Health & Place 75 (2022) 102791

Contents lists available at ScienceDirect

Health and Place

journal homepage: www.elsevier.com/locate/healthplace

Children's longitudinal bodyweight in Australia: Influence of migrant mothers' long-term residency, attachment to, and level of childhood overweight in country-of-birth

Susan Hartono [a,*], Tom Cochrane [a], Theo Niyonsenga [a,b], Yohannes Kinfu [b,c,d,e]

[a] Health Research Institute, University of Canberra, Bruce, A.C.T., Australia
[b] Faculty of Health, University of Canberra, Bruce, A.C.T., Australia
[c] College of Medicine, Qatar University, Doha, Qatar
[d] Department of Health Metrics, University of Washington, Seattle, USA
[e] Murdoch Children's Research Institute, Melbourne, Australia

ARTICLE INFO

Keywords:
Obesity
Migrant
Acculturation
Children
Longitudinal
Australian environment

ABSTRACT

Immigration creates opportunities and imposes constraints associated with acculturation. We used the Australian national longitudinal survey of children aged 2 to 17 to evaluate the influence of mothers' long-term residency in Australia, mothers' attachment to country-of-birth, and macro indicators of childhood overweight environment at mothers' country-of-birth on children's longitudinal bodyweight. Both mothers' long-term exposure to the Australian environment and attachment to country-of-birth were associated with increased children's bodyweight z-scores. The childhood overweight environment in mothers' country-of-birth continued to influence their children's bodyweight after immigration. A better understanding of factors related to mothers' migration and children's bodyweight status is necessary to identify risk factors and migrant sub-groups needing extra support.

1. Introduction

Childhood overweight/obesity is a global health problem (Karnik and Kaneka, 2012). It is associated with adverse health effects (Sahoo et al., 2015) and lower educational outcomes (Segal et al., 2019), puts a heavy financial burden on individuals and society (Clifford et al., 2015), and influences future bodyweight and health status in adulthood (Ng and Cunningham, 2020). Unfortunately, many children born to migrant parents (Nisco et al., 2019), including Australia (Zulfiqar et al., 2019), are disproportionally affected by overweight/obesity. Hence, identifying risk factors specific to the migrant population is necessary to better understand the mechanism contributing to the disparities and to identify subgroups that may need further support related to childhood obesity.

Parental influences on their children's energy intakes and expenditures are often guided by migrant parents' habits and views related to bodyweight status, which sometimes differ from non-migrant parents (Lindsay et al., 2018; Renzaho et al., 2012). The differences in habits and views may stem from different obesogenic environments and perceptions of ideal body shape between the migrant parents' country of birth (COB) and the host country (Babatunde-Sowole et al., 2018; Addo et al., 2021). For example, the countries of origin may have better access to incidental physical activity and more limited access to fast food outlets than the host countries (Babatunde-Sowole et al., 2018; Addo et al., 2021). Another difference between parents' COB and the host country may be about food availability and general societal views on ideal body type (Addo et al., 2021). Some countries of origin may have a more recent prolonged famine or food scarcity period, which created cultural evolution regarding food production, food storage, and societal preference for bigger body sizes (Renzaho, 2004). According to the biocultural model (Ulijaszek and Lofink, 2006), such evolution could help tackle undernutrition in food scarce countries. However, it may be ineffective in environments of food abundance, as is the case in most host countries.

Once residing in the host country, migrant parents are exposed to new ways of life and environments associated with bodyweight (Renzaho, 2004). A more extended stay in the host country facilitates

* Corresponding author.
E-mail addresses: susan.hartono@canberra.edu.au (S. Hartono), tom.cochrane@canberra.edu.au (T. Cochrane), theo.niyonsenga@canberra.edu.au (T. Niyonsenga), yohannes.kinfu@canberra.edu.au (Y. Kinfu).

https://doi.org/10.1016/j.healthplace.2022.102791
Received 11 September 2021; Received in revised form 2 March 2022; Accepted 11 March 2022
Available online 22 March 2022

contact and participation with the new society, increasing the migrant parents' likelihood of adopting the host country's ways of life and beliefs systems (Berry, 2003). However, this migrant parents' acculturation process is not linear, as the degree of maintaining their original culture influences the absorption of new habits and beliefs (Berry, 2003). In other words, migrants often retain some COB habits and values while adopting new practices and value systems from the host country (Berry, 2003). For example, migrants who immigrate at a later age, choose to speak their COB language at home, or live in a neighbourhood with a high migrant concentration may have, ceteris paribus, stronger ethnic identity (Epstein and Heizler, 2015; Mu, 2015). Hence, it is likely that these migrant parents with these characteristics maintain a stronger connection with their COB than those who do not, and they may not readily change their COB behaviours and beliefs and adopt the host country's ways.

Previous research often used generational status, years of residence or proportion of life living in the host country to measure acculturation or exposure to the host country's society and environment (Garcia--Perez, 2016; Diep et al., 2017; Quon et al., 2012; Melius and Cannonier, 2016). Only a few studies outside of the United States of America (USA) have examined children's bodyweight status and its relationship with migrant parents' exposure to the host country (Zhang et al., 2019). However, the evidence from the USA or those other studies is inconclusive (Garcia-Perez, 2016; Diep et al., 2017; Quon et al., 2012). Conceptual and methodological limitations may explain the differences in results. Conceptually, some studies viewed acculturation as a unidirectional phenomenon by not including measures related to migrant parents' attachment to COB (Garcia-Perez, 2016; Diep et al., 2017; Quon et al., 2012). Other studies did not effectively control for an exhaustive set of factors related to children's bodyweight in the statistical modelling process (Diep et al., 2017; Quon et al., 2012). Still, others treat migrant parents as a homogenous group (Garcia-Perez, 2016).

Methodologically, many studies have used cross-sectional data/designs (Diep et al., 2017; Melius and Cannonier, 2016; Zhang et al., 2019). Children's bodyweight and migrant parents' experience in the host country, however, change over time. Hence, a longitudinal design (not cross-sectional) would be best to investigate this. Moreover, previous studies were dominated by studies using non-nationally representative samples, such as using only Hispanic/Latinos samples in the USA (Melius and Cannonier, 2016), low SES populations (Kaufman--Shriqui et al., 2013), or convenience samples (Strickman-Stein et al., 2010), limiting the scope for generalisation. Furthermore, the studies also differed in terms of how COB characteristics are captured in the statistical analysis. For example, some studies used COB macro-economic indicators to explain differences in views and behaviours related to bodyweight status between the host country and migrants from different countries (Zulfiqar et al., 2019). As shown in this paper, the prevalence of childhood overweight in the COB and its rate of change over time could better capture the differences between past and present countries. We argue that these macro indicators better reflect genetic predisposition, obesogenic environment, and societal views regarding fatness and ideal body weight at the country level.

We hoped to clarify the inconclusive findings from the existing studies and provide better information for policymakers by addressing the conceptual and methodological shortcomings in answering our research questions. Our study aimed to understand how migrant mothers are exposed to a new environment different from their COB and how this exposure and other migrant-related factors influence their children's bodyweight over time. Specifically, our study answered four research questions. After accounting for children's characteristics, children's early life histories, family and neighbourhood characteristics, (1) to what extent children's bodyweight is affected by their migrant mothers' exposure to Australia after the adjustment for mothers' attachment to COB and macro-indicators of childhood overweight environment at mothers' COB? (2) On its own, what is the impact of mothers' attachment to COB on their children's bodyweight? (3) Does children's bodyweight differ if the mothers were born in a country different from Australia regarding the macro-indicators of childhood overweight environment? (4) Does the relationship between migrant mothers' exposure to Australia and children's bodyweight differ by the level of attachment to COB? We focused on mothers for conceptual and methodological reasons. Firstly, mothers tend to assume greater responsibility for food-related activities (Rhodes et al., 2016) and childcare (Folbre et al., 2005) and mothers' factors are associated with children's bodyweight status (Dhana et al., 2018). Secondly, a high proportion of fathers' data were missing.

To provide better evidence, we addressed conceptual shortcomings in previous studies in three important ways. Firstly, we introduced proxy measures of mothers' attachment to COB in the models to capture the complex process of acculturation (Berry, 2003). Secondly, the macro indicators of childhood overweight environment were added to the statistical model to illustrate better the genetic predisposition, societal views related to the biocultural model of overweight/obesity (Ulijaszek and Lofink, 2006) and obesogenic environment (Swinburn et al., 1999) at mothers' COB. Lastly, we introduced a comprehensive set of covariates to control for and reflect the ecological model of childhood overweight/obesity (Harrison et al., 2011) and obesogenic environment (Swinburn et al., 1999). The method section provides more details about these variables. Furthermore, we addressed methodological shortcomings of previous research by: (1) using longitudinal data from a nationally representative sample and (2) using appropriate statistical modelling methods to account for correlated data, sampling design, and subpopulation analysis.

2. Methods

For our study, we used a sample of children of migrant families in Australia. Using Australia to study migrant mothers' exposure and its impact on children's bodyweight is very attractive. Apart from being a major migrant-receiving country, almost half of Australia's population have at least one parent born overseas (Australian Bureau of Statistics, 2017).

3. Sample

We used seven waves of the restricted release data from an ongoing nationally representative population-based biennial longitudinal survey: Longitudinal Study of Australian Children (LSAC) (Australian Institute of Family Studies, 2018). LSAC employed a two-stage clustered sampling design. Specifically, the primary sampling units (i.e., postcodes, stratified by states/territories and urban/rural statuses) were randomly sampled (Soloff et al., 2005). Children within postcodes were randomly sampled next (Soloff et al., 2005). The list of children within postcodes was obtained from Australia's national health insurance database, known as Medicare, which holds a user database for all Australian residents and citizens (Soloff et al., 2005). Based on this database, approximately 18800 families of the target children were identified and contacted. Approximately half of those contacted participated in Wave 1 in 2004, which consisted of 10090 infants (birth B-cohort, aged 0–1 year, 50.61%) and kindergarten children (kindergarten K-cohort, aged 4–5 years) (Soloff et al., 2005). Detailed information on the LSAC survey and sample design is described elsewhere (Australian Institute of Family Studies, 2018; Soloff et al., 2005).

We used data from children residing with female guardians (referred to as 'mother'), who may be biological, non-biological mothers or other female relatives caring for the child. The data for our analytical sample is restricted to those belonging to overseas-born mothers who had at least one overseas-born parent (i.e., both mother and at least one maternal grandparent of the study child were born overseas). This analytical sample was motivated by the focus on influence of the migration-related experience of mothers born and raised in a society and environment possibly different from Australia. Our selection strategy

excluded mothers born from Australian parents but who had lived outside of Australia temporarily. The resulting 2298 children with migrant mothers (47% B-cohort) were used for further analysis (Fig. 1).

4. Ethical consideration

The Australian Institute of Family Studies Ethics Committee approved the LSAC study, and all parents provided written informed consent. Since we used secondary data collected at a population level, we received an exemption from further institutional ethics approval. We also obtained permission to use LSAC data for research purposes from the Australian Data Archives and National Centre for Longitudinal Data.

5. Variables in our study

5.1. Outcome variable: children's bodyweight

Weight and height data for children aged two years and above were collected in every wave, with the last data in our study being collected in 2016 (Wave 7) when the children were 12–13 (B-cohort) and 16–17 (K-cohort) years. Details on anthropometric data collections are described elsewhere (Australian Institute of Family Studies, 2018). We used these data to calculate children's Body Mass Index (BMI). In cases where we were unable to calculate the BMI, we assigned them to missing. These included observations with improbable height data as they did not increase with age over time, except height data for girls aged 14 years and older (Fig. 1). After cleaning the data, we converted children's BMIs to standardised BMI z-scores (zBMI), using Stata zantro function (Vidmar et al., 2013). The STATA user code harmonises children's bodyweight status according to the World Health Organization (WHO) Child Growth Standards (World Health Organization, 2006) and WHO Growth Reference (de Onis et al., 2007).

5.2. Exposure to Australian society and environment

The survey recorded mothers' information on the date of interview, date of birth and year of arrival in Australia were. This information was used to calculate the mothers' proportion of life spent in Australia, which is a proxy for the exposure to Australian society and environment. A higher proportion means a longer time spent in Australia relative to COB and a stronger exposure to the Australian society and environment.

5.3. Attachment to country of birth

Migrant's attachment to COB was measured using four variables: mothers' age on arrival in Australia, mothers' primary language spoken at home, the proportion of residents in the neighbourhood that speak a language other than English (LOTE), and immigrant concentration in the neighbourhood. The older the age on arrival in the host country, the longer the mother was exposed to the COB environment, increasing the possibility of maintaining or retaining their COB cultural and value system. For our study, we assumed that mothers did not transit and live in other countries before entering Australia. Because only the year of arrival was recorded, we assumed that the arrival date was on the first day of July of the year they arrived when calculating the age on arrival.

The survey collected data on the primary language spoken at home in every wave. We grouped all mothers who used LOTE at home into one category and mothers who spoke English as the reference category, creating a binary variable. The use of heritage language has been linked to ethnic identity (Mu, 2015). Therefore, mothers from non-English speaking countries and used LOTE at home were assumed to maintain a stronger connection to their origin.

We used the proportion of residents born overseas and the proportion of residents speaking LOTE at home to measure neighbourhood cultural influence. The former was calculated from the proportion of residents born in Australia, and the latter was from the proportion of residents

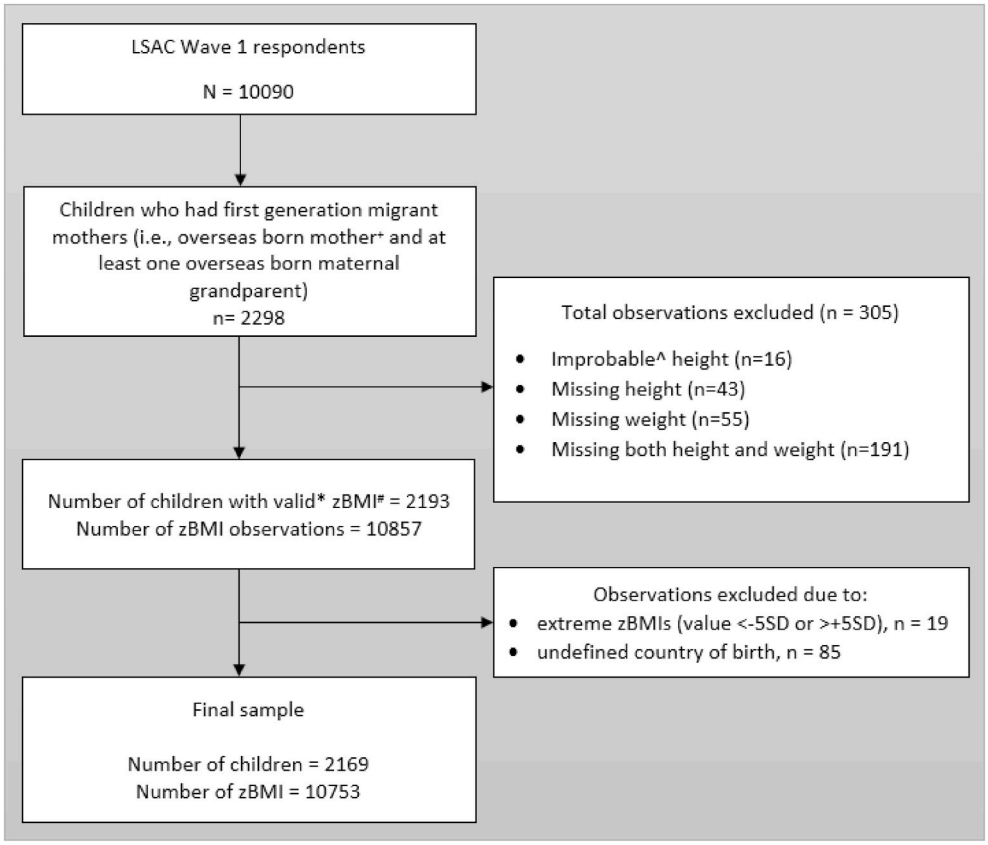

Fig. 1. Inclusion and exclusion processes of the analytical sample.
Note: + Include biological, non-biological mothers or other female guardians of the study child
^ Height that did not increase with age, except in girls aged 14 years or older*
BMI z-score (zBMI) was determined after removing anthropometric observations with improbable height, missing height, missing weight, or missing both height and weight
Data collection for both children's height and weight were conducted when children were two years and above.

speaking English only at home. The data to construct the neighbourhood factors were from the Australian Bureau of Statistics Census of Population and Housing, which were available in LSAC and linked to each study child in every wave (Australian Institute of Family Studies, 2018).

5.4. Macro indicators of childhood overweight environment at migrant mothers' country-of-birth

To reflect the differences in genetic predisposition, obesogenic environment, and societal views on fatness and ideal bodyweight between Australia and migrant mothers' COB, we identified three interrelated variables: (1) the ratio of 'baseline' childhood overweight prevalence in mothers' COB to that in Australia, (2) the ratio of the annual rate of change in childhood overweight prevalence in mothers' COB to Australia, and (3) the interaction between the ratio of baseline prevalence (i.e., the first variable) and the ratio of annual change (i.e., the second variable).

The year 1975 was set as the baseline for the first variable (the ratio of baseline prevalence) because this was the earliest historical data available for analysis (Abarca-Gómez et al., 2017). At the global level, obesity was declared a public health concern in 1997 (James, 2008). However, some countries with a better economic and political situation (including the US) expressed concern about obesity much earlier (James, 2008). These early starters are likely to have earlier awareness of the obesity problem and may have also implemented relevant obesity programs than COBs with a later start. Therefore, the ratio of baseline prevalence can be used to indicate how different/similar migrant mothers' COB with Australia was in economic, public policy, and childhood overweight environments in 1975. The ratios have three possible groups of scores: indicates that the baseline prevalence in migrant mothers' COB is times lower than Australia; indicates that migrant mothers' COB's estimates is similar to Australia; and lastly means the baseline prevalence in migrant mothers' COB is times higher than Australia.

Before constructing the second variable, we predicted the annual rate of change in childhood overweight prevalence in each country. A high positive rate of change may indicate an unfavourable childhood obesity related environment than in Australia. Therefore, the second variable was constructed by taking the ratio of the annual rate of change in childhood overweight prevalence in migrant mothers' COB to that of Australia. The interpretation of the scores in this second variable is similar to the interpretation of the first variable. The steps in constructing the second variable and the data source for the macro indicators are detailed in the Appendix. Also, we excluded 85 observations due to undefined COB (Fig. 1).

5.5. Child-, household-, and neighbourhood-specific covariates

Following the obesogenic environment (Swinburn et al., 1999) and ecological model of obesity (Harrison et al., 2011), we included both time-varying and non-time varying child-, household-, and neighbourhood-specific covariates associated with childhood overweight/obesity in our analytical models. Child-specific covariates included age (in completed years), gender, early life history (birthweight z-score and age in days of first receiving food/drink not breastmilk), and health behaviours (total hours per week spent on screen-based activities and the composite index of fruit and vegetable consumption). A higher number of the fruit and vegetable consumption composite index means a higher frequency of consuming fruits and vegetables in the last 24 h.

Household-specific covariates were mothers' education status (i.e., mothers had other qualifications after school completion, versus the reference category of no other qualification), median weekly household income, and the number of other children living in the house. Neighbourhood covariate was the neighbourhood socio-economic level, measured by the Index of Relative Socio-Economic Advantage and Disadvantage (IRSAD). IRSAD was developed by the Australian Bureau of Statistics for each locality in Australia (Australian Bureau of Statistics, 2018) to indicate the relative economic and social advantage and disadvantage of the residents in the neighbourhood, with a high score indicating a greater advantage and relative absence of disadvantage (Australian Bureau of Statistics, 2018).

Dietary and screen time data were collected from primary caregivers (when children were 2–9 years of age) or from the children when they were ten years or older (Australian Institute of Family Studies, 2018). The data for household- and neighbourhood-specific covariates were collected in every wave. The appendix provides details on constructing the composite index of fruit and vegetable consumption, total weekly hours spent on screen-based activities, mothers' education status, median weekly household income, and the neighbourhood socio-economic level.

5.6. Statistical analysis

All statistical analyses were conducted in Stata/MP 16.0 (StataCorp LP, College Station, TX), and results with were considered statistically significant. To eliminate influence of extreme values due to possible data entry errors, we excluded 19 zBMI observations (Fig. 1) with values under -5SD or above +5SD (Vidmar et al., 2013). Children's zBMI was fitted with two-level random intercept linear regression analysis for survey data to account for clustering and sample design structure. Level one was the wave-specific observations, and level two was the children.

To answer our research questions, we first ran a model with only mothers' proportion of life in Australia as the predictor of children's zBMI (unadjusted model, i.e., Model 1). Secondly, we added attachment to COB variables and macro indicator of COB childhood overweight to Model 1 (i.e., Model 2). Thirdly, we added the covariates to Model 2 (i.e., Model 3). Lastly, we interacted the proportion of life with the attachment to COB variables (Model 4).

In all models, the age of the children was fitted using the cubic polynomial model. We also tested probable non-linear relationships between children's zBMI and variables representing exposure to the Australian environment or attachment to COB, but no evidence of such relationships were found. All variables were time-variant variables, except child's gender, birthweight, age at first food/drink not breastmilk, mothers' age on arrival, and COB childhood overweight factors. We ignored all missing data in the analyses since the proportion of missing data in each variable was small, ranging from 0.01% to 1.65% of the total observations.

Although our analytical sample was a subset of the total LSAC sample, we did not drop the excluded data in running our models. Instead, we used the subpopulation option in the svy suite of Stata to indicate which observations were included in the models. This method was used to preserve the sample design structure, ensure appropriate estimation of variances and standard errors, and minimise bias (Chantala et al., 2006). We also attempted to minimise bias associated with an unequal probability of selection, response and non-response by applying the scaled sampling weights appropriate for multilevel analysis (Carle, 2009). Sensitivity analyses showed that results using scaled sampling weights to effective sample size were very similar to those using scaled sampling weights to efficient sample size. Hence, we only present results from models using scaled sampling weights to effective sample size.

Due to changes in family structure (e.g., separation, death), children could have different mothers between Wave 1 and Wave 7. Hence, the mothers' COB could change. Only two children had different mothers' COB, and sensitivity analysis showed that we did not need to exclude these children from the analysis.

6. Results

6.1. Descriptive

The analysis used data from Wave 1 (2004) to Wave 7 (2016), totalling 10753 person-period zBMI observations from 2169 children, averaging five waves worth of data per child. Table 1 describes children's, mothers', family's and neighbourhood's characteristics when zBMI was first observed. Most children were born in Australia. For children who were born overseas, the majority of them were K-cohort children. Approximately 11% of the children were in the overweight/obese category. The mothers were born from 113 countries, and a high proportion of them came from the United Kingdom, New Zealand, and China. On average, the mothers immigrated to Australia as young adults (i.e., aged 19.25 years). At least half of the mothers had lived in Australia 37.50% of their life. Most mothers had qualifications beyond school completion, and almost half of them conversed using LOTE at home.

Table 1
Child, mother, country of birth, family, and neighbourhood characteristics of the unweighted sample when child's zBMI was first observed.

	Included sample
Children's characteristics	
Number of children	2169
Children born overseas, %	8.58
Male children, %	50.53
Mean zBMI, (SD)	0.60 (1.13)
Distribution of suboptimal bodyweight status, %	
[a]Wasted or thinness	0.97
[a]At risk of overweight	21.62
[a]Overweight	8.07
[a]Obesity	2.90
Mean age in years (SD)	3.44 (1.16)
Mean birthweight in grams (SD)	3356.65 (580.60)
Mean age (in days) of first food/drink not breastmilk (SD)	101.45 (77.13)
Mean total frequency of fruit and vegetable consumption in the last 24 h (SD)	3.16 (1.37)
Mean total weekly hours of screen-time (SD)	4.39 (1.99)
Mothers' characteristics	
Proportion of life spent in Australia	
Mean (SD)	45.67 (28.85)
25th percentile	21.43
50th percentile	37.50
75th percentile	71.43
Age (in years) on arrival	
Mean (SD)	19.25 (10.73)
25th percentile	10
50th percentile	21
75th percentile	28
Had other qualifications after school completion, %	69.80
Speaking LOTE at home, %	49.17
Mothers' origin characteristics	
Number of countries of birth	113
Top 3 country-of-birth, %	
United Kingdom	21.25
New Zealand	12.54
China	6.18
Mean childhood OV prevalence in 1975, (SD)	7.47 (6.42)
Mean childhood OV prevalence in 2016, (SD)	25.22 (11.11)
Mean percent point of annual change in childhood OV prevalence 1975–2016, (SD)	0.43 (0.44)
Family characteristics	
Mean number of other children lived in the house (SD)	1.39 (1.17)
Mean weekly household income in AUD, (SD)	1428.51 (1204.62)
Neighbourhood characteristics	
Mean IRSAD z-score as indicator of SES (SD)	0.19 (1.03)
Mean proportion of residents in neighbourhood speaking LOTE at home (SD)	19.67 (16.35)
Mean proportion of residents in neighbourhood who were born overseas (SD)	20.28 (12.27)

Abbreviations: zBMI body mass index z-score, SD standard deviation; LOTE language other than English; OV Overweight; AUD Australian dollar; IRSAD. Index of Relative Socio-economic Advantage and Disadvantage; SES socio-economic status.

[a] According to WHO Child Growth Standard (World Health Organization, 2006) or WHO Growth Reference (de Onis et al., 2007), depended on child's age at first observation.

6.2. Migrant mothers' long-term residency in Australia and children's zBMI

The null model showed that children's zBMI was highly correlated within children (ICC = 0.74), as expected of repeated measurements taken from one individual over time. Table 2 presents the results of our two-level linear regression analyses, including ICC for each model. Mothers' proportion of life spent in Australia was positively and significantly associated with their children's zBMI, even after controlling for other migrant-specific factors and all covariates (Model 3). Note that the coefficient represents the increase in zBMI for every ten units of increase in the proportion of life in Australia.

Table 2
Influence of mothers' long-term residency in Australia, attachment to COB, and macro indicators of childhood overweight environment in mothers' COB on children's zBMI.

	Model 1[§]	Model 2[§§]	Model 3[§§§]
Predictors	Coefficient (95% CI)	Coefficient (95% CI)	Coefficient (95% CI)
Exposure to Australia			
Mothers' proportion of life living in Australia[#]	0.02** (0.01–0.04)	0.05** (0.01–0.08)	0.08** (0.03–0.13)
Attachment to COB			
Mothers' age on arrival[^]		0.02 (-0.02 to 0.07)	0.07* (0.01–0.13)
Mother spoke LOTE at home		0.23*** (0.12–0.34)	0.24*** (0.14–0.35)
Proportion of residents in the neighbourhood who spoke LOTE at home[#]		0.02* (0.00–0.04)	0.03** (0.01–0.05)
Proportion of overseas born residents in the neighbourhood[#]		-0.03** (-0.04 to -0.01)	-0.02* (-0.04 to -0.00)
Macro indicators of childhood overweight environment at COB			
Ratio of annual rate of change in COB to Australia		-0.01 (-0.04 to 0.02)	-0.01 (-0.05 to 0.02)
Ratio of baseline prevalence in COB to Australia		-0.21* (-0.39 to -0.02)	-0.19* (-0.38 to -0.01)
Ratio of annual rate of change x ratio of baseline prevalence		0.41*** (0.30–0.52)	0.39*** (0.27–0.50)
Constant	0.51*** (0.42–0.60)	0.03 (-0.33 to 0.38)	-0.11 (-0.59 to 0.37)
Variance components			
Between-children variance	1.04 (0.95–1.14)	0.99 (0.91–1.08)	0.95 (0.87–1.03)
Within-children variance	0.37 (0.35–0.39)	0.37 (0.35–0.39)	0.36 (0.35–0.38)
Within cluster correlation, ICC	0.74	0.73	0.72

Abbreviations: COB country of birth; zBMI body mass index z-score; CI confidence interfal; LOTE language other than English; ICC intra cluster correlation.
*$p < 0.05$.
**$p < 0.01$.
***$p < 0.001$.
[§] Model 1: exposure to Australia was the only predictor, no covariates were included.
[§§] Model 2: predictors were the exposure to Australia, attachment to COB, and COB childhood overweight factors, no covariates were included.
[§§§] Model 3: it was model 2, adjusted by all covariates.
[#] Coefficient represents an increase in every 10 units.
[^] Coefficient represents an increase in every 5 units.

6.3. Migrant mothers' attachment to COB and children's zBMI

After adjusting all variables in the model, the results (Model 3, Table 2) reveal that mothers who came to Australia at a later age, spoke a LOTE at home, or lived in a neighbourhood with a higher proportion of residents speaking a LOTE at home were associated with higher zBMI in their children. In contrast, living in a community with a higher proportion of overseas-born residents was associated with lower children's zBMI. Note that the coefficient of mothers' age on arrival represents the increase in zBMI for every five years increase in mothers' age on arrival.

6.4. Childhood overweight environment at mothers' COB

The childhood overweight environment in mothers' COB influenced migrant children's zBMI (Model 3, Table 2), and the predicted zBMI of 17-year-old adolescents by the two macro indicators are shown in Fig. 2. Fig. 2 was divided into four quadrants to ease the interpretation of the results. The first quadrant (Q1) is for the predicted adolescents' zBMI if their mothers were born in COBs with both a higher ratio of annual change and a higher ratio of baseline than Australia. The second quadrant (Q2) is for COBs with a lower ratio of annual change but a higher ratio of baseline than Australia. The third quadrant (Q3) is for COBs with both a lower ratio of annual change and ratio of baseline than Australia. Lastly, the fourth quadrant (Q4) is for COBs with a higher ratio of annual change but with a lower ratio of baseline than Australia.

Overall, the predicted zBMIs of 17-year-old adolescents in the first and fourth quadrants (especially those with a higher ratio of annual change) tended to rank higher than those in the second and third quadrants. The results from the first quadrant also indicate that if the mothers were born in COBs with both a higher baseline prevalence and a higher annual rate of change in childhood overweight prevalence, their children's zBMIs tended to be in the highest quintile ranking than that of others at age 17. Note that we also plotted the same graph as Fig. 2 for children aged 5 and 10 years. The resulting conclusions are similar to Fig. 2. Therefore, we only presented the graph for 17-year adolescents.

Using data on the baseline prevalence and annual rate of change in the childhood overweight prevalence, we predicted the zBMI of the 17-year-old adolescents by mothers' COB, and the quintile ranking is presented in Fig. 3. The graph shows that adolescents whose mothers were born in the Americas, North Africa, Middle East, and Oceania countries tended to have higher zBMI than other adolescents.

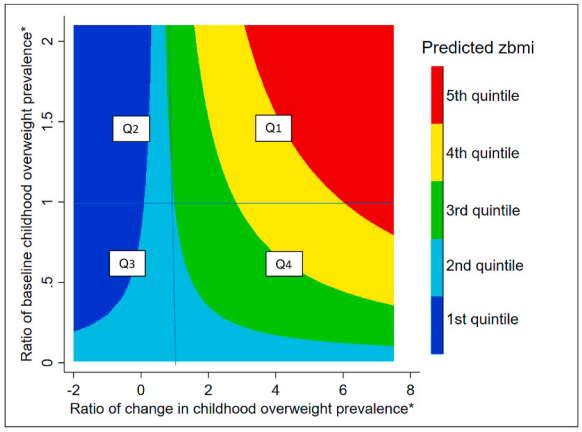

Fig. 2. Predicted zBMI for 17-year-old adolescents by the ratio of baseline childhood overweight prevalence and ratio of the annual rate of change in childhood overweight prevalence. Note: Q1 the first quadrant - COB had higher baseline prevalence and higher annual rate of change in childhood overweight prevalence than Australia; Q2 the second quadrant - COB had higher baseline prevalence and lower annual rate of change in childhood overweight prevalence than Australia; Q3 the third quadrant - COB had lower baseline prevalence and lower annual rate of change in childhood overweight prevalence than Australia; and Q4 the fourth quadrant - COB had lower baseline prevalence and higher annual rate of change in childhood overweight prevalence than Australia.
* ratio at migrant mothers' COB to Australia.

6.5. Interaction between migrant mothers' proportion of life living in Australia and attachment to the COB

The effect of migrant mothers' proportion of life spent in Australia on children's zBMI only marginally differed by migrant mothers' language at home ($p = 0.046$). No other variables representing the mothers' attachment to COB produced significant interaction with the mothers' proportion of life (results not shown).

7. Discussion

The size of the migrant population globally (Mcauliffe and Triandafyllidou, 2021) and in Australia (Australian Bureau of Statistics, 2017) has become significant due to the increasing trend in international migration (Mcauliffe and Triandafyllidou, 2021). However, children in the migrant population are disproportionally affected by overweight/-obesity (Zulfiqar et al., 2019). Hence, we aimed to understand the relationship between mothers' migration-related factors and their children's bodyweight over time. Specifically, we investigated the net relationship of migrant mothers' exposure to Australian society and environment, attachment to COB, and macro indicators of childhood overweight environment at COB on their children's bodyweight over time. To the best of our knowledge, our study was the first that used macro indicators of childhood overweight environment at migrant mothers' COB as predictors of children's bodyweight in the host country.

Our study contributes to the body of knowledge by refining the understanding of migrant-specific risk factors which can be used to identify children in migrant populations at risk of higher bodyweight status, and for designing health programs and public policy to reduce the disparities. Accordingly, we had three important and significant findings. Firstly, mothers' long-term residency increased the likelihood of higher bodyweight in their children after accounting for the mothers' attachment to the COB, macro indicators of childhood overweight environment at mothers' COB, and the covariates. Secondly, children's bodyweight tended to increase if their mothers maintained their attachment to their COB. Thirdly, the childhood overweight environment at mothers' COB influenced their children's bodyweight in Australia. Specifically, the children tended to have higher bodyweight than other children in the migrant population if their mothers were born in countries with a much higher childhood overweight prevalence in 1975 and a much higher annual rate of change in childhood overweight prevalence than in Australia.

Our results, drawn from a nationally representative sample of children in Australia and using advanced methods, confirm previous findings on (1) the positive relationship between migrant mothers' exposure to the host country and their children's bodyweight over time (Garcia-Perez, 2016), and (2) the positive relationship between migrant mothers' language at home and children's bodyweight over time (Sussner et al., 2009). Our study also showed a positive relationship between mothers' age on arrival and children's zBMI over time, which was different from non-significant finding in previous cross-sectional population study of kindergarten children in the USA (Baker et al., 2015). Furthermore, we added new knowledge by providing evidence on the influence of the childhood obesity environment of the migrant mothers' COB on their children's bodyweight status, even after the migrant mothers emigrated and resided in a new country over many years. Thus, our study shows that both migrant mothers' past and present environment, and the mothers' effort to maintain the connection between the two worlds are determinants of children's adverse bodyweight.

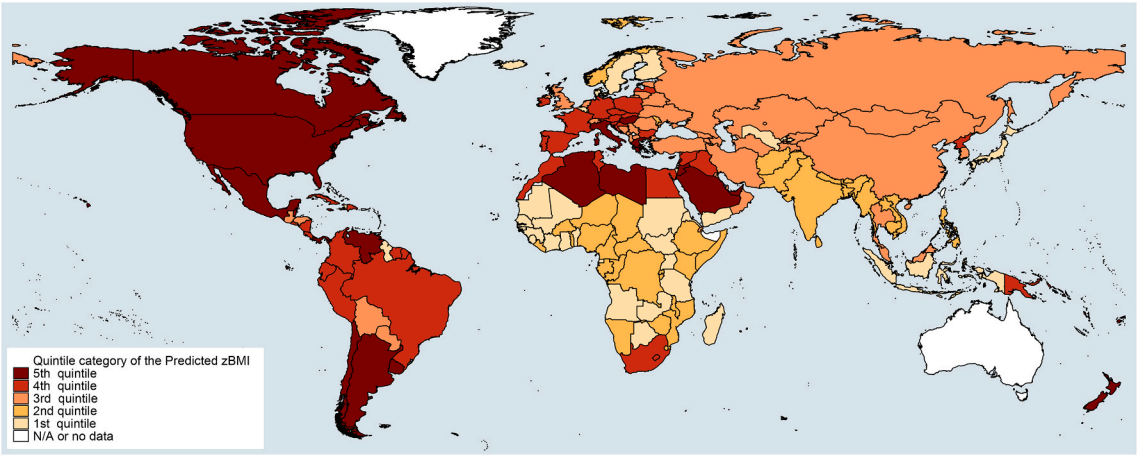

Fig. 3. Quintile rankings of the predicted zBMI of 17-year-old adolescents in Australia, by migrant mothers' country-of-birth.

Our predictions show that adolescents are at risk of higher zBMI over time if their mothers were from North and South America, North Africa, Middle East, and Oceania. These findings agree with previous studies using regional categories (Achat and Stubbs, 2012; Hartono et al., 2021; Maximova et al., 2011). Hence, our study contributes new knowledge that the childhood overweight environment at mothers' COB may underline the mechanism of why migrants from certain regions are at risk of higher bodyweight status. Future study investigating the influence of childhood overweight/obesity environment at migrant parents' COB on children's energy intake and expenditure would be very beneficial for the understanding of bodyweight status among children in migrant families.

Using non-representative samples and acculturation scales, previous studies showed that the bodyweight status of children and adolescents with parents that had COB cultural orientation (traditional) or had both Australian and COB cultural orientation (integration) differed from that of parents with Australian cultural orientation (assimilation) or not adhering to any (marginalisation) (Renzaho et al., 2008; Griffith et al., 2014). Our study, however, did not find a significant interaction effect between migrant mothers' exposure to Australia and attachment to COB on children's zBMI. The difference in the findings partly might be due to our use proxy acculturation measures.

Migrants (e.g., in the USA and Australia) have reported the tendency to eat a larger portion of convenient, highly processed, and highly caloric food after migrating to the host country while having less time to do physical activity (including incidental physical activity) (Addo et al., 2021). Adolescents whose parents were from Sub-Saharan African countries also reported pressure from their parents to increase their body size, as their parents considered a bigger body size as an ideal (Renzaho et al., 2012). Our findings, combined with the previous reports on migrants' energy intakes and expenditure in the host country, emphasise the importance of offering culturally tailored support to (1) both new migrants and migrants who have become long-term residents in the host country, and extra support to (2) migrants from certain regions-of-birth.

8. Strengths and limitations

The conceptual and methodological strengths of our study increase the confidence in the generalisation of our findings. Firstly, we used longitudinal data from a nationally representative sample of children in Australia, covering their lives from age 2 to 17. Secondly, we included variables representing (1) the concept of acculturation as a complex phenomenon, (2) obesogenic environments, and (3) the ecological model of childhood overweight/obesity. Thirdly, we recognised that migrants are heterogeneous regarding their bodyweight related behaviours and views. Hence, we added variables representing how different the childhood overweight/obesity environment in each COB is to Australia. Lastly, we used advanced statistical models, powered by a large sample size, which account for clustering, the use of subpopulation, sampling design, unequal probability of selection, response and non-response in our analysis.

Our study, however, also has some limitations. First, we used the estimated childhood overweight prevalence in COB, which has been smoothed (Abarca-Gómez et al., 2017), instead of using the actual data from each country. It would be good to see if the use of raw data would change the results – although we believe that the estimated data described the childhood overweight/obesity situation in COB quite well - especially data from countries that are likely to be more accurate and complete. Secondly, our macro indicator of COB was time-invariant, although the obesogenic environment and the society's behaviour and perception change over time. Hence, we recommend future work including time-variant macro indicators of childhood overweight/-obesity environment. Thirdly, the use of COB macro-level indicators to infer individual differences may bias our findings (i.e., ecological inference Schuessler, 1999). Future similar study using statistical model to minimise this bias (such as the use of random coefficient model) is recommended. Fourthly, we could not find a significant interaction between exposure to Australia and attachment to COB. The proxy measures of acculturation in our study might partly cause non-significant results. Hence, we suggest the use of standardised acculturation measures on the representative sample of the migrant population. Fifthly, our study focused only on migrant mothers. Hence, the question about the influence of migrant fathers and blended family structures remain. It is likely that the influence on children's bodyweight will be stronger if both fathers and mothers are from the same COB. Therefore, we suggest a similar future longitudinal study to investigate the individual and the combined influences of migrant parents' long-term residence, attachment to, and level of childhood overweight in COB on their children's bodyweight. The fathers' data available in our current study were not adequate for this purpose. Lastly, some other factors that seemed to be relevant to overweight and obesity among children and adolescents in migrant families - such as perception of body image, physical activity, and the westernization of eating habits - were not included in the analysis. The perception of body image was not the focus of this study. Therefore, a future longitudinal study - investigating the influence of past and present environments on migrant parents' bodyweight perception, and how this perception influences children's bodyweight - is highly recommended to further understand the mechanism underlying the disparities. The LSAC data on physical activity were not suitable for our study design. Hence, we used screen time as a proxy for physical inactivity. Information on the

westernization of eating habits was not available. However, our index of fruits and vegetables consumption would capture some of the children's eating habits after living in Australia. We used both screen time and index of fruits and vegetables consumption as control variables.

9. Conclusions

Both migrant mothers' current and past environments continued to affect their offspring's bodyweight status after immigration. In other words, the risk of childhood overweight/obesity in COB did not disappear after moving into Australia – and the risks continued to increase with longer time residing in Australia. Within the migrant population in Australia, children from some countries were disproportionally affected, especially if their mothers were born in a country with both a higher prevalence of childhood overweight in 1975 and a higher annual increase in childhood overweight prevalence than Australia. Continued culturally tailored supports should be offered to both newly arrived migrants and migrants who have become long-term residents of Australia. Future population studies investigating the influence of childhood overweight/obesity environment in migrant parents' COB on energy intake and expenditure would deepen the understanding of the disparities in migrant children.

Data availability

The restricted datasets of The Longitudinal Study of Australian Children used in the current study were obtained from https://growingupinaustralia.gov.au/data-and-documentation/accessing-lsac-data. The restricted datasets contained sensitive information, such as country of birth. Hence the datasets were not publicly available. Access to these data was granted upon rigorous arrangements and approval by the Australian Data Archives and National Centre for Longitudinal Data. The application and instructions for data access can be found in https://dataverse.ada.edu.au/dataverse/ncld.

Funding

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Disclaimer

Findings and views reported in this manuscript are solely those of the authors.

Contributors

All authors involved in the conceptualisation and the design of the study. SH conducted the literature search. SH, YK, and TN engaged in developing the analytical strategies. SH and YK identified relevant data. SH obtained the data from Data Custodian and analysed data. All authors discussed and interpreted the results. SH drafted the manuscript. All authors critically reviewed the manuscript for important intellectual content and approved the final version. All authors have read and approved the paper for submission. All authors agree to be accountable for all aspects of the work. Our work complies with the journal's Ethical Policies and has been conducted after relevant ethical review.

Declaration of competing interest

The authors declare no competing interests.

Acknowledgements

we used restricted datasets from the Longitudinal Study of Australian Children. The Longitudinal Study of Australian Children is a project initiated and funded by the Australian Government, and conducted in partnership with the Department of Social Services, the Australian Institute of Families Studies, and the Australian Bureau of Statistics, with advice provided by a consortium of leading researchers known as the LSAC Consortium Advisory Group.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.healthplace.2022.102791.

References

Abarca-Gómez, L., Abdeen, Z.A., Hamid, Z.A., Abu-Rmeileh, N.M., Acosta-Cazares, B., Acuin, C., Adams, R.J., Aekplakorn, W., Afsana, K., Aguilar-Salinas, C.A., Agyemang, C., Ahmadvand, A., Ahrens, W., Ajlouni, K., Akhtaeva, N., Al-Hazzaa, H. M., Al-Othman, A.R., Al-Raddadi, R., Al Buhairan, F., Al Dhukair, S., Ali, M.M., Ali, O., Alkerwi, A.A., Alvarez-Pedrerol, M., Aly, E., Amarapurkar, D.N., Amouyel, P., Amuzu, A., Andersen, L.B., Anderssen, S.A., Andrade, D.S., Ängquist, L. H., Anjana, R.M., Aounallah-Skhiri, H., Araújo, J., Ariansen, I., Aris, T., Arlappa, N., Arveiler, D., Aryal, K.K., Aspelund, T., Assah, F.K., Assunção, M.C.F., Aung, M.S., Avdicová, M., Azevedo, A., Azizi, F., Babu, B.V., Bahijri, S., Baker, J.L., Balakrishna, N., Bamoshmoosh, M., Banach, M., Bandosz, P., Banegas, J.R., Barbagallo, C.M., Barceló, A., Barkat, A., Barros, A.J.D., Barros, M.V.G., Bata, I., Batieha, A.M., Batista, R.L., Batyrbek, A., Baur, L.A., Beaglehole, R., Romdhane, H. B., Benedics, J., Benet, M., Bennett, J.E., Bernabe-Ortiz, A., Bernotiene, G., Bettiol, H., Bhagyalaxmi, A., Bharadwaj, S., Bhargava, S.K., Bhatti, Z., Bhutta, Z.A., Bi, H., Bi, Y., Biehl, A., Bikbov, M., Bista, B., Bjelica, D.J., Bjerregaard, P., Bjertness, E., Bjertness, M.B., Björkelund, C., Blokstra, A., Bo, S., Bobak, M., Boddy, L.M., Boehm, B.O., Boeing, H., Boggia, J.G., Boissonnet, C.P., Bonaccio, M., Bongard, V., Bovet, P., Braeckevelt, L., et al., 2017. Worldwide trends in body-mass index, underweight, overweight, and obesity from 1975 to 2016: a pooled analysis of 2416 population-based measurement studies in 128.9 million children, adolescents, and adults. Lancet 390, 2627–2642. https://doi.org/10.1016/S0140-6736(17)32129-3.

Achat, H.M., Stubbs, J.M., 2012. Socio-economic and ethnic differences in the prevalence of overweight and obesity among school children. J. Paediatr. Child Health 50, E77–E84. https://doi.org/10.1111/j.1440-1754.2012.02474.x.

Addo, I.Y., Brener, L., Asante, A.D., de Wit, J., 2021. Socio-cultural beliefs about an ideal body size and implications for risk of excess weight gain after immigration: a study of Australian residents of sub-Saharan African ancestry. Ethn. Health 26 (8), 1209–1224. https://doi.org/10.1080/13557858.2019.1607261.

Australian Bureau of Statistics, 2017. Cultural diversity in Australia [Online]. Canberra: Australian Bureau of Statistics. Available: https://www.abs.gov.au/ausstats/abs@.nsf/Lookup/by%20Subject/2071.0~2016~Main%20Features~Cultural%20Diversity%20Data%20Summary~30.

Australian Bureau of Statistics, 2018. Technical paper: Socio-Economic Indexes for Areas (SEIFA) 2016. Australian Bureau of Statistics, Canberra.

Australian Institute of Family Studies, 2018. Longitudinal Study of Australian Children Data User Guide - December 2018. Institute of Family Studies, Melbourne.

Babatunde-Sowole, O.O., Power, T., Davidson, P., Ballard, C., Jackson, D., 2018. Exploring the diet and lifestyle changes contributing to weight gain among Australian West African women following migration: a qualitative study. Contemp. Nurse 54 (2), 150–159. https://doi.org/10.1080/10376178.2018.1459760.

Baker, E.H., Rendall, M.S., Weden, M.M., 2015. Epidemiological Paradox or immigrant vulnerability? Obesity among young Children of immigrants. Demography 52, 1295–1320. https://doi.org/10.1007/s13524-015-0404-3.

Berry, J.W., 2003. Conceptual approaches to acculturation. In: Chun, K.M., Organista, P. B., Marin, G. (Eds.), Acculturation: Advances in Theory, Measurement, and Applied Research. American Psychological Association, Washington, DC.

Carle, A.C., 2009. Fitting multilevel models in complex survey data with design weights: recommendations. BMC Med. Res. Methodol. 9 (49), 1–13. https://doi.org/10.1186/1471-2288-9-49.

Chantala, K., Suchindran, C., Blanchette, D., 2006. Adjusting For Unequal Selection Probability In Multilevel Models: a Comparison Of Software Packages. 2006 Proceedings of the Survey Research Methods Section, Joint Statistical Meeting, pp. 2815–2824.

Clifford, S.A., Gold, L., Mensah, F.K., Jansen, P.W., Lucas, N., Nicholson, J.M., Wake, M., 2015. Health-care costs of underweight, overweight and obesity: Australian population-based study. J. Paediatr. Child Health 51, 1199–1206. https://doi.org/10.1111/jpc.12932.

de Onis, M., Onyango, A.W., Borghi, E., Siyam, A., Nishida, C., Siekmann, J., 2007. Development of a WHO growth reference for school-aged children and adolescents. Bull. World Health Organ. 85, 660–667. https://doi.org/10.2471/BLT.07.043497.

Dhana, K., Haines, J., Liu, G., Zhang, C., Wang, X., Field, A.E., Chavarro, J.E., Sun, Q., 2018. Association between maternal adherence to healthy lifestyle practices and risk of obesity in offspring: results from two prospective cohort studies of mother-child pairs in the United States. BMJ 362, k2486. https://doi.org/10.1136/bmj.k2486.

Diep, C.S., Baranowski, T., Kimbro, R.T., 2017. Acculturation and weight change in Asian-American children: evidence from the ECLS-K:2011. Prev. Med. 99, 286–292. https://doi.org/10.1016/j.ypmed.2017.03.019.

Epstein, G.S., Heizler, O., 2015. Ethnic identity: a theoretical framework. IZA J. Migrat. 4, 9. https://doi.org/10.1186/s40176-015-0033-z.
Folbre, N., Yoon, J., Finnoff, K., Fuligni, A.S., 2005. By what measure? Family time devoted to children in the United States. Demography 42, 373–390. https://doi.org/10.1353/dem.2005.0013.
Garcia-Perez, M., 2016. Converging to American: healthy immigrant effect in Children of immigrants. Am. Econ. Rev. 106, 461–466. https://doi.org/10.1257/aer.p20161110.
Griffith, M., Mellor, D., Green, J., Renzaho, A.M., 2014. Migration-related influences on obesity among sub-Saharan African migrant adolescents in Melbourne, Australia. Nutr. Diet. 71, 252–257. https://doi.org/10.1111/1747-0080.12135.
Harrison, K., Bost, K.K., Mcbride, B.A., Donovan, S.M., Grigsby-Toussaint, D.S., Kim, J., Liechty, J.M., Wiley, A., Teran-Garcia, M., Jacobsohn, G.C., 2011. Toward a developmental conceptualization of contributors to overweight and obesity in childhood: the Six-Cs model. Child Dev. Perspect. 5, 50–58. https://doi.org/10.1111/j.1750-8606.2010.00150.x.
Hartono, S., Cochrane, T., Niyonsenga, T., Kinfu, Y., 2021. A longitudinal analysis of the effect of maternal region-of-birth on transitions in children's bodyweight status from early childhood to late adolescence in Australia: a population -based cohort study. Prev. Med. 153, 106832 https://doi.org/10.1016/j.ypmed.2021.106832.
James, W.P., 2008. WHO recognition of the global obesity epidemic. Int. J. Obes. 32 (Suppl. 7), S120–S126. https://doi.org/10.1038/ijo.2008.247.
Karnik, S., Kaneka, A., 2012. Childhood obesity: a global public health crisis. Int. J. Prev. Med. 3 (1), 1–7.
Kaufman-Shriqui, V., Fraser, D., Friger, M., Bilenko, N., Vardi, H., Abu-Saad, K., Elhadad, N., Mor, K., Feine, Z., Shahar, D.R., 2013. Factors associated with childhood overweight and obesity among acculturated and new immigrants. Ethn. Dis. 23, 329–335.
Lindsay, A.C., Le, Q., Greaney, M.L., 2018. Infant feeding beliefs, attitudes, knowledge and practices of Chinese immigrant mothers: an integrative review of the literature. Int. J. Environ. Res. Publ. Health 15 (1), 21. https://doi.org/10.3390/ijerph15010021.
Maximova, K., O'Loughlin, J., Gray-Donald, K., 2011. Healthy weight advantage lost in one generation among immigrant elementary schoolchildren in multi-ethnic, disadvantaged, inner-city neighborhoods in Montreal, Canada. Ann. Epidemiol. 21 (4), 238–244. https://doi.org/10.1016/j.annepidem.2011.01.002.
Mcauliffe, M., Triandafyllidou, A. (Eds.), 2021. World Migration Report 2022. International Organization for Migration (IOM), Geneva.
Melius, J., Cannonier, C., 2016. Exploring U.S. Hispanic parents' length of time in the United States: influences on obesity outcomes among U.S. Hispanic children. Soc. Work. Health Care 55, 826–842. https://doi.org/10.1080/00981389.2016.1223259.
Mu, G.M., 2015. A meta-analysis of the correlation between heritage language and ethnic identity. J. Multiling. Multicult. Dev. 36, 239–254. https://doi.org/10.1080/01434632.2014.909446.
Ng, C.D., Cunningham, S.A., 2020. In, out, and fluctuating: obesity from adolescence to adulthood. Ann. Epidemiol. 41, 14–20. https://doi.org/10.1016/j.annepidem.2019.12.003.
Nisco, M.L., Baumgartner, E., Van Hook, J., 2019. The weight of school entry: weight gain among Hispanic children of immigrants during the early elementary school years. Demogr. Res. 40, 95–120. https://doi.org/10.4054/DemRes.2019.40.5.
Quon, E.C., Mcgrath, J.J., Roy-Gagnon, M., 2012. Generation of immigration and body mass index in Canadian youth. J. Pediatr. Psychol. 37, 843–853. https://doi.org/10.1093/jpepsy/jss037.
Renzaho, A.M., 2004. Fat, rich and beautiful: changing socio-cultural paradigms associated with obesity risk, nutritional status and refugee children from sub-Saharan Africa. Health Place 10, 105–113. https://doi.org/10.1016/S1353-8292(03)00051-0.
Renzaho, A.M., Mccabe, M., Swinburn, B., 2012. Intergenerational differences in food, physical activity, and body size perceptions among African migrants. Qual. Health Res. 22, 740–754. https://doi.org/10.1177/1049732311425051.
Renzaho, A.M., 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. Int. J. Obes. 32, 594–600. https://doi.org/10.1038/ijo.2008.2.
Rhodes, K., Chan, F., Prichard, I., Coveney, J., Ward, P., Wilson, C., 2016. Intergenerational transmission of dietary behaviours: a qualitative study of Anglo-Australian, Chinese-Australian and Italian-Australian three-generation families. Appetite 103, 309–317. https://doi.org/10.1016/j.appet.2016.04.036.
Sahoo, K., Sahoo, B., Choudhury, A.K., Sofi, N.Y., Kumar, R., Bhadoria, A.S., 2015. Childhood obesity: causes and consequences. J. Fam. Med. Prim. Care 4, 187–192. https://doi.org/10.4103/2249-4863.154628.
Schuessler, A.A., 1999. Ecological inference. Proc. Natl. Acad. Sci. U.S.A. 96 (19), 10578–10581. https://doi.org/10.1073/pnas.96.19.10578.
Segal, A.B., Huerta, M.C., Sassi, F., 2019. Understanding the effect of childhood obesity and overweight on educational outcomes: an interdisciplinary secondary analysis of two UK cohorts. Lancet 394, S84. https://doi.org/10.1016/S0140-6736(19)32881-8.
Soloff, C., Lawrence, D., Johnstone, R., 2005. LSAC Technical Paper No. 1: Sample Design. Australian Institute of Family Studies, Melbourne.
Strickman-Stein, N., Gervais, M.D., Ludwig, D.A., Messiah, S.E., Lipshultz, S.E., Miller, T. L., 2010. Body mass index as a function of length of United States residency among Haitian immigrant children. Ethn. Dis. 20 (1), 22.
Sussner, K.M., Lindsay, A.C., Peterson, K.E., 2009. The influence of maternal acculturation on child body mass index at age 24 months. J. Am. Diet Assoc. 109, 218–225. https://doi.org/10.1016/j.jada.2008.10.056.
Swinburn, B., Egger, G., Raza, F., 1999. Dissecting obesogenic environments: the development and application of a framework for identifying and prioritizing environmental interventions for obesity. Prev. Med. 29, 563–570. https://doi.org/10.1006/pmed.1999.0585.
Ulijaszek, S.J., Lofink, H., 2006. Obesity in biocultural perspective. Annu. Rev. Anthropol. 35, 337–360. https://doi.org/10.1146/annurev.anthro.35.081705.123301.
Vidmar, S.I., Cole, T.J., Pan, H., 2013. Standardizing anthropometric measures in children and adolescents with functions for egen: update. Stata J. 13 (2), 366–378. https://doi.org/10.1177/1536867X1301300211.
World Health Organization, 2006. WHO Child Growth Standards: Length/height-For-Age, Weight-For-Age, Weight-For-Length, Weight-For-Height and Body Mass Index-For-Age: Methods and Development. World Health Organization, Geneva.
Zhang, Q., Liu, R., Diggs, L.A., Wang, Y., Ling, L., 2019. Does acculturation affect the dietary intakes and body weight status of children of immigrants in the U.S. and other developed countries? A systematic review. Ethn. Health 24, 73–93. https://doi.org/10.1080/13557858.2017.1315365.
Zulfiqar, T., Strazdins, L., Dinh, H., Banwell, C., D'este, C., 2019. Drivers of overweight/obesity in 4–11 Year old Children of Australians and immigrants; evidence from growing up in Australia. J. Immigr. Minority Health 21, 737–750. https://doi.org/10.1007/s10903-018-0841-3.