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Effect of migrant parents' bodyweight perception on children's body bodyweight: A longitudinal analysis of population cohort study

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ABSTRACT

Children of migrants in Australia are disproportionally affected by overweight/obesity. Their parents, however, are likely to put little effort into lifestyle changes if unable to recognise their children's suboptimal bodyweight. We examined the potential impact of migrant parents' bodyweight perception on their children's bodyweight over time and whether the region-of-birth of parents and acculturation to the host nation's way of life moderated the relationship, as very little is known about these in the Australian context. We analysed a sample of 2046 children of migrant parents drawn from 8 waves of population-based cohort data, the Longitudinal Study of Australian Children, capturing their lived experience from ages 2 to 17. After controlling for child, parent, family, and neighbourhood factors influencing children's bodyweight, multilevel models showed higher children's bodyweight in subsequent waves if their parents perceived children's bodyweight as lower than their actual bodyweight (i.e., underestimation). However, the rate of increase in children's bodyweight attenuated over time. The effect of migrant parents' underestimation on children's subsequent bodyweight differed by region-of-birth, with higher children's bodyweight in successive waves if their parents were from the Americas, compared to migrant parents from North/West Europe. Parents' acculturation, however, did not have a discernible effect. Although migrant parents' bodyweight perception of their children's bodyweight status influenced children's bodyweight in subsequent waves, this factor was not enough to explain the extent of disparities in children's bodyweight observed in the Australian migrant population. Further research is needed to assess the effects of other types of perception (such as perceptions of healthy weight and physical exercise) on bodyweight disparities in children of migrants.

1. Introduction

Childhood overweight and obesity (OVOB) is a global public health problem (Di Cesare et al., 2019) associated with adverse physical and psychological health (Berardis & Sokal, 2014; Quek, Tam, Zhang, & Ho, 2017) and lower educational outcomes (Ma et al., 2020). As the condition continues to adulthood (Ward et al., 2017), childhood OVOB is a risk factor for a range of chronic conditions (Llewellyn, Simmonds, Owen, & Woolacott, 2016), leading to higher health costs (Schell, Just, & Levitsky, 2020). While OVOB can affect children of all backgrounds, those born to migrants in developed countries tend to be disproportionately affected (Hartono, Cochrane, Niyonsenga, & Kinfu, 2021; Zulfiqar, Burns, D'Este, & Strazdins, 2019). Hence, it is crucial to understand the underlying contributing factors to develop and promote effective childhood OVOB prevention and treatment strategies.

The aetiology of childhood OVOB is complex, with different factors (including parents' factors) interacting at various levels, contributing to children's bodyweight (Harrison et al., 2011). Within this complex landscape, parents play an essential role in shaping their children's immediate obesogenic environment (Harrison et al., 2011) and the psychosocial aspects of interpersonal interactions affecting children's bodyweight (Harrist et al., 2012). Some parental decisions (such as child feeding practices, food purchases or about activity during free time that can substantially impact bodyweight) are likely to be influenced by the parental perception of 'good' bodyweight status for their children. For example, bigger body sizes for children are considered healthier by parents from certain migrant groups (Trigwell, Watson, Murphy, Stratton, & Cable, 2014; van Eijsden, Meijers, Jansen, de Kroon, & Vrijkotte, 2015), and this, in turn, is likely to lead to incorrect perceptions of

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Abbreviations

AME	The Americas/Caribbean
COB	Country of birth
ESEA	East/South-East Asia
IOTF	International Obesity Taskforce
LOTE	Language other than English
LSAC	Longitudinal Study of Australian Children
MENA	Middle East/North Africa
NWEU	North/West Europe
OCE	Oceania, excluding Australia
OVOB	Overweight/obese
SCA	South/Central Asia
SEEU	South/East Europe
SSA	Sub-Saharan Africa

children's bodyweight status (Pasch et al., 2016). Additionally, as revealed by various studies, such misconceptions (e.g., assigning a normal bodyweight category when the child is in the overweight category or underestimation) are more common among migrants, especially those who have stayed longer in the host country (Natale et al., 2016; Remmers et al., 2014).

Since parents' perception can influence the obesogenic family environment and children's obesogenic behaviour (Flores-Peña et al., 2017; Min, Wang, Xue, Mi, & Wang, 2017; Vangeepuram et al., 2016), parental bodyweight perception also influences children's bodyweight (Kaufman-Shriqui et al., 2013). For example, for Korean American migrants, parental bodyweight underestimation was a strong predictor of higher bodyweight in children (Jang et al., 2017). This finding, unfortunately, could not be generalised to other migrant groups: it is restricted to one single population group, has a small sample and is based on convenient sampling, which is prone to systematic biases (Landers & Behrend, 2015; Tyrer & Heyman, 2016). Additionally, the study was cross-sectional and can only show an association, not a causal relationship. This also means that it does not fully capture the intrinsic relationship between parental bodyweight perception and children's bodyweight that tends to work through time. Such complex relationships require a longitudinal research design that we endeavour to apply in this paper.

However, our study is not the first to pursue a longitudinal perspective. There are already a few other studies on the topic (e.g., Gerards et al., 2014; Manios et al., 2022; Parkinson et al., 2017; Vrijkotte, Varkevisser, van Schalkwijk, & Hartman, 2020). Still, all are from outside Australia and do not point in the same direction (e.g., Gerards et al., 2014; Manios et al., 2022; Parkinson et al., 2017; Vrijkotte et al., 2020). Furthermore, most of the studies treated parental bodyweight perception as a time-invariant predictor of children's subsequent bodyweight (e.g., Gerards et al., 2014; Manios et al., 2022; Parkinson et al., 2017; Vrijkotte et al., 2020). However, parental bodyweight perception tends to evolve with time, depending on various factors, such as socio-economic status, level of health literacy, the parents' weight, and many more (Blanchet, Kengneson, Bodnaruc, Gunter, & Giroux, 2019; Tompkins, Seablom, & Brock, 2015). Additionally, previous studies that included migrant parents in the sample did not separate migrants from non-migrants in the analysis (Manios et al., 2022) or did not report the effect of parents' weight perception for migrant parents as the migration characteristics were controlled for in their models (Kaufman-Shriqui et al., 2013; Vrijkotte et al., 2020). Furthermore, sociocultural factors were suggested as potential moderator for the relationship between parents' weight perception and children's bodyweight (Harrist et al., 2012). Still, such knowledge is lacking for the migrant population.

Thus, our study is the first to investigate the longitudinal effect of migrant parents' bodyweight perception on children's longitudinal bodyweight from 2 to 17 years using a representative sample of the migrant population. Focusing on the Australian context, the migrants in our sample came from 120 countries. Our study's specific goals revolved around four research questions. We sought to answer the following: (1) does migrant parents' misperception of children's current bodyweight status affect the children's subsequent bodyweight? (2) Does the relationship between parents' bodyweight misperception and children's subsequent bodyweight remain constant over time? (3) does the relationship between the parent's perception and children's subsequent bodyweight differ by region-of-birth of the parents? Finally, (4) does the relationship between the migrant parent's perception and children's subsequent bodyweight differ by acculturation factors? We did so after controlling for factors influencing children's bodyweight (i.e., children's early life history and characteristics of the child, parent, family, and neighbourhood).

Our study expands existing knowledge and provides policy-relevant evidence to improve child wellbeing. For one, perception is one critical psychosocial risk factor that is amenable to change and can be used to influence the outcome of childhood OVOB (Harrist et al., 2012). As parents' misperception about their children's bodyweight is associated with the obesogenic environment within a family, children's obesogenic behaviour, and lack of motivation for behavioural change (Flores-Peña et al., 2017; Merema et al., 2016; Min et al., 2017; Vangeepuram et al., 2016), quantifying the underlying link contributes to improving childhood OVOB intervention and management programs (Cheng et al., 2020). Furthermore, with the growth of the migrant population in Australia (Australian Bureau of Statistics, 2022), the disparities of childhood OVOB in the migrant population (Hartono et al., 2021; Zulfiqar et al., 2019), and the tendency for some migrant parents to prefer bigger body sizes (Trigwell et al., 2014; van Eijsden et al., 2015), which leads to a higher proportion of migrant parents' weight underestimation of children's bodyweight category (Natale et al., 2016; Remmers et al., 2014), the implications for long-term population health are critical. Currently, almost half of the Australian population has at least one overseas-born parent (Australian Bureau of Statistics, 2022). Given this proportion is bound to increase, the understanding of a key modifiable risk factor for childhood OVOB among the migrant population is very relevant. Also, no previous studies investigated the effect of migrant parents' weight misperception on children's bodyweight in Australia. Lastly, the question remains important due to the inconclusive results from previous studies.

Through our study, we hoped to clarify the inconclusive findings from previous studies. Additionally, our research would add knowledge of the longitudinal effect of migrant parents' bodyweight perception on the longitudinal bodyweight of their children. Furthermore, the answers to some of our research questions would contribute to the understanding of childhood OVOB disparities in the migrant population. By addressing previous shortcomings, the results will generate evidence for policymakers and health practitioners working on migrant health. Firstly, we used a nationally representative sample of children in Australia whose parents were born in one of 120 countries, representing the diverse nature of the migrant population. Using Australian national data representing its multicultural population will allow greater generalisability of our findings for the heterogeneous migrant population in Australia and other high-migrant countries. Secondly, the use of longitudinal data capturing children's life from early childhood (i.e., two years) to late adolescence period (i.e., 17 years) and their parents would allow us to understand how parents' bodyweight perception and migrant-specific factors, which develop over time, influence children's bodyweight, which also evolves. Lastly, we used a comprehensive set of control variables important for children's bodyweight. These control variables also reflect the obesogenic environment (Swinburn, Egger, & Raza, 1999) and the ecological model of childhood OVOB (Harrison et al., 2011).

2. Method

2.1. Sample

This study used data from a longitudinal survey, the Longitudinal Study of Australian Children (LSAC). The children sampled in LSAC were nationally representative of children living in Australia (Australian Institute of Family Studies, 2018), which were obtained through a two-stage sampling process (Soloff, Lawrence, & Johnstone, 2005). In the first stage, postcodes were randomly selected (stratified by states/territories and urban/rural status) (Soloff et al., 2005). In the second stage, the target children within postcodes were randomly selected, and their families were contacted to participate in the survey (Soloff et al., 2005). The target children were identified from the Medicare database, the public health insurance system covering all Australian citizens and permanent residents (Soloff et al., 2005). This process resulted in 10090 participating children (and their families) in wave 1 in 2004 (Australian Institute of Family Studies, 2018). The participating children were grouped into two cohorts: Baby Cohort (B-cohort, n = 5107) and Kindergarten Cohort (K-cohort, n = 4983) (Australian Institute of Family Studies, 2018). In wave 1, children in B-cohort aged 0–1 year and children in K-cohort aged 4–5 years. LSAC study was still ongoing when writing this paper, with the children and their families surveyed every two years (Australian Institute of Family Studies, 2018). In this study, we used LSAC data from wave 1 to wave 8 (collected in 2018) covering children's life from ages 2 to 17.

2.2. Children's subsequent bodyweight

The outcome of interest in this paper was the children's subsequent bodyweight, recorded in successive waves. In LSAC, the height and bodyweight of children aged two years and above were measured directly in every wave (Australian Institute of Family Studies, 2018). The anthropometric data collection procedure has been provided elsewhere (Australian Institute of Family Studies, 2018). The height and bodyweight data were converted to raw Body Mass Index (BMI). If the data were questionable (i.e., zero bodyweight or the height did not increase with age - except for girls aged 14 years and above), we assigned them as missing (n = 74). We converted the raw BMI to the standardised BMI z-score (zBMI) using a Stata user ado file, zanthro, developed by Vidmar, Cole, and Pan (2013), which standardises children's bodyweight status according to the World Health Organisation Child Growth Standards (World Health Organization, 2006) and the World Health Organisation Growth Reference (de Onis et al., 2007).

Following Vidmar et al. (2013), we excluded 83 extreme zBMI observations to reduce the influence of extreme data points, possibly due to data entry errors. Since the outcome of interest was the zBMI in the subsequent waves, we only used data from children with at least two zBMI observations.

2.3. Migrant parent's bodyweight misperception of children's current bodyweight status

The main predictor was parental bodyweight misperception of their children's current bodyweight status, which measures parental accuracy in assessing their children's current bodyweight. This variable was constructed by comparing parents' judgment of their children's bodyweight status and children's actual bodyweight status, determined by the International Obesity Taskforce (IOTF) standard (Cole, Bellizzi, Flegal, & Dietz, 2000; Cole, Flegal, Nicholls, & Jackson, 2007). In LSAC, parents' judgment of their children's bodyweight status was collected only from one parent per study child, the child's primary carer. To simplify the term, we called the primary carer 'parent' in this paper.

Accordingly, we created three bodyweight perception categories: (1) underestimation, (2) correct estimation, and (3) overestimation. A parent's perception was judged 'underestimation' if their perceived bodyweight category was lower than the child's actual BMI category according to the IOTF standard (e.g., parent put their children in the 'underweight' category when the IOTF category was 'normal bodyweight'). Correct estimation was defined if parental judgment matched the IOTF category. If the parent assigned their child a higher bodyweight category than the IOTF BMI category, their response was considered an overestimation. This variable was created for every wave. Further details on the construction of parents' bodyweight perception variable are available in the Appendix.

2.4. Factors linked to migration characteristics of parents

As mentioned, data for constructing the parental bodyweight misperception variable were sourced from the primary carers. Accordingly, all parents-related variables in this study were also sourced from the primary carers. In this paper, region of birth, the proportion of life living in Australia, age at arrival, speaking a language other than English (LOTE) and living in a multicultural neighbourhood were the parent's migrant-specific factors.

Previous study has shown broad regional similarities in biological disposition, views, habits, environment, and outcomes related to childhood OVOB (Abarca-Gómez et al., 2017; Harrison et al., 2011; Odeniyi, Embleton, Ngongalah, Akor, & Rankin, 2020; Stryjecki, Alyass, & Meyre, 2018). Therefore, we grouped migrant parents into regions of birth. The region of birth was constructed using the Standard Australian Classification of Countries (Australian Bureau of Statistics, 2016), which was developed to reflect a broad level of shared social, cultural, economic, and political environments (Australian Bureau of Statistics, 2016). Accordingly, the migrant parent's country of birth (COB) was then grouped into eight regions of birth: (1) Oceania excluding Australia (OCE); (2) North/West Europe (NWEU) as the reference group; (3) South/East Europe (SEEU); (4) Middle East/North Africa (MENA); (5) Sub-Saharan Africa (SSA); (6) East/South East Asia (ESEA); (7) South/Central Asia (SCA); and (8) the Americas/Caribbean (AME).

Several acculturation-related variables were used in this study. Parents' exposure to Australian society and environment was measured using the proportion of life living in Australia. The higher the proportion, the more the parent was exposed to Australian society and environment. Parents' age at arrival to Australia indicated the number of years parents were exposed to the culture and environment at their COB, with older age at arrival indicating more substantial exposure to their COB. For this variable, we assumed that the parent did not transit and lived elsewhere before migrating to Australia because information on the resident country before migrating to Australia was unavailable in LSAC. To measure migrant parents' attachment to their COB and culture, we used speaking LOTE at home, the proportion of people speaking LOTE in the neighbourhood, and the proportion of migrants in the neighbourhood, which were available in every wave. The Appendix details methods used in constructing these predictors.

2.5. Covariates: child-, parent-, family-, and neighbourhood-specific factors

The variables used as covariates in this study were chosen based on models of obesity (Harrison et al., 2011; Swinburn et al., 1999) and their association with bodyweight (Sahoo et al., 2015; Scott, Ng, & Cobiac, 2012). The child-specific covariates included in our analyses were age (in years), gender, early childhood histories (i.e., birthweight and age at first food and drink not breastmilk), and health behaviour (index of fruit and vegetable consumption, and daily average of screen-based activity in hours). Information on the child's gender, birthweight, and age at first food and drink not breastmilk, was collected in wave 1. The data source for the fruit and vegetable consumption index was the frequency of fruit and vegetable consumption in the last 24 h, while the data source for the daily average of screen time was the number of hours spent on a range of screen-based activities in a week. The consumption and screen-time data were reported by their primary carers or the children themselves (if aged ten years and above) at every wave.

Parent- and family-specific covariates were age (in years), gender, having a qualification after high school completion, the average weekly total time working and studying, BMI, and the number of other children living in the house. The average weekly time working and studying was used to measure the parental ability to spend time with their children. Parental BMI was added as a covariate as parents' BMI is associated with children's bodyweight (Lee, Ledoux, Johnston, Ayala, & O'Connor, 2019) and parental bodyweight perception (Peyer, Welk, Bailey-Davis, Yang, & Kim, 2015). Data on parents' BMI were supplied by LSAC, based on parents' self-reported height and bodyweight. The data for these parent- and family-specific covariates were available at every wave. Parent's gender was also available at every wave as a different parent could appear in subsequent waves (i.e., changed due to events such as death or relationship breakdown).

The neighbourhood factor was the neighbourhood's socio-economic status, available in every wave. This was measured using the Index of Relative Socio-Economic Advantage and Disadvantage developed for each locality in Australia (Australian Bureau of Statistics, 2018). A higher score of this variable indicates the presence of more advantages and a relative absence of disadvantages (Australian Bureau of Statistics, 2018). The Appendix provides more information on the constructions of the covariates.

2.6. Statistical analysis

Since our research focused on the children's bodyweight from migrant families, our analysis was restricted to children whose parents were born overseas. The χ^2 test assessed the association between migrant parents' bodyweight perception and children's BMI category according to the IOTF standard. Two-level random intercept linear regression models for survey data assessed parental bodyweight perception on children's subsequent bodyweight. The two-level model handled the clustered structure of the data, with the first level being the observation at each wave and the second level being the individual children. The survey model handled the two-staged sample design structure.

To answer our research questions, we ran several statistical models as follows. Firstly, an unadjusted (bivariate) model (model 1) was run to assess the effect of migrant parents' bodyweight perception on children's subsequent bodyweight. Secondly, we used a method described by Singer and Willett (2003) to assess if the effect of bodyweight perception on children's bodyweight changed over time (model 2) by adding an interaction of parents' bodyweight perception and time to model 1. The time here refers to the number of years between current data collection and baseline. In our study, the maximum number of observations for each child was seven (or seven biennial data collections). Hence the maximum time was 12 years. In model 3, all covariates listed in section 2.6 were added to model 2. In model 4, an interaction term of parental bodyweight perception and region of birth was added to model 3 to see if the effect of parental bodyweight perception on children's bodyweight differed by region of birth. In model 5, acculturation variables were added to see if the interaction effect from model 4 would persist. Finally, in model 6, we added the interaction term between the acculturation variable and parental bodyweight perception to investigate if the effect of parental bodyweight perception on children's subsequent bodyweight differed by parental acculturation.

Although we only used data from children of migrant parents, we did not drop the observations from the non-migrant group in the statistical analysis. Instead, we used the subpopulation option in the Stata survey analysis to indicate the included observations. This method ensures appropriate estimation of variances and standard errors by maintaining the sample design structure (Chantala, Suchindran, & Blanchette, 2006).

In all statistical models, all variables were treated as time-varying, except the child's gender, birthweight, and age at first food/drink not breastmilk. Migrant-specific factors such as region of birth and age at arrival were treated as time-variant variables because the child's primary carer could change between waves. This change was often caused by changes in family composition (e.g., separation, death, or other changes causing the child to be cared for by a different parent). The child's age was modelled as a cubic polynomial, representing the data's best fit. In the analysis, we ignored all missing data since the proportion of missing data was small (maximum 2.43%).

We also applied the scaled sampling weights to the effective sample size (Carle, 2009), which we constructed previously (Hartono, Cochrane, Niyonsenga, & Kinfu, 2022) in all our statistical models. The scaled sampling weights for a multilevel model minimise bias associated with the unequal probability of selection, response, and non-response (Carle, 2009). All the two-level random intercept linear regression analyses were conducted using meglm in the svy suite of commands in Stata/MP 17.0 (StataCorp LP, College Station, TX) with $p < 0.05$ considered statistically significant.

3. Results

3.1. Sample characteristics

The number of children's subsequent zBMI observations for the final analysis were 9572 from 2046 children of migrant parents, averaging 4.68 subsequent zBMI observations per child. Table 1 shows the characteristics of the sample at baseline. Less than 9% of the children were born outside Australia. The average age of the children at baseline was around three years, and the child mostly lived with another sibling. Approximately 9% and 18% of the children were in the underweight and OVOB categories, respectively.

Almost all migrant parents included in this study were biological mothers of the child. Most parents had another qualification after high school completion and spent about 16 h per week on activities outside child/family care. Approximately 57% and 38% of the parents were in normal and OVOB status, respectively. In our sample, 120 countries made up the eight regions of birth. Most migrant parents were born in North/West Europe, East/Southeast Asia, and Oceania countries. Most of these migrants came to Australia as young adults and have spent approximately 50% of their life in Australia. Nearly half of these parents spoke LOTE at home but did not live in a neighbourhood with a high proportion of residents who spoke LOTE at home, nor a neighbourhood with a high proportion of overseas-born residents.

Table 2 shows the distribution of parental bodyweight perception by parental region of birth and the IOTF bodyweight status of the children at baseline. Results from the χ^2 tests show that for each migrant group, parents' bodyweight perception was not equally distributed within the children's bodyweight category. In general, most parents were accurately assigned a bodyweight category when their children were in normal bodyweight status. Incorrect perception of children's bodyweight status occurred mainly when the children were in suboptimal bodyweight status, with overestimation occurring when the child had underweight status and underestimation if the child was in OVOB status. Comparing migrant groups, a higher proportion (74.26%) of correct estimation was observed among parents from NWEU, while parents from MENA had the lowest proportion (58.94%). MENA parents also had the highest proportion of underestimation, at 36.42%.

3.2. The influence of migrant parents' bodyweight underestimation and overestimation on their children's bodyweight in subsequent observations

Table 3 lists the regression coefficients with associated 95% confidence interval limits from statistical models used in this study. Migrant parents' bodyweight underestimation of their children's bodyweight was associated with higher children's zBMI in subsequent waves, compared with migrant parents' correct estimation, in the unadjusted model (i.e., Model 1). This significant association remained after

Table 1
Characteristics of the sample at first observation of zBMI (baseline).

Variable	All sample
Children's characteristics	
Cohort, n (%)	
Baby-cohort	926 (45.26)
Kindergarten-cohort	1120 (54.74)
Children born overseas, n (%)	166 (8.11)
Female, n (%)	994 (48.58)
Age, mean years (SD)	3.41 (1.11)
Birthweight, mean z-score (SD)	−0.15 (1.06)
Age first had food or drink except breastmilk, mean days (SD)	100.99 (78.12)
Index of daily fruits and vegetable consumption, mean (SD)	1.86 (0.79)
Daily total screen time, mean hours (SD)	0.63 (0.28)
Children's subsequent zBMI, mean (SD)	0.57 (1.19)
BMI category*	
Underweight	181 (8.85)
Normal bodyweight	1499 (73.26)
Overweight or obese	366 (17.89)
Migrant parents' & family characteristics	
Number of other children living in the house, mean (SD)	1.38 (1.13)
Parent's age, mean (SD)	35.57 (5.45)
Female, n (%)	1985 (97.02)
Biological parent, n (%)	2036 (99.51)
Had other qualifications after high school, n (%)	1454 (71.14)
BMI category	
Underweight (BMI <18.5)	95 (4.94)
Normal bodyweight (BMI ≥ 18.5 & BMI <25)	1096 (56.94)
Overweight (BMI ≥ 25 & BMI <30)	468 (24.31)
Obese (BMI ≥ 30)	266 (13.82)
Weekly total time spent on working and studying, mean hours (SD)	16.07 (18.47)
Region-of-birth, n (%)	
Oceania excluding Australia	338 (16.52)
North and West Europe	577 (28.20)
South and East Europe	132 (6.45)
The Middle East and North Africa	151 (7.38)
Sub-Saharan Africa	117 (5.72)
East and Southeast Asia	435 (21.26)
South and Central Asia	174 (8.50)
The Americas and Caribbean	122 (5.96)
Age (in years) on arrival	
Mean (SD)	18.55 (11.18)
25th percentile	8
50th percentile	21
75th percentile	28
The proportion of life spent in Australia	
Mean (SD)	54.62 (26.80)
25th percentile	32.61
50th percentile	48.57
75th percentile	80.39
Speaking LOTE at home, n (%)	954 (46.63)
Neighbourhood characteristics	
Neighbourhood socioeconomic status, mean z-score (SD)	0.21 (1.04)
Proportion of residents speaking LOTE in neighbourhood, mean proportion (SD)	19.18 (15.95)
Proportion of migrants in the neighbourhood, mean proportion (SD)	19.97 (12.13)

Abbreviation: SD standard deviation; BMI Body Mass Index; LOTE language other than English.
Note: *based on International Obesity Task Force standard (Cole et al., 2000, 2007).

adjusting for migrant-, child-, parent-, family-, and neighbourhood-factors (Model 5). However, the rate of increasing children's zBMI due to migrant parents' bodyweight underestimation attenuated over time (see Fig. 1). Contrastingly, no significant relationship between migrant parents' bodyweight overestimation and children's bodyweight in subsequent observations was found.

3.3. The effect of parental bodyweight perception on children's subsequent bodyweight by parental region of birth and acculturation

Table 3 shows that the effect of parental underestimation on children's subsequent zBMI was moderated by parental region of birth. Controlling for parental acculturation and all covariates (i.e., Model 5 in Table 3), the influence of NWEU parents' underestimation on children's subsequent zBMI differed from that of AME groups. That is, children's subsequent zBMI was higher among children of the AME group compared with children of NWEU if their parents underestimated their current bodyweight status instead of the correct estimation (see Fig. 2). No statistically significant difference between region of birth was found for the effect of overestimation on subsequent bodyweight.

Lastly, we found non-significant interaction effects of migrant parents' bodyweight perception and our acculturation-related variables, indicating that the effect of migrant parents' bodyweight perception on their children's subsequent zBMIs did not differ by our parental acculturation measures (results not shown).

4. Discussion

The international migrant population has grown globally and in Australia (Australian Bureau of Statistics, 2022; McAuliffe & Triandafyllidou, 2021). Hence, health concerns that disproportionally affect the migrant population (such as childhood obesity) have become an important issue, especially in the context of public health. Our study, which aimed to understand the impact of migrant parents' bodyweight perception on their children's subsequent bodyweight over time and how migrant factors change the relationship between the two, contributes to the body of knowledge of suboptimal bodyweight among children in the migrant population. The acquired knowledge can be used for designing and improving public policy and health programs that aim to reduce the disparities in children's bodyweight. To the best of our knowledge, our study is the first to analyse the net influence of migrant parents' longitudinal bodyweight perception on children's longitudinal bodyweight using a nationally representative sample of children from different origins, covering almost the entire childhood and adolescence periods from aged 2–17 years.

Through our analyses, several important findings were noted. Firstly, only migrant parental underestimation of children's current bodyweight status affected children's body bodyweight in subsequent observations. Compared to migrant parents who correctly estimated their children's bodyweight, a significantly higher bodyweight in subsequent waves was observed if migrant parents thought that their children's current bodyweight status was lower than actual. As previous studies on the topic did not focus on the migrant population (e.g., Gerards et al., 2014; Manios et al., 2022; Parkinson et al., 2017; Vrijkotte et al., 2020), our finding adds not only new knowledge specifically for the migrant population but also supports previous findings from longitudinal studies for children of the general population (Manios et al., 2022; Vrijkotte et al., 2020). Our finding does not support conclusions of no relationship (Parkinson et al., 2017) or lower children's bodyweight with parental underestimation (Gerards et al., 2014). The study samples may explain the difference in the findings as the former only included OVOB children in the sample and focused on parents' bodyweight perception of their OVOB children, while we did not restrict the bodyweight category of the children. In addition, the use of children's BMI based on self-reported bodyweight and height in Gerards et al.'s (2014) study may contribute to the difference in the findings, as it is known that parents often report incorrect height and bodyweight of their children (O'Connor & Gugenheim, 2011).

Secondly, while parental bodyweight underestimation was related to higher children's bodyweight in subsequent observations, the rate of increase in children's bodyweight attenuated over time. This could be interpreted as the influence of migrant parents' bodyweight underestimation on children's bodyweight became weaker as the child grew

Table 2
Parental bodyweight perception by parental region-of-birth and children's bodyweight status according to IOTF standard, at baseline.

Parental bodyweight perception	All	Children BMI category according to IOTF standard			p-value*
		Underweight	Normal bodyweight	OVOB	
Oceania excl. Australia (OCE)					<0.001
Underestimation	83 (24.78)	0.00	20 (8.40)	63 (94.03)	
correct estimation	233 (69.55)	13 (43.33)	216 (90.76)	4 (5.97)	
Overestimation	19 (5.67)	17 (56.67)	2 (0.84)	0.00	
North and West Europe (NWEU)					<0.001
Underestimation	116 (20.17)	0.00	33 (7.32)	83 (97.65)	
correct estimation	427 (74.26)	12 (30.77)	413 (91.57)	2 (2.35)	
Overestimation	32 (5.57)	27 (69.23)	5 (1.11)	0.00	
South and East Europe (SEEU)					<0.001
Underestimation	41 (31.30)	0.00	17 (17.89)	24 (92.31)	
correct estimation	84 (64.12)	4 (40.00)	78 (82.11)	2 (7.69)	
Overestimation	6 (6.00)	6 (60.00)	0.00	0.00	
Middle East and North Africa (MENA)					<0.001
Underestimation	55 (36.42)	0.00	18 (18.37)	37 (88.10)	
correct estimation	89 (58.94)	5 (45.45)	79 (80.61)	5 (11.90)	
Overestimation	7 (4.64)	6 (54.55)	1 (1.02)	0.00	
Sub-Saharan Africa (SSA)					<0.001
Underestimation	24 (20.51)	0.00	11 (12.09)	13 (92.86)	
correct estimation	81 (69.23)	2 (16.67)	78 (85.71)	1 (7.14)	
Overestimation	12 (10.26)	10 (83.33)	2 (2.20)	0.00	
East and Southeast Asia (ESEA)					<0.001
Underestimation	125 (29.07)	0.00	64 (19.51)	61 (89.71)	
correct estimation	279 (64.88)	14 (41.18)	258 (78.66)	7 (10.29)	
Overestimation	26 (6.05)	20 (58.82)	6 (1.83)	0.00	
South and Central Asia (SCA)					<0.001
Underestimation	51 (29.48)	0.00	25 (22.52)	26 (100.00)	
correct estimation	103 (59.54)	17 (47.22)	86 (77.48)	0.00	
Overestimation	19 (10.98)	19 (52.78)	0.00	0.00	
The Americas and Caribbean (AME)					<0.001
Underestimation	39 (31.97)	0.00	9 (11.39)	30 (88.24)	
correct estimation	75 (61.48)	2 (22.22)	69 (87.34)	4 (11.76)	
Overestimation	8 (6.56)	77.78	1.27	0.00	

*Based on χ^2 test, testing the association between parental bodyweight perception and children's BMI category according to the IOTF standard, for each region-of-birth.
Abbreviation: IOTF International Obesity Task Force; BMI Body Mass Index; OVOB overweight/obese.

older. The finding on the reduced rate of increase in children's bodyweight over time is in line with the knowledge that parental bodyweight underestimation occurs more often among younger children than among older children (Rietmeijer-Mentink, Paulis, van Middelkoop, Bindels, & van der Wouden, 2013).

Harrist et al. (2012) postulated that sociocultural factors likely moderated the relationship between parents' bodyweight perception and children's bodyweight. Our third finding was only one region of birth had a different relationship between migrant parents' underestimation and children's bodyweight in subsequent observations. Specifically, a much higher bodyweight in subsequent waves was observed in children of the Americas group if their parents underestimated their children's current bodyweight when compared with children of North/West Europe parents. Lastly, acculturation did not significantly moderate the relationship between migrant parents' bodyweight perception and children's subsequent bodyweight. Our result on acculturation was not what we hypothesised, although it was not surprising given the previous findings of no significant effect of parental acculturation on parental weight perception (Kengneson et al., 2022; McLeod, Bates, Heard, Bohnert, & Santiago, 2018).

4.1. Implications for research and practice

As shown previously, children's longitudinal bodyweight differed by parental region of birth and acculturation (Hartono et al., 2021, 2022; Zulfiqar et al., 2019). However, parental region of birth and acculturation do not directly influence children's bodyweight. Proximal factors likely explain the bodyweight disparities in children of the migrant population. Hence, our study tried to investigate a proximal factor explaining the difference in children's bodyweight observed in the migrant population. Although our findings show that migrant parents' bodyweight perception was an important factor in predicting children's subsequent bodyweight in general, this factor alone is not enough to explain the extent of disparities in children's bodyweight observed in the migrant population. Previous studies found differences between migrant and non-migrant (as well as within migrant groups) in factors related to children's bodyweight (e.g., infant feeding practices, food availability, food practices at home and children's physical activity) (Bolton et al., 2018; Lacoste, Dancause, Gosselin-Gagne, & Gadais, 2020; Skala et al., 2012). Other types of perception may influence the difference in these health behaviours, such as the perception of the role of food in the development of childhood OVOB (Wilson & Renzaho, 2015), the perception of physical activity, and the perception of what constitutes healthy weight held by certain migrant groups (Zulfiqar, D'Este, Strazdins, & Banwell, 2020; Zulfiqar, Strazdins, & Banwell, 2021). Accordingly, a future longitudinal study using representative data of the migrant population to investigate other types of childhood-OVOB-related perceptions predicting the disparities in children's bodyweight in the migrant population is needed.

Parental decisions affecting children's bodyweight are often determined by parents' bodyweight perception of their children's bodyweight (Min et al., 2017). Furthermore, parents who do not recognise suboptimal bodyweight in their children tend to be unconcerned about their children's health and do not show readiness for lifestyle changes (Merema et al., 2016), posing a significant barrier to prevention and intervention programs and hindering the outcome of public health messaging on healthy behaviours to tackle childhood OVOB (Cheng et al., 2020). The policymakers could use our findings to increase

Table 3
The effect of migrant parents' bodyweight perception on children's subsequent zBMI using two-level random intercept linear regression models for survey data.

Predictor	Model 1[a]	Model 2[b]	Model 3[c]	Model 4[d]	Model 5[e]
	Coefficient (95% CI)	Coefficient (95% CI)	Coefficient (95% CI)	Coefficient (95% CI)	Coefficient (95% CI)
Parent's bodyweight perception (REF: correct estimation)					
Underestimation	0.23*** (0.19–0.27)	0.43*** (0.34–0.52)	0.43*** (0.33–0.52)	0.43*** (0.31–0.54)	0.44*** (0.32–0.55)
Overestimation	−0.07 (−0.14 to 0.00)	−0.02 (−0.22 to 0.18)	0.01 (−0.18 to 0.20)	0.01 (−0.20 to 0.23)	0.01 (−0.20 to 0.23)
Parent's bodyweight perception x time					
Underestimation x time		−0.05*** (−0.07 to −0.03)	−0.05*** (−0.07 to −0.03)	−0.05*** (−0.07 to −0.03)	−0.05*** (−0.07 to −0.03)
Overestimation x time		−0.01 (−0.06 to 0.03)	−0.02 (−0.07 to 0.02)	−0.02 (−0.07 to 0.02)	−0.02 (−0.07 to 0.02)
Time		0.01 (−0.00 to 0.02)	0.20*** (0.12–0.25)	0.19*** (0.12–0.25)	0.17*** (0.11–0.23)
Parent's bodyweight perception x region-of-birth					
Underestimation x OCE				0.11 (−0.02 to 0.24)	0.11 (−0.02 to 0.25)
Underestimation x SEEU				−0.09 (−0.24 to 0.07)	−0.08 (−0.23 to 0.07)
Underestimation x MENA				0.00 (−0.17 to 0.17)	0.01 (−0.16 to 0.17)
Underestimation x SSA				−0.08 (−0.29 to 0.12)	−0.07 (−0.28 to 0.13)
Underestimation x ESEA				−0.08 (−0.20 to 0.04)	−0.08 (−0.21 to 0.04)
Underestimation x SCA				0.01 (−0.17 to 0.18)	0.01 (−0.17 to 0.19)
Underestimation x AME				0.28** (0.10–0.47)	0.28** (0.09–0.46)
Overestimation x OCE				0.00 (−0.30 to 0.31)	0.01 (−0.29 to 0.32)
Overestimation x SEEU				−0.04 (−0.31 to 0.24)	−0.03 (−0.30 to 0.24)
Overestimation x MENA				−0.08 (−0.45 to 0.29)	−0.08 (−0.45 to 0.29)
Overestimation x SSA				−0.05 (−0.52 to 0.41)	−0.06 (−0.52 to 0.41)
Overestimation x ESEA				−0.00 (−0.25 to 0.25)	−0.01 (−0.25 to 0.24)
Overestimation x SCA				0.05 (−0.22 to 0.31)	0.05 (−0.21 to 0.31)
Overestimation x AME				0.03 (−0.31 to 0.37)	0.05 (−0.30 to 0.40)
Parent's region-of-birth (ref: North/West Europe)					
Oceania excl. Australia (OCE)				0.14 (−0.01 to 0.29)	0.13 (−0.02 to 0.27)
South/East Europe (SEEU)				0.14 (−0.06 to 0.33)	0.02 (−0.19 to 0.23)
Middle East/North Africa (MENA)				0.51*** (0.27–0.74)	0.35** (0.10–0.60)
Sub-Saharan Africa (SSA)				−0.06 (−0.27 to 0.16)	−0.09 (−0.31 to 0.13)
East/South-East Asia (ESEA)				0.10 (−0.02 to 0.23)	−0.01 (−0.16 to 0.14)
South/Central Asia (SCA)				−0.07 (−0.24 to 0.10)	−0.18 (−0.37 to 0.01)
The Americas/Caribbean (AME)				0.12 (−0.07 to 0.30)	0.06 (−0.13 to 0.24)
Constant	0.56*** (0.51–0.61)	0.52*** (0.46–0.58)	0.07 (−0.46 to 0.60)	−0.02 (−0.54 to 0.50)	−0.29 (−0.88 to 0.31)
Variance components					
Between-children variance	1.02 (0.94–1.12)	1.02 (0.93–1.12)	0.92 (0.84–1.00)	0.89 (0.82–0.97)	0.88 (0.81–0.95)
Within-children variance	0.32 (0.30–0.34)	0.32 (0.30–0.34)	0.31 (0.30–0.33)	0.31 (0.30–0.33)	0.31 (0.30–0.33)
Within cluster correlation, ICC	0.76	0.76	0.74	0.74	0.74

Abbreviations: zBMI body mass index z-score; CI confidence interval; ICC intra cluster correlation.
*$p < 0.05$.
**$p < 0.01$.
***$p < 0.001$.
[a] Model 1: bivariate model, with parental bodyweight perception as the only predictor.
[b] Model 2: predictors were parental bodyweight perception and interaction between parental bodyweight perception and time, no covariates were included.
[c] Model 3: it was Model 2, adjusted for all covariates.
[d] Model 4: it was Model 3, with the interaction between parents' bodyweight perception and parents' region-of-birth was added to the model.
[e] Model 5: it was Model 4, with added acculturation measures to the model.

awareness among health practitioners about parental underestimation of children's bodyweight in the migrant population and the impact of such underestimation on children's bodyweight over time. Through this awareness, health practitioners will better engage with migrant parents in conversation to correctly identify their children's suboptimal bodyweight and to understand the associated outcome if misperception persists. Finally, our findings could also be used to inform health practitioners that the outcome of the health program to tackle childhood OVOB may depend on the parents' perception. In other words, by understanding parents' baseline weight perception, health practitioners could predict parents' likelihood to change or engage in the health program.

4.2. Strengths and limitations

Using nationally representative longitudinal data of children and their migrant parents (born from 120 countries) covering children's life from 2 to 17 years increases the generalisability of our findings. In addition, the use of parental weight perception observed in several waves as the predictor and children's bodyweight observed in subsequent waves as the outcome of interest is a better reflection of the real-world phenomena if we want to know how parental bodyweight perception (which probably influences parental decision-making process) makes differences in their children's bodyweight. Lastly, we used an advanced statistical method to increase confidence in our findings by reducing statistical bias. This includes statistical methods which took account of clustering, the use of subpopulation, preservation of sample design, unequal probability of selection, response, and non-response in the analysis.

Our study has some limitations. Firstly, data on parental bodyweight perception were collected longitudinally from the primary carers of the children. In LSAC, these primary carers were overwhelmingly biological mothers of the children. Although female carers tend to be the primary decision-makers in childcare, food purchases, food preparation, and food production, their decisions are often influenced by their male partners (Lora, Cheney, & Branscum, 2017). In addition, fathers' bodyweight perception often differs from mothers', which may affect children's bodyweight differently (Vollmer & Mobley, 2017). Hence, a

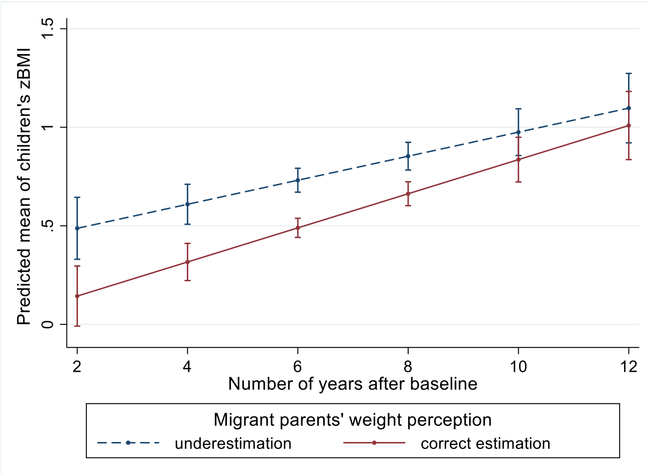

Fig. 1. The effect of migrant parents' bodyweight underestimation on children's subsequent zBMI over time.

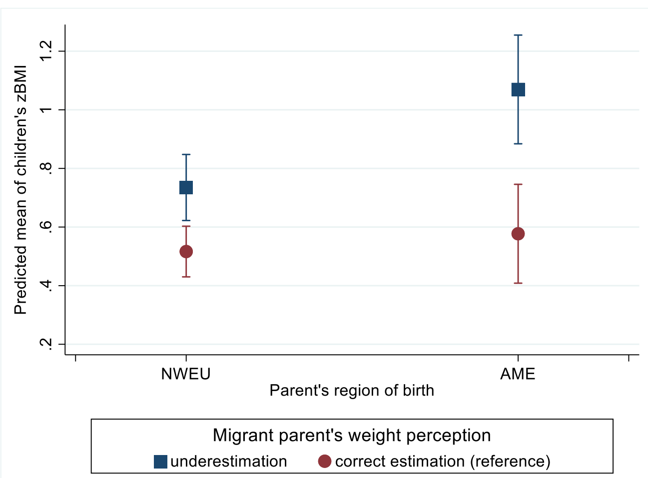

Fig. 2. The effect of migrant parents' bodyweight underestimation on children's subsequent zBMI by parent's region-of-birth.

future study of mothers' and fathers' bodyweight perception as predictors of children's bodyweight is desirable. Secondly, this study did not investigate the effect of children's bodyweight perception, which may significantly influence their bodyweight (Sonneville et al., 2016). This is particularly relevant because as children grow older, they tend to disagree with their parents regarding bodyweight perception (Ling & Stommel, 2019). Therefore, a future study is recommended to investigate the combined longitudinal effect of migrant parents' and children's bodyweight perception on children's bodyweight over time. Thirdly, our study could not separate migrant parents who immigrated directly to Australia from those who migrated elsewhere first before arriving in Australia. However, as per Ravenstien's 'laws of migration' (Grigg, 1977), some migrants may likely have first immigrated to place(s) where the intervening cost of migration is lower and may have a similar or different environment to Australia's before arriving in Australia. Thus, future research can look at the role of step migration in the relationship between parental weight perception and children's bodyweight. Lastly, although we tried to minimise the variability within our migrant sample by separating them into eight regions of birth and adding a range of migrant-related factors in the final analysis, it is likely that variability still exists between migrants of one region of birth. Although LSAC did not collect data on ethnicity, a future study can employ alternative data sources and use a finer categorisation (e.g., separating the Americas to North and South America regions) to capture the effects of cultural background better than attempted in the current study.

5. Conclusions

Migrant parents' inability to correctly assign children's current bodyweight status influences subsequent bodyweight in children. However, this parental inability does not seem to fully explain the disparities of suboptimal bodyweight in children of migrants. Our study's results justify educational programs to help parents identify their children's suboptimal bodyweight with the hope that improved bodyweight estimation will lead to better engagement with prevention and treatment programs for childhood suboptimal bodyweight.

Ethical statement

The Longitudinal Study of Australian Children (LSAC) study was approved by the Australian Institute of Family Studies Ethics Committee. Written informed consent was given by all parents participating in the LSAC study. We received approval from the Australian Data Archives and National Centre for Longitudinal Data to use the LSAC data for research purposes. Since this study analysed secondary data, it was considered exempt from the requirement of further submission for institutional ethical approval.

Contributors

All authors participated in the conceptualisation of the study. SH conducted the literature search. SH, TN, and YK developed the study design and analytical strategy. SH and YK identified the relevant data. SH applied and obtained the data from Data Custodian. SH analysed and interpreted the results. SH drafted the manuscript. TN, TC, and YK guided the manuscript structure and supported the manuscript's drafting. 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, and the work complies with the Journal's Ethical Policies and has been conducted after relevant ethical review.

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Disclaimer

The findings and views expressed in this manuscript are solely those of the authors.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

The authors do not have permission to share data.

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Appendix A. Supplementary data

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