WWW.OEAW.AC.AT

ÖAW AUSTRIAN ACADEMY OF SCIENCES

VIENNA INSTITUTE OF DEMOGRAPHY

WORKING PAPERS

11/2018

THE EFFECT OF NATIVITY, DURATION OF RESIDENCE, AND AGE AT ARRIVAL ON OBESITY: EVIDENCE FROM AN AUSTRALIAN LONGITUDINAL STUDY

SANTOSH JATRANA, KEN RICHARDSON AND SAMBA SIVA RAO PASUPULETI

Vienna Institute of Demography
Austrian Academy of Sciences
Welthandelsplatz 2, Level 2 | 1020 Wien, Österreich
vid@oeaw.ac.at | www.oeaw.ac.at/vid

Vienna Institute of Demography

VID – VIENNA INSTITUTE OF DEMOGRAPHY

Abstract

The motivation for this paper arises from the lack of longitudinal studies which investigate changes in obesity patterns of immigrants and the effect of age at arrival on these patterns and changes. Additionally, few studies examined empirically the pathways by which changes in obesity occur overtime. We investigated differences in the levels of obesity among foreign-born people from English Speaking and non-English Speaking countries relative to native-born Australians, and how those differences changed with duration of residence and age at arrival using a large representative longitudinal dataset. We also explored whether the association between nativity, duration of residence (DoR) and obesity is mediated by English language proficiency, socioeconomic factors and health behaviour factors. We found that the odds of being obese were significantly smaller among foreign-born people, both from English speaking countries and non-English speaking countries compared with native-born people. Relative to the native-born, immigrants from non-English speaking countries lost their measurable obesity advantage with respect to the native-born after 20 years of residence in Australia, whereas immigrants from English speaking countries did not. We did not find a substantial modification in these associations by age at arrival for either immigrants from non-English speaking or English speaking countries. We found some evidence of a mediating role of English language proficiency on obesity for foreign-born people from non-English speaking countries. Given increasing proportions of foreign-born people in Australia, particularly from non-English speaking countries, our results underscore the role of English language proficiency in designing healthy weight interventions.

Keywords

Nativity, longitudinal studies, obesity, Australia.

Authors

Santosh Jatrana (corresponding author), Centre for Social Research Swinburne, Faculty of Business & Law, Swinburne University of Technology, Hawthorn, Australia.
Email: sjatrana@swin.edu.au

Ken Richardson, Department of Public Health, University of Otago, Wellington, New Zealand. Email: ken.richardson@otago.ac.nz

Samba Siva Rao Pasupuleti, Institute of Liver and Biliary Sciences, New Delhi, India.

Acknowledgements

This paper is based on research being conducted as part of the research project 'Investigating the dynamics of migration and health in Australia: A Longitudinal study'. It is supported by an Australian Research Council Discovery Grant (DP DP120104604) to the lead author. The funders had no role in study design, data collection and analysis, decision to publish, or preparation of the manuscript. The paper uses the unit record data from the Household, Income and Labour Dynamics in Australia (HILDA) Survey, which is funded by the Commonwealth Department of Families, Housing, Community Services and Indigenous Affairs (FaHCSIA) and is managed by the Melbourne Institute of Applied Economic and Social research at the University of Melbourne. The research findings and views reported in this paper, however, are those of the authors and should not be attributed to either FaHCSIA or the Melbourne Institute. An earlier version of this paper was presented at 2014 Population Association of America Meeting in Boston (1-3 May). The authors wish to thank the participants and the discussants for their useful comments that helped improve the manuscript.

The Effect of Nativity, Duration of Residence, and Age at Arrival on Obesity: Evidence from an Australian Longitudinal Study

Santosh Jatrana, Ken Richardson, Samba Siva Rao Pasupuleti

1. Introduction

The motivation for this paper arises from the lack of longitudinal studies which investigate changes in obesity patterns of immigrants and the effect of age at arrival (AA) on these patterns and changes. Obesity is one of the five leading global risks for mortality (World Health Organization, 2009), a major determinant of cardiovascular diseases, diabetes, and certain types of cancer (World Health Organisation, 2006), and an international public health concern due to significant social, health, and economic costs. There has been an unprecedented increase in overweight and obesity rates all over the globe including Australia (Australian Bureau of Statistics, 2012a;Finucane et al, 2011; Prentice, 2006). For example, the prevalence of overweight and obesity has increased in Australia over time, from 56% in 1995 to 61% in 2007–08(Australian Bureau of Statistics, 2012a). In 2011-12, 63% of Australians aged 18 years and over were overweight or obese, comprised of 35% overweight and 28% obese(Australian Bureau of Statistics, 2012a).

In general, foreign-born (FB) individuals appear to have lower BMI and are less likely to be overweight or obese upon arrival in the host country than native-born (NB) people (see Goulão, Santos, and Carmo, 2015; Oza-Frank and Cunningham, 2010 for a review). However, an increase in obesity levels with increased duration of residence in the host country has been noted among various immigrant groups in the USA (Antecol and Bedard 2006; Bates et al. 2008; Goel et al. 2004; Gordon-Larsen et al. 2003; Himmelgreen et al. 2004;Kaplan et al. 2004; Kaushal 2009; Oza-Frank and Cunnigham, 2010; Park, Myers, Kao, & Min, 2009; Sanchez-Vaznaugh et al. 2008), Canada (Cairney and Ostbye 1999; McDonald and Kennedy 2005; Setia et al. 2009), Australia (Hauck, Hollingsworth and Morgan 2011), Germany (Sander 2008), and Norway (Gele and Mbalilaki 2013). Past research has also shown that immigrants who arrive at younger ages are at higher risk of overweight or obesity with increasing length of residence than immigrants who arrive at older ages (Kaushal, 2009; Oza-Frank and Venkat Narayan, 2010; Roshania, Narayan and Oza-Frank, 2008). However, the heterogeneity in weight and obesity rates among migrant population upon arrival and over time as a result of actual differences between groups such as risk factors, gender, age at the time of migration, and duration of residency in the host country, have also been acknowledged and documented (Calzada & Anderson-Worts, 2009; Delavari, Sonderlund, Swinburn, Mellor, & Renzaho, 2013; Gordon-Larsen, Harris, Ward, & Popkin, 2003; Kaushal, 2009; Renzaho, Swinburn, & Burns, 2008; Statistics Canada, 2005; Taylor, Grande, Parsons, Kunst, & Zhang, 1997).

A limitation of much of the published work described above on migration and obesity is that until very recently, much of the international and national research evidence has come from single or repeated cross-sectional datasets, which provide only snapshot(s) in time of differences in the health outcome between migrants and non-migrants. However, processes such as migration are dynamic and require several years to have their full impact on health. The effect of migration on obesity will therefore be more difficult to determine from purely cross-sectional data. Estimating migration effects presents additional challenges because exposure to migration is not a random event. Migrants and non-migrants may differ in important ways due to self-selection and other processes: for example, migration into a new country sparks a process of labour market adjustment that NB workers do not undergo, and that may bias estimation of the exposure-outcome relationship by introducing confounding factors (Rothman, Greenland and Lash 2008). Similarly, many factors that influence obesity (e.g., diet and exercise) may change over time in individuals, particularly for immigrants as they experience the host culture, and not taking these individual-level changes into account can produce biased estimates. In contrast, Setia et al (Setia et al., 2009) used longitudinal data and mixed effects models to evaluate 12-year changes in BMI among white and non-white immigrants relative to Canadian born individuals. However, Setia et al did not measure the change in BMI over time of various immigrant groups vis-à-vis the Canadian born. Without this comparison, the different immigrant trajectories in obesity cannot be attributed to immigrant status.

Moreover, most longitudinal studies have used balanced panels and ignored potential biases caused by panel attrition (Chiswick, Lee and Miller, 2008; De Maio and Kemp, 2010; Fuller-Thomson, Noack and George, 2011; Kennedy and McDonald, 2006; Kim et al., 2013; Newbold, 2010; Setia et al., 2011). Additionally, the pathways and mechanisms by which obesity changes overtime are poorly understood, limiting the ability to implement policies that result in improved health for all, including immigrants. Most of the existing research has focussed on acculturation as a possible explanation for any decline in health with years in the host country (Abraido-Lanza et al., 2006; Antecol and Bedard, 2006; Lara et al., 2005). However, as we discuss later, the theory of acculturation needs further scrutiny because of its simplistic inherent assumptions. As we explain later, other processes such as changes in English language proficiency, and socioeconomic status that could impact the obesity levels of immigrants as they stay longer in the host country need to be more developed (Alidu and Grunfeld, 2018; Murphyet al.,2017).

Such methodological and theoretical considerations motivated this paper. Longitudinal data can help identify differences in causal relationships between obesity and potential determinants for foreign-born and native-born people. The present study advances the migrant health literature by (i) using a nationally representative longitudinal data (HILDA) (Household, Income, and Labour Dynamics in Australia) with 5 years of follow-up to provide estimates of nativity gap in obesity (i.e., nativity/duration of residence effects are measured relative to native Australians); (ii) providing a baseline for future fixed effects obesity analyses of HILDA data using the same method as this paper; (iii) explicit recognition that confounding is not an issue for nativity/duration of residence exposures;

(iv) reducing bias from loss to follow up by using unbalanced panel and; (v) exploring some possible mechanisms through which obesity changes over time post migration.

Using so-called hybrid regression models (explained in the next section) that separate within-person and between-person variations over time, we examine the associations of nativity (native-born (NB) and immigrants from English speaking (ES) and non-English speaking (NES) countries of origin) and duration of residence (DoR) with prevalence of obesity, and whether the association between nativity–DoR and obesity prevalence overtime is modified by age at arrival in Australia. We also examine the mediating role of English language proficiency, socioeconomic status and health behaviour factors in the association between nativity and duration of residence and obesity.

Examining the issue of differences in obesity levels between immigrants and Australian born people, and how these differences changes over time, is an important policy issue in Australia which has one of the highest proportions of immigrant population in the world: an estimated 26% of the total population is born overseas, and net overseas migration is the major contributor to population growth in Australia (Australian Bureau of Statistics, 2012b). Moreover, one fifth of people born in Australia had at least one overseas-born parent (Australian Bureau of Statistics, 2005). As the number of immigrants in Australia continues to rise, it has become increasingly important to know how health risk factors such as BMI and obesity differ between foreign-born and native-born individuals, and how they change over time, since this will help identify vulnerable immigrant populations. The issue of migrant health has become additionally important because the goal of Australia's migration programme has moved towards meeting the labour market needs of the Australian economy(Birrell, 2003), and good health is important to fully realising the social and economic potential of immigrants.

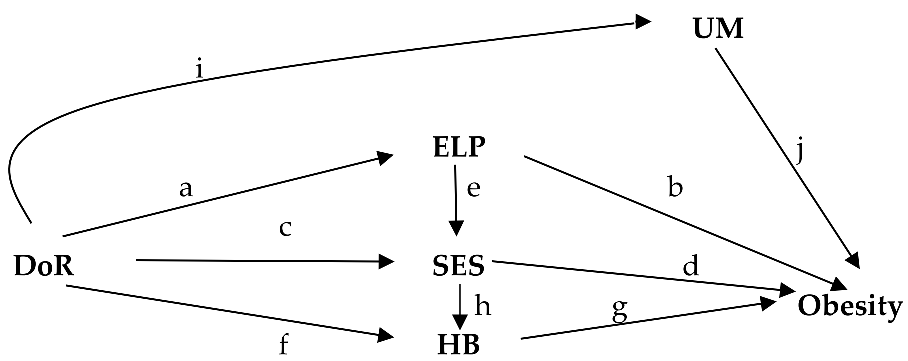
Furthermore, under Australian point-based system of determining the eligibility of applicants to immigrate, points are awarded for age and English language proficiency. This makes an improved understanding of the interrelationship between age at arrival and English language proficiency with obesity prevalence, nativity, and duration of residence very timely.

2. Migration and Obesity: Explanatory Mechanisms

There are several mechanisms that could impact the BMI levels of immigrants as they stay longer in the host county. Researchers have often focussed on acculturation as a possible explanation for any changes in BMI/obesity with years in the host country (Delavari, Sonderlund et al., 2013a). The process of change in obesity levels is likely to be influenced by factors including genetic and physiological factors, epi-genetic factors, physical activity, socioeconomic status, pressure towards assimilation, and public perception of immigrants, as well as individual factors including English language skills, socio-economic status and stress (Murphy, Robertson et al. 2017). In this study, we use DoR as a measure of acculturation, and English language proficiency, socioeconomic status, and health behaviour as paths/mechanisms that might mediate the relationship between nativity, country of birth, DoR and obesity.

A conceptual framework of the causal relationship between acculturation/duration of residence and obesity is presented in Fig. 1 as a directed acyclic graph (DAG). Such graphs summarise hypothesised causal relations amongst variables (Greenland, Pearl and Robins, 1999; Gunasekara et al., 2014; VanderWeele and Robins, 2007), and Fig. 1 posits that DoR could impact on obesity levels through four main causal pathways.This framework also provides the basis upon which modelling decisions were made. The first set of DoR-obesity paths pass first through English language proficiencyi.e., a+b, a+e+d, a+e+h+g using the path labels from Fig. 1. The second set of paths pass first through socioeconomic factors (income, employment and education) i.e., c+d, c+h+g. The third causal path passes first through health behaviour i.e., f+g. The fourth set of causal paths pass through unmeasured mediators (such as discrimination/racism) i.e., i+j. To simplify the DAG, node UM includes the null (no) mediator i.e, the direct path from duration of residence to obesity is a subset of i+j. The DAG makes explicit an assumption of no confounding of the association between DoR and health.

Figure 1: Directed Acyclic Graphs (DAGs) of the relationship between duration of residence and obesity



Note: DoR= Duration of Residence, ELP = English Language Proficiency, SES = Socio-Economic Status (level of education, marital status, household equivalised income and employment status), UM = Unknown mediator(s), HB = Health Behaviors (smoking, drinking and physical activity).

2.1. The English Language Proficiency Pathway

The pathway by which language proficiency is associated with obesity is complex and operates though several mechanisms (Himmelgreen, Pérez-Escamilla et al. 2004, Akresh 2007). Language may affect obesity through its association with psychological stress. For example, among both Latinos and Asians, lack of English language proficiency has been associated with increased psychological distress (Zhang et al. 2012); poorer mental health, in turn, has been found to be associated with increased BMI (Rosmond et al. 1996). Lack of proficiency in the language can affect obesity through other multiple pathways such as discrimination, relocation stresses, or lack of access to jobs. For example, inability to speak the receiving country's language may invite discrimination (Yoo, Gee and Takeuchi 2009) which in turn, has been shown to be associated with increased body mass index (Hunte and Williams 2009). Similarly, proficiency in the language of the host country is a necessary resource that enhances one's ability to navigate the host culture (Gee, Walsemann and Takeuchi 2010). Alternatively, low English proficiency may affect the relationship between nativity and obesity via SES (employment, income) as language proficiency is a prerequisite for labour market and educational attainment (Gee, Walsemann and Takeuchi 2010). English proficiency could also be a marker for exposure to unhealthy diet and life style (Gee, Walsemann and Takeuchi 2010).

2.2. The SES Pathway

Regarding the SES pathway (c+d), the relationship between SES and obesity is complex (Dinsa et al. 2012; Kinge et al. 2015; McLaren 2007; Pampel, Denney and Krueger 2012) and can mediate through knowledge of the aetiology of disease and causes of obesity, as well as barriers associated with money, time and opportunities (e.g. within a local neighbourhood) to eat a healthy diet or take part in physical activity (Murphy et al. 2017), and living in a neighbourhood more supportive of healthy behaviours (Albrecht et al. 2015). Economic drivers can influence food choices and associated obesity rates, with migrant populations purchasing low cost, readily available high calorie food (Alidu and Grunfeld 2018). Thus, SES may affect the association between duration of residence and obesity via the health behaviours path (c+h+g).

2.3. The Health Behaviour Pathway

Theories of acculturation suggest that as DoR increases immigrants are more likely to replace healthier home country foods with fast-foods, do less physical activity, and adopt other risky health behaviours leading to the eventual loss of any initial health advantage(Abraído-Lanza, Chao and Flórez 2005; Gerber, Barker and Puhse 2012; Lara et al. 2005). Over time these rates are thought to converge to host country levels (Hyman 2001). Changes in dietary behaviour and physical activity are the two main behavioural processes that contribute to changes in obesity. While the theory of acculturation provides an important framework within which the nativity gap in health between immigrants and native-born people can be considered, it may provide a simplistic view of the complexity of mechanisms by which immigrants' health change over time. The theory of acculturation requires careful scrutiny because of its inherent assumptions. For example, acculturation research assumes that the country of origin has better health behaviours than the country migrated to, and that migration to western countries is accompanied by negative behavioural changes. We return to this point later in the discussion.

Regarding the relationship between DoR and these pathways (English language proficiency, SES and health behavior), there may be various distinct processes occurring simultaneously: (1) increasing DoR also leads to improvement in English language proficiency which results in immigrants particularly from Non-English speaking countries rating their health more positively (a+b); (2) increasing DoR leads to improved SES and resultant better health either directly or via English language proficiency (c+d or a+e+d); (3) increasing DoR leads immigrants to rate their health worse due to adoption of negative behaviours prevalent in Australia (f+g or c+h+g), and (4) increasing DoR may impact on health through unknown mediators such as discrimination/racism (i+j).

3. Methodology

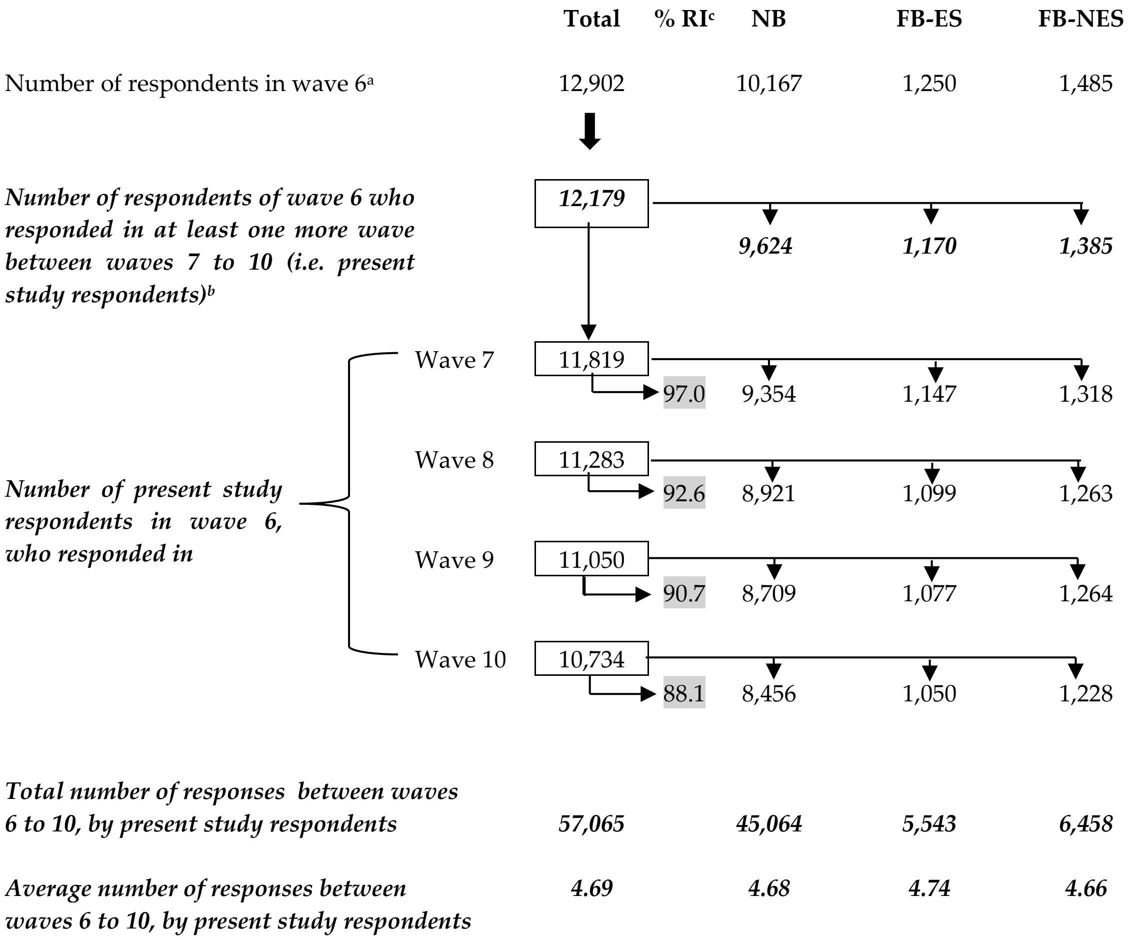
3.1. Data

This study uses data from HILDA, a longitudinal survey of Australian residents occupying private dwellings (Watson and Wooden 2012). The HILDA survey began in 2001 with a large and nationally representative sample of 7,682 households having at least one eligible member aged 15 years or above. So far, sixteen waves are available for researchers. Individuals aged 15 years and over were interviewed in each of the subsequent waves, and some non-respondents in wave 1 were successfully interviewed and followed in later waves. Additionally, new individuals that resulted from the structural changes of households were followed in all subsequent waves. The principal technique used for data collection was face-to-face questionnaire interviews. Telephone interviews and assisted interviews were also conducted to ensure a high response rate but only for the respondents who had moved to locations not covered by the network of face-to-face interviewers.

Information on BMI was not collected in the first five waves. However, from wave 6 (2006), information on height and weight was obtained from each respondent as a part of the self-completion questionnaire. This information was used to calculate BMI using the formula BMI=weight/height2.Analyses were conducted on an unbalanced panel of individuals who responded in wave 6 and in at least one wave between waves 7(2007) to 10 (2010). Using an unbalanced panel makes better use of the information collected and helps control for health selection bias. Both balanced and unbalanced panel data require more than one response per time period/wave for each respondent. But the essential difference between them lies in the number of observation/time periods per individual. In the balanced panel data the number of time periods/waves is the same for all individuals while for the unbalanced panel data, the number of time periods/waves is specific to each individual. All the questionnaires in HILDA survey are provided only in the English language. Language difficulties between the interviewer and the respondent are most often resolved by another household member acting as an interpreter. Few interviews are conducted in the presence of a professional interpreter (Summerfield et al. 2013).

The flow of study respondents between waves is depicted in Figure 2. A total of 12,902 respondents with non-missing information on country of birth responded in wave 6, with 12,179 responding at least once between waves 7 to 10. Altogether, there were 57,065 responses from these 12,179 respondents between waves 6 and 10.The average number of times a survey member responded out of the five waves (6, 7, 8, 9 and 10) was similar among native-born people (4.68), and foreign-born people from English speaking and non-English speaking (4.74 and 4.66 respectively).

Figure 2: HILDA survey flow chart of the study respondents by country of birth



[a]: total number excludes those three people for whom country of birth is missing;
[b]: total number excludes those people for whom country of birth is missing;
[c]: RI: per cent of present study respondents in wave 6 who were re-interviewed in various waves.
Note: Country of birth is defined as NB (native-born) and FB (foreign-born) from English-speaking (ES) and non-English-speaking (NES) countries.

3.2. Measurement of Study Variables

The outcome variable in this study is obesity level, which was calculated using the WHO definition of obesity, i.e., a respondent was considered obese if they had a BMI above 30 (WHO 1995). These cut-off points are based on associations between chronic disease and mortality and have been adopted for use internationally by the WHO (2000). They are useful for identification of individuals and groups at risk of morbidity and mortality, and identification of priorities for intervention at community levels (WHO 2000). There are several new large well conducted studies that have shown a clear relationship between obesity and increased mortality and morbidity (Jiang et al. 2013; Lenz, Richter and Muhlhauser 2009).

Age at wave 6 (henceforth age) and sex were the main time invariant control variables since they were considered to be effect modifiers of the exposure-health relationship. The cut point for the age groups was chosen to account for respondents' life-stages (early adulthood, middle adulthood (early-middle and late-middle) and late adulthood) of relevance to adapting to the host culture, whilst also ensuring sufficient statistical power. Time-varying covariates used in the analysis were selected on theoretical grounds and included English language proficiency, household equivalised income, current marital status, level of education, and employment status. Since they may also mediate the relation between immigrant status and obesity, models that included and excluded these variables were fitted. Physical activity, smoking, and drinking were the health behaviour variables used in the regression analysis to test their mediating role in the association between nativity/DoR and obesity.

English language proficiency (ELP)

Regardless of the country of birth, respondents in HILDA survey were asked whether English is the only language spoken at home or someone speaks language other than English at home. Where a language other than English was also spoken at home, they were further asked: *'How well would you say you speak English?'*, and the possible responses were: "very well", "well", "not well", and "not at all". Based on the above questions, this study have further recoded English language proficiency (ELP) into three categories: proficient (respondents who speaks only English language at home), good (very well/well) and not good (not well/not at all).

Marital status

The respondents' current marital status at each wave indicated whether they were legally married, in a de facto relationship, separated, divorced, widowed or never married and not in de facto relationship and was categorised into married/in de facto, separated/divorced/widowed and never married/not in de facto.

Level of education

The education variable used in this analysis was the highest level of education at Wave 6, categorised into the following four groups: less than12 years of schooling, exactly 12 years of schooling, diploma level and university level.

Employment status

Employment or labour force status is a time-varying variable, asked at each wave of HILDA survey. Employment status was broadly categorized as employed, unemployed, and not active in the labour force. These broad categories of employment status were based on the Australian Bureau of Statistics (ABS) classifications (Australian Bureau of Statistics 2001).

Household equivalised income

This paper has used equivalised annual household income adjusted for household structure and divided into four categories, (in AUS $): less than 20,000; between 20,000 and 40,000; between 40,000 and 60,000; and greater than 60,000.

Smoking status

A current smoking status variable was measured from responses to questions "*Do you smoke cigarettes or any other tobacco products?*" Response categories included: "No, I have never smoked", "No, I no longer smoke", "Yes, I smoke daily", "Yes, I smoke at least weekly (but not daily)", and "Yes, I smoke less often than weekly". We recoded this measure into three categories: current smoker, ex-smoker and never smokers.

Drinking status

Drinking status was based on the question '*how often do you drink alcohol*?. Response categories included "Has never drunk alcohol", "No longer drinks", "Drinks very rarely", "Drinks less than *once* a week", "Drinks on 1 or 2 days a week", "Drinks on 3 or 4 days a week", and "Drinks on 5 or 6 days a week" and "Drinks every day". We recoded this measure into three categories as never drunk, former drinker and current drinker.

Physical activity

Physical activity was measured from responses to questions *"In general how often do you participate in moderate or intense physical activity for at least 30 min? Moderate physical activity will cause a slight increase in breathing and heart rate such as brisk walking."* The possible six responses are: *'not at all', 'less than once a week', '1-2 times a week','3 times a week', 'more than three times a week (but not every day)', and 'every day'*. A three-category physical activity variable was created: not participating in any types of physical activities (no physical activities at all), insufficient physical activities (less than three times a week), and those who had sufficient physical activities (three or more times a week or every day). The grouping of physical activity in our study is based on the National Physical Activity Guidelines for Australian adults (Australian Institute of Health and Welfare 2012) and is also close to the recommended guidelines of the WHO (2010). Similar cut-offs have been used in other related empirical research utilising the HILDA survey data (Angrave, Charlwood and Wooden 2015; Perales et al. 2014).

Time effects were accounted for by including dummy variables for waves 7-10. The number of times a respondent responded out of five waves (6, 7, 8, 9 and 10) was also used in the regression analysis to reduce health selection bias. Additionally, a measure of attrition status (the last wave in which a respondent provided information, modelled as a binary variable (waves 7-8, and 9-10)) was used to test the effect of health selection bias (Becketti et al. 1988)(results not shown but available on request).

The main exposure variables for this study were: nativity status and duration of residence in Australia at wave 6. Nativity status was divided into two groups namely native-born or foreign-born people, with the foreign-born level further divided by country of birth (CoB), broadly categorised as English speaking (ES) or non-English speaking (NES) countries. Immigrants from the United Kingdom (65.8%), United States of America (3.5%), New Zealand (20.3%), Canada (1.9), Ireland (3.0%) and South Africa (5.4%) made up the English-speaking group, and other immigrants comprised the non-English speaking group. This list of main English-speaking countries provided here is based on the Australian Bureau of Statistics classification of migrants. It is a list of the main countries from which Australia receives, or has received significant numbers of overseas settlers who are likely to speak English. The list therefore includes South Africa. Although large numbers of South Africans do not speak English as their first language, those who migrate to Australia are likely to speak English (Australian Bureau of Statistics 2013). Foreign-born from NES countries were from the Philippines (6.5%), Italy (6.2%), Germany (5.8%), the Netherlands (5.8%), Vietnam (5.5%), India (4.7%), China (3.8%), Sri Lanka (3.0), Malaysia (2.9%), Hong Kong (2.2%), Poland (2.7%), Yugoslavia (2.6%), Fiji (2.4), Lebanon (2.3%) and Croatia (2.1%), and the remaining 40% were from other NES countries, with each country accounting for less than 2.0% of the total NES sample.

Several considerations influenced our decision to categorise the country of birth into ES and NES countries. First, we wanted to ensure sufficient sample size and consistency with our earlier work. Second, following Schwartz's model (Schwartz et al. 2010), we consider language as a proxy of social and cultural practices which determines how quickly one adopts the receiving culture (including receiving-cultural practices, values and identifications). In our categorisation, 80% of migrants from NES countries originate largely from Asia, Africa, the Caribbean, and the Middle East—regions where collectivism (focus on the well-being of the family, clan, nation, or religion) is emphasized over individualism(focus on the needs of the individual person) (Triandis 1995). On the other hand, 95% of the migrants from ES countries are primarily from North America (US and Canada), Western Europe (UK), and Oceania (New Zealand)—regions where individualism is emphasized more than collectivism (Triandis 1995). As a result, there are likely to be greater gaps in cultural values between migrants from NES to Australia than between migrants from ES countries and the native-born in Australia. This degree of similarity (actual or perceived) between the heritage and receiving cultures will determine, at least in part, not only how much acculturation is needed to adapt to the receiving culture but also the ease of integrating into the host culture (Rudmin2003). Apart from the cultural similarity, historically the major English speaking countries such as the US, the UK, Canada, Australia, and New Zealand are bound together through years of political and cultural evolution that also separates them from the rest of the world. These countries are all former overseas outposts of England that have evolved into nation states governed, populated, and settled by decedents of the original Anglo-Saxons. We would expect that the health habits and behaviours of immigrants from English speaking countries prior to migration and upon arrival would be similar to native-born Australians given a similar cultural background. Similar categorisations of country of birth have been used by others in the migrant health literature (McDonald and Kennedy 2004; Setia et al. 2011; Setia et al. 2009; Setia et al. 2012).

Fourth, we have historical evidence from the US that migrants from non-English speaking countries such as Poland, Italy, and Germany, as well as non-English speaking Jewish migrants (in other words migrants who could have been included in the ES countries based on 'western culture') were marginalized from the population of the US which is largely British-descent (Schildkraut 2005; Sterba 2003). Their recognizable foreign accents, or inability to speak the receiving country's language, identify them as migrants—and this may invite discrimination from native-born individuals (Yoo, Gee, & Takeuchi, 2009).

Duration of Residence (DoR) is based on the question 'In what year did you first come to Australia to live for 6 months or more (even if you have spent time abroad since)' and is calculated as the year of survey minus the year of arrival for each immigrant. Duration of residence was categorised as less than 10 years, 10-19 years, and greater than or equal 20 years in Australia, and combined with the nativity status variable described above. The main exposure variable for the duration of residence analysis therefore had levels: "ES; DoR < 10 years", "ES; DoR 10-19 years", "ES; DoR ≥ 20 years", "NES; DoR < 10 years", "NES; DoR 10-19 years", "NES; DoR ≥ 20 years", and "native-born". Age at arrival was grouped into two categories: less than 25 years and greater than or equal to 25 years. The cut points for duration of residence were chosen to: (1) reflect the empirical evidence suggesting that after 10 years an initial health advantage is lost (Gee, Kobayashi and Prus 2004); (2) ensure sufficient statistical power and allow reasonable estimates of uncertainty; (3) allow for the adoption of host country lifestyle and diet to affect obesity. The cut point for age at arrival (25 years) was chosen to differentiate between early and late exposures to the host country's culture while ensuring sufficient statistical power. To test the sensitivity of our results to the BMI cut-points used, we performed additional analyses for obesity defined as BMI ≥ 27 and BMI ≥ 33. Sensitivity tests of our age at arrival and duration of residence categorisations were also implemented.

3.3. Statistical Methods

We used 'hybrid' logistic regression models (Allison 2005), known as multi-level group-mean-centred logistic regression models in the multi-level modelling literature, to investigate the longitudinal association between nativity, country of birth, duration of residence, age at arrival, and levels of obesity. Multi-level group-mean-centred mixed ('hybrid') models give better estimates for both the time-varying variables and the time-invariant variables than those obtained by using the conventional mixed effects models (Allison 2005). Additionally, because hybrid approaches model both within and between-person variability, estimation may be more efficient than those obtained through conventional fixed effects models.

Four models were used. In model I, age, sex, wave (year) and number of times a person responded out of the five waves between waves 6 to 10 were the variables included in the model along with the main exposure variables nativity/country of birth (Table A2); duration of residence (Table A2); nativity and age at arrival (Table A3); duration of residence and age at arrival (Table A4). Model II adds English language proficiency to the covariates of Model 1. In model III, in addition to the variables in model II, level of education, marital status, employment status and household equivalised income were added. Model IV additionally adds health behaviour variables to model III variables. Thus, the mediating role by English language proficiency, SES variables and health behaviour was tested by excluding (Model 1) or including them as covariates (Models II to IV) (Hafeman 2009).

The hybrid logistic models used in this study have the following form:

$$logit(P_{it}) = \alpha_i + \beta_1(X_{it} - \overline{X}_{i.}) + \beta_2\overline{X}_{i.} + \gamma Z_i + \varepsilon_{it} \qquad (1)$$

Where P_{it} is the probability that the i^{th} respondent (i=1,2,3...,n, where n is sample size) in the t^{th} wave (t= 1 to 10) is obese.

In the above regression models α_i represents a random effect to account for clustering at the individual level, $X_{it} - \overline{X}_i$ represents within person variability of covariates X_{it}, $\overline{X}_i$ is the corresponding person-level mean (over time) of X_{it}, Z_i is a vector of time-invariant covariates, and β_1, β_2 and γ are coefficient vectors to be estimated. Note that wave (time) effects are included in X_{it}, and the terms $\overline{X}_{i.}$ and Z_i only change between people.

All analyses were done by using Statistical Analysis Software (SAS) package version 9.3. In particular, we used the Glimmix procedure for regression analyses. To guard against possible inconsistencies due to the choice of covariance structure, we obtained robust standard errors for the parameters by using a sandwich estimator i.e., specifying the 'empirical=MBN' option in Glimmix (Diggle et al. 2002; Huber 1967; Liang and Zeger 1986; White 1980). The design adjusted sandwich estimator used in this study is less biased than the classical sandwich estimator (Morel 1989; Morel, Bokossa and Neerchal 2003).

We received institutional review exemption from the Deakin University Human Research Ethics Committee, reference number 2013-118/ 20-05-2013.Respondents in the HILDA survey do not give written consent, but consent is implied when they agree to be interviewed. When children (15-17 years old) are interviewed, verbal consent is given by their parent/guardian (or written consent if away at a boarding school). Clinical records are not used in the HILDA study.

4. Results

4.1. Descriptive Findings

Background characteristics of respondents at base-line (wave 6) are shown in Table 1A. A total of 12,179 respondents with non-missing information on CoB responded in wave 6 and at least once more between waves 7 and 10. Of these 9,624 respondents (79%) were NB, 1,170 (9.6%) were born in ES countries and the remaining 1,385 (11.4%) were born in NES countries (Table 1A). There were more females (6,466) in the sample than males (5,713). Most of the FB had been in Australia more than 20 years. Roughly two thirds of the FB from NES countries was not proficient in English. More NB (36.9%) than FB respondents (27.6%) had 12 years of schooling or less. Fewer of the NB were either married or in de facto relation (59.4%) than the FB (71.0%). Similarly, 13.6% of the NB were either separated or widowed, compared with 16.6% of the FB. Similar proportions of the NB and FB were unemployed (3.0 and 2.4% respectively). Fewer of the NB than the FB had equivalised incomes less than $20,000.

While 15.8% of FB respondents were current smokers from NES countries, the corresponding proportions for the FB from ES counties and the NB were 18.7% and 21.8%. Similarly, while 72.2% of the FB from NES countries were current drinkers, the corresponding proportions for the FB from ES countries and the NB was 88.5% and 83.5%. In contrast, levels of sufficient physical activity were less among the FB from NES countries (44.3%) than the FB from ES countries (52.7%) and the NB (50.8%). Around 21.8% of the NB, 20.3% of the FB from ES countries and 17.1% of the FB from NES countries were obese at wave 6.

Table 1A: Base-line (wave 6) characteristics of the study respondents by nativity

Characteristic	ALL		Only FB		Nativity						
					NB		ES		NES		
	N	%	N	%	N	%	N	%	N	%	P-value
Sex											
Male	5713	46.9	1198	46.9	4515	46.9	579	49.5	619	44.7	**0.053**
Female	6466	53.1	1357	53.1	5109	53.1	591	50.5	766	55.3	
Age group											
15-29	3113	25.6	322	12.6	2791	29.0	92	7.9	230	16.6	**<0.001**
30-44	3411	28.0	681	26.7	2730	28.4	314	26.8	367	26.5	
45-59	3061	25.1	821	32.1	2240	23.3	394	33.7	427	30.8	
60+ years	2594	21.3	731	28.6	1863	19.4	370	31.6	361	26.1	
Duration of residence											
<10 years	283	2.3	283	11.1			101	8.6	182	13.2	**<0.001**
10-19 years	625	5.1	625	24.5			193	16.5	432	31.2	
>= 20 years	1644	13.5	1644	64.4			874	74.8	770	55.6	
English proficiency											
Proficient	10999	90.3	1621	63.4	9378	97.4	1146	98.0	475	34.3	**<0.001**
Good	1048	8.6	802	31.4	246	2.6	24	2.1	778	56.2	
Not good	132	1.1	132	5.2	0	0.0	0	0.0	132	9.5	
Level of education											
<12 years of schooling	4255	34.9	704	27.6	3551	36.9	335	28.6	369	26.6	**<0.001**
Exactly 12 year school	1799	14.8	404	15.8	1395	14.5	150	12.8	254	18.3	
Diploma	3624	29.8	766	30.0	2858	29.7	395	33.8	371	26.8	
University education	2497	20.5	681	26.7	1816	18.9	290	24.8	391	28.2	
Current marital status											
Married/in de facto	7532	61.8	1814	71.0	5718	59.4	844	72.1	970	70.0	**<0.001**
Separated/Widowed	1736	14.3	424	16.6	1312	13.6	208	17.8	216	15.6	
Never married/ never in de facto relation	2910	23.9	317	12.4	2593	27.0	118	10.1	199	14.4	
Employment status											
Employed	7873	64.6	1523	59.6	6350	66.0	730	62.4	793	57.3	**<0.001**
Unemployed	347	2.8	61	2.4	286	3.0	23	2.0	38	2.7	
Not in labour force	3959	32.5	971	38.0	2988	31.1	417	35.6	554	40.0	
Equivalised income											
<=20,000	2734	22.4	680	26.6	2054	21.3	241	20.6	439	31.7	**<0.001**
(20,000-40,000]	5443	44.7	1045	40.9	4398	45.7	481	41.1	564	40.7	
(40,000-60,000]	2621	21.5	527	20.6	2094	21.8	272	23.3	255	18.4	
>60,000	1381	11.3	303	11.9	1078	11.2	176	15.0	127	9.2	
Smoking											
Never smoked	5694	51.9	1101	49.4	4593	52.5	452	41.5	649	56.8	**<0.001**
Former smoker	2989	27.2	745	33.4	2244	25.7	433	39.8	312	27.3	
Current smoker	2290	20.9	385	17.3	1905	21.8	204	18.7	181	15.8	
Drinking											
Never drunk	1159	10.5	297	13.3	862	9.8	41	3.8	256	22.4	**<0.001**
Former drinker	726	6.6	146	6.5	580	6.6	85	7.8	61	5.3	
Current drinker	9102	82.8	1790	80.2	7312	83.5	966	88.5	824	72.2	
Physical activity											
Not at all	1141	10.3	285	12.7	856	9.7	123	11.2	162	14.1	**<0.001**
Insufficient activity	4350	39.4	875	38.9	3475	39.5	396	36.1	479	41.6	
Sufficient activity	5553	50.3	1089	48.4	4464	50.8	579	52.7	510	44.3	
Obesity status	2240	21.2	406	18.7	1834	21.8	217	20.3	189	17.1	**<0.001**
Sample size	*12179*	*100*	*2555*	*21.0*	*9624*	*79.0*	*1170*	*9.6*	*1385*	*11.4*	

* Chi-square tests were performed to estimate the significance of bivariate associations between covariates and nativity. Notes: The sum of row counts with respect to each characteristic need not equal the corresponding sample size because of missing values. Note 2: Nativity is categorised as NB (native-born), FB (foreign-born) from English-speaking (ES) and non-English-speaking (NES) countries.

Table 1B shows empirical obesity transition probabilities between successive waves used in this analysis: on average, of those who were not obese at wave t, 94.6% remained not obese in the wave t+1, and 83.7% of the obese people at wave t remained obese in the wave t+1. Approximately 5.4% of people moved from not-obese to obese, and 16.3% from obese to not-obese, suggesting that off-diagonal transitions were an important component of longitudinal obesity dynamics during the 5-year period of this study.

Table 1B: Empirical transition probabilities (%) computed from counts of the number of times respondents reported the indicated pair of obesity states in successive observations over waves 6 to 10. Transition probabilities were derived by dividing these counts by row totals

Obesity status transition probabilities		**Wave 't+1'**	
		Not obese	**Obese**
Wave 't'	**Not obese**	94.56	5.44
	Obese	16.35	83.65

4.2. Effect of Nativity and Duration of Residence in Australia: Regression Results

Table A1 in the Appendix shows results of regression analysis with nativity/country of birth as the main exposure variables. Table A2 shows results of regression analysis with nativity/duration of residence as the main exposure variables.

Model I results from Table A1 indicate that after controlling for age and sex, wave effects, and the number of times a person responded out of 5 waves, the odds of being obese was significantly smaller among foreign-born people from English speaking countries (OR 0.41, CI 0.24 to 0.72) and foreign-born people from non-English speaking countries (OR 0.29, CI 0.18 to 0.46), when compared with native-born people. Adjusting for suspected mediators including English language proficiency (model II), level of education, marital status, employment status and household equivalised income (model III), and health behaviour variables (model IV) did not alter this conclusion, or substantially change the magnitude of the nativity effect. This suggests that mediation of the relationship between nativity and obesity by English language proficiency, socio-demographic and health behaviour variables used in the analysis was unimportant.

Model I results from Table A2 showed that after controlling for age and sex, wave effects, and the number of times a person responded out of 5 waves, obesity was less likely among foreign-born people from English speaking countries relative to native-born people when duration of residence was less than 10 years (OR 0.22, CI 0.05 to 0.98) and 20 years or more (OR 0.50, CI 0.26 to 0.95). There was no significant difference in their obesity levels relative to the native-born when duration of residence was 10 to 19 years, and no evidence of significant differences in estimated coefficients by duration of residence. For the foreign-born from non-English speaking countries the odds of obesity were lower than native-born people when duration of residence was less than 10 years (OR 0.15, CI 0.06, 0.38) and 10 to 19 years (OR 0.06, CI 0.03, 0.11). After 20 years of duration of residence, however, obesity levels for foreign-born people from non-English speaking countries were not significantly different from those of native-born people. In this case, the estimated coefficients for duration of residence less than 20 years were significantly different from that for duration of residence of at least 20 years.

Additionally adjusting for English language proficiency (model II) made only one change to the above conclusions. Immigrants from English speaking countries with duration of residence 20 years or more now had levels of obesity that were not significantly different from Native-born people. Further adjusting for SES factors (Model III) caused small changes to the effect magnitudes but not to the conclusions drawn from model II. Adjusting for health behaviour variables (smoking, drinking and physical activity) to mode III did not alter this conclusion.

4.3. Differential Effect of Nativity and Duration of Residence by Age at Arrival in Australia

Table A3 shows results of regression analysis with nativity/age at arrival as the main exposure, and Table A4 does the same with duration of residence/age at arrival as the main exposure. Results of models I, II and III and IV in Table A3 show that except for FB people from English speaking countries who arrive in Australia before 25 year of age, foreign-born people both from English speaking and non-English speaking countries had significantly lower odds of being obese relative to Native-born people irrespective of age at arrival.

Results in Table A4 show that there was no significant difference between longstanding immigrants (20+ years of residence) and native-born Australians by age at arrival. In fact except for the youngest and most recent immigrants (duration of residence<10 years and age at arrival<25 years), foreign-born people with duration of residence less than 20 years had significantly lower odds of obesity compared to the Native-born regardless of age at arrival.

Including a measure of attrition status (i.e., those who dropped out before wave 9) and its interaction with the main exposure did not change our conclusions. Similarly, changing the definition of obesity by reducing or increasing the BMI cut-off generally had little effect on odds ratio estimates and no effect on overall conclusions for nativity or duration of residence/ /age at arrival (results not shown but available on request). Sensitivity analyses suggest our conclusions are reasonably robust to changes in the definition of obesity.

4.4. Sensitivity Analyses

Changing the definition of obesity (Tables 6A and 6B) by reducing or increasing the BMI cut-off generally had little effect on odds ratio estimates and no effect on overall conclusions for CoB/DoR or DoR/AA (compare with Tables A2 and A4).

Table 6A: Multilevel hybrid logistic regression Model I results showing the odds ratios and their 95% confidence intervals (CI) for the prevalence of obesity by country of birth and duration of residence combined for three definitions of obesity (compared with the base Model I analysis of Table A2)

Factor	BMI ≥ 27		BMI ≥ 30		BMI ≥ 33	
	Odds ratio	CI	Odds ratio	CI	Odds ratio	CI
DoR/CoB)						
ES; DoR < 10	0.23*	(0.06, 0.87)	0.22*	(0.05, 0.98)	0.34*	(0.14, 0.79)
ES; DoR 10 to 19	0.35*	(0.13, 0.95)	0.33	(0.10, 1.13)	0.64	(0.41, 1.00)
ES; DoR >= 20	0.55*	(0.34, 0.89)	0.50*	(0.26, 0.95)	0.81*	(0.67, 1.00)
NES; DoR < 10	0.13**	(0.04, 0.36)	0.15**	(0.06, 0.38)	0.34**	(0.18, 0.65)
NES; DoR 10 to 19	0.08**	(0.04, 0.16)	0.06**	(0.03, 0.11)	0.39**	(0.27, 0.56)
NES; DoR >= 20	1.24	(0.73, 2.10)	0.88	(0.48, 1.64)	0.99	(0.80, 1.23)
NB (R)						

Table 6B: Multilevel hybrid logistic regression Model I results showing the odds ratios and their 95% confidence intervals (CI) for the prevalence of obesity by duration of residence and age at arrival (DoR/AA)for three definitions of obesity (compared with the base Model I analysis of Table A4)

Factor	BMI ≥ 27		BMI ≥ 30		BMI ≥ 33	
	Odds ratio	CI	Odds ratio	CI	Odds ratio	CI
DoR in Australia						
DoR <10; AA < 25	0.47	(0.09, 2.40)	0.46	(0.15, 1.42)	0.33*	(0.11, 0.97)
DoR <10; AA>=25	0.10**	(0.04, 0.26)	0.10**	(0.04, 0.22)	0.38**	(0.22, 0.66)
DoR 10-19; AA < 25	0.23**	(0.09, 0.57)	0.27**	(0.14, 0.55)	0.48**	(0.30, 0.74)
DoR 10-19; AA >=25	0.08**	(0.04, 0.18)	0.09**	(0.04, 0.19)	0.45**	(0.31, 0.66)
DoR >=20; AA < 25	0.80	(0.52, 1.23)	0.68	(0.40, 1.14)	0.89	(0.75, 1.07)
DoR >=20; AA >=25	0.74	(0.39, 1.40)	0.75	(0.34, 1.66)	0.88	(0.67, 1.15)
NB (R)						

A finer categorisation of DoR (compare Tables A2 and 6C) suggests that measurably lower odds of obesity with respect to the NB was confined to the DoR group 5-9 years for immigrants from ES countries. Measurably lower odds of obesity relative to the NB for immigrants from NES countries was spread across most DoR categories with between 5 and 30 years residence in Australia. There was some indication of higher odds of obesity relative to the NB for immigrants from NES counties with at least 30 years residence in Australia, though the statistical significance of this result was marginal.

Table 6C: Multilevel Model I hybrid logistic regression results showing the odds ratios and their 95% confidence intervals (CI) for the prevalence of obesity by country of birth and duration of residence combined using a finer categorisation of DoR than the Model I base analysis in Table A2

Factor	Model I	
	Odds ratio	**CI**
DoR/CoB		
ES; <5 years	1.02	(0.05, 22.39)
ES; 5-9 years	0.11**	(0.03, 0.41)
ES; 10-14 years	0.52	(0.07, 3.93)
ES; 15-19 years	0.25	(0.05, 1.24)
ES; 20-24 years	0.87	(0.21, 3.60)
ES; 25-29 years	0.49	(0.08, 3.07)
ES; >=30 years	0.50	(0.23, 1.08)
NES; <5 years	0.30	(0.06, 1.44)
NES; 5-9 years	0.10**	(0.04, 0.27)
NES; 10-14 years	0.06**	(0.02, 0.14)
NES; 15-19 years	0.06**	(0.03, 0.13)
NES; 20-24 years	0.25	(0.06, 1.12)
NES; 25-29 years	0.05**	(0.02, 0.17)
NES; >=30 years	2.29*	(1.17, 4.49)
Australia (R)		

Note: Country of birth was categorised as NB, FB from English-speaking and non-English-speaking countries. Duration of residence was categorised into less than 5 years, 5-9, 10-14, 15-19, 20-24, 25-29 years, and greater than or equal 30 years in Australia.

Increasing the number of AA categories (compare Tables A3 and 6D) showed that for immigrants from ES countries, the odds of obesity relative to the NB were measurably reduced for arrival ages between 15 and 45 years. For immigrants from NES countries, odds of obesity were measurably less than for the NB for arrival ages less than 45 years, though the significance of the result for ages less than 15 years was marginal.

Table 6D: Multilevel hybrid logistic regression results Model I showing the odds ratios and their 95% confidence intervals (CI) for the prevalence of obesity by country of birth and age at arrival (compare with the Model I base analysis of Table A3)

Factor	Model I	
	Odds ratio	**CI**
Country of birth and age at arrival		
ES; AA < 15	0.81	(0.38, 1.73)
ES; AA 15-24	0.28*	(0.09, 0.89)
ES; AA 25-44	0.23**	(0.09, 0.60)
ES; AA 45-64	1.10	(0.06, 20.43)
NES; AA < 15	0.50*	(0.26, 0.98)
NES; AA 15-24	0.38*	(0.17, 0.89)
NES; AA 25-44	0.10**	(0.05, 0.20)
NES; AA 45-64	0.62	(0.05, 7.88)
Australia (R)		

Note: Country of birth is categorised as NB, FB from ES and NES countries. Age at arrival is categorised into less than 15 years, 15-24, 25-44, and 45-64.

Sensitivity analyses suggest our conclusions are reasonably robust to changes in the definition of obesity. Nevertheless, higher levels of categorisation for AA and DoR appear to provide a more nuanced view than our "base" analyses, suggesting there is ample scope for more detailed research in the future.

5. Discussion and Conclusion

The purpose of this study was to investigate differences in the levels of obesity among foreign-born people from English Speaking and non-English Speaking countries relative to native-born Australians, and how those differences changed with duration of residence and age at arrival. We were also interested in examining the mediating role of English language proficiency, SES and health behaviour factors in the association between nativity, duration of residence and obesity. Unlike analyses that examined these research questions using cross-sectional data, we used 5 waves of longitudinal data to investigate the nature of the association between migration and obesity in the Australian setting. Extending previous longitudinal work, including that of Setia et al. (Setia et al. 2011; Setia et al. 2009, 2012), we used hybrid regression models to help reduce estimation bias. With respect to our research questions, we found that:

1. The odds of being obese was patterned by nativity with foreign-born people, both from English speaking countries and non-English speaking countries had lower odds of being obese as compared with the native-born people.
2. Relative to the native-born, foreign-born people from English speaking and non-English speaking countries had an obesity advantage for less than 10 years of duration of residence, though the significance was marginal for foreign-born from English speaking countries. Immigrants from non-English speaking countries lost

their measurable obesity advantage with respect to the native-born after 20 years of residence in Australia, whereas immigrants from English speaking countries did not.

3. We did not find a substantial modification in these associations by age at arrival for either immigrants from English speaking or non-English speaking or countries.
4. We did not find any evidence of the mediating role of SES and health behaviour factors in the association between nativity, duration of residence and obesity. However, English language proficiency mediated the relationship between nativity/DoR and obesity for immigrants from English speaking countries and the effect was marginal.

In response to our first research question, we found that immigrants from both ES and NES countries had lower odds of being obese (OR 0.41, CI 0.24 to 0.72 and OR 0.29, CI 0.18 to 0.46 respectively) relative to NB people. These results are consistent with previous studies that have shown that foreign nativity was associated with lower BMI, overweight and obesity (Antecol and Bedard 2006; Lauderdale and Rathouz 2000; Popkin and Udry 1998; Sanchez-Vaznaugh et al. 2008). Our study contributes to this literature by adding a longitudinal lens to the analysis. The finding of apparently lower odds of being obese for the immigrants relative to native-born people corroborates the presence of a 'healthy migrant effect' which posits that only those with good health are selected for migration. The selection of healthy persons from the source country could be due to the requirement that potential migrants undergo medical screening (direct selection), or from immigration policies favouring tertiary education, occupational skills and wealth (indirect selection though the use of 'point system' to determine the eligibility of applicants to immigrate), or by self-selection among immigrant populations such that healthier individuals are more likely to migrate (Akresh 2007; Antecol and Bedard 2006; Biddle, Kennedy and McDonald 2003; McDonald and Kennedy 2004).

Australia uses a 'point system' to determine the eligibility of applicants to immigrate with points for productivity-related factors such as language, education, age and skills. Selecting immigrants by this system is likely to result in their being healthy, although it is reasonable to assume that the points system would not apply to English migrants who arrived before the abandonment of the White Australian policy in 1973 and to New Zealand migrants. In combination these two groups make up a large proportion of the FB from ES countries. Most migrants in Australia also undergo medical screening in order to satisfy the health requirement specified in the Migration Regulations (Department of Immigration and Border Protection 2014). The health requirement is designed to reduce demand on the Australian health care system and ensure that additional pressure is not put on health care and community services that are in short supply (Department of Immigration and Border Protection 2014). However, the strength of health selection actually imposed on immigrants differs between migrant groups and over time as the goals of Australia's migration policy have changed. Presumably, after the tightening of Australian migration policy in the 1980s and, a greater focus on better labour market performance of migrants to Australia, health criteria were more diligently enforced resulting in more intense health selection of migrants.

Additionally, and also consistent with previous studies, we found that immigrants from both English speaking and non-English speaking countries living in Australia for less than 10 years were significantly less likely to be obese than the native-born people, though the significance was marginal for immigrants from English speaking countries. Immigrants from non-English speaking countries lost their measurable obesity advantage with respect to the native-born after 20 years of residence in Australia, whereas immigrants from ES did not lose their obesity advantage even after 20 years of stay (though again the significance of the results for the ES group was not compelling). Our results indicate that not all groups show increase in obesity with longer duration.

Why did NES immigrants lose their health advantage after 20 years? What it is about the Australian culture or food environment that can change immigrants' diets or weight outcomes? These results might reflect differential pattern of adaptation in Australia in which immigrants from ES countries maintain the lifestyle of the home country for a longer period so that the "protective effect" of foreign nativity on obesity prevalence is maintained among immigrants from ES countries while immigrants from NES countries lost it. One of the major explanations for the observed decline in health in terms of increased weight or obesity levels with increased duration of residence in the host country has focused on acculturation. Acculturation into the host society worsens immigrant health through various mechanisms such as loss of protective cultural practices and the adoption of unhealthy behaviours which are deleterious to continued good health (Abraido-Lanza et al. 2006; Antecol and Bedard 2006; Lara et al. 2005). Changes in diet (Akresh, 2007; Van Hook, Baker, Altman, & Frisco, 2012) and physical activity (McCullough and Marks 2014) are the main component of acculturation used for explaining post-migration changes in health among immigrants. We did not have data on diet, but our analysis did include health behaviour including physical activity. While we did not find convincing evidence that health behavior mediates the DoR-obesity association for any immigrant group, we did find in our other work that DoR affects physical activity among the FB from NES countries (Joshi2017). We found that immigrants from NES countries maintained their disadvantage in their engagement with physical activity, albeit reduced, and still had the lower odds of physical activity vis-à-vis NB Australians (though marginally) even after 20 years of DoR (Joshi 2017).

While the theory of acculturation provides an important framework within which the nativity gap in obesity between immigrants and NB people can be considered, it may provide a simplistic view of the complexity of mechanisms by which immigrant obesity levels change over time. The theory of acculturation requires careful scrutiny because of its inherent assumptions. The basic assumption is that the longer one resides in the host country the greater is the exposure to the host culture and the stronger the influence of the host culture on behaviour. Acculturation research assumes that the country of origin has better health behaviours than the country migrated to, and that migration to western countries is accompanied by negative behavioural changes. In terms of dietary changes, the theory ignores the role of globalisation and transnational processes in changing the diet in low-to-middle income countries. Indeed, Martinez (2013) has convincingly shown that Latino immigrants who migrated to the US on or after 2000, were fully engaged in negative dietary practices prior to migration. In short, their exposure to westernized dietary practices did not start after arrival in the host society (Martinez 2013:p, 128). Moreover, much of the early theoretical evidence on acculturation comes from the Hispanic population in the US after World War II, and its extension to immigrant groups of other national origin may be less valid (Salant & Lauderdale 2003). In terms of physical activity, Australia will be more health promoting for some behaviours than the person's original country e.g., less air pollution, more green space, and more exercise facilities will encourage physical activity post migration. In other instances, there may be no differences in the health behaviours of immigrants because of greater prior similarities between Australia and the country of origin.

The role of government migration policy over the past several decades may provide another explanation for a decline in the health in terms of increased obesity levels of immigrants. Australia's immigration policies have evolved over the years from a narrowly targeted programme designed to achieve the 'populate or perish' objective after World War II, to a more open programme since the 1980s aimed primarily at meeting the labour market needs of Australian economy (Spinks 2010). Because the post-world war II focus was on increasing numbers to defend the country in the event of another war, it seems reasonable to suppose that health-selection barriers for migrants were, in practice, low. It also seems reasonable to suppose that after the tightening of Australian migration policy in the 1980s, with a focus on better labour market performance of migrants to Australia, health criteria were more diligently enforced. Introduction of various policy measures in the mid-1980s which emphasised skills, education and language proficiency, may have added indirect forms of health selection to these direct (medical screening) forms. Note that the DoR period 0-9 years, 10-19 years, and 20 years or longer correspond to arrival periods after 1996, between 1986 and 1995, and before 1986, respectively. Under these assumptions, a significant proportion of migrants with duration of residence less than 20 years have been subject in practice to more intense health-selection pressures than those with longer durations of residence, resulting in overall better health for those who settled in Australia after the mid-1980s compared with earlier migrants.

Our results for age at arrival effects contrast with previous studies (Kaushal 2009; Oza-Frank and Venkat Narayan 2010; Roshania et al. 2008) which reported a modification in the association between duration of residence and obesity by age at arrival. However, given broad confidence intervals, we may lack the statistical power to detect differences between the groups, hence, our findings should be considered tentative until replicated. On the other hand, migration studies are not generally able to separate out the effect of age at migration from duration of residence in the host population (Kinra 2004). Moreover, the existing studies reporting age at arrival results were cross-sectional making it difficult to disentangle age/period/cohort effects. Kaushal's study tried to overcome this limitation by using 15 years of cross-sectional data to create a synthetic cohort, allowing her to control for age and period of arrival and to separate the effects of duration of residence from the cohort effect. However, the key limitation of her study was that it did not follow the same people over time and 'the observed increases in obesity may be due to differences in individuals tracked in different years' (Kaushal 2009). Park et al's (2009) study also suffered from the same limitation. Moreover, two of these studies (Oza-Frank and Venkat Narayan 2010; Roshania et al. 2008) examined overweight/obesity transitions within immigrant groups and did not (as here) compare changes in weight/obesity of immigrants relative to native-born people, making comparison with our results problematic. In migration studies, the lack of independence between age, age at arrival, and duration of residence makes it harder to isolate the independent contribution of age at migration and total duration of new exposure (Kinra 2004). Thus, an individual-level analysis could not simultaneously include age, age at arrival, and duration of residence as continuous covariates. This is not necessarily true when such covariates are grouped, though correlations between the categories may hinder identification of significant differences. However, this does not seem to be the case here, except perhaps for the youngest and most recent migrant group.

We did not find any convincing evidence of mediation of the relationship between nativity- duration of residence and obesity by socio-demographic factors and health behaviour factors used in the analysis. Other studies also found no significant association between SES and obesity (Bertera, Bertera, and Shankar, 2003; Khan, Sobal, & Martorell, 1997). We did find that English language proficiency mediated the relationship between duration of residence and obesity for immigrants from English speaking countries. Once the English language proficiency was controlled for (Table A2, Model II), the advantage of immigrants from English speaking countries relative to NB Australian disappeared and also they were not measurably different from the NB in terms of obesity for DoR 20 or more years. We also found a hint about the role of ELP in mediating the relationship between DoR and obesity when we did a sensitivity analysis by removing these so called 'western countries' (e.g., France, Germany) from the NES category and adding them to ES countries (i.e., making this a "European" national grouping that ignores language differences). We found a change in statistical significance for DoR for FB from ES countries: the odds ratio estimate for DoR < 20 years became significant, while the estimate for DoR > 20 years lost significance (results not shown but available on request). While the change in estimates between the different categorisations for language might not be significant (given the wider CIs), perhaps they are driven by language differences which reduce as DoR increases. Controlling for ELP seems to reduce the difference (between the different categorisations), as one might expect. There are two possible mechanisms through which ELP may be operating as a mediator which affect the weight gain among immigrants from NES countries. First, a limited proficiency in English language could convey incorrectly the nutritional information on food and drug labelling, and this could lead to adoption of poorer foods. Similarly, a better proficiency in English language could motivate an immigrant from anon-English speaking background to make better use of information (e.g., from the mass media) and promotion of recreational physical activities (Caperchione, Kolt and Mummery 2013). Second, given that English proficiency and labour market success are closely related, those with limited English skills are also likely to be in the lower income quartiles.

This finding is consistent with the earlier research evidence suggesting that the ability to speak English language influences the obesity levels of immigrants (Gee et al.2010, Gee et al., 2008). However, the effect of language proficiency on health is complex and may operate through several mechanisms (Gee et al.2010). The study by Gee et al. (2010) even challenges the presumption that use of English represents acculturation and suggests new avenues of research focussed on bilingualism (Schachter, Kimbro, and Gorman 2012).

Our study makes a significant contribution to the literature by overcoming some limitations of previous work using longitudinal data and both conventional mixed and hybrid models. Our results have implications for theory, methods and policy. Existing acculturation theory may provide an overly simplistic view of complex issues. As mentioned before, further research should explore potential pathways through which immigrants lose their health advantage over time in the host country. One such pathway could be the experience of acculturative stress and discrimination, impacting food habits and physical activity patterns through changes in mental health, feelings of marginality, and identity confusion (Berry et al. 1987; Rudmin 2009). Agne et al.'s study of Latino immigrants to the USA (Agne et al. 2012) and Delavari et al.'s study of Iranian immigrants to Australia (Delavari, Farrelly and Renzaho 2013) found that unhealthy eating was used as a way of coping with the stress of immigration. Similarly, another study showed that obesity rose with duration of residence only among Asian Americans who reported racial discrimination; among Asian American who reported no discrimination, there was no relation between obesity and duration (Gee, Ro, Gavin, & Takeuchi, 2008). However, the acculturation model has been criticised and there remains a number of challenges regarding operational definitions, contextual forces and relationships to psychosocial and health outcomes that must be addressed (Rudmin 2009). Future work should include both pre and post-migration food habits and stress associated with acculturation in order to determine what actually drives change in weight over time. Another area of future research is to compare non-mobile cohorts from source countries with immigrants (see for example Gibson, McKenzie and Stillman 2011; McKenzie, Gibson and Stillman 2007; Stillman, McKenzie and Gibson 2009). Given the current evidence of increasing BMI and obesity in the developing world and increasing proportions of immigrants from these countries, it is important that research into the epidemiology of global obesity be undertaken.

From a policy perspective, our results have several clear implications for the design of future obesity prevention and reduction programmes. Given increasing proportions of foreign-born people in Australia, it is of concern that they arrive healthier than the native-born people but lose their health advantage over time. With the obesity rates of immigrants from non-English speaking countries become indistinguishable from those of native-born Australians over time, downstream increases in the incidence of diabetes, heart disease, hypertension, and cancer may follow, in turn impacting health care resources (Bray 2004). Our findings underscore why prevention programmes should be separately designed and specifically targeted at native-born and (different) immigrant groups e.g., programmes designed to prevent or delay onset of obesity among foreign-born immigrants.

There were some important limitations to this study that merit consideration. First, out height and weight data were self-reported and unverified by actual measurements.

Although previous studies have widely used this method of measuring BMI and found a high level of agreement between self-report and measured height and weight (Willett 1998), systematic biases of underestimating weight and overestimating height have been observed (Engstrom et al. 2003; Kuczmarski, Kuczmarski and Najjar 2001; Majid Ezzati et al. 2006; Palta et al. 1982; Stewart et al. 1987; Villanueva 2001). Such systematic misreporting would bias our estimates of obesity prevalence. However, we are not aware of studies which have examined whether foreign-born groups report weight and height differently than native-born people, making it difficult to determine the direction of this potential bias. Response bias would influence our findings if there was differential reporting of height and weight by nativity. Moreover, we have adjusted for most of the factors associated with biased reporting of weight and height e.g., age, gender, education.

Second, we do not focus on migrant generation status since our major research question deals with what happens as migrants stay longer in the host country. First generation migrants (i.e., those born overseas) were treated as a foreign-born group because only they experienced the process of migration itself. Second generation migrants (i.e., those born in Australia and having at least one foreign-born parent) were included in the native-born group.

Third, we had sufficient power to examine nativity/ duration of residence associations with obesity only by a crude binary categorisation for age at arrival, and even then our ability to detect differences by age at arrival may have been limited. Similarly, we were not able to adequately account for the important heterogeneity among immigrants from English speaking countries and non-English speaking countries because of small sample size. Particularly several dimensions of non-English speaking countries immigrant diversity were not captured in our analyses. Small numbers prevented the use of smaller sub-groups for the foreign-born. Future studies should disaggregate data by nativity, country of birth, and age at arrival at higher resolution to avoid masking important sources of heterogeneity.

Fourth, it was not possible to separate duration of residence effects, from period/cohort effects because of perfect linear relationship (perfect multicollinearity) between DoR, year of arrival and year of survey. Similarly, within-survey temporal trends can be caused by both a decline in the health of the study sample over time through aging, and external influences manifest in respondent health during the course of the survey (e.g., changes in health policy). One important variable in the context of migration is age at migration (Leão, Sundquist, Johansson, & Sundquist, 2009). However, migration studies are not generally able to separate out the effect of age at migration from duration of residence in the host population (Kinra, 2004). We had limited power to examine the effect of nativity/DoR and age at arrival with health.

Fifth, we examined the mediation by English language proficiency, SES and health behaviour factors in the relation between nativity/DoR and obesity. However, we have not focussed on the dietary mechanism(s) through which levels of obesity increases over time and we recommend that future studies should examine the dietary/ nutrient determinants of changes in obesity over time among immigrants vis-à-vis non-immigrants.

References

Abraido-Lanza, A.F., A.N. Armbrister, K.R. Florez, and A.N. Aguirre. 2006. "Toward a theory-driven model of acculturation in public health research." American Journal of Public Health 96(8):1342-1346.

Abraído-Lanza, A.F., M.T. Chao, and K.R. Flórez. 2005. "Do healthy behaviors decline with greater acculturation? Implications for the Latino mortality paradox." Social Science & Medicine 61 (6): 1243-1255.

Agne, A., R. Daubert, M. Munoz, I. Scarinci, and A. Cherrington. 2012. "The Cultural Context of Obesity: Exploring Perceptions of Obesity and Weight Loss Among Latina Immigrants." Journal of Immigrant and Minority Health 14(6):1063-1070.

Akresh, I.R. 2007. "Dietary Assimilation and Health among Hispanic Immigrants to the United States." Journal of Health & Social Behavior 48(4):404-417.

Albrecht, S.S., T.L. Osypuk, N.R. Kandula, L.C. Gallo, F. Le-Scherban, S. Shrager, and A.V. Diez Roux. 2015. "Change in waist circumference with longer time in the United States among Hispanic and Chinese immigrants: the modifying role of the neighborhood built environment." Annals of Epidemiology 25(10):767-772.e762.

Alidu, L.and E.A. Grunfeld. 2018. "A systematic review of acculturation, obesity and health behaviours among migrants to high-income countries." Psychology & Health 33(6):724-745.

Allison, P. 2005. Fixed effects regression analysis for longitudinal data using SAS. Cary, North Carolina: SAS Institute Inc.

Angrave, D., A. Charlwood, and M. Wooden. 2015. "Long working hours and physical activity." Journal of Epidemiology and Community Health 69(8):738-744.

Antecol, H.and K. Bedard. 2006. "Unhealthy assimilation: Why do immigrants converge to American health status levels?" Demography 43(2):337-360.

Australian Bureau of Statistics. 2001. "Labour Statistics: Concepts, Sources and Methods." edited by ABS. Canberra.

Australian Bureau of Statistics. 2005. "Yearbook Australia." Canberra, Australia.

—. 2012a. "Australian Health Survey: First Results, 2011-12 ". Canberra: Australian Bureau of Statistics.

—. 2012b. "Census data and analysis–TableBuilder. http://www.abs.gov.au/websitedbs/censushome.nsf/home/tablebuilder?opendocument&navpos=240. Accessed May 10, 2014.". http://www.abs.gov.au/websitedbs/censushome.nsf/home/tablebuilder?opendocument&navpos=240. Accessed May 10, 2014.

Australian Institute of Health and Welfare. 2012. "Australia's Health 2012: The Thirteenth Biennial Health Report of the Australian Institute of Health and Welfare." edited by AIHW. Canberra.

Bates, L.M., D. Acevedo-Garcia, M. Alegría, and N. Krieger. 2008. "Immigration and Generational Trends in Body Mass Index and Obesity in the United States: Results of the National Latino and Asian American Survey, 2002–2003." American Journal of Public Health 98(1):70-77.

Becketti, S., W. Gould, L. Lillard, and F. Welch. 1988. "The Panel Study of Income Dynamics after Fourteen Years: An Evaluation." Journal of Labor Economics 6(4):472-492.

Berry, J., U. Kim, T. Minde, and D. Mok. 1987. "Comparative Studies of Acculturative Stress." Int Migr Rev 21:491 - 495.

Bertera, E. M., R. L. Bertera,and S. Shankar.2003. "Acculturation, Socioeconomic Factors and Obesity Among Immigrants from El Salvador Living in the Washington, D.C. Area." Journal of Ethnic & Cultural Diversity in Social Work 12(2): 43-59.

Biddle, N., S. Kennedy, and J.T. McDonald. 2003. "Health assimilation patterns among Australian immigrants ". mimeo.

Birrell, B. 2003. "Immigration policy and the Australian labour market " Economic Papers: A journal of applied economics and policy 22(1):36-45.

Bray, G.A. 2004. "Medical consequences of obesity." Journal of Clinical Endocrinology and Metabolism 89(6):2583-2589.

Cairney, J.and T. Ostbye. 1999. "Time since immigration and excess body weight." Canadian Journal of Public health 90(2):120-124.

Calzada, P. J., & Anderson-Worts, P. 2009. The obesity epidemic: are minority individuals equally affected? Prim Care, 36(2), 307-317. doi:10.1016/j.pop.2009.01.007

Caperchione, C.M., G.S. Kolt, and W.K. Mummery. 2013. "Examining Physical Activity Service Provision to Culturally and Linguistically Diverse (CALD) Communities in Australia: A Qualitative Evaluation." PLoS ONE 8(4):e62777.

Chiswick, B.R., Y.L. Lee, and P.W. Miller. 2008. "Immigrant selection system and immigrant health." Contemporary Economic Policy 26(4):555-578.

Dallman, M.F., N. Pecoraro, S.F. Akana, S.E. la Fleur, F. Gomez, H. Houshyar, M.E. Bell, S. Bhatnagar, K.D. Laugero, and S. Manalo. 2003. "Chronic stress and obesity: A new view of "comfort food"." Proceedings of the National Academy of Sciences of the United States of America 100(20):11696-11701.

De Maio, F.G.and E. Kemp. 2010. "The deterioration of health status among immigrants to Canada." Global Public Health 5(5 (Suppl)):462-478.

Department of Immigration and Border Protection. 2014. https://www.immi.gov.au/allforms/health-requirements/overview-health-req.htm accessed 06-04-2014.

Delavari, M., A. Farrelly, and A. Renzaho. 2013. "Experiences of migration and the determinants of obesity among recent Iranian immigrants in Victoria, Australia." Ethnicity & Health 18(1):66-82.

Delavari, M., Sonderlund, A. L., Swinburn, B., Mellor, D., & Renzaho, A. 2013. Acculturation and obesity among migrant populations in high income countries--a systematic review. BMC Public Health, 13, 458. doi:10.1186/1471-2458-13-458

Department of Immigration and Border Protection. 2014. "https://www.immi.gov.au/allforms/health-requirements/overview-health-req.htm accessed 06-04-2014."

Diggle, P.J., P.J. Heagerty, K.Y. Liang, and S.L. Zeger. 2002. Analysis of longitudinal data: Oxford University Press.

Dinsa, G.D., Y. Goryakin, E. Fumagalli, and M. Suhrcke. 2012. "Obesity and socioeconomic status in developing countries: a systematic review." Obesity Reviews 13(11):1067-1079.

Engstrom, J.L., S.A. Paterson, A. Doherty, M. Trabulsi, and K.L. Speer. 2003. "Accuracy of Self-Reported Height and Weight in Women: An Integrative Review of the Literature." The Journal of Midwifery & Women's Health 48(5):338-345.

Finucane, M. M., Stevens, G. A., Cowan, M. J., Danaei, G., Lin, J. K., Paciorek, C. J., . . . Ezzati, M. 2011. National, regional, and global trends in body-mass index since 1980: systematic analysis of health examination surveys and epidemiological studies with 960 country-years and 9.1 million participants. The Lancet, 377(9765), 557-567. doi:10.1016/S0140-6736(10)62037-5.

Fuller-Thomson, E., A.M. Noack, and U. George. 2011. "Health decline among recent immigrants to Canada: Findings from a nationally-representative longitudinal survey." Canadian Journal of Public health 102(4):273-280.

Gee, G., A. Ro., A. Gavin., & D. Takeuchi. 2008. "Disentangling the effects of racial and weight discrimination on body mass index and obesity among Asian Americans. " American Journal of Public Health 98: 493 – 500.

Gee, E.M., K.M. Kobayashi, and S.G. Prus. 2004. "Examining the healthy immigrant effect in mid- to later life: findings from the Canadian Community Health Survey." Canadian Journal of Aging 23 (Suppl. 1):s61-s69.

Gee, G.C., K.M. Walsemann, and D.T. Takeuchi. 2010. "English proficiency and language preference: testing the equivalence of two measures." American Journal of Public Health 100(3):563-569.

Gele, A.and A. Mbalilaki. 2013. "Overweight and obesity among African immigrants in Oslo." BMC Research Notes 6(1):119.

Gerber, M., D. Barker, and U. Puhse. 2012. "Acculturation and physical activity among immigrants: A systematic review." Journal of Public Health 20(3):313-341.

Gibson, J., D. McKenzie, and S. Stillman. 2011. "What happens to diet and child health when migration splits households? Evidence from a migration lottery program." Food Policy 36(1):7-15.

Goel, M.S., E.P. McCarthy, R.S. Phillips, and C.C. Wee. 2004. "Obesity among US immigrant subgroups by duration of residence." Journal of the American Medical Association 292(23):2860-2867.

Gordon-Larsen, P., K.M. Harris, D.S. Ward, and B.M. Popkin. 2003. "Acculturation and overweight-related behaviors among Hispanic immigrants to the US: the National Longitudinal Study of Adolescent Health." Social Science & Medicine 57(11):2023-2034.

Goulão, B., O. Santos,and I. d. Carmo. 2015. "The impact of migration on body weight: a review." Cadernos de Saúde Pública 31: 229-245.

Greenland, S., J. Pearl, and J.M. Robins. 1999. "Causal diagrams for epidemiologic research." Epidemiology 10(1):37-48.

Gunasekara, F.I., K. Richardson, K. Carter, and T. Blakely. 2014. "Fixed effects analysis of repeated measures data." International Journal of Epidemiology 43(1):264-269.

Gushulak, B. 2007. "Healthier on arrival? Further insight into the "healthy immigrant effect"." Canadian Medical Association Journal 176(10):1439-1440.

Hauck, K., B. Hollingsworth, and L. Morgan. 2011. "BMI differences in 1st and 2nd generation immigrants of Asian and European origin to Australia." Health & Place 17(1):78-85.

Hafeman, D. 2009. "Proportion Explained": A causal interpretation for standard measures of indirect effect?" American Journal of Epidemiology 170(11):1443.

Himmelgreen, D. A., Pérez-Escamilla, R., Martinez, D., Bretnall, A., Eells, B., Peng, Y., & Bermúdez, A. 2004. The longer you stay, the bigger you get: Length of time and language use in the U.S. are associated with obesity in Puerto Rican women. American Journal of Physical Anthropology, 125(1), 90-96. doi:10.1002/ajpa.10367.

Huber, P.J. 1967. "The behavior of maximum likelihood estimates under nonstandard conditions." Pp. 221-233 in Presented at Proceedings of the fifth Berkeley symposium on mathematical statistics and probability.

Hunte, H.E.R.and D.R. Williams. 2009. "The Association Between Perceived Discrimination and Obesity in a Population-Based Multiracial and Multiethnic Adult Sample." American Journal of Public Health 99(7):1285-1292.

Hyman, I. 2001. Immigration and Health. Ottawa: Health Canada.

Jatrana, S., S.S. Pasupuleti, and K. Richardson. 2014. "Nativity, duration of residence and chronic health conditions in Australia: Do trends converge towards the native-born population?" Social Science&Medicine 119:53-63.

Jiang, J., J. Ahn, W.-Y. Huang, and R.B. Hayes. 2013. "Association of obesity with cardiovascular disease mortality in the PLCO trial." Preventive Medicine 57(1):60-64.

Joshi, S. 2017. "Understanding health behaviour trajectories of immigrants in Australia: a longitudinal investigation." School of Humanities and Social Sciences, Deakin University.

Kaplan, M.S., N. Huguet, J.T. Newsom, and B.H. McFarland. 2004. "The association between length of residence and obesity among Hispanic immigrants." American Journal of Preventive Medicine 27(4):323-326.

Kaushal, N. 2009. "Adversities of acculturation? Prevalence of obesity among immigrants." Health Economics 18(3):291-303.

Kennedy, S.and J.T. McDonald. 2006. "Immigrant Mental Health and Unemployment." The Economic Record 82(259):445-459.

Khan, L., J.Sobal.and R. Martorell.1997. "Acculturation, socioeconomic status, and obesity in Mexican Americans, Cuban Americans, and Puerto Ricans." InternationalJournal of Obesity and realted Metabolic Disorders 21(2) : 91 - 96.

Kim, I.H., C. Carrasco, C. Muntaner, K. McKenzie, and S. Noh. 2013. "Ethnicity and postmigration health trajectory in new immigrants to Canada." American Journal of Public Health 103(4):e96-e104.

Kinge, J.M., B.H. Strand, S.E. Vollset, and V. Skirbekk. 2015. "Educational inequalities in obesity and gross domestic product: evidence from 70 countries." Journal of Epidemiology and Community Health 69(12):1141-6.

Kinra, S. 2004. "Commentary: Can conventional migration studies really identify critical age-period effects?" International Journal of Epidemiology 33(6):1226-1227.

Kuczmarski, M.F., R.J. Kuczmarski, and M. Najjar. 2001. "Effects of Age on Validity of Self-Reported Height, Weight, and Body Mass Index: Findings from the Third National Health and Nutrition Examination Survey, 1988–1994." Journal of the American Dietetic Association 101(1):28-34.

Lara, M., C. Gamboa, M.I. Kahramanian, and L.S. Morales. 2005. "Acculturation and Latino health in the United States: a review of the literature and its sociopolitical context." Annual Review of Public Health 26:367-397.

Lauderdale, D.S.and P.J. Rathouz. 2000. "Body mass index in a US national sample of Asian Americans: effects of nativity, years since migration and socioeconomic status." International Journal of Obesity Related Metabolic Disorders 24:1188-1194.

Leão, T.S., J. Sundquist, S.-E. Johansson, and K. Sundquist. 2009. "The influence of age at migration and length of residence on self-rated health among Swedish immigrants: a cross-sectional study." Ethnicity & Health 14(1):93-105.

Lenz, M., T. Richter, and I. Muhlhauser. 2009. "The morbidity and mortality associated with overweight and obesity in adulthood: a systematic review." Dtsch Arztebl Int 106(40):641-648.

Liang, K.Y.and S.L. Zeger. 1986. "Longitudinal data analysis using generalized linear models." Biometrika 73(1):13-22.

Majid Ezzati, M., H. Martin, S. Skjold, S. Vander Hoorn, and C.J. Murray. 2006. "Trends in national and state-level obesity in the USA after correction for self-report bias: analysis of health surveys." Journal of the Royal Society of Medicine 99:250-257.

Markides, K.S.and K. Eschbach. 2005. "Aging, migration, and mortality: current status of research on the Hispanic paradox." The Journals of Gerontology Series B, Psychological Sciences and Social Sciences 60 Spec No 2:68-75.

Martínez, A.D. 2012. "Reconsidering acculturation in dietary change research among Latino immigrants: challenging the preconditions of US migration." Ethnicity & Health 18(2):115-135.

McCullough, M.B.and A.K. Marks. 2014. "The immigrant paradox and adolescent obesity: examining health behaviors as potential mediators." Journal of Developmental & Behavioral Pediatrics 35(2):138-143.

McDonald, J.T.and S. Kennedy. 2004. "Insight into the 'healthy immigrant effect': health status and health service use of immigrants to Canada " Social Science & Medicine 59:1613-1627.

McDonald, J.T.and S. Kennedy. 2005. "Is migration to Canada associated with unhealthy weight gain? Overweight and obesity among Canada's immigrants." Social Science & Medicine 61(12):2469-2481.

McKenzie, D., J. Gibson, and S. Stillman. 2007. "Moving to opportunity, leaving behind what? Evaluating the initial effects of a migration policy on incomes and poverty in a source country." New Zealand Economic Papers 41(2):197–224.

McLaren, L. 2007. "Socioeconomic status and obesity." Epidemiologic Reviews 29:29-48.

Morales, L.S., M. Lara, R.S. Kington, and R.O. Valdez. 2002. "Socioeconomic, cultural, and behavioral factors affecting Hispanic health outcomes." Journal of Health Care for the Poor and Underserved 13(4):477-503.

Morel, J.G. 1989. "Logistic regression under complex survey designs." Survey Methodology 15:203-223.

Morel, J.G., M.C. Bokossa, and N.K. Neerchal. 2003. "Small sample correction for the variance of GEE estimators." Biometrical Journal 4(395-409).

Murphy, M., W. Robertson, and O. Oyebode. 2017. "Obesity in International Migrant Populations." Current Obesity Reports 6(3):314-323.

Newbold, K.B. 2010. "The short-term health of Canada's new immigrant arrivals: evidence from LSIC." Ethnicity and Health 14(3):315-336.

Oza-Frank, R.and K. Venkat Narayan. 2010. "Effect of length of residence on overweight by region of birth and age at arrival among US immigrants." Public Health Nutrition 13(06):868-875.

Oza-Frank, R., and S. A. Cunningham. 2010. "The weight of US residence among immigrants: a systematic review. " Obesity Reviews 11(4): 271-280.

Palta, M., R.J. Prineas, R. Berman, and P. Hannan. 1982. "Comparison of Self-Reported and Measured Height and Weight." American Journal of Epidemiology 115(2):223-230.

Pampel, F.C., J.T. Denney, and P.M. Krueger. 2012. "Obesity, SES, and economic development: A test of the reversal hypothesis." Social Science & Medicine 74(7):1073-1081.

Park, J., D.Myers, D. Kao., and S. Min. 2009. "Immigrant obesity and unhealthy assimilation: alternative estimates of convergence or divergence 1995-2005." Social Science and Medicine 69(11): 1625-1633.

Perales, F., J. del Pozo-Cruz, J. del Pozo-Cruz, and B. del Pozo-Cruz. 2014. "On the associations between physical activity and quality of life: findings from an Australian nationally representative panel survey." Quality of Life Research 23(7):1921-1933.

Popkin, B.M.and J.R. Udry. 1998. "Adolescent obesity increases significantly in second and third generation U.S. immigrants: The National Longitudinal Study of Adolescent Health." Journal of Nutrition 128(4):701-706.

Prentice, A. M. 2006. The emerging epidemic of obesity in developing countries. Int J Epidemiol, 35(1), 93-99. doi:10.1093/ije/dyi272.

Renzaho, A. M. N., Swinburn, B, & Burns, C. 2008. "Maintenance of traditional cultural orientation is associated with lower rates of obesity and sedentary behaviours among African migrant children to Australia." International Journal of Obesity 32(4): 594-600.

Roshania, R., K.M.V. Narayan, and R. Oza-Frank. 2008. "Age at Arrival and Risk of Obesity Among US Immigrants." Obesity 16(12):2669-2675.

Rosmond, R., L. Lapidus, P. Marin, and P. Bjorntorp. 1996. "Mental distress, obesity and body fat distribution in middle-aged men." Obes Res 4(3):245-252.

Rothman, K., S. Greenland, and T. Lash. 2008. Modern epidemiology: Lippincott Williams & Wilkins.

Rudmin, F. 2003. "Catalogue of Acculturation Constructs: Descriptions of 126 Taxonomies, 1918-2003." Online Readings in Psychology and Culture (Unit 8, Chapter 8).

Rudmin, F. 2009. "Constructs, measurements and models of acculturation and acculturative stress." International Journal of Intercultural Relations 33(2):106-123.

Sanchez-Vaznaugh, E., I. Kawachi, S. Subramanian, B. Sanchez, and D. Acevedo-Garcia. 2008. "Differential effect of birthplace and length of residence on body mass index (BMI) by education, gender and race/ethnicity." Social Science & Medicine 67(8):1300 - 1310.

Salant, T., & Lauderdale, D. S. 2003. "Measuring culture: a critical review of acculturation and health in Asian immigrant populations." Social Science & Medicine 57(1): 71-90.

Sander, M. 2008. Changes in Immigrants' Body Mass Index with Their Duration of Residence in Germany.

Schachter, A., R. T. Kimbro,and B. K., Gorman. 2012. "Language Proficiency and Health Status: Are Bilingual Immigrants Healthier?" Journal of Health and Social Behavior, 53(1): 124-145.

Schildkraut, D.J. 2005. Press "one" for English: Language policy, public opinion, and American identity. Princeton, NJ: Princeton University Press.

Schwartz, S.J., J.B. Unger, B.L. Zamboanga, and J. Szapocznik. 2010. "Rethinking the concept of acculturation: implications for theory and research." American Psychologist 65(4):237-251.

Setia, M., A. Quesnel-Vallee, M. Abrahamowicz, P. Tousignant, and J. Lynch. 2009. "Convergence of body mass index of immigrants to the Canadian-born population: evidence from the National Population Health Survey (1994–2006)." European Journal of Epidemiology 24(10):611-623.

Setia, M., A. Quesnel-Vallee, M. Abrahamowicz, P. Tousignant, and J. Lynch. 2012. "Different Outcomes for Different Health Measures in Immigrants: Evidence from a Longitudinal Analysis of the National Population Health Survey (1994–2006)." Journal of Immigrant and Minority Health 14(1):156-165.

Setia, M., J. Lynch, M. Abrahamowicz, P. Tousignant, and A. Quesnel-Vallee. 2011. "Self-rated health in Canadian immigrants: Analysis of the Longitudinal Survey of Immigrants to Canada." Health & Place 17(2):658-670.

Singh, G.K.and M. Siahpush. 2002. "Ethnic-immigrant differentials in health behaviors, morbidity, and cause-specific mortality in the United States: an analysis of two national data bases." Human Biology 74(1):83-109.

Spinks, H. 2010. "Australia's Migration Program." in Social Policy Section. Canberra: Parliament of Australia, Department of Parliamentary Services.

Statistics Canada. 2005." Health Reports." Ottawa: Health Statistics Division.

Sterba, C.M. 2003. Good Americans: Italian and Jewish immigrants during the First World War. New York: Oxford University Press.

Stewart, A.W., R.T. Jackson, M.A. Ford, and R. Beaglehole. 1987. "Understanding of relative weight by use of self-reported height and weight." American Journal of Epidemiology 125(1):122-126.

Stillman, S., D. McKenzie, and J. Gibson. 2009. "Migration and mental health: Evidence from a natural experiment." Journal of Health Economics 28(3):677-687.

Taylor, A., E.D. Grande, J. Parsons, P. Kunst, and Y. Zhang. 1997. "Migrant Health Survey October 1996 – February 1997." edited by The Migrant Health Service South Australia Health Commission. Adelaide, South Australia.

Triandis, H.C. 1995. Individualism and collectivism. Boulder, CO: Westview Press.

Van Hook, J., E. Baker, C.E. Altman, and M.L. Frisco. 2012. "Canaries in a coalmine: Immigration and overweight among Mexican-origin children in the US and Mexico." Social Science & Medicine 74(2):125-134.

VanderWeele, T.J.and J.M. Robins. 2007. "Directed acyclic graphs, sufficient causes, and the properties of conditioning on a common effect." American Journal of Epidemiology 166(9):1096.

Villanueva, E.V. 2001. "The validity of self-reported weight in US adults: a population based cross-sectional study." BMC Public Health 1:11 doi:10.1186/1471-2458-1181-1111.

Watson, N.and M.P. Wooden. 2012. "The HILDA Survey: a case study in the design and development of a successful Household Panel Survey." International and Life Course Studies: International Journal 3(3):13.

White, H. 1980. "A heteroskedasticity-consistent covariance matrix estimator and a direct test for heteroskedasticity." Econometrica: Journal of the Econometric Society 48:817-838.

WHO. 2000. "Obesity: preventing and managing the global epidemic Report of a WHO Consultation (WHO Technical Report Series 894)." WHO.

Willett, W. 1998. Nutritional Epidemiology. New York: Oxford University Press.

World Health Organization. 1995. "Physical status: the use and interpretation of anthropometry." in WHO technical report series. Geneva: WHO.

World Health Organisation. 2006. "The World Health Report 2006- Working Together for Health." edited by WHO. Geneva.

World Health Organization. 2009. "Global Health Risks." Geneva: World health Organization.

World Health Organization. 2010. "Global Recommendations on Physical Activity for Health." edited by WHO. Geneva.

Yoo, H.C., G.C. Gee, and D.T. Takeuchi. 2009. "Discrimination and health among Asian American immigrants: Disentangling racial from language discrimination." Social Science and Medicine 68:726-732.

Zhang, W., S. Hong, D.T. Takeuchi, and K.N. Mossakowski. 2012. "Limited English proficiency and psychological distress among Latinos and Asian Americans." Social Science & Medicine 75(6):1006-1014.

APPENDIX

Table A1: Multilevel hybrid logistic regression results showing the odds ratios and their 95% confidence intervals (CI) for the prevalence of obesity by nativity

Factor	Model I		Model II		Model III		Model IV	
	Odds ratio	95% CI	Odds ratio	95% CI	Odds ratio	95% CI	Odds ratio	95% CI
Intercept	0.00**	(0.00, 0.00)	0.00**	(0.00, 0.00)	0.00**	(0.00, 0.00)	0.00**	(0.00, 0.00)
Country of birth								
ES countries	0.41**	(0.24, 0.72)	0.43**	(0.25, 0.76)	0.49**	(0.30, 0.81)	0.50**	(0.31, 0.80)
NES countries	0.29**	(0.18, 0.46)	0.36**	(0.19, 0.68)	0.39**	(0.21, 0.70)	0.39**	(0.22, 0.68)
Australia (R)								
Age group								
15-29 years (R)								
30-44 years	8.94**	(6.21, 12.87)	8.58**	(5.96, 12.37)	6.84**	(4.48, 10.44)	5.29**	(3.50, 8.01)
45-56 years	22.91**	(15.91, 32.98)	21.73**	(15.05, 31.38)	14.04**	(8.86, 22.25)	10.28**	(6.53, 16.17)
>=60	8.74**	(5.88, 12.98)	8.15**	(5.46, 12.15)	2.92**	(1.65, 5.19)	1.95*	(1.11, 3.43)
Sex								
Female	1.15	(0.88, 1.51)	1.17	(0.89, 1.53)	1.07	(0.81, 1.42)	0.95	(0.72, 1.25)
Male (R)								
Wave number	1.16**	(1.12, 1.20)	1.16**	(1.12, 1.20)	1.15**	(1.11, 1.19)	1.15**	(1.11, 1.19)
Number of times responded	0.98	(0.83, 1.17)	0.99	(0.83, 1.17)	1.00	(0.84, 1.19)	1.07	(0.90, 1.27)
English proficiency								
Not good (W)			1.43	(0.49, 4.21)	1.55	(0.52, 4.60)	1.87	(0.65, 5.39)
Not good (B)			3.16	(0.43, 23.01)	2.55	(0.37, 17.58)	2.00	(0.30, 13.58)
Good (W)			1.29	(0.81, 2.04)	1.31	(0.82, 2.08)	1.36	(0.85, 2.17)
Good (B)			0.56	(0.28, 1.13)	0.69	(0.35, 1.34)	0.55	(0.28, 1.10)
Proficient (R)								
Eqivalised income (W)					1.02	(0.99, 1.05)	1.03	(0.99, 1.06)
Eqivalised income (B)					0.89**	(0.84, 0.95)	0.92*	(0.87, 0.98)
Marital status								
Never married (W)					0.45**	(0.31, 0.66)	0.45**	(0.30, 0.65)
Never married (B)					0.43**	(0.28, 0.65)	0.56**	(0.37, 0.86)
Widowed (W)					0.52**	(0.36, 0.76)	0.53**	(0.36, 0.78)
Widowed (B)					0.85	(0.54, 1.34)	0.77	(0.50, 1.20)
Currently married (R)								
Level of education								
Less than 12 years (W)					0.92	(0.41, 2.08)	0.89	(0.39, 2.04)
Less than 12 years (B)					7.13**	(4.61, 11.04)	5.96**	(3.92, 9.08)
Exactly 12 years (W)					1.05	(0.50, 2.19)	1.07	(0.50, 2.25)
Exactly 12 years (B)					3.22**	(1.98, 5.22)	2.92**	(1.83, 4.66)
Diploma (W)					0.96	(0.45, 2.07)	0.94	(0.43, 2.04)
Diploma (B)					4.76**	(3.14, 7.22)	4.17**	(2.81, 6.19)
University education (R)								
Employment status								
Not working (W)					1.06	(0.86, 1.30)	1.05	(0.85, 1.30)
Not working (B)					1.47	(0.93, 2.33)	1.10	(0.69, 1.74)
Unemployed (W)					1.48*	(1.07, 2.05)	1.50*	(1.08, 2.08)
Unemployed (B)					4.89*	(1.24, 19.28)	6.33**	(1.58, 25.37)
Employed (R)								
Smoking								
Former smoker (W)							0.99	(0.74, 1.33)
Former smoker (B)							2.50**	(1.73, 3.61)
Current smoker (W)							0.61*	(0.41, 0.90)
Current smoker (B)							0.77	(0.53, 1.13)
Never smoked (R)								
Drinking								
Former drinker (W)							0.78	(0.51, 1.18)
Former drinker (B)							1.92	(0.83, 4.46)
Current drinker (W)							0.82	(0.58, 1.17)
Current drinker (B)							0.80	(0.46, 1.40)
Never drunk (R)								
Physical activity								
Sufficient (R)								
Insufficient (W)							1.38**	(1.21, 1.56)
Insufficient (B)							8.04**	(5.42, 11.92)
Not at all (W)							1.44**	(1.17, 1.78)
Not at all (B)							33.82**	(18.15, 3.01)

Note: (R) indicates reference group,(W) indicates within person exposure effect ($i.e., X_{it} - \bar{X}_i$) for a time-varying variable$X$, and (B) indicates between person exposure effect (i.e., $\bar{X}_i$) for a time-varying variable$X$. Nativity is categorised as NB (native-born), FB (foreign-born) from English-speaking (ES) and non-English-speaking (NES) countries. Widowed stands for widowed/separated/divorced.

Model I includes age, sex, wave effects and number of responses out of the five waves (waves 6 to 10) as the covariates.
Model II adds ELP to the covariates of Model I.
Model III adds household equivalised income, marital status, level of education and labour force participation status to the covariates of Model II.
Model IV adds health behaviour variables to the covariates of Model III. * p<0.05; ** p<0.01.

Table A2: Multilevel hybrid logistic regression results showing the odds ratios and their 95% confidence intervals (CI) for the prevalence of obesity by nativity and duration of residence combined

Factor	Model I		Model II		Model III		Model IV	
	Odds ratio	95% CI	Odds ratio	95% CI	Odds ratio	95% CI	Odds ratio	95% CI
Intercept	0.00**	(0.00, 0.00)	0.00**	(0.00, 0.00)	0.00**	(0.00, 0.00)	0.00**	(0.00, 0.00)
DoR/nativity								
ES; DOR < 10 years	0.22*	(0.05, 0.98)	0.14**	(0.04, 0.56)	0.20*	(0.06, 0.68)	0.21*	(0.05, 0.80)
ES; DOR 11 to 20	0.33	(0.10, 1.13)	0.28*	(0.08, 0.98)	0.39	(0.13, 1.16)	0.45	(0.16, 1.32)
ES; DOR > 20	0.50*	(0.26, 0.95)	0.53	(0.28, 1.01)	0.59	(0.33, 1.08)	0.59	(0.34, 1.01)
NES; DOR < 10	0.15**	(0.06, 0.38)	0.11**	(0.04, 0.30)	0.13**	(0.05, 0.36)	0.12**	(0.05, 0.33)
NES; DOR 11to20	0.06**	(0.03, 0.11)	0.05**	(0.02, 0.11)	0.08**	(0.04, 0.19)	0.08**	(0.03, 0.18)
NES; DOR >=20	0.88	(0.48, 1.64)	0.84	(0.42, 1.69)	0.82	(0.41, 1.63)	0.85	(0.43, 1.67)
Australia (R)								
Age group								
15-29 years (R)								
30-44 years	9.33**	(6.48, 13.43)	8.81**	(6.10, 12.73)	6.81**	(4.45, 0.41)	5.24**	(3.45, 7.96)
45-56 years	21.15**	(14.59, 30.64)	19.60**	(13.46, 28.55)	12.99**	(8.17, 0.65)	9.26**	(5.87, 14.63)
>=60	7.52**	(4.97, 11.36)	6.64**	(4.37, 10.09)	2.43**	(1.36, 4.36)	1.64	(0.93, 2.89)
Sex								
Female	1.19	(0.91, 1.55)	1.17	(0.90, 1.53)	1.09	(0.82, 1.44)	0.96	(0.73, 1.26)
Male (R)								
Wave number	1.16**	(1.12, 1.20)	1.16**	(1.12, 1.20)	1.15**	(1.11, 1.19)	1.15**	(1.11, 1.19)
Number of times responded	0.99	(0.83, 1.18)	0.99	(0.84, 1.18)	1.02	(0.85, 1.21)	1.08	(0.91, 1.28)
English proficiency								
Not good (W)			1.63	(0.56, 4.77)	1.56	(0.52, 4.65)	1.91	(0.66, 5.49)
Not good (B)			6.41*	(1.02, 40.23)	3.76	(0.61,23.16)	2.32	(0.36, 14.70)
Good (W)			1.37	(0.86, 2.18)	1.32	(0.83, 2.10)	1.36	(0.85, 2.17)
Good (B)			0.97	(0.49, 1.91)	0.98	(0.49, 1.96)	0.78	(0.39, 1.58)
Proficient (R)								
Eqivalised income (W)					1.02	(0.99, 1.05)	1.03	(0.99, 1.06)
Eqivalised income (B)					0.89**	(0.83, 0.94)	0.92*	(0.87, 0.98)
Marital status								
Never married (W)					0.44**	(0.30, 0.65)	0.44**	(0.30, 0.65)
Never married (B)					0.42**	(0.27, 0.65)	0.57**	(0.37, 0.87)
Widowed (W)					0.52**	(0.35, 0.76)	0.53**	(0.36, 0.78)
Widowed (B)					0.84	(0.53, 1.32)	0.77	(0.50, 1.20)
Currently married (R)								
Level of education								
Less than 12 years (W)					0.93	(0.41, 2.09)	0.89	(0.39, 2.05)
Less than 12 years (B)					6.30**	(4.07, 9.74)	5.54**	(3.64, 8.42)
Exactly 12 years (W)					1.04	(0.50, 2.18)	1.07	(0.50, 2.27)
Exactly 12 years (B)					2.87**	(1.77, 4.65)	2.73**	(1.71, 4.36)
Diploma (W)					0.95	(0.44, 2.05)	0.94	(0.43, 2.05)
Diploma (B)					4.20**	(2.77, 6.35)	3.89**	(2.62, 5.78)
University education (R)								
Employment status								
Not working (W)					1.06	(0.86, 1.30)	1.04	(0.84, 1.29)
Not working (B)					1.48	(0.94, 2.35)	1.09	(0.69, 1.73)
Unemployed (W)					1.49*	(1.08, 2.05)	1.51*	(1.08, 2.09)
Unemployed (B)					6.46**	(1.63, 5.56)	6.85**	(1.72, 27.29)
Employed (R)								
Smoking								
Former smoker (W)							0.99	(0.74, 1.33)
Former smoker (B)							2.45**	(1.70, 3.54)
Current smoker (W)							0.61*	(0.41, 0.90)
Current smoker (B)							0.73	(0.50, 1.07)
Never smoked (R)								
Drinking								
Former drinker (W)							0.78	(0.51, 1.18)
Former drinker (B)							1.81	(0.78, 4.19)
Current drinker (W)							0.82	(0.58, 1.17)
Current drinker (B)							0.72	(0.41, 1.27)
Never drunk (R)								
Physical activity								
Sufficient (R)								
Insufficient (W)							1.38**	(1.22, 1.57)
Insufficient (B)							8.42**	(5.67, 12.52)
Not at all (W)							1.45**	(1.18, 1.78)
Not at all (B)							33.68**	(18.17, 2.41)

Note: (R) indicates reference group, (W) indicates within person exposure effect ($i.e., X_{it} - \bar{X}_i$) for a time-varying variable$X$, and (B) indicates between person exposure effect (i.e., $\bar{X}_i$) for a time-varying variable X. Nativity is categorised as NB (native-born), FB (foreign-born) from English-speaking (ES) and non-English-speaking (NES) countries. Widowed stands for widowed/separated/divorced. Duration of residence is categorised into less than 10 years, 10-19 years, and greater than or equal 20 years in Australia, and is combined with the nativity variable described above.

Model I includes age, sex, wave effects and number of responses out of the five waves (waves 6 to 10) as the covariates.
Model II adds ELP to the covariates of Model I.
Model III adds household equivalised income, marital status, level of education and labour force participation status to the covariates of Model II.
Model IV adds health behaviour variables to the covariates of Model III. * p<0.05; ** p<0.01.

Table A3: Multilevel hybrid logistic regression results showing the odds ratios and their 95% confidence intervals (CI) for the prevalence of obesity by nativity and age at arrival (AA)

Factor	Model I		Model II		Model III		Model IV	
	Odds ratio	95% CI	Odds ratio	95% CI	Odds ratio	95% CI	Odds ratio	95% CI
Intercept	0.00**	(0.00, 0.00)	0.00**	(0.00, 0.00)	0.00**	(0.00, 0.00)	0.00**	(0.00, 0.00)
Nativity and AA								
ES; AA < 25	0.53	(0.27, 1.03)	0.54	(0.28, 1.04)	0.60	(0.32, 1.13)	0.61	(0.34, 1.11)
ES; AA >= 25	0.24**	(0.10, 0.59)	0.26**	(0.11, 0.65)	0.35**	(0.16, .77)	0.35**	(0.18, 0.71)
NES; AA < 25	0.47**	(0.28, 0.80)	0.48*	(0.26, 0.91)	0.54	(0.29, 1.01)	0.51*	(0.27, 0.94)
NES; AA >= 25	0.11**	(0.06, 0.21)	0.08**	(0.04, 0.17)	0.15**	(0.07, 0.33)	0.19**	(0.09, 0.42)
Australia (R)								
Age group								
15-29 years (R)								
30-44 years	9.69**	(6.73, 13.96)	9.56**	(6.64, 13.77)	7.02**	(4.59, 0.72)	5.40**	(3.57, 8.19)
45-56 years	25.14**	(17.52, 36.09)	24.65**	(17.17, 35.40)	15.03**	(9.48, 3.82)	10.74**	(6.81, 16.94)
>=60	10.18**	(6.86, 15.13)	9.70**	(6.51, 14.45)	3.10**	(1.74, 5.53)	2.07*	(1.17, 3.64)
Sex								
Female	1.15	(0.88, 1.49)	1.13	(0.87, 1.47)	1.07	(0.81, 1.41)	0.94	(0.71, 1.24)
Male (R)								
Wave number	1.16**	(1.12, 1.20)	1.16**	(1.12, 1.20)	1.15**	(1.11, 1.19)	1.15**	(1.11, 1.19)
Number of times responded	0.97	(0.82, 1.14)	0.97	(0.82, 1.15)	1.01	(0.85, 1.20)	1.07	(0.90, 1.27)
English proficiency								
Not good (W)			1.59	(0.55, 4.65)	1.53	(0.52, 4.55)	1.87	(0.65, 5.40)
Not good (B)			19.47**	(2.89,131.06)	6.34	(0.90, 4.70)	3.36	(0.47, 24.02)
Good (W)			1.32	(0.83, 2.09)	1.32	(0.83, 2.10)	1.36	(0.85, 2.17)
Good (B)			0.85	(0.44, 1.64)	0.80	(0.41, 1.55)	0.63	(0.32, 1.24)
Proficient (R)								
Eqivalised income (W)					1.02	(0.99, 1.05)	1.03	(1.00, 1.06)
Eqivalised income (B)					0.89**	(0.84, 0.95)	0.92**	(0.87, 0.98)
Marital status								
Never married (W)					0.45**	(0.31, 0.65)	0.44**	(0.30, 0.65)
Never married (B)					0.41**	(0.27, 0.64)	0.56**	(0.37, 0.86)
Widowed (W)					0.52**	(0.36, 0.76)	0.53**	(0.36, 0.78)
Widowed (B)					0.83	(0.53, 1.31)	0.77	(0.49, 1.19)
Currently married (R)								
Level of education								
Less than 12 years (W)					0.92	(0.41, 2.08)	0.89	(0.39, 2.04)
Less than 12 years (B)					6.46**	(4.17, 9.01)	5.73**	(3.76, 8.72)
Exactly 12 years (W)					1.04	(0.50, 2.17)	1.07	(0.51, 2.24)
Exactly 12 years (B)					2.96**	(1.83, 4.78)	2.84**	(1.78, 4.52)
Diploma (W)					0.95	(0.44, 2.04)	0.94	(0.43, 2.03)
Diploma (B)					4.37**	(2.89, 6.61)	4.06**	(2.74, 6.01)
University education (R)								
Employment status								
Not working (W)					1.06	(0.86, 0.30)	1.05	(0.85, 1.30)
Not working (B)					1.50	(0.95, 2.36)	1.11	(0.70, 1.76)
Unemployed (W)					1.49*	(1.08, 2.05)	1.50*	(1.08, 2.08)
Unemployed (B)					6.49**	(1.66,25.35)	6.60**	(1.65, 26.38)
Employed (R)								
Smoking								
Former smoker (W)							0.99	(0.74, 1.33)
Former smoker (B)							2.51**	(1.74, 3.62)
Current smoker (W)							0.61*	(0.41, 0.90)
Current smoker (B)							0.77	(0.53, 1.13)
Never smoked (R)								
Drinking								
Former drinker (W)							0.78	(0.51, 1.18)
Former drinker (B)							1.97	(0.85, 4.57)
Current drinker (W)							0.82	(0.58, 1.17)
Current drinker (B)							0.80	(0.46, 1.40)
Never drunk (R)								
Physical activity								
Sufficient (R)								
Insufficient (W)							1.38**	(1.21, 1.56)
Insufficient (B)							7.91**	(5.34, 11.72)
Not at all (W)							1.44**	(1.17, 1.78)
Not at all (B)							32.90**	(17.64,61.36)

Note: (R) indicates reference group,(W) indicates within person exposure effect ($i.e., X_{it} - \bar{X}_i$) for a time-varying variable$X$, and (B) indicates between person exposure effect (i.e., $\bar{X}_i$) for a time-varying variable X. Nativity is categorised as NB (native-born), FB (foreign-born) from English-speaking (ES) and non-English-speaking (NES) countries. Widowed stands for widowed/separated/divorced. Age at arrival (AA) is categorised into less than 25 years, and greater than or equal 25 years

Model I includes age, sex, wave effects and number of responses out of the five waves (waves 6 to 10) as the covariates. Model II adds ELP to the covariates of Model I. Model III adds household equivalised income, marital status, level of education and labour force participation status to the covariates of Model II.
Model IV adds health behaviour variables to the covariates of Model III. * p<0.05; ** p<0.01.

Table A4: Multilevel hybrid logistic regression results showing the odds ratios and their 95% confidence intervals (CI) for the prevalence of obesity by duration of residence and age at arrival (DoR/AA)

Factor	Model I		Model II		Model III		Model IV	
	Odds ratio	95% CI	Odds ratio	95% CI	Odds ratio	95% CI	Odds ratio	95% CI
Intercept	0.00**	(0.00, 0.00)	0.00**	(0.00, 0.00)	0.00**	(0.00, 0.00)	0.00**	(0.00, 0.00)
DoR and AA								
DoR <10; AA < 25	0.45	(0.18, 1.17)	0.57	(0.21, 1.54)	0.53	(0.16, 1.74)	0.40	(0.11, 1.39)
DoR <10; AA>=25	0.08**	(0.03, 0.17)	0.05**	(0.02, 0.12)	0.09**	(0.04, 0.22)	0.10**	(0.04, 0.25)
DoR 10-19; AA < 25	0.22**	(0.11, 0.47)	0.24**	(0.11, 0.52)	0.28**	(0.13, 0.60)	0.26**	(0.12, 0.55)
DoR 10-19; AA >=25	0.05**	(0.03, 0.10)	0.05**	(0.02, 0.10)	0.09**	(0.04, 0.20)	0.10**	(0.04, 0.23)
DoR >=20; AA < 25	0.63	(0.36, 1.08)	0.63	(0.36, 1.10)	0.67	(0.39, 1.15)	0.67	(0.41, 1.11)
DoR >=20; AA >=25	0.72	(0.32, 1.65)	0.61	(0.26, 1.47)	0.70	(0.31, 1.57)	0.74	(0.35, 1.56)
Australia (R)								
Age group								
15-29 years (R)								
30-44 years	9.71**	(6.72, 14.01)	9.98**	(6.92, 14.40)	7.33**	(4.78,11.25)	5.53**	(3.63, 8.42)
45-56 years	22.06**	(15.21, 32.00)	22.90**	(15.79, 33.20)	14.43**	(9.04,23.04)	10.15**	(6.39, 16.14)
>=60	7.86**	(5.18, 11.94)	7.70**	(5.06, 11.73)	2.67**	(1.48, 4.82)	1.73	(0.97, 3.07)
Sex								
Female	1.17	(0.90, 1.52)	1.15	(0.88, 1.49)	1.08	(0.82, 1.42)	0.95	(0.72, 1.25)
Male (R)								
Wave number	1.16**	(1.12, 1.20)	1.16**	(1.12, 1.20)	1.15**	(1.11, 1.19)	1.15**	(1.11, 1.19)
Number of times responded	0.99	(0.84, 1.18)	0.98	(0.83, 1.16)	1.02	(0.86, 1.21)	1.08	(0.91, 1.28)
English proficiency								
Not good (W)			1.59	(0.54, 4.66)	1.56	(0.52, 4.66)	1.90	(0.66, 5.47)
Not good (B)			7.50*	(1.16, 48.38)	4.37	(0.72,26.63)	2.61	(0.42, 16.34)
Good (W)			1.35	(0.85, 2.14)	1.32	(0.83, 2.10)	1.35	(0.85, 2.17)
Good (B)			0.84	(0.48, 1.47)	0.83	(0.47, 1.48)	0.65	(0.36, 1.18)
Proficient (R)								
Eqivalised income (W)					1.02	(0.99, 1.05)	1.03	(0.99, 1.06)
Eqivalised income (B)					0.89**	(0.84, 0.95)	0.93*	(0.87, 0.98)
Marital status								
Never married (W)					0.45**	(0.31, 0.65)	0.44**	(0.30, 0.65)
Never married (B)					0.42**	(0.28, 0.65)	0.56**	(0.37, 0.86)
Widowed (W)					0.52**	(0.35, 0.76)	0.53**	(0.36, 0.78)
Widowed (B)					0.84	(0.53, 1.32)	0.78	(0.50, 1.21)
Currently married (R)								
Level of education								
Less than 12 years (W)					0.93	(0.41, 2.09)	0.89	(0.39, 2.04)
Less than 12 years (B)					6.20**	(4.02, 9.58)	5.54**	(3.64, 8.42)
Exactly 12 years (W)					1.04	(0.50, 2.17)	1.06	(0.50, 2.25)
Exactly 12 years (B)					2.83**	(1.76, 4.55)	2.71**	(1.70, 4.31)
Diploma (W)					0.95	(0.44, 2.04)	0.93	(0.43, 2.03)
Diploma (B)					4.15**	(2.75, 6.27)	3.90**	(2.63, 5.78)
University education (R)								
Employment status								
Not working (W)					1.06	(0.86, 1.30)	1.06	(0.86, 1.31)
Not working (B)					1.48	(0.94, 2.33)	1.10	(0.70, 1.75)
Unemployed (W)					1.49*	(1.08, 2.06)	1.50*	(1.08, 2.08)
Unemployed (B)					6.16**	(1.58,24.00)	6.86**	(1.74, 27.13)
Employed (R)								
Smoking								
Former smoker (W)							0.99	(0.74, 1.33)
Former smoker (B)							2.43**	(1.68, 3.50)
Current smoker (W)							0.61*	(0.41, 0.90)
Current smoker (B)							0.75	(0.51, 1.10)
Never smoked (R)								
Drinking								
Former drinker (W)							0.77	(0.51, 1.18)
Former drinker (B)							1.88	(0.81, 4.36)
Current drinker (W)							0.82	(0.58, 1.17)
Current drinker (B)							0.77	(0.44, 1.34)
Never drunk (R)								
Physical activity								
Insufficient (W)							1.38**	(1.21, 1.56)
Insufficient (B)							8.01**	(5.40, 11.89)
Not at all (W)							1.44**	(1.17, 1.77)
Not at all (B)							32.51**	(17.51,60.37)
Sufficient (R)								

Note: (R) indicates reference group,(W) indicates within person exposure effect ($i.e., X_{it} - \bar{X}_i$) for a time-varying variable$X$, and (B) indicates between person exposure effect (i.e., $\bar{X}_i$) for a time-varying variable X. Widowed stands for widowed/separated/divorced. Duration of residence is categorised into less than 10 years, 10-19 years, and greater than or equal 20 years in Australia, and is combined with the nativity status variable described above. Age at arrival is categorised into less than 25 years, and greater than or equal 25 years.

Model I includes age, sex, wave effects and number of responses out of the five waves (waves 6 to 10) as the covariates. Model II adds ELP to the covariates of Model I. Model III adds household equivalised income, marital status, level of education and labour force participation status to the covariates of Model II.
Model IV adds health behaviour variables to the covariates of Model III. * p<0.05; ** p<0.01.

VIENNA INSTITUTE OF DEMOGRAPHY

Working Papers

Nitsche, Natalie and Sarah Hayford, *Preferences, Partners, and Parenthood: Linking Early Fertility Desires, Union Formation Timing, and Achieved Fertility*, VID Working Paper 10/2018.

Riederer, Bernhard, *Experts' Expectations of Future Vulnerability at the Peak of the "Refugee Crisis"*, VID Working Paper 9/2018.

Cukrowska-Torzewska, Ewa and Anna Matysiak, *The Motherhood Wage Penalty: A Meta-Analysis*, VID Working Paper 8/2018.

Nitsche, Natalie and Hannah Brückner, *High and Higher: Fertility of Black and White Women with College and Postgraduate Education in the United States*, VID Working Paper 7/2018.

Beaujouan, Éva, *Late Fertility Intentions and Fertility in Austria*, VID Working Paper 6/2018.

Brzozowska, Zuzanna, Isabella Buber-Ennser, Bernhard Riederer and Michaela Potančoková, *Didn't plan one but got one: unintended and sooner-than-intended births among men and women in six European countries*, VID Working Paper 5/2018.

Berghammer, Caroline and Bernhard Riederer, *The Part-Time Revolution: Changes in the Parenthood Effect on Women's Employment in Austria*, VID Working Paper 4/2018.

Bora, Jayanta Kumar, Rajesh Raushan and Wolfgang Lutz, *Contribution of Education to Infant and Under-Five Mortality Disparities among Caste Groups in India*, VID Working Paper 3/2018.

Matysiak, Anna, Tomáš Sobotka and Daniele Vignoli, *The Great Recession and Fertility in Europe: A Sub-National Analysis*, VID Working Paper 2/2018.

Abel, Guy, Valeria Bordone, Raya Muttarak and Emilio Zagheni, *Bowling Together: Scientific Collaboration Networks of Demographers at European Population Conferences*, VID Working Paper 1/2018.

Nitsche, Natalie, *Partners' Educational Pairings, Work Divisions, and Fertility: Evidence from Germany*, VID Working Paper 19/2017.

Spahl, Wanda, Sabine Weiss, Judith Kohlenberger and Isabella Buber-Ennser, *Immigration and the Social Welfare State in Austria, Germany, and Switzerland: A Comparative Meta-Study*, VID Working Paper 18/2017.
