 years after index pregnancy in Australian women;[101] and among U.S. women aged 40-70 years.[83] Two other U.S. studies found conflicting results regarding parity and the risk of excessive GWG; one found that nulliparity versus one or more previous births was associated with increased risk,[92] while the other found higher odds of excessive GWG among multiparous compared to nulliparous women.[91]

The combination of high BMI and high GWG increases a woman's risk of long term obesity[102] and complications in subsequent pregnancies;[103] with findings that those unable to lose pregnancy weight by one year postpartum are more likely to retain this weight long term.[88] Women with high GWG and postpartum weight retention in the first pregnancy are also more likely to retain it to the second one, and so this cycle continues with subsequent pregnancies.[99]

Within ALSWH, weight gain over a 10-year period (from baseline age of 18-23 years) was associated with initial BMI.[10] Women who were able to maintain their weight to within 5% of their baseline weight over four years (from Survey One to Survey Two) were, among other factors, more likely to have never been married, have no children, and have a healthy weight at baseline.[95] While behavioural factors such as physical activity, sitting time and energy intake were associated with higher weight gain among primiparous compared to multiparous ALSWH young women, changes in these behaviours did not explain the differences in rate of weight gain that were found.[10]

While becoming a mother has previously been associated with better adherence to dietary guidelines, it has also been associated with increased energy intake. Both the transition to motherhood[104,105] and changes in cohabitation[105] are associated with increased weight gain through: changes in food and nutritional status, increased energy intake, and higher sugar pattern and high-fat scores[105] as well as changing roles and responsibilities. A U.K. study found that both parity in women and fathering among men were positively associated with adiposity in later life, suggesting that both SEP and lifestyle factors associated with child-rearing may play a larger role in this relationship than the biological effects of childbearing.[85]

2.3.2 The role of age at birth of first child

A bio-developmental perspective inextricably links women's health in the long term to biological readiness at the time of their first birth, and suggests that an optimal age for a first birth is shortly after the reproductive system is ready (i.e. after the end of puberty).[106] In contrary to this, Mirowsky[106] supports a bio-social perspective, which does not see a disadvantage in delaying motherhood until women are aged in their thirties; the social, emotional and economic benefits this delay brings may indeed compensate for any costs associated with biological ageing.

While a bio-developmental view suggests an optimal age for first birth shortly after the reproductive system is ready (i.e. after the end of puberty), Mirowsky[106] supports the biosocial view, which says that delaying motherhood until women are aged in their thirties should not be seen as a disadvantage; that the social, emotional and economic benefits this delay brings may compensate for any costs associated with biological ageing.

Age at birth of the first child is also associated with weight; a U.S. study[107] found that, compared to women who were aged above 30 years at the birth of their first child, women aged between 24-30 years had an increased risk of becoming overweight one and a half years after the index pregnancy. The authors suggested this could be due to social differences in the initiation of child bearing. This is supported by results from a U.K. Biobank study, which found a linear and inverse association between age at first birth and body adiposity in later life, with a suggestion that the effect may be stronger among women with a lower SEP.[85] Additionally, a Swedish study among older women found that compared to women who gave birth for the first time between age 20-22, women aged between 17-19 years had a 16% increase in odds of overweight and 30% increase in odds of obesity; while women aged 23 years and above at birth of the first child had a 12-23% and 26-35% decreased risk in odds of overweight and obesity, respectively.[108] Other studies have found a mixed association between age at birth of the first child and weight, or none at all. Within the Swedish SPAWN study there was no association between age at birth of first child and GWG[81] or weight retention at one year postpartum.[99] Additionally, another U.S. study[98] did not find an association between maternal age and risk of excessive long term weight gain after pregnancy.

In relation to having children, a U.S. study[80] found an ideal age at birth of first child of 26.8 years; first births earlier or later than this age were associated with a steeper weight trajectory, with the rate of change over time not being influenced by parity. Living with an adult child at baseline was also associated with a higher baseline weight but not with rate of change;[80] while living with a minor child was associated with a significantly higher baseline weight for men, but not women.

2.3.3 The role of birth spacing

Various terms are used within the literature to refer to the time interval between children. Birth interval and birth spacing refer to the time between one birth and the next; while inter-pregnancy and birth-to-pregnancy (BTP) intervals refers to the time between one birth and the beginning of the subsequent pregnancy. In some studies, the interval between births has been weakly correlated with weight change;[90] while in others among multiparous women, both shorter birth intervals and high GWG are associated with increased risk of obesity.[81] One mechanism through which short birth intervals may be linked to poor maternal outcomes is the maternal depletion hypothesis, which states that short birth intervals do not allow sufficient recovery from the physiological stress of pregnancy.[109] Other suggested mechanisms are postpartum stress and socioeconomic factors,[109] as well as inadequate time to lose any excess GWG.[110]

In a Latin American study of 520,690 parous women,[109] women with short inter-pregnancy interval (< 6 months) were, among other things, at increased risk of maternal death and anaemia; while a longer birth interval (> 59 months) was associated with increased risk of pre-eclampsia and eclampsia.[109] This study in developing countries also found similar rates of pre-eclampsia among parous women who gave birth five or more years ago, as with women who were nulliparous; this suggests that any protective effect against pre-eclampsia that is acquired through pregnancy is lost after a long inter-pregnancy interval[91].

Extremes of the age distribution, along with marital status, higher parity and lower SEP, have been associated with shorter inter-pregnancy intervals.[111] A U.S. study of women with two consecutive pregnancies found that the time interval between pregnancies was not associated with the risk of becoming overweight, however it was weakly correlated with weight change.[107] Another U.S. study found that, regardless of GWG, multiparous women with short inter-pregnancy intervals were at increased risk of long term obesity, compared to multiparous women with longer pregnancy intervals.[110] A Swedish study among primiparous women with inter-pregnancy intervals ranging from 1-10 years found that, independently of pre-pregnancy BMI, an increase in BMI (as little as one unit) in the inter-pregnancy interval was associated with an increased risk of maternal and perinatal complications, including both gestational hypertension and diabetes.[112] Two studies[110,113] suggest an optimal inter-pregnancy interval of 18-23 months, with the combination of a short inter-pregnancy interval and excessive GWG further increasing the maternal risk of obesity.[110] After weighing up the evidence of adverse maternal and perinatal outcomes associated with the interval between births, The WHO technical consultation on birth spacing concluded with recommending a birth-to-pregnancy interval of 24 months.[114]

2.3.4 The role of breastfeeding

The WHO recommends exclusive breastfeeding of infants up to six months, followed by an introduction of complementary foods and continued breastfeeding thereafter.[115] These recommendations are based on numerous positive and protective short/long term effects for both the infant and mother.[115-120] Given this, the Australian Dietary Guidelines recommend exclusive breastfeeding of infants up to six months, with further continued breastfeeding up to 12 months.[121]

To varying degrees, breastfeeding has been associated with short and long term body weight for the mother and her offspring. For the child, the evidence convincingly suggests a protective effect of breastfeeding on overweight/obesity development in the short and long term, particularly with increasing breastfeeding duration;[117,122-125] while for mothers the evidence is less conclusive. While some studies have found a protective association between breastfeeding and post-partum weight at six and 18 months, regardless of BMI,[126] and at seven-years postpartum,[127] others have found no association.[82,128] A systematic review and meta-analysis found insufficient evidence to indicate an association between breastfeeding and postpartum weight change, and has suggested a stronger influence of GWG, age, and pre-pregnancy BMI.[128]

Factors influencing breastfeeding initiation, duration and intensity may be on an individual, group, or societal level. On an individual level, maternal or infant attributes positively associated with initiation and duration of breastfeeding include: higher maternal age;[129-131] higher maternal education in some studies[129,130,132,133] but not others;[131] higher family income;[129] maternal attitude towards breastfeeding;[131] being married, in some studies[130,134] but not all;[131] living with a partner;[133] and history of prior breastfeeding,[133,135] which may be more strongly associated with subsequent feeding than parity.[136] The findings between parity and breastfeeding duration are in fact mixed: some studies find a positive association[137,138] and that multiparous women are more likely to breastfeed for longer,[131] while other have found no association.[139] Factors negatively associated with breastfeeding duration include: low milk supply and feeding difficulties in the first month;[131] early introduction of pacifiers;[131,140] maternal smoking,[130,131,141] early return to employment;[131,132] caesarean delivery,[134] which is also negatively associated with breastfeeding initiation and self-efficacy;[138] having a partner with a low education or occupational status;[134] high pre-pregnancy BMI;[141,142] and excessive GWG.[143] Pre-pregnancy BMI is also associated with confidence in, social influence towards, and social knowledge of breastfeeding;[144] with beliefs about the benefits of breastfeeding influencing intention.

On a group level, features of the home/work/community environment, including parental leave use, flexible working conditions,[132] and social support may all influence breastfeeding duration. There is also an intergenerational influence, with women who were themselves breastfed as an infant being more likely to intend to, initiate, and persevere with breastfeeding.[145] On a societal level, higher rates of breastfeeding have been found in Europe and Australia compared to the U.S. and Canada;[129] with parental leave policies, flexible working conditions,[132] cultural norms surrounding breastfeeding, and the visibility of breastfeeding in public all being important.[121]

The timing and type of breastfeeding intervention also influence effectiveness, with a combination of antenatal and postnatal interventions and involving the partner/significant care-giver being important.[121] Population-wide interventions have the potential to increase social inequalities if greater uptake and improvements are seen among advantaged individuals.[146] Lower education has been associated with reduced odds of breastfeeding in Australia[119,129,131] and in other high income countries,[129,130,133,142,147] while another study has found negligible social differences in ceasing exclusive breastfeeding at three months.[148]

Given the weak evidence for the association between breastfeeding and body weight for women, an interest in social differences in breastfeeding within this thesis is based on the other numerous benefits of breastfeeding, including the association with offspring body weight in the short and longer term. Overall, while not associated with long term weight in women, evidence suggests that breastfeeding is beneficial for metabolism in the offspring, and hence their long term risk of overweight and obesity. Given that breastfeeding is also associated with improved mother-child bonding and attachment,[119] and lower perceived stress levels and depression,[149] supporting women to breastfeed where possible is of importance.

2.4 Social inequalities in body weight

As mentioned in **Chapter 2.1.2**, SEP can be measured in varying ways and at varying points over the life course, reflecting different aspects of social stratification. The distinction between the exposures of childhood and adult SEP is important for understanding mechanisms through which social inequalities may influence body weight over the life course.

2.4.1 Childhood socioeconomic position and body weight

Many studies in high income countries have shown an inverse association between childhood SEP and BMI[11,78,150,151] and weight[15,152,153] in early adulthood, as well as BMI,[16,78] body fat mass, and central adiposity[15] in mid-life. With regards to obesity in adolescence, a U.K. study found no social trends,[152] while a Danish study[154] found BMI in adolescence and early adulthood to be socially patterned. Childhood SEP is most commonly measured using father's occupation[15,16,78,150] (or if missing, then father's education[153]), however some studies have used both mother's and father's education.[11] With regards to the effect of early life SEP on weight gain, the results are varying. Among women, both parent's and own low education or low SEP (based on occupation) have been associated with high long term weight gain in older women;[15] while among women aged approximately 18 to 45 years, higher childhood SEP has been found to have a greater protective affect over the life course,[11] even independently of adult SEP.[78]

2.4.1.1 *Mechanisms linking childhood socioeconomic position and body weight*

Mechanisms through which childhood SEP may influence weight include a genetic pre-disposition, developmental programming of obesity and the shared environment,[151] which may promote poor dietary habits and low levels of physical activity.

One of the suggested biological mechanisms for social inequalities in health is SEP differences in epigenetic changes, resulting from an interaction between our genes and the environment. Pregnancy, early life, and adolescence are considered important sensitive periods of high epigenetic plasticity, particularly with regard to metabolic programming.[155] Epigenetic changes include structural and functional adaptations of the foetus through intrauterine growth and the prenatal programming of metabolism and adipose tissue,[7] as well as altered inflammatory markers in later life.[156] This includes DNA methylation of pro-inflammatory genes, which is also found to be socially patterned.[157] Physical birth characteristics such as weight and length are often used as a proxy for foetal development and nutrition, and have also been linked to both incidence of and as a risk factor for later life diseases, such as coronary heart disease, type 2 diabetes, hypertension, and glucose intolerance.[158] According to the developmental origins of health and disease, it is the so called 'mismatch' between the predicted intrauterine and actual postnatal nutritional environments that is said to significantly affect later disease development,[159] as well as the specific timing of exposures during gestation.[159] Additionally, adverse intrauterine exposures such as maternal stress can alter hypothalamic-pituitary-adrenal activity and further influence offspring obesity, insulin resistance, lipid abnormalities, and anxiety.[160]

Aside from developmental programming, other possible explanations for the association between parental and offspring obesity are genetic predisposition and the shared environment.[151] Diet and physical activity patterns are established early in life[161,162] and are therefore highly influenced by parental diet and lifestyle patterns, which may include poor knowledge of the benefits of exercise and a healthy diet.[163] Early socioeconomic circumstances also influence neighbourhood of residence, which an Australian study found to be inversely associated with BMI and, perhaps, just as important as adult SEP in explaining increased levels of overweight/obesity in areas of higher disadvantage.[17] This may be due to an environment characterised by reduced opportunities for exercise and recreation, or encouragement of over-consumption;[17] alternatively, it could be that neighbourhood remoteness and low levels of safety make individuals less likely to use outdoor spaces.

Another suggested mechanism linking early life circumstances and later life BMI is early adiposity rebound: this refers to the age at which BMI steadily increases, after an initial increase in BMI in infancy and then a decrease in early childhood,[164] and is associated with both low SEP in childhood[165] and high parental BMI.[166] Early adiposity rebound is additionally associated with early menarche,[167] which is associated with lower SEP at age seven and downward social mobility.[168] A greater risk of overweight and obesity is also found in the offspring of overweight/obese parents.[169]

2.4.2 Adult socioeconomic position and body weight

Many studies in high income countries such as the U.S., Australia, U.K., and Sweden have shown a well-established inverse association between adult SEP and BMI across the life course; specifically among women in early to mid-adulthood[16-21] and mid-to-late adulthood,[12,15,16] although some studies have reported no association between own education in early adulthood and BMI or weight change.[95,170] The inverse association between own SEP and body weight has been found using a variety of measures of SEP, such as education,[9-15] occupation,[9,15,16] or area level disadvantage,[17] although the association with income is less well established.[9] Education is an important measure of SEP, since it precedes occupation and income. Indeed, a Finnish study investigating the association between multiple measures of SEP and five-year weight gain in mid-aged women found that, after full adjustment, only the association between education and weight gain remained.[171] Weight differences by adult SEP are also reportedly increasing among younger female cohorts,[95,172,173] who have an increased risk of obesity and a higher mean weight gain over four-year,[95] five-year,[173] and 10-year[10] periods. Within the ALSWH, own adult SEP has previously been shown to be inversely associated with both baseline weight and weight change in the relative short term from 1996 (aged 18-23 years) to 2000,[161] and up to 2006 (aged 28-33 years) using highest achieved education.[10]

Different measures of inequality have been able to provide some insight into the contribution of inequality to obesity prevalence. While the reliability of gross domestic product (GDP) to predict obesity in OECD countries has been questioned,[174] a recent study among 70 countries found a positive association between educational inequalities and GDP;[175] additionally, while education was positively associated with obesity among countries with a low GDP, conversely there was a negative association in countries with a high GDP.[175] Using the ratio of income among the richest and poorest 20% in 21 countries, Pickett et al[176] found that income inequality was related to obesity among both men and women in high income countries. A commonly used measure of inequality is the GINI coefficient, which represents inequality in a country's distribution of income; at a mean value of 31.7, GINI indexes range from the lowest in Sweden (23) to the highest in Mexico (48.2).[174] With regard to both obesity prevalence and the increase in obesity prevalence between 2002-2010, a recent study found that the GINI index could explain 16% of the variation in men and 35% of variation in women, but only when the U.S. and Mexico were included in the analysis;[174] with both these countries removed, the associations completely disappeared among men and almost among women, most likely because both obesity and income inequality are high in these two countries.[174]

2.4.2.1 *Mechanisms linking adult socioeconomic position and body weight*

Education empowers individuals with a sense of personal control and enables people to access a larger range of resources which may assist in making healthy lifestyle choices.[38] Higher education also increases an individual's capacity for resource substitution.[38] This means that while higher educated individuals are at lower risk of experiencing high risk situations, they are also less susceptible to the effects of high risk events,[38] such as poor health, loss of income, or breakdown of a relationship.

Suggested mechanisms through which SEP may affect body weight are health related behaviours, material resources, and psychosocial factors[170] with a well-established association with weight change, as outlined in **Chapter 2.2.1**; including smoking, physical activity, energy intake, energy balance,[15] alcohol consumption,[61] sitting time,[56] marital status,[10] and neighbourhood characteristics.[57] We also see social differences in smoking prevalence on a number of levels; higher educated individuals are less likely to smoke and, among those who do smoke, are more likely to quit both before and after a health crisis.[38]

Some studies report that having a low education is associated with poorer nutritional knowledge;[163] this includes differing social and cultural norms/values that influence weight perception, as well as variation in eating behaviours and an understanding of the importance of healthy weight maintenance.[63,177] Low education is also associated with low levels of physical activity,[163,178] which is associated with higher weight gain.[15] Among the ALSWH young cohort, physical activity is inversely associated with average annual percentage weight change over a ten year period (up to age 28-33 years); while sitting time and energy intake are positively associated with weight change.[10] Together, these three factors constitute energy level balance, which is inversely associated with weight gain among ALSWH young women.[56] Additionally, poorer nutritional intake is found among unmarried women and those in manual occupations.[58] However, beyond the usual conversation about energy balance and body weight, recent evidence suggests that changes to intestinal microbiota may also play a significant role for metabolism, and hence obesity development,[179] thus being an important area for further study.

As discussed with regard to mechanisms linking childhood SEP and body weight, epigenetic changes may also influence the relationship between adult SEP and body weight. While the genotype remains relatively stable, the phenotype is influenced by epigenetic processes that activate or silence genes. With regard to the aetiology of obesity, epigenetic processes that can influence weight include DNA methylation[180] and histone modifications,[181] which affect deposition of fat tissue and inflammation. Differences in DNA methylation of pro-inflammatory genes is seen based on SEP over the life course,[157] with lifestyle factors playing a role in these epigenetic modifications.
Chronic stress may be another mechanism linking low SEP with poor health in general, through increased diurnal cortisol levels and allostatic load, resulting from cumulative damage due to the physiological response to stress.[182] Such stress may result from the family or the workplace, with social differences found in coping resources, including personal resources and social support.[183] While low SEP is associated with less sedentary work, this may also mean higher physical demands that carry an increased risk of injury, or work that is characterised by a lack of autonomy.[184] An Australian study found higher BMI among women who were unemployed or in low status occupations, working few hours, and/or receiving welfare benefits.[178] A low education may also impose a double burden on

health, where it not only restrains income through occupation, but also makes it harder to manage on a lower income.[38] However, despite the influence of psychosocial stress on the relationship between job status and body weight,[178] a recent review did not find an association between psychological workload (for example, job demand, job strain, and job stress) and obesity in women.[185]

Despite the various behavioural, psychosocial, and material factors associated with weight change, that are discussed in this section and in **Chapter 2.2.1**, these determinants alone have not been able to explain socioeconomic differences in weight.[178] Given this, there is a need to investigate alternative explanations or mechanisms through which socioeconomic differences in weight are established, maintained or increased.

Chapter 3. Thesis rationale and objectives

3.1 Thesis rationale

As shown in **Chapter 2**, many studies in high income show a well-established inverse association between adult SEP and BMI across the life course; that is, higher SEP is associated with a lower BMI. This is specifically found among women in early to mid-adulthood[16-21] and mid to late adulthood,[12,15,16] and using a number of different measures of SEP. Weight differences by adult SEP are also reportedly increasing among younger female cohorts.[95,172,173] Given this, studies investigating determinants of patterns of long term weight change, including the importance of individual social characteristics and contextual conditions, are of increasing priority.

To summarise the key points in **Chapter 2**, a number of lifestyle and behavioural characteristics have been associated with increased body weight: energy expenditure –low physical activity and high fat and energy intake;[15] alcohol consumption (a possible u-shaped association);[61] quitting smoking;[15] increased sitting time, menopause and high BMI;[56] and being married.[10] In addition to this, pregnancy may act as a sensitive period for overweight and obesity development in women. One suggested mechanism is parity, for which there is evidence of a moderate[76,77] to strong[10,78-80] association with long term weight. While GWG is associated with an increased risk of gestational diabetes mellitus, hypertension, preeclampsia, preterm birth, and delivery complications,[73] it is also associated with weight at up to one-year postpartum,[96,98] as well as in the longer term -at 15-21-year follow-up[88,93,99-101] and among mid-aged women.[83] The combination of high BMI and high GWG also increases a woman's risk of long term obesity.[102]

While weight during pregnancy is an obvious issue for women themselves, there is evidence that epigenetic changes can influence the risk of obesity for the offspring. Mechanisms include the developmental programming of metabolism and adipose tissue,[7] altered inflammatory markers in later life,[156] altered hypothalamic-pituitary-adrenal activity,[160] genetic predisposition, and the shared environment.[151] This highlights the importance of reproductive events for the possible intergenerational transfer of obesity risk from mother to child.

An understanding of socioeconomic differences in body weight in relation to reproductive events is lacking within the literature. This thesis builds on existing research to better understand socioeconomic differences in body weight among women of reproductive age. Such information is important in identifying women at risk of an unfavourable weight trajectory, as well as establishing whether reproductive events make women further vulnerable to excess gains in weight in the long term. Self-reported data from the ALSWH and Swedish register data were used to explore the association between education and body weight, and whether this association is modified by reproductive events.

3.2 Thesis objectives

The objectives of this research were to:

- Document the burden and distribution of overweight and obesity among Australian women of reproductive age
- Document reproductive characteristics (including age at birth of the first child, total number of children, birth intervals, and breastfeeding) among Australian women of reproductive age
- Investigate the social patterning of body weight, including the importance of the timing of SEP measurement
- Investigate the social patterning of reproductive characteristics that are important for understanding body weight. This includes the aforementioned reproductive characteristics, as well as pre-pregnancy BMI and GWG; and
- Investigate the importance of pre-pregnancy weight status in combination with gestational weight gain for women's long term weight trajectories
- Explore the role of reproductive events in modifying the social patterning of body weight among women

Chapter 4. Methodology

This chapter summarises the study designs and two main sources of data used to address the key research questions. Data from the ALSWH were used in four out of the five studies, while data compiled from a number of national Swedish registers were used to address one of the research questions. These two data sources were chosen as they contain high quality data and were considered the best available datasets to answer the research questions outlined below.

4.1 Study design

This PhD builds on existing research to better understand the association between SEP and body weight in relation to reproductive events among women of childbearing age. As outlined in Figure 4.1, this research specifically investigates:

- The association between adult SEP and body weight among women of reproductive age, including the importance of the timing of SEP measurement (Path One: *Study 1*)

- Socioeconomic differences in reproductive events and characteristics, including
    - age at birth of the first child, child birth intervals, total number of children, and breastfeeding (Path Two: *Study 2 and Study 4*)
    - pre-pregnancy BMI and GWG (Path Three: *Study 3*)

- Whether the association between SEP and body weight is modified by reproductive events (Path Four: *Study 5*)

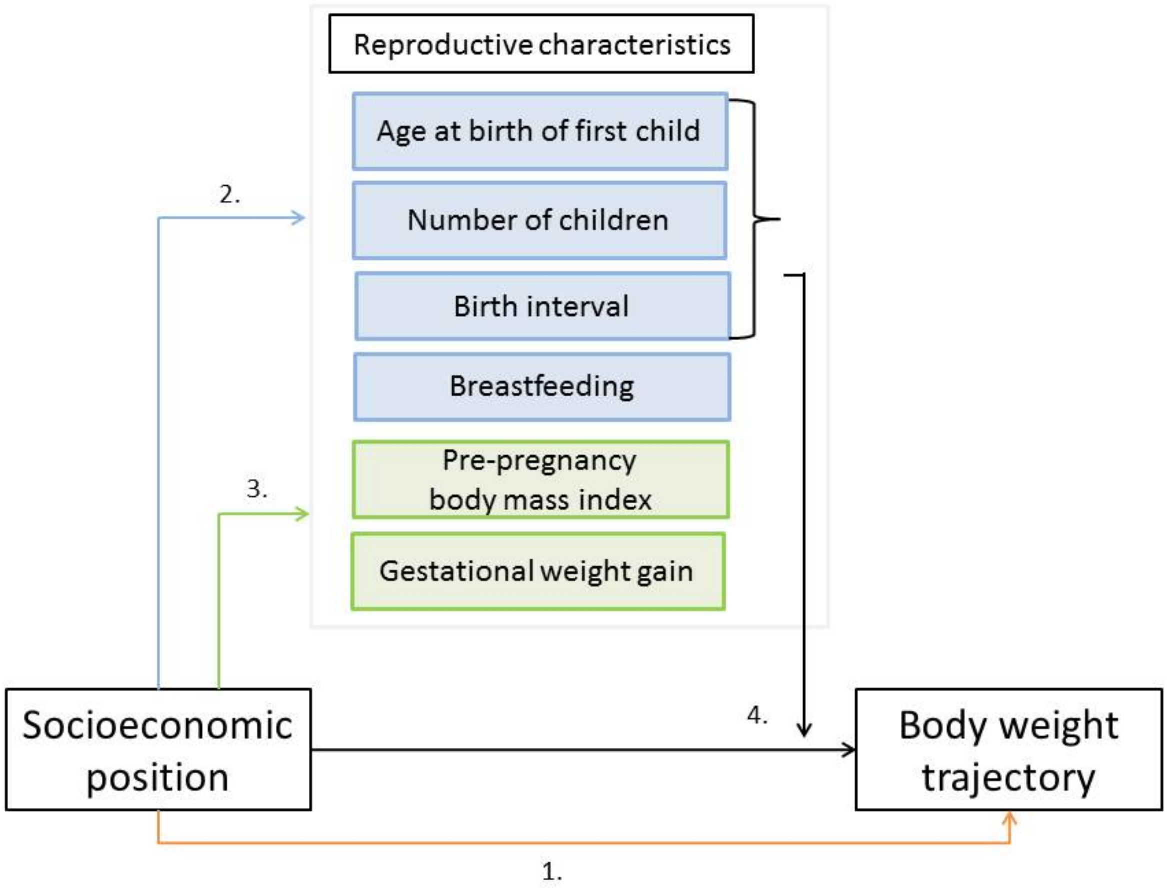


Figure 4.1: The thesis explores the association between socioeconomic position and body weight trajectory in relation to reproductive events among women of childbearing age through four main paths

Casual diagrams are a useful tool for mapping out *a priori* associations and making transparent the assumptions held for the models we run, and are presented below for *Study 2, 3, and 4* (Figures 4.3 - 4.5). For *Study 1 and 5*, schematic representations for the associations under investigation are shown instead (Figure 4.2 and Figure 4.6), given the complicated and interwoven relationship between variables in longitudinal data.

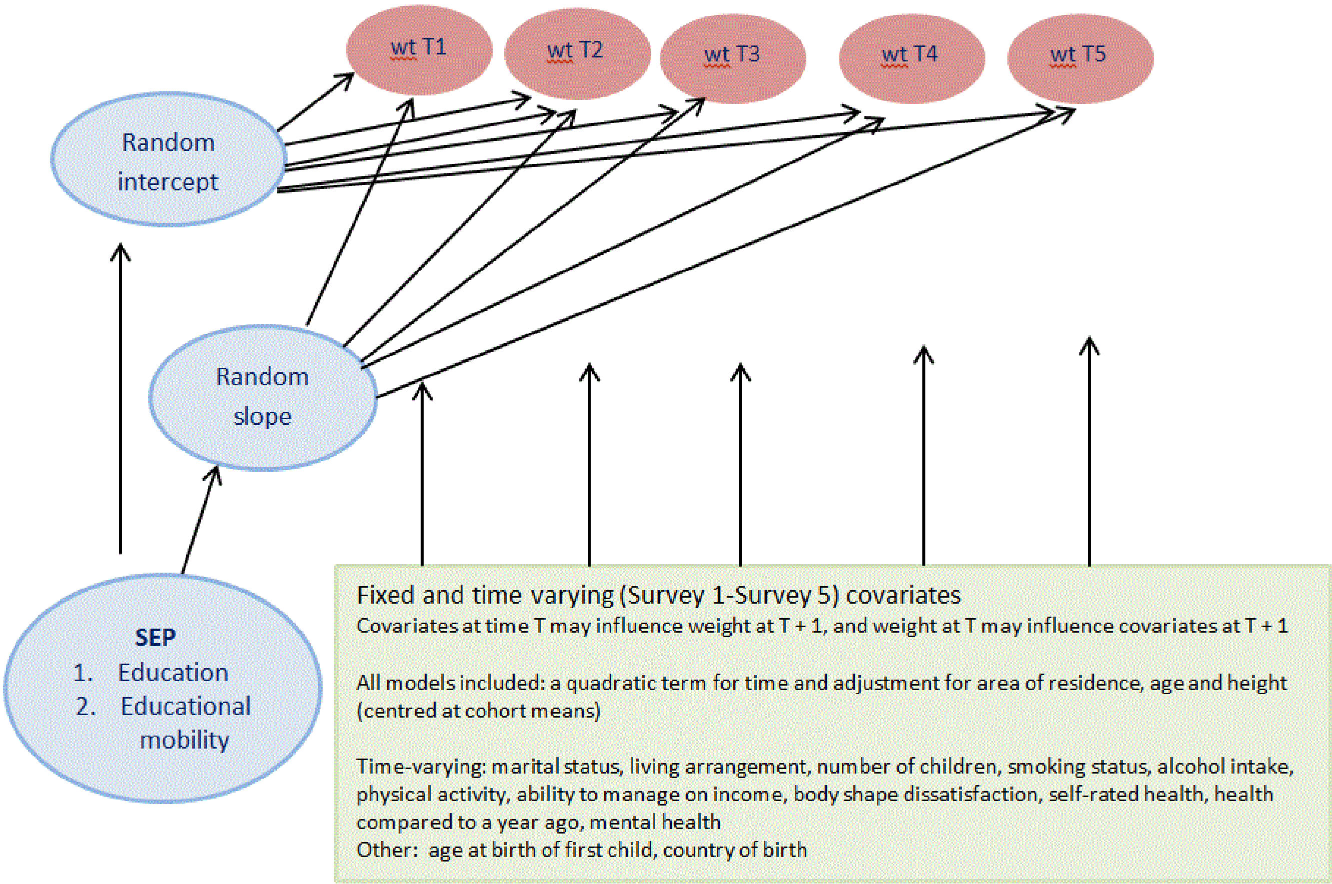
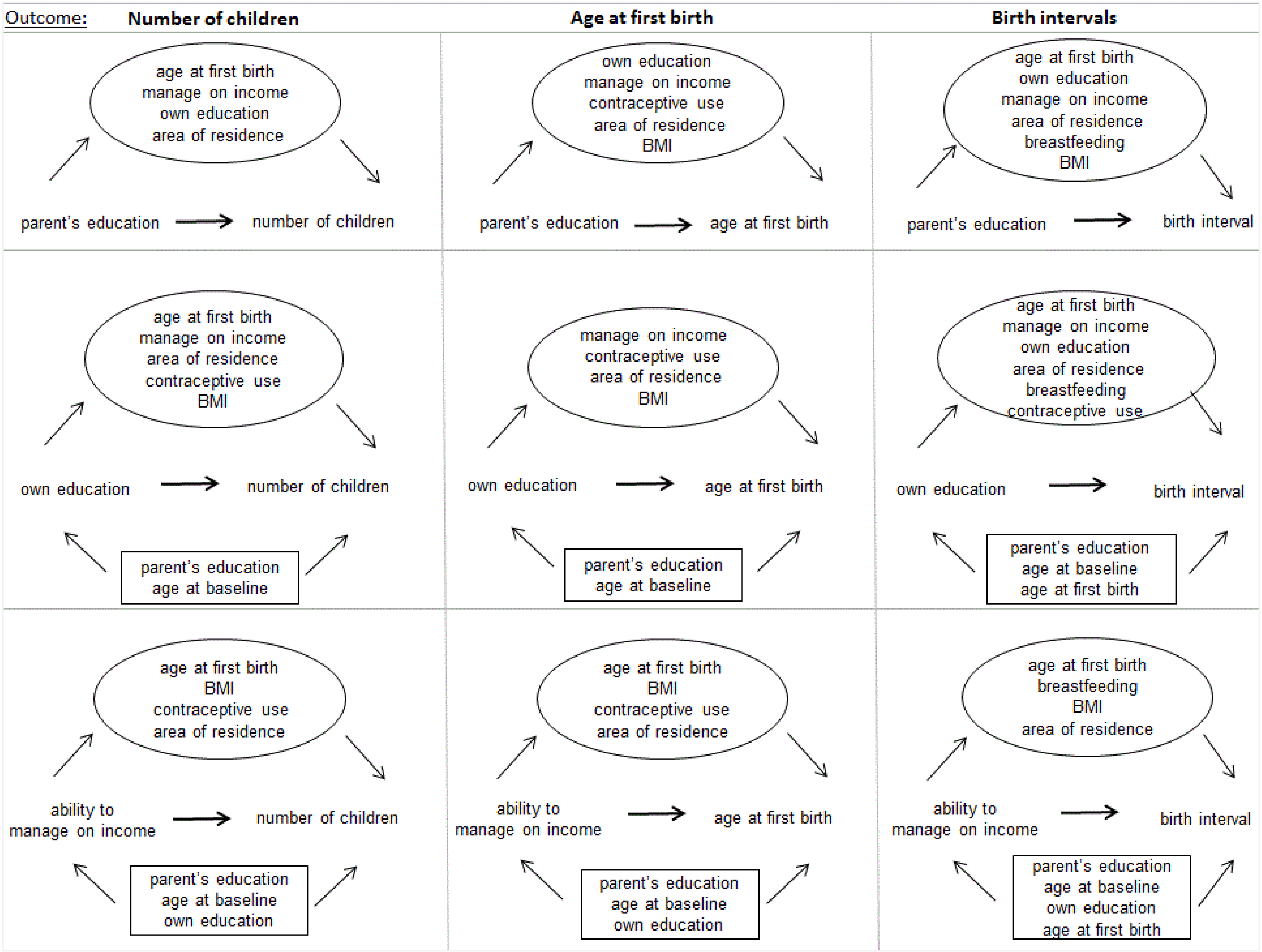


Figure 4.2: Schematic representation of *Study 1* - Socioeconomic position and body weight trajectory over time


Outcome:
Number of children
Age at first birth
Birth intervals
age at first birth
manage on income
own education
area of residence
parent's education
number of children
own education
manage on income
contraceptive use
area of residence
BMI
parent's education
age at first birth
age at first birth
own education
manage on income
area of residence
breastfeeding
BMI
parent's education
birth interval
age at first birth
manage on income
area of residence
contraceptive use
BMI
own education
number of children
parent's education
age at baseline
manage on income
contraceptive use
area of residence
BMI
own education
age at first birth
parent's education
age at baseline
age at first birth
manage on income
own education
area of residence
breastfeeding
contraceptive use
own education
birth interval
parent's education
age at baseline
age at first birth
age at first birth
BMI
contraceptive use
area of residence
ability to
manage on income
number of children
parent's education
age at baseline
own education
age at first birth
BMI
contraceptive use
area of residence
ability to
manage on income
age at first birth
parent's education
age at baseline
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parent's education
age at baseline
own education
age at first birth

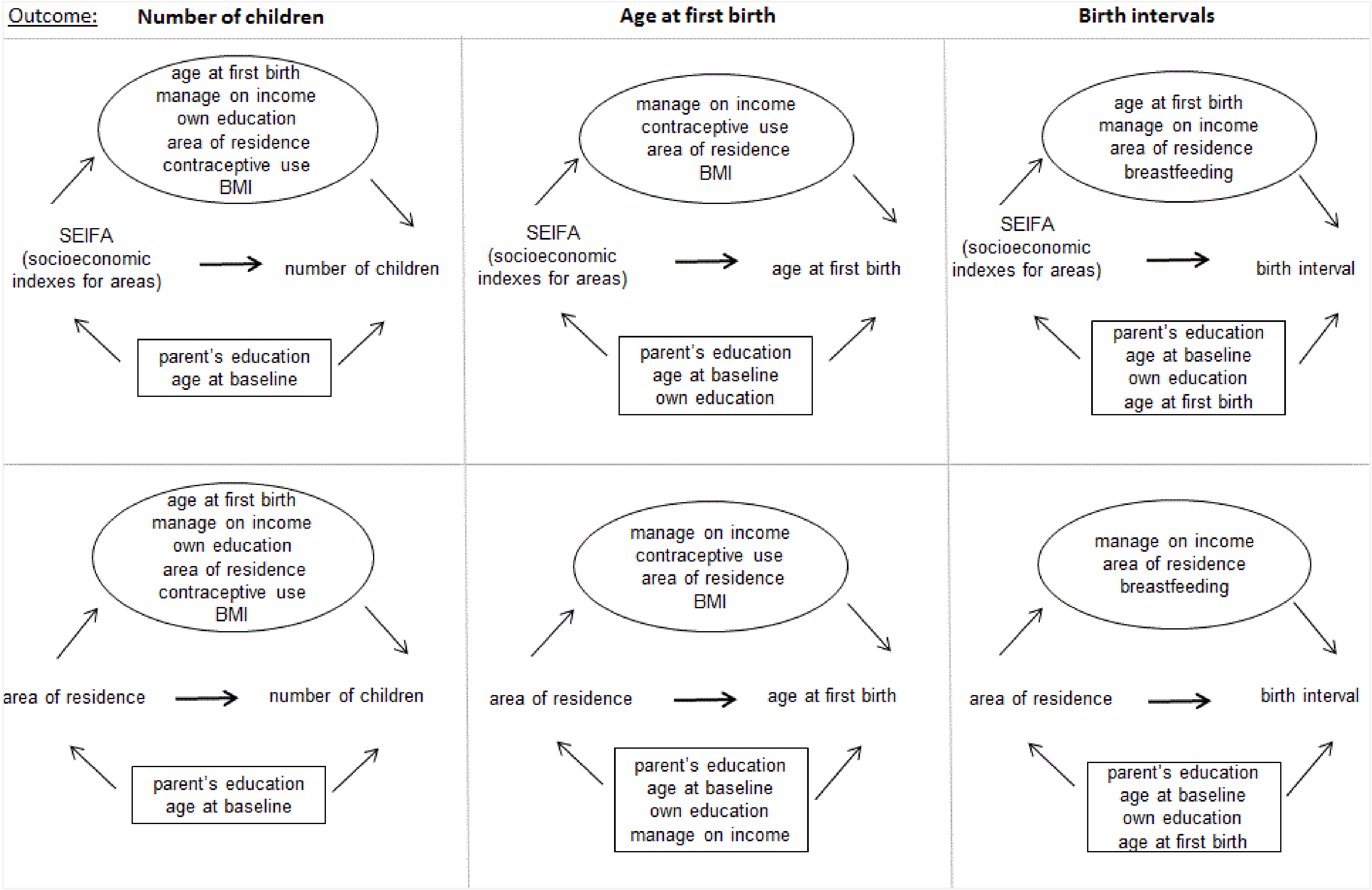


Figure 4.3: Causal diagram of *Study 2* - Socioeconomic position and reproductive characteristics

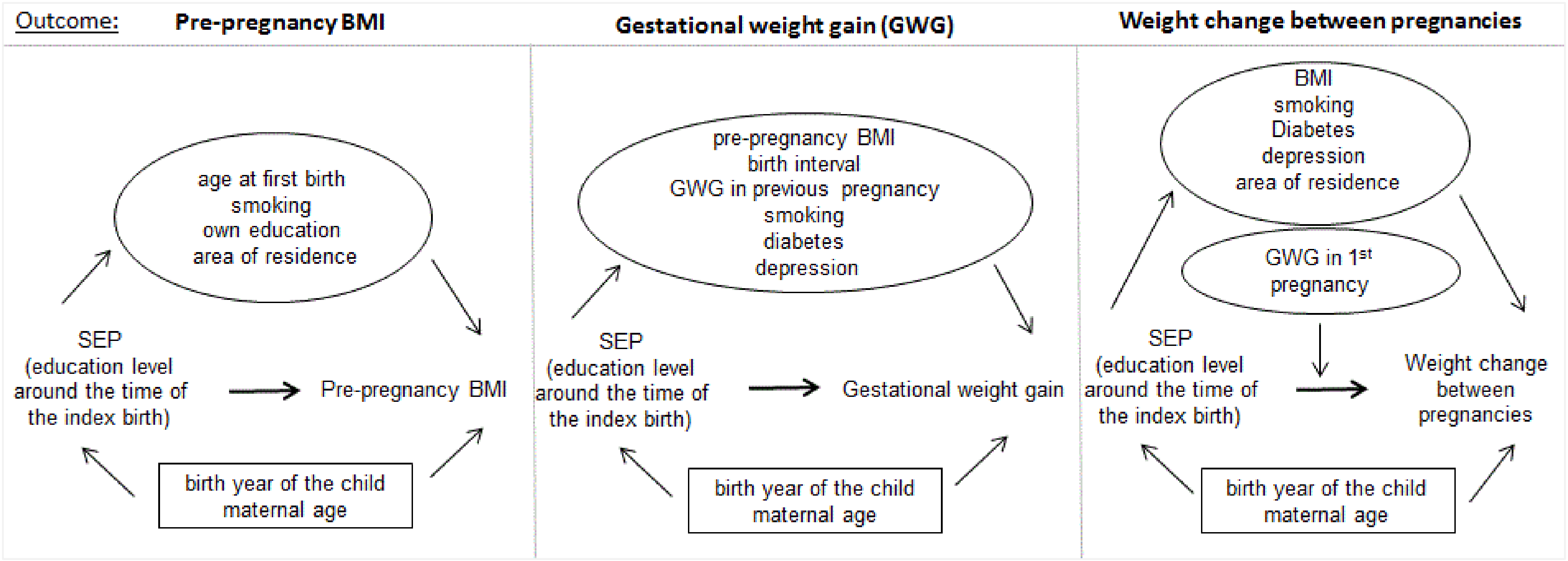
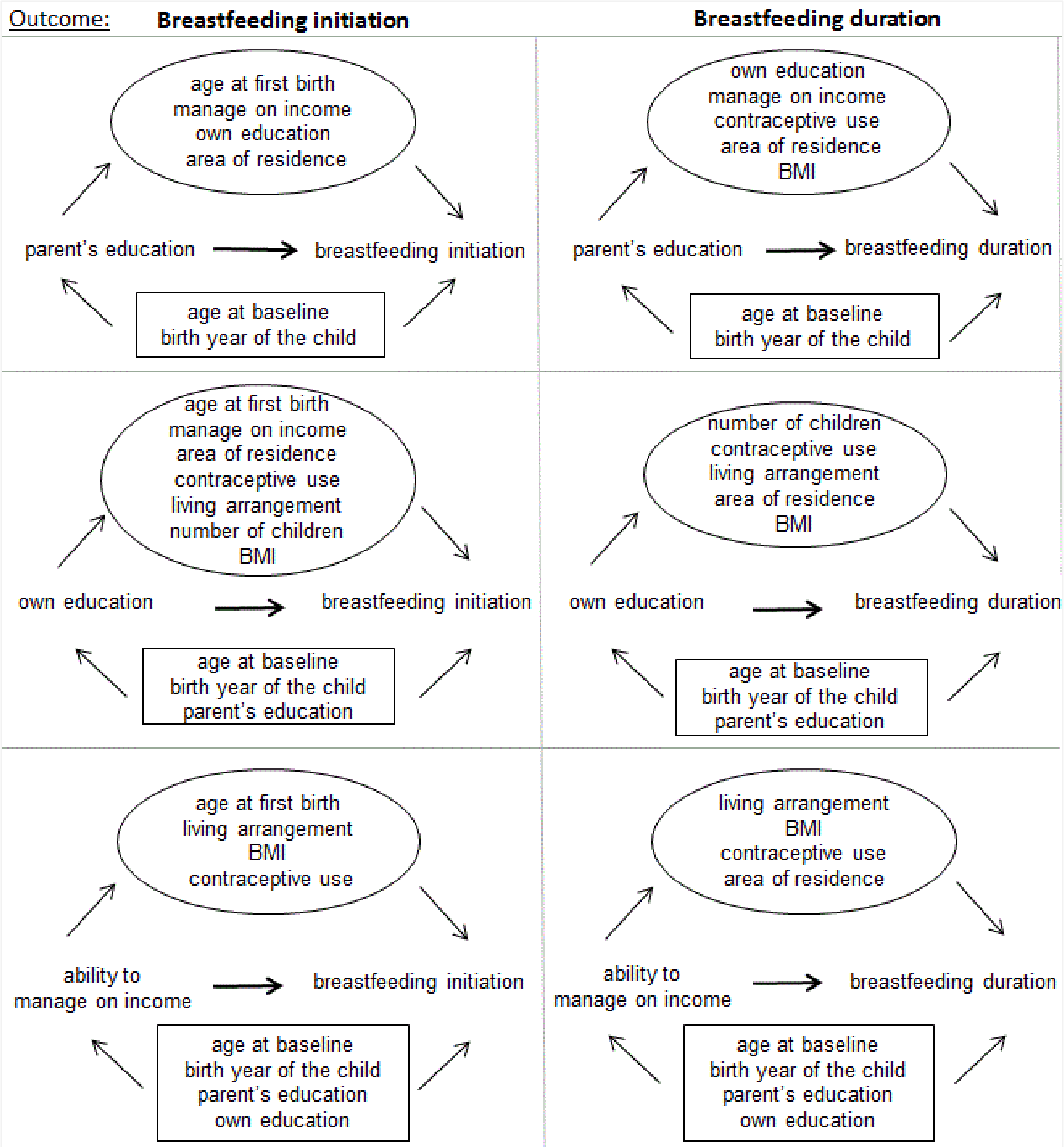


Figure 4.4: Causal diagram of *Study 3* - Social patterning of pre-pregnancy BMI and gestational weight gain


Outcome:
Breastfeeding initiation
Breastfeeding duration
age at first birth
manage on income
own education
area of residence
parent's education
breastfeeding initiation
age at baseline
birth year of the child
own education
manage on income
contraceptive use
area of residence
BMI
parent's education
breastfeeding duration
age at baseline
birth year of the child
age at first birth
manage on income
area of residence
contraceptive use
living arrangement
number of children
BMI
own education
breastfeeding initiation
age at baseline
birth year of the child
parent's education
number of children
contraceptive use
living arrangement
area of residence
BMI
own education
breastfeeding duration
age at baseline
birth year of the child
parent's education
age at first birth
living arrangement
BMI
contraceptive use
ability to
manage on income
breastfeeding initiation
age at baseline
birth year of the child
parent's education
own education
living arrangement
BMI
contraceptive use
area of residence
ability to
manage on income
breastfeeding duration
age at baseline
birth year of the child
parent's education
own education

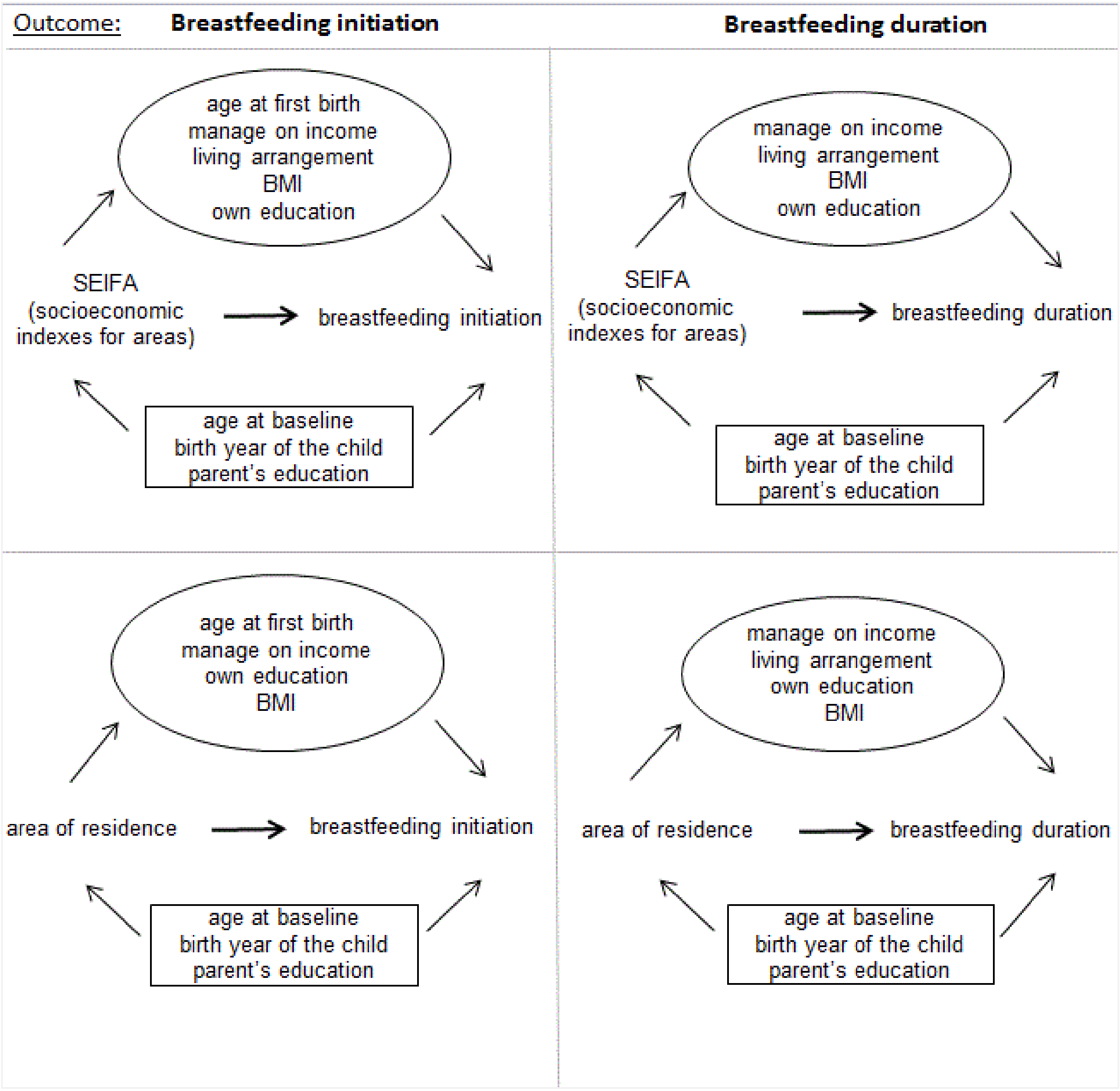


Figure 4.5: Casual diagram of *Study 4* - Socioeconomic position and breastfeeding initiation and duration

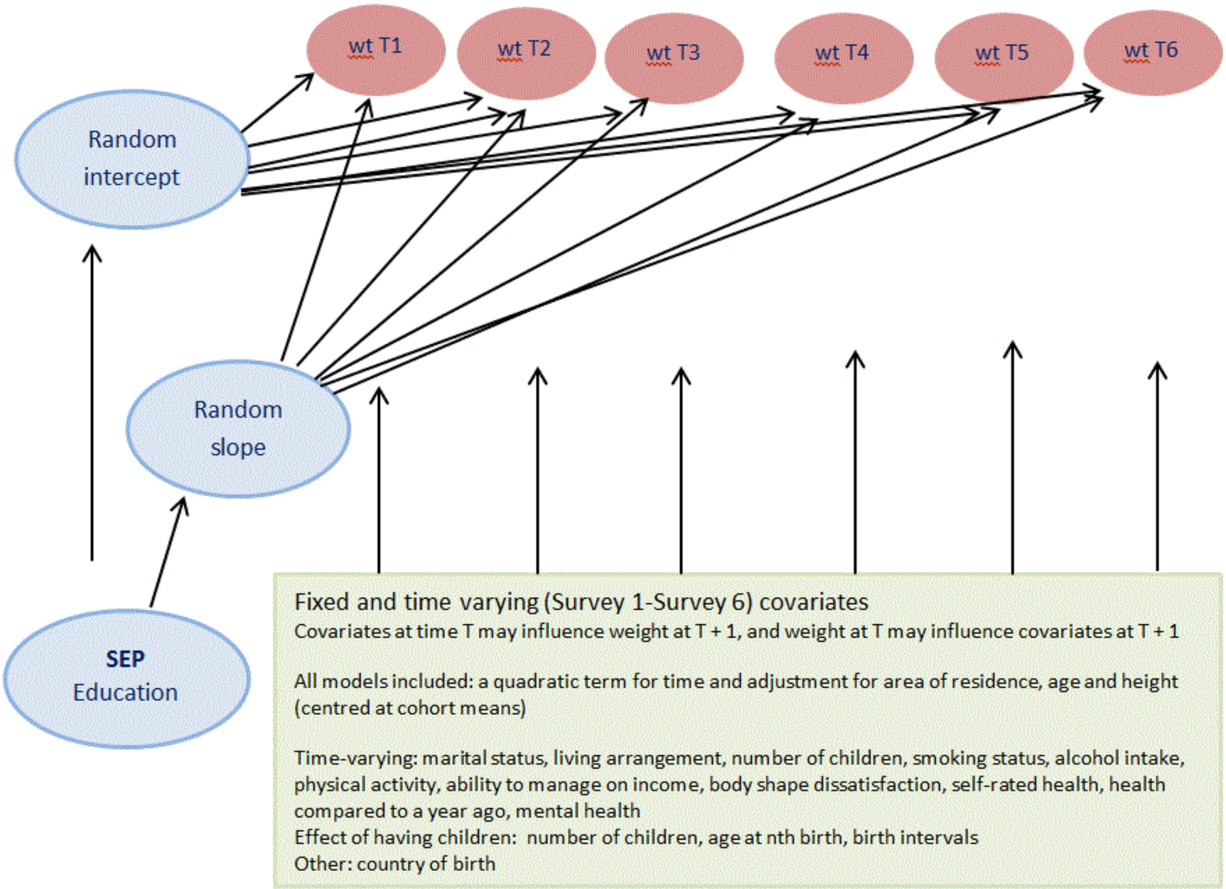


Figure 4.6: Schematic representation of *Study 5* - The combined effect of education and reproduction on body weight trajectory

4.2 Study populations

Two large data sources were used to answer the questions outlined in this thesis. The main source of data was the Australian Longitudinal Study on Women's Health (ALSWH) 1973-1978 cohort. An overview of measurements common to all studies using the ALSWH is included below, while specific details about the final study sample and statistical analyses for each research question are included in the relevant chapters.

As indicated in the literature review (**Chapter 2**), pre-pregnancy BMI and GWG are two important components in understanding the puzzle of increasing body weight in relation to reproduction. Very few studies contain this information (including the ALSWH cohort), however we were fortunate to have access to Swedish national registers, allowing us to explore the social patterning of both these reproductive characteristics. A description of these registers is provided in **Chapter 4.2.2**. A general overview of the sources of data and sample sizes for each study can be found in Table 4.1 below, while an in-depth discussion of the strengths and limitations of using these two data sources is included in **Chapter 10.3.1**.

4.2.1 The Australian Longitudinal Study on Women's Health (ALSWH)

The ALSWH began in 1996, using a sample of women randomly selected from the national health insurance database (Medicare), consisting of all Australian citizens and residents, including immigrants and refugees,[186] with a deliberate oversampling of rural/remote women. The initial sample of 41,500 women comprise the three original ALSWH cohorts: the 'young' cohort aged 18-23 years at baseline (born 1973-78), the 'mid' cohort aged 45-50 years (born 1946-51) and the 'older' cohort aged 70-75 years (born 1921-26). The surveys, which were completed at baseline and at approximate three- to four-year intervals thereafter, include a range of questions (demographic, social, physical, psychological, behavioural) which aim to capture multiple aspects contributing to Australian women's health, well-being, and service use. The ALSWH study has obtained informed consent from all study participants and is approved by the Human Research Ethics Committees of the University of Newcastle and the University of Queensland, Australia.

Table 4.1: Overview of data sources and sample sizes for each of the five analyses included within the thesis

Data Source	**The Australian Longitudinal Study on Women's Health 1973-78 cohort (aged 18-23 years at baseline, 1996)**				**Swedish Register data** (See section 4.2.2)
Study and title	***Study 1:*** SEP and body weight	***Study 2:*** SEP and reproduction (age at first birth and birth intervals)	***Study 4:*** SEP and breastfeeding initiation and duration	***Study 5:*** SEP and body weight in relation to reproductive history	***Study 3:*** SEP and pre-pregnancy BMI and GWG
Years of data used	1996-2009	1996-2015	1996-2012	1996-2012	1982-2010
Population	Women who reported their body weight in at least two surveys, with information available for the two outcomes	Women who answered Surveys One and Seven (in order to have up to date birth information)	Parous women who answered Surveys One and Six (in order to have up to date birth information)	Women who reported their body weight in at least two surveys, with information available for highest education	Women with a first and second singleton birth and with available information for pre-pregnancy BMI, GWG, as well as education and smoking status
Sample size	Varies for the two outcomes (see below) i)10,018 ii) 9,907	6,899	4,777	9,336	163,352
Exposure: Measure of socioeconomic position	i) Highest achieved education (at Survey Five, else Survey Four) ii) Own educational mobility	i) Highest achieved education (at Survey Seven, else Survey Six) ii) Parental education iii) Area of residence iv) SEIFA index for disadvantage v) Financial stress (ability to manage on income)	i) Highest achieved education (at Survey Six, else Survey Five) ii) Parental education iii) Area of residence iv) SEIFA index for disadvantage v) Financial stress (ability to manage on income)	i) Highest achieved education (at Survey Six, else Survey Five)	Education recorded in the year of each index birth

Outcome	Body weight trajectory from 1996-2009	1) Age at birth of first child 2) Birth interval between the first and second child 3) Total number of children	For each child 1) Breastfeeding initiation (dichotomous) 2) Breastfeeding for at least six months (not at all; no; yes) among women who had initiated breastfeeding	Body weight trajectory from 1996-2012	1) BMI before the first and second pregnancy. 2) BMI change between pregnancies 3) GWG in the first and second pregnancy
Statistical analysis All studies use descriptive statistics (t-tests and Pearson's chi-square tests)	Linear mixed models (SAS PROC MIXED) with a random intercept and slope	Multinomial logistic regression	Logistic regression	Linear mixed models (SAS PROC MIXED) with a random intercept and slope	Multinomial logistic regression with * Healthy BMI status and * Adequate GWG as the reference. Linear regression investigating ii) BMI change between pregnancies
Minimal adjustment	Area of residence, age and height (cohort mean centred)	Age at baseline and parent's highest education	Age at baseline, child's year of birth	Area of residence, age and height (cohort mean centred)	Birth year of index child
Additional descriptive variables and covariates used in the model	Physical activity, alcohol intake, mental health, self-rated health, number of children, smoking status, age at first birth, living arrangement, marital status, health transition, shape dissatisfaction, income management, country	Own education, area of residence, ability to manage on income, age at birth of first child and duration of breastfeeding (as specified)	Parental education	Country of birth, physical activity, alcohol intake, mental health, financial stress (ability to manage on income), self-rated health, age at birth of first child, marital status, shape dissatisfaction	Maternal age, pre-pregnancy BMI and smoking status during each pregnancy, GWG in first pregnancy (for second pregnancy outcomes)

	of birth				
Sensitivity analysis	Comparison of included and excluded sample Analyses for both exposures were run using data imputed for women with one body weight (N=13,862) using PROC MI with 20 imputations and a fully conditional specification Analyses for education level were also conducted using a) Education at Survey Five and b) Educational mobility from Survey Two to Five only (no carrying forward) Analyses using BMI as the outcome were also modelled	Analyses: a)Using information up to Survey Six (to estimate the effect of incomplete fertility) b)Excluding 365 women who already had a child/children at Survey One	a) Outcome 2 among all women, and not just those who had initiated breastfeeding (N=4,777) b) Both outcomes reanalysed with imputed data (PROC MI with 20 imputations and a fully conditional specification) (N=5,917)	As for *Study 1,* analyses using BMI as the outcome were also modelled	Comparison of included and excluded sample Analyses: a) Among women with full term pregnancies only (N=152,202) b) First birth outcomes among all women with a first birth (but not necessarily a second) (N=440,639)

SEIFA (socioeconomic indexes for areas score)

Approval to access the ALSWH data for the purposes outlined in this thesis was granted by the ALSWH Publications, Analyses and Sub-studies Committee in January, 2013.

4.2.1.1 *The ALSWH 1973-78 cohort*

The sample for four out of the five studies included in this thesis came from the ALSWH cohort born in 1973-78 (n=14,247; conducted in 1996; women aged 18-23 years). When compared to the 1996 national census, these women were generally found to be representative of the female population for their age, with a slight over-representation of tertiary educated women.[95] Of the 14,247 women who answered the baseline survey in 1996 at age 18-23 years, 9,688 (68%) completed Survey Two (2000; aged 22-27 years); 9,081 (64%) completed Survey Three (2003; aged 25-30 years); 9,145 (64%) completed Survey Four (2006; aged 28-33 years); 8,200 (58%) completed Survey Five (2009; aged 31-36 years); 8,010 completed Survey Six (56%); and 6,901 (48%) competed Survey Seven (2015; aged 37-42 years). Analysis of the relatively high attrition between baseline and Survey Two (68% response) has concluded that possible biases due to loss to follow-up do not limit significant longitudinal analysis of these data.[187] This attrition is thought to be a result of a high level of mobility, including extended travel abroad; changes in surname upon marrying; unlisted phone numbers; and in spite of it being compulsory, not being registered to vote.[188] Attrition has remained fairly stable since Survey Two, as shown. The characteristics of women who have remained in the cohort have also been compared with subsequent censuses; similar differences were found when using the 2001[189] and 2006[190] censuses, as with the 1996 census. The following differences were found when comparing the 1973-78 cohort to women in the 2011 census; indigenous Australians and women born in non-English speaking countries were under-represented, and increasingly more so over time; women who spoke a language other than English were under-represented; married women were slightly over-represented, while women who were separated/divorced/widowed and who were never married were under-represented; lone-person households and women in employment were over-represented; and women with a high education were greatly over-represented (63% in ALSWH, compared to 38% of women in the 2011 census).[191]

Considerable time was spent with data management, particularly with regard to preparing the child birth information. While date of birth information was provided from Survey Three onwards, there were inconsistencies in some of the responses given. This required that the data be thoroughly checked for consistencies.

Throughout the duration of this thesis, additional waves of survey data have been made available. Given this, the number of surveys used varies for each of the included studies: *Study 1* and *Study 4* use data up to Survey Five; Study 5 uses data up to Survey Six; and *Study 2* uses data up to Survey Seven. Each woman had her own ID alias, which allowed for longitudinal linkage of data across the different surveys.

4.2.1.1.1 Measurements

Exposure – Socioeconomic position

The main indicator of SEP was the woman's own education. At each survey women were asked "What is the highest qualification you have completed?" Possible responses were no formal qualifications; year 10 or equivalent (for example, School Certificate); year 12 or equivalent (for example, Higher School Certificate); Trade/apprenticeship (for example, hairdresser, chef); Certificate/diploma (for example, child care, technician); University degree; and Higher University degree (for example, Grad Dip, Masters, PhD). Women's highest achieved education was measured at Survey Six (age 34-39 years; if missing then Survey Five, aged 31-36 years) for *Study 1, 4 and 5*, while for *Study 2* it was measured at Survey Seven (aged 37-42 years; if missing then Survey Six). Highest education was categorised as low (≤ 12 years); intermediate (trade/apprentice/certificate/diploma); or high (degree/higher).

In some of the studies, parental education (highest of mother's or father's, or other main caregivers when they were growing up) was used as a proxy for early life SEP. This variable was categorised in the same way as for the woman herself, with the additional response category of 'not applicable/don't know'.

Other measures of SEP that were used include area of residence (urban (major cities); rural (inner regional); or remote (outer regional/remote)) and the distribution of socioeconomic conditions based on neighbourhood, which was measured using quintiles of SEIFA (socioeconomic indexes for areas) scores, with higher scores indicating less disadvantage.[192]

Outcomes

The outcome in *Study 1* (**Chapter 5**) was body weight trajectory from 1996 to 2012. Throughout the course of the PhD, information from Survey Six became available and, as such, *Study 5* (**Chapter 9**) includes information about body weight trajectory from 1996-2015.

Study 2 (**Chapter 6**) and *Study 4* (**Chapter 8)** have various reproductive characteristics as the outcome. *Study 2* uses information about the woman's age at birth of her first child and, for multiparous women, the birth interval between the first and second birth. *Study 4* uses information about the duration of breastfeeding for each child to establish whether women breastfed or not and, for those who had initiated breastfeeding, whether they had breastfed for at least six months.

Study 5 (**Chapter 9**) brings together information about reproductive characteristics to investigate whether SEP differences in body weight trajectory are modified by reproductive events.

4.2.1.2 *Statistical analysis*

Detailed information of statistical analysis and methods used for each study are included in the relative **Chapters 5, 6, 8 and 9** and are summarised in Table 4.1. Descriptive statistics were generated for all variables, including t-tests for continuous variables and Pearson's chi-square tests for categorical variables to explore the association between exposures and outcomes. All analyses were completed using SAS for Windows (SAS Institute Inc., Cary, NY) version 9.3 or 9.4.

Due to the longitudinal nature of the data and the importance of dealing with missing data, multilevel linear mixed models (using SAS PROC MIXED), which are robust under the assumption of missing at random, were used to explore the social patterning of weight trajectory (*Study 1 and 5)*. As such, from the 14,247 women in the young cohort, the sample was restricted to women who reported their body weight in two or more surveys (n=11,436 for *Study 1*, n=11,564 for *Study 5*). Due to deliberate initial oversampling of women living in rural and remote areas of Australia, area of residence, categorised as urban (major cities), rural (inner regional), and remote (outer regional/remote), was adjusted for in all models. Additionally, all models included age and height centred at the cohort mean.

In investigating the social patterning of reproductive characteristics (*Study 2 and 4)*, in order to have the most recent child birth information, all analyses were restricted to women who had answered the baseline and most recent survey; for *Study 2* the most recent survey was Survey Seven (n=6,899), and for *Study 4* this was Survey Six (n=8,009), which was then restricted to parous women, resulting in a sample size of n=4,777. Multinomial logistic regression was then used to investigate the association between SEP and: in *Study 2,* i) age at birth of first child (24-29.99 years as reference); ii) birth interval between the first and second child (18-27 months as reference); and iii) total number of children: and in *Study 4,* whether each child iv) was breastfed; and v) for those who were breastfed, whether this was sustained for at least six months.

A number of variables commonly associated with SEP and body weight were considered for inclusion in the models. At each survey, questions were asked to determine marital status (married/de facto, separated/divorced/widowed, never married); living arrangement (partner/children; alone; parents/relatives; non-family); total number of children (none; one; two; three or more) based on reported dates of birth of children; smoking status (current smoker; non-smoker; ex-smoker); alcohol intake (never/rarely; risky/high risk 15+ drinks/week; low risk ≤ 14 drinks/week), based on the Australian National Health and Medical Research Council (NHMRC) guidelines;[193] physical activity as MET/mins per week (nil/sedentary 0-40; low 40 - < 600; moderate 600 - < 1200; high ≥ 1200);[194] ability to manage on income (impossible/always difficult; sometimes difficult; not too bad/easy); body shape dissatisfaction (not at all; slightly; moderately; markedly); self-rated health (excellent; very good; good; poor/fair); and health transition (better; about the same; worse), comparing health to a year ago.

Mental health (poor ≤ 52; good > 52) was measured using the Mental Health Index (MHI-5) subscale of the SF-36 (Medical Outcomes Study short form 36 health survey).[195] Country of birth was asked at baseline (Australia; other English speaking; Europe (including Turkey, Russia); Asia; other (including Middle East)).

In analysing the moderating effect of reproductive characteristics on the association between SEP and body weight trajectory (*Study 5*), the aim was to keep this analysis as simple to interpret as possible. Goodness-of-fit tests such as the Akaike Information Criterion (AIC) were used to find the most parsimonious and interpretable model.

4.2.2 Swedish register data

Large quantities of accurate and reliable information on pre-pregnancy BMI and GWG are seldom available. Analysis of these two important reproductive factors was made possible due to the rich and large data collected in Swedish registers (**Chapter 7**), which is a real strength of this thesis.

Sweden is fortunate to have a wealth of registers - administered by central authorities and agencies such as Statistics Sweden (Statistiska Centralbyrån - SCB) and The National Board of Health and Welfare (Socialstyrelsen) – which are available for conducting unique and important research. The wide use of these registers in a number of areas of research, including health and social welfare, is made possible due to the existence of a Swedish Personal Identification Number (PIN - Personnummer) which is issued to all Swedish residents at the time of birth or migration. This PIN allows the merging of data from various registers, including the possibility of connecting data between family members using the Multi-generation register.

Swedish register data has previously been used to demonstrate i) an inverse association between education and BMI before the first pregnancy; and ii) a protective effect of education in avoiding excessive GWG in the first pregnancy among women with a healthy pre-pregnancy BMI.[196] In order to achieve adequate statistical power to extend this research and looking at these patterns in subsequent pregnancies, access to the complete Swedish population of parous women was required.

To access these data, the Umeå Swedish Initiative for Research on Microdata in the Social and Medical Sciences (SIMSAM) lab steering committee was approached regarding a suggested collaboration. An application comprising a full outline and overview of the research project, detailed research questions, proposed methods, and a list of all variables required was submitted. A list of the variables included in this study and the registers used can be found in Table 4.2.

In line with the Swedish Personal Information (Personuppgiftslagen) and Secrecy Acts (Offentlighets och Sekretesslagen), which protect personal integrity and ensure confidentiality of sensitive data, a subset of de-identified data for analysis was prepared by the data manager. This included an alias PIN for each woman, allowing data to be linked longitudinally. Before receiving access to these sensitive data, a contract was signed with the data controller (Umeå SIMSAM Lab) stating that data would only be used for this specific analysis and would not be taken from the secured lab environment.

Table 4.2: Description of variables required for *Study 3*, with data accessed through the Umeå SIMSAM Lab

Register used and variable description
Swedish Medical Birth Register
Child ID
Maternal ID (pregnant woman)
Country of birth
Date of birth
Mother's height (cm) for each pregnancy
Maternal weight at antenatal care (kg)
Maternal weight at delivery (kg)
Maternal weight gain by time of delivery
Pregnancy length in weeks
Family situation
Smoking at admission (early pregnancy)
Child's parity
Delivery parity
Multiplicity
Child's parity (first digit) and number of births (second digit) when multiple births
Date of birth (child)
Stillborn
Education Register (RAM85-RAM89)
Mother's education – 1985-89
Longitudinal integration database for health insurance and labour market studies (LISA90-LISA10)
Personal ID
Highest level of education
Highest level of education – aggregated to 7 levels

4.2.2.1 *Statistical analysis*

Detailed information on the statistical analysis and methods used for *Study 3* is included in **Chapter 7** and summarised in Table 4.1. Descriptive statistics were generated for all variables, including t-tests for continuous variables and Pearson's chi-square tests for categorical variables, to explore the association between exposures and outcomes. All analyses were completed using SAS for Windows (SAS Institute Inc., Cary, NY) version 9.3.

The social patterning of pre-pregnancy BMI and GWG for each pregnancy was explored using multinomial logistic regression. Linear regression investigated the social patterning of change in BMI between pregnancies. Sensitivity analyses were conducted, as outlined in Table 4.1.

Chapter 5. Social inequalities in body weight

It is well established that individuals with a lower SEP have poorer health outcomes compared to individuals with a higher SEP. While this includes body weight at numerous points across the life course, an analysis of the impact of SEP at different periods in the life course is lacking in the literature.

Chapter 5.1 presents results from *Study 1* in this thesis, which uses education as a measure of SEP. The study investigates and quantifies the association of education with body weight trajectory among young Australian women, while also examining whether the timing of education measurement influences this association. In order to adapt to the format of this thesis, only the numbering of tables and figures have been modified from the original published version. This manuscript has been formatted according to the journal's requirements.

5.1 Educational mobility and weight gain over 13 years in a longitudinal study of young women (*Study 1*)

- **Holowko N,** Jones M, Tooth L, Koupil I, Mishra G. Educational mobility and weight gain over 13 years in a longitudinal study of young women. *BMC Public Health.* 2014 Nov 25; 14:1219.

Access: http://www.biomedcentral.com/1471-2458/14/1219

Abstract

Background: Limited evidence exists about the role of education and own educational mobility on body weight trajectory. A better understanding of how education influences long term weight gain can help us to design more effective health policies.

Methods: Using random effects models, the association between i) highest education (n=10 018) and ii) educational mobility over a 9 year period (n=9 907) and weight gain was analysed using five waves of data (over 13 years) from the Australian Longitudinal Study on Women's Health 1973-78 cohort (from 18-23 years to 31-36 years).

Results: Highest educational attainment was inversely associated with weight at baseline and weight gain over 13 years. Compared to high educated women, those with a low (12 years or less) or intermediate (trade/certificate/diploma) education, respectively, weighed an additional 2.6 kg (95% CI:1.9 to 3.1) and 2.5 kg (95%CI:1.9 to 3.3) at baseline and gained an additional 3.9 kg (95%CI:2.6 to 5.2) and 3.1 kg (95%CI:2.6 to 3.9) over 13 years. Compared to women who remained with a low education, women with the greatest educational mobility had similar baseline weight to the women who already had a high education at baseline (2.7 kg lighter (95%CI:-3.7 to -1.8) and 2.7 kg lighter (95%CI:-3.4 to -1.9), respectively) and similarly favourable weight gain (gaining 3.1 kg less (95%CI:-4.0 to -2.21) and 4.2 kg less (95%CI:-4.8 to -3.4) over the 13 years, respectively).

Conclusions: While educational attainment by mid-thirties was positively associated with better weight management, women's weight was already different in young adult age, before their highest education was achieved. These findings highlight a potential role of early life factors and personality traits which may influence both education and weight outcomes.

Key words: educational status, longitudinal studies, social inequalities, weight trajectory, weight gain

5.1.1 Introduction

Overweight and obesity are of high concern due to adverse health risks associated with increased body weight; including cardiovascular disease, hypertension and cancer;[3] excess obstetric risks for both mother and offspring;[5] and the intergenerational transfer of adult metabolic risk through intrauterine growth and prenatal programming of adipose tissue.[7] With a noted steady pattern of weight gain across the life course,[9,10] investigating determinants of patterns of long term weight change is of increasing priority.

Studies in high income countries, including the U.S., Australia, U.K. and Sweden, show an inverse association between adult socioeconomic position (SEP) and body mass index (BMI) across the life course, using education[9-15] and occupation.[9,15,16] This trend is found among women in early-mid[11-14,78,153,172] and mid-late adulthood,[12,15,16] while some studies report no association.[95,170] Suggested mechanisms include health related behaviours and social/material resources with an established association with weight gain; including physical activity (low levels), high fat/energy intake;[15,197] smoking (quitting);[15] alcohol consumption (mixed associations, potentially u-shaped);[61] sitting time (increased levels);[198] marital status (partnered), higher initial BMI and having children.[10]

High mean weight gain over four[95] and 10 year[10] periods is found in women aged 18–23 years, and over five years[173] in women aged 35–44 years; with weight differences by SEP increasing among younger female cohorts.[95,172] This trend is significant in itself, let alone increasing maternal BMI being considered a high risk obstetric condition, associated with gestational diabetes mellitus[5] and hypertension,[199] as well as offspring obesity in childhood.[200]

Previous research using the Australian Longitudinal Study on Women’s Health (ALSWH) 1973–78 cohort found that highly educated women in their early twenties had a significantly lower BMI four years later;[161] and that in relation to having children, high educated women (at age 28–33 years) also gained relatively less weight over a 10 year period.[10] Within the U.S. Coronary Artery and Risk Development in Young Adults (CARDIA) study,[201] among 18–30 year old women, only education at follow-up seven years later was inversely associated with BMI change.

Few studies have explored the effect of when education is measured (early or later adulthood) and changes in education level on body weight trajectory. Such knowledge may assist in better understanding the social patterning of body weight and differing associations found between different studies.[95,161,170,201]

This research explores how education may influence long term weight gain in women, by investigating the effect of education measured in early and later adulthood. We focused on detailed investigation of the relationship between i) highest achieved education by mid-thirties and ii) educational mobility (from early-mid twenties to early-mid thirties) with baseline body weight and rate of change over 13 years. We also explored baseline characteristics in women based on their highest achieved education.

5.1.2 Methods

Study participants

The ALSWH began in 1996, using a sample of women randomly selected from the national health insurance database (Medicare), consisting of all Australian citizens and residents, with a deliberate oversampling of rural/remote women. Detailed information about the three original ALSWH cohorts (41 500 women) can be found elsewhere.[188] The ALSWH study is approved by the Human Research Ethics Committees of the Universities of Newcastle and Queensland. Informed consent was given by all participants of the study.

Our sample was drawn from the cohort born 1973–78; aged 18-23 at baseline and found generally representative of the female population for their age.[202]

Of the 14 247 women who answered the baseline survey, 9 688 (68%) completed Survey Two (2000; aged 22–27 years); 9 081 (64%) completed Survey Three (2003; aged 25–30 years); 9 145 (64%) completed Survey Four (2006; aged 28–33 years); and 8 200 (58%) completed Survey Five (2009; aged 31–36 years). Relatively high attrition between baseline and Survey Two is thought to result from, among other things, a high level of geographical mobility and changes in surname upon marrying.[188]

Our sample was restricted to women with body weight reported in two or more surveys, resulting in 11 436 women (Figure 5.1). For our analysis with a main exposure of highest achieved education the sample size was 10 018 women, and for educational mobility (from early to mid-twenties up to early to mid-thirties) it was 9 907 women.

We additionally ran the analyses for both exposures using data imputed for all women with one body weight (n = 13 862). We used PROC MI, with 20 imputations using fully conditional specification, to impute all outcomes, exposures, and covariates used in the mixed models. We also included auxiliary variables associated with missingness in the imputation model.[203]

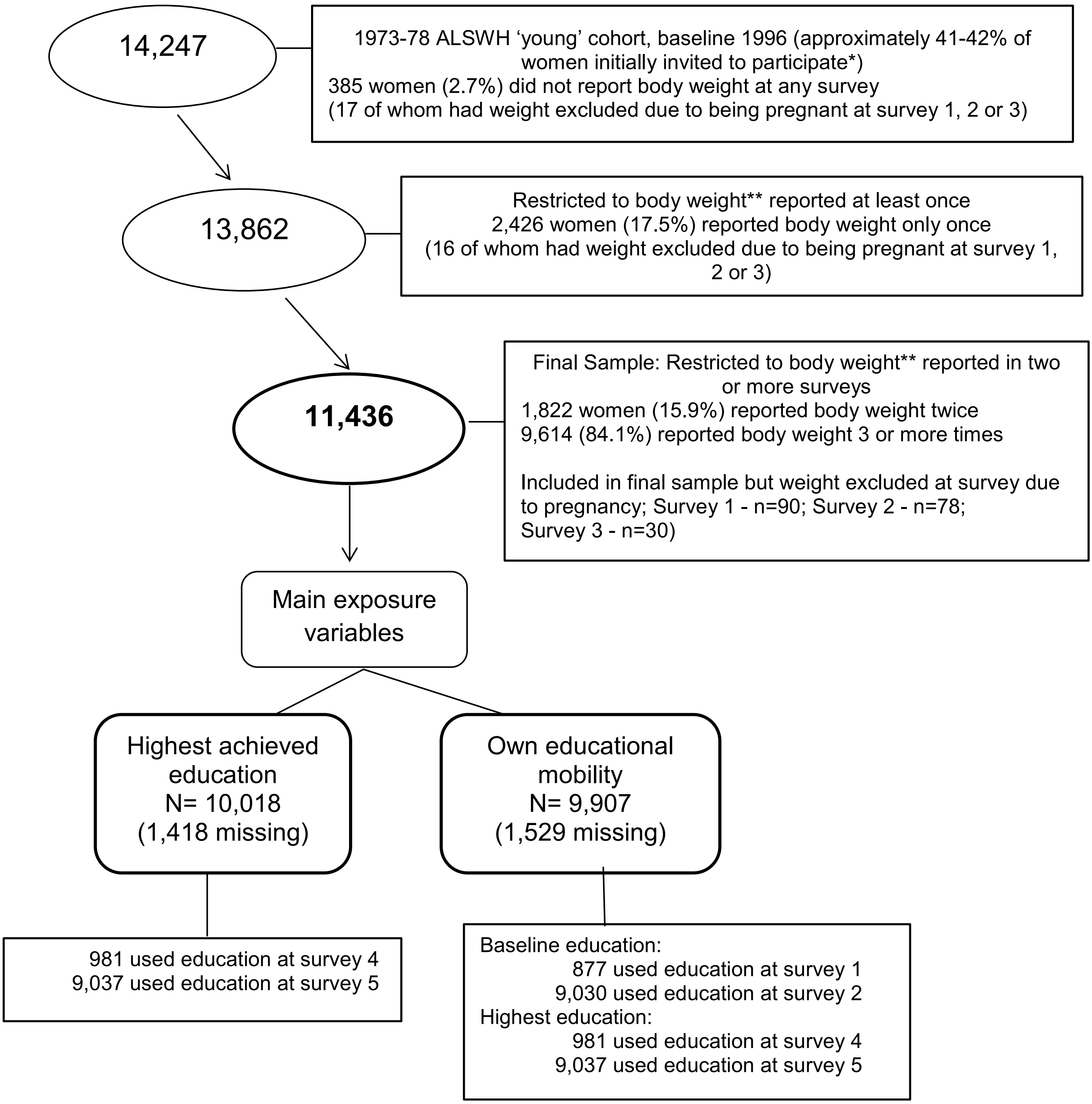
Measures

Outcome - Body weight and weight gain

At each survey, women were asked "How much do you weigh without clothes or shoes (if you are not sure, please estimate)". Women could answer in kilograms/grams or stones/pounds (these measurements were then converted into kilograms/grams). From Survey Four (2006, aged 28-33 years) onwards, pregnant women were specifically asked to report their weight in the month prior to their pregnancy. Given this, weight for women pregnant at Survey One (1996, n = 90), Two (2000, n = 78) or Three (2003, n = 30) was excluded from that respective survey.

Exposures - Indicators of socioeconomic position

Two key SEP indicators were explored: (i) highest achieved education, measured as participants own education at Survey Five (or Survey Four if missing) categorised as: low (high school certificate or lower), intermediate (trade/apprentice/certificate/diploma) or high (degree/higher degree); and (ii) educational mobility, from Survey Two (carried forward from Survey One if missing) to Survey Five (carried forward from Survey Four if missing) (Figure 5.1). Using education from Survey Two gave the youngest women in the cohort opportunity to have completed a degree. Educational mobility was categorised as: stable low, low-intermediate, stable intermediate, upgrade to high (low-high and intermediate-high) and stable high.



*see alswh.org.au/about/sample

**refers to non-pregnant body weight – reported body weight for women pregnant at survey 1, 2 or 3 was excluded (see methods)

Figure 5.1: Inclusion/exclusion of subjects in our analyses, from women in the ALSWH cohort born 1973-78

Note: This figure was included as electronic supplementary material in the published article

Sensitivity analyses for education level were conducted using i) education at Survey Five only (n = 9 037); and ii) educational mobility from Survey Two to Five (no carrying forward) as the main exposure (n = 8 162) (results available upon request). Sensitivity analyses using all women with one body weight are presented in Additional information, Tables 5.5 and 5.6.

Covariates

Demographic, psychosocial, material, behavioural and reproductive variables

Due to deliberate initial oversampling of women living in rural and remote areas of Australia, area of residence, categorised as urban (major cities), rural (inner regional), and remote (outer regional/remote), was adjusted for in all models. Additionally, all models included age and height centred at the cohort means of 20.8 years and 165.9 cm. The following variables commonly associated with socioeconomic position and body weight were considered for inclusion.

At each survey, questions were asked to determine marital status (married/de facto, separated/divorced/widowed, never married); living arrangement (partner/children; alone; parents/relatives; non-family); number of children (none; one; two; three or more) based on reported dates of birth of children; smoking status (current smoker; non-smoker; ex-smoker); alcohol intake (never/rarely; risky/high risk 15+ drinks/week; low risk ≤ 14 drinks/week;), based on the Australian National Health and Medical Research Council (NHMRC) guidelines;[193] physical activity as MET/mins per week (nil/sedentary 0–40; low 40- < 600; moderate 600 - < 1200; high ≥ 1200);[194] ability to manage on income (impossible/always difficult; sometimes difficult; not too bad/easy) ; body shape dissatisfaction (not at all; slightly; moderately; markedly); self-rated health (excellent; very good; good; poor/fair); and health transition (better; about the same; worse), comparing health to a year ago.

Mental health (poor ≤ 52; good > 52) was measured using the Mental Health Index (MHI-5) subscale of the SF-36 (Medical Outcomes Study short form 36 health survey).[195] Age at birth of first child was based on most recent information. Country of birth was asked at baseline (Australia; other English speaking; Europe (including Turkey, Russia); Asia; other (including Middle East)).

For descriptive analyses, the World Health Organisation's (WHO) categories for BMI were used; underweight (< 18.50 kg/m^2), healthy weight (18.50-24.99 kg/m^2), overweight (25.00-29.99 kg/m^2) and obese (≥ 30.00 kg/m^2).[204]

Statistical analyses

Cross sectional analyses investigated trends in weight with increasing age, from 18–23 to 31–36 years. Unweighted statistics are presented, since weighting for area of residence (due to an oversampling of rural women) did not result in significantly different results.

Random effects models (using SAS PROC MIXED) were used to investigate the association of education and educational mobility with weight measured at five time points over 13 years. While mixed models are robust to missing data under the assumption of missing at random (MAR), results from sensitivity analyses using imputed data can be found in Additional information, Tables 5.5 and 5.6. Each subject had their own intercept and slope (random effects), accounting for correlations between observations within individuals.[205] All other variables were modelled as fixed effects. The time scale used was number of years between baseline (1996) and the return of each survey. A quadratic term for time was included in all models, given a slight attenuation in the increase of weight over time. Results from the random effects Models 1 were used to plot baseline weight and weight gain overtime in the figures presented.

Final selection of covariates was based on 10% or greater change in primary point estimates, which according to Greenland[206] is more robust than stepwise regression or significance testing approaches. None of the covariates were highly correlated with the SEP exposures, which could have introduced bias in the adjusted models. Covariates were included as categorical or ordinal, fixed or time-varying using model comparison. Model assessment was made comparing Akaike Information Criteria (AIC) goodness of fit statistics, with lower values indicating a better fit. All analyses were completed in SAS version 9.4 for Windows (SAS Institute Inc., Cary, NC).

5.1.3 Results

A higher percentage of the 2 811 women excluded from our final sample had a low education, no children, never/rarely drink alcohol, had poor mental health and were underweight, born outside of Australia, current smokers and sedentary (Table 5.1). These women had a younger mean age at birth of first child.

Mean body weight increased from 62.7 kg at Survey One to 71.3 kg at Survey Five. The greatest increases in educational mobility were between baseline and Survey Two; at which point 35% of women had a low, 26% had an intermediate and 39% a high education (results available upon request). In contrast, at Survey Five 18% of women had a low, 28% an intermediate and 54% a high education.

Education and weight gain over 13 years

Results from the random effects model show an inverse association between highest achieved education and both baseline weight and weight gain. Compared to women with a high education (Table 5.2, Model 1) who were lightest at baseline and gained the least per year (~0.8 kg), women with a lower education were approximately 2.5 kg heavier at baseline and gained approximately an additional 0.24-0.29 kg/year.

Weight gain among all education groups has only slightly attenuated over time (Figure 5.2).

The significant association between highest achieved education and both baseline weight and weight gain remained after adjusting for covariates; social differences in weight gain did not change, while differences in baseline weight by education level narrowed slightly (Table 5.2, Model 2).

Table 5.1: Baseline characteristics of 1973-78 cohort ALSWH women included/excluded from the sample† (N = 14 247)

Baseline characteristics	Included N = 11 436†	Excluded N = 2 811†	P-value *
Mean (Std Dev)			
Weight (kg)	62.7 (12.5)	61.8 (13.3)	<0.0001
Height (cm)	165.9 (7.1)	165.3 (8.2)	<0.0001
Age at birth of first child **	27.1 (4.3)	23.1 (3.7)	0.0089
Percentage (%)			
BMI			<0.0001
Underweight (< 18.5)	9.5	13.6	
Normal weight (18.5 -24.9)	69.0	64.3	
Overweight (25.0 – 29.9)	15.3	15.4	
Obese (≥ 30.0)	6.2	6.7	
Education ***			<0.0001
Low	70.7	74.0	
Intermediate	17.1	19.7	
High	12.2	6.3	
Number of children			<0.0001
No children	93.1	97.6	
1	5.3	1.6	
2	1.3	0.7	
3+	0.3	0.1	
Marital status			<0.0001
Never married	77.7	71.8	
Married/de facto	21.6	26.4	
Separated/divorced /widowed	0.7	1.9	
Living arrangement			<0.0001
Parents/relatives	49.3	44.9	
Partner/children	26.9	35.9	
Non-family	17.7	13.1	
Alone	6.1	6.1	
Physical activity			<0.0001
Nil/Sedentary	6.0	10.0	
Low	37.1	37.3	
Moderate	13.4	11.7	
High	43.5	41.0	

Baseline characteristics	Included N = 11 436[†]	Excluded N = 2 811[†]	P-value *
Alcohol intake			<0.0001
Never/rarely	41.8	49.8	
Low risk	52.9	43.5	
Risky/high risk	5.3	6.7	
Smoking status			<0.0001
Non-smoker	54.1	44.9	
Ex-Smoker	15.1	15.9	
Current smoker	30.8	39.2	
Mental health (based on MHI-5)			<0.0001
Poor (≤ 52)	20.7	25.8	
Good (> 52)	79.3	74.2	
Self-rated health			<0.0001
Excellent	12.8	11.4	
Very good	39.9	33.1	
Good	35.8	40.7	
Poor/Fair	11.5	14.8	
Ability to manage on income			<0.0001
Easy/Not too bad	50.1	41.4	
Difficult sometimes	32.6	35.5	
Impossible/Always difficult	17.4	23.1	
Body shape dissatisfaction			<0.0001
Not at all	8.8	12.8	
Slightly	25.9	23.4	
Moderately	31.9	28.9	
Markedly	33.3	34.9	
Country of birth			<0.0001
Australia	92.6	86.9	
Other English speaking	3.6	4.6	
Europe	0.9	1.6	
Asia	2.0	5.4	
Other (incl. Middle East)	0.8	1.5	
Area of residence			0.4444
Urban (major cities)	51.9	51.4	
Rural (inner regional)	30.4	29.8	
Remote (outer regional/ remote)	17.7	18.8	

† sample sizes change slightly due to missing values for some variables.
** p-values from independent t-tests for continuous variables and from Pearson chi-square tests for categorical variables.*
*** age at birth of first child is based on reported information up to Survey Five.*
**** education at baseline (Low - higher school certificate or lower (≤ 12 years), Intermediate - trade/certificate/diploma, High - degree/higher degree).*

Educational mobility and weight gain over 13 years

Results from the random effects model show weight at baseline was significantly different for women defined by their educational mobility. Compared to women with a stable low education, who were the heaviest at baseline (Table 5.3, Model 1), women with a stable high education or who upgraded to a high education (greatest educational mobility) weighed significantly less at baseline (~2.7 kg lighter; 1.8 kg and 2.1 kg lighter, respectively, when fully adjusted).

Highest achieved education was indicative of weight change, with women who achieved the highest education level by Survey Five gaining slightly less weight per year. Compared to women with a stable low education who gained 1.1 kg/year (~1.5 kg/year fully adjusted), women with a stable high education gained 0.3 kg/year less and women who upgraded to the highest education gained 0.24 kg/year less (0.2 kg/year fully adjusted). There was no significant difference between the women with a stable low and low-intermediate education. Women with a stable intermediate education gained marginally less per survey compared to women who were stable low. Weight gain among all categories of educational mobility has slightly attenuated over time (Figure 5.3).

Table 5.2: Baseline weight and weight gain* over 13 years by highest education† in 1973-78 cohort ALSWH women (n = 9 573)**

	% weighted (unweighted)	Model 1 Estimate (95% CI)	Model 2 Estimate (95%CI)
Baseline weight (kg)		60.51 (60.06, 60.97)	58.89 (58.11, 59.68)
Difference in baseline weight by highest achieved education†			
High	51.3 (46.9)	reference	reference
Intermediate	29.5 (31.1)	2.48 (1.87, 3.08)	1.67 (1.08, 2.26)
Low	19.3 (22.0)	2.63 (1.93, 3.33)	1.70 (1.00, 2.39)
Increase per year (kg)		0.82 (0.77, 0.87)	1.18 (1.12, 1.24)
Difference in increase per year by highest achieved education†			
High		reference	reference
Intermediate		0.24 (0.19, 0.28)	0.23 (0.19, 0.28)
Low		0.29 (0.24, 0.35)	0.27 (0.22, 0.33)
Attenuation per year (time*time)		-0.02 (-0.26, -0.20)	-0.05 (-0.06, -0.05)

* *random effects models (intercept and slope) with weight measured at age 18–23 years, 22–27 years, 25–30 years, 28–33 years and 31–36 years.*

† *education achieved at Survey Five (Low - higher school certificate or lower (≤ 12 years), Intermediate - trade/certificate/diploma, High - degree/higher degree).*

*** sample slightly smaller than the 10 018 women who had a value for highest achieved education, due to missing values for some covariates.*

Model 1 – Baseline centred age, baseline centred height and area of residence.

Model 2- Model 1 + country of birth, physical activity, alcohol intake, mental health, income management, self-rated health, age at first birth, living arrangements, marital status, shape dissatisfaction.

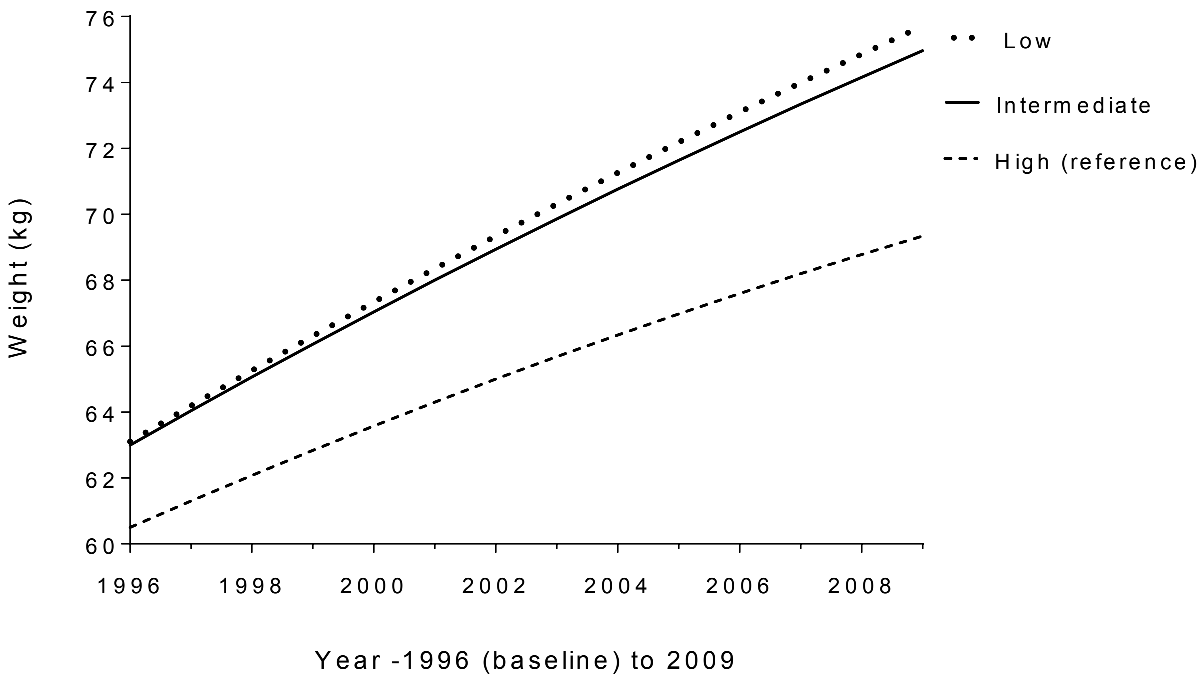


Figure 5.2: Highest achieved education and weight gain over 13 years in women from the 1973-78 ALSWH cohort (n=9 573)

Difference in baseline weight and weight gain over 13 years (random effects model with a random intercept and slope, adjusted for area of residence and baseline centred age and height), based on highest achieved education at Survey Five (age 31-36 years). Education categorised as 'Low' (higher school certificate or lower - ≤ 12 years), 'Intermediate' (trade/certificate/diploma) or 'High' (degree or higher)

Sensitivity analyses for both exposures (see Methods) showed similar associations to those presented with marginally lower estimates (results available upon request). Additionally, sensitivity analyses using imputed data showed the same associations to those presented (see Additional information, Tables 5.5 and 5.6).

Baseline characteristics of women based on their highest achieved education

While the mean age at baseline was similar for all education groups, women with a high education by Survey Five were significantly lighter and taller at baseline (Table 5.4). At baseline, a greater proportion of these women had never had children (98%); with an older mean age at birth of first child (29.1 years), compared to intermediate (26.6 years) and low (25.3 years) educated women.

Table 5.3: Baseline weight and weight gain* over 13 years by educational mobility† in 1973-78 cohort ALSWH women (n = 9 463)**

	% weighted (unweighted)	Model 1 Estimate (95% CI)	Model 2 Estimate (95% CI)
Baseline weight (kg)		63.15 (62.46, 63.85)	57.85 (56.77, 58.92)
Difference in baseline weight by educational mobility†			
Stable low	18.9 (21.7)	reference	reference
Low-intermediate	9.9 (10.9)	-0.78 (-1.78, 0.27)	-0.78 (-1.78, 0.21)
Stable intermediate	19.8 (20.5)	0.17 (-0.68, 1.02)	0.31 (-0.51, 1.12)
Upgrade to high	12.8 (12.0)	-2.71 (-3.68, -1.75)	-2.13 (-3.07, -1.19)
Stable high	38.6 (34.9)	-2.66 (-3.41, -1.91)	-1.77 (-2.52, -1.02)
Increase per year (kg)		1.12 (1.06, 1.18)	1.45 (1.39, 1.52)
Difference in increase per year by educational mobility†			
Stable low		reference	reference
Low-intermediate		0.04 (-0.09, 0.07)	0.01 (-0.07, 0.08)
Stable intermediate		-0.09 (-0.15, -0.22)	-0.07 (-0.13, -0.002)
Upgrade to high		-0.24 (-0.31, -0.17)	-0.20 (-0.27, -0.13)
Stable high		-0.32 (-0.37, -0.26)	-0.28 (-0.33, -0.22)
Attenuation per year (time x time)		-0.02 (-0.03, -0.02)	-0.05 (-0.06, -0.05)

** random effects models (intercept and slope) with weight measured at age 18–23 years, 22–27 years, 25–30 years, 28–33 years and 31–36 years*

† change in education level from age 22–27 years to age 31–36 years: (Low - higher school certificate or lower (≤ 12 years), Intermediate - trade/certificate/diploma, High - degree/higher degree). Upgrade to high includes women who had a low (70%) or intermediate (30%) education who later upgraded to a high education.

*** sample slightly smaller than the 9,907 women who had a value for change in education level, due to missing values for some covariates.*

Model 1 – baseline centred age, baseline centred height and area of residence.

Model 2 - Model 1 + physical activity, alcohol intake, mental health, self-rated health, number of children, smoking, age at first birth, living arrangement, marital status, health transition, shape dissatisfaction, income management and country of birth.

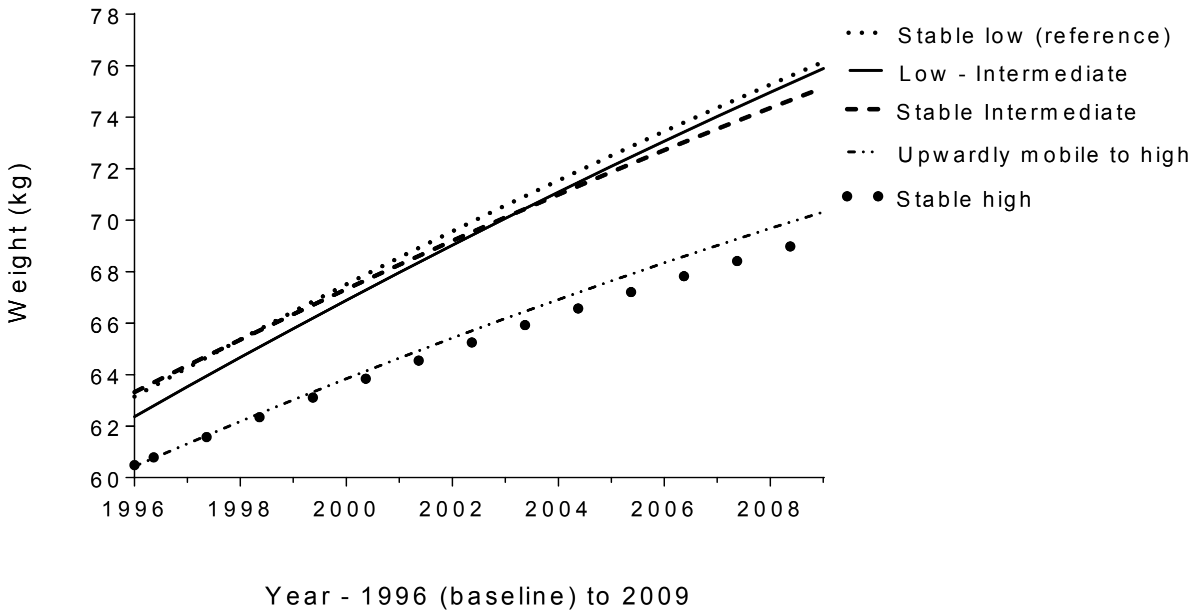


Figure 5.3: Educational mobility and weight gain over 13 years in women from the 1973-78 ALSWH cohort (n=9,463)

Difference in baseline weight and weight gain over 13 years (random effects model with a random intercept and slope, adjusted for area of residence and baseline centred age and height), based on educational mobility from Survey Two (age 22-27 years) to Survey Five (age 31-36 years). Educational mobility categorised as 'stable low' (low-low), 'low-intermediate', 'stable intermediate' (intermediate-intermediate), 'upgrade to high education' (low-high or intermediate-high) or 'stable high' (high)

Compared to the other two education groups, a significantly smaller proportion of high educated women were separated/divorced/widowed, with the greatest proportion having never married (~89%). In contrast to high educated women, at baseline a larger proportion of low educated women were sedentary or had low physical activity levels; never/rarely drank or had risky drinking levels; were current smokers; had poor mental health; were Australian born; and lived in a rural or remote area.

While the above differences at baseline based on highest achieved education were noted, these covariates did not have a large effect on the association between education and body weight, as seen in the fully adjusted models (Tables 5.2 and 5.3, Model 2).

Table 5.4: Baseline characteristics in 1973-78 cohort ALSWH women based on highest achieved education† (n = 10 018)

	Highest achieved education†			
Baseline characteristics	**Low** (21%) n = 2 087‡	**Intermediate** (30%) n = 2 994‡	**High** (49%) n = 4 937‡	chi^2 / F statistic (P-value)
Mean (Std Dev)				
Age (years)	20.8 (1.5)	20.8 (1.4)	20.7 (1.5)	9.23 (<0.0001)
Weight (kg)	63.7 (13.1)	63.6 (13.3)	61.8 (11.1)	23.6 (<0.0001)
Height (cm)	165.4 (7.4)	165.7 (7.3)	166.4 (6.8)	18.4 (<0.0001)
Age at birth of first child**	25.3 (4.3)	26.6 (4.1)	29.1 (3.4)	529.6 (<0.0001)
Percentage (%)				
BMI				* 44.3 (<0.0001)
Underweight (< 18.5)	9.2	9.1	9.4	
Normal weight (18.5 -24.9)	62.3	66.4	73.5	
Overweight (25.0 – 29.9)	18.9	16.5	13.3	
Obese (≥ 30.0)	9.6	8.0	3.8	
Number of children				509.9 (<0.0001)
No children	83.7	91.3	98.2	
1	12.3	6.8	1.5	
2	3.3	1.6	0.2	
3+	0.7	0.3	0.02	
Marital status				704.0 (<0.0001)
Never married	62.3	71.5	88.7	
Married/de facto	36.0	27.7	11.1	
Separated/divorced /widowed	1.7	0.8	0.2	
Physical activity				73.5 (<0.0001)
Nil/Sedentary	8.4	6.6	4.4	
Low	40.1	37.6	35.4	
Moderate	12.6	13.4	13.9	
High	38.9	42.4	46.3	
Alcohol intake				121.5 (<0.0001)
Never/rarely	48.8	42.8	36.9	
Low risk	44.8	51.6	58.7	
Risky/high risk	6.4	5.6	4.4	
Smoking status				429.7 (<0.0001)
Non-smoker	40.9	47.8	65.2	

	Highest achieved education†			
Ex-Smoker	18.4	17.0	12.7	
Current smoker	40.7	35.2	22.1	
Mental health (based on MHI-5)				56.8 (<0.0001)
Poor (≤ 52)	24.4	21.5	17.1	
Good (> 52)	75.6	78.5	82.9	
Country of birth				72.0 (<0.0001)
Australia	94.6	95.0	91.1	
Other English speaking	3.6	2.6	4.1	
Europe	0.6	0.8	1.1	
Asia	0.7	1.0	2.7	
Other (incl. Middle East)	0.5	0.6	1.0	
Area of residence				420.3 (<0.0001)
Urban (major cities)	37.3	46.6	61.2	
Rural (inner regional)	36.5	32.4	26.5	
Remote (outer regional/ remote)	26.2	21.0	12.3	

† achieved at Survey Five (age 31–36 years) (if missing, then from Survey Four) categorised as 'Low' - higher school certificate or lower (≤12 years), 'Intermediate' - trade/certificate/diploma or 'High' - degree/higher degree.

‡ sample sizes change slightly due to missing values for some variables.

**Mantel-Haenszel chi-square used when >10% data was missing.*

*** age at birth of first child is based on reported information up to Survey Five.*

5.1.1 Discussion

This study investigated body weight trajectories over 13 years among Australian women aged 18–23 years at baseline. The results suggest that while the mean trend is increasing body weight for all women, adult education level is significantly associated with weight trajectory.

We found that high educated women benefited from gaining less weight over a 13 year period. This is consistent with other studies which have found an inverse association between education and long term weight gain.[9-12 ,85] A Finnish study,[171] investigating the association between multiple measures of SEP and five year weight gain in mid-aged women, found that after full adjustment for a range of SEP measures (including parental education, childhood education, childhood and adulthood socioeconomic difficulties, own occupational social class and material resources) only the association between education and weight gain remained; suggesting this might be due to education preceding occupation and income.[171] Given this, one may assume that formal education itself encourages better health and a more promising weight trajectory; possibly through an increased knowledge of health behaviours and greater access to resources. However, assuming that knowledge results in positive behavioural change/practices should be questioned; as shown in a U.S. longitudinal study[11] which found the BMI trajectory of socially advantaged groups to be increasing and indeed higher than socially disadvantaged groups born 10 years earlier, although this could be confounded by timing of measurement.

While women with a high education at Survey Five had the lowest baseline weight and weight trajectory, two interesting findings were apparent regarding educational mobility. Firstly, women who remained with a low education at both time points had a steeper weight trajectory than those who went on to upgrade their education. Secondly, we found that lower educated women with the greatest educational mobility had a similarly favourable baseline weight and trajectory to those who had already achieved this high education earlier on. Our finding support those from a U.S. study of 18–30 year olds which found that, among white women, while education at baseline was only associated with BMI at this same time point, education at follow-up (7 years after baseline) was associated with both baseline weight and weight at follow-up.[201] Our analysis of educational mobility adds to this knowledge by highlighting that, with regards to baseline weight and weight trajectory, little additional advantage is seen in women who obtained this level of education early on compared to later.

This suggests that using education in early adulthood as a fixed marker of SEP may be inaccurate and in fact downplay the association between education and body weight trajectory. It may explain why some studies find an association between education and weight trajectory only among older women[153] or not at all when measuring education at baseline;[95,170] while others, find a negative association when using education in later adulthood.[15,173]

Additionally, these results suggest that health behaviours/knowledge we might expect in highly educated women may be more related to factors operating earlier in life that lead to obesity, including early developmental patterns.[207] One explanation is that education attainment is influenced by IQ, however the early life environment in which cognitive ability and personality development are nurtured[208] must also be important, not least due to the types of resources available and psychosocial factors that make up that environment, as well as possible early socioeconomic disadvantage. We also tried adjusting for both mother's and father's education, separately and mutually, and found our associations remained the same, with marginally reduced estimates (results not shown). This suggests that even when we take into account early life SEP, there is still an effect of own education. It could be that some shared personality traits exist, which may make an individual more likely to engage in (and successfully obtain) a high education and also more successful at weight management, such as persistence and self-directedness.[209]

The main strength of this study is having five waves of data collected over 13 years in a large sample. This gave women adequate time to have completed their education and allowed for a more in-depth analysis into changes in education level than would have been possible with fewer time points. Use of longitudinal methods accommodated for correlation between multiple observations per individual, while allowing for time-varying covariates and changes in behavioural/demographic characteristics which may influence body weight. Additionally, sensitivity analyses showed similar associations to those presented, including analyses using imputed data for both exposures and outcomes.

Potential study limitations should not be overlooked. Consistent with findings in other developed countries, a Melbourne study found an average weight gain of 0.4 kg/year;[173] while our study found an average gain in mean weight of 0.7 kg/year (8.6 kg over the follow-up period). While self-reporting includes the possibility of overestimated height and underestimated weight, both are found reasonable to use within epidemiological studies.[210] If weight underreporting is consistent, Baltrus et al.[153] suggest weight trajectory estimates should not be affected; although Brown et al.[10] state this may not apply to overweight/obese women, who have a greater tendency for weight underestimation, resulting in estimates biased towards the null. Since education is positively associated with height, we also looked at BMI trajectories and found the same associations as we did with body weight; we chose the latter as it offers a more interpretable result. Given that the significance of weight is dependent on height, we tried to account for this by adjusting all models for height centred at the cohort mean.

An overrepresentation of tertiary educated women in this cohort (12%, compared to 3% in the closes Australian census),[202] together with a slightly higher proportion of high educated women included (12%) than excluded (6%) from the sample may influence generalizability of results through selection bias.

In conclusion, our study highlights the importance of when education is measured, how it is used in analyses and the theoretical/causal model that is to be tested; all of which may influence the interpretation of results and the mechanisms through which SEP is thought to influence weight change. Using earlier education to measure the association between SEP and body weight trajectory may result in biased estimates, underestimating the association. High achieved education was significantly associated with a more favourable weight trajectory; with little increased advantage among those who had obtained this high education early on, compared to the women with a lower education who upgraded over the 13 year period. This suggests that behavioural characteristics and health knowledge often associated with a high education may already differentiate women early on; including personality traits related to weight management;[209] early life factors, such as food/flavour preferences;[211] and modelling of parental physical activity and nutritional patterns.[212]. Overall, understanding the role of education and the mechanisms through which it may influence body weight may help to identify women, and hence children, at increased risk of an unhealthy weight trajectory.

5.1.2 Additional information

The following information was included as electronic supplementary material to the published study included in this chapter.

Table 5.5: Baseline weight and weight gain* over 13 years by highest education† in 1973-78 cohort ALSWH women, using multiply imputed data (n=13,862)**

	% weighted (unweighted)	Model 1 Estimate (95% CI)	Model 2 Estimate (95%CI)
Baseline weight (kg)		60.44 (59.99, 60.88)	57.58 (56.72, 58.44)
Difference in baseline weight by highest achieved education†			
High	49.1 (44.5)	Reference	Reference
Intermediate	29.7 (31.3)	2.07 (1.45, 2.69)	1.18 (0.59, 1.78)
Low	21.2 (24.2)	2.29 (1.53, 3.05)	1.11 (0.36, 1.87)
Increase per survey (kg)		0.72 (0.66, 0.77)	1.23 (1.16, 1.29)
Difference in increase per survey by highest achieved education†			
High		Reference	Reference
Intermediate		0.27 (0.23, 0.31)	0.24 (0.21, 0.28)
Low		0.34 (0.30, 0.38)	0.29 (0.25, 0.33)
Attenuation per survey (time*time)		-0.01 (-0.02, -0.01)	-0.05 (-0.05, -0.04)

* *random effects models (intercept only) with weight measured at age 18-23 years, 22-27 years, 25-30 years, 28-33 years and 31-36 years*

† *education achieved at Survey Five (Low - higher school certificate or lower (≤ 12 years), Intermediate - trade/certificate/diploma, High - degree/higher degree)*

*** women with at least one body weight measurement available*

Model 1 – Baseline centred age, baseline centred height and area of residence

Model 2- Model 1 + country of birth, physical activity, alcohol intake, mental health, income management, self-rated health, age at first birth, living arrangements, marital status, shape dissatisfaction

Table 5.6: Baseline weight and weight gain* over 13 years by educational mobility† in 1973-78 cohort ALSWH women, using multiply imputed data (n=13,862)**

	% weighted (unweighted)	Model 1 Estimate (95% CI)	Model 2 Estimate (95% CI)
Baseline weight (kg)		62.50 (61.80, 63.21)	56.21 (55.06, 57.37)
Difference in baseline weight by educational mobility†			
Stable low	20.7 (23.8)	Reference	Reference
Low-intermediate	10.4 (11.4)	-0.94 (-2.03, 0.15)	-0.84 (-1.85, 0.17)
Stable intermediate	20.0 (20.7)	0.53 (-0.38, 1.45)	0.74 (-0.14, 1.63)
Upgrade to high	13.3 (12.3)	-1.99 (-2.97, -1.02)	-1.19 (-2.14, -0.24)
Stable high	35.6 (31.9)	-2.02 (-2.77, -1.27)	-0.87 (-1.62, -0.12)
Increase per survey (kg)		1.07 (1.00, 1.13)	1.51 (1.44, 1.59)
Difference in increase per survey by educational mobility†			
Stable low		Reference	Reference
Low-intermediate		0.01 (-0.06, 0.06)	0.01 (-0.05, 0.07)
Stable intermediate		-0.12 (-0.17, -0.07)	-0.09 (-0.15, -0.04)
Upgrade to high		-0.28 (-0.34, -0.23)	-0.23 (-0.29, -0.17)
Stable high		-0.37 (-0.41, -0.32)	-0.32 (-0.37, -0.27)
Attenuation per survey (time*time)		-0.01 (-0.02, -0.01)	-0.05 (-0.05, -0.04)

* *random effects models (intercept only) with weight measured at age 18-23 years, 22-27 years, 25-30 years, 28-33 years and 31-36 years*

† *change in education level from early-mid twenties to early-mid thirties: (Low - higher school certificate or lower (≤ 12 years), Intermediate - trade/certificate/diploma, High - degree/higher degree). Upgrade to high includes women who had a low (70%) or intermediate (30%) education who later upgraded to a high education.*

*** women with at least one body weight measurement available*

Model 1 – baseline centred age, baseline centred height and area of residence

Model 2 - Model 1 + physical activity, alcohol intake, mental health, self-rated health, number of children, smoking, age at first birth, living arrangement, marital status, health transition, shape dissatisfaction, income management and country of birth

5.2 Conclusion

This study found an overall increase in mean weight over 13 years among all groups over time, with a steeper increase over time among women with a lower education. On average, those who remained with a low education were heaviest at baseline and had the largest increase in weight over time. As expected, given that height does not vary among people of this age range, we also found the same effects when modelling BMI as the outcome.

In contrast, women with high educational mobility had a similarly favourable mean baseline weight and weight trajectory to women with a high education at baseline: this suggests that women who go on to be educationally mobile are already different beforehand (in terms of body weight) to those who will not. Given this, it is important for those interested in the association between education and body weight (including epidemiologists, public health practitioners, and policy makers) be mindful of and to consider the importance of educational mobility. What is it that this this mobility actually represents? What it is about women who pursue and secure a high education that makes them better at managing their weight?

An analysis of the characteristics of women based on categories of educational mobility at baseline (aged 18-23 years, Table 5.7) and at Survey Five (aged 31-36 years, Table 5.8) showed that with increasing category of educational mobility, from stable low to stable high: women gave birth to their first child at an older age; a lower percentage of women had an obese weight status, and were separated/divorced/widowed; and a higher percentage of women were non-smokers, had a low-risk intake of alcohol, had a moderate or high level of physical activity, reported a good level of mental health, were born outside of Australia, lived in an urban area, and did not have any children. Interestingly, at Survey Five, a lower percentage of women with a stable low education had an overweight weight status, compared to women with a low-intermediate or a stable intermediate education (Table 5.8).

While further research may benefit by investigating socioeconomic mobility through alternative measures of SEP that can also reflect downward social mobility, this study was restricted to only using education, given that it is a stable measure of SEP among women of reproductive age (see **Chapter 2.1.2**).

Table 5.7: Baseline characteristics of women from the 1973-78 ALSWH cohort, based on educational mobility† (from age 18-23 years to age 31-36 years) (n=9,776)

	Educational mobility†					
	Stable low (22.4%) n=2,194‡	**Low-Intermediate** (9.1%) n=889‡	**Stable Intermediate** (19.1%) n=1,867‡	**Upgrade to high**[a] (12.8%) n=1,247‡	**High** (36.6%) n=3,579‡	**p-value**
Baseline characteristics						
Mean (Std Dev)						
***Weight** (kg)*	63.6 (13.1)	62.9 (12.6)	63.9 (13.7)	61.6 (11.4)	61.9 (10.9)	<0.0001
***Height** (cm)*	165.5 (7.4)	165.6 (7.4)	165.6 (7.2)	166.4 (6.8)	166.4 (6.8)	<0.0001
Percentage (%)						
BMI[b]						<0.0001
Underweight	9.3	8.9	9.2	10.4	8.9	
Normal weight	62.8	68.5	65.2	73.5	73.7	
Overweight	18.4	15.6	17.0	12.5	13.5	
Obese	9.5	7.0	8.6	3.6	3.9	
Number of children						*<0.0001
No children	82.9	84.6	93.5	96.0	98.7	
1	12.1	10.2	5.4	3.2	1.2	
2	4.2	4.7	0.9	0.6	0.1	
3+	0.7	0.5	0.2	0.2	0	
Marital status						*<0.0001
Never married	62.9	67.0	73.7	86.9	89.3	
Married/de facto	35.4	31.9	25.6	12.8	10.5	
Separated/divorced /widowed	1.7	1.1	0.6	0.3	0.2	
Physical activity						<0.0001
Nil/Sedentary	8.2	7.1	6.6	5.1	4.2	
Low	39.4	38.7	37.9	34.9	35.5	
Moderate	12.9	12.4	13.5	13.7	14.2	
High	39.6	41.8	42.1	46.3	46.2	
Alcohol intake						<0.0001
Never/rarely	48.9	44.6	42.1	37.2	36.5	
Low risk	44.7	49.9	52.8	57.4	59.4	
Risky/high risk	6.4	5.6	5.1	5.5	4.1	
Smoking status						<0.0001
Non-smoker	41.8	41.7	51.9	56.9	68.1	
Ex-Smoker	18.9	17.3	15.9	14.1	12.1	
Current smoker	39.3	41.0	32.2	29.0	19.8	
Mental health (based on MHI-5)						<0.0001

Poor (≤ 52)	24.0	22.8	20.7	21.2	15.6	
Good (> 52)	76.0	77.2	79.3	78.8	84.4	
Country of birth						<0.0001
Australia	94.8	93.7	95.3	90.6	91.5	
Other English speaking	3.4	3.4	2.4	4.5	3.9	
Europe	0.6	0.8	1.0	1.1	1.1	
Asia	0.7	1.4	0.9	3.0	2.5	
Other (incl. Middle East)	0.5	0.8	0.4	0.8	1.0	
Area of residence						<0.0001
Urban (major cities)	37.1	42.5	49.4	58.1	62.2	
Rural (inner regional)	36.5	34.7	31.5	28.6	25.7	
Remote (outer regional/ remote)	26.4	22.9	19.1	13.3	12.1	

† Low - higher school certificate or lower (≤ 12 years), Intermediate - trade/certificate/diploma

High - degree/higher degree

[a] Upgrade to high= low-high and intermediate-high

[b] Weight status based on the WHO BMI categories: Underweight (< 18.5); Normal weight (18.5-24.9); Overweight (25-29.9); obese (≥ 30)

‡ sample sizes change slightly due to missing values for some variables

**Mantel-Haenszel chi square used when > 10% data was missing*

*** Age at birth of first child is based on reported information up to survey five*

A number of individual demographic, psychosocial, material, behavioural and reproductive variables included in the models were associated with increased mean body weight: women were heavier with increasing dissatisfaction with their body shape; women who were never married or separated/divorced/widowed were lighter than women who were married/de facto; women who reported their self-rated health to be ‘good’ or ‘poor/fair’ were heavier than women who reported it to be ‘very good’; women with a low-risk level of consumption of alcohol were lighter than women with a risky level of consumption; women who were physically active were increasingly lighter than women who were sedentary; and women born in Asia were considerably lighter than women born in Australia.

For both exposures, the intra-class correlation was calculated as approximately 0.87 (results not shown); that is, 87% of the total variation in weight could be explained by differences between women (and hence 13% of the variation explained by within-individual differences).

Table 5.8: Characteristics of women from the 1973-78 ALSWH cohort at Survey Five (aged 31-36 years), based on educational mobility† (from age 18-23 years to age 31-36 years) (n=9,776)

	Educational mobility†					
	Stable low (22.4%) n=2,194‡	**Low-Intermediate** (9.1%) n=889‡	**Stable Intermediate** (19.1%) n=1,867‡	**Upgrade to high[a]** (12.8%) n=1,247‡	**High** (36.6%) n=3,579‡	**p-value**
Survey Five characteristics						
Mean (Std Dev)						
***Weight** (kg)*	74.7 (19.1)	74.4 (18.6)	73.4 (18.2)	69.0 (15.4)	68.6 (14.7)	<0.0001
Age at birth of first child**	25.3 (4.4)	25.4 (4.5)	27.2 (3.8)	28.2 (4.2)	29.4 (3.0)	<0.0001
Percentage (%)						
BMI[b]						<0.0001
Underweight	3.0	2.1	1.6	2.8	3.3	
Normal weight	43.0	42.2	46.8	58.7	60.1	
Overweight	25.5	30.0	27.9	23.8	23.3	
Obese	28.5	25.6	23.8	14.6	13.3	
Number of children						<0.0001
No children	24.7	33.3	31.6	51.6	45.4	
1	18.4	20.6	20.7	22.2	18.9	
2	33.3	28.5	33.4	18.4	26.0	
3+	23.6	17.7	14.3	7.8	9.8	
Marital status						<0.0001
Never married	14.4	20.6	14.7	21.7	17.7	
Married/de facto	78.1	72.1	79.1	73.6	78.8	
Separated/divorced /widowed	7.5	7.3	6.2	5.1	3.5	
Physical activity						<0.0001
Nil/Sedentary	18.0	14.6	17.3	11.3	9.9	
Low	39.4	42.9	41.9	36.6	38.3	
Moderate	20.7	19.9	18.4	25.3	24.0	
High	21.9	22.6	22.4	26.9	27.8	
Alcohol intake						<0.0001
Never/rarely	44.4	41.0	39.0	31.9	30.6	
Low risk	50.2	53.9	56.1	63.9	66.1	
Risky/high risk	5.4	5.1	4.9	4.2	3.3	
Smoking status						<0.0001
Non-smoker	46.1	45.7	57.0	56.7	73.4	
Ex-Smoker	31.1	31.2	27.4	30.1	19.2	
Current smoker	22.8	23.1	15.6	13.2	7.5	

Mental health (based on MHI-5)						<0.0001
Poor (≤ 52)	17.3	18.2	15.5	12.9	11.2	
Good (> 52)	82.7	81.8	84.5	87.1	88.8	
Area of residence						<0.0001
Urban (major cities)	40.2	47.3	52.9	64.6	68.7	
Rural (inner regional)	36.1	33.0	29.9	22.5	19.2	
Remote (outer regional/ remote)	23.7	19.7	17.2	12.9	12.1	

† Low - higher school certificate or lower (≤ 12 years), Intermediate - trade/certificate/diploma

High - degree/higher degree

‡ sample sizes change slightly due to missing values for some variables

[a] Upgrade to high= low-high and intermediate-high

[b] Weight status based on the WHO BMI categories: Underweight (< 18.5); Normal weight (18.5-24.9); Overweight (25-29.9); obese (≥ 30)

**Mantel-Haenszel chi square used when > 10% data was missing*

*** Age at birth of first child is based on reported information up to survey five*

In addition to individual characteristics, which may influence both weight management and educational achievement, certain life events may also exercise an effect. A number of different reproductive outcomes have been associated with body weight at different stages of the life course, and in varying degrees and consensus. This includes age at menarche (first menstruation), which is inversely associated with BMI in mid-adulthood,[85] as well as a number of reproductive characteristics outlined within the literature review (**Chapter 2**).

The following three chapters look specifically at a number of these characteristics to document their social patterning among women of reproductive age, specifically: age at birth of the first child and birth intervals (**Chapter 6**), pre-pregnancy BMI and GWG (**Chapter 7**), and infant breastfeeding (**Chapter 8**). For the most part, these studies use highest achieved education as a measure of SEP. This was done for a number of reasons: firstly, the literature details a well-established association between SEP and body weight when measured using education,[9-15] occupation[9,15,16] and area level disadvantage,[17] while the association with income is less well established;[9] secondly, education is an important measure of SEP, since it precedes occupation and income; and thirdly, education is a more stable measure of SEP,[18] particularly for women of childbearing age, since having children means an absence (albeit perhaps temporary) from the paid labour market, a reduction in income, and increased costs associated with childcare.

Chapter 6. Social inequalities in reproductive characteristics: the timing of first birth and birth spacing

As outlined in the literature review (**Chapter 2**), the timing of reproduction has been associated to varying degrees with increased body weight among women. In the previous study (**Chapter 5**) which investigated the association between education and body weight, a number of individual demographic, psychosocial, material, behavioural, and reproductive variables were adjusted for in the final model, including age at birth of the first child. In this fully adjusted model, women who had their first child aged ≥ 26 years were slightly lighter than women who did not have children. An understanding of the social patterning of reproductive characteristics is not well developed, particularly among a contemporary cohort of Australian women of reproductive age. **Chapter 6.1** presents results from *Study 2*, which investigates this gap within the literature.

6.1 Socioeconomic position and reproduction: findings from the Australian Longitudinal Study on Women's Health (*Study 2*)

This manuscript has been submitted for publication and is currently under review.

Abstract

Objective: To investigate the association of socioeconomic position (SEP) with reproductive outcomes among Australian women.

Methods: Data from the Australian Longitudinal Study on Women's Health's (population-based cohort study) 1973-78 cohort were used (N=6,899, aged 37-42 years in 2015). The association of SEP (childhood and own, multiple indicators) with age at first birth, birth-to-pregnancy intervals and total number of children was analysed using multinomial logistic regression.

Results: 14% of women had their first birth aged < 24 years. 29% of multiparous women had a BTP interval within the WHO recommendation (18-27 months). Women with a low SEP had increased odds of a first birth < 24 years: low (OR 7.0: 95% C.I. 5.3, 9.3) or intermediate education (OR 3.8: 2.8, 5.1); living in rural (OR 1.8: 1.5, 2.2) or remote (OR 2.1: 1.7, 2.7) areas; who found it sometimes (OR 1.8: 1.5, 2.2) or always difficult (OR 2.0: 1.6, 2.7) to manage on their income; and did not know their parent's education (OR 4.5: 3.2, 6.4). Low SEP was associated with having a much longer than recommended birth-to-pregnancy interval.

Conclusion: As the first Australian study describing social differences in reproductive characteristics, these findings provide a base for reducing social inequalities in reproduction. Assisting adequate birth-to-pregnancy spacing is important, particularly for women with existing elevated risks due to social disadvantage; including having a first birth < 24 years of age and a longer than recommended BTP interval. This may include services/access to postnatal support, free family planning/contraception clinics, and improved family policies.

Key words: socioeconomic position, educational status, reproduction, age at first birth, birth intervals, birth-to-pregnancy interval

6.1.1 Introduction

Describing current reproductive patterns is important for predicting future needs for prenatal/postnatal care, family services/policies (i.e., parental leave and childcare), and the potential consequences of these present-day trends. Reproductive characteristics (parity, maternal age, and birth intervals) are also associated with both maternal and neonatal outcomes.

Increased parity (3+ children) is associated with greater chronic disease risk, including diabetes and high blood pressure,[213] and mortality (u-shaped association).[214] In the U.S.,[82] U.K.,[84] and Sweden,[15] parity is also positively associated with obesity among women in mid-to-later life; with greater 10-year weight gain among parous, compared to nulliparous, Australian women.[10] Overall, the greatest increases in weight due to childbearing are suggested to be after the first birth.[86]

Both extremes of the maternal age distribution are associated with adverse pregnancy outcomes. For the infant, young maternal age is associated with increased risk of preterm birth and small for gestational age,[215] and older maternal age (> 40 years) with increased risk of still birth.[216] While a u-shaped association been maternal age and low birth weight is suggested,[215 ,217] a comparative study found that after adjusting for socioeconomic position (SEP), this risk remains only among women aged < 16 years or ≥ 35 years.[217]

For the mother, young maternal age is associated with increased risk of endometrial and cervical cancer,[218] increased mortality,[214] and poorer mental health;[219] while older maternal age is associated with increased risk of maternal death, chronic hypertension,[220] gestational diabetes, breast and brain cancers,[218] as well as ovarian ageing, subfertility, and hence increased need for assisted reproduction.[221] Despite these possible risks, biological trade-offs associated with ageing may be offset by the emotional, social and financial advantages gained,[106] including fewer depressive and anxiety symptoms among mothers aged ≥ 37 years.[221]

Age at first birth is also associated with child birth intervals; with shorter intervals among women in their thirties or older, compared to women in their twenties[222] or younger.[223] This may result from limited time when desiring a larger family,[222] or minimising labour market absence and career disruption [224]. Social factors associated with shorter birth intervals include poor housing and smoking,[225] low SEP,[111,225] being married, and having had unwanted pregnancies.[223]

A systematic review summarises both short (< 18 months) and long birth intervals (> 59 months) as being associated with adverse pregnancy outcomes, including preeclampsia, preterm birth, and maternal death.[226,227] Although the effect of short birth intervals may be weaker with advanced maternal age,[215] they are further associated with increased risk of adverse neonatal and infant outcomes.[228]

Describing social differences in reproduction encourages consideration of SEP specific factors which may promote or discourage a healthy reproductive profile, including establishing oneself within (and limiting absence from) the paid workforce.[106,224] In the U.S.[229] and Sweden,[230] women's SEP (education,[229,230] income,[229] occupation[230]), and their partner's education[229] are negatively associated with parity. A strong correlation between maternal and offspring age at first birth also highlights intergenerational influences of reproduction;[231] and although disadvantaged women have increased risk of having an early first birth, this may not contribute to poor health beyond the influence of early life disadvantage itself.[232]

The Australian mean maternal age at first birth increased from 27.8 years in 2003 to 28.6 years in 2013 (overall, the mean age at birth increased from 29.5 years to 30.1 years over this same period).[233] In 2013, 17% of Australian mothers were aged < 24 years and 22% were aged ≥ 35 years;[233] with the proportion of women having their first child ≥ 35 years of age increasing from 11.8% in 2003 to 13.9% in 2012.[234] This increased trend of delayed childbearing is familiar in high income countries and, while overall lower fertility rates are seen in areas of most advantage in Australia,[235] little is known about the social patterning (i.e., the influence of social of characteristics such as education, income, and area of residence) of reproductive characteristics.

Using a recent cohort of Australian women of child-bearing age, this study describes i) age at birth of the first child; ii) birth interval and BTP interval between the first and second child; and iii) total number of children: and iv); and the social patterning of these trends, which may indicate further health inequalities associated with reproduction.

6.1.2 Methods

Study participants

The Australian Longitudinal Study on Women's Health (ALSWH) comprises three nationally representative cohorts of Australian citizens and residents randomly selected from the national health and insurance database (Medicare). These women completed a self-reported survey in 1996 (baseline) and at approximate three year intervals thereafter. Detailed information about the ALSWH cohorts can be found elsewhere.[188]

The study sample includes women from the 1973-78 cohort (14,247 women; aged 18-23 years at baseline). Besides a slight over-representation of tertiary educated women, this cohort is generally representative of the female population for their age.[95] At Survey Two (conducted in 2000; aged 22-27 years) the response rate was 68% (n=9,688 completed the survey). This relatively high attrition between baseline and Survey Two is believed to result from high geographical mobility, change of surname upon marriage, extended travel abroad, unlisted phone numbers and being unregistered to vote.[188] Following this, 9,081 women (64%) completed Survey Three (2003; aged 25-30 years); 9,145 (64%) completed Survey Four (2006; aged 28-33 years); 8,200 (58%) completed Survey Five (2009; aged 31-36 years); 8,010 (56%) completed Survey Six (2012; aged 34-39 years); and 6,901 (48%) completed Survey Seven (2015; aged 37-42 years).

To utilise the most recent child birth information, the sample was restricted to women who answered Surveys One and Seven. The full sample includes 6,899 women, after excluding two women with an implausible birth interval between the first and second or second and third singleton child. A comparison of baseline characteristics among women included/excluded from the sample is included in Additional information Table 6.4, and considered in the discussion.

Exposure - Indicators of socioeconomic position

Own education and parent's highest education were collected at Survey Two, when participants were aged 22-27 years and theoretically had time to achieve a high education. All other SEP measures were collected at baseline (unless otherwise specified). Own education was categorised as low (≤ 12 years); intermediate (trade/apprentice/certificate/diploma); and high (degree/higher). Parent's highest education (highest of mother's or father's) was categorised as very low (≤ 10 years); low (≤ 12 years/equivalent); intermediate (trade/certificate/diploma); high (degree/higher); and don't know/not applicable.

Area of residence was categorised as urban (major cities); rural (inner regional); and remote (outer regional/remote). Distribution of socioeconomic conditions based on neighbourhood was measured using quintiles of SEIFA (Socioeconomic Indexes for Areas) scores for education and occupation (higher scores indicating less disadvantage).[192] A sense of ability to manage on income (a measure of financial stress) was categorised as impossible/always difficult; sometimes difficult; and not too bad/easy.

Outcome measures

Age at birth of the first child was calculated using dates of birth of the woman and her first child. Based on sufficient size of the sample distribution, this score difference was divided into groups of possible clinical significance (< 24; 24-29; 30-34; ≥ 35.0 years), similar to those used in other studies.[214,215]

The WHO states that birth-to-pregnancy (BTP) intervals < 18 months or > 59 months are associated with adverse maternal and perinatal outcomes.[114] While a BTP interval of 24 months after a live birth is recommended, the WHO birth spacing consultation committee were divided between recommending 18 and 27 months, due to acknowledged residual elevated risks;[114] given this, 18-27 months was used as the reference group. The birth interval between children was calculated in months by dividing the difference of these dates by 30.4. Nine months (average gestation) was subtracted from this when categorising BTP intervals based on the WHO recommendation (categorised as < 18; 18-27; 28-59; > 59 months). BTP interval was used as the outcome when investigating the association between SEP and birth interval.

Total number of children was categorised as none; one; two; and three or more.

Covariates

At each survey women reported their living arrangement (living with partner/children; and other (alone, parents/relatives, non-family)); use of contraceptives (yes; not needed (pregnant, tubal ligation, vasectomy, can't have children); and no); marital status (married/de facto; separated/divorced/widowed; and never married); whether they had fertility issues (dichotomous) based on the question "Have you and your partner (current or previous) ever had problems with infertility (that is, tried unsuccessfully to get pregnant for 12 months or more)?" Weight status at age 37-42 years was based on self-reported weight and height (kg/m^2), and categorised using the WHO's BMI categories of underweight (< 18.50 kg/m^2), normal weight (18.50-24.99 kg/m^2, hereafter 'healthy weight'), overweight (25.00-29.99 kg/m^2) and obese (≥ 30.00 kg/m^2).[204] Given a large percentage of women were born in Australia, country of birth (reported at baseline) was dichotomised.

Duration of breastfeeding each child (in complete months) was taken from Surveys Five, Six and Seven, and was categorised based on meeting the Australian Infant Feeding guidelines (no; < 6 months; and ≥ 6 months).[121]

Statistical analyses

Descriptive analyses, including t-tests and Pearson's chi-square tests, were used to describe the sample and explore the association between maternal and SEP characteristics with the reproductive characteristics. Distribution of age at each birth was plotted, stratified by total number of children. Multinomial logistic regression models were used to investigate the association between the various measures of SEP and i) age at birth of first child (reference 24-29 years); ii) the birth interval between the first and second child (reference 18-27 months); and iii) total number of children (reference two children). All models were minimally adjusted for age at baseline and parent's education (early life SEP). Variables which may introduce further confounding bias were identified in the theoretical model and adjusted for as indicated in the footnotes for the regression tables. Sensitivity analyses were performed to explore the possible data limitation of incomplete fertility, with similar results found when only using data up to Survey Six. Additional sensitivity analyses excluding women who already had children at the time of the first survey (aged 18-23 years; that is, before the measure of own SEP was taken) yielded similar results to those presented (results available upon request).

Analyses were completed in SAS version 9.4 (SAS Institute Inc., Cary, NC). The ALSWH study is approved by the Human Research Ethics Committees of the Universities of Newcastle and Queensland. Informed consent was given by all participants of the study.

6.1.3 Results

A large proportion of women were Australian born, lived in an urban area and found it easy to manage on their income (Table 6.1). At Survey Seven (aged 37-42 years: Interquartile range (IQR) 38.0-40.8), approximately one-fifth of women had no children and ~50% had one or two children; 58% had a high education; and almost half the sample had a healthy body mass index, while a similar percentage were overweight or obese. With increasing parity, a smaller proportion of women had a high-educated parent, while a larger proportion had a very low-educated parent (results not shown). All socioeconomic indicators were associated with age at birth of the first child.

Age at birth

The mean age at birth of the first child was 29.5 years (Standard Deviation (SD) 4.9; median 29.8; n=5,410), at second birth 31.6 years (SD 4.3; median 31.9; n=4,458) and at third birth 32.8 years (SD 4.0; median 33.3; n=1,754) (results not shown). Parity was inversely associated with age at the first and second birth (Figure 6.1). Women with one child gave birth at a similar mean age (33.0 years, median 34.6) as women with two children gave birth to their second child (32.8 years, median 33.2), and women with three or more children gave birth to their third child (32.8 years, median 33.3).

Disadvantaged women had increased odds of having their first child < 24 years of age (Table 6.2); this included 7 times the odds among women with a low education and almost 4 times the odds among women with an intermediate education; and approximately twice the odds among women living in rural or remote areas, and women who found it difficult to manage on their income (Table 6.2, Model 1). Additionally, women who did not know their parent’s education level had over four times the odds of a first birth < 24 years of age.

Table 6.1: Reproductive and demographic characteristics (at Survey One (baseline) and Survey Seven, unless specified) among ALSWH 1973-78 cohort who answered Surveys One and Seven (N=6,899). Proportions also stratified by age at first birth among parous women (n=5,410[a])

			Age at birth of first child (parous women)				
			< 24 years	24-29 years	30-34 years	≥ 35 years	P-value
			n=779 (14.4%)	n=1,969 (36.4%)	n=1,934 (35.8%)	n=728 (13.5%)	
	n	%	%	%	%	%	
Baseline characteristics							
Country of birth	6,853						0.047
Australia	6,374	93.0	14.5	36.7	35.5	13.3	
Other English speaking	479	7.0	13.2	30.9	39.6	16.3	
Parent's highest education[*]	5,763						<0.0001
Very low	1,342	23.3	17.3	40.8	31.9	10.0	
Low	711	12.3	13.3	36.2	37.5	13.0	
Intermediate	1,732	30.1	13.4	37.6	35.6	13.4	
High	1,555	27.0	7.6	33.7	41.4	17.2	
Don't know/not applicable	423	7.3	34.1	34.5	22.8	8.6	
Own education[**] (Survey Two)	6,274						<0.0001
Low	1,875	29.9	28.5	36.8	24.1	10.6	
Intermediate	1,516	24.2	16.7	41.3	31.8	10.2	
High	2,883	45.9	3.5	34.3	45.2	17.0	
Area of residence	6,893						<0.0001
Urban (major cities)	3,692	53.6	9.3	34.9	40.1	15.7	
Rural (inner regional)	2,036	29.5	18.3	37.0	33.2	11.5	
Remote (outer regional/ remote)	1,165	16.9	22.9	39.9	27.1	10.1	
SEIFA quintiles	6,875						<0.0001
0	1,175	17.1	26.2	36.2	26.4	11.2	
1	1,268	18.5	19.4	38.5	31.5	10.6	
2	1,354	19.7	14.0	40.2	33.8	12.0	
3	1,445	21.0	11.3	36.7	37.4	14.5	
4	1,631	23.7	4.6	31.2	46.3	17.9	
Ability to manage on income	6,879						<0.0001
Not too bad/easy	3,629	52.7	10.6	38.6	37.1	13.7	
Sometimes difficult	2,165	31.5	17.8	33.7	35.2	13.3	
Impossible/Always difficult	1,085	15.8	20.3	34.7	32.2	12.8	
Contraceptive use[***]	6,865						<0.0001[b]
Yes	4,936	71.9	12.9	39.1	35.1	12.8	
Not needed	1,833	26.7	15.1	29.7	39.3	15.9	
No	96	1.4	70.8	14.6	10.1	4.5	

Characteristics at Survey Seven							
Age Mean 39.4, Median 39.1, IQR (38.0-40.8)							
Number of children	6,899						<0.0001
0	1,489	21.6	-	-			
1	952	13.8	8.5	16.7	28.7	46.1	
2	2,704	39.2	9.8	36.7	43.8	9.7	
3+	1,754	25.4	24.7	46.6	27.2	1.4	
Breastfed first child	5,410						<0.0001
No	705	13.0	21.0	29.9	25.1	24.0	
< 6 months	1,382	25.6	20.4	38.0	30.4	11.2	
≥ 6 months	3,323	61.4	10.5	37.1	40.2	12.2	
Fertility	6,897						<0.0001
Never tried	1,081	15.7	-	-	-	-	
No - Did not have an issue	4,284	62.1	16.2	38.8	34.4	10.6	
Yes – Self/partner unsuccessful ≥ 12 months	1,532	22.2	8.4	28.3	40.2	23.1	
Contraceptive use[***]	6,616						<0.0001
Yes	3,272	49.5	11.4	33.8	42.0	12.8	
Not needed	2,164	32.7	17.7	45.2	28.0	9.1	
No	1,180	17.8	15.4	23.1	32.6	28.9	
Highest education[**]	6,871						<0.0001
Low	861	12.5	31.2	39.6	21.2	8.0	
Intermediate	2,010	29.3	21.7	41.0	27.8	9.5	
High	4,000	58.2	6.4	33.1	43.5	17.0	
Living arrangement	6,550						<0.0001[b]
Partner/Children	5,832	89.0	13.9	36.7	35.7	13.7	
Other (parents/relatives, non-family, alone)	718	11.0	65.9	14.6	7.3	12.2	
Marital status	6,548						<0.0001
Married/de facto	5,223	79.8	12.3	36.9	36.8	14.0	
Separated/Widowed/Divorced	541	8.3	27.5	39.6	27.5	5.4	
Never married	784	11.9	33.1	19.4	19.4	28.1	
Weight status[****]	6,282						<0.0001
Underweight	156	2.5	13.3	29.2	41.7	15.8	
Healthy weight	3,128	49.8	8.1	36.7	39.8	15.4	
Overweight	1,616	25.7	15.9	35.2	35.3	13.6	
Obese	1,382	22.0	22.2	36.8	31.0	10.0	

[a] *sample sizes vary slightly due to missing information for some variables*

[b] *Fisher's exact test*

[*] *Parent's highest education (measured at Survey Two) categorised as very low (≤ 10 years); low (≤ 12 years); intermediate (trade/certificate/diploma); high (degree/higher); and don't know/not applicable*

*** Own education categorised as low (≤ 12 years); intermediate (trade/apprentice/certificate/diploma); and high (degree/higher)*
**** Contraceptive use – not needed (pregnant, tubal ligation, vasectomy, can't have children)*
***** Weight status is based on the WHO's BMI categories; 'healthy weight' refers to the WHO category of 'normal weight'*
IQR – Interquartile Range: SEIFA – Socioeconomic Indexes for Areas

Conversely, disadvantaged women were also less likely to have their first birth at ≥ 35 years of age (Table 6.2), including women who did not know their parent's education.

Birth interval and BTP interval

Overall, the mean birth interval between the first and second child was 33.5 months (SD 22.4; median 28.0, n=4,458), and between the second and third child 37.8 months (SD 25.8; median 31.1; n=1,754) (results not shown). The interval between the first and second birth was slightly shorter among women with three or more children (31.2 months, median 25.6), compared to women with 2 children (34.8 months, median 30.0) (Figure 6.1).

Based on the most recent survey (aged 37-42 years), the mean (median) birth interval between the first and second child was 47.2 months (34.0) among women who had their first child before age 24 years, 33.0 months (28.1) among women with a first birth between 24-29 years, 29.4 months (27.0) among women with a first birth between 30-34.99 years, and 24.8 months (25.0) among women with a first birth at age 35 years or older (results not shown).

Overall, 30% of parous women had a BTP interval between the first and second child that approximated the WHO recommendation (18-27 months), while 43% of women had a BTP interval of < 18 months and 6% had a BTP interval of > 59 months. Some evidence of social patterning in BTP interval between the first and second child was found, particularly for having a BTP of greater than 59 months; approximately two and a half times the odds among women with less than a university education; and approximately three times the odds among women who found it always difficult to manage on their income, and among women who did not know their parent's education level (Table 6.3, Model 1). After full adjustment, this significant association only remained among women who found it difficult to manage on their income (Table 6.3, Model 2).

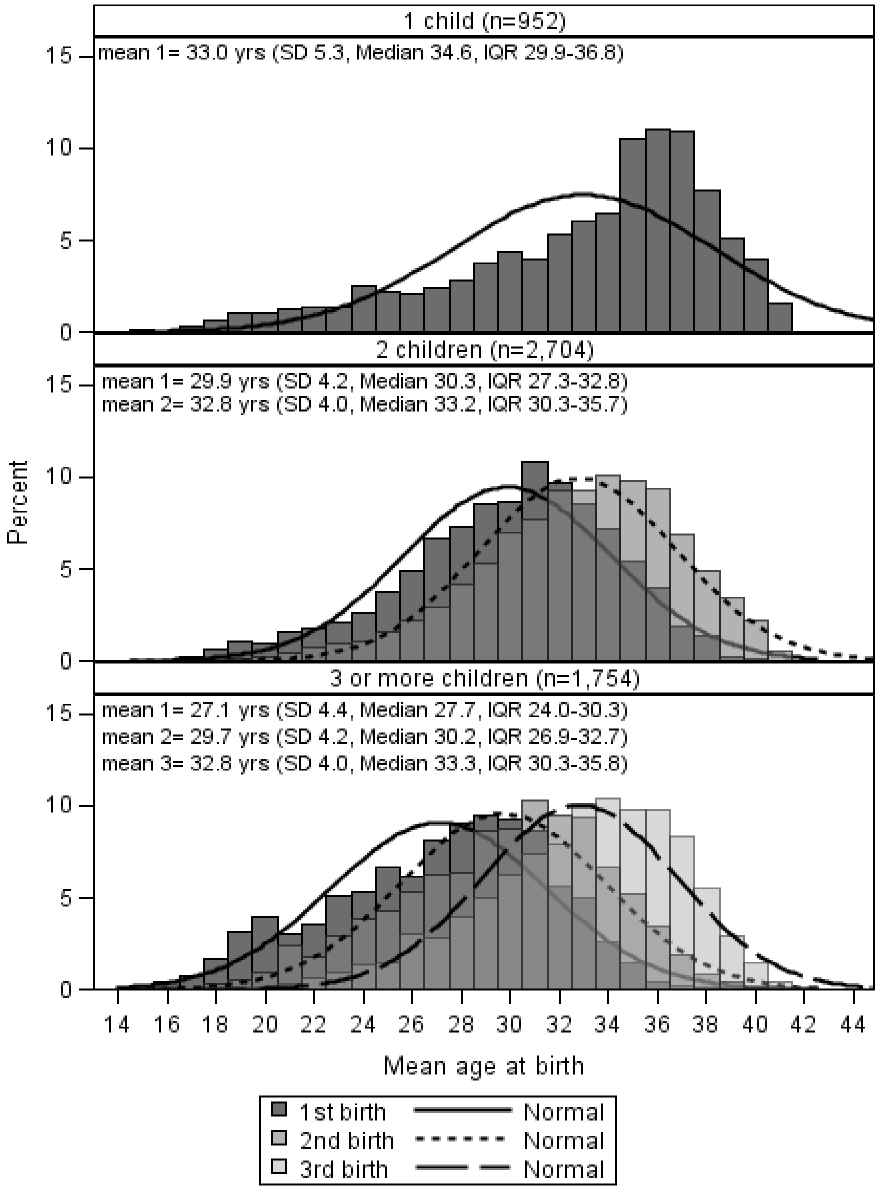


Figure 6.1: Mean age at each birth (in years, including normal distribution) among parous ALSWH women (N=5,410), stratified by parity at Survey Seven (2015; aged 37-42 years)

The standard deviation (SD), median and interquartile range (IQR) is shown in parentheses after the mean age at each birth. The overall mean age at the first birth was 29.5 years (n=5,410), at the second birth 31.6 years (n=4,458) and at the third birth 32.8 years (n=1,754). The overall mean age at the first birth was 29.5 years (n=5,410), at the second birth 31.6 years (n=4,458) and at the third birth 32.8 years (n=1,754).

Table 6.2: Association of indicators of socioeconomic position with age at birth of the first child among parous ALSWH women, born 1973-78 (n=5,410). Odds ratios from multinomial logistic regression (with 95% C.I.)

		Age at birth of the first child							
		Model 1[a]				Model 2[b]			
		< 24 years	24-29 years	30-34 years	≥ 35 years	< 24 years	24-29 years	30-34 years	≥ 35 years
Complete cases N=4,422	%	n= 627 (14%)	n=1,631 (37%)	n=1,577 (36%)	n= 587 (13%)	n= 627 (14%)	n=1,631 (37%)	n=1,577 (36%)	n= 587 (13%)
Parent's highest education[*]									
High	26.3	1.00	1.00	1.00	1.00				
Intermediate	23.5	**1.5 (1.1, 2.0)**	1.00	**0.8 (0.6, 0.9)**	**0.7 (0.5, 0.9)**				
Low	12.4	**1.6 (1.1, 2.3)**	1.00	0.8 (0.7, 1.1)	**0.7 (0.5, 0.9)**				
Very low	30.6	**1.8 (1.4, 2.5)**	1.00	**0.6 (0.5, 0.8)**	**0.5 (0.4, 0.6)**				
Don't know/not applicable	26.3	**4.5 (3.2, 6.4)**	1.00	**0.6 (0.4, 0.8)**	**0.5 (0.3, 0.8)**				
Own education[**]									
High	46.6	1.00	1.00	1.00	1.00				
Intermediate	23.9	**3.8 (2.8, 5.1)**	1.00	**0.6 (0.5, 0.7)**	**0.6 (0.4, 0.7)**				
Low	29.4	**7.0 (5.3, 9.3)**	1.00	**0.5 (0.4, 0.6)**	**0.7 (0.6, 0.9)**				
Area of residence									
Urban	52.2	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Rural	30.2	**1.8 (1.5, 2.2)**	1.00	**0.8 (0.7, 0.9)**	**0.7 (0.6, 0.9)**	**1.6 (1.3, 2.0)**	1.00	**0.8 (0.7, 0.9)**	**0.7 (0.6, 0.9)**
Remote	17.6	**2.1 (1.7, 2.7)**	1.00	**0.6 (0.5, 0.8)**	**0.6 (0.4, 0.8)**	**1.9 (1.5, 2.4)**	1.00	**0.7 (0.5, 0.8)**	**0.6 (0.5, 0.8)**
Ability to manage on income									
Not too bad/easy	53.1	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Sometimes difficult	31.9	**1.8 (1.5, 2.2)**	1.00	1.1 (0.9, 1.3)	1.1 (0.9, 1.4)	**1.7 (1.4, 2.1)**	1.00	1.1 (0.9, 1.3)	1.2 (0.9, 1.4)
Impossible/always difficult	15.0	**2.0 (1.6, 2.7)**	1.00	1.0 (0.8, 1.2)	1.1 (0.8, 1.5)	**1.9 (1.5, 2.5)**	1.00	1.0 (0.8, 1.2)	1.1 (0.9, 1.5)
SEIFA[***] *ed/occ quintiles*		**0.8 (0.7, 0.8)**	1.00	**1.2 (1.1, 1.2)**	**1.2 (1.1, 1.3)**	**0.8 (0.7, 0.9)**	1.00	**1.1 (1.1, 1.2)**	**1.1 (1.1, 1.2)**

[a]Model 1= adjusted for age at baseline and parent's education (except for [*]). Note that these estimates were very similar when adjusted only for age at baseline.

[b]Model 2= Model 1 + adjusted for variables included in parentheses after each of the following SEP exposures: area of residence (own education, manage on income at baseline); ability to manage on income at baseline (own education); SEIFA (own education).

[*] Parent's highest education categorised as very low (≤ 10 years); low (≤ 12 years); intermediate (trade/certificate/diploma); high (degree/higher); and don't know/not applicable

** *Own education categorised as low (≤ 12 years); intermediate (trade/apprentice/certificate/diploma); and high (degree/higher)*

*** *SEIFA: Socioeconomic Indexes for Areas score (higher scores indicating greater advantage)*[192]

Example of reading a result from the table: Compared to having a first birth between the ages 24-29 years (reference), women with an intermediate (OR 3.8: 95% C.I. 2.8, 5.1) or low education (OR 7.0: 5.3, 9.3) had increased odds of having their first birth before the age of 24 years, compared to women with a high education (reference) (Model 1)

Table 6.3: Association of indicators of position with the birth-to-pregnancy interval between the first and second child, among multiparous ALSWH women born 1973-78 (n=4,458). Odds ratios from multinomial logistic regression (with 95% C.I.)

		Birth-to-pregnancy interval[a] between the first and second child (months)							
		Model 1[b]				Model 2[c]			
Complete cases N=3,681	%	< 18 n=1,672 (45%)	18 – 27 n=1,077 (29%)	28 - 59 n=724 (20%)	> 59 n=208 (6%)	< 18 n=1,672 (45%)	18 – 27 n=1,077 (29%)	28 - 59 n=724 (20%)	> 59 n=208 (6%)
Parent's highest education[*]									
High	25.9	1.00	1.00	1.00	1.00				
Intermediate	30.9	1.2 (1.0,1.5)	1.00	1.1 (0.9,1.4)	1.1 (0.7,1.6)				
Low	12.4	1.2 (0.9,1.6)	1.00	0.9 (0.6,1.2)	1.2 (0.7,2.0)				
Very low	23.8	1.0 (0.8,1.2)	1.00	1.0 (0.8,1.3)	1.4 (0.9,2.2)				
Don't know/not applicable	7.0	1.1 (0.8,1.6)	1.00	**1.8 (1.2,2.7)**	**3.1 (1.8,5.3)**				
Own education[**]									
High	47.2	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Intermediate	23.7	0.9 (0.8,1.1)	1.00	**1.6 (1.3,2.0)**	**2.6 (1.8,3.9)**	0.9 (0.8,1.1)	1.00	**1.5 (1.2,1.9)**	1.5 (1.0,2.3)
Low	29.0	1.1 (0.9,1.3)	1.00	**1.4 (1.1,1.8)**	**2.6 (1.8,3.9)**	1.1 (0.9,1.3)	1.00	1.2 (0.9,1.5)	1.0 (0.6,1.5)
Ability to manage on income									
Not too bad/easy	53.9	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Sometimes difficult	31.4	0.9 (0.8,1.1)	1.00	0.9 (0.8,1.2)	**1.6 (1.1,2.3)**	0.9 (0.8,1.1)	1.00	0.9 (0.7,1.1)	1.3 (0.9,1.8)
Impossible/always difficult	14.7	1.1 (0.9,1.4)	1.00	**1.2 (0.9,1.6)**	**3.0 (2.0,4.4)**	1.1 (0.9,1.4)	1.00	1.2 (0.9,1.6)	**2.3 (1.5,3.5)**
SEIFA[***] *ed/occ quintiles*		1.0 (0.9,1.1)	1.00	1.0 (0.9,1.0)	0.9 (0.8,1.0)	1.0 (0.9,1.1)	1.00	1.0 (0.9,1.1)	1.1 (1.0,1.3)

[a] Birth-to-pregnancy intervals based on the WHO consultation on birth spacing[114]

[b] Model 1= adjusted for age at baseline and parent's education. Note that these estimates were very similar when adjusted only for age at baseline.

[c] Model 2= Model1 + adjusted for variables included in parentheses after each of the following SEP exposures: own education (age at first birth); ability to manage on income (age at first birth, own education); SEIFA (age at first birth, own education)

[*] Parent's highest education categorised as very low (≤ 10 years); low (≤ 12 years); intermediate (trade/certificate/diploma); high (degree/higher); and don't know/not applicable

[**] Own education categorised as low (≤ 12 years); intermediate (trade/apprentice/certificate/diploma); and high (degree/higher)

[***] SEIFA: Socioeconomic Indexes for Areas score (higher scores indicating greater advantage)[192]

Example of reading a result from the table: Compared to having a BTP interval of 18-27 months (reference) between the first and second child, women with an intermediate or low education (OR 2.6: 95% C.I. 1.8, 3.9) had increased odds of having a BTP interval greater than 59 months, compared to high educated women (reference) (Model 1)

Total number of children

There was not a strong association between the different measures of SEP and total number of children. Compared to women with a high education, those with a low education had slightly increased odds of having 3 or more children (OR 1.3: 1.1, 1.5), than 2 children. Women living in a remote area also had increased odds of having 3 children (OR 1.3: 1.1, 1.6) (Additional information, Table 6.5).

6.1.4 Discussion

This study describes reproductive characteristics (age at birth of the first child, the birth interval and BTP interval between the first and second child, and total number of children), and the association of SEP with these characteristics among a cohort of Australian women of childbearing age. Overall, an inverse association was found between parity and age at birth of the first child; women with one child gave birth to this child at around the same mean age (33.0 years) that women with two children gave birth to their second child, and women with three or more children gave birth to their third child. Additionally, disadvantaged women had increased odds of having a first birth < 24 years of age, and of having a longer than recommended BTP interval.

There was a strong inverse association between both education (at age 22-27 years) and parent's education level with having a first birth < 24 years of age. Additionally, women who did not know their parent's education level were most likely to have a first birth < 24 years of age. Given that SEP is negatively associated with parity,[229,230] and early maternal age and increasing parity are associated with increased chronic disease risk [213], it is important that already disadvantaged groups are not further burdened by potential increased disease risks associated with early reproduction.

There was some evidence of socioeconomic differences in BTP interval between the first and second child. An inverse association was found between own education and having a longer than recommended BTP interval, although this was not significant after adjustment for factors including age at first birth. Women who did not know their parent's education level were also more likely to have a longer than recommended BTP interval. This result was similar in additional analyses investigating the BTP interval between the second and third child (available upon request). While the BTP interval can be influenced by a number of factors, including miscarriages and still births, the reliability of this specific data for our sample limited our ability to analyse this further; the complex relationship between maternal age and maternal obesity may also contribute to the outcome of a longer BTP interval. Among the multiparous women in our sample, a larger proportion of the following groups of women had a longer than recommended BTP interval: women with fertility issues, who did not use contraception, with ≤ 12 years of education at age 36-42 years, who had never married, and women with an underweight or obese weight status (Additional information, Table 6.6).

We did not find a significant association between any of the SEP measures and having a BTP interval < 18 months; this may be due to both low SEP[111,225] and higher maternal age[225] both being associated with shorter BTP intervals. Finding ways to assist women to allow adequate spacing between pregnancies remains important, however, given that almost half of multiparous women had a shorter than recommended BTP interval between the first and second child. Assistance may include improving services for and access to postnatal support, as well as free family planning clinics and contraception, and improved access to abortion. Macro factors, such as government policies targeted towards families, may also be influential through buffering financial costs associated with paid workforce absence;[236] this includes increasing the availability and decreasing the costs of child care.

Sub-fertility may explain nulliparity and/or primiparity, as well as older maternal age at first birth and a longer than recommended BTP interval. Despite the potential data limitation of incomplete fertility (women in this sample were aged 37-42 years, IQR 38.0-40.8), ~80% of the sample had at least one child. The Australian total fertility rate was 1.88 in 2013,[234] and given a 2006 estimation that 27% of women aged 30-39 years and 15% of women aged 40-44 years will remain without children,[237] we approximate that over 90% of these ALSWH women have already had their first child. While it is possible that some nulliparous women will go on to have children, and some women with one child will go on to have several, the mean age at birth of first child (29.5 years) among these ALSWH women was only marginally higher than the 2012 Australian mean of 28.4 years.[234] Sensitivity analyses using Survey Six data also showed similar estimates (available upon request), therefore the social patterns presented in this paper are not expected to change with the inclusion of additional surveys.

What is expected is a slight increase in the mean age at first and second birth, and the proportion of multiparous women having a shorter than recommended BTP interval.[222] Increasing maternal age is associated with greater maternal and neonatal risks[216] and short birth intervals[223] (which is associated with later obesity[110]), and has potential consequences for women's and children's health in the short/long term. These trends could mean an increasing number of women presenting with a high-risk pregnancy, and hence increased demand for antenatal and postnatal health care services. As such, it is important to consider possible ways in which government policies may influence the timing of reproduction;[236] in the example of Sweden, given a BTP interval of < 30 months, parental leave payments remain based upon the woman's salary before having children.[236] This has resulted in reducing the average birth interval, regardless of SEP,[236] and is an example of how initiatives may influence birth intervals and minimise financial disadvantages associated with having children.

Teenage pregnancies are of clinical significance, however the sample size limited our ability to run such analyses (225 women had their first child < 20 years of age). Evidence guiding the WHO BTP recommendation of 24 months[114] has also been questioned in a recent analysis, comparing birth outcomes using a matched versus traditionally unmatched design. Ball et al[238] found a weaker than typically reported effect of short intervals on odds of preterm birth and low birth weight, and no effect of longer intervals on the risk of preterm.[238] In both designs, a long interval was associated with increased risk of small for gestational age and low birth weight.[238] We are unaware of any studies validating the WHO BTP interval recommendations.

We included women who answered the most recent survey, in order to not underestimate reproductive events. In comparison to women included in the study, disadvantaged women were more likely to be excluded; including those who did not know their parent's education or had a parent with a very low education; who had a low education themselves; and women who found it always difficult/impossible to manage on their income (Additional information,

Table 6.4). Given this, it is possible that social differences in reproductive events are even greater than reported.

Conclusion

This study shows an inverse association between parity and age at birth of the first and second child. Women with one child gave birth at the same mean age as women with two and three or more children gave birth to their second and third child, respectively. Already disadvantaged women (low or intermediate education; who did not know their parent's education; living in rural or remote areas) had increased odds of having a first birth < 24 years of age, and tended to have a much longer than recommended BTP interval between their first two children. Many complex factors influence women's reproductive patterns, including the formation and dissolution of relationships. Despite such factors often being beyond a woman's control, greater support is required to assist all women in managing reproductive events and to allow an adequate spacing between pregnancies. The social patterning of age at first birth and BTP intervals suggests that additional support may be required for disadvantaged women, who are already at increased disease risk.

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6.1.5 Additional Information

Table 6.4: Baseline characteristics among ALSWH women from the 1973-78 cohort who were included/excluded from the sample (N=14,247[†])

	Included		Excluded		p-value [‡]
Baseline characteristics					
Mean (SD)					
Weight (kg)	62.6	(12.2)	62.5	(13.2)	0.761
Height (cm)	165.8	(7.1)	165.3	(7.7)	0.0002
Total (Percentage)					
Country of birth					<0.0001
Australia	6,374	(93.0)	6,552	(90.0)	
Other English speaking	479	(7.0)	727	(10.0)	
Area of residence					<0.0001
Urban (major cities)	3,692	(53.6)	3,683	(50.2)	
Rural (inner regional)	2,036	(29.5)	2,271	(30.9)	
Remote (outer regional/ remote)	1,165	(16.9)	1,390	(18.9)	
Parent's highest education[*]					<0.0001
Very low	1,342	(23.3)	1,020	(27.6)	
Low	711	(12.3)	463	(12.5)	
Intermediate	1,732	(30.1)	973	(26.4)	
High	1,555	(27.0)	687	(18.6)	
Don't know/not applicable	423	(7.3)	548	(14.9)	
Own education[**]					<0.0001
Low	4,738	(68.9)	5,391	(76.8)	
Intermediate	1,108	(16.1)	1,384	(18.9)	
High	1,031	(15.0)	534	(7.3)	
Ability to manage on income					<0.0001
Not too bad/easy	3,629	(52.8)	3,236	(44.2)	
Sometimes difficult	2,165	(31.5)	2,541	(34.7)	
Impossible/Always difficult	1,085	(15.7)	1,539	(21.1)	
Living arrangement					<0.0001
Partner/Children	1,655	(24.4)	2,358	(32.8)	
Other (parents/relatives, non-family, alone)	5,135	(75.6)	4,838	(67.2)	
Marital status					<0.0001
Married/de facto	1,338	(19.5)	1,855	(25.4)	

Separated/Widowed/Divorced	37	(0.5)	97	(1.3)	
Never married	5,499	(80.0)	5,351	(73.3)	
Contraceptive use* **					<0.0001
Yes	4,936	(71.9)	5,171	(71.3)	
Not needed	1,833	(26.7)	1,853	(25.5)	
No	96	(1.4)	230	(3.2)	
Weight status ****					<0.0001
Underweight	570	(9.0)	664	(10.9)	
Healthy weight	4,401	(69.9)	4,034	(66.0)	
Overweight	950	(15.1)	984	(16.1)	
Obese	380	(6.0)	432	(7.1)	

† sample sizes change slightly due to missing values for some variables

‡ p-values from independent t-tests for continuous variables and from Pearson chi-square tests for categorical variables

** Parent's highest education categorised as very low (≤ 10 years); low (≤ 12 years); intermediate (trade/certificate/diploma); high (degree/higher); and don't know/not applicable*

*** Own education categorised as low (≤ 12 years); intermediate (trade/apprentice/certificate/diploma); and high (degree/higher)*

**** Contraceptive use – not needed (pregnant, tubal ligation, vasectomy, can't have children)*

***** Weight status is based on the WHO's BMI categories; 'healthy weight' refers to the WHO category of 'normal weight'*

SD – Standard Deviation

Table 6.5: Association of indicators of socioeconomic position with total number of children among ALSWH women, born 1973-78 (n=6,899). Odds ratios from multinomial logistic regression (with 95% C.I.)

		Total number of children							
		Model 1[a]				**Model 2[b]**			
		0	1	2	3+	0	1	2	3+
Complete cases N=5,645	%	n= 1,218 (21.7%)	n=743 (13.2%)	n=2,206 (39.3%)	n=1,454 (25.9%)	n= 1,218 (21.7%)	n=743 (13.2%)	n=2,206 (39.3%)	n=1,454 (25.9%)
*Parent's highest education**									
High	27.2	1.00	1.00	1.00	1.00				
Intermediate	30.0	**0.8 (0.6, 0.9)**	0.9 (0.7, 1.1)	1.00	1.0 (0.8, 1.1)				
Low	12.4	0.9 (0.7, 1.1)	0.9 (0.7, 1.2)	1.00	1.0 (0.8, 1.3)				
Very low	23.2	0.8 (0.7, 1.0)	0.9 (0.7, 1.1)	1.00	1.1 (0.9, 1.3)				
Don't know/not applicable	7.2	1.1 (0.8, 1.4)	1.1 (0.8, 1.5)	1.00	1.2 (0.9, 1.6)				
*Own education***									
High	47.6	1.00	1.00	1.00	1.00				
Intermediate	23.9	0.9 (0.8, 1.1)	1.1 (0.9, 1.4)	1.00	1.0 (0.8, 1.2)				
Low	28.6	0.9 (0.7, 1.1)	1.3 (1.0, 1.5)	1.00	**1.3 (1.1, 1.5)**				
Area of residence									
Urban	53.2	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Rural	29.9	0.9 (0.8, 1.0)	**0.8 (0.7, 0.9)**	1.00	1.1 (0.9, 1.3)	0.9 (0.8, 1.1)	**0.8 (0.6, 0.9)**	1.00	1.1 (0.9, 1.3)
Remote	16.9	0.8 (0.7, 1.0)	0.9 (0.7, 1.1)	1.00	**1.3 (1.1, 1.6)**	0.9 (0.7, 1.1)	0.8 (0.7, 1.1)	1.00	**1.3 (1.1, 1.6)**
Ability to manage on income									
Not too bad/easy	53.4	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Sometimes difficult	31.2	0.9 (0.8, 1.1)	1.2 (1.0, 1.4)	1.00	1.0 (0.9, 1.2)	0.9 (0.8, 1.1)	1.2 (1.0, 1.5)	1.00	1.0 (0.8, 1.1)
Impossible/always difficult	15.4	1.1 (0.9, 1.3)	1.1 (0.9, 1.4)	1.00	0.8 (0.7, 1.0)	1.1 (0.9, 1.4)	1.1 (0.9, 1.4)	1.00	0.8 (0.7, 1.0)
*SEIFA*** ed/occ quintiles*		1.1 (1.0, 1.1)	1.1 (1.0, 1.2)	1.00	1.0 (0.9, 1.0)	1.0 (1.0, 1.1)	1.1 (1.0, 1.2)	1.00	1.0 (0.9, 1.1)

[a]Model 1= adjusted for age at baseline and parent's education (except for [*]). Note that these estimates were very similar when adjusted only for age at baseline.

[b]Model 2= Model 1 + adjusted for variables included in parentheses after each of the following SEP exposures: area of residence (own education, manage on income at baseline); ability to manage on income at baseline (age at first birth, own education); SEIFA (own education).

[*] Parent's highest education categorised as very low (≤ 10 years); low (≤ 12 years); intermediate (trade/certificate/diploma); high (degree/higher); and don't know/not applicable

[**] Own education categorised as low (≤ 12 years); intermediate (trade/apprentice/certificate/diploma); and high (degree/higher)

[***] SEIFA: Socioeconomic Indexes for Areas score for education and occupation (higher scores indicating greater advantage)[192]

Table 6.6: Reproductive and demographic characteristics (at Survey One (baseline) and Survey Seven, unless specified) among multiparous ALSWH 1973-78 cohort who answered Surveys One and Seven. Proportions also stratified by the birth-to-pregnancy interval between the first and second child (n=4,458[a])

			Birth-to-pregnancy interval[b] between the first and second child (months)				
			< 18 n=2,001 (45%)	18 – 27 n=1,291 (29%)	28 - 59 n=901 (20%)	> 59 n=265 (6%)	**P-value**
	n	**%**	**%**	**%**	**%**	**%**	
<u>**Baseline characteristics**</u>							
Country of birth	4,429						0.044
Australia	4,117	93.0	45.0	28.9	20.3	5.8	
Other English speaking	312	7.0	43.9	29.2	18.9	8.0	
Parent's highest education[*]	3,748						<0.0001
Very low	902	24.1	42.5	31.0	19.8	6.7	
Low	460	12.3	49.3	28.9	16.1	5.7	
Intermediate	1,157	30.9	48.3	27.6	19.6	4.5	
High	961	25.6	44.1	31.4	19.7	4.8	
Don't know/not applicable	268	7.1	38.1	23.9	27.2	10.8	
Own education[**] (Survey Two)	4.074						<0.0001
Low	1,235	30.3	43.3	26.6	21.8	8.3	
Intermediate	975	23.9	39.6	28.4	24.0	8.0	
High	1,864	45.8	48.8	30.9	17.0	3.3	
Area of residence	4,454						0.703
Urban (major cities)	2,287	51.4	44.4	29.8	20.2	5.6	
Rural (inner regional)	1,365	30.7	45.1	28.5	20.3	6.1	
Remote (outer regional/ remote)	802	18.0	46.0	27.1	20.1	6.8	
SEIFA quintiles	4,443						0.014
0	803	18.1	43.6	26.1	23.2	7.1	
1	838	18.8	43.5	28.6	21.1	6.8	
2	880	19.8	45.0	29.0	18.7	7.3	
3	932	21.0	45.0	30.2	19.6	5.2	
4	990	22.3	47.3	30.1	18.9	3.7	
Ability to manage on income	4,449						<0.0001
Not too bad/easy	2,362	53.1	46.5	29.3	20.0	4.2	
Sometimes difficult	1,420	31.9	42.9	29.8	20.3	7.0	
Impossible/Always difficult	667	15.0	43.3	26.2	20.7	9.8	
Contraceptive use[***]							0.0025

Yes	3,340	75.2	43.2	29.8	21.0	6.0	
Not needed	1,024	23.1	50.0	27.3	17.4	5.3	
No	77	1.7	46.7	20.8	22.1	10.4	
<u>**Characteristics at Survey Seven**</u>							
Age Mean 39.5, Median 39.5, IQR (39.0-41.0)							
Number of children	4,458						<0.0001
2	2,704	60.7	39.2	30.8	23.8	6.2	
3+	1,754	39.3	53.7	26.1	14.7	5.5	
Breastfed first child	4,458						<0.0001
No	450	10.1	42.7	26.7	21.7	8.9	
< 6 months	1,136	25.5	42.2	25.6	23.9	8.3	
≥ 6 months	2,872	64.4	46.3	30.6	18.5	4.6	
Fertility	4,458						<0.0001
No - Did not have an issue	3,554	79.7	45.8	29.9	18.9	5.4	
Yes – Self/partner unsuccessful ≥ 12 months	904	20.3	41.5	25.2	25.2	8.1	
Contraceptive use[***]	4,310						0.0003
Yes	2,212	51.3	43.5	29.1	22.0	5.4	
Not needed	1,657	38.5	47.6	29.1	17.6	5.7	
No	441	10.2	40.6	27.4	22.7	9.3	
Highest education[**]	4,446						<0.0001
Low	662	14.0	41.3	24.3	24.4	10.0	
Intermediate	1,327	29.8	40.6	28.6	22.8	8.0	
High	2,497	56.2	48.1	30.3	17.8	3.8	
Living arrangement	4,258						0.453[b]
Partner/Children	4,244	99.7	44.8	29.1	20.2	5.9	
Other (parents/relatives, non-family, alone)	14	0.3	42.9	21.4	21.4	14.3	
Marital status	4,255						<0.0001[b]
Married/de facto	3,863	90.8	45.4	29.4	19.9	5.3	
Separated/Widowed/Divorced	338	7.9	40.5	26.6	23.7	9.2	
Never married	54	1.3	24.1	20.3	25.9	29.6	
Weight status[****]	4,075						<0.0001
Underweight	95	2.3	45.3	27.4	18.9	8.4	
Healthy weight	2,107	51.7	46.5	30.1	19.1	4.3	
Overweight	1,067	26.2	43.5	31.4	19.7	5.4	
Obese	806	19.8	42.8	26.7	22.6	7.9	

[a] *sample sizes vary slightly due to missing information for some variables*

[b] *Birth-to-pregnancy intervals based on the WHO consultation on birth spacing*[114]

[c] *Fisher's exact test*

[*] *Parent's highest education (measured at Survey Two) categorised as very low (≤ 10 years); low (≤ 12 years); intermediate (trade/certificate/diploma); high (degree/higher); and don't know/not applicable*

[**] *Own education categorised as low (≤ 12 years); intermediate (trade/apprentice/certificate/diploma); and high (degree/higher)*

[***] *Contraceptive use – not needed (pregnant, tubal ligation, vasectomy, can't have children)*

[****] *Weight status is based on the WHO's BMI categories; 'healthy weight' refers to the WHO category of 'normal weight'*

IQR – Interquartile Range: SEIFA – Socioeconomic Indexes for Areas

6.2 Conclusion

This study found that among a sample of contemporary Australian women of childbearing age, SEP was associated with age at birth of the first child. Disadvantaged women (with a low education themselves, or with a parent with a low education) were more likely to have a first birth before 24 years of age. We also found limited evidence of social patterning of the birth interval between children. This relationship appeared to be inverse, with women who had a higher education having reduced odds of a longer than recommended BTP interval; this is not unexpected, given that women with a higher education tended to start having their children at an older age.

There are many complex factors influencing women's reproductive patterns, including the formation and dissolving of relationships. Despite such factors often being beyond a woman's control, understanding the health and social risks associated with an early or later age at first birth and pregnancy spacing will empower women with knowledge to make well informed family planning decisions. The social patterning of age at first birth and birth intervals suggests particular support is required for disadvantaged women, who are already at increased disease risk; this includes women with a low education, who have a parent with a very low education, as well as those living in rural and remote areas.

As outlined, factors on a macro level (including government policies surrounding the provision of childcare and parental leave entitlements) can also influence decisions regarding the timing of reproduction. Adequate government financial support for parents means that individuals can be absent from the paid workforce to care for their child during their first year of life, without the expectation of privately funding this opportunity; this would otherwise only be available to those with increased financial resources to do so, including those from privileged backgrounds or who are older and have had greater opportunity to accumulate wealth. Within Sweden, uptake of government financial incentives that encourage a shorter birth interval between children has been similar across all SEP groups,[236] therefore it is speculated that social differences in birth spacing may be less pronounced in such contexts. Given that child birth intervals can influence women's opportunity to return to their pre-pregnancy weight, we may also then speculate that social differences in weight change between pregnancies may also be narrower in countries where the universal provision of family entitlements is prioritised.

Chapter 7. Social inequalities in pre-pregnancy body mass index and gestational weight gain

While the timing of reproduction has been associated to varying degrees with body weight in later life, more proximal factors associated with each pregnancy are shown to be well associated with long term body weight in women. This is outlined in the literature review (**Chapter 2**), and includes both pre-pregnancy body mass index and GWG.

There is a well-established inverse association between SEP and pre-pregnancy BMI, however an understanding of the social patterning of BMI change between pregnancies and GWG in subsequent pregnancies is needed. This is an important area of research, since we know that what happens before, during, and after gestation can have long term effects for both the mother and her offspring, with increasing evidence suggesting an intergenerational transfer of obesity through the early developmental period.[239,240]

Both pre-pregnancy obesity and paternal obesity, independent of maternal obesity, have been associated with DNA methylation and epigenetic changes in imprinted genes of the offspring.[241] Methylation changes at the imprinted gene level have also been associated with other adverse outcomes, such as certain types of cancer.[242] Despite this, there is also evidence that the epigenome is modified by changes in exposure, be they in utero or throughout the life course.[180] So while preventing negative health outcomes is of priority, we are reminded of the benefit of positive lifestyle changes at any stage of the life course.

Pre-pregnancy BMI and GWG are two reproductive characteristics that are important for understanding weight increases in relation to reproduction, however both are seldom available. While this data are collected in the Swedish Medical Birth Register and has been used in a number of studies, it should also be noted that there is a large amount of missing data for GWG (which can be calculated using data on two of the following: pre-pregnancy weight, weight gain, and weight at delivery). A report by Socialstyrelsen[243] (the Swedish National Board of Health and Welfare) shows that in 1990 and 1991, no weight data were collected, with a further restriction of no weight gain data being collected in 1992 and 1993. While a previous Swedish study[48] reports being unable to find any clear patterns (by region or over time) for missing data on BMI, another study[74] using data from the Swedish Medical Birth Register (1994-2002) were able to calculate GWG for 37.7% of the full population; with GWG available for 37.2% of underweight and 40.4% of obese women. Given this, and that the data is collected for clinical purposes, it may be that high risk pregnancies are over-represented in the available data. An in-depth analysis of patterns of missing GWG data is an important area for further research, as is confirmation of these results in other data sets.

Some sensitivity analyses were performed for this study, including a comparison of the women included and excluded from the study; the overall mean GWG in the first pregnancy was 14.4 kg (std dev 4.8) and in the second pregnancy 13.4 kg (std dev 4.6). In comparison with other Nordic cohorts, the mean GWG in our cohort seems reasonable, with the mean GWG in the Danish 'Smoke free Newborn Study'[244] being 13.9 kg (std dev 4.9). Other studies stratify mean GWG by parity and report a slightly higher GWG among primiparous compared to multiparous women: in the Danish National Birth Cohort,[245] the mean GWG was 15.7 kg (std dev 5.9) among primiarous women and 14.6 kg (std dev 5.7) among multiparous women; and in the Norwegian Mother and Child Cohort Study (MoBA)[246] the mean GWG 15.5 kg (std dev 6.1) among primiparous women and 14.7 kg (std dev 5.9) among multiparous women.

Chapter 7.1 includes results from *Study 3*, which investigates the social patterning of these two reproductive characteristics in the Swedish population. In order to adapt to the format of this thesis, only the numbering of tables and figures have been modified from the original published version. This manuscript has been formatted according to the journal's requirements.

7.1 Social inequalities in body mass index and gestational weight gain in the first and second pregnancy among Swedish women (*Study 3*)

- **Holowko N,** Chaparro MP, Nilsson K, Ivarsson A, Mishra G, Koupil I, Goodman A. Social inequalities in body mass index and gestational weight gain in the first and second pregnancy among Swedish women. *Journal of Epidemiology and Community Health*. 2015; 69(12):1154-61.

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Abstract

Background: High pre-pregnancy body mass index (BMI) and inappropriate gestational weight gain (GWG) are associated with adverse short and long-term maternal and neonatal outcomes and may act as modifiable risk factors on the path to overweight/obesity, but their social patterning is not well established. This study investigates the association of education with BMI and GWG across two consecutive pregnancies.

Methods: The study includes 163 352 Swedish women, having their first and second singleton birth in 1982-2010. In both pregnancies, we investigated the association of women's education with i) pre-pregnancy weight status and ii) adequacy of GWG. We used multinomial logistic regression, adjusting for child's birth year, mother's age and smoking status.

Results: Overall, the odds of starting either pregnancy at an unhealthy BMI were higher among women with a low education compared to more highly educated women. Lower education also predicted a greater increase in BMI between pregnancies, with this effect greatest among women with excessive GWG in the first pregnancy ($p<0.0001$ for interaction). Education was also inversely associated with odds of excessive GWG in both pregnancies among healthy weight status women, but this association was absent or even weakly reversed among overweight and obese women.

Conclusion: Lower educated women had the largest BMI increase between pregnancies, and these inequalities were greatest among women with excessive GWG in the first pregnancy. The importance of a healthy pre-pregnancy BMI, appropriate GWG and a healthy postpartum weight should be communicated to all women, which may assist in reducing existing social inequalities in body weight.

What is already known on this subject?

- High pre-pregnancy body mass index and excessive gestational weight gain have been associated with adverse short and long-term consequences for mother and child

- In the first pregnancy, low socioeconomic position is associated with high pre-pregnancy body mass index and excessive gestational weight gain (among women of healthy weight status). Low socioeconomic position is also associated with long term obesity

What this study adds?

- Women with a low education had increased risk of starting their first and second pregnancies at an unhealthy weight and had the greatest increase in body mass index between pregnancies. This association was strongest among women who gained weight excessively in their first pregnancy

- Among healthy weight women, there was a protective effect of education on excessive gestational weight gain in both pregnancies. Among overweight and obese women, in both pregnancies there was either no significant association between education and gestational weight gain or even a trend in the opposite direction

- Given that gestational weight gain is a modifiable risk factor on the path to overweight/obesity development, ensuring women and practitioners are aware of the most up-to-date guidelines is of priority

Key Words: educational status; socioeconomic position; body mass index; gestational weight gain; social inequalities; pregnancy.

7.1.1 Introduction

Obesity increases the risk of chronic disease, and contributes largely to overall disease burden.[3] While Sweden's prevalence of overweight/obesity is lower than many other high income countries (~40% of women aged 16-84 years),[49] it has increased significantly among all Swedish counties from 1992 to 2010.[48] This is important since pre-pregnancy obesity and excessive gestational weight gain (GWG) are associated with increased risk of several adverse maternal, neonatal and child outcomes.[73,199] In addition, the transition to motherhood involves psychological and behavioural changes that may influence future weight,[247] including through excess GWG and weight retained postpartum.[100,102]

Studies conducted in Australia[10,95] and the U.K.[248] found greater weight gain over 4 years[95] and 10 years[10,248] among parous women compared to nulliparous, with on average 0.3-4.0 kg extra per pregnancy.[248] Likewise in Sweden[15] and the U.S.,[82] increasing parity is associated with long-term obesity, with some evidence that this particularly reflects the role of the first pregnancy.[79,86]

In the U.S.[73,249] and Europe[244] excessive GWG is common, particularly among younger women[250] and women with pre-pregnancy overweight/obesity.[248,251] For example, one small Swedish study found excessive GWG among 87% of overweight and 53% of obese women.[251] This matters since high GWG is the strongest predictor of post-partum weight retention[86,96,100,102,103,107] and of becoming overweight/obese after pregnancy.[107] By contrast, pre-pregnancy BMI is positively associated with weight retention in some[79,96,100] but not all studies.[88,244] These factors likely interact, with greatest weight retention observed among women with both high pre-pregnancy BMI and excessive GWG.[102] The risk of repetition in subsequent pregnancies is plausible,[99] highlighting the importance of accurate GWG advice.

Women with a low socioeconomic position (SEP) are at higher risk of pre-pregnancy overweight/obesity,[3,196] and this social differential seems to have widened over time among obese individuals in Sweden.[252] Lower SEP (measured by education or occupation) is also inversely associated with weight retention[103,248] and long-term BMI in women,[9-11] though less is known about the role of SEP for GWG. A Swedish study of primiparous women found that education was protective of excessive GWG only among women of healthy weight status,[196] while a U.S. study found a protective effect of high SEP that was dependent on race and neighbourhood residence.[253]

While GWG is higher in primiparous than multiparous women,[254] we know of no studies investigating SEP differences in BMI change or GWG in the first and second pregnancy. Since GWG is a key modifiable risk factor for development of overweight/obesity, understanding the relationship across consecutive pregnancies may reveal whether the risk is further increased in already disadvantaged groups. This study aimed to investigate the association between education and i) women's change in BMI from before the first pregnancy (BMI1) to before the second (BMI2); and ii) gestational weight gain in the first pregnancy (GWG1) and in the second (GWG2).

7.1.2 Methods

We used data from the Swedish Medical Birth Register and the Education Register, accessed through the Umeå SIMSAM Lab (http://www.org.umu.se/simsam/english/). We focused on the 853 148 women with a first and second singleton birth between 1982 and 2010.

Of these women, 522 581 had pre-pregnancy BMI available for both pregnancies and 196 739 (23%) also had complete information on GWG1 and GWG2 (weight data not collected in 1990 and 1991).[255] We excluded 2 029 women with implausible (Additional information 7.1), 16 774 with missing education data, and 14 584 with missing data on smoking during pregnancy. This left a study population of 163 352 (19% of the total population).

In assessing the potential for selection bias, we found similar characteristics in the women excluded due to missing information (n=689 796) as in our study population (N=163 352). The only significant differences were small: excluded women had a higher mean BMI1 (~0.4 kg/m^2 higher) and BMI2 (~0.6 kg/m^2 higher) and were slightly more likely to be non-smokers (84% vs. 81% in the first pregnancy). Excluded women also had marginally higher education levels (35% vs. 32% in the first pregnancy).

Primary exposure – education

Woman' education was recorded for each index child's birth year, except for births in 1982-1984, where education was recorded in 1985 since no annual education was available. Education was categorised as low (primary and lower secondary, ≤ 10 years education), intermediate (upper secondary, ≤ 13 years education) or high (post-secondary).

Outcome variables - BMI and GWG in the first and second pregnancy

BMI before the first pregnancy (BMI1) and the second pregnancy (BMI2) were calculated based on height and pre-pregnancy weight. Self-reported/measured pre-pregnancy weight was recorded at registration for antenatal care (~8-12 weeks gestation) from 1992 onwards, and was calculated by combining self-reported/measured weight at delivery and GWG for women giving birth before 1992[255] (the extent of self-report vs. measured weights is unknown). Based on pre-pregnancy BMI and WHO definitions,[204] weight status before the first and second pregnancy was categorised as underweight (< 18.50 kg/m²), healthy weight (18.50-24.99 kg/m²), overweight (25.00-29.99 kg/m²) or obese (≥ 30.00 kg/m²).

Using the U.S. Institute of Medicine's (IOM) guidelines, we defined adequate GWG as: 12.5-18 kg for underweight; 11.5-16 kg for healthy weight; 7-11.5 kg for overweight; and 5-9 kg for obese women.[256] GWG1 and GWG2 were categorised as excessive if above this recommended weight gain, and as inadequate if below. While the IOM guidelines have been criticised in Sweden as being too generous, particularly for overweight/obese women,[74] to date they remain the only official GWG guidelines.

Covariates

For each pregnancy, we obtained data on mother's cigarette smoking as recorded at first antenatal care visit (non-smoker, 1-9 cigarettes/day, 10+ cigarettes/day) and mother's age. The WHO recommends an interval of 18-27 months between a live birth and the next pregnancy, implying an ideal interval around 27-36 months between subsequent births.[114] We categorised the birth interval between child 1 and 2 as < 27, 27-36, 36.1-68, > 68 months).

Statistical analyses

Descriptive statistics explored the association of education and maternal characteristics with the two main outcomes: i) BMI change between pregnancies, stratified by GWG1; and ii) GWG1 and GWG2, stratified by weight status before the pregnancy in question.

Multinomial logistic regression investigated social patterning of GWG1 and GWG2 (stratified by weight status). Initially, all were minimally adjusted for the index child's birth year (Model 1), followed by adjustment for mother's age, pre-pregnancy BMI and smoking status (Model 2). Analysis of GWG2 was further adjusted for birth interval in Model 2. We also tested for interactions to see whether the association between education and GWG differed between the two pregnancies.

In supplementary analyses (Additional information, Table 7.4), multinomial logistic regression investigated social patterning of weight status prior to both pregnancies, additionally adjusted for mother's age and smoking status (Model 2). Analysis of weight status prior to the second pregnancy was further adjusted for GWG1 and birth interval (Model 3).

All findings were very similar in sensitivity analyses including full term pregnancies only (N=152 202). All findings with respect to first births were very similar in analyses including all women with a first birth (but not necessarily second, N=440 639). Analyses were performed using SAS 9.3 (SAS Institute Inc., Cary, NC). The study was approved by the regional ethics board in Umeå (Dnr 2010-157-31 Ö).

7.1.3 Results

Approximately 15% of the women in the sample had a low education (Table 7.1). The mean age at the birth of first child was 26.3 years, and 29.4 years at the birth of the second child. Slightly more women smoked during the first pregnancy (19%) than the second (16%). Fewer women had a healthy weight status before the second pregnancy (~69%) than the first (~75%).

BMI before the first and second pregnancy

BMI1 was similar across education groups, despite high-educated women having their first birth at a mean age ~3.5 and ~5.8 years older than intermediate- and low-educated women, respectively (Figure 7.1). Adjusting for age at first birth, low- and intermediate-educated women had markedly increased odds of overweight and obesity before the first pregnancy, and also increased odds of underweight status (Additional information, Table 7.4). These differences were only marginally attenuated following adjustment for smoking, indicating that smoking status accounts for only a small part of the association between education and weight status.

Lower education was also associated with a greater BMI change between pregnancies (a mean absolute increase per year of +0.27 kg/m^2 among low-educated, +0.21 kg/m^2 among intermediate-educated and +0.16 kg/ m^2 among high-educated women). This meant that the education gradient in the odds of overweight and obesity had grown even steeper by the start of the second pregnancy ($p<0.0001$ for interaction, Additional information, Table 7.4).

Finally, the magnitude of the association between education and BMI change was moderated by GWG1 ($p<0.0001$, Figure 7.2). Specifically, the relative difference in BMI change between education groups was greater among women who gained weight excessively during their first pregnancy than among women gaining weight adequately or inadequately (Figure 7.2).

Table 7.1: Description of study population of Swedish women with a first and second singleton birth between 1982-2010 (N=163 352)

	1st pregnancy	2nd pregnancy
	Mean (Std dev)	*Mean (Std dev)*
Height (cm)	166.5 (6.0)	166.5 (6.0)
Weight (kg)	63.0 (10.7)	65.0 (11.8)
Age at birth of index child	26.3 (4.3)	29.4 (4.4)
	n (%)	n (%)
Education[a]		
Low	27,976 (17.1)	25,195 (15.4)
Intermediate	83,794 (51.3)	83,697 (51.2)
High	51,582 (31.6)	54,460 (33.3)
Weight status		
Underweight (BMI < 18.5)	9,503 (5.8)	7,834 (4.8)
Healthy weight (BMI 18.5-24.9)	122,242 (74.8)	112,013 (68.6)
Overweight (BMI 25.0–29.9)	24,783 (15.2)	32,395 (19.8)
Obese (BMI ≥ 30.0)	6,824 (4.2)	11,110 (6.8)
Gestational Weight Gain[b]		
Inadequate	37,926 (23.2)	41,726 (25.5)
Adequate	64,762 (39.7)	67,969 (41.6)
Excessive	60,664 (37.1)	53,657 (32.9)
Interval since last birth[c]		
< 27 months	n/a	60,771 (37.2)
27-36 months		40,388 (24.7)
36.1-68 months		50,787 (31.1)
> 68 months		11,406 (7.0)
Smoking status		
Non-smoker	131,863 (80.7)	137,155 (83.9)
1-9 cigarettes/day	21,386 (13.1)	17,226 (10.6)
10+ cigarettes /day	10,103 (6.2)	8,971 (5.5)

BMI= body mass index

[a] *Education level at the time of the index pregnancy: Low - primary and lower secondary ≤ 10 years, Intermediate - upper secondary ≤ 13 years, High - post secondary*

[b] *Gestational weight gain based on the Institute of Medicine's guidelines for BMI specific weight gain in pregnancy*

[c] *Based on the WHO recommendation of a birth to pregnancy interval of 18-27 months after a live birth (equivalent to a 27-36 month birth interval)*

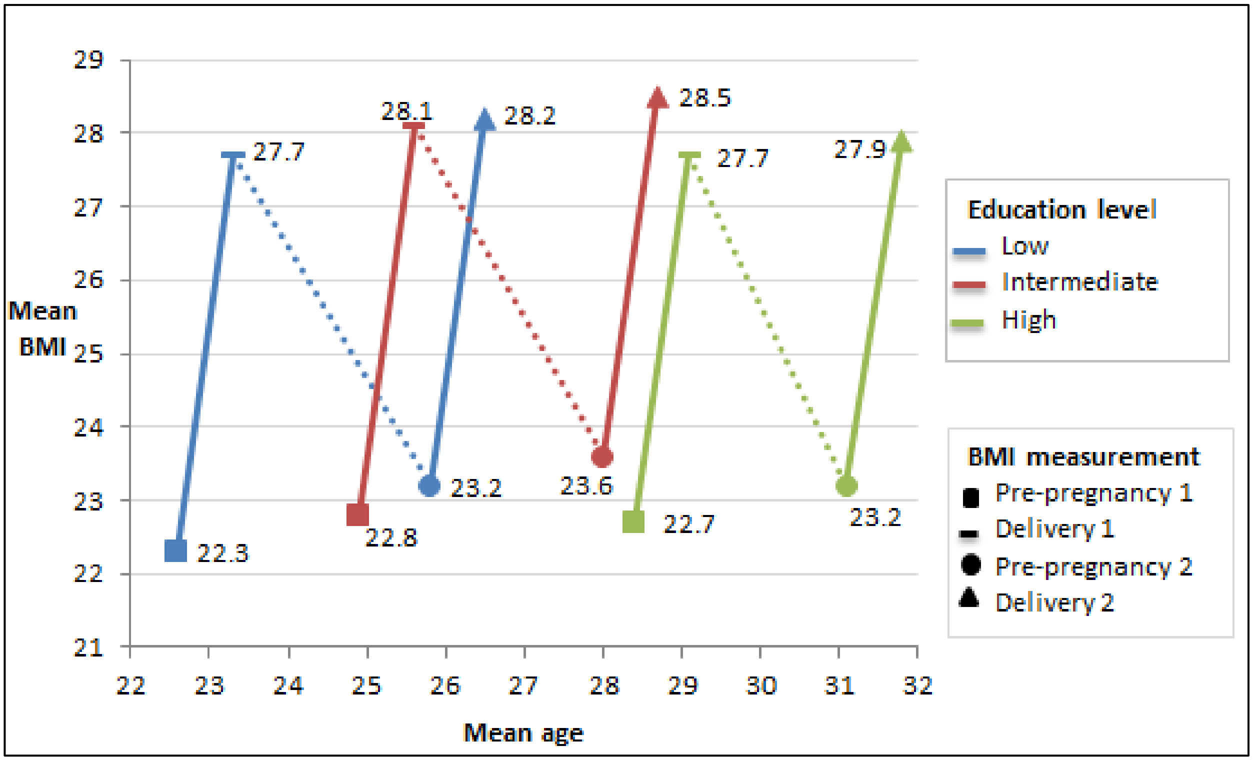

Figure 7.1: Descriptive figure showing mean body mass index (BMI) measured at 4 time points (before the first pregnancy, at first delivery, before the second pregnancy and at the second delivery), stratified by women's education level (N=163 352)

BMI at all 4 time points was significantly associated with education level (p <0.0001)

Education level measured near the time of the index pregnancy: Low - primary and lower secondary ≤ 10 years, Intermediate - upper secondary ≤ 13 years, High - post secondary

Note: The dotted line represents the time period between the first delivery and before the second pregnancy, time for which we do not have weight information

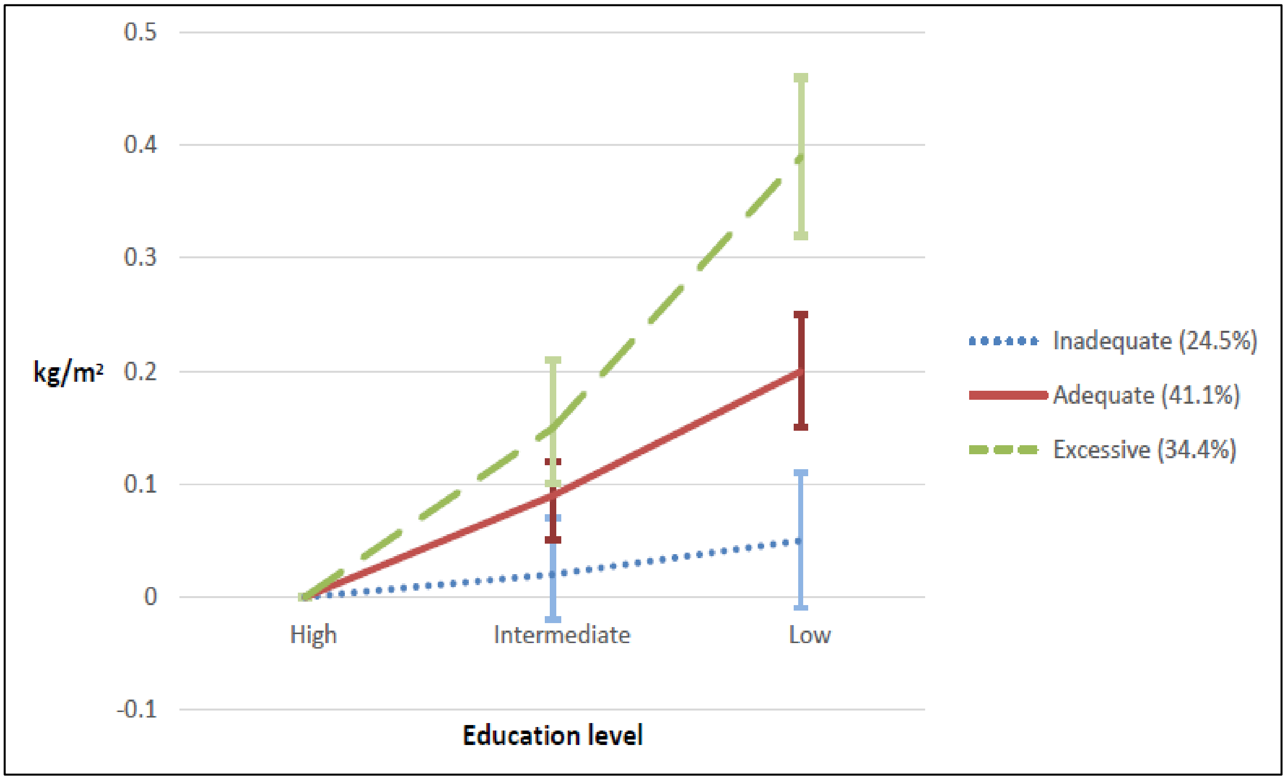

Figure 7.2: Mean change in body mass index (BMI) between the first and second pregnancy by education level, stratified by gestational weight gain in the first pregnancy (N=163 352)

The figure shows the additional increase in BMI between pregnancies among lower compared to high-educated women (reference group).

Education level was measured near the time of the first pregnancy: Low - primary and lower secondary ≤ 10 years, Intermediate - upper secondary ≤ 13 years, High - post secondary

GWG is based on the Institute of Medicine's guidelines for BMI specific weight gain in pregnancy.

Note: Analysis adjusted for birth interval between child 1 and 2, own age and birth year.

Significant interaction found between education and gestational weight gain (p <0.0001)

GWG in the first and second pregnancy

The proportion of women with adequate GWG1 and GWG2 was slightly higher among underweight than healthy weight women, and markedly higher among healthy weight than overweight or obese women (Table 7.2 and Figure 7.3).

In the second pregnancy, a smaller proportion of women gained weight excessively, while a larger proportion of women gained weight inadequately or adequately (Table 7.2).

Inadequate weight gain was particularly striking among underweight and healthy weight women; this was observed in ~40% of underweight and ~30% of healthy weight women in both pregnancies.

Compared to WHO recommended birth intervals,[114] a longer interval was associated with increased odds of excessive GWG2 among healthy and overweight women, while a shorter interval was associated with decreased odds of excessive GWG2 (Table 7.3). A shorter interval was also associated with increased odds of inadequate GWG2 among healthy and underweight women (Table 7.3).

Social patterning of GWG

Among healthy weight women there was an association between increasing education and a decreased proportion of excessive GWG1 and GWG2 (Table 7.2). These associations were attenuated but remained highly significant after adjusting for maternal BMI (continuous – separate results not shown); estimates further marginally attenuated after adjusting for maternal smoking (Table 7.3, Model 2) and birth interval (Table 7.3, Model 3). Overall, these associations were stronger in the first pregnancy ($p<0.0001$ for interaction, Table 7.3).

Higher education also predicted decreased odds of excessive GWG1 and GWG2 among underweight women (Table 7.2, Table 7.3). There was again a trend towards a stronger effect in the first pregnancy, but this was not significant ($p=0.24$).

By contrast, in regression analyses among overweight and obese women, the education gradient in excessive GWG showed a trend in the opposite direction (though non-significant among obese women, Table 7.3); that is, there was a trend towards lower odds of excessive GWG among low-educated overweight or obese women. Low-educated overweight women also had increased odds of inadequate GWG1 and GWG2, compared to high-educated women (Table 7.3, Model 2). Among overweight women, the effect of education on GWG was stronger in the first pregnancy ($p=0.04$ for interaction).

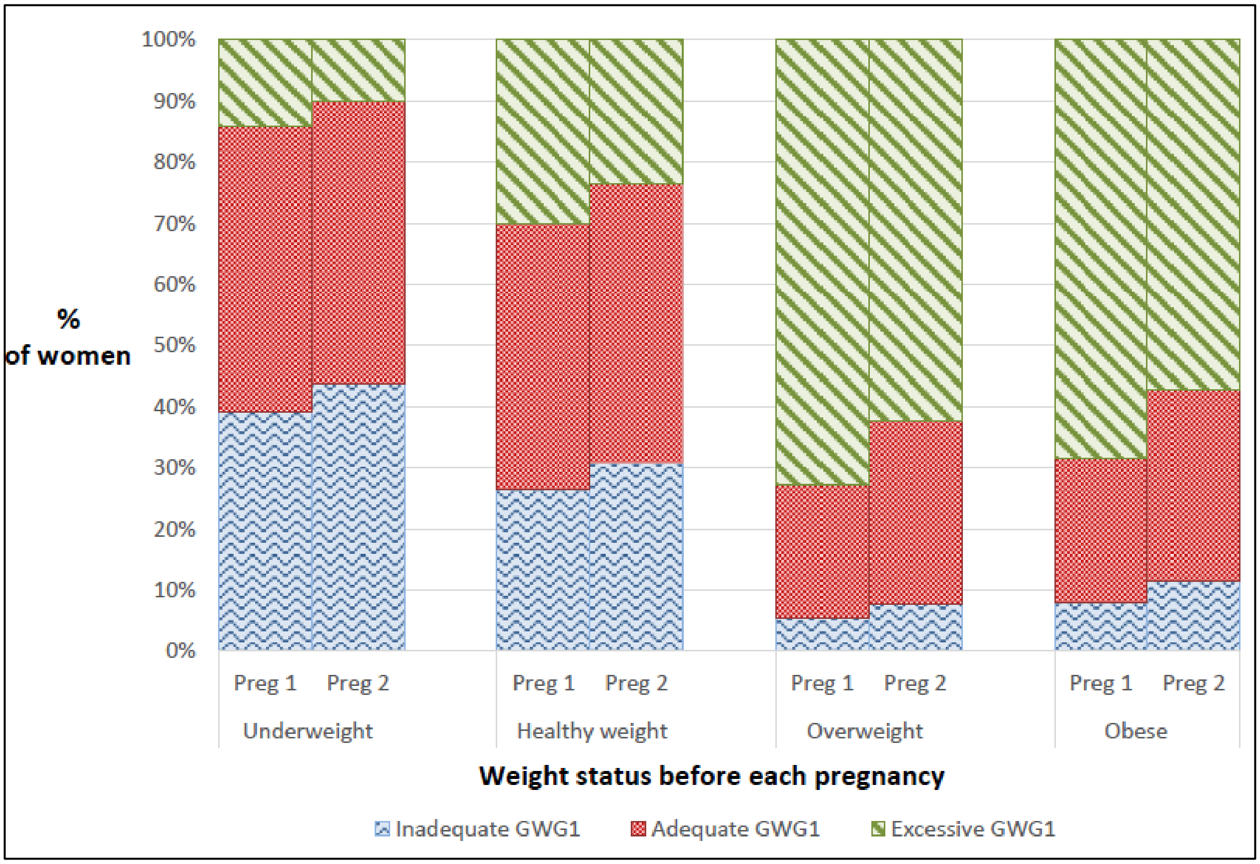

Figure 7.3: Proportion of women gaining weight inadequately, adequately and excessively in each pregnancy, stratified by pre-pregnancy weight status

The figure shows a large proportion of overweight and obese women gaining weight excessively in both pregnancies, as well as a considerable proportion of underweight and healthy weight women gaining weight inadequately in both pregnancies.

Preg1=pregnancy 1, Preg2= pregnancy 2

GWG= Gestational weight gain is based on the Institute of Medicine's guidelines for BMI specific weight gain in pregnancy

Table 7.2: Bivariate association between education and gestational weight gain in first (GWG1) and second pregnancy (GWG2), among Swedish women with a first and second singleton birth in 1982-2010, stratified by weight status before each pregnancy (N=163 352)

	Gestational weight gain[a]									
	1st pregnancy: GWG1					2nd pregnancy: GWG2				
Education* stratified by weight status	N	Inadequate (%)	Adequate (%)	Excessive (%)	p-value	N	Inadequate (%)	Adequate (%)	Excessive (%)	p-value
Underweight					<0.0001					<0.0001
High	2 102	44.7	46.1	9.2		1 967	47.4	44.6	8.0	
Intermediate	4 799	37.7	47.9	14.4		3 938	42.7	47.4	9.9	
Low	2 602	37.7	44.6	17.7		1 929	43.3	44.6	12.1	
Healthy weight[b]					<0.0001					<0.0001
High	40 273	28.3	46.5	25.2		39 651	31.8	47.4	20.8	
Intermediate	61 528	25.4	43.0	31.6		55 802	30.1	45.5	24.4	
Low	20 441	25.8	39.5	34.7		16 560	30.8	42.6	26.6	
Overweight					<0.0001					<0.0001
High	7 430	5.1	22.5	72.4		10 058	6.4	30.0	63.6	
Intermediate	13 457	5.1	22.1	72.8		17 424	7.8	30.0	62.2	
Low	3 896	7.2	20.9	71.9		4 913	10.5	28.7	60.8	
Obese					0.17					0.0002
High	1 777	7.5	24.0	68.5		2 784	9.6	30.0	60.4	
Intermediate	4 010	7.7	23.4	68.9		6 533	11.9	31.5	56.6	
Low	1 037	9.7	24.1	66.2		1 793	12.2	33.3	54.5	

*GWG= Gestational weight gain. *Education level near the time of index pregnancy: Low - primary and lower secondary ≤ 10 years, Intermediate - upper secondary ≤ 13 years, High - post secondary*

[a]BMI-specific gestational weight gain, classified by IOM criteria and NRC. [b]Healthy weight refers to the WHO BMI weight status category of 'normal weight', i.e. with BMI of 18.50-24.99 kg/m^2.

Table 7.3: Association between education and gestational weight gain in the first and second pregnancy, among Swedish women with a first and second singleton birth between 1982-2010. Odds ratios and 95% CI from multinomial regression analysis (n=163 352)

	IOM gestational weight gain[b] (adequate GWG as reference)											
Education[a]	**Inadequate**						**Excessive**					
stratified by weight status	**Model 1**		**Model 2**		**Model 3**		**Model 1**		**Model 2**		**Model 3**	
	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI
1st Pregnancy												
Underweight												
High (Ref)	1.00		1.00				1.00		1.00			
Intermediate	**0.85**	**0.76, 0.96**	**0.86**	**0.77, 0.97**			**1.35**	**1.12, 1.63**	**1.32**	**1.09, 1.60**		
Low	0.94	0.82, 1.09	0.97	0.84, 1.13			**1.68**	**1.35, 2.08**	**1.59**	**1.27, 1.98**		
Healthy weight[c]												
High (Ref)	1.00		1.00				1.00		1.00			
Intermediate	**0.97**	**0.94, 1.00**	**0.97**	**0.93, 0.99**			**1.26**	**1.22, 1.30**	**1.22**	**1.18, 1.26**		
Low	**1.06**	**1.02, 1.12**	1.05	0.99, 1.10			**1.44**	**1.38, 1.51**	**1.36**	**1.30, 1.43**		
Overweight												
High (Ref)	1.00		1.00				1.00		1.00			
Intermediate	0.97	0.84,1.13	0.95	0.81, 1.10			0.96	0.89, 1.03	0.98	0.91, 1.05		
Low	**1.42**	**1.17, 1.73**	**1.36**	**1.11, 1.66**			0.97	0.87, 1.08	1.00	0.90, 1.05		
Obese												
High (Ref)	1.00		1.00				1.00		1.00			
Intermediate	0.95	0.74, 1.21	0.89	0.69, 1.14			0.99	0.86, 1.14	1.03	0.89, 1.19		
Low	1.03	0.74, 1.44	0.94	0.67, 1.33			0.92	0.75, 1.12	0.97	0.79, 1.19		
2nd Pregnancy												
Underweight												
High (Ref)	1.00		1.00		1.00		1.00		1.00		1.00	

Intermediate	**0.89**	**0.79, 1.00**	0.89	0.79, 1.01	0.91	0.81, 1.03	1.08	0.87, 1.34	1.04	0.84, 1.30	1.01	0.81, 1.26
Low	0.97	0.83, 1.12	0.96	0.82, 1.12	0.99	0.85, 1.16	**1.31**	**1.02, 1.68**	1.21	0.93, 1.58	1.17	0.89, 1.52
Child 1-2interval[d] (months)												
< 27					**1.30**	**1.16, 1.46**					0.87	0.72, 1.06
27-36 (Ref)					1.00						1.00	
36.1– 68					0.97	0.85, 1.10					1.12	0.92, 1.38
> 68					1.01	0.77, 1.32					1.13	0.73, 1.74
Healthy weight[c]												
High (Ref)	1.00		1.00		1.00		1.00		1.00		1.00	
Intermediate	**1.04**	**1.01, 1.08**	1.02	0.98, 1.05	1.03	1.00, 1.06	**1.17**	**1.13, 1.21**	**1.14**	**1.10, 1.18**	**1.10**	**1.06, 1.14**
Low	**1.22**	**1.16, 1.28**	**1.13**	**1.08, 1.19**	**1.15**	**1.09, 1.21**	**1.32**	**1.26, 1.39**	**1.29**	**1.22, 1.35**	**1.22**	**1.16, 1.28**
Child 1-2interval[d] (months)												
< 27					**1.20**	**1.16, 1.25**					**0.87**	**0.84, 0.91**
27-36 (Ref)					1.00						1.00	
36.1– 68					0.98	0.94, 1.02					**1.16**	**1.12, 1.21**
> 68					1.06	1.00, 1.12					**1.31**	**1.23, 1.40**
Overweight												
High (Ref)	1.00		1.00		1.00		1.00		1.00		1.00	
Intermediate	**1.23**	**1.10, 1.37**	**1.15**	**1.03, 1.29**	**1.15**	**1.03, 1.29**	**0.93**	**0.88, 0.98**	0.95	0.89, 1.01	**0.93**	**0.88, 0.99**
Low	**1.75**	**1.51, 2.02**	**1.51**	**1.30, 1.76**	**1.51**	**1.30, 1.76**	**0.87**	**0.79, 0.94**	0.92	0.84, 1.00	**0.90**	**0.82, 0.98**
Child 1-2interval[d] (months)												
< 27					1.09	0.97, 1.22					**0.85**	**0.79, 0.90**
27-36 (Ref)					1.00						1.00	
36.1– 68					0.92	0.81, 1.04					1.03	0.96, 1.10
> 68					1.11	0.93, 1.32					**1.13**	**1.02, 1.25**
Obese												
High (Ref)	1.00		1.00		1.00		1.00		1.00		1.00	

Intermediate	**1.22**	**1.04, 1.44**	1.11	0.93, 1.31	1.10	0.92, 1.30	0.96	0.87, 1.07	0.96	0.87, 1.07	0.95	0.86, 1.06
Low	**1.30**	**1.05, 1.61**	1.10	0.87, 1.38	1.08	0.86, 1.37	0.94	0.82, 1.08	0.95	0.82, 1.10	0.93	0.81, 1.08
Child 1-2interval[d] (months)												
< 27					1.01	0.84, 1.20					0.99	0.88, 1.10
27-36 (Ref)					1.00						1.00	
36.1– 68					0.94	0.79, 1.13					0.93	0.83, 1.04
> 68					1.12	0.88, 1.42					1.13	0.96, 1.32

CI=confidence intervals, GWG=gestational weight gain, IOM= Institute of Medicine, OR=odds ratio, Ref= reference group

Model 1: adjusted for birth year of index child and woman's age, Model 2: Model 1 + BMI and smoking at index pregnancy, Model 3: Model 2 + birth interval between child 1 and 2.

Model 1 - overall interaction between education and parity was significant (p<0.0001). Interaction stratified by pre-pregnancy BMI: underweight p=0.24, healthy weight p<0.0001, overweight p=0.04, obese p=0.19.

[a] Education level at the time of the index pregnancy: Low - primary and lower secondary ≤ 10 years, Intermediate - upper secondary ≤ 13 years, High - post secondary

[b] BMI-specific gestational weight gain, classified by IOM criteria and NRC. Adequate gestational weight gain as the reference.

[c] Healthy weight refers to the WHO BMI weight status category of 'normal weight', i.e. with BMI of 18.50-24.99 kg/m^2.

[d] Based on the WHO recommendation of a birth to pregnancy interval of 18-27 months after a live birth (equivalent to a 27-36 month birth interval)

Results in bold indicate statistical significance at the 0.05 level.

7.1.4 Discussion

Among women in Sweden, we found that those with a lower education were more likely to start their first and second pregnancy at an unhealthy weight; these women also experienced a greater increase in BMI between pregnancies. The education gradient for change in BMI was particularly large among women who had experienced the risk factor of gaining weight excessively in the first pregnancy. We also found that, among women with a healthy pre-pregnancy weight status, those with a lower education were in both pregnancies more likely to experience excessive GWG. However, this educational gradient in excessive GWG was generally non-significant among women who started their pregnancy overweight or obese, and moreover the trend was consistently in the opposite direction. Thus, higher education appeared not to be protective against excessive GWG among overweight/obese women.

The protective association between higher education and pre-pregnancy weight status supports previous findings focused on first pregnancies among Swedish women.[196] In our study, BMI1 and BMI2 were very similar between education groups, despite the fact that the average age at first birth was considerably older among high educated women (~3.5 and ~5.8 years older). This is important from a public health perspective, underlining that increasing BMI is not solely determined by age and remains a modifiable maternal and neonatal risk factor.

The inverse association found for education and BMI change between pregnancies is similar to other studies of education and postpartum weight retention[103,248] and long-term BMI.[9-11] This educational gradient in BMI change amplified the pre-existing gradient in overweight/obesity, generating an educational gradient in overweight/obesity that was even stronger in the second pregnancy than the first (even after adjusting for birth interval). This finding highlights chains of interacting risks that may magnify existing social inequalities over time, as does our finding that the educational gradient in BMI change was particularly steep among women with excessive GWG1.

Consistent with evidence of excessive GWG accelerating overweight/obesity development in women,[100,102] we found increased odds of overweight/obesity before the second pregnancy among women with excessive GWG in the first pregnancy. As weight gain is largely a modifiable risk factor, accurate information and implementation of existing guidelines may considerably improve GWG outcomes. Although accurate advice in itself may not be enough to assist women to gain weight adequately,[257] being advised to gain too much weight is associated with excessive GWG.[92] This may be due to practitioners being unaware of current guidelines[258] or advising women incorrectly, particularly overweight/obese women.[259] Ensuring there is wide access to up-to-date guidelines may provide women (especially low educated women) the opportunity to set a healthy, weight-status-appropriate GWG target. Similar to a U.S. study,[86] we found a higher proportion of women gaining weight adequately in the second pregnancy, compared to the first. However it remains of clinical importance that ~40% of underweight and ~30% of healthy weight women gained inadequately in both pregnancies.

Among healthy and underweight women, we found a protective association between education and odds of excessive GWG in the first pregnancy. This accords with results among healthy weight women in a smaller Swedish study of first births.[196] Possible explanations for this association include improved diet/physical activity patterns, greater compliance to medical instruction, better access to information and earlier weight trajectories, as well as personality characteristics and reinforced social norms among higher educated women. The potential mediating/moderating role of behavioural factors such as smoking, diet and physical activity on weight gain in pregnancy should be addressed in future studies. Also of interest would be investigation of whether/how the associations with women’s current educational level may reflect differences in women’s growth trajectories and health or personality characteristics emerging earlier during their life course.

By contrast, the protective effect of education on excessive GWG was absent among overweight and obese women. Indeed, if anything, the trend was in the opposite direction, although it only reached significance for overweight women in the second pregnancy. The reason for this absence (or even reversal) of the education gradient is unclear; speculatively, it may be that overweight/obese women are a more closely monitored group, particularly if they experience excessive GWG in the first pregnancy. In any case, these results suggest that maintaining a healthy weight during pregnancy may be a challenge for women from all educational groups, particularly if the woman’s pre-pregnancy BMI is high.

Finally, a shorter than WHO recommended birth interval[114] was associated with increased odds of inadequate GWG2 among healthy and underweight women. Increased odds of excessive GWG2 were found among healthy and overweight women with a longer than recommended birth interval. This suggests that women with a shorter and longer than recommended birth interval may be potentially at-risk and require additional monitoring and advice.

Strengths and limitations

While using high-quality register data is a strength, potential limitations include a large proportion of women excluded due to missing data, partly due to administrative reasons (data not collected during two calendar years). Reassuringly, the characteristics of excluded women were very similar to women with complete data. Nevertheless, the potential for some selection bias remains. For example, a relatively high proportion of women lacked data on GWG, and it is possible that women appearing to gain weight appropriately would be less closely monitored and as such be missing GWG data. Additionally, we cannot exclude possible measurement error due to using self-reported data on height and weight, although both are found reasonable for epidemiological studies.[210]

While a steady increase in prevalence of pre-pregnancy overweight/obesity has been observed over time in Sweden, there was an unexpectedly large increase from 1989 to 1992, which we suspect is a possible artefact of changes in BMI measurement before and after 1992. While this is unlikely to vary by education level and significantly influence our results, all models were minimally adjusted for birth year of the child to account for this. Finally, it is arguably a limitation that we applied the 2009 IOM guidelines to data collected in Sweden and between 1982 and 2010, i.e., prior to when the guidelines were written. We made this decision based on i) an absence of Swedish guidelines and ii) a desire to define weight gain in relation to what is healthy for mother and child, even if this does not necessarily match the advice women received.

Conclusion

Our results show a protective effect of education for starting pregnancy at a healthy weight; avoiding a high BMI increase between pregnancies; and (among healthy-weight women) avoiding excessive GWG. While assisting women to start their first pregnancy at a healthy weight should remain a priority, targeting GWG as a key modifiable risk factor on the path to overweight/obesity should also be considered; namely, focusing on achieving GWG within the IOM guidelines, as well as returning to a healthy postpartum weight within a reasonable time frame. Our research identifies women who may be at particular increased risk of later overweight/obesity. This includes low educated women who gain weight excessively in the first pregnancy, and are therefore particularly likely to experience a large BMI increase between pregnancies. It also includes overweight/obese women of any educational group, who are particularly likely to experience excessive GWG during pregnancy.

Pregnancy is a time when women are both concerned about their child's health and heavily engaged with health professionals; as such, it provides a unique opportunity for lifestyle modifications which may prevent overweight/obesity and improve long-term health outcomes for mother and child. Our results could inform the design of both universal and targeted interventions, including supporting women to start their pregnancy at a healthy BMI, to gain weight appropriately and to return to a healthy pre-pregnancy BMI in a reasonable time.

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Competing interests

None declared.

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7.1.5 Additional information

Additional Information 1: Study sample exclusion criteria

We excluded women with a height <= 70cm or >= 200cm, pre-pregnancy weight of <= 34 kg or <= 200 kg; GWG >= 41 kg. Additionally we excluded implausible combinations of BMI and height: BMI <16 and height >=180cm; BMI > 35 and height < 130; BMI < 12. We further sequentially excluded 2,029 women with implausible values; 3 women with an inter-birth interval <9 months; 222 women with weight change per year between pregnancies greater than 15 kg; and 1,804 women with GWG in the first or second pregnancy of less than 1 kg or greater than 35 kg, consistent with an earlier analysis of Swedish data[196] and a population study which suggested that extremes in GWG may be related to uncommon pathologies[101].

Table 7.4: Association between education and weight status before the first and second pregnancy, among Swedish women with a first and second singleton birth in 1982-2010. Odds ratios and 95% CI from multinomial regression analysis (N=163 352)

	Pre-pregnancy weight status						
	Underweight		**Healthy weight**[b]	**Overweight**		**Obese**	
Education[a]	OR	95% CI	Ref	OR	95% CI	OR	95% CI
1st Pregnancy							
Model 1 (adjusted for birth year of child and woman's age)							
High (Ref)	1.00		1.00	1.00		1.00	
Intermediate	**1.10**	**1.04, 1.17**	1.00	**1.46**	**1.41, 1.51**	**2.22**	**2.08, 2.36**
Low	**1.46**	**1.36, 1.56**	1.00	**1.50**	**1.43, 1.58**	**2.41**	**2.20, 2.63**
Model 2 (Model 1 + smoking)							
High (Ref)	1.00		1.00	1.00		1.00	
Intermediate	**1.07**	**1.00, 1.14**	1.00	**1.44**	**1.39, 1.49**	**2.17**	**2.04, 2.31**
Low	**1.35**	**1.26, 1.45**	1.00	**1.46**	**1.39, 1.53**	**2.22**	**2.03, 2.43**
2nd Pregnancy							
Model 1 (adjusted for birth year of child and woman's age)							
High (Ref)	1.00		1.00	1.00		1.00	
Intermediate	1.04	0.98, 1.11	1.00	**1.47**	**1.43, 1.52**	**2.30**	**2.19, 2.42**
Low	**1.36**	**1.26, 1.46**	1.00	**1.66**	**1.59, 1.73**	**2.89**	**2.70, 3.09**
Model 2 (Model 1 + smoking)							
High (Ref)	1.00		1.00	1.00		1.00	
Intermediate	1.00	0.94, 1.06	1.00	**1.46**	**1.42, 1.51**	**2.26**	**2.15, 2.37**
Low	**1.20**	**1.11, 1.30**	1.00	**1.62**	**1.55, 1.69**	**2.70**	**2.52, 2.90**
Model 3 (Model 2 +GWG1 and child 1-2 interval)							
High (Ref)	1.00		1.00	1.00		1.00	
Intermediate	1.06	0.99, 1.12	1.00	**1.38**	**1.34, 1.43**	**2.07**	**1.97, 2.18**
Low	**1.28**	**1.18, 1.38**	1.00	**1.53**	**1.46, 1.60**	**2.50**	**2.32, 2.69**
1st pregnancy GWG[c] (GWG1)							
Inadequate	**2.03**	**1.93, 2.13**	1.00	**0.54**	**0.51, 0.56**	**0.40**	**0.37, 0.44**
Adequate (Ref)	1.00		1.00	1.00		1.00	
Excessive	**0.34**	**0.31, 0.37**	1.00	**3.43**	**3.33, 3.53**	**5.57**	**5.30, 5.85**
Interval[d] between child 1 and 2 (months)							
< 27	1.03	0.97, 1.10	Ref	**1.10**	**1.06, 1.13**	**1.08**	**1.02, 1.14**

27 – 36 (Ref)	1.00		Ref	1.00		1.00	
36.1 - 68	**0.92**	**0.86, 0.98**	Ref	**1.11**	**1.08, 1.16**	**1.11**	**1.05, 1.17**
> 68	**0.77**	**0.68, 0.88**	Ref	**1.22**	**1.15, 1.29**	**1.43**	**1.32, 1.55**

CI=confidence intervals, OR=odds ratio, Ref= reference group, GWG=gestational weight gain

Model 1 interaction between education and parity was significant (P< 0.001)

[a] Education level at the time of the index pregnancy: Low - primary and lower secondary ≤ 10 years, Intermediate - upper secondary ≤ 13 years, High - post secondary to postgraduate

[b] Healthy weight refers to the WHO BMI weight status category of 'normal weight'

[c] GWG based on the Institute of Medicine's guidelines for BMI specific weight gain in pregnancy

[d] Based on the WHO recommendation of a birth to pregnancy interval of 18-27 months after a live birth (equivalent to a 27-36 month birth interval)

7.2 Conclusion

Sweden - a country with universal family policies - generally has lower health inequalities compared to other regions like the U.K., where benefits are more targeted towards the disadvantaged.[33] Despite faring better with regard to health inequalities, the study of Swedish women presented in this chapter shows persisting socioeconomic differences in pre-pregnancy BMI, which are further influenced by GWG. Since GWG is a modifiable risk factor, greater focus should be placed on ways to assist women in meet the existing guidelines for healthy weight gain during pregnancy.

While a number of intervention studies have been conducted to investigate ways to reduce excessive GWG, a systematic review of 27 intervention trials initially concluded there was insufficient evidence as to which types of interventions were most effective.[260] A meta-analysis of nine trials found that interventions involving diet and physical activity were more effective at reducing excessive GWG than traditional prenatal advice,[261] and an update of the aforementioned systematic review concluded that diet, exercise or a combination of both are effective in reducing excessive GWG, particularly among women with an overweight or obese weight status.[262]

As already mentioned, although up-to-date advice alone does not guarantee that women will gain weight adequately during pregancy,[257] there is an association between being advised to gain too much weight and actually doing so.[92] This may be due to practitioners being unaware of current guidelines,[258] or possibly advising women incorrectly, particularly women with an overweight or obese weight status.[259] This suggests that greater attention is needed to ensure that medical practitioners are aware of the current guidelines, and that they are prepared to, and skilled in, discussing weight with women.

In addition to this, identifying factors in the post-partum period, which may inhibit or enable a reduction in weight, may assist in providing women with the support required to achieve a healthy postnatal weight status. This research also highlights the importance of a healthy pre-conception weight status, which indicates that reaching women once they are already pregnant is too late; investigating ways to reduce weight at a population level should be prioritised, both for the health of all adults, as well as mothers and their offspring.

Chapter 8. Social inequalities in breastfeeding initiation and duration

Breastfeeding is widely believed to aid the loss of weight in the early postpartum period, and has been associated, to varying degrees, with short and long term body weight for the mother and offspring. For the child, there is convincing evidence to suggest a protective effect of breastfeeding on overweight/obesity development in the short and long term, particularly with increasing breastfeeding duration.[117,122-125]

However, the evidence of a protective effect of breastfeeding on weight development for the mother is less conclusive. While some studies have found a protective association between breastfeeding and post-partum weight at six and 18 months, regardless of body mass index (BMI),[126] and at seven-years postpartum,[127] others have found no association.[82,128] Pre-pregnancy BMI is associated with confidence in, social influence towards, and social knowledge of breastfeeding:[144] and while this same study did not find an association between BMI and beliefs and attitudes towards breastfeeding,[144] another study found that overweight and obese women were less likely to breastfeed and planned to breastfeed for a shorter period, compared to healthy weight women.[142]

In addition to high BMI,[141] excessive GWG is also associated with earlier termination of breastfeeding.[143] A recent systematic review and meta-analysis also found insufficient evidence to indicate an association between breastfeeding and postpartum weight change, and have suggested a stronger influence of GWG, maternal age and pre-pregnancy BMI.[128]

Regardless of any effect of breastfeeding on body weight for the mother, evidence suggests that breastfeeding can impact eating patterns and set metabolism in the offspring, which influences their long term risk of overweight and obesity. Given this, and the other positive effects of breastfeeding, such as improved mother-child bonding and attachment,[119] and lower perceived stress levels and depression,[149] supporting women to breastfeed where possible is of importance.

Chapter 8.1 presents results from *Study 4*, which investigates social differences in breastfeeding initiation and duration in contemporary Australia. Education is used as the measure of SEP in childhood and adulthood, since it tends have a higher response rate than questions regarding occupation or income, and is generally more stable.[18] This is particularly important among parous women who may be temporarily absent from the paid workforce.

In order to adapt to the format of this thesis, only the numbering of tables and figures have been modified from the original manuscript under revision. This manuscript has been formatted according to the journal's requirements. A media release for this publication was issued on March 22, 2016, resulting in numerous print articles and two live radio interviews.

8.1 High education and increased parity are associated with breastfeeding initiation and duration among Australian women (*Study 4*)

- **Holowko N**, Jones M, Tooth L, Koupil I, Mishra G. High education and increased parity are associated with breastfeeding initiation and duration among Australian women. *Public Health Nutrition.* 2016. Oct 19 (14):2551-61. doi 10.1014/S1368980016000367.

Abstract

Objective: Breastfeeding is associated with positive maternal and infant health and development outcomes. To assist in identifying women less likely to meet infant nutritional guidelines, we investigated the role of socioeconomic position and parity on initiation of and sustaining breastfeeding for at least six months.

Design: Prospective cohort study.

Setting: Australia.

Subjects: Parous women from the Australian Longitudinal Study on Women's Health (born 1973-78), with self-reported reproductive and breastfeeding history (N= 4,777).

Results: While 89% of women (83% of infants) had ever breastfed, only 60% of infants were breastfed for at least six months. Multiparous women were more likely to breastfeed their first child (~90% vs. ~71% of primiparous women), and women who breastfed their first child were more likely to breastfeed subsequent children. Women with a low education (adjusted OR 2.09: 95% C.I. 1.67, 2.62) or a very low educated parent (OR 1.47: 1.16, 1.88) had increased odds of not initiating breastfeeding with their first or subsequent children. While fewer women initiated breastfeeding with their youngest child, this was most pronounced among high educated women.

While ~60% of women breastfed their first, second and third child for at least six months, low educated women (first child adjusted OR 2.19: 1.79, 2.68) and women with a very low (OR 1.82: 1.49, 2.22) or low educated parent (OR 1.69: 1.33, 2.14) had increased odds of not breastfeeding for at least six months.

Conclusions: A greater understanding of barriers to initiating and sustaining breastfeeding, some of which are socioeconomic-specific, may assist in reducing inequalities in infant breastfeeding.

Key words: breastfeeding initiation, breastfeeding duration, social inequalities, socioeconomic position, infant feeding guidelines

8.1.1 Introduction

The Australian Dietary Guidelines recommend exclusive breastfeeding of infants up to at least six months, with further continued breastfeeding up to 12 months and beyond.[121] These recommendations are based on the numerous positive and protective short/long term effects of breastfeeding for both the infant and mother,[115-120] and are in accordance with the World Health Organization's (WHO) recommendation of exclusive breastfeeding up to six months, followed by an introduction of complementary foods and continued breastfeeding thereafter.[115]

In 2010, it was estimated that breastfeeding was initiated with 96% of Australian infants, however only 15% of infants were exclusively breastfed up to the recommended six months (21% predominantly breastfed).[119] With 60% of infants breastfed at all (be it exclusive, full/predominant or complementary) at six months, information about breastfeeding duration based on birth order is scarce.

Maternal attributes positively associated with breastfeeding initiation and duration include: higher maternal age;[119,129-131,134] higher maternal education,[119,129,130,132-134] though not in all studies;[131] higher family income;[129] being married,[130,134] though not in all studies;[131] living with a partner;[133] history of prior breastfeeding;[133,135,136] and having a healthy pre-pregnancy body mass index.[141-143] Higher parity has also been positively associated with breastfeeding initiation[134] and more frequently with breastfeeding duration;[131,137,138] while difficulties with infant feeding in the first month postpartum are negatively associated with breastfeeding duration.[131] Further social and demographic characteristics positively associated with breastfeeding, such as father's preference for breastfeeding, can be found summarised in the 2013 Australian Dietary Guidelines (Table 4.2 in the referenced document).[263]

While lower education has been associated with reduced odds of breastfeeding in Australia[119,129,131] and other high income countries,[129,130,133,142,147] one study found negligible social differences in ceasing exclusive breastfeeding at three months.[148] In 2004-05, an Australian study found a 26% increase in odds of breastfeeding at six months in neighbourhoods of increasing socioeconomic position (SEP) advantage, as measured by quintiles of SEIFA (a measure of the distribution of socioeconomic conditions based on neighbourhood);[264] these social inequalities have increased since 1995 and are similar when investigating odds of breastfeeding at three and twelve months.[265]

Given the association of breastfeeding with positive maternal and infant health and development outcomes, it is important to understand how SEP and parity relate to breastfeeding initiation and duration in Australia today. Such information will assist in identifying groups of women less likely to meet the guidelines and thus encourage consideration of strategies to overcome SEP specific barriers to breastfeeding. This study uses childhood and adulthood measures of SEP to identify whether initiation of breastfeeding and breastfeeding for at least six months i) varies by parity and ii) is socially patterned.

8.1.2 Methods

Study design and participants

We used data from the Australian Longitudinal Study on Women's Health (ALSWH); a prospective cohort study comprising of Australian citizens and permanent residents randomly selected from the national health and insurance database (Medicare), with an intentional oversampling of women in rural/remote areas. Women completed a self-reported questionnaire in 1996 (baseline) and at approximate 3-4 yearly intervals thereafter. The ALSWH study has obtained informed consent from all study participants and is approved by the Human Research Ethics Committees of the Universities of Newcastle and Queensland. Further details about ALSWH recruitment and study design can be found elsewhere.[188 ,202]

Our sample is drawn from the ALSWH cohort born in 1973-78 (aged 18-23 years at baseline, n=14,247). Analysis of the relatively high attrition between baseline and Survey Two (68% response rate; n=9,688; conducted in 2000; women aged 22-27 years) has concluded that possible biases due to loss to follow-up do not limit significant longitudinal analysis of these data.[187] Since Survey Two, attrition has remained fairly stable: Survey Three 64% (n=9,081; 2003; aged 25-30 years); Survey Four 64% (n=9,145; 2006; aged 28-33 years); Survey Five 58% (n=8,200; 2009; aged 31-36 years); and at Survey Six 56% (n=8,010; 2012; aged 34-39 years).

In order to use the most recent child birth information, we restricted the sample to parous women who answered Surveys One and Six (n=5,917). Our final sample included complete cases for all exposures (N=4,777).

Measurements

Exposure - Indicators of socioeconomic position

Parental education (highest of mother's or father's), a marker of early life SEP, was collected at Survey Two and categorised as very low (≤ 10 years); low (≤ 12 years/equivalent); intermediate (trade/certificate/diploma); high (degree/higher); or not applicable/don't know.

Own highest achieved education was collected at age 34-39 years and categorised as low (≤ 12 years); intermediate (trade/apprentice/ certificate/diploma); or high (degree/higher).

Area of residence at baseline was categorised as urban (major cities); rural (inner regional); or remote (outer regional/remote). Distribution of socioeconomic conditions based on neighbourhood (Socio-Economic Indexes for Area (SEIFA) score for education and occupation) was collected at baseline and divided into quintiles, with lower scores indicating greater disadvantage[264] and was included as a continuous variable in the models. Financial stress was measured by asking women about their ability to manage on their income. This was collected at age 34-39 years and categorised as always difficult (impossible/always); sometimes difficult; or easily managed (not too bad/easy).

Outcome measures

Duration of breastfeeding was taken from Survey Six (if missing, then Survey Five) from the question 'How many complete months have you breastfed each of your children?' Given that 92.4% of women had three or less children, we analysed breastfeeding with the first, second or third child only, categorised as not initiated; < 6 months; or ≥ 6 months. For each child, two dichotomous outcomes were: initiation of breastfeeding; and, among those who had initiated breastfeeding, whether they were breastfed (at all) for up to at least six months.[121]

Additional covariates

Parity (total number of children) was categorised as one; two; three or more. Age at birth of the first child was calculated by subtracting the woman's date of birth from that of her first child. This score was categorised as < 20.0; 20.0-24.99; 25-29.99; 30-34.99; or ≥ 35.0 years. Fertility issues, measured at Survey Six, were dichotomised based on the question "Have you and your partner (current or previous) ever had problems with infertility (that is, tried unsuccessfully to get pregnant for 12 months or more)?"

Body mass index at age 34-39 years was based on self-reported weight and height (kg/m^2). Using the WHO's categories, weight status was defined as; underweight (< 18.50 kg/m^2), healthy weight (18.50-24.99 kg/m^2), overweight (25.00-29.99 kg/m^2) or obese (≥ 30.00 kg/m^2).[204] Country of birth was categorised as 'Australia' or 'other', since few women were born outside of Australia.

Statistical analysis

Descriptive analyses, including t-tests and Pearson's chi-square tests, were used to describe the sample and explore the association between maternal and own SEP characteristics with the breastfeeding patterns, with results considered statistically significant with $p < 0.05$. 'Lasagne plots'[266] were created to show breastfeeding patterns stratified by parity, and proportions were plotted to document breastfeeding patterns stratified by highest education and total parity.

Logistic regression was used to i) describe the patterns of breastfeeding by parity; and investigate the association between the SEP measures and ii) initiating breastfeeding with each child, and iii) breastfeeding each child for at least six months (among women who had initiated breastfeeding with that child). All models were adjusted for age at baseline (centred at the cohort mean) and the child's year of birth (Odds Ratio (OR) 1). OR2 further adjusted for parental education.

We ran sensitivity analyses i) investigating the association between SEP and odds of breastfeeding each child for at least six months among all women with an index child, and not only those who had initiated breastfeeding; and ii) for both outcomes using data imputed for all parous women (n=5,917). We ran PROC MI, with 20 imputations using fully conditional specification, to impute all outcomes, exposures, and covariates used in the multinomial logistic models. We also included auxiliary variables associated with missingness in the imputation model.[203]

All analyses were completed in SAS version 9.4 (SAS Institute Inc., Cary, NC).

8.1.3 Results

At Survey Six and a mean age of 36.8 years (median 36.9 years, inter-quartile range 35.6-38.1), approximately 79% of the sample was multiparous, with almost half of women having two children. Almost three-quarters of the women were aged between 25-35 years at first birth (median 29.3 years), and half of the sample had a high education and lived in an urban area (Table 8.1). Approximately 60% of women had breastfed the first, second and third child for at least six months (Table 8.1).

Patterns of breastfeeding by parity

Overall, 89% of the ALSWH population had ever breastfed (Table 8.1) and 83% of the children included in the analyses were breastfed; while 59% of infants were breastfed for at least six months, and 68% of women had breastfed at least one child for at least six months. Breastfeeding of firstborn children was more common among women who continued to deliver more children; while ~71% of primiparous initiated breastfeeding with their first child (44.9% breastfed for at least six months, 26.5% breastfed for less than six months – results not shown), compared to 90.5% of women with two children and 88.7% of women with three or more children (Figure 8.1).

With the first child, a lower percentage of primiparous women breastfed for up to at least six months (45%), compared to almost two-thirds of multiparous women (Figure 8.1). Among women with three or more children, breastfeeding initiation and duration tended to be similar with the first and second child (Figure 8.1). However, 20% of multiparous women did not initiate breastfeeding with their youngest child (Figure 8.1).

Table 8.1: Reproductive and demographic characteristics among parous ALSWH women born 1973-78 (N=4,777)

	Overall (N=4,777)			Breastfeeding each child											
		Ever breastfed		Child 1 (n=4,777)				Child 2 (n=3,769)				Child 3 (n=1,408)			
Characteristics	n (%)	Yes 89%	p-value	No 14%	< 6 mths 26%	≥ 6 mths 60%	p-value	No 17%	< 6 mths 24%	≥ 6 mths 59%	p-value	No 21%	< 6 mths 21%	≥ 6 mths 58%	p-value
Country of birth			0.81				0.74				0.76				0.17
Australia	4,472 (94)	89		14	26	60		17	24	59		27	14	59	
Other	305 (6)	89		13	25	62		17	26	57		20	22	58	
Parental education*			0.008				<0.0001				<0.0001				<0.0001
Very low	1,172 (25)	89		15	30	55		19	26	55		19	27	54	
Low	590 (12)	90		12	29	59		16	28	56		20	22	58	
Intermediate	1,465 (31)	89		14	24	62		17	23	60		21	19	60	
High	1,177 (25)	91		12	19	69		16	16	68		19	14	67	
Not applicable/Don't know	373 (8)	84		20	35	45		21	32	47		30	26	43	
Area of residence (baseline)			0.049				0.14				0.25				0.03
Urban (major cities)	2,420 (51)	89		14	25	61		18	22	60		24	19	57	
Rural (inner regional)	1,485 (31)	88		15	27	58		17	25	58		17	25	58	
Remote (outer regional/ remote)	872 (18)	91		12	27	61		16	24	60		18	22	60	
Ability to manage on income			0.102				<0.0001				0.0001				0.54
(age 34-39 years)															
Easy to manage	2,491 (52)	89		14	23	63		17	29	54		19	20	61	
Sometimes difficult	1,662 (34)	90		14	29	57		18	26	56		22	22	56	
Always difficult	664 (14)	87		15	31	54		17	21	62		20	23	57	
Highest achieved education**			0.047				<0.0001				<0.0001				<0.0001

(age 34-39 years)															
Low	786 (16)	87		19	35	46		20	29	51		22	26	52	
Intermediate	1,457 (31)	89		15	33	52		16	31	53		17	26	57	
High	2,534 (53)	90		12	19	69		17	17	65		22	16	62	
Completed parity			<0.0001				<0.0001				<0.0001				
1	1,008 (21)	71		29	26	45									
2	2,361 (49)	93		10	27	63		21	24	55					
3+	1,408 (30)	95		11	24	65		12	23	65		21	21	58	
Age at first birth			<0.0001				<0.0001				<0.0001				0.004***
< 20.0	221 (5)	86		27	33	40		24	34	42		20	29	51	
20.0 – 24.99	752 (16)	91		14	32	54		14	29	57		13	26	61	
25-29.99	1,717 (36)	93		10	28	62		13	24	63		20	19	61	
30.0-34.99	1,773 (37)	89		13	21	66		23	18	59		33	16	51	
≥ 35	314 (6)	64		36	22	42		45	21	34		100	0	0	
Fertility issues (age 34-39 years)			0.038				0.19				0.016				0.31
No	3,762 (79)	90		14	26	60		17	23	60		20	20	60	
Yes: Self/partner >12 months	1,015 (21)	87		15	27	58		20	25	55		21	25	54	
Weight status (WHO) (age 34-39 years)			<0.0001				<0.0001				<0.0001				0.0003
Underweight	109 (2)	89		14	22	64		18	19	63		15	18	67	
Healthy weight	2,333 (50)	91		12	21	67		16	19	65		20	16	64	
Overweight	1,235 (26)	90		13	28	59		17	25	58		20	22	58	
Obese	1,048 (22)	85		20	34	46		22	30	48		23	28	49	

[*] Parental education (highest of mother's or father's) categorised as very low (≤ 10 years); low (≤12 years/equivalent); intermediate (trade/certificate/diploma); high (degree/higher); and not applicable/don't know

[**] Own highest education categorised as low (≤ 12 years), intermediate (trade/apprent./cert./dipl.), high (degree/higher)

[***] Mantel-Haenszel chi-square

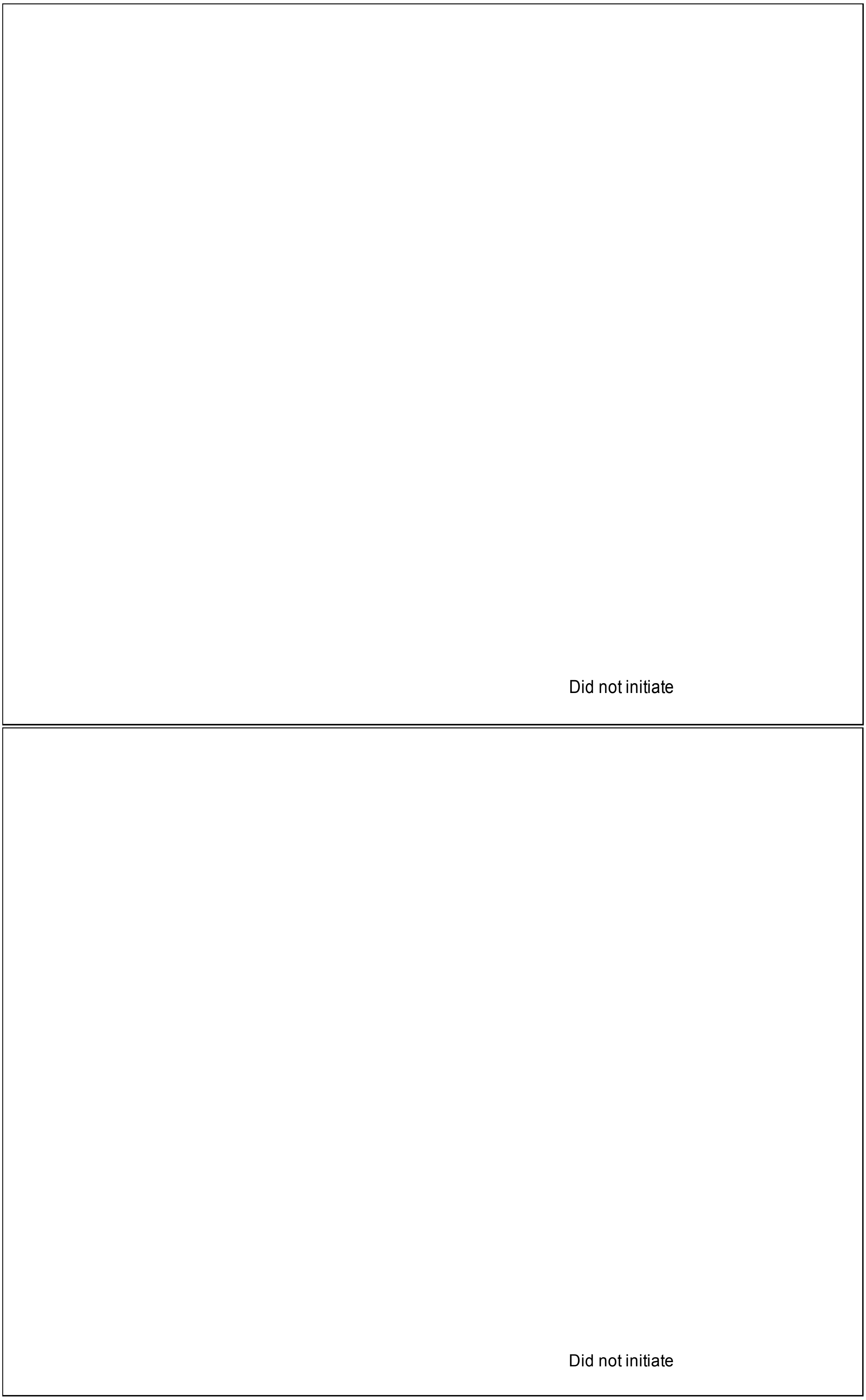

Figure 8.1: Percentage of multiparous ALSWH women (born 1973-78) breastfeeding each index child for at least six months, stratified by parity

Overall, women who breastfed their first child for at least six months were most likely to also do so with their second child, unless it was their youngest child; multiparous women tended to be less likely to initiate breastfeeding with their youngest child.
Note: among women with one child, 28.6% did not initiate breastfeeding, while 44.9% breastfed for at least six months and 26.5% breastfed for less than 6 months (data not shown).

SEP and breastfeeding initiation and duration

A slightly higher percentage of high-educated women initiated breastfeeding with the first child, compared to lower educated women (Figure 8.2). Further analysis stratified by total parity showed this was only apparent among multiparous women (Additional information, Figure 8.3). With regard to the second and third child, the percentage of women initiating breastfeeding was highest among women with an intermediate education (Figure 8.2 and Additional information, Table 8.4). Overall, women were less likely to initiate breastfeeding with their youngest child (Figure 8.2). Stratification by total parity showed that the largest absolute decrease in the percentage of women initiating breastfeeding with their youngest, compared to oldest child, was among high educated women (Additional information, Figure 8.3).

Stronger social patterning was found in breastfeeding for at least six months, where higher educated women were more likely to do so with each child (Figure 8.2). However, while the percentage of low- and intermediate-educated women breastfeeding for at least six months increased slightly from the first to the third child, this was not the case with high-educated women (Figure 8.2). These women were less likely to breastfeed their youngest child for at least six months.

Results from logistic regression models adjusted for woman's age and birth year of the index child (Tables 8.2 & 8.3, OR1), and further adjusted for parental education (OR2), confirmed that compared to high-educated women, low-educated women had 1.5 to 2 times increased odds of not having initiated breastfeeding with any of their children (Table 8.2). As well as intermediate-educated women, low-educated women also had increased odds of not breastfeeding their first, second and third child for at least six months (Table 8.3).

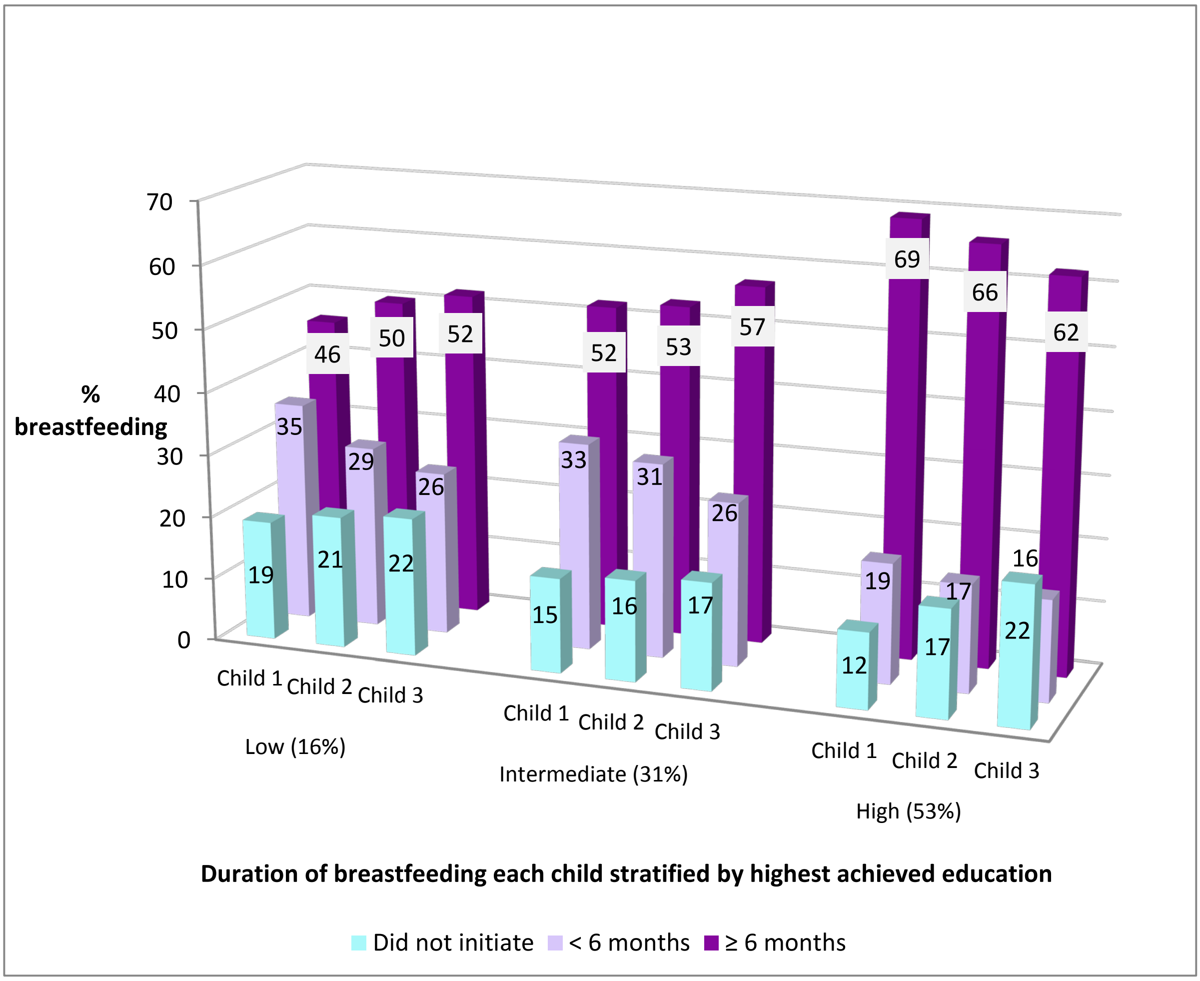

Figure 8.2: Percentage of ALSWH women (born 1973-78) initiating breastfeeding and breastfeeding for at least six months, stratified by highest achieved education (N=4,777)

Additionally, women with a very low-educated parent had increased odds of not initiating breastfeeding with their first and second child (Table 8.2) and also not breastfeeding their first, second or third child for at least six months (Table 8.3). Women who did not know their parent's education had approximately twice the odds of not initiating breastfeeding with their first and second child, and ~3.7 times increased odds with the third child (Table 8.2). These women also had at least 2.5 times increased odds of not breastfeeding for at least six months (Table 8.3). Women who found it difficult to manage on their income had 1.3-1.4 times increased odds of not breastfeeding for at least six months with their first and second child (Table 8.3). Area of residence and SEIFA index of SEP were not significantly associated with breastfeeding initiation or duration.

Table 8.2: Socioeconomic position and odds of not initiating breastfeeding with the first, second and third child, among ALSWH women (born 1973-78) (N=4,177)

Exposures	**First child (n=4,177)**		**Second child (n= 3,769)**		**Third child (n= 1,408)**	
	OR1 (95% C.I.)	OR2 (95% C.I.)	OR1 (95% C.I.)	OR2 (95% C.I.)	OR1 (95% C.I.)	OR2 (95% C.I.)
Parental education [a]						
High	1.00 (ref)		1.00 (ref)		1.00 (ref)	
Intermediate	1.31 (1.04, 1.65)		1.17 (0.92, 1.48)		1.43 (0.98, 2.10)	
Low	1.11 (0.82, 1.51)		1.07 (0.78, 1.46)		1.25 (0.77, 2.01)	
Very low	**1.47 (1.16, 1.88)**		**1.42 (1.11, 1.81)**		1.31 (0.87, 1.96)	
Not applicable/Don't know	**2.22 (1.62, 3.05)**		**1.97 (1.39, 2.78)**		**3.68 (2.18, 6.22)**	
Own highest education [b]						
High	1.00 (ref)	1.00 (ref)	1.00 (ref)	1.00 (ref)	1.00 (ref)	1.00 (ref)
Intermediate	**1.41 (1.16, 1.71)**	**1.31 (1.07, 1.61)**	1.13 (0.92, 1.38)	1.05 (0.85, 1.30)	0.98 (0.71, 1.36)	0.88 (0.63, 1.24)
Low	**2.09 (1.67, 2.62)**	**1.89 (1.49, 2.40)**	**1.78 (1.40, 2.25)**	**1.59 (1.24, 2.05)**	**1.79 (1.25, 2.57)**	**1.53 (1.04, 2.25)**
Area of residence						
Urban	1.00 (ref)	1.00 (ref)	1.00 (ref)	1.00 (ref)	1.00 (ref)	1.00 (ref)
Rural	1.19 (0.99, 1.43)	1.14 (0.95, 1.37)	0.97 (0.80, 1.18)	0.93 (0.77, 1.14)	0.77 (0.57, 1.06)	0.72 (0.53, 1.00)
Remote	0.93 (0.74, 1.18)	0.88 (0.69, 1.12)	0.99 (0.79, 1.26)	0.94 (0.74, 1.20)	0.93 (0.65, 1.33)	0.88 (0.61, 1.26)
Ability to manage on income						
Easy to manage	1.00 (ref)	1.00 (ref)	1.00 (ref)	1.00 (ref)	1.00 (ref)	1.00 (ref)
Sometimes difficult	1.05 (0.88, 1.26)	1.02 (0.85, 1.23)	1.16 (0.96, 1.40)	1.13 (0.94, 1.36)	**1.36 (1.01, 1.82)**	1.33 (0.99, 1.79)
Always difficult	1.16 (0.91, 1.48)	1.13 (0.88, 1.45)	1.14 (0.88, 1.48)	1.11 (0.85, 1.44)	1.34 (0.91, 1.99)	1.31 (0.88, 1.95)
SEIFA ed/occ quintiles [c]	**0.92 (0.87, 0.98)**	0.95 (0.89, 1.01)	0.95 (0.89, 1.01)	0.97 (0.91, 1.03)	1.05 (0.95, 1.16)	1.09 (0.98, 1.21)

OR1: Minimally adjusted for baseline age and birth year of the index child *OR2: OR1 + parent's education*

[a] Parental education (highest of mother's or father's) categorised as very low (≤ 10 years); low (≤ 12 years/equivalent); intermediate (trade/certificate/diploma); high (degree/higher); and not applicable/don't know *[b] Own education categorised as low (≤ 12 years); intermediate (trade/apprentice/ certificate/diploma); and high (degree/higher)* *[c] SEIFA: Socio-Economic Indexes for Areas (education and occupation) NOTE: When we further adjusted for the most recent birth interval, estimates were very similar (fractionally lower)*

Table 8.3: Socioeconomic position and odds of not breastfeeding for at least six months, among ALSWH women (born 1973-78) who had initiated breastfeeding with each index child

Exposures	First child (n=4,106)		Second child (n= 3,112)		Third child (n= 1,119)	
	OR1 (95% C.I.)	OR2 (95% C.I.)	OR1 (95% C.I.)	OR2 (95% C.I.)	OR1 (95% C.I.)	OR2 (95% C.I.)
Parental education [a]						
High	1.00 (ref)		1.00 (ref)		1.00 (ref)	
Intermediate	**1.34 (1.11, 1.63)**		**1.57 (1.24, 1.98)**		1.50 (0.99, 2.26)	
Low	**1.69 (1.33, 2.14)**		**1.99 (1.51, 2.63)**		**1.73 (1.07, 2.82)**	
Very low	**1.82 (1.49, 2.22)**		**1.84 (1.45, 2.34)**		**2.34 (1.55, 3.52)**	
Not applicable/Don't know	**2.47 (1.87, 3.26)**		**2.56 (1.85, 3.55)**		**2.86 (1.64, 4.99)**	
Own highest education [b]						
High	1.00 (ref)	1.00 (ref)	1.00 (ref)	1.00 (ref)	1.00 (ref)	1.00 (ref)
Intermediate	**2.17 (1.85, 2.54)**	**2.01 (1.71, 2.37)**	**2.03 (1.69, 2.44)**	**1.89 (1.57, 2.27)**	**1.86 (1.35, 2.55)**	**1.64 (1.18, 2.27)**
Low	**2.49 (2.05, 3.02)**	**2.19 (1.79, 2.68)**	**1.97 (1.58, 2.47)**	**1.72 (1.36, 2.18)**	**2.06 (1.43, 2.98)**	**1.72 (1.18, 2.52)**
Area of residence						
Urban	1.00 (ref)	1.00 (ref)	1.00 (ref)	1.00 (ref)	1.00 (ref)	1.00 (ref)
Rural	1.04 (0.89, 1.21)	0.98 (0.84, 1.14)	1.09 (0.91, 1.30)	1.02 (0.85, 1.22)	1.26 (0.93, 1.72)	1.18 (0.86, 1.60)
Remote	0.97 (0.81, 1.17)	0.89 (0.74, 1.07)	1.00 (0.81, 1.24)	0.92 (0.74, 1.14)	1.07 (0.75, 1.52)	0.99 (0.70, 1.43)
Ability to manage on income						
Easy to manage	1.00 (ref)	1.00 (ref)	1.00 (ref)	1.00 (ref)	1.00 (ref)	1.00 (ref)
Sometimes difficult	**1.40 (1.21, 1.62)**	**1.36 (1.17, 1.58)**	**1.32 (1.11, 1.57)**	**1.30 (1.09, 1.55)**	1.11 (0.82, 1.49)	1.05 (0.78, 1.42)
Always difficult	**1.46 (1.19, 1.78)**	**1.41 (1.16, 1.73)**	**1.49 (1.19, 1.87)**	**1.45 (1.15, 1.82)**	1.15 (0.78, 1.68)	1.11 (0.75, 1.63)
SEIFA ed/occ quintiles [c]	**0.91 (0.87, 0.96)**	**0.95 (0.89, 0.99)**	**0.90 (0.85, 0.96)**	**0.93 (0.88, 0.99)**	**0.88 (0.80, 0.98)**	0.93 (0.84, 1.03)

OR1: Minimally adjusted for baseline age and birth year of the index child *OR2: OR1 + parent's education*

[a]Parental education (highest of mother's or father's) categorised as very low (≤ 10years); low (≤ 12 years/equivalent); intermediate (trade/certificate/diploma); high (degree/higher); and not applicable/don't know *[b]Own education categorised as low (≤ 12 years); intermediate (trade/apprentice/ certificate/diploma); and high (degree/higher)* *[c] SEIFA: Socio-Economic Indexes for Areas (education and occupation)*

Sensitivity analyses showed marginally stronger associations between SEP and breastfeeding for at least six months when analysed among all parous women (Additional information, Table 8.4), and not just among those who had initiated breastfeeding (Table 8.3). Additionally, analyses using multiply imputed data for all exposures and outcomes showed comparable estimates for the association between SEP and breastfeeding initiation (Additional information, Table 8.5) and breastfeeding for at least six months (Additional information, Table 8.6).

8.1.1 Discussion

This study investigated the association between SEP and parity on breastfeeding initiation and duration among a cohort of Australian women. While 60% of women breastfed their first, second and third child for at least six months, we found differences based on completed parity, where multiparous women were more likely to have met this target. While a higher percentage of high-educated women breastfed each child for at least six months, women were less likely to initiate breastfeeding with their youngest child; a difference which was greatest among higher educated women. Overall, women with a lower education were less likely to initiate breastfeeding or to breastfeed for at least six months.

Among our sample, 89% of women had initiated breastfeeding. While a previous Australian study suggested there was an increase in the rate of breastfeeding initiation of infants (to 96% in 2010),[119] our finding of 83% of infants being breastfed is in accordance with a 2001 estimate.[267] Despite this result, we found an increase in the percentage of infants who were breastfed for at least six months; 59% in our study compared to the 2001 Australian estimate of 50% of infants being breastfed at six months (be it exclusive, full/predominant or complementary).[267] Our results indicate that greater support is required in the early phase to assist women in successfully initiating breastfeeding, but more importantly to overcome difficulties in sustaining breastfeeding, be they medical or otherwise.

Consistent with previous Australian findings,[119] we found that low-educated women were less likely to initiate breastfeeding or to breastfeed for at least six months. This may be a result of higher educated women being more receptive to advised health behaviours, or conversely to reduced family support and assistance for breastfeeding among the disadvantaged. While adequate milk supply and no feeding difficulties in the first month postpartum[131] are positively associated with breastfeeding duration, other factors positively associated with breastfeeding initiation and duration, which may also be socially patterned, include: maternal positive attitude towards breastfeeding;[131] not smoking while breastfeeding;[130,131,141] and gestational weight gain within the U.S. Institute of Medicine's guidelines.[143] Higher rates of breastfeeding have been found in Europe and Australia, compared to the U.S. and Canada,[129] which encourages us to consider the importance of social/political contexts in shaping features of the home, work and community environments which may support breastfeeding. This includes not returning to employment early,[131,135] parental leave policies and flexible working conditions;[132] as well as social support, positive cultural norms surrounding breastfeeding, and the visibility of breastfeeding in public.[121] Our finding that all women, particularly those with a high education, were less likely to breastfeed their youngest child may be due to women returning to work soon after having reached their desired number of children, in order to limit their absence from the workforce.

The timing and type of breastfeeding intervention can also influence effectiveness, with a combination of antenatal and postnatal interventions, as well as involving the partner/significant care-giver, being important.[121] However, since population-wide interventions can potentially increase social inequalities through greater uptake and improvements among advantaged individuals,[146] it is important to identify specific barriers to breastfeeding among the most disadvantaged. Evidence suggests that peer support programmes in combination with professional support are effective in increasing breastfeeding rates.[268] With high maternal BMI being associated with socioeconomic disadvantage[141-143] as well as difficulties in breastfeeding,[269] we should not discount this as another key area in reducing inequalities in breastfeeding.

We also found that women with a very low-educated parent, as well as those who did not know their parent's education, were more likely to not initiate breastfeeding. These women, and additionally those with an intermediate- or low-educated parent, were also more likely to not breastfeed for at least six months. This is a concern which highlights possible intergenerational chains of risk, with previous studies showing that women who were themselves breastfed as an infant were more likely to intend to, initiate and persevere with breastfeeding.[145] Not knowing their parent's education level may reflect a poor relationship with their parent or increased family dysfunction, or possibly a low level of education which they do not want to disclose.

Despite potential bias in using income measures as a proxy for SEP among women of reproductive age, it is important to estimate the extent to which material circumstances make it easier or more difficult for women to breastfeed. While we acknowledge that our measurement of financial stress is not ideal (due to the uniform timing of data collection, which does not take account of the individual reproductive histories), our results indicate that material circumstances are important for breastfeeding duration. Women who found it difficult to manage on their income were more likely to not breastfeed their first or second child for at least six months. We speculate this may be due to single mothers and those on a low income being forced back into the labour market earlier than women with the resources to remain at home. Sensitivity analyses using this same measure of financial stress at earlier time points found that if anything, the significant estimates reported possibly underestimate the association.

Having a child may introduce financial strain on the family, through additional costs of care and preclusion from the labour market, and as such the legislative and regulatory environment, as well as social context, is important for providing parents with the support required to make positive choices for their offspring. This includes adequate employment leave and entitlements, marketing restrictions for infant formula, reducing discrimination towards those who breastfeed, and creating breastfeeding friendly workplaces and communities.[121]

With a higher percentage of multiparous women having initiated breastfeeding and breastfed their first child for at least six months, we further speculate that women with hormonal imbalances may find it more difficult to breastfeed and may also be less fertile.

Strengths and limitations

Despite a higher representation of high-educated women, the ALSWH 1973-78 cohort is a nationally representative sample providing longitudinal data over 16 years for women of reproductive age. Very few studies and registers provide information about breastfeeding patterns and behaviours, and while we lack information for some WHO infant feeding categories (exclusive; predominant; and complementary), our analyses still provide valuable information on a national level regarding breastfeeding initiation and duration. From an Australian perspective this is particularly important, since there is a lack of national monitoring of breastfeeding, which would be particularly useful for priority groups (i.e., young mothers, low SEP, indigenous Australians).[121] Additionally, despite rates of breastfeeding initiation and duration being available in most Australian states/territories, consistency in the measurement and collection of these data varies.[121] We acknowledge the potential for recall bias in using breastfeeding duration recorded when women were aged in their thirties, particularly for women who may have had their child many years earlier.

Conclusion

While overall rates of infant breastfeeding initiation have not increased substantially in Australia since 2001, a greater percentage of infants were breastfed for at least six months. Despite this, high-educated multiparous women were less likely to breastfeed their youngest child and disadvantaged women (with a lower education or a low-educated parent) were less likely to initiate breastfeeding or to breastfeed for at least six months. These groups may need greater attention from health care professionals in the antenatal and postnatal periods, in order to gain a greater understanding of and overcome SEP specific barriers to breastfeeding initiation and sustained duration, which may assist in reducing existing inequalities in infant breastfeeding.

8.1.2 Additional information

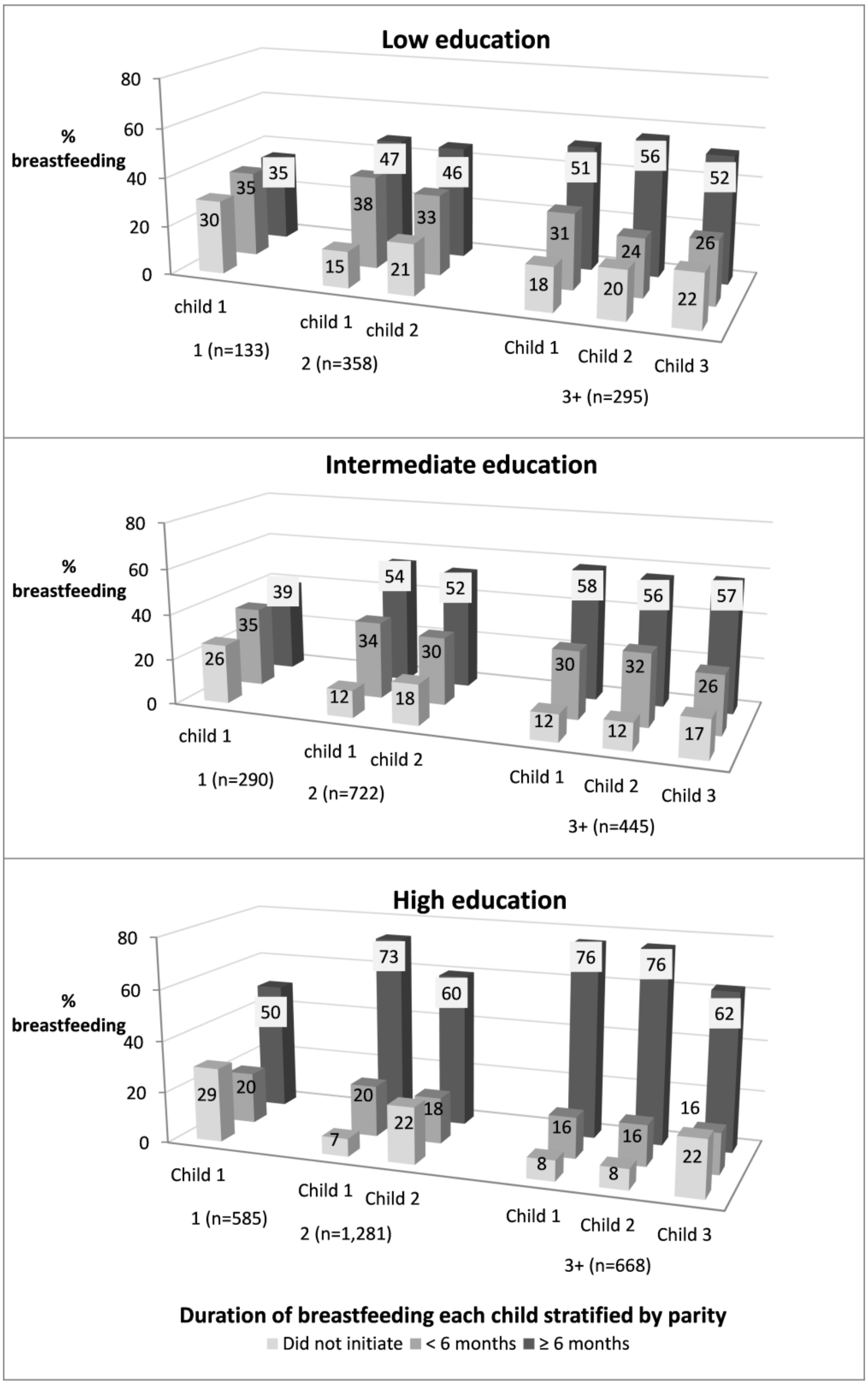

Figure 8.3: Duration of breastfeeding, stratified by highest achieved education and total parity

While overall, a larger percentage of high educated women breastfed each child for at least six months, the largest absolute decrease in the percentage of women who breastfed for at least six months with their youngest, compared to oldest child, was among high educated women.

Table 8.4: Socioeconomic position and odds of not sustaining breastfeeding for at least six months, among ALSWH women (born 1973-78) with an nth child (N=4,777)

Exposures	First child (n=4,777)		Second child (n= 3,769)		Third child (n= 1,408)	
	OR1 (95% C.I.)	OR2 (95% C.I.)	OR1 (95% C.I.)	OR2 (95% C.I.)	OR1 (95% C.I.)	OR2 (95% C.I.)
Parental education [a]						
High	1.00 (ref)		1.00 (ref)		1.00 (ref)	
Intermediate	**1.37 (1.16, 1.61)**		**1.43 (1.19, 1.72)**		1.51 (1.11, 2.06)	
Low	**1.55 (1.26, 1.90)**		**1.64 (1.30, 2.07)**		1.55 (1.06, 2.27)	
Very low	**1.79 (1.51, 2.13)**		**1.73 (1.43, 2.10)**		**1.96 (1.42, 2.70)**	
Not applicable/Don't know	**2.65 (2.08, 3.37)**		**2.57 (1.95, 3.39)**		**3.65 (2.33, 5.71)**	
Own highest education [b]						
High	1.00 (ref)	1.00 (ref)	1.00 (ref)	1.00 (ref)	1.00 (ref)	1.00 (ref)
Intermediate	**2.04 (1.78, 2.34)**	**1.89 (1.64, 2.17)**	**1.75 (1.50, 2.04)**	**1.61 (1.38, 1.89)**	**1.50 (1.16, 1.94)**	**1.32 (1.01, 1.72)**
Low	**2.61 (2.20, 3.10)**	**2.29 (1.92, 2.73)**	**2.04 (1.69, 2.47)**	**1.78 (1.46, 2.17)**	**2.08 (1.54, 2.80)**	**1.73 (1.26, 2.36)**
Area of residence						
Urban	1.00 (ref)	1.00 (ref)	1.00 (ref)	1.00 (ref)	1.00 (ref)	1.00 (ref)
Rural	1.10 (0.96, 1.26)	1.04 (0.91, 1.19)	1.05 (0.91, 1.22)	0.99 (0.86, 1.16)	1.04 (0.81, 1.33)	0.97 (0.75, 1.24)
Remote	0.96 (0.82, 1.12)	0.88 (0.75, 1.04)	1.00 (0.84, 1.20)	0.92 (0.77, 1.10)	0.99 (0.75, 1.32)	0.92 (0.69, 1.23)
Ability to manage on income						
Easy	1.00 (ref)	1.00 (ref)	1.00 (ref)	1.00 (ref)	1.00 (ref)	1.00 (ref)
Sometimes difficult	**1.30 (1.14, 1.48)**	**1.26 (1.11, 1.44)**	**1.29 (1.12, 1.49)**	**1.26 (1.09, 1.45)**	1.25 (0.99, 1.58)	1.21 (0.95, 1.53)
Always difficult	**1.40 (1.18, 1.67)**	**1.36 (1.14, 1.62)**	**1.42 (1.17, 1.73)**	**1.37 (1.13, 1.67)**	1.28 (0.94, 1.74)	1.23 (0.89, 1.68)
SEIFA ed/occ quintiles [c]	**0.90 (0.86, 0.94)**	**0.94 (0.90, 0.98)**	**0.91 (0.86, 0.95)**	**0.94 (0.89, 0.99)**	0.95 (0.87, 1.02)	0.99 (0.91, 1.07)

OR1: Minimally adjusted for baseline age and birth year of the index child *OR2: OR1 + parent's education*

[a]Parental education (highest of mother's or father's) categorised as very low (≤ 10years); low (≤ 12 years/equivalent); intermediate (trade/certificate/diploma); high (degree/higher); and not applicable/don't know *[b]Own highest education categorised as low (≤ 12 years); intermediate (trade/apprentice/ certificate/diploma); and high (degree/higher)* *[c] SEIFA: Socio-Economic Indexes for Areas (education and occupation)*

Table 8.5: Socioeconomic position and odds of not initiating breastfeeding with the first, second and third child, among ALSWH women (born 1973-78) - multinomial logistic regression models using multiply imputed data (N=5,917)

Exposures	**First child (n=5,917)**		**Second child (n= 4,629)**		**Third child (n= 1,736)**	
	OR1 (95% C.I.)	OR2 (95% C.I.)	OR1 (95% C.I.)	OR2 (95% C.I.)	OR1 (95% C.I.)	OR2 (95% C.I.)
Parental education [a]						
High	1.00 (ref)		1.00 (ref)		1.00 (ref)	
Intermediate	1.30 (1.04, 1.62)		1.14 (0.90, 1.45)		1.35 (0.90, 2.02)	
Low	1.18 (0.89, 1.57)		1.09 (0.81, 1.47)		1.23 (0.75, 2.00)	
Very low	**1.43 (1.14, 1.80)**		**1.38 (1.07, 1.72)**		1.31 (0.89, 1.93)	
Not applicable/Don't know	**2.08 (1.54, 2.81)**		**1.88 (1.36, 2.61)**		**3.11 (1.84, 5.26)**	
Own highest education [b]						
High	1.00 (ref)	1.00 (ref)	1.00 (ref)	1.00 (ref)	1.00 (ref)	1.00 (ref)
Intermediate	**1.36 (1.14, 1.62)**	**1.28 (1.07, 1.53)**	1.15 (0.96, 1.39)	1.09 (0.91, 1.32)	1.06 (0.79, 1.41)	0.97 (0.71, 1.31)
Low	**2.05 (1.68, 2.50)**	**1.87 (1.52, 2.31)**	**1.85 (1.50, 2.29)**	**1.69 (1.35, 2.11)**	**1.95 (1.41, 2.68)**	**1.70 (1.25, 2.39)**
Area of residence						
Urban	1.00 (ref)	1.00 (ref)	1.00 (ref)	1.00 (ref)	1.00 (ref)	1.00 (ref)
Rural	**1.25 (1.06, 1.47)**	**1.20 (1.02, 1.41)**	1.00 (0.84, 1.19)	0.97 (0.81, 1.15)	0.85 (0.64, 1.12)	0.80 (0.60, 1.06)
Remote	1.02 (0.83, 1.25)	0.96 (0.78, 1.19)	1.03 (0.84, 1.28)	0.98 (0.80, 1.22)	1.06 (0.77, 1.45)	1.00 (0.72, 1.37)
Ability to manage on income						
Easy to manage	1.00 (ref)	1.00 (ref)	1.00 (ref)	1.00 (ref)	1.00 (ref)	1.00 (ref)
Sometimes difficult	1.13 (0.96, 1.33)	1.10 (0.93, 1.30)	1.13 (0.95, 1.34)	1.11 (0.93, 1.31)	**1.33 (1.02, 1.73)**	**1.30 (1.00, 1.71)**
Always difficult	1.23 (0.99, 1.52)	1.19 (0.96, 1.48)	1.23 (0.98, 1.54)	1.20 (0.95, 1.50)	1.37 (0.97, 1.93)	1.31 (0.92, 1.87)
SEIFA ed/occ quintiles [c]	**0.90 (0.85, 0.95)**	**0.92 (0.87, 0.97)**	**0.92 (0.87, 0.97)**	**0.93 (0.88, 0.99)**	0.98 (0.89, 1.07)	1.01 (0.92, 1.10)

OR1: Minimally adjusted for baseline age and birth year of the index child *OR2: OR1 + parent's education*

[a]Parental education (highest of mother's or father's) categorised as very low (≤ 10years); low (≤ 12 years/equivalent); intermediate (trade/certificate/diploma); high (degree/higher); and not applicable/don't know *[b]Own education categorised as low (≤ 12 years); intermediate (trade/apprentice/ certificate/diploma); and high (degree/higher)* *[c] SEIFA: Socio-Economic Indexes for Areas (education and occupation)*

Table 8.6: Socioeconomic position and odds of not sustaining breastfeeding for at least six months, among ALSWH women (born 1973-78) who initiated breastfeeding with each child - multinomial logistic regression models using multiply imputed data (N=5,061)

Exposures	First child (n=5,061)		Second child (n= 3,811)		Third child (n= 1,366)	
	OR1 (95% C.I.)	OR2 (95% C.I.)	OR1 (95% C.I.)	OR2 (95% C.I.)	OR1 (95% C.I.)	OR2 (95% C.I.)
Parental education [a]						
High	1.00 (ref)		1.00 (ref)		1.00 (ref)	
Intermediate	**1.34 (1.11, 1.63)**		**1.53 (1.16, 2.02)**		1.50 (0.99, 2.26)	
Low	**1.69 (1.33, 2.14)**		**1.62 (1.15, 2.29)**		**1.73 (1.07, 2.82)**	
Very low	**1.82 (1.49, 2.22)**		**1.72 (1.28, 2.33)**		**2.34 (1.55, 3.52)**	
Not applicable/Did not know	**2.31 (1.76, 3.03)**		**2.44 (1.65, 3.61)**		**2.86 (1.64, 4.99)**	
Own highest education [b]						
High	1.00 (ref)	1.00 (ref)	1.00 (ref)	1.00 (ref)	1.00 (ref)	1.00 (ref)
Intermediate	**2.16 (1.88, 2.50)**	**2.03 (1.75, 2.35)**	**1.97 (1.57, 2.47)**	**1.89 (1.57, 2.27)**	**1.86 (1.35, 2.55)**	**1.64 (1.18, 2.27)**
Low	**2.38 (2.00, 2.83)**	**2.13 (1.77, 2.56)**	**2.03 (1.69, 2.44)**	**1.72 (1.36, 2.18)**	**2.06 (1.43, 2.98)**	**1.72 (1.18, 2.52)**
Area of residence						
Urban	1.00 (ref)	1.00 (ref)	1.00 (ref)	1.00 (ref)	1.00 (ref)	1.00 (ref)
Rural	1.08 (0.94, 1.24)	1.02 (0.89, 1.18)	1.09 (0.91, 1.30)	1.02 (0.85, 1.22)	1.26 (0.93, 1.72)	1.18 (0.86, 1.60)
Remote	0.93 (0.79, 1.09)	0.86 (0.72, 1.01)	1.01 (0.81, 1.24)	0.92 (0.74, 1.14)	1.07 (0.75, 1.52)	0.99 (0.70, 1.43)
Ability to manage on income						
Easy to manage	1.00 (ref)	1.00 (ref)	1.00 (ref)	1.00 (ref)	1.00 (ref)	1.00 (ref)
Sometimes difficult	**1.40 (1.21, 1.62)**	**1.34 (1.18, 1.53)**	**1.32 (1.11, 1.57)**	**1.30 (1.09, 1.55)**	1.11 (0.82, 1.49)	1.05 (0.78, 1.42)
Always difficult	**1.46 (1.19, 1.78)**	**1.51 (1.27, 1.80)**	**1.49 (1.19, 1.87)**	**1.45 (1.15, 1.82)**	1.15 (0.78, 1.68)	1.11 (0.75, 1.63)
SEIFA ed/occ quintiles [c]	**0.87 (0.86, 0.94)**	**0.92 (0.88, 0.97)**	**0.90 (0.85, 0.96)**	**0.93 (0.88, 0.99)**	0.92 (0.83, 1.01)	0.93 (0.84, 1.03)

OR1: Minimally adjusted for baseline age and birth year of the index child *OR2: OR1 + parent's education*

[a]Parental education (highest of mother's or father's) categorised as very low (≤ 10years); low (≤ 12 years/equivalent); intermediate (trade/certificate/diploma); high (degree/higher); and not applicable/don't know *[b]Own education categorised as low (≤ 12 years); intermediate (trade/apprentice/ certificate/diploma); and high (degree/higher)* *[c] SEIFA: Socio-Economic Indexes for Areas (education and occupation)*

8.2 Conclusion

While breastfeeding is not associated with long term body weight among women, it is associated with reduced odds of overweight and obesity in the adult offspring; therefore, focusing on socioeconomic specific barriers to breastfeeding may assist in reducing social inequalities in body weight in the long term. Given that breastfeeding is also beneficial for child-parent bonding and attachment, and that social differences in breastfeeding initiation and duration were found in this study, promoting breastfeeding when it is possible should be continued and supported, particularly among disadvantaged women.

The provision of paid parental leave entitlements offers numerous important benefits for healthy early development and should continue to be prioritised. A recent Swedish study found that rates of breastfeeding declined among women of all SEP groups (measured using education, marital status, or disposable income) between 2004-2010, though the differences between groups did not increase.[270] This study did not find a significant association between level of disposable income and the odds of breastfeeding at one week, four months, or six months, although education was significantly inversely associated with breastfeeding at each time point.[270] These results suggest that other factors beyond financial stress may be driving social differences in breastfeeding; given that, even in Sweden – a country with a generous welfare state, that can minimise the financial stress experienced due to child-rearing - educational differences in breastfeeding remained.

As discussed within this chapter, greater support is required in the early phase to assist women to successfully initiate breastfeeding and, more importantly, to overcome difficulties in sustaining breastfeeding, be they medical or otherwise. Both antenatal and postnatal interventions are important,[121] since breastfeeding intention is highly correlated with actually breastfeeding. This highlights the import role of both midwives and prenatal care providers for encouraging and supporting women to breastfeed, particularly women who are most disadvantaged. A focus on socioeconomic specific barriers to breastfeeding is needed not only at the individual level, but at the group and societal levels. This includes features of the home/work/community environment, such as access to and duration of parental leave, employment flexibility, and social support, as well as addressing the cultural norms surrounding breastfeeding and the visibility of breastfeeding in public.[121] This has the potential for intergenerational influence beyond that for the offspring, with previous studies finding that women who were themselves breastfed as an infant were more likely intend to, to initiate, and to persevere with breastfeeding.[145]

Additionally, attention should be paid to the timing of interventions, in order to increase their effectiveness through adopting a multi-faceted approach,[271] and using a combination of antenatal and postnatal interventions which also involve the partner/significant care-giver.[121] Doing so may assist in reducing social inequalities in breastfeeding and hence long term obesity in the offspring.

Chapter 9. The role of reproductive factors in modifying the association between education and body weight trajectory

Study 1 (**Chapter 5**) found social differences in body weight over 16 years among a contemporary cohort of Australian women; low educated women started at a heavier weight and gained more weight over time, compared to high educated women. While age at first birth is inversely associated with adiposity in later life, and total parity is positively associated, a U.K. study suggests that lifestyle factors associated with child rearing may be more important than the biological effects of child bearing.[85] **Chapter 9.1** presents results from the final study within this thesis, which aims to investigate whether such social differences in body weight remain after accounting for women's reproductive histories.

In order to adapt to the format of this thesis, only the numbering of tables and figures have been modified from the original manuscript submitted for review. This manuscript has been formatted according to the journal's requirements.

9.1 Combined effect of education and reproductive history on the weight trajectories of young Australian women: a longitudinal study (*Study 5*)

- **Holowko N**, Jones M, Tooth L, Koupil I, Mishra G. Combined effect of education and reproductive histories on weight trajectories of young Australian women: A longitudinal study. *Obesity (Silver Spring).* 2016. Oct 21 (10):2224-31. doi: 10.1002/oby.21610.

Abstract

Objective: To investigate the combined effect of education and reproductive history on weight trajectory.

Methods: We analysed the association of education with weight trajectory (1996-2012) in relation to reproductive history among 9,336 women (born 1973-78) from the Australian Longitudinal Study on Women's Health using random effects models.

Results: Compared to women with a university degree/higher, lower educated women were 2 kg heavier at baseline and gained an additional 0.24 kg/year. Giving birth was associated with an increase in weight which was more pronounced among women having their first birth < 26 years of age (2.1 kg, 95% C.I. 1.5, 2.7), compared to 26-32 years or > 32 years. While younger first time mothers had a steeper weight trajectory (~+0.16 kg/year, 0.1, 0.3), this was less steep among lower educated women. High-educated women with a second birth between 26-32 years had 0.9 kg decreased weight after this birth, while low-educated women gained 0.9 kg.

Conclusions: While the effect of having children on weight in young adulthood was minimal, women with their first birth < 26 years of age had increased risk of weight gain, particularly primiparous women. Educational differences in weight persisted after accounting for reproductive history, suggesting a need to explore alternative mechanisms through which social differences in weight are generated.

What is already known about this subject:

- Socioeconomic position is inversely associated with body weight among women in adult life
- Reproduction may also act as a possible catalyst for overweight and obesity development in women
- Some studies have found higher weight gain among parous compared to nulliparous women, however the combined effect of socioeconomic position and reproductive events on body weight trajectory is not fully understood

What this study adds:

- There was not a large effect of having children on body weight over time (from age 18-23 years to age 34-39 years)
- Women having their first birth < 26 years of age had increased risk of weight gain
- Educational differences in weight persisted after accounting for the number and spacing of pregnancies, suggesting a need to explore alternative mechanisms through which social differences in weight are generated.

9.1.1 Introduction

Almost two-thirds of the Australian population were overweight/obese in 2014-15,[2] with a trend of increasing body mass index (BMI) among both Australian men and women from 1980-2007.[1]

There is a well-established inverse association between socioeconomic position (SEP) and body weight among women in early to mid-adulthood[10-14,78,272] and mid-late adulthood.[12,14] Weight differences are also reportedly increasing among younger female cohorts,[173] and there is evidence of educational differences in mean BMI having widened, particularly among the top 5% of the BMI distribution.[1] Suspected mechanisms through which SEP differences in weight may manifest include the widely researched areas of social, physical and behavioural characteristics: low physical activity;[10] high energy intake;[15] increased sitting time;[56] quitting smoking;[88] alcohol consumption (u-shaped association);[61] and being married or having a partner.[10]

Reproduction may also act as a possible catalyst for overweight/obesity development in women. While both high pre-pregnancy BMI and excessive gestational weight gain are individually and in combination associated with high postpartum weight retention,[102] other aspects of reproduction are also associated with adiposity. Some studies find a positive association between number of children and prevalence of obesity in mid-to-later life,[15,78,82,84] while others find the greatest effects are in relation to having the first child.[79,80] With regard to age at birth of first child, some studies suggest a linear and inverse association with adiposity,[85] while others suggest a u-shaped association.[80] Short birth intervals are also associated with increased risk of maternal obesity.[110]

Compared to women without children, studies in the U.S.[76] and Sweden[77] have attributed only marginally higher 5-10 year weight gain to having had children. Other studies suggest that there is an effect of having children; in the U.S., an additional 3-6 kg weight gain over 10 years is associated with one or more births (or 'short' pregnancies < 20 weeks gestation) within this period.[79] Another U.S. study showed greater 15-year weight gain among parous women, compared to nulliparous, with higher education also associated with faster weight gain over time.[80]

While the literature outlines associations between SEP[10-14,78,173,272] and reproductive factors (number of children,[15,78,79,82,84] age at first birth,[80,85] and birth intervals[110]) with greater long term body weight, to our best knowledge no studies have investigated their combined effect. This study investigates the combined effect of education and reproductive history (including age at each birth, total number of children and birth intervals) on the weight trajectory of young women, in order to establish paths through which reproduction may become a sensitive period for weight development.

9.1.2 Methods

The Australian Longitudinal Study on Women's Health (ALSWH) is a population-based cohort study, consisting of a sample of Australian citizens and permanent residents randomly selected from the national health and insurance database (Medicare). A self-reported survey was completed in 1996 (baseline) and at ~3-4 year intervals thereafter. The surveys include demographic, social, physical, psychological and behavioural questions covering major aspects of women's health, well-being and health-service use. Further details about ALSWH recruitment and study design can be found elsewhere.[188,202]

Our sample is from the ALSWH cohort born in 1973-78 (aged 18-23 years at baseline); with ~41% of women initially sampled having completed the baseline survey (n= 14,247, ~2.1% of the Australian population of the same age). These women are generally found representative of Australian women of this age; although women with a high education, married/de facto, or born in Australia were slightly over-represented, and women in the workforce were slightly under-represented.[202] Analysis of the relatively high attrition between baseline and Survey Two (68% response rate; n=9,688; conducted in 2000; women aged 22-27 years) has concluded that possible biases due to loss to follow-up do not limit significant longitudinal analysis of these data.[187] This attrition is thought to be a result of a high level of mobility, including extended travel abroad; changes in surname upon marrying; unlisted phone numbers; and not being registered to vote.[188] Attrition at subsequent surveys was: Survey Three 64% (n=9,081; 2003; aged 25-30 years); Survey Four 64% (n=9,145; 2006; aged 28-33 years); Survey Five 58% (n=8,200; 2009; aged 31-36 years); and at Survey Six 56% (n=8,010; 2012; aged 34-39 years).

We restricted our sample to women who reported their body weight in at least two surveys (n=11,564) and had information available for highest achieved education (N=9,336). Compared to women who answered more than one survey, those who answered only Survey One were slightly younger (20.65 vs. 20.78 years old) and lighter at baseline (61.48kg vs. 62.73kg), and significantly more likely to have a low education (74.5% vs 70.8%), find it difficult to manage on their income (23.5% vs 17.5%), have poor mental health (26.2% vs 20.9%) and less likely to live in an urban area (51.4% vs 53.9%).

Measurements

Exposures - Indicator of socioeconomic position and reproductive events

Our main exposure was the woman's highest achieved education, collected at age 34-39 years (if missing then at 31-36 years) and categorised as low (≤ 12 years); intermediate (trade/apprentice/certificate/diploma); or high (degree/higher).

Age at delivery of the first and second child was calculated using the woman's and children's dates of birth. Age at each index delivery was then categorised into three groups of sufficient size based on our sample distribution (< 26 years; 26-32 years; > 32 years).

Birth interval between the first and second, and second and third child was calculated in months by subtracting dates of birth. Time since each delivery was measured as a time-varying covariate and calculated based on the woman's age at the index delivery (< 26 years; 26-32 years; > 32 years). This variable had a value of zero up until the delivery of the nth child, from which point the number of months since delivering that nth child was recorded.

Total number of children was calculated based on self-reported dates of birth of children and categorised as no children; one; two; or three or more children. Due to unreliability of self-reported data on stillbirths and live births, total parity was not calculated.

Outcome – Body weight

Women self-reported their weight at each survey by answering "How much do you weigh without clothes or shoes (if you are not sure, please estimate)?" All answers (recorded in kilograms/grams or stones/pounds) were converted into kilograms/grams. From Survey Four onwards, pregnant women were specifically asked to report their weight in the month prior to conception. Given this, weight at the respective survey was excluded for women who were pregnant at Survey One (1996, n=90), Two (2000, n=78) or Three (2003, n=30).

Covariates

Variables commonly associated with SEP and body weight were measured at each self-reported survey as follows: marital status (married/de facto; separated/divorced/widowed; never married); smoking status (current smoker; non-smoker; ex-smoker); alcohol intake (never/rarely; low risk ≤ 14 drinks/week; risky/high risk 15+ drinks/week);[193] physical activity as MET/mins per week (nil/sedentary 0-40; low 40 - < 600; moderate 600 - < 1200; high ≥ 1200);[194] ability to manage on their available income (impossible/always difficult; sometimes difficult; not too bad/easy); body dissatisfaction, as measured by the question "In the past month, how dissatisfied have you felt about your shape?" (not at all; slightly; moderately; markedly); self-rated health (excellent; very good; good; poor/fair); and health compared to a year ago (better; about the same; worse).

Mental health (poor ≤ 52; good > 52) was measured using the Mental Health Index (MHI-5) subscale of the SF-36 (Medical Outcomes Study short form 36 health survey).[195] Country of birth was dichotomised, given that a large proportion of women were born in Australia. Area of residence at baseline was categorised as urban (major cities); rural (inner regional); or remote (outer regional/remote).

Statistical analysis

Descriptive analyses, using ANOVA and Pearson's chi-square tests, were used to describe the sample at age 18-23 years and 34-39 years, including the association of highest education with number of children, and mean weight at age 34-39 years based on these characteristics. In order to visualise the combined effects of education with reproductive characteristics, mean weight at each survey was plotted based on highest achieved education and combinations of categories of age at first birth and number of deliveries by age 34-39 years i.e., no children; first delivery < 26 years, 1 child; first delivery < 26 years, 2+ children. Detailed information based on the various combinations of categories of age at first and second delivery is found in Additional information, Figure 9.2.

We used random effects linear mixed models (SAS PROC Mixed) to model self-reported body weight over 16 years (continuous outcome variable) by highest achieved education, while taking into account the number and timing of reproductive events. The effect of each category of age at birth is modelled in reference to all other women. To account for correlations between observations and within individuals, all models included a random intercept and slope for each individual,[205] while all other variables were modelled as fixed-effects (included as categorical or ordinal, fixed- or time-varying based on model comparison). The time scale was number of years since baseline, with a quadratic term for time included in all models to account for a slight attenuation in weight over time. Model 1 is adjusted for area of residence (due to an initial oversampling of women living in rural/remote areas), as well as age and height at baseline centred at the cohort means (20.7 years and 165.6 cm). Reproductive history is included in Model 2, while additional covariates associated with SEP and body weight and reproduction were included in Model 3.

Akaike Information Criteria (AIC) goodness of fit statistics were used to assess initial model fit, with lower values indicating a better model. In order to find the most parsimonious and interpretable model, estimates of Type 3 fixed-effects were then considered using a stricter value of $p<0.01$, in order to exclude interactions and variables possibly resulting from random error. Sensitivity analysis modelling BMI over time showed the same association with education as those presented (Additional information, Table 9.4).

The ALSWH study has obtained informed consent from all study participants and is approved by the Human Research Ethics Committees of the University of Newcastle and the University of Queensland.

9.1.3 Results

While a quarter of women had an overweight or obese weight status at baseline, by age 34-39 years almost half the sample had a BMI ≥ 25 (Table 9.1). Half of the sample had achieved a university degree or higher and the mean age at first delivery was 28.1 years, with a mean birth interval between children of almost three years. Almost a third of women did not have children and over half the sample had two or more children (Table 9.1).

Highest achieved education was inversely associated with total number of children at age 34-39 years (Table 9.2). While a similar percentage of women of all education groups had one child, significantly fewer women with a high education had more than two children (Table 9.2).

Overall effect of having children on body weight

Figure 9.1 descriptively shows the mean body weight at six time points (from age 18-23 years to 34-39 years), with weight differences increasing overtime based on i) age at first delivery, and ii) whether women had more than one child. Overall, women who had their first child at a younger age tended to be heavier at each survey. Additionally, with the exception of women who had their first birth > 32 years, women who went on to have a second child were lighter than women who did not (Figure 9.1).

Individual and combined effects of education and timing of births on self-reported body weight

There was an overall large increase in mean body weight over time and increased differences by highest achieved education (Additional information, Figure 9.2). The random effects model supports an inverse association between education and both baseline weight and weight gain over 16 years after adjusting for behavioural and lifestyle factors: compared to high educated women, low and intermediate educated women weighed an additional ~2.2 kg at baseline and gained an extra ~0.24 kg per year (Table 9.3, Model 2).

Table 9.1: Characteristics of sample at baseline and Survey Six among ALSWH women born 1973-78 (N=9,336)

	Baseline 1996: 18-23 years N=9,336	**Survey Six** 2012: 34-39 years N=7,927
<u>**Social and anthropometric characteristics**</u>		
Mean (SD)		
Age (years)	20.8 (1.5)	36.7 (1.5)
Weight (kg)	62.6 (12.1)	72.7 (17.7)
Height (cm)	165.7 (7.2)	-
Percentage (%)		
BMI		
Underweight (< 18.5)	9.3	2.4
Normal weight (18.5-24.9)	69.7	48.7
Overweight (25.0–29.9)	15.1	26.0
Obese (≥ 30.0)	5.9	22.9
Highest achieved education [a]		
Low	69.3	16.2
Intermediate	16.6	29.6
High	14.1	54.2
Marital status		
Never married	79.0	13.9
Married/de facto	20.4	78.8
Separated/divorced /widowed	0.6	7.3
Physical activity		
Nil/Sedentary	5.6	14.8
Low	37.0	37.9
Moderate	13.6	21.3
High	43.7	26.0
Alcohol intake		
Never/rarely	40.3	37.2
Low risk	52.6	58.2
Risky/high risk	5.1	4.6
Smoking status		
Non-smoker	56.2	52.0
Ex-Smoker	14.8	36.4
Current smoker	29.0	11.7
Mental health (based on MHI-5)		
Poor (≤ 52)	19.7	13.6
Good (> 52)	80.3	86.4

Country of birth		
Australia	92.9	-
Other	7.1	-
Area of residence		
Urban (major cities)	52.9	57.7
Rural (inner regional)	30.1	26.6
Remote (outer regional/ remote)	17.1	15.7
Reproductive characteristics		
Mean (SD)		
Age at first delivery	-	28.1 (4.6)
Birth interval between child 1 & 2 (months)	-	33.0 (21.3)
Birth interval between child 2 & 3 (months)	-	36.5 (23.8)
Percentage (%)		
Total number of children		
No children	93.9	27.7
1 child	4.8	16.5
2children	1.1	35.0
3+ children	0.2	20.8

[a] Own education categorised as low (≤ 12 years); intermediate (trade/apprentice/ certificate/diploma); and high (degree/higher)
SD – standard deviation

An inverse association was found between highest achieved education and mean weight at each follow-up, regardless of total number of children (Additional information Figure 9.2, and Table 9.2). With the exception of women with a first delivery < 26 years who had only delivered one child, higher educated women tended to have the lowest mean weight over time, in particular those who were multiparous (Additional information, Figure 9.2). The mean weight at age 34-39 years was greatest for high educated women without any children and intermediate educated women with one child (Table 9.2): for low educated women, there was no statistically significant difference in mean body weight based on total number of children (p=0.18, Table 9.2).

Table 9.2: Mean weight (SD) at Survey Six (age 34-39 years) by total number of children and highest achieved education, among ALSWH women born 1973-78 (n=9,336)

	Mean weight (kg) at age 34-39 years by total number of children										
	Overall		*No children*		*1 child*		*2children*		*3+children*		*p- value**
Highest education[a]	%	Mean (SD)	%	Mean (SD)	%	Mean (SD)	%	Mean (SD)	%	Mean (SD)	
Low	16.2	76.5 (19.2)	16.9	77.4 (22.2)	15.9	78.8 (22.5)	37.2	75.6 (17.4)	30.0	76.0 (17.7)	0.18
Intermediate	29.6	75.1 (19.0)	23.3	79.6 (23.6)	16.2	74.7 (18.3)	37.9	73.8 (16.5)	22.6	73.1 (17.3)	<0.0001
High	54.2	70.2 (16.1)	33.3	71.6 (18.0)	16.9	69.7 (15.2)	32.7	69.5 (14.9)	17.0	70.0 (15.8)	0.003

[a] *Own highest education categorised as low (≤ 12 years); intermediate (trade/apprentice/ certificate/diploma); and high (degree/higher)*

**p-value from ANOVA test comparing the difference in mean weight among women of different education levels and based on total number of children   SD – standard deviation*

Effect of the first delivery and its timing

Having a first delivery was associated with an increase in body weight that was unattributed to other factors and most pronounced among younger first-time mothers. After the first delivery, women aged > 32 years were 0.7 kg heavier, while those aged between 26-32 years or < 26 years were 1.2 kg and 2.1 kg heavier, respectively (Table 9.3, Model 2).

While women with a first delivery < 26 years of age also had a steeper weight trajectory (0.17 kg/year), a test for interaction showed a statistically significant attenuation in this trajectory among lower educated women (-0.22 kg/year). There was indication of further increased weight gain after having the first child among lower educated women aged ≥ 26 years, however this interaction was not statistically significant, possibly due to low numbers.

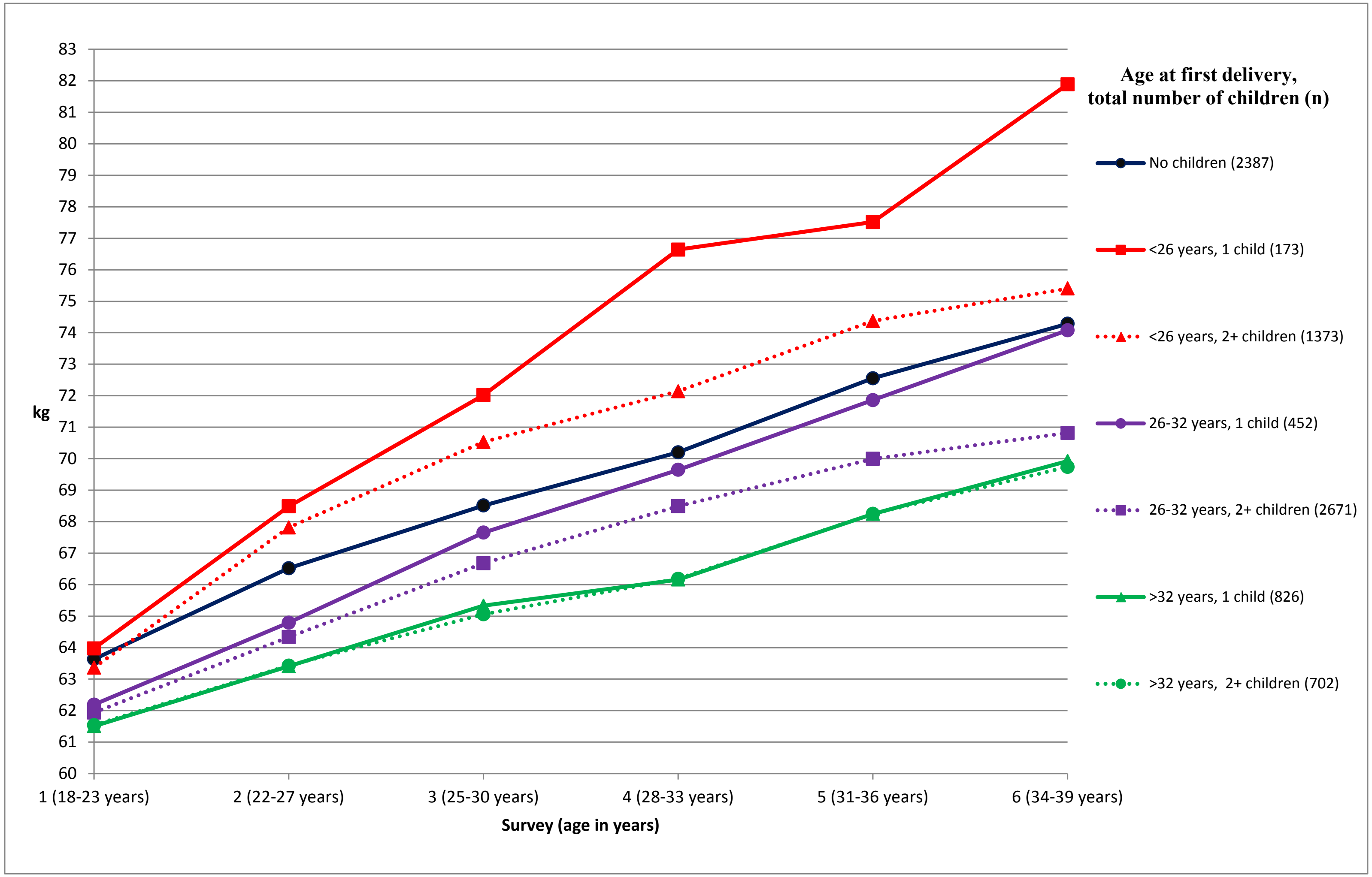

Figure 9.1: Mean body weight at each survey based on categories of age at first delivery and total number of children

With the exception of women having their first child > 32 years, multiparous women had a lower mean weight from mid –twenties onwards, compared to primiparous women. Highest achieved education categorised as low (≤ 12 years); intermediate (trade/apprentice/ certificate/diploma); and high (degree/higher)

Table 9.3: Effect estimates from random effects linear mixed models of self-reported body weight over 16 years by highest achieved education (at Survey Six, age 34-39 years) among women from the 1973-78 ALSWH cohort (n=9,127*) (bolded estimates significant at p <0.05)

	% weighted [a] (unweighted)	Model 1 Estimate (95% CI)	Model 2 Estimate (95% CI)	Model 3 Estimate (95% CI)
Baseline weight (kg)		**60.66 (60.22, 61.09)**	**60.78 (60.34, 61.21)**	**54.89 (53.74, 56.04)**
Difference in baseline weight by highest achieved education [b]				
High	50.0 (54.2)	Reference	Reference	Reference
Intermediate	31.4 (29.6)	**2.62 (2.01, 3.24)**	**2.24 (1.62, 2.86)**	**1.76 (1.16, 2.36)**
Low	18.6 (16.2)	**2.89 (2.11, 3.67)**	**2.26 (1.48, 3.05)**	**1.71 (0.95, 2.45)**
Increase per year since baseline (kg)		**0.82 (0.78, 0.85)**	**0.69 (0.65, 0.73)**	**0.69 (0.65, 0.73)**
Difference in increase per year by highest achieved education [b]				
High		Reference	Reference	Reference
Intermediate		**0.19 (0.15, 0.23)**	**0.24 (0.19, 0.29)**	**0.23 (0.18, 0.27)**
Low		**0.23 (0.19, 0.28)**	**0.23 (0.16, 0.30)**	**0.21 (0.14, 0.28)**
Effect of having children [c]				
Age at first delivery				
< 26 years			**2.07 (1.48, 2.66)**	**1.67 (1.10, 2.24)**
26 – 32 years			**1.16 (0.86, 1.47)**	**0.86 (0.55, 1.16)**
> 32 years			**0.72 (0.25, 1.18)**	0.22 (-0.23, 0.68)
Age at second delivery				
< 26 years			1.69 (-0.03, 3.40)	1.27 (-0.39, 2.93)
26 – 32 years			**-0.91 (-1.43, -0.39)**	**-1.36 (-1.86, -0.86)**
> 32 years			-0.36 (-0.90, 0.18)	**-0.92 (-1.45, -0.39)**
Time since first delivery (based on categories of age at first delivery)				
< 26 years			**0.16 (0.04, 0.28)**	**0.16 (0.04, 0.27)**
26 – 32 years			-0.02 (-0.14, 0.09)	-0.04 (-0.15, 0.07)
> 32 years			0.05 (-0.15, 0.25)	0.06 (-0.13, 0.26)
Time since second delivery (based on categories of age at second delivery)				
< 26 years			-0.08 (-0.20, 0.04)	-0.07 (-0.18, 0.05)
26 – 32 years			**-0.14 (-0.24, -0.04)**	-0.09 (-0.19, 0.01)
> 32 years			-0.15 (-0.32, 0.01)	0.01 (-0.15, 0.17)
Significant interactions with education				
Education x Age at second delivery				
< 26 years				
High			Reference	Reference
Intermediate			-1.19 (-3.18, 0.81)	-1.05 (-2.98, 0.88)

Low	0.76 (-1.31, 2.83)	1.03 (-0.97, 3.03)
26-32 years		
High	Reference	Reference
Intermediate	**1.10 (0.32, 1.87)**	**1.02 (0.28, 1.77)**
Low	**1.88 (0.94, 2.82)**	**1.91 (0.99, 2.83)**
> 32 years		
High	Reference	Reference
Intermediate	0.78 (-0.11, 1.66)	0.83 (-0.03, 1.69)
Low	**1.67 (0.46, 2.88)**	**1.74 (0.57, 2.91)**
Education x Time since first delivery (based on categories of age at first delivery)		
< 26 years		
High	Reference	Reference
Intermediate	**-0.22 (-0.35, -0.09)**	**-0.19 (-0.31, -0.07)**
Low	**-0.22 (-0.36, -0.07)**	**-0.20 (-0.34, -0.06)**
26-32 years		
High	Reference	Reference
Intermediate	**-0.30 (-0.43, -0.16)**	**-0.26 (-0.39, -0.13)**
Low	**-0.21 (-0.38, -0.04)**	**-0.18 (-0.35, -0.02)**
> 32 years		
High	Reference	Reference
Intermediate	-0.29 (-0.62, 0.03)	-0.22 (-0.53, 0.10)
Low	-0.42 (-0.88, 0.05)	-0.29 (-0.75, 0.16)

[a] *% weighted for area of residence at baseline*

[b] *Own education categorised as low (≤ 12 years); intermediate (trade/apprentice/ certificate/diploma); and high (degree/higher)*

[c] *The effect of having children was quantified for each additional child 1) by the initial change in weight recorded at the first survey after having the index child (for age at index delivery) and 2) by the change in trajectory overtime after the index birth (for time since index delivery). The effect of each category of age at birth was modelled in reference to all other women*

** Sample slightly smaller than the 9,336 women who had a value for highest achieved education, due to missing values for some covariates*

Model 1 - adjusted for baseline centred age, baseline centred height and area of residence

Model 2 - Model 1 + the effect of having children (age at first and second, time since first and second delivery, and interaction effects)

Model 3 - Model 2 + country of birth, physical activity, alcohol intake, mental health, income management, self-rated health, age at first birth, marital status, shape dissatisfaction

Note: Interaction terms should be interpreted in combination with the main effects. For example (Model 2), having a second birth between age 26-32 years was associated with a 0.91 kg reduction in weight among high educated women only. Significant interaction showed that, compared to high educated women, *intermediate educated women gained 0.19 kg (1.10, 95% C.I 0.32, 1.87) and low educated women gained 0.97 kg (1.88, 95% C.I. 0.94, 2.82) after their second birth*

Effect of the second delivery and its timing

Having a second delivery between 26-32 years of age was associated with a 0.9 kg reduction in weight (Table 9.3, Model 2). A statistically significant interaction between highest achieved education and having a second delivery showed that this reduction was only among high educated women: intermediate educated women tended to only gain a marginal amount, while low educated women gained 0.9 kg.

We did not find a significant effect of having a third child nor the birth interval between children (results not shown) on body weight trajectory.

9.1.1 Discussion

Using 16 years of data from a nationally representative Australian cohort, we investigated the association of education with body weight over time in relation to reproduction. Overall, we found a large increase in mean body weight over time and increased educational differences: compared to high educated women, lower educated women were ~2 kg heavier at baseline and gained an additional ~0.24 kg/year. While the effects of having children were not large, having a first birth was associated with an increase in weight which was more pronounced among women giving birth < 26 years (2 kg), regardless of education level. These younger first time mothers also had a steeper weight trajectory, which was most pronounced among higher educated women. Having a second birth between 26-32 years was associated with a 0.9 kg decrease in weight among high educated women only; among low educated women this was associated with a 0.9 kg increase.

While some studies have found no association between age at birth of first child and weight at 1 year postpartum,[99] our study is in accordance with studies which have found increased risk of higher weight gain among younger mothers. A U.S. study found that, compared to mothers aged ≥ 30 years, those aged 24-30 years had increased risk of becoming overweight 1.5 years after their first pregnancy;[107] while a Swedish study[108] found increased risk of becoming overweight or obese among women having their first child aged between 17-19 years, compared to women aged ≥ 23 years. Another study has suggested a u-shaped association, with an optimal age of 26.8 years and first births earlier or later than this associated with a steeper weight trajectory.[80]

While other studies in the U.S.,[82] U.K.[84] and Sweden[15] show a positive association between parity and the prevalence of obesity in mid-to-later life, some studies suggest that the greatest gains in weight due to childbearing are mainly after the first and not subsequent births.[86,87] We found that multiparous women tended to have a lower weight at each survey, compared to primiparous women, which we speculate may be due to a healthier hormonal profile among women able to successfully give birth to more than one child. In contrast, a U.S. Study[273] found a similar increased risk of becoming obese among primiparous and multiparous women, compared to nulliparous women. Excess gestational weight gain is one suggested mechanism for higher long term weight among primiparous compared to nulliparous women,[110] although we did not have such information available to include in our analyses.

We did not find a significant effect of the birth interval between children on body weight, despite previous literature suggesting that a short birth-to-pregnancy interval (usually < 12 months between the end of one pregnancy and the start of the next) is associated with increased risk of obesity after childbirth.[107,110] We also did not find a significant effect of having a third child on body weight (results not shown); only one-fifth of women in this sample had more than two children, so data from future surveys will be useful in addressing the effect of higher parity, particularly among women with completed parity. Given the significant interaction between education and having a second birth, together with fewer higher educated women going on to have more than one child, we suspect that women planning to have only two children probably wait until they have had this second child before trying to lose additional weight.

A main strength of this study is having longitudinal data over 16 years for a large sample of women of reproductive age, including a number of behavioural and demographic covariates associated with body weight. Application of statistical methods for longitudinal data analyses accounted for correlation between multiple observations per individual and catered for the richness of the data by including time-varying covariates. Given that a large percentage of women had more than one child, we were also able to account for the effect of the birth interval between children on body weight.

Potential study limitations include self-reporting of height and body weight which, respectively, are notoriously over- and under-reported, particularly among heavier women,[10] although both are found reasonable to use in epidemiological studies.[210] Compared with Australian estimates,[2] a significantly smaller percentage of ALSWH women were overweight/obese (~49% vs ~63%); these estimates may not be directly comparable due to an over-representation of high-educated women in the ALSWH, and these population estimates including both men and women, and older adults. Despite this, we are not aware of any studies indicating that weight underestimation differs according to SEP. We have modelled self-reported body weight, adjusting for height centred at the cohort mean to improve model fit and allow baseline weight to vary by participant's height. However, we also report consistent modelling results for BMI in the data supplement. An additional limitation is an over-representation of high educated women in this cohort at baseline (12% compared to the 1991 Australian census estimate of 3%),[202] and the selective attrition over subsequent surveys, resulting in 54% of the sample having a high education at the most recent follow-up. Within the epidemiological and public health literature, highest achieved education is a commonly used measure of SEP. An earlier analysis showed poor model fit when modelling education as a time-varying exposure and, given the findings from a previous ALSWH study,[272] we used highest achieved education as a suitable measure of our exposure, adult SEP.

We acknowledge the potential limitation of capturing incomplete reproductive histories, given that women were aged 34-39 years when total number of children was calculated. While a proportion of the 28% of women who did not have children (mean age of 36.4 years) may go on to have children, given a 2006 estimation that 15% of women aged 40-44 years will remain without children,[237] we estimate that 90% of women in this cohort have already had their first child. Additionally, the mean age at birth of the first child among these ALSWH women (28.1 years) was similar to the 2012 Australian average of 28.4 years.[234] Due to unavailability of reliable information on the number of still births, we were unable to calculate total parity, and so have approximated this by using the number of reported dates of birth. Additionally, compared with the 2011 census,[191] generalisability of results may be restricted for under-represented groups (indigenous Australians, women born in non-English speaking countries, women who speak a language other than English), who may also have different educational opportunities and reproductive patterns.

Overall, there was a considerable increase in self-reported weight among this cohort over 16 years. Our study highlights that the timing of first birth and its interaction with education are both important. Women who had their first child < 26 years were at increased risk of gaining weight, particularly those who did not have additional children. We found substantial educational differences in body weight after taking into account the number and timing of reproductive events, suggesting a need to explore alternative mechanisms through which social differences in weight are generated.

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9.1.2 Additional information

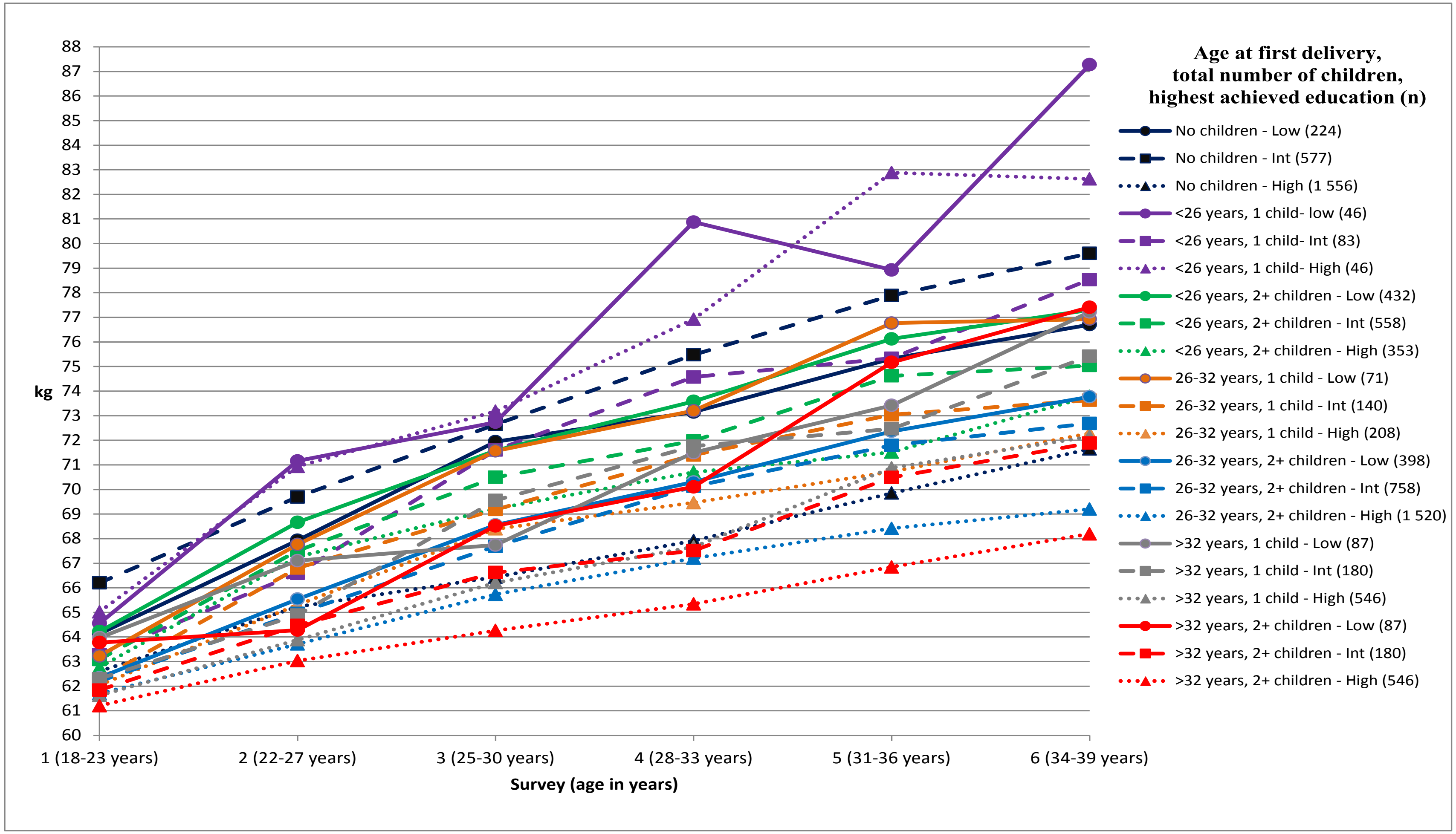

Figure 9.2: Mean weight at each survey based on highest achieved education and combinations of categories of age at first delivery and total number of children

Highest achieved education categorised as low (≤ 12 years); intermediate (trade/apprentice/ certificate/diploma); and high (degree/higher)

Table 9.4: Effect estimates from random effects linear mixed models of BMI over 16 years by highest achieved education (at Survey Six, age 34-39 years) among women from the 1973-78 ALSWH cohort (n=9,127*) (bolded estimates are significant at p <0.05)

	% weighted [a] (unweighted)	Model 1 Estimate (95% CI)	Model 2 Estimate (95% CI)	Model 3 Estimate (95% CI)
Baseline BMI		**22.08 (21.92, 22.23)**	**22.12 (21.96, 22.27)**	**19.94 (19.53, 20.36)**
Difference in baseline BMI by highest achieved education [b]				
High	50.0 (54.2)	Reference	Reference	Reference
Intermediate	31.4 (29.6)	**0.92 (0.70, 1.14)**	**0.78 (0.56, 1.01)**	**0.61 (0.40, 0.83)**
Low	18.6 (16.2)	**0.96 (0.68, 1.25)**	**0.75 (0.46, 1.04)**	**0.55 (0.28, 0.83)**
Increase in BMI per year since baseline		**0.28 (0.27, 0.30)**	**0.24 (0.22, 0.26)**	**0.34 (0.32, 0.35)**
Difference in BMI increase per year by highest achieved education [b]				
High		Reference	Reference	Reference
Intermediate		**0.07 (0.06, 0.09)**	**0.09 (0.07, 0.11)**	**0.08 (0.07, 0.10)**
Low		**0.09 (0.07, 0.11)**	**0.09 (0.06, 0.11)**	**0.08 (0.06, 0.10)**
Effect of having children [c]				
Age at first delivery				
<26 years			**0.77 (0.55, 0.99)**	**0.63 (0.42, 0.84)**
26 – 32 years			**0.40 (0.28, 0.51)**	**0.29 (0.55, 1.16)**
>32 years			**0.25 (0.08, 0.42)**	0.07 (-0.10, 0.23)
Age at second delivery				
<26 years			0.51 (-0.12, 1.43)	0.37 (-0.24, 0.98)
26 – 32 years			**-0.34 (-0.53, -0.15)**	**-0.50 (-0.69, -0.32)**
>32 years			-0.19 (-0.39, 0.01)	**-0.39 (-0.59, -0.20)**
Time since first delivery (based on categories of age at first delivery)				
<26 years			**0.06 (0.02, 0.10)**	**0.06 (0.01, 0.10)**
26 – 32 years			-0.003 (-0.04, 0.04)	-0.01 (-0.05, 0.03)
>32 years			0.03 (-0.05, 0.10)	0.04 (-0.04, 0.11)
Time since second delivery (based on categories of age at second delivery)				
<26 years			-0.03 (-0.08, 0.01)	-0.03 (-0.07, 0.01)
26 – 32 years			**-0.06 (-0.09, -0.02)**	**-0.04 (-0.07, -0.003)**
>32 years			-0.05 (-0.11, 0.01)	0.01 (-0.05, 0.07)
Significant interactions with education				
Education x Age at second delivery				
<26 years				

High	Reference	Reference
Intermediate	-0.35 (-1.08, 0.39)	-0.31 (-1.02, 0.40)
Low	0.20 (-0.57, 0.96)	0.30 (-0.44, 1.04)
26-32 years		
High	Reference	Reference
Intermediate	**0.39 (0.11, 0.68)**	**0.37 (0.10, 0.65)**
Low	**0.65 (0.31, 1.00)**	**0.67 (0.33, 1.01)**
>32 years		
High	Reference	Reference
Intermediate	0.31 (-0.02, 0.63)	**0.32 (0.001, 0.64)**
Low	**0.62 (0.18, 1.07)**	**0.65 (0.22, 1.09)**
Education x Time since first delivery (based on categories of age at first delivery)		
<26 years		
High	Reference	Reference
Intermediate	**-0.08 (-0.13, -0.03)**	**-0.07 (-0.11, -0.02)**
Low	**-0.06 (-0.12, -0.01)**	**-0.06 (-0.11, -0.04)**
26-32 years		
High	Reference	Reference
Intermediate	**-0.11 (-0.16, -0.06)**	**-0.10 (-0.14, -0.05)**
Low	**-0.07 (-0.13, -0.01)**	**-0.06 (-0.12, -0.001)**
>32 years		
High	Reference	Reference
Intermediate	-0.10 (-0.22, 0.02)	-0.07 (-0.18, 0.05)
Low	-0.11 (-0.29, 0.06)	-0.07 (-0.24, 0.10)

[a] % weighted for area of residence at baseline

[b] Own education categorised as low (≤ 12 years); intermediate (trade/apprentice/ certificate/diploma); and high (degree/higher)

[c] The effect of having children was quantified for each additional child 1) by the initial change in BMI recorded at the first survey after having the index child (for age at index delivery) and 2) by the change in BMI trajectory overtime after the index birth (for time since index delivery)

** Sample slightly smaller than the 9,336 women who had a value for highest achieved education, due to missing values for some covariates*

Model 1 - adjusted for baseline centred age, baseline centred height and area of residence

Model 2 - Model 1 + the effect of having children (age at first and second, time since first and second delivery, and interaction effects)

Model 3 - Model 2 + country of birth, physical activity, alcohol intake, mental health, income management, self-rated health, age at first birth, marital status, shape dissatisfaction

Note: Interaction terms should be interpreted in combination with the main effects. For example (Model 2), having a second birth between age 26-32 years was associated with a 0.34 point reduction in BMI among *high educated women only. Significant interaction showed that, compared to high educated women, intermediate educated women gained 0.05 BMI points (0.39, 95% C.I 0.11, 0.68) and low educated women gained 0.31 BMI points (0.65, 95% C.I. 0.31, 1.00) after their second birth*

9.2 Conclusion

This study showed that reproduction does contribute to social inequalities in weight gain among women; the effect estimates for the association between education and weight trajectory reduced when the timing and spacing of having children was modelled. We found that women who had their first child before the age of 26 years were at increased risk of gaining excessive weight, particularly those who did not go on to have additional children. The intra-class correlation was calculated as approximately 0.87 (results not shown); that is, 87% of the total variation in weight could be explained by differences between women (and hence 13% of the variation explained by within-individual differences). Least-square means were used to estimate the marginal effects for each of the linear mixed models presented in the manuscript (Table 9.3); these results are shown in Table 9.5 below.

However, educational differences in body weight over time persisted after accounting for women's reproductive histories. While the final models adjust for a number of lifestyle factors associated with increasing body weight, it is acknowledged that such measures are often imperfectly measured. Nevertheless, these results suggest that alternative mechanisms through which social differences in weight are generated should also be explored. No significant effect of the birth interval between children on body weight trajectories was found, possibly since shorter birth intervals were seen mostly among higher educated women. It could be that existing advantage among high educated women, with regard to a number of health risks, may buffer any disadvantages associated with shorter birth intervals. In addition, these shorter birth intervals may be a part of the reproductive plan of high educated women, hence greater effort is applied to reducing body weight after having had their last planned child. A detailed discussion of these findings and those previously discussed in this thesis will be presented in the following chapter (**Chapter 10**).

Table 9.5: Marginal effects (estimated using least-square means) from linear mixed models of body weight over 16 years by achieved education (at Survey Six, aged 34-39 years) among women from the 1973-78 ALSWH cohort (n=9,127*)

	% weighted [a] (unweighted)	Model 1 Estimate (95% CI)	Model 2 Estimate (95% CI)	Model 3 Estimate (95% CI)
Baseline weight (kg) by highest education[b]				
High	50.0 (54.2)	66.28 (65.92, 66.65)	68.20 (67.24, 69.17)	67.26 (66.35, 68.22)
Intermediate	31.4 (29.6)	70.57 (70.07, 71.07)	72.31 (71.44, 73.18)	70.93 (70.09, 71.78)
Low	18.6 (16.2)	71.24 (70.55, 71.93)	74.13 (73.03, 75.24)	72.72 (71.65, 73.79)
Effect of having children [c]				
Age at first delivery				
< 26 years			72.58 (71.89, 73.27)	71.14 (70.46, 71.83)
26 – 32 years			72.13 (71.48, 72.78)	70.75 (70.11, 71.39)
> 32 years			71.90 (71.18, 72.62)	70.43 (69.72, 71.14)
Education x Age at second delivery				
< 26 years				
High			69.05 (67.32, 70.79)	67.93 (66.25, 69.61)
Intermediate			72.58 (71.28, 73.88)	71.07 (69.81, 72.34)
Low			75.37 (73.85, 76.89)	73.89 (72.42, 75.37)
26-32 years				
High			67.75 (66.68, 68.82)	66.61 (65.58, 67.65)
Intermediate			72.41 (71.39, 73.42)	70.78 (69.79, 71.77)
Low			74.62 (73.31, 75.94)	72.99 (71.72, 74.27)
> 32 years				
High			68.02 (66.94, 69.10)	66.82 (65.78, 67.87)
Intermediate			72.52 (71.41, 73.63)	70.89 (69.81, 71.97)
Low			74.78 (73.30, 76.27)	73.12 (71.68, 74.56)

[a] *% weighted for area of residence at baseline*

[b] *Own education categorised as low (≤ 12 years); intermediate (trade/apprentice/ certificate/diploma); and high (degree/higher)*

[c] *In Models 2 and 3, the effect of having children was quantified for each additional child 1) by the initial change in BMI recorded at the first survey after having the index child (for age at index delivery) and 2) by the change in BMI trajectory overtime after the index birth (for time since index delivery)*

** Sample slightly smaller than the 9,336 women who had a value for highest achieved education, due to missing values for some covariates*

Model 1 - adjusted for baseline centred age, baseline centred height and area of residence

Model 2 - Model 1 + the effect of having children (age at first and second, time since first and second delivery, and interaction effects)

Model 3 - Model 2 + country of birth, physical activity, alcohol intake, mental health, income management, self-rated health, age at first birth, marital status, shape dissatisfaction

Chapter 10. Discussion and conclusions

This chapter begins by summarising the main findings from analyses presented in **Chapters 5 to 9**. Following this is a discussion of these findings, both within the context of the existing literature and also framed around the central themes of the thesis, including the public health implications of this research; namely, are there social differences i) in body weight among women in adult life? and ii) in reproductive characteristics?; and do socioeconomic inequalities in body weight persist after accounting for reproductive histories? A discussion of overall strengths and limitations is then presented, while the chapter closes with an overview of directions for future research within this area of public health and some final conclusions.

10.1 Summary of main findings

A summary of the main findings from each of the studies included in this thesis can be found in Table 10.1.

The association of highest achieved education with body weight over 13 years was examined in **Chapter 5**. Overall, highest achieved education was inversely associated with both weight at baseline and weight gain over 13 years. On average, the analysis showed that women with a low or intermediate education were heavier at baseline and gained an additional 3.9 kg and 3.1 kg, respectively, over 13 years, compared to women with a high education; in the cross-sectional analysis, women with a high education gained an average of 6.9 kg over the 13 year period, while women with an intermediate and low education, respectively, gained an average of 10.2 kg and 11.0 kg. This study also showed that, compared to women who remained with a low education, those who went on to achieve a high education had a similarly favourable weight trajectory when compared to the women who already had achieved a high education at baseline. In other words, while educational attainment by mid-thirties was positively associated with better weight management, body weight was already different in young adult age, before their highest education was achieved.

Table 10.1: Summary of main findings from the five studies included in the thesis

Study	Years data source	Main findings
Study 1: SEP and body weight	1996-2009 ALSWH	○ Education was inversely associated with baseline weight and body weight trajectory over 13 years ○ Compared to women who remained with a low education, those who went on to achieve a high education had a similarly favourable weight trajectory when compared to the women who already had achieved a high education at baseline. ○ It may be important to explore early life factors which may influence both education and weight outcomes
Study 2: SEP and reproduction (age at first birth, birth intervals and total number of children)	1996-2015 ALSWH	○ 14% of women had their first birth < 24 years of age. Disadvantaged women (lower education, living in a rural/remote area) were more likely to do so ○ The mean birth interval between the first and second child was 33.5 months; the longest interval was among women having their first child < 24 years (47.2 months, compared to ~25-29 months among women ≥ 30 years) ○ There was some evidence suggesting that disadvantaged women were more likely to have a longer than recommended birth-to-pregnancy interval ○ There was not a strong association of SEP with total number of children; slight increase odds of having 3+ children among women living in remote areas ○ Support is required to assist women in planning reproduction, particularly those who are socially disadvantaged
Study 3: SEP and pre-pregnancy BMI and GWG	1982-2010 Swedish Registers	○ Women with a low education were more likely to start either pregnancy at an unhealthy BMI (underweight, overweight or obese), compared to women with a high education. ○ Education was inversely associated with odds of excessive GWG in both pregnancies among healthy weight women, while this association was absent (or weakly reversed) among overweight and obese women. ○ Lower educated women had the largest BMI increase between pregnancies, and these inequalities were greatest among women with excessive GWG in the first pregnancy
Study 4: SEP and breastfeeding initiation and duration	1996-2012 ALSWH	○ 89% of women had ever breastfed and 60% of infants were breastfed for at least six months ○ Multiparous women were more likely to breastfeed their first child, and women who breastfed their first child were more likely to breastfeed subsequent children ○ Fewer women initiated breastfeeding with their youngest child - this was most pronounced among high educated women ○ ~60% of women breastfed their first, second and third child for at least six months ○ Disadvantaged women (own or parent with a low education) were less likely to initiate breastfeeding or to breastfeed for at least six months
***Study 5*:** SEP and body weight in relation to reproductive history	1996-2012 ALSWH	○ Reproduction contributed to social differences in body weight, despite educational differences persisting ○ Women having their first birth < 26 years of age had increased weight, particularly those who did not have additional children ○ Having a second birth between 26-32 years was associated with 0.9 kg decreased weight among high educated women, while low educated women gained 0.9 kg. ○ There was no significant effect of the birth interval between children on body weight

Chapters 6 and 7 presented results from studies using data from Australia and Sweden to explore social differences in reproductive characteristics commonly associated with body weight. In **Chapter 6**, the social patterning of age at birth of first child and the birth interval between the first and second child was presented. With 14% of the sample having their first birth before the age of 24 years, disadvantaged women were significantly more likely to do so: this includes women with an intermediate or low education, those who did not know their parent's education level, and those who lived in a rural or remote area. There was some evidence to suggest that women with less than a university education, those who found it always difficult to manage on their income, and women who did not know their parent's education were more likely to have a longer BTP interval than the recommended 18-27 months (particularly greater than 59 months).

Chapter 7 used register data from Sweden to examine social differences in pre-pregnancy BMI and GWG in two subsequent pregnancies. Women with a low education were more likely to start either pregnancy at an unhealthy (underweight, overweight, or obese), rather than healthy weight status, compared to women with a high education. Education was also inversely associated with odds of excessive GWG in both pregnancies among women with a healthy weight status, but this association was absent or even weakly reversed among overweight and obese women. Lower educated women had the largest BMI increase between pregnancies, and these inequalities were greatest among women with excessive GWG in the first pregnancy.

Within the lay community, breastfeeding is commonly believed to influence postpartum weight, despite insufficient supporting evidence. Regardless, breastfeeding is associated with weight in the offspring, and as such plays a role in later weight development. Given this, **Chapter 8** presented results from a study investigating the association between SEP and breastfeeding initiation and duration. Overall, the study showed that 89% of women had ever breastfed and 60% of infants were breastfed for at least six months. Multiparous women were more likely to breastfeed their first child (~90% vs. ~71% of primiparous women), and women who breastfed their first child were more likely to breastfeed subsequent children. Women with a low education, themselves, or a very low educated parent had increased odds of not initiating breastfeeding with their first or subsequent children. While fewer women initiated breastfeeding with their youngest child, this was most pronounced among high educated women. While ~60% of women breastfed their first, second and third child for at least six months, low educated women and those with a very low or low educated parent had increased odds of not breastfeeding for at least six months.

Given that reproduction is commonly implicated in contributing to weight gain in women, the study presented in **Chapter 9** investigated the combined effect of education and reproductive history on weight trajectory in a contemporary cohort of Australian women. The study found that while having children did not have a large effect on body weight over time, age at first birth mattered; women having their first birth < 26 years of age were at increased risk of gaining weight, particularly those who did not have additional children. Regardless of age at first birth, multiparous women were generally lighter than primiparous women at each follow-up. Having a second birth between 26-32 years was associated with 0.9 kg decreased weight among high educated women, while low educated women gained 0.9 kg. There was no significant effect of the birth interval between children on body weight among multiparous women. Overall, while reproduction contributed to social inequalities in body weight over time, the effect of education persisted after accounting for reproductive events; this suggests the need to also explore alternative mechanisms through which social differences in weight are generated.

10.2 Discussion and public health implications

Health is a product of both individual and contextual characteristics. Social positions and value are defined by the way society is structured, including the distribution of power, goods, and resources. Factors such as age, sex, ethnicity, education, and social background individually and in combination influence one's susceptibility to disease/injury exposures and risks[19] through resources and health experiences.

A life course perspective helps us to understand how social inequalities in health and disease may be produced and reproduced through biological, psychosocial, and behavioural factors operating at various stages across the lifespan.[34] This research investigates the social patterning of body weight in relation to reproduction among young adult women. While the focus in this instance is the mothers themselves, extensive research has documented the association of maternal attributes and changes during pregnancy with both short and long term outcomes for the offspring, of which body weight is one. From an intergenerational perspective, pregnancy is a critical period for weight development in the offspring, with epigenetic changes and early life factors influencing weight in later life. Pregnancy is also a critical period due to a number of obstetric and neonatal risks and complications. Given this, while mothers are the focus of the studies included in this thesis, the flow on effect for their offspring is acknowledged as being important for perpetuating intergenerational disadvantage and contributing to an overall increase in overweight and obesity prevalence.

10.2.1 Social inequalities in body weight

Consistent with other studies which have found an inverse association between education and long term weight gain,[9-12,85] *Study 1* demonstrated that having a high education was associated with lower body weight overtime, with little additional advantage among women who obtained a high level of education early on compared to later. This suggests that using education in early adulthood as a fixed marker of SEP may downplay the association between education and body weight trajectory. It may also explain why some studies find an association between education and weight trajectory only among older women,[153] while others find a negative association when using education in later adulthood.[15,173]

Additionally, these results suggest that positive health behaviours/knowledge associated with a healthy weight, and commonly attributed to a higher education, may be more related to factors operating earlier in life, including early developmental patterns.[207] Our results remained more or less the same when we further adjusted for parental education (as a measure of early life SEP), as well as behavioural and demographic characteristics. This suggests a residual effect of own education. The early life environment shapes the individual, through the availability of resources, psychosocial factors that make up the early environment, and the nurturance of cognitive ability and personality development.[208] The results from *Study 1* are also supported in other findings where, despite numerous adult factors (behavioural, psychosocial, and material) being associated with weight change, these determinants alone have not been able to explain SEP differences in weight.[178] Given this, there is a need to investigate alternative explanations or mechanisms through which socioeconomic differences in weight are established, maintained or increased. One suggested mechanism is reproduction, which has been explored in detail within this thesis.

10.2.2 Social inequalities in reproductive events

While *Study 2* found that disadvantaged women (with a low education or a low educated parent) were at increased odds of having their first child before the age of 24 years, another study has suggested that the effect of having an early first birth may not increase the risk of poor health beyond the influence of early life disadvantage itself.[188] There was a tendency for these disadvantaged women to also have a much longer than recommended BTP interval between their first two children. While it is important that all women are aware of the potential increased disease risks associated with the timing of reproduction, this is particularly so for those who are already disadvantaged and could be further burdened. Macro factors, such as government policies targeted at families, may also be important in supporting parents and influencing family planning: this could be through buffering financial costs associated with workforce absence,[236] including the availability and cost of child care, or by encouraging shorter birth intervals through financial incentives.[236] While in Sweden, the uptake of such incentives has been similar across all SEP groups,[236] care must be taken to ensure that these incentives are truly equitable for all individuals. This includes ensuring flexibility of, and opportunities within, the paid labour market. Given the strong correlation between women's age at first birth and that of her offspring,[231] this also highlights the potential intergenerational influences of reproduction.

Study 3 found a significant inverse association between SEP and body weight status before and between pregnancies among women, which is confirmed in other studies of weight retention[103,248] and long-term BMI.[9-11] Importantly, high educated women started their first pregnancy at a similar BMI to lower educated women, despite this being on average ~3.5 and ~5.8 years later than low and intermediate educated women. This is important from a public health perspective, since it underlies that increasing BMI is not solely determined by age and remains a modifiable maternal and neonatal risk factor for all women.

Women who gained weight excessively in the first pregnancy had an even steeper BMI increase between pregnancies and increased odds of being overweight or obese before the second pregnancy. This is consistent with evidence of excessive GWG accelerating overweight and obesity development in women,[100,102] highlighting GWG as a part of a chain of interacting risks that may magnify existing social inequalities over time, and reinforcing the importance of adequate weight gain during pregnancy.

Excessive GWG was most pronounced among women with an overweight or obese weight status, for whom the U.S. IOM guidelines outline a more modest range of healthy weight gain, and in the first pregnancy compared to the second. This could be due to increased knowledge the second time around, or perhaps additional monitoring of women who gained weight excessively in the first pregnancy, due to adverse consequences related to excessive GWG, such as gestational diabetes or hypertension. Recent studies have also questioned existing measures of GWG, highlighting that the strong correlation between GWG and gestational age may distort the association of GWG with adverse maternal and perinatal outcomes, in particular the risk of preterm birth.[274 ,275] Johansson et al[275] suggest an alternative measurement of GWG that transforms maternal weight gain into a z-score standardised for gestational age

Among women with an underweight or healthy weight status, having a lower education was associated with increased risk of excessive GWG in the first pregnancy: this was also the case among women with a healthy weight status before the second pregnancy. Though behavioural factors such as smoking, diet and physical activity are often implicated in explaining weight gain, and a previous ALSWH study finding differences in these behaviours between primiparous and multiparous women, these factors have been insufficient in explaining differences in the rate of weight gain.[10] With increasing advances in statistical models to test for mediation, future studies should investigate the potential mediating/moderating role of social differences in these behavioural factors on GWG. Also of interest would be investigation of whether and how the association of education with weight trajectory reflects differences in women's early growth trajectories and health.

Overall, GWG is largely a modifiable risk factor, and women are entitled to accurate information about how much gain is healthy for them and their child. This starts with ensuring that health practitioners are aware of the most relevant and up-to-date guidelines, and are skilled in discussing weight issues with women. Although accurate advice alone may not be enough to assist women to gain weight adequately,[257] being advised to gain too much weight is associated with excessive GWG.[92] Indeed, studies have detailed that many practitioners are unaware of the current guidelines[258] or are advising women incorrectly, particularly those women with an overweight or obese weight status.[259] Therefore, ensuring all women are advised correctly, in particular those who are already disadvantaged, gives the opportunity for women to set a healthy, weight-status-appropriate

GWG target. Assisting women to achieve a healthy pre-pregnancy BMI, appropriate GWG and a healthy postpartum weight should remain a public health priority that is communicated to all women, since this may assist in reducing existing social inequalities in body weight.

The protective effects of breastfeeding for body weight in the offspring are clearly documented and outlined in **Chapter 2**. Consistent with previous Australian findings,[119] *Study 4* found that SEP was significantly associated with breastfeeding; disadvantaged women (with a lower education or a low educated parent) were less likely to initiate breastfeeding or to breastfeed for at least six months. This may be a result of higher educated women being more receptive to advised health behaviours, or conversely to reduced family support and assistance for breastfeeding among the disadvantaged. The findings from this study suggest a need for a greater understanding of barriers to initiating and sustaining breastfeeding for all women, as well as those which may be socioeconomic-specific, since this may assist in reducing inequalities in infant breastfeeding. This may include factors positively associated with breastfeeding initiation and duration, including: maternal positive attitude towards breastfeeding;[131] not smoking while breastfeeding;[130,131,141] GWG within the U.S. IOM guidelines;[143] adequate milk supply, and no feeding difficulties in the first month postpartum.[131]

As with the timing of first and subsequent births, the social/political context is also important in shaping features of the home, work, and community environments which may support breastfeeding. The finding that all women, particularly those with a high education, were less likely to breastfeed their youngest child may be due to women returning to work soon after having reached their desired number of children, in order to limit their absence from the workforce. Overall, social policies should be designed to support families to meet the existing Australian Infant Feeding guidelines. This includes allowing sufficient paid parental leave so that, where it is possible to do so, all women have the opportunity to breastfeed each child for at least six months, and not just those with the financial resources to be absent from the paid workforce. Investing in paid parental leave, and not just maternity leave, also allows both parents the opportunity to form a strong attachment with their child; this is not only important for the child's development, but also for normalising workplace absence for family reasons, and hence supporting women (where able) to meet the breastfeeding guidelines. Flexible working conditions and the provision of subsidised, affordable child-care allows parents to participate in the paid workforce and also buffers the large financial costs associated with having children. In this way society invests in assisting parents to raise healthy children.

Interventions to improve breastfeeding initiation and duration also require careful consideration in order to not increase social inequalities, through greater uptake and improvements among advantaged individuals.[146] Research suggests that such interventions are most effective when they involve the partner/significant care-giver,[121] with peer support programmes in combination with professional support also being effective in increasing breastfeeding rates.[268] Another important aspect of the political context is regulations surrounding the marketing of infant formulas as a substitute for breastmilk. In low and middle income countries, promotion of breastmilk substitutes (in the media and by professionals) and free provision of these products is negatively associated with breastfeeding behaviours.[276]

A common thread within this thesis is the importance of a healthy weight status, and this is also the case with regard to success in breastfeeding. High maternal BMI is associated with socioeconomic disadvantage,[141-143] as well as difficulties in breastfeeding.[269] While having a healthy weight status reduces the risk of excessive GWG and the health consequences associated with this, addressing the importance of a healthy weight status before pregnancy may also have the potential effect of reducing social inequalities in breastfeeding.

10.2.3 The moderating effect of reproduction on social inequalities in body weight

While adjusting for a number of behavioural factors, the final study in this thesis (*Study 5*) investigated whether there was a moderating effect of timing of reproduction on the association between SEP and body weight trajectory. Overall, *Study 5* found considerable increases in the mean body weight over time; and while reproduction contributed to social inequalities in body weight, the effect of education persisted. This suggests, first and foremost, that maintaining a healthy weight is a challenge for all women. This was also found during pregnancy (in *Study 3)*, where no significant association between education and excessive GWG was found among women with an overweight or obese weight status, despite a large percentage of these women gaining weight excessively. *Study 5* also did not find a significant association between the birth interval between children and body weight, despite previous literature suggesting that a short BTP interval (usually < 12 months) is associated with increased risk of obesity after childbirth;[107,110] nor was there a significant effect of having a third child.

While the effect of having children was not large, the timing of the first birth was important. Despite some studies finding no association between age at birth of the first child and weight at one year postpartum,[99] *Study 5* is in accordance with studies finding an increased risk of higher weight gain over time among younger mothers.[80,107,108] Giving birth to the first child before the age of 26 years was associated with an increased spike in weight after the birth and a steeper weight trajectory, which was slightly attenuated over time among lower educated women.

Multiparous women tended to have a lower weight at each survey, compared to primiparous women which, speculatively, may be due to a healthier hormonal profile among women able to successfully give birth to more than one child. Having a second birth between 26-32 years was associated with a 0.9 kg decrease in weight among high educated women only; while among low educated women this was associated with a 0.9 kg increase. Given the significant interaction between education and having a second birth, together with fewer higher educated women going on to have more than one child, it could be that women planning to have only two children may wait until they have had this second child before trying to lose any additional weight.

10.3 Strengths and limitations

Strengths and limitations specific to each of the five studies included within this thesis are detailed in their associated chapters (**Chapters 5 to 9**). This section offers an overall consideration of the impact of these strengths and limitations.

10.3.1 Strengths

The thesis benefited from using two rich data sources with complementary information, which allowed for a detailed investigation of the social patterning of body weight in relation to reproduction; the ALSWH contains information on behavioural, demographic and social characteristics, while Swedish register data contains information on pre-pregnancy BMI and GWG (which is not commonly available). While using these different data sets is a strength, it is acknowledged that the two source populations are very different in composition: approximately 47% of Swedish men and women (40% of women) were overweight or obese in 2014,[277] compared to 63% of Australian men and women (56% of women) in 2014-15.[2] Additionally, regardless of education level, ALSWH women gave birth to their first child at an older age, compared to the sample of women from the Swedish total population (Table 10.2). While BMI around the average age at first birth could only be approximated for ALSWH women, these women were heavier before their first pregnancy than women in the Swedish sample.

Despite these differences in composition, social differences in body weight and reproductive characteristics were found using both data sources. This suggests that social differences in health outcomes are embedded even within contexts of greater social equity. Excessive GWG was most prevalent among Swedish women with an overweight or obese pre-pregnancy weight status (~70% before the first pregnancy and ~60% before the second pregnancy), with social patterning found only among women with a healthy pre-pregnancy weight status. Given that ALSWH women were heavier before their first pregnancy, with the mean BMI being at the healthy weight/overweight threshold (Table 10.2), it is speculated that a large proportion of these women may have gained weight excessively, also. No social differences in excessive GWG were found among Swedish women with an overweight or obese pre-pregnancy weight status; given that the prevalence of overweight and obesity is greater in Australia than in Sweden, it is therefore hypothesised that advice and assistance to gain weight adequately during pregnancy may be needed for all Australian women, regardless of SEP.

Table 10.2: Comparison of the mean age at birth and BMI among women from ALSWH and our Swedish sample

	Mean age (years) and BMI before pregnancy with the first child			
Highest education	**ALSWH**		**Swedish total population**	
	Age	**BMI ***	**Age**	**BMI**
Low	27.1	26.0	22.6	22.3
Intermediate	28.2	25.8	24.9	22.8
High	30.8	24.4	28.4	22.7

**BMI around the time of the first birth is given as an approximation, using the nearest ALSWH survey for the mean age at birth of the first child based on data available at Survey Seven*

There are a number of strengths in using data from ALSWH. Firstly, the study includes a large random sample of Australian citizens and permanent residents selected from the national health and insurance database (Medicare). Secondly, this prospective longitudinal study includes detailed survey questions covering major aspects of women's health, well-being and health-service use, including demographic, social, physical, psychological and behavioural information. This means that repeated measures over 13 years (*Study 1*), 16 years (*Study 4* and *5*) and 19 years (*Study 3)* were available for analysis, providing the unique opportunity to track body weight trajectories over time and reproductive characteristics up until women were aged in their late-thirties to early-forties. In addition to this, few longitudinal studies of body weight have the opportunity to include consideration of behavioural factors. While this was not the focus of this thesis, testing and adjusting for behavioural factors was important for weight trajectory analyses.

As detailed in **Chapter 4.2.2**, Swedish register data contains a wealth of secure information which is able to be merged owing to Personal Identification Numbers that are issued to all Swedish residents. This provides a unique opportunity to analyse health and social data using very large samples, allowing for greater statistical power.

10.3.2 Limitations

For both data sources, the following section summarises the three main types of bias within epidemiological studies: *selection bias*, resulting from how subjects are selected into a study; *information bias*, resulting from errors in the way information is collected; and *residual confounding bias*, or systematic errors occurring when results are biased based on a third variable (or multiple).

Selection bias

While selection bias may arise from the relatively high attrition between baseline and Survey Two (n=9,688; conducted in 2000; women aged 22-27 years) of ALSWH, prior analysis of this attrition has concluded that possible biases due to loss to follow-up are unlikely to have an important effect on longitudinal analysis of these data.[187] Attrition has remained fairly stable since Survey Two (68% response rate): at Survey Three 64%; Survey Four 64%; Survey Five 58%; Survey Six 56%; and at Survey Seven 48% (n=6,901, 86% compared to Survey Six). In addition to this, the ALSWH young cohort includes a slight over representation of tertiary educated women.[95] Such selection bias is not expected to change the nature of the relationships identified in the studies included in this thesis.

While selection bias is limited when using register data that largely contains the total population, an absence of information on GWG in the Swedish register was the greatest source of attrition for *Study 3*. As described at the beginning of **Chapter 7**, this is partly due to weight data not being collected during two calendar years, and the overall limited collection of data on weight at delivery. While there may be centre or regional differences in diligence in collecting this information (which could be investigated in detail in the future), it is speculated that women appearing to gain weight adequately during pregnancy may have been less closely monitored group.

While there is always the possibility of researcher-introduced selection bias due to inclusion/exclusion criteria, Table 4.1 outlines a number of additional analyses that were conducted in order to test the reliability of results. In **Chapter 5** (*Study 1*) and **Chapter 9** (*Study 5),* sensitivity analyses showed similar associations to those presented with marginally lower estimates. In **Chapter 6** (*Study 2*) and **Chapter 7** (*Study 3*), we found similar associations to those presented. While sensitivity analyses in **Chapter 8** (*Study 4*) suggested that our results potentially underestimate the association between SEP and breastfeeding duration (when including all women and not just those who had initiated breastfeeding), outcomes using multiply imputed data were similar to those presented in the main analysis.

Information bias

As with all studies including any measurement of body weight, self-reported data are sensitive to height being overestimated and weight underestimated. Given this, *Study 1, 3 and 5* may include outcome misclassification (including weight status). While it is suggested that weight trajectory estimates should not be affected if weight underreporting is consistent,[153] this may not apply to heavier women, who have a greater tendency towards underestimation.[10] Arguably, this could also be the case for women with an underweight weight status. Nevertheless, weight misclassification is most likely to be non-differential: that is, unrelated to the main exposure and similar for all women, regardless of the number of surveys completed. I am unaware of any studies indicating that weight underestimation differs according to SEP. In using the ALSWH, there is also the possibility of large variations in body weight between surveys (every three to four years) that are not captured in the reported body weights. While this is less of an issue in measuring weight trends over longer periods of time, measurements of behavioural characteristics would be more sensitive to such fluctuations.

Given inconsistencies in reporting the number of live births, still births and miscarriages (which made this additional information unreliable to use), total number of children (using recorded dates of birth) was used as a proxy for parity. It is therefore possible that, in some cases, still births or miscarriages may have been included in the reporting of dates of birth of children.

Recall bias in reporting pre-pregnancy weight may also be included in Swedish register data, due to variability in the timing of the first antenatal visit (week of gestation). Variation in the timing of the final measure of GWG (in relation to the birth) may have introduced additional errors and there may be further inconsistencies in how this was measured: some medical practitioners may have weighed women upon presentation of labour (measured), others may have asked them how much they gained (self-reported), while others may have checked the recorded value at last antenatal visit. A protocol for how this is collected is missing, and no further clarification could be found despite consulting a Swedish expert on these data.

Few studies or registers provide information about breastfeeding patterns and behaviours. While investigation of the social patterning of breastfeeding duration was possible using the ALSWH, information to distinguish between the WHO infant feeding categories of exclusive, predominant or complimentary breastfeeding was lacking. It would be beneficial to collect this information in the future, to allow for in depth investigation into mechanisms that support women to meet the existing infant feeding guidelines.

Confounding bias

While a number of variables were included in the analyses to adjust for possible confounding bias, residual confounding may still be present due to unmeasured or imprecisely measured variables. SEP is difficult to measure, particularly among women of reproductive age, who may start having children before having completed their education and entering the workforce. As mentioned in **Chapter 2.1.2,** the choice of SEP measure needs to go beyond what is simply available within the data and must reflect the causal association being tested;[18,41,42] each measure may influence health in a different way and at different stages of the life course.[43] Despite these challenges, education is the most frequently used measure of SEP among women of reproductive age; it is relatively easy to measure and reflects social capital, while being less sensitive to short or long spells out of paid employment, which also applies to students and retired individuals.

The ALSWH contains rich information on behavioural and social characteristics which were possible to include in the analyses, however information on pre-pregnancy BMI and GWG was not available. Such information would have been valuable to include in *Study 5*, and also to enable a comparison with the results using Swedish data (Study 3).

Within the Swedish data, birth year of the child was adjusted for in order to account for the possible artefact of changes in BMI measurement over time (though these changes are unlikely to have varied by SEP), and maternal age at birth which accounted for secular changes over time. Behavioural factors in adulthood may mediate the association between SEP and both pre-pregnancy BMI and GWG, however, other than maternal smoking in early pregnancy (which is likely to be imprecisely measured), such variables were not available within the Swedish registers.

10.4 Directions for future research

Research presented in this thesis shows an inverse association between SEP and body weight across the life course among women, which persists after accounting for women's reproductive histories. This finding suggests that, in addition to reproduction, further investigation of alternative factors influencing these social differences in body weight is needed. A number of areas for future research are identified, which replicate or build upon the findings of this thesis.

SEP and body weight:

- In order to test the robustness of results, these findings should be replicated in other longitudinal studies; this includes studies that have measured body weight, and those using alternative measures of adiposity, such as waist circumference or waist-to-hip ratio

- While social differences in body weight also persisted after adjusting for early life SEP, further research could investigate the effect of intergenerational social mobility on body weight across generations, as well as trends among men
- While physical activity is important for cardiovascular health and stress relief, its influence on weight reduction is questioned,[278] unlike the effect of how much and what we eat. Recent evidence suggests that changes to intestinal microbiota may play a significant role for metabolism and hence obesity development.[179] Since these microbiota respond to the quality and type of foods we eat, understanding the association between SEP, diet and the intestinal microbiota may be an important area for future research
- Interventions on a macro level, such as food taxes, have the ability to encourage individuals towards healthier food choices and to reduce overweight and obesity,[279] and their effect could be investigated in greater detail. An example of this is the taxation of sugar-sweetened beverages, where the type and level of tax introduced can deter consumption, and these tax funds can reinvested in health promotion[280]

SEP and reproductive factors:

Social differences in body weight remained after accounting for reproductive factors. As evidenced in **Chapter 2**, increased maternal weight before and during pregnancy, as well as breastfeeding practices, are associated with increased risk of overweight and obesity in the offspring. Given this, addressing social inequalities in reproductive factors has a potential to reduce the intergenerational transfer of obesity. A number of areas for further research within this area were identified:

- Finding ways to improve women's health from early on: this includes assisting young women to achieve and maintain a healthy weight, so that they are more likely to start their first pregnancy (whether planned or unplanned) at a healthy weight status
- Social differences in achieving adequate GWG were mostly found among women with a healthy weight status. Since a large proportion of women gained weight excessively, interventions to improve GWG among all women are still required
- The existing literature suggests that many women are either unaware of or incorrectly advised with regard to the U.S. IOM's GWG guidelines, which are

specifically based on the woman's weight status before pregnancy. This suggests room for improvement through finding ways to

    - ensure practitioners are aware of the guidelines
    - training practitioners to be skilled and comfortable in discussing weight with their patients
    - ensure the guidelines are readily available to women

- Replication of the findings for SEP and breastfeeding are required. Further studies should collect information on exclusivity of breastfeeding (exclusive/predominant/partial), as well as reasons for why women do not start or continue with breastfeeding
- There is a need to identify barriers to breastfeeding initiation and duration. This may assist in developing timely interventions that address the greatest needs

10.5 Conclusions

This research investigated the social patterning of body weight over time in relation to reproductive events, using education as the main measure of SEP.

Social differences were found in a number of reproductive characteristics. Using ALSWH data, disadvantaged women were more likely to have a first birth before 26 years of age and to have a longer than recommended interval between the birth of the first and second child. Given that breastfeeding has a protective effect on overweight and obesity development in the offspring, we also investigated social differences in breastfeeding and found that women with a low education were less likely to initiate or to sustain breastfeeding for at least six months.

Using Swedish register data, low educated women were more likely to start their pregnancy at an unhealthy weight status (underweight, overweight, or obese) and had a higher weight gain between pregnancies. While a large proportion of women with an overweight or obese weight status gained weight excessively in both pregnancies, existing social differences in BMI were further increased among women who gained weight excessively in the first pregnancy. A high percentage of women with an overweight or obese weight status gain weight excessively during pregnancy. Given this, and that the prevalence of overweight and obesity is greater in Australia than in Sweden, the burden of excessive GWG is possibly greater also. Since GWG is a modifiable risk factor, greater support is required to assist women to gain weight adequately, as well as to understand the reasons for doing so.

The social differences in reproductive characteristics that were found suggest a need to empower and support all women, particularly those with a low SEP, with regard to the importance and relevance of: the timing of reproduction; starting their first pregnancy at a healthy weight; gaining weight adequately during pregnancy; returning to a healthy postpartum weight within a reasonable time frame; and the benefits of breastfeeding. Doing so may assist in reducing future health risks for women and their offspring.

The final study in this thesis showed that reproduction does contribute to social inequalities in weight gain among women; additionally, women who had their first child before the age of 26 years were at increased risk of gaining excessive weight, particularly those who did not go on to have additional children. However, despite these important findings, educational differences in body weight persisted after accounting for the number and spacing of births. This suggests a need to also explore alternative mechanisms through which social differences in weight are generated.

In conclusion, a healthy pre-conception weight status is important and so ways to maintain a healthy body weight at a population level should be prioritised. Given the research findings, even greater support is required for women with a low SEP, who have increased risk of starting their first pregnancy overweight or obese, and of gaining weight excessively during pregnancy. Given the further social differences in reproductive characteristics that were presented, and the contribution of reproduction to social inequalities in body weight among women, greater support is required to assist women in planning their reproductive events; including reducing the number of early pregnancies, and allowing women sufficient time to i) (where able) breastfeed each child for at least six months (national infant feeding recommendation), and ii) recover between one birth and the next.

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