



## Original Article

## Lifestyle behaviours of immigrant and Australian children: Evidence from a nationally representative sample

Shahnawaz Ahmed<sup>a,\*</sup>, Riaz Uddin<sup>a,b</sup>, Jenny Ziviani<sup>a</sup>, Sjaan Gomersall<sup>a</sup>, Asaduzzaman Khan<sup>a,\*\*</sup><sup>a</sup> School of Health and Rehabilitation Sciences, The University of Queensland, Brisbane, Australia<sup>b</sup> Institute for Physical Activity and Nutrition (IPAN), Deakin University, Geelong, Australia

## ARTICLE INFO

## Keywords:

Physical activity  
Screen time  
Sleep  
Fruit  
Vegetable  
HIC  
LMIC

## ABSTRACT

This study aimed to examine the prevalence of physical activity (PA), screen time (ST), sleep, and fruit and vegetable intake of children with low-and-middle-income countries (LMIC) parents, high-income countries (HIC), and Australian children, and whether these behaviours are associated with their immigrant status. Data for this study were from wave 7 of the Birth cohort (B cohort) of the Longitudinal Study of Australian Children. We used generalized estimating equations (GEE) to examine associations between health behaviours and immigrant status. The models were adjusted for a number of covariates. Children with LMIC parents had lower odds of meeting PA and sleep recommendations and higher odds ratio (OR) of meeting fruit and vegetable intake, and ST recommendations than Australian or HIC children. Children with LMIC parents had one-third the odds of meeting the PA recommendations (OR 0.39 [95%CI 0.22–0.70]) than Australian children. No significant differences were observed in lifestyle behaviours among children with HIC parents and Australian children. Lifestyle behaviours of children with LMIC parents differed from those of HIC and Australian children. However, children with HIC parents and Australian children had comparable lifestyle behaviours. Identified disparities in lifestyle behaviours among immigrant children can inform strategies to bring equity in Australian children's lifestyles. Our study underscores the importance of culturally appropriate targeted interventions to promote PA and sleep of children with LMIC parents.

## Introduction

Unhealthy lifestyle behaviours such as insufficient physical activity (PA), unhealthy diet, high screen time (ST), and inadequate sleep have been linked with a higher risk of childhood-onset of obesity, poor psychosocial health, poor academic performance, cardiovascular risk factors, metabolic syndrome, and type 2 diabetes mellitus.<sup>1–5</sup> Although behavioural risk factors such as insufficient PA, high ST, inadequate sleep, and unhealthy diet are established in childhood, there is also evidence that they will continue to present into adulthood.<sup>6–8</sup> For example, childhood metabolic risk factors have been linked to long-term adverse health effects such as cardiovascular diseases in early adulthood and continue over adult years.<sup>7,8</sup> Childhood, therefore, establishes the foundation for future health, growth, and wellbeing.<sup>9</sup>

Despite the evidence to support the importance of health behaviours in childhood, many children fail to attain the recommended health behaviours.<sup>10–13</sup> For example, globally, in 2016, 81% of school-going

adolescents aged 11–17 years did not accumulate the recommended 60 min of daily moderate-to vigorous-intensity PA (MVPA).<sup>14</sup> Children and adolescents aged 5–18 years from developed countries also exceed the recommendations of 2 h or less of ST daily.<sup>15</sup> Furthermore, a review from 20 countries among children aged 5–18-year-old reported a decline of more than 1 h of sleep duration over the study period (1905–2008).<sup>13</sup> Available evidence from Australia demonstrates that children's adherence rates are 7% for recommended daily vegetable intake (5-serves/day) and 79% for fruit intake (2-serves/day).<sup>16</sup> Thus, efforts to promote healthy behaviours during childhood could be the most cost-effective and feasible approach for achieving long-term health and wellbeing.<sup>17</sup>

Most studies of health behaviours in children have been conducted, and only a few have included multiple health behaviours. The International Study of Childhood Obesity, Lifestyle, and the Environment project examined PA, ST, and sleep duration in relation to adiposity, dietary patterns, and quality of life of children aged 11–13 years from 12 countries including Australia.<sup>18,19</sup> However, the most recent Australian Report Card on Physical Activity for Children and Youth shows that

\* Corresponding author. School of Health and Rehabilitation Sciences, The University of Queensland, Brisbane, QLD 4072, Australia.

\*\* Corresponding author. School of Health and Rehabilitation Sciences, The University of Queensland, Brisbane, QLD, 4072, Australia.

E-mail addresses: [shahnawaz.ahmed@uqconnect.edu.au](mailto:shahnawaz.ahmed@uqconnect.edu.au) (S. Ahmed), [a.khan2@uq.edu.au](mailto:a.khan2@uq.edu.au) (A. Khan).

**Abbreviations**

B cohort	Birth cohort
AIFS	Australian Institute of Family Studies
ABS	Australian Bureau of Statistics
K cohort	Kindergarten cohort
BMI	body mass index
DSS	Department of Social Services
HIC	High-income countries
LMIC	Low- and middle-income countries
LSAC	Longitudinal Study of Australian Children
PA	Physical activity
ST	Screen time

MVPA	Moderate-to vigorous-intensity PA
CI	Confidence intervals
GEE	Generalized estimating equations
OR	Odds ratio
SD	Standard Deviation
SES	Socio-economic status
GNI	Gross national income
TV	Television
SEP	Socio-economic position
SA2	Statistical Area 2
SPSS	Statistical Package for Social Science
USA	United States of America
UK	United Kingdom

15%–41% and 32% are meeting the MVPA and ST recommendations, respectively.<sup>20</sup> A recent study found that 79% met their recommended daily intake of fruit; 56% followed the sleep guidelines, 20% met their PA guidelines, 18% adhered to the guidelines for ST, and only 7% of Australian children were meeting their recommended daily intake of vegetables.<sup>16</sup> Thus, it is important to understand lifestyle behaviours, which can inform policies pointing at optimising the health and well-being of children.

Globally, international migration has grown rapidly; however, little is known about the immigrant child's lifestyle behaviours specifically. Recent systematic review suggests that immigrant children are under-represented in health behaviour research globally, and prior studies typically have not specified the country of origin of immigrants.<sup>21,22</sup> Australia has one of the most culturally diverse populations in the world,<sup>23</sup> and immigrant children represent one-third of the total child population in Australia.<sup>24</sup> The impact of these multifaceted issues on immigrants' health behaviours in the Australian context is poorly understood. While limited, research from Australia indicates that immigrant children are less active, more involved in ST, and have low fruit and vegetable consumption.<sup>25</sup> However, this study did not explore all the behaviours together, did not compare PA, ST and sleep behaviours with the Australian Guidelines, and there are no data about the sleep behaviour of immigrant children in Australia.

The pattern of immigration from different countries has changed over time in Australia: most notably, Asian immigrants of mostly low-and-middle-income backgrounds have begun to arrive at an accelerated rate in recent years.<sup>23,25,26</sup> Available evidence suggests a lower prevalence of PA among immigrants from developing countries such as those in Asia and Africa than immigrants from developed countries such as the United Kingdom (UK), Ireland, and New Zealand.<sup>27</sup> However, these studies are limited to PA only and have not looked at high-income countries (HIC) and low-and middle-income countries (LMIC) immigrants separately. An earlier systematic review on immigrant children in the United States of America (USA) reported that immigrant children from Asian backgrounds consumed more fruit and vegetables but did not separate their analysis according to HIC and LMIC.<sup>28</sup> In the present study, we aimed to estimate the prevalence of PA, ST, sleep, and fruit and vegetable intake of immigrant and Australian children. Further, we sought to examine if these behaviours vary among children of immigrant (HIC and LMIC) backgrounds and Australian children.

**Material and methods***Study participants and recruitment*

This study used data from the Longitudinal Study of Australian Children (LSAC), which tracks a cohort of infants from birth (B cohort) and a cohort of children from 4 to 5 years of age (K cohort) with biennial data collection from 2004.<sup>29</sup> The present study was based on data from

Wave 7 of the B-cohort of the LSAC, collected in 2016. Wave 7 was the first wave that captured whether participating children achieved compliance with the recommended 60 min of MVPA per day along with information on ST, sleep, and diet and therefore offered the first opportunity to examine the PA, ST, sleep, and dietary habits simultaneously. A detailed description of the LSAC methodology has been published elsewhere.<sup>30</sup> The study sample size consisted of 3381 children aged 12–13 years.

*Outcome measures*

**Physical activity.** A single item was used to capture participating children's PA; specifically, children were asked: "About how many days each week do you do at least 60 min of moderate or vigorous physical activity?" According to the current Australian guidelines, sufficient PA is defined as accumulating 60 min MVPA per day for children aged 5–17 years.<sup>16</sup> The study children completed this item by responding with the number of days per week they did  $\geq$  60 min of MVPA. PA was dichotomized as either meeting (60 min/day for 7 days) or not meeting (< 60 min/day for 7 days) the PA guidelines.

**Screen time.** Study children were asked to report recreational ST using two items: (a) "Total minutes of TV watched on an average week at home?" (b) "Total minutes per week of electronic gaming on an average at home?". According to the current Australian guidelines, recreational ST was defined as no more than 2 h per day for children aged 5–17 years<sup>16</sup> and subsequently classified as meeting or not meeting guidelines.

**Sleep.** Study children were asked to indicate their typical time of sleep onset and typical wake-up time during school days and non-school days. Children answered the following questions (a) "About what time do you fall asleep on a usual school night?", (b) "About what time do you wake up in the morning on a usual school day?", (c) "About what time do you fall asleep on the nights when you do not have school the next day?", and (d) "About what time do you wake up in the morning on the days when you do not have school?". According to the current Australian guidelines: an uninterrupted 9–11 h of sleep per night is recommended for children aged 5–13 years and 10 h for those aged 14–17 years<sup>16</sup> and subsequently classified as meeting or not meeting guidelines.

**Fruit and vegetable intake.** Study children were asked to indicate their fruit and vegetable consumption as follows: "Think about yesterday, how often did you have fresh fruit?" "Think about yesterday, how often did you have cooked vegetables?" "Think about yesterday, how often did you have raw vegetables?" Response options included "not at all", "once", "twice", and "more than twice". Then classified vegetables and fruit as intake  $\geq$  2 times/day or not intake ( $\geq$  2 times/day).

**Table 1**

Characteristics of immigrant children from low-and-middle-income countries (LMIC), high-income countries (HIC) and Australian children.

Characteristics	Australian ( <i>n</i> = 2260)	HIC ( <i>n</i> = 619)	LMIC ( <i>n</i> = 343)
Mean age in years ( <i>SD</i> )	12.48 (0.51)	12.49 (0.51)	12.43 (0.50)
Female, <i>n</i> (%)	1116 (49.4)	306 (49.4)	157 (45.8)
Region of residence, <i>n</i> (%)			
Metropolitan area	1177 (52.1)	440 (71.3)	289 (85.0)
Non-metropolitan area	1082 (47.9)	177 (28.7)	51 (15.0)
Child's mother speaks English language at home, <i>n</i> (%)	2149 (97.5)	540 (91.2)	125 (43.4)
Family rules about quantity of TV, <i>n</i> (%)	1331 (60.4)	371 (61.2)	214 (64.3)
High SEP, <i>n</i> (%)	554 (29.9)	180 (34.4)	100 (34.8)
Middle SEP, <i>n</i> (%)	961 (51.9)	275 (52.6)	121 (42.2)
Low SEP, <i>n</i> (%)	336 (18.2)	68 (13.0)	66 (23.0)
Mother's weight status, <i>n</i> (%)			
Normal weight	780 (36.1)	236 (40.1)	144 (45.0)
Overweight	638 (29.5)	166 (28.2)	61 (19.1)
Obese	106 (4.9)	24 (4.1)	17 (5.3)
Maternal employment status, <i>n</i> (%)			
Employed	1784 (78.9)	477 (77.1)	269 (78.4)
Child BMI, mean ( <i>SD</i> )	20.3 (3.7)	20.4 (3.8)	20.3 (3.7)
Child participated in team sport, <i>n</i> (%)	1107 (49.3)	312 (50.7)	133 (39.9)

Numbers may not add to total sample size (*n* = 3381) due to missing values. Excluded from the analysis (*n* = 159), comprising mixed immigrant background (*n* = 36), confidential data (*n* = 16), and don't know about immigrant background (*n* = 107). HIC= High-income countries, LMIC = Low- and middle-income countries, BMI = Body Mass Index, SEP = Socio-economic Position.

**Immigrant status.** Children were classified as Australians if they were born in Australia with both Australian-born parents. Children were classified as immigrants if they were born in Australia and one or more of their parents were born overseas.<sup>22,31</sup> Immigrant children were then further classified according to the economic development of their parent's (mother or father or both) birth country. Parents can play an important role in increasing a child's lifestyle behaviours, and mothers generally take on more childcare responsibilities.<sup>32</sup> Parental socio-economic status (SES) influences children's and adolescents' healthy lifestyles; for example, higher screen time is more likely among children with low parental SES than children with higher SES backgrounds.<sup>33</sup> To our knowledge, only one study with representative samples has looked at immigrant children by the socio-economic development of mothers' country of origin,<sup>25</sup> where the outcome was obesity-related risk factors. The classification was based on gross national income (GNI), using the World Bank Classification, 2018.<sup>34</sup> Children were classified as immigrants of a low-and-middle-income country (LMIC) if one or more of their parents were born in LMIC (hereafter LMIC children). Children were classified as immigrants of high-income countries (HIC) if one or more of their parents was born in a HIC (hereafter HIC children). A child was classified as mixed background when one parent comes from an LMIC and another from a HIC.

#### Covariates

Based on previous research,<sup>25</sup> potential covariates were identified for the analyses. Child's age, sex, body mass index (BMI), area of residence, number of siblings, child's mother's language spoken at home, participation in team sports, family rules about quantity of television (TV), and socio-economic position (SEP) were considered as covariates. Family SEP summarized the social and economic capital available to families and included combined annual family income, both parent's employment status and education.<sup>26,35</sup>

#### Statistical analysis

Proportions of study children with sufficient PA, ST, and sleep and consumption of fruit, raw vegetable, and cooked vegetable were compared between immigrant status using chi-square tests. A series of generalized estimating equations (GEE) with an exchangeable correlation were used to examine the associations of PA, ST, sleep, and fruit and vegetable intake with different population groups (children of LMIC, HIC immigrant and Australian parents). GEE was used to take into account the nested structure of the data, as children were nested within Statistical Area 2 (SA2) identifiers to model spatial clustering. A robust standard

error estimator was used to reduce the influence of outliers. A set of covariates initially considered for adjustments included: age, sex, BMI, language spoken at home, area of residence, family rules about quantity of TV, participation in team sports, SEP, PA, and ST. Covariates were examined to identify any collinearity issues. There were no collinearity issues associated with the above covariates. The results for the current GEE models are presented as odds ratios (ORs) and their 95% confidence intervals (*CI*). All statistical analyses were performed using Statistical Package for Social Science (IBM SPSS, version 25; Chicago, IL, USA).

#### Results

Of the final analytical sample (*n* = 3222), 2260 (70.1%) were children of Australian parents (reference group), 619 (19.2%) were HIC children, and 343 (10.7%) were LMIC children. Thirty-six children (1%) were from a mixed background. The ratio of mother vs. father as an immigrant was 17.7% vs. 17.9%, respectively. **Table 1** presents the summary characteristics of the study participants. The mean age of the study children was 12.4 years (*SD*: ± 0.514), and 48.2% were female. The study participants who lived in metropolitan areas were 85.0%, 71.3%, and 52.1% for LMIC, HIC and Australian children, respectively. English was spoken at home by 43.4% of mothers from LMIC compared to 91.2% from HIC mothers and 97.5% for Australian mothers.

The proportion of children meeting lifestyle behaviour guidelines is presented in **Fig. 1**. About 6%, 11%, and 11% of children meeting PA recommendations were from LMIC, HIC, Australian children, respectively. A third (37%) of children from LMIC met the recommendations for ST, followed by children of HIC (29%), and Australian (27%) parents. Seventy-six percent of HIC children met sleep recommendations of 9–11 h of sleep per day, followed by 75% and 71%, Australian and LMIC children, respectively. Sixty-three percent of children of LMIC, 59%, and 55% of children from HIC and Australia, respectively, consumed fruits ≥ 2 times/day. About 34%, 32% and 28% of children who consumed cooked vegetables ≥ 2 times/day were from LMIC, HIC, and Australia, respectively. Twenty-four percent of LMIC children, 23% and 20% of children from HIC and Australian parents, respectively, consumed raw vegetables ≥ 2 times/day.

GEE modelling (presented in **Table 2**) revealed that compared to Australian children, LMIC children had lower odds of meeting the PA recommendations (*OR* 0.39 [95%*CI* 0.22–0.70], *p* = 0.002). LMIC children had lower odds of meeting sleep recommendations (0.70 [95%*CI* 0.52–0.95], *p* = 0.021) than Australian children. LMIC children had higher odds of meeting ST recommendations (1.86 [95%*CI* 1.38–2.51],

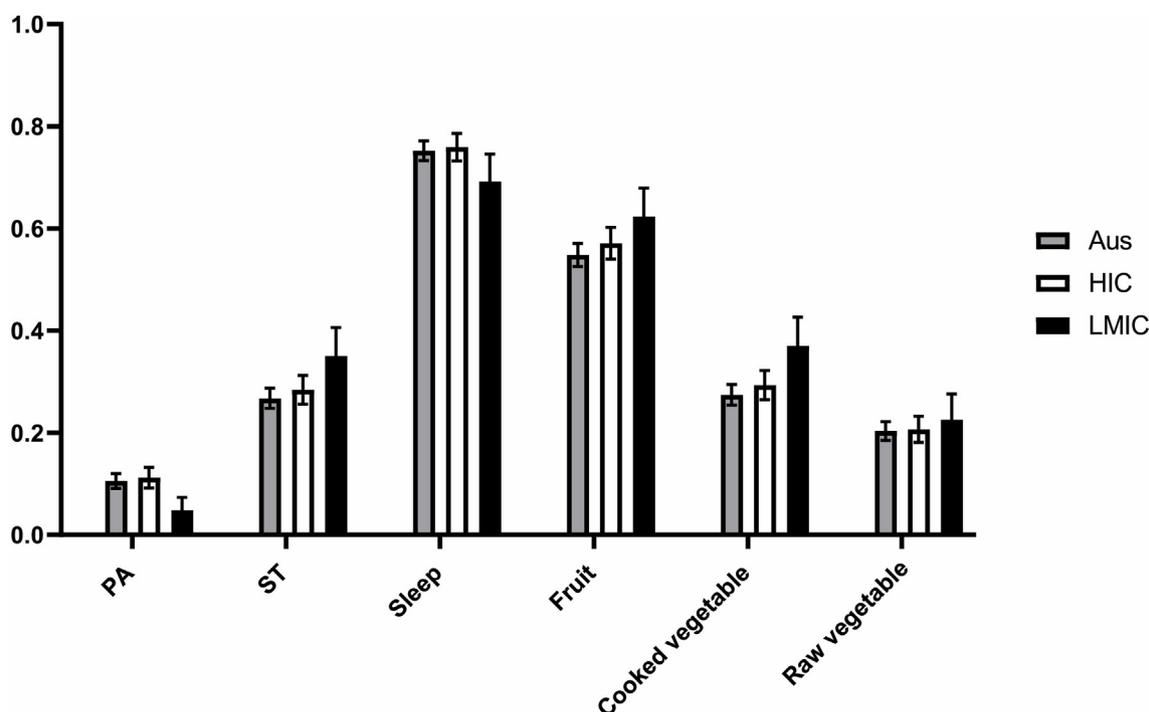


Fig. 1. Prevalence of meeting lifestyle behaviour guidelines, by immigrant children from low-and-middle-income countries (LMIC), high-income countries (HIC) and Australian children. HIC = High-income countries, LMIC = Low- and middle-income countries, PA = Physical activity (60 min/day for 7 days MVPA), ST = Screen time ( $\leq 2$  h/day), Sleep (9–11 h/night), Fruit intake ( $\geq 2$  times/day), Cooked vegetable intake ( $\geq 2$  times/day), Raw vegetable intake ( $\geq 2$  times/day).

$p = 0.001$ ) than Australian children. LMIC children also had higher odds of frequent fruit ( $\geq 2$  times/day) (1.54 [95%CI 1.16–2.05],  $p = 0.002$ ) and cooked vegetable ( $\geq 2$  times/day) (1.51 [95%CI 1.15–1.98],  $p = 0.003$ ) consumption than Australian children. No statistically significant findings were observed in raw vegetable intake of immigrant children from LMIC and Australian children. Among the adjusted covariates, sex, ST, sleep, PA, BMI, and SEP were significant in the analyses (Table 2). Additional analyses on examining the role of duration of immigration on lifestyle behaviours across HIC and LMIC immigrants found that duration of immigration was not significant in any of the behaviours examined ( $p = 0.536$ – $0.966$ ).

Our study found that compared to HIC children, LMIC children had lower odds of meeting PA (0.32 [95%CI 0.15–0.66],  $p = 0.002$ ) and sleep recommendations (0.62 [95%CI 0.44–0.86],  $p = 0.004$ ) and higher odds of meeting ST (1.52 [95%CI 1.08–2.15],  $p = 0.015$ ), fruit intake (1.33 [95%CI 0.97–1.82],  $p = 0.072$ ), and cooked vegetable intake (1.54 [95%CI 1.13–2.09],  $p = 0.006$ ) (presented in Supplementary Table 1) recommendations. No statistically significant findings were observed in raw vegetable intake of children of immigrant parents from LMIC and HIC (Supplementary Table 1). Our study also identified no statistically significant differences between HIC children and Australian children in relation to the odds of meeting recommendations on PA, ST, sleep, and fruit and vegetable intake.

## Discussion

The present study has examined the lifestyle behaviours of Australian and immigrant children aged 12–13 years. Overall, the compliance with guidelines on PA, ST, and vegetable consumption is low across all groups. There were lower odds of meeting PA and sleep guidelines among LMIC children compared to HIC and Australian children. Meeting ST, fruit and cooked vegetable consumption guidelines were more common in LMIC children than HIC and Australian children.

LMIC children had lower odds of meeting PA recommendations than Australian and HIC children in the present study. Our findings are consistent with research conducted from developed countries that

demonstrate immigrant children are less likely to engage in PA compared to native children.<sup>36–38</sup> However, the studies did not classify immigrant children according to parental socio-economic background. The significant differences identified in the prevalence of PA between LMIC and Australian children could be partly due to predisposing factors such as culturally bound values and beliefs, attitudes, environmental factors (access/availability), and lack of motivation to engage in PA, or perceived importance of PA among LMIC immigrants.<sup>27,39</sup> Our study also identified significant differences in PA between the immigrant groups. This could be partly due to immigrant parents from LMIC are lacking knowledge on PA's health benefits or perhaps the high cost of attending gym or lack of culturally sensitive physical activity facilities. Another potential explanation might be HIC children (such as the United Kingdom, Ireland, and New Zealand) experiencing the advantages of better socio-economic backgrounds and similar physical activity infrastructure from their country of origin. Immigrant parents who do not use English as their preferred language may not be able to access PA promotional materials available in English or utilise the services and opportunities that support and promote PA for their children. Our study reported a lack of difference in PA between immigrant children from HIC and Australian children. Our study, therefore, underscores future research to understand factors responsible for the lower level of PA in immigrant children from LMIC, specifically.

Our study found that immigrant children from LMIC had higher odds of meeting ST recommendations compared to HIC and Australian children. This could be partly due to immigrant parents being more concerned about their children's educational success and encouraging them to spend more time in education<sup>40</sup>; screening devices may be allowed to be used for educational purposes, not for recreation. In addition, immigrant families may experience financial difficulties, and not able to make the screen devices accessible to their children. This finding contradicts previous studies from the USA and UK, where immigrant children and adolescents were more engaged in screen-based activities than native-born children<sup>36,41</sup>; however, these studies did not differentiate between HIC and LMIC groups. Using a nationally representative sample of USA adolescents, a recent study reported no significant association

**Table 2**

Examination of lifestyle behaviours between immigrant children from low-and-middle-income countries (LMIC), high-income countries (HIC) and Australian children.

Characteristics	Model 1		Model 2		Model 3		Model 4		Model 5		Model 6	
	Meeting PA guidelines (60 min/day for 7 days MVPA): Yes/No		Meeting ST guidelines (< 2 h/day): Yes/No		Meeting sleep guidelines (9–11 h/day): Yes/No		Fruit intake (> 2 times/day): Yes/No		Cooked vegetable intake (> 2 times/day): Yes/No		Raw vegetable intake (> 2 times/day): Yes/No	
	Adjusted OR (95% CI)	p-value	Adjusted OR (95% CI)	p-value	Adjusted OR (95% CI)	p-value	Adjusted OR (95% CI)	p-value	Adjusted OR (95% CI)	p-value	Adjusted OR (95% CI)	p-value
Immigrant status												
Australian	1.00 (Ref.)		1.00 (Ref.)		1.00 (Ref.)		1.00 (Ref.)		1.00 (Ref.)		1.00 (Ref.)	
HIC	0.97 (0.70–1.36)	0.890	1.14 (0.91–1.44)	0.241	0.94 (0.74–1.19)	0.622	1.15 (0.93–1.41)	0.183	1.25 (1.01–1.56)	0.038	1.16 (0.91–1.48)	0.215
LMIC	0.39 (0.22–0.70)	0.002	1.86 (1.38–2.51)	0.001	0.70 (0.52–0.95)	0.021	1.54 (1.16–2.05)	0.002	1.51 (1.15–1.98)	0.003	1.26 (0.92–1.73)	0.138
Age	1.09 (0.83–1.43)	0.532	1.10 (0.83–0.91)	0.287	0.72 (0.60–0.87)	0.001	0.92 (0.77–1.08)	0.338	0.98 (0.82–1.17)	0.856	1.09 (0.89–1.33)	0.385
Sex (Female)	0.46 (0.35–0.62)	0.001	2.46 (2.39–3.50)	0.001	0.96 (0.79–1.16)	0.686	1.37 (1.16–1.02)	0.001	0.96 (0.80–1.15)	0.702	1.06 (0.86–1.30)	0.537
BMI	0.96 (0.92–1.00)	0.088	0.95 (0.93–0.98)	0.002	0.96 (0.94–0.98)	0.003	1.00 (0.98–1.02)	0.592	1.01 (0.99–1.04)	0.197	1.00 (0.97–1.03)	0.881
SEP	0.91 (0.80–1.04)	0.202	1.50 (1.35–1.67)	0.001	1.11 (1.00–1.22)	0.035	1.14 (1.05–1.24)	0.002	1.12 (1.01–1.23)	0.019	1.19 (1.05–1.34)	0.004
ST: < 2 h/day (Ref.)	1.00	0.001	–	–	1.00	0.249	1.00	0.001	1.00	0.258	1.00	0.002
> 2 h/day	0.54 (0.40–0.74)				0.87 (0.70–1.09)		0.59 (0.49–0.72)		0.89 (0.73–1.08)		0.70 (0.56–0.87)	
Sleep: 9–11 h/day (Ref.)	1.00	0.054	1.00	0.249	–	–	1.00	0.475	1.00	0.597	1.00	0.869
< 9 h and > 11 h	1.34 (0.99–1.82)		0.87 (0.70–1.09)				0.93 (0.76–1.13)		1.05 (0.86–1.29)		0.98 (0.77–1.24)	
PA: 60 min/day for 7 days MVPA (Ref.)	–	–	1.00	0.001	1.00	0.249	1.00	0.001	1.00	0.243	1.00	0.246
60 min/day for < 7 days MVPA			0.55 (0.40–0.74)		0.87 (0.70–1.09)		0.61 (0.45–0.80)		0.84 (0.63–1.12)		0.82 (0.60–1.13)	
Family rules about quantity of TV: Yes	0.95 (0.71–1.26)	0.737	0.60 (0.49–0.73)	0.001	0.78 (0.64–0.95)	0.014	–	–	–	–	–	–

Model 1: adjusted for age, sex, ST, sleep, duration of immigrant status, BMI, Family rules about quantity of TV and SEP.

Model 2: adjusted for age, sex, sleep, duration of immigrant status, BMI, PA, Family rules about quantity of TV and SEP.

Model 3: adjusted for age, sex, PA, ST, duration of immigrant status, BMI, Family rules about quantity of TV and SEP.

Model 4, 5, and 6: adjusted for age, sex, PA, ST, sleep, duration of immigrant status, BMI, and SEP.

HIC= High-income countries, LMIC = Low- and middle-income countries, PA = physical activity, ST = screen-time, BMI = Body Mass Index, SEP = Socio-economic Position, Ref. = Reference.

between ST use and immigration status.<sup>42</sup> Our study only examined ST, determined by watching TV and playing electronic games. With the expanding opportunities for media engagement, future research would benefit from examining a wider range of ST, such as smartphone use or the usage of social media platforms that are popular among teens, to explore this question further.

A recent global systematic review found that only one study had been conducted on sleep behaviour, with immigrant children in the Netherlands reporting less sleep per night than their native-born equivalents.<sup>43</sup> Cultural practices such as parenting style and room sharing (multiple persons sleeping in one room) have been shown to influence sleep behaviours, such as sleep onset and sleep duration.<sup>43,44</sup> In our study, immigrant children from LMIC had lower odds of meeting sleep guidelines than HIC and Australian children. Irregular bedtimes and no set family routine may contribute to disparities in sleep quality and duration. Lack of parental knowledge about healthy sleep habits and the significance of bedtime routines may also be associated with harmful sleep practices.<sup>45</sup> A recent qualitative study among Brazilian mothers living in the USA also reported inconsistencies in mothers' awareness of the importance of sleep and their parenting practices.<sup>46</sup> It is important for the health and wellbeing of LMIC children that we better understand the facilitators and barriers to them having optimal sleep behaviours.

Immigrant children are influenced by the food culture of the host country and social contexts such as schools or peers, which potentially lead to changes in their dietary habits.<sup>47</sup> Our study found low

consumption of vegetables in all groups, while immigrant children from LMIC had higher odds of consuming more fruit and cooked vegetable than those from HIC children and Australian children. This finding is consistent with previous research in Australia, which reported that vegetable consumption was highest among immigrant children, while also contradicts with our study that fruit consumption did not differ between immigrant and Australian children.<sup>25</sup> Immigrants carry over their dietary preferences and practices but often begin to include westernized foods into their diet.<sup>28</sup> A recent systematic review reported Asian children who lived in the USA to have high intakes of fruits, vegetables, white rice, high fat and high sugar foods.<sup>28</sup> One probable reason for dietary changes over time among immigrant children is acculturation, the process by which individuals from one cultural context adapt to another cultural context.<sup>48</sup> Alternatively, parents of HIC children are likely to have come from a country where the diet has already become more westernized, and so the acculturation process may have started even before arrival to Australia. It should be noted that the measures for fruit and vegetable consumption used in this study were determined by the frequency of consumption, not by serving size. Therefore, the study child may have eaten more or less than one serving of fruit and vegetables on each occasion. Thus, more comprehensive research, including consideration of serving sizes, is needed to inform prevention and intervention efforts.

The findings point towards the evidence about the disparities in lifestyle behaviours among children with an immigrant background and

can inform strategies to bring equity in the lifestyle of Australian children irrespective of their immigrant background. However, each group (Australian, HIC, and LMIC) has areas to improve on, and special considerations such as language and cultural differences need to consider among immigrant children from LMIC.

This study's strength is analysing an extensive, nationally representative sample of Australian children. The clustering of data was considered using GEE modelling. However, the study has some limitations that should be acknowledged. Our study assessed only children aged 12–13 years, which constrains the generalization of the study findings beyond this age range. The cross-sectional design of the current study does not allow for any cause-effect interpretation. All lifestyle behaviour data were self-reported in our study. ST was measured using time watching TV and playing electronic games and did not include time spent on social media, video-chatting or browsing the internet, which is likely to have underestimated the overall ST. Sleep duration was measured using sleep onset and wake-up time, which may not indicate uninterrupted sleep.

## Conclusions

Our findings highlight that HIC and Australian children have comparable lifestyle behaviours while differences exist in LMIC children compared to HIC and Australian children. LMIC children had lower odds of meeting PA and sleep guidelines, but higher odds of meeting ST, cooked vegetable, and fruit consumption guidelines compared to HIC and Australian children. Our study underscores the importance of targeted, culturally appropriate intervention strategies for promoting and supporting adherence to the health behaviour guidelines among Australian children, with particular emphasis on LMIC children.

## Submission statement

The work has neither been published nor submitted elsewhere and will not submit to any other journal under review in this journal (except in the form of an abstract or as part of a published lecture or academic thesis), its publication is approved by all authors and tacitly or explicitly by the responsible authorities where the work was carried out, and that, if accepted, it will not be published elsewhere including electronically in the same form, in English or any other language, without the written consent of the copyright-holder.

## Authors' contributions

SA and AK conceptualized and designed the study and carried out the analysis. SA, AK, JZ, RU, and SG interpreted the data. SA led the manuscript writing. AK, JZ, RU, and SG reviewed, revised, and approved the final manuscript as submitted.

## Ethical approval statement

The LSAC received ethics approval from the Australian Institute of Family Studies Ethics Committee (AIFS 15-01), which stated that for each participating child, their parent/guardian provided written informed consent. This secondary analysis was approved by The University of Queensland Human Ethics Committee (2021/HE000253).

## Conflict of 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.

## Acknowledgments

This paper uses data from Growing Up in Australia, the Longitudinal Study of Australian Children, which was conducted in partnership with

the Department of Social Services (DSS), the Australian Institute of Family Studies (AIFS) and the Australian Bureau of Statistics (ABS). The authors thank the LSAC study participants, staff, and others relevant personalities for their contributions. SA is supported by the Australian Government Research Training Scholarship and Research Training Tuition Fee Offset Scholarship. RU is supported by an Alfred Deakin Postdoctoral Research Fellowship.

## Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.smhs.2022.02.002>.

## References

1. Leech RM, McNaughton SA, Timperio A. The clustering of diet, physical activity and sedentary behavior in children and adolescents: a review. *Int J Behav Nutr Phys Activ*. 2014;11:4. <https://doi.org/10.1186/1479-5868-11-4>.
2. Kell KP, Cardel MI, Bohan Brown MM, et al. Added sugars in the diet are positively associated with diastolic blood pressure and triglycerides in children. *Am J Clin Nutr*. 2014;100(1):46–52. <https://doi.org/10.3945/ajcn.113.076505>.
3. Carson V, Stone M, Faulkner G. Patterns of sedentary behavior and weight status among children. *Pediatr Exerc Sci*. 2014;26(1):95–102. <https://doi.org/10.1123/pes.2013-0061>.
4. Carson V. Cardiovascular risk in children and adolescents with type 1 and type 2 diabetes mellitus. *Curr Cardiovasc Risk Rep*. 2012;6(6):591–600. <https://doi.org/10.1007/s12170-012-0274-9>.
5. Jones S, Khanolkar AR, Gevers E, et al. Cardiovascular risk factors from diagnosis in children with type 1 diabetes mellitus: a longitudinal cohort study. *BMJ Open Diabetes Res Care*. 2019;7(1), e000625. <https://doi.org/10.1136/bmjdr-2018-000625>.
6. Biddle SJ, Pearson N, Ross GM, et al. Tracking of sedentary behaviours of young people: a systematic review. *Prev Med*. 2010;51(5):345–351. <https://doi.org/10.1016/j.ypmed.2010.07.018>.
7. Hayes G, Dowd KP, MacDonncha C, et al. Tracking of physical activity and sedentary behavior from adolescence to young adulthood: a systematic literature review. *J Adolesc Health*. 2019;65(4):446–454. <https://doi.org/10.1016/j.jadohealth.2019.03.013>.
8. Craigie AM, Lake AA, Kelly SA, et al. Tracking of obesity-related behaviours from childhood to adulthood: a systematic review. *Maturitas*. 2011;70(3):266–284. <https://doi.org/10.1016/j.maturitas.2011.08.005>.
9. Patton GC, Sawyer SM, Santelli JS, et al. Our future: a Lancet commission on adolescent health and wellbeing. *Lancet*. 2016;387(10036):2423–2478. [https://doi.org/10.1016/s0140-6736\(16\)00579-1](https://doi.org/10.1016/s0140-6736(16)00579-1).
10. Kohl 3rd HW, Craig CL, Lambert EV, et al. The pandemic of physical inactivity: global action for public health. *Lancet*. 2012;380(9838):294–305. [https://doi.org/10.1016/s0140-6736\(12\)60898-8](https://doi.org/10.1016/s0140-6736(12)60898-8).
11. Manyanga T, Barnes JD, Chaput JP, et al. Prevalence and correlates of adherence to movement guidelines among urban and rural children in Mozambique: a cross-sectional study. *Int J Behav Nutr Phys Activ*. 2019;16(1):94. <https://doi.org/10.1186/s12966-019-0861-y>.
12. Matricciani L, Frayssse F, Grobler AC, et al. Sleep: population epidemiology and concordance in Australian children aged 11–12 years and their parents. *BMJ Open*. 2019;9(Suppl 3):127–135. <https://doi.org/10.1136/bmjopen-2017-020895>.
13. Matricciani L, Olds T, Petkov J. In search of lost sleep: secular trends in the sleep time of school-aged children and adolescents. *Sleep Med Rev*. 2012;16(3):203–211. <https://doi.org/10.1016/j.smrv.2011.03.005>.
14. World Health Organization. Global Health Observatory (GHO) Data: Prevalence of Insufficient Physical Activity. WHO Library. Geneva: World Health Organization. [https://www.who.int/gho/ncd/risk\\_factors/physical\\_activity/en/](https://www.who.int/gho/ncd/risk_factors/physical_activity/en/); [Accessed 21 May 2020].
15. Tremblay MS, Carson V, Chaput JP, et al. Canadian 24-hour movement guidelines for children and youth: an integration of physical activity, sedentary behaviour, and sleep. *Appl Physiol Nutr Metabol*. 2016;41(6 Suppl 3):S311–S327. <https://doi.org/10.1139/apnm-2016-0151>.
16. Hardy LL, Mirshahi S, Bellew W, et al. Children's adherence to health behavior recommendations associated with reducing risk of non-communicable disease. *Prev Med Rep*. 2017;8:279–285. <https://doi.org/10.1016/j.pmedr.2017.10.006>.
17. World Health Organisation. *Report of the Commission on Ending Childhood Obesity*. Geneva: WHO; 2016. . Accessed May 21, 2020.
18. Thivel D, Tremblay MS, Katzmarzyk PT, et al. Associations between meeting combinations of 24-hour movement recommendations and dietary patterns of children: a 12-country study. *Prev Med*. 2019;118:159–165. <https://doi.org/10.1016/j.ypmed.2018.10.025>.
19. Sampasa-Kanyinga H, Standage M, Tremblay MS, et al. Associations between meeting combinations of 24-h movement guidelines and health-related quality of life in children from 12 countries. *Publ Health*. 2017;153:16–24. <https://doi.org/10.1016/j.puhe.2017.07.010>.
20. Schranz N, Glennon V, Evans J, et al. Results from Australia's 2018 report card on physical activity for children and youth. *J Phys Activ Health*. 2018;15(S2):S315–s317. <https://doi.org/10.1123/jpah.2018-0418>.

21. Ahmed S, Uddin R, Ziviani J, et al. Global prevalence of physical activity, sedentary behaviour, and sleep of immigrant children: a systematic review. *J Racial Ethn Health Disp*. 2020. <https://doi.org/10.1007/s40615-020-00898-1>.
22. Lacoste Y, Dancause KN, Gosselin-Gagne J, et al. Physical activity among immigrant children: a systematic review. *J Phys Activ Health*. 2020;17(10):1047–1058. <https://doi.org/10.1123/jpah.2019-0272>.
23. Raymer J, Baffour B. Subsequent migration of immigrants within Australia, 1981–2016. *Popul Res Pol Rev*. 2018;37(6):1053–1077. <https://doi.org/10.1007/s11113-018-9482-4>.
24. Washbrook E, Waldfogel J, Bradbury B, et al. The development of young children of immigrants in Australia, Canada, the United Kingdom, and the United States. *Child Dev*. 2012;83(5):1591–1607. <https://doi.org/10.1111/j.1467-8624.2012.01796.x>.
25. Zulfiqar T, Strazdins L, Dinh H, et al. Drivers of overweight/obesity in 4–11 Year old children of Australians and immigrants; evidence from growing up in Australia. *J Immigr Minority Health*. 2019;21(4):737–750. <https://doi.org/10.1007/s10903-018-0841-3>.
26. Zulfiqar T, Strazdins L, Banwell C, et al. Growing up in Australia: paradox of overweight/obesity in children of immigrants from low-and-middle-income countries. *Obes Sci Pract*. 2018;4(2):178–187. <https://doi.org/10.1002/osp4.160>.
27. Singh GK, Yu SM, Siahpush M, et al. High levels of physical inactivity and sedentary behaviors among US immigrant children and adolescents. *Arch Pediatr Adolesc Med*. 2008;162(8):756–763. <https://doi.org/10.1001/archpedi.162.8.756>.
28. Diep CS, Foster MJ, McKyer EL, et al. What are Asian-American youth consuming? A systematic literature review. *J Immigr Minority Health*. 2015;17(2):591–604. <https://doi.org/10.1007/s10903-013-9905-6>.
29. Vella SA, Cliff DP, Magee CA, et al. Associations between sports participation and psychological difficulties during childhood: a two-year follow up. *J Sci Med Sport*. 2015;18(3):304–309. <https://doi.org/10.1016/j.jsams.2014.05.006>.
30. Australian Institute of Family Studies. *Survey Methodology: The Longitudinal Study of Australian Children Data User Guide*; 2015. Available from <http://www.growingupinaustralia.gov.au/data/docs/userguide/11-surveymethodology.html>. Accessed May 19, 2020.
31. Australian Bureau of statistics. Cultural Diversity in Australia; Reflecting a Nation: Stories from the 2011 Census. Available from: <http://www.abs.gov.au/ausstats/abs@.nsf/Looku>. Accessed August 23, 2021.
32. O'Connor TM, Jago R, Baranowski T. Engaging parents to increase youth physical activity a systematic review. *Am J Prev Med*. 2009;37(2):141–149. <https://doi.org/10.1016/j.amepre.2009.04.020>.
33. Männikkö N, Ruotsalainen H, Miettunen J, et al. Parental socioeconomic status, adolescents' screen time and sports participation through externalizing and internalizing characteristics. *Heliyon*. 2020;6(2), e03415. <https://doi.org/10.1016/j.heliyon.2020.e03415>.
34. 2018-2019 Nccbil. Available from <https://blogs.worldbank.org/opendata/new-country-classifications-income-level-2018-2019>. Accessed October 28, 2020.
35. Blakemore T, Strazdins L, Gibbings J, et al. Measuring family socioeconomic position. *Aust Soc Pol*. 2009;8:121–168.
36. Taverno Ross SE, Larson N, Graham DJ, et al. Longitudinal changes in physical activity and sedentary behavior from adolescence to adulthood: comparing U.S.-born and foreign-born populations. *J Phys Activ Health*. 2014;11(3):519–527. <https://doi.org/10.1123/jpah.2011-0359>.
37. Reimers AK, Brzoska P, Niessner C, et al. Are there disparities in different domains of physical activity between school-aged migrant and non-migrant children and adolescents? Insights from Germany. *PLoS One*. 2019;14(3), e0214022. <https://doi.org/10.1371/journal.pone.0214022>.
38. Bhatnagar P, Shaw A, Foster C, et al. Generational differences in the physical activity of UK South Asians: a systematic review. *Int J Behav Nutr Phys Activ*. 2015;12:96. <https://doi.org/10.1186/s12966-015-0255-8>.
39. Joshi S, Jatrana S, Paradies Y. Are immigrants more physically active than native-born Australians and does it change over time? Evidence from a nationally representative longitudinal survey. *J Phys Activ Health*. 2017;14(2):145–154. <https://doi.org/10.1123/jpah.2016-0002>.
40. Chen J H. "Children's time use in immigrant and native families: national evidence from Australia". Soc Sci Res. doi:10.1016/j.sresresearch.2021.102665.
41. Taverno Ross SE, Francis LA, BeLue RZ, et al. Associations between physical activity and overweight among U.S. youth by immigrant generation: results from the 2007 National Survey of Children's Health. *J Phys Activ Health*. 2012;9(6):840–848. <https://doi.org/10.1123/jpah.9.6.840>.
42. Williams W, Li K, Haynie D, et al. Physical activity and sedentary behavior of US immigrant versus non-immigrant adolescents: findings from the NEXT Generation Health Study data. *Ethn Health*. 2018;23(3):329–338. <https://doi.org/10.1080/13557858.2016.1265644>.
43. Labree LJ, van de Mheen HD, Rutten FF, et al. Sleep duration differences between children of migrant and native origins. *Z Gesundh Wiss*. 2015;23(3):149–156. <https://doi.org/10.1007/s10389-015-0665-8>.
44. Magee CA, Huang XF, Iverson DC, et al. Examining the pathways linking chronic sleep restriction to obesity. *J Obes*. 2010;2010:821710. <https://doi.org/10.1155/2010/821710>.
45. McDowall PS, Galland BC, Campbell AJ, et al. Parent knowledge of children's sleep: a systematic review. *Sleep Med Rev*. 2017;31:39–4710. <https://doi.org/10.1016/j.smrv.2016.01.002>.
46. Lindsay AC, Moura Arruda CA, Tavares Machado MM, et al. Exploring Brazilian immigrant mothers' beliefs, attitudes, and practices related to their preschool-age children's sleep and bedtime routines: a qualitative study conducted in the United States. *Int J Environ Res Publ Health*. 2018;15(9):1923. <https://doi.org/10.3390/ijerph15091923>.
47. Satia-Abouta J, Patterson RE, Neuhouser ML, et al. Dietary acculturation: applications to nutrition research and dietetics. *J Am Diet Assoc*. 2002;102(8):1105–1118. [https://doi.org/10.1016/s0002-8223\(02\)90247-6](https://doi.org/10.1016/s0002-8223(02)90247-6).
48. Berry JW. Immigration, acculturation, and adaptation. *Appl Psychol*. 1997;46(1):5–34. <https://doi.org/10.1111/j.1464-0597.1997.tb01087.x>.