The longitudinal relationship between early-life screen viewing and 24-hour movement behaviours – findings from a multi-ethnic birth cohort study

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**ABSTRACT**

**Background** Screen viewing is a sedentary behaviour reported to interfere with sleep and physical activity. However, few longitudinal studies have examined such associations in preschool children and none have accounted for compositional nature of these behaviours. To address these evidence gaps, we investigated the associations of total and device-specific screen viewing time (SVT) at ages 2-3 years with accelerometer-measured 24-hour movement behaviours, including sleep, sedentary behaviour (SB), light physical activity (LPA) and moderate-to-vigorous physical activity (MVPA) at age 5.5 years.

**Methods** Growing Up in Singapore Towards healthy Outcomes (GUSTO) is a mother-offspring cohort study; children’s daily total and device-specific SVT (television, handheld devices and computers) were reported by parents at ages 2-3. Movement behaviours over 7 consecutive days were measured at age 5.5 using wrist-worn accelerometers. We examined the associations of SVT with movement behaviours using Dirichlet regression that accounts for the compositional nature of such behaviours.

**Findings** Total SVT age 2-3 was significantly associated with movement behaviours in relation to SB at age 5.5 (sleep: p =0.008, LPA and MVPA: p<0.0001). Compared to children having ≤ 1 h/day of SVT, those having ≥ 3 h/day had more SB (439.8 vs 480.0 mins/day) but less LPA (384.6 vs 356.2) and MVPA (76.2 vs 63.4) time. Not substantial difference in sleep (539.5 vs 540.4) was observed. Similar trends were observed for television viewing and handheld device viewing.

**Interpretation** Higher SVT in toddlerhood was associated with greater SB but shorter time engaged in LPA and MVPA in later childhood. Our findings indicate the displacement of PA by screen viewing during the early years, and suggest that reducing SVT in early childhood may promote healthier behaviours and associated outcomes later in life.

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**Research in context**

**Evidence before this study**

Early childhood is a critical period for developing behavioural habits that persist into adolescence and adulthood. Screen viewing was suggested to have detrimental effects on child health, including an increased risk for obesity, reduced motor and cognitive development and poorer psychosocial health. According to an estimation from United Nations International Children Education Fund, World Health Organization and the World Bank, in 2016, more than 41 million children younger than 5 years were overweight and obese; the number kept increasing during the past few years and was estimated to be over 50 million by 2030. Likely mechanisms relating screen viewing to obesity include the inverse relationships of screen viewing with physical activity, and of screen viewing with sleep. However, the longitudinal effects of screen viewing on movement behaviours within a finite 24-h period are unknown. To identify studies that have explored the relationships between screen viewing with physical activity, sedentary behaviour and sleep in children, we searched PubMed without date restrictions, with the primary search terms “children”, “screen viewing”, “media use”, "television viewing”, “physical activity”, “exercise”, “fitness”, “sleep” and “movement behaviour” in various combinations. Most studies assessing associations of screen viewing with physical activity and sleep target school-aged children and youth. A systematic review concluded that associations between screen time and physical activity were weak and inconsistent in school-aged children and youth. The literature consistently supports the importance of reducing screen viewing for adequate sleep duration among children and youth. We further observed that most of the existing studies reporting on screen viewing with movement behaviours used a cross-sectional design. No previous study has assessed the associations between screen viewing and movement behaviours using composition techniques, which consider the compositional nature of movement behaviours within a defined 24-hour period.

**Added value of this study**

By using analyses accounting for compositional time use, we showed higher engagement in total and device-specific screen viewing during toddlerhood in Singapore was associated with greater sedentary behaviours and lower moderate-to-vigorous physical activity, light physical activity. These findings extend existing research in preschool- and school-aged children through the use of a longitudinal study design and the objective assessments of all movement behaviours, thereby strengthening the existing mechanisms/literature/knowledge linking screen viewing with later child health.

**Implications of all the available evidence**

Our analysis addresses an important research gap and establishes a platform for research to further explore the roles played by content type, timing, and co-use of media in unfavourable movement behaviours. The findings suggest that further research into the longitudinal effects of screen viewing on other movement behaviours is warranted, and support public health efforts to reduce early years screen time and minimize its likely negative impact on children health behaviours and health.

**INTRODUCTION**

Screen viewing is increasingly prevalent and has globally become a part of common sedentary behaviour (SB). Excessive screen viewing time (SVT) has been reported to be associated with poorer health outcomes in children, including increased obesity risk, reduced motor and cognitive development and worse psychosocial health (1). Considering the detrimental effects of excessive SB on health, the WHO (2) and several countries have developed and issued recommendations to limit screen time to one hour per day or less among children aged 2-4/5 years. On the other hand, concerns about the recommendation of a universal cut-off for children’s overall screen time have been raised (3, 4), considering the relatively weak evidence and the differential effects of different forms of screen time.

One of the suggested mechanisms through which screen viewing may influence health is by displacing time that would otherwise be spent engaged in physical activity (PA). This proposed hypothesis has, to our knowledge, been rarely investigated in preschool-aged children but has received some support from studies in adolescents. Some studies suggested that high levels of SVT were strongly associated with decreases in PA (5, 6). On the other hand, a previous meta-analysis and more recent research reported that such associations are either weak or non-existent (7, 8). As such, evidence of the relationships between SVT and PA is mixed and inconclusive. Meanwhile, inadequate sleep is another possible mechanism linking SVT and health. School-aged children and adolescents who spend excessive time watching screens may be more likely to have inadequate sleep, which is usually measured by less total sleep time and later bedtimes (9). Such associations are concerning since they already occur in infancy and can persist to mid-childhood (10).

However, studies investigating the associations of SVT with other behaviours (i.e., PA, sleep) are mainly in school-aged children and youth, and adequate empirical evidence is scarce in young children. Moreover, studies are largely cross-sectional and could be affected by reverse causation. They also usually focus on conventional electronic devices such as televisions, computers, and evidence is sparse regarding newer portable devices such as smartphones and tablets with broader capabilities (e.g. internet). Such newer forms of screen devices, allowing real-time interaction and potentially continuous stimulation for children, provide a different type of exposure and have become increasingly common in young children (12). Studies have also been criticized for investigating PA, SB, and sleep in isolation or with only partial adjustment for time spent in other behaviors (13, 14). Indeed, this approach fails to take into account that any increase in one behaviour necessarily leads to a decrease in at least one of the remaining behaviours.

PA, SB and sleep represent the movement spectrum across the entire day and are referred to as “movement behaviours” (14). Since 2016, several individual countries and the WHO (2) have developed integrated movement guidelines for children, which highlight the importance of targeting all movement behaviours to maximize health benefits. According to previous evidence from our mother-offspring cohort in Singapore, the majority of children aged 5.5 years engaged in excessive screen viewing time, had inadequate sleep and low levels of PA; only one in 20 children met all the integrated guidelines (15). Such a high prevalence of unfavorable behaviours highlights the necessity of identifying opportunities to improve all these behaviours in young children. Recent studies have repeatedly suggested the conceptualisation of individuals’ daily activity data as compositions, made up of time spent in sleep, SB, and PA at different intensities [light PA (LPA) and moderate-to-vigorous PA (MVPA)], which is constrained by a daily sum of 24 hours (14, 16). The 24-h movement data require different analytical methods than traditional regressions, to take their compositional nature into account. Although composition techniques have been proposed to be valid approaches for analysing data as part of a whole (17) and implemented in a number of research areas (18, 19), few studies have implemented them in movement behaviour research (16, 20), and none has explored how screen viewing behaviour affects these activity components.

To address existing research gaps, we aimed to investigate the associations of total and device-specific SVT at ages 2-3 years with accelerometer-measured movement components, including sleep, SB, LPA and MVPA at age 5.5 years.

**METHODS**

**Study design**

This study was part of Growing Up in Singapore Towards healthy Outcomes (GUSTO), an ongoing mother-offspring multi-ethnic Asian cohort study. Pregnant women were recruited during their first ultrasound scan visit between June 2009 and September 2010 at two major public maternity units in Singapore (KK Women’s and Children’s Hospital and National University Hospital). The inclusion criteria were: 1) pregnant women who were Singaporean citizens or permanent residents from Chinese, Malay or Indian ethnicity, 2) intended to deliver in one of the above-mentioned maternity units and 3) to stay in Singapore for at least the next 5 years. Of the 1,247 pregnant women enrolled, 1,171 singleton newborns were followed up. All participants gave written informed consent. The National Healthcare Group Domain Specific Review Board and the SingHealth Centralised Institutional Review Board provided approval for the GUSTO study. This study was registered at clinicaltrials.gov as NCT01174875. More details of the study design and protocols are available elsewhere (21).

**Screen viewing at age 2-3 years**

During clinic visits at ages 2 and 3 years, time spent on screen devices was assessed as part of a questionnaire on the child’s outdoor and indoor activities. Trained interviewers asked the mother how much time, in 5-min increments, their child spent on average both on weekdays and weekends using the following screen devices: 1) television viewing and/or television games (e.g., PlayStation®, Wii, Xbox), further referred to as ‘television’, 2) computers, and 3) handheld video games (e.g., Game Boy®) and hand phones including tablets, further referred to as ‘handheld devices’. The activities undertaken while using handheld devices were not specified. Device-specific SVT was calculated as follows: (Weekday × 5 + weekend day × 2) / 7, to obtain average times spent on television, computer and handheld device each day. Total SVT was calculated as the sum of time spent on the three types of screens. SVT was further categorized into three levels (≤1, 1-3, ≥3 h/day) for the main analyses. The 1-h cut-off point is based on the international recommendation for children aged 2-5 years of no more than 1 h/day (2); the 3-h cut-off point was used because around one third of this sample engaged in ≥3 hours of SVT per day.

**Physical activity, sedentary behaviour and sleep duration at age 5.5 years**

Movement behaviours including PA, SB and sleep were assessed objectively with children wearing triaxial accelerometers (ActiGraph™ wGT3X+-BT) 24-h a day for 7 days at age 5.5 years. At the age 5.5 years study visit, clinical staff attached an accelerometer on each child’s non-dominant wrist with a non-removable strap. Children were asked to wear the accelerometer for 7 days and nights and remove it on the 8th day.

Data processing has been described in detail elsewhere (15). Briefly, the raw data files were processed in R-package GGIR (version 1.6–0) (22) that auto-calibrates the raw triaxial accelerometer signals and converts them into vector magnitude units corrected for gravity, termed the Euclidean norm minus one (ENMO) (22). Files were excluded from all analyses if they failed to record a minimum of 16 h/day for at least 3 days of wearing time. Non-wear time was estimated based on the standard deviation and value range of each axis, using a 60-minute window with 15-minute increments (23). Application of the wearing time inclusion criteria excluded 25 children (4.6%) for further analyses, whose descriptive characteristics did not differ from the included children. Sleep duration (including night-time and daytime sleep) was estimated using the method by van Hees et al. as part of GGIR processing (24). According to Hildebrand et al.’s prediction equations (25, 26), the following acceleration intensity thresholds (m*g*) were used to classify activity during the waking period: SB (ENMO≤35 m*g*), LPA (ENMO 35-200 m*g*) and MVPA (ENMO>200 m*g*). Since each included participant had at least 3 valid days of data, weekdays were weighted so that all weekdays together had a weight of 5/7, and weekend days were similarly weighted so that all weekend days had a weight of 2/7, making the data representative of a full week.

**Covariates**

As part of interviewer-administered questionnaires, socio-demographic information was obtained at enrolment, including ethnicity (Chinese, Malay, Indian; all children had homogenous parentage), maternal highest level of education (primary or secondary, post-secondary, university), monthly household income (<4000, 4000-5999, ≥6000 Singapore dollars). Maternal pre-pregnancy weight was self-reported; maternal height was measured at 26-28 weeks’ gestation using a stadiometer (SECA model 213, Hamburg, Germany). Children’s height and weight were measured at the 2-year clinic visit, using the same stadiometer and a weighing scale (SECA model 803). These were used to calculate maternal pre-pregnancy and children’s body mass indexes (BMIs, in kg/m2). Information on maternal age at delivery and offspring’s date of birth, sex and birth order (first-, second-or later-born) was extracted from medical records.

**Statistical analysis**

To assess whether children included in the present analyses where different from those who were not included, Fisher Exact test and Student's t-test were applied to categorical and continuous socio-demographic characteristics.

We used the average of both SVT measures when available (n=523) to improve the precision of the SVT variable. When only a single SVT measure was available (either 2 (n=8) or 3 years of age (n=21)), we used that measure in place of the average to maximize our sample size (total sample n=552). Proportions of daily average time spent on each movement component (sleep, SB, LPA, MVPA) for the valid accelerometer wearing time were calculated and used in further regression analyses. We employed Dirichlet regression to simultaneously model the proportions of all components at 5.5 years, because the proportions of all movement components for each subject, by definition, always sum up to 1 (27). To assess the effects of SVT on the relative distributions of different components of 24-h movement patterns, the “alternative” parameterization was used as proposed by Maier (28). The parametrization for the expected proportion (i.e., mean) is similar to multinomial regression, where we used “SB time” as the reference category and logit function to link the mean with the systematic component, which is a linear combination of predictors (29). Hence, the parameter of each predictor can be interpreted as odds ratio after being exponentiated (29), which eases interpretation of the associations. With regards to dispersion parameter, we first fitted two models (one with constant and one with varying dispersion) and then compare them using likelihood ratio tests. No significant difference in model fit was found between the two models (p >0.05); therefore, we assumed a common dispersion parameter for all participants.

Dirichlet regression models were used to examine adjusted associations between SVT (total, television, handheld devices) and the proportions of movement behaviours. The multivariable models consisted of socio-demographic variables, including the child's sex, ethnicity, birth order, BMI at age 2 years, household income, and maternal education level, pre-pregnancy BMI and age at delivery, and study centre. In models with television and hand-held devices viewing times as exposures, each exposure was adjusted for the other device-specific viewing time. Additional regression models were built using continuous SVT (h/day) at 2-3 years. In addition to providing the odds ratio, we obtained the marginal mean of the proportion for each component at 5.5 years and multiplied by 1440 to estimate its corresponding time in minutes per day. (see Appendix 1, page 1 for details).

In the sensitivity analyses, we conducted additional Dirichlet regression using complete screen viewing data at 2 years (n=531), 3 years (n=541) and both 2 and 3 years (n=523). Moreover, to partly reduce the residual confounding, we further controlled for some baseline movement behaviours (i.e., outdoor PA and non-screen-based SB at 2 years). In addition to Dirichlet regression, we also applied the commonly used compositional data analysis (CoDA) approach (17, 30), to assess the robustness of our results.

All statistical analyses were conducted using R version 3.4.3. The Dirichlet regression was performed using the DirichletReg package (28).

**Role of the funding source**

The sponsor of the study had no role in study design, data collection, data analysis, data interpretation, or writing of the report. The corresponding author had full access to all the data in the study and had final responsibility for the decision to submit for publication.

**RESULTS**

Of the 987 children that had parent-reported screen data at either 2 or 3 years, 840 attended the 5.5 years visit, and 577 wore an accelerometer. Among those who attended the 5.5 years visit, 552 (65.7%) had at least 3 days of accelerometer data and were included in the analysis (Figure 1). Children included in the present analysis were similar to the children not included with regard to the sociodemographic variables (Table 1).

Table 2 shows the descriptive characteristics of parent-reported SVT at age 2-3 years and accelerometer-measured movement behaviours at age 5.5 years. Children spent on average 2.5 (± 1.8) h/day watching screen devices at 2-3 years, mainly composed of television and handheld devices. Given that computers were used by a small minority of children and that they spent on average relatively little time on computers, its use was not examined separately in subsequent analyses. With regard to movement behaviours assessed by accelerometry at age 5.5 years, children wore the device for 6.9 (± 1.5) days and 23.8 (± 0.6) h/day. Further details are provided in Table 2.

Table 3 presents the adjusted odds ratio for associations of average total and device-specific SVT (≤1, 1-3, ≥3h/day) at 2-3 years with proportions of movement behaviours at 5.5 years. We found significant associations between total SVT and movement behaviours (sleep: p =0.008, LPA and MVPA: p<0.0001). Specifically, compared to children having ≤1 h of SVT per day, children having ≥3 h of SVT at 2-3 years had a lower expected proportion of time spent in other movement behaviours relative to SB at 5.5 year (OR (95%CI): sleep is 0.92 (0.87, 0.97), LPA is 0.85 (0.80, 0.90), MVPA is 0.76 (0.68, 0.85)). Among various movement behaviours, the effects appeared strongest for MVPA. Significant dose-response relationships between total SVT and activity components (OR (95%CI): sleep is 0.99 (0.97, 1.00), LPA is 0.97 (0.96, 0.99), MVPA is 0.95 (0.93, 0.97)), as shown in Table 4.

Examining device-specific SVT (television and handheld devices), we found that their association with the proportion of time spent in sleep relative to SB was insignificant, while their association with time spent in other movement behaviours relative to SB was significant. In particular, time spent on television viewing was negatively associated with LPA and MVPA; similar negative associations also persisted for 1-3 hours of viewing time on handheld devices. Both television and handheld devices viewing time had stronger effects on MVPA when compared with LPA (Table 3). In analyses using continuous screen viewing variables, we had similar observations where significant dose-response relationships were found between device-specific SVT and LPA as well as MVPA but not sleep (Table 4).

In sensitivity analyses, we observed similar results (see Appendix 2, page 2 for results from 523 children with complete data at both 2 and 3 years).

Table 5 presents estimated daily time spent in activity components across SVT levels. With regard to total SVT we observed pronounced increases in SB (439.8 vs 480.0 mins/day) but decreases in LPA (384.6 vs 356.2) and MVPA (76.2 vs 63.4) among children watching screens for ≤1 h compared to ≥3 h; however, we did not observe substantial differences in sleep duration (539.5 vs 540.4). Similar trends were observed for television viewing and handheld device viewing time.

**DISCUSSION**

In this multi-ethnic Asian cohort study, we found that children as young as 2-3 years of age with more SVT were less likely at a later age of 5.5 years to spend time sleeping and to engage in LPA and MVPA when compared to SB. In absolute terms, children with more SVT spent more time in SB but less time in LPA and MVPA. Time spent in sleep did not differ much. Consistent associations with LPA and MVPA at preschool age were found for earlier life screen viewing time from television and less-than-3-hours viewing time using handheld devices.

In our study, we took the nature of compositional data into account to provide a comprehensive investigation of all movement behaviours. This extends the available evidence, because despite the importance of considering the proportional nature of 24-h movement data, to our knowledge no study to date has assessed the associations between SVT and movement behaviours using compositional techniques. Previous studies have reported that SVT is positively associated with adiposity in children, and proposed displacement hypothesis as one mechanism underlying the associations (31). According to this hypothesis, screen viewing is assumed to reduce energy expenditure by displacing PA. This displacement hypothesis has received some support, mainly from studies in older children and adolescents (11). Existing evidence in preschool-aged children, although very limited, also suggests an inverse association between SVT and PA time: DuRant et al. reported in a cross-sectional study that children aged 3-4 years with greater television viewing time engaged in less PA (32). Our study found that greater early life SVT was associated with a reduction in PA later in life, which may indicate time displacement from PA at 5.5 years. Our findings thereby provide stronger evidence to support the displacement hypothesis. In addition, our study in preschool-aged children extends the existing evidence considerably into early life, demonstrating consistent longitudinal associations between SVT and PA at different intensities.

Another hypothesis is that media exposure may have indirect effects on health outcomes through sleep deprivation. Inadequate sleep has been reported to be associated with developmental problems such as increased risk of obesity and attention-deficit/hyperactivity disorder in preschool- and school-aged children (33). Previous evidence also suggested negative relationships between sleep and SVT across various screen devices (e.g., television and handheld device) in children of similar age (9, 34). In the present study, however, it appeared that sleep duration did not differ much between SVT levels during toddlerhood. Inconsistencies with previous studies may be due to variations in study design and sleep measurements but may also reflect more consistent bedtime routines after children attend preschools. As such, understanding the characteristics of the screen utilization patterns that are most disruptive to sleep, such as usage before sleep, content of the programming, or interactivity of the user, would be useful. For instance, research has indicated that psychological stimulation from media content (e.g. violent or scary media before bed time) could mediate the effect of screen media use on sleep (35). Meanwhile, further research comprehensively examining associations between screen viewing and sleep in preschool-aged children, rather than only focusing on sleep duration, is warranted to better understand these relationships.

In the present study, children spent on average more than 2 hours per day watching screen devices at 2-3 years, and only a small proportion of children met WHO recommendations of no more than 1 h/day of SVT (2). Television was still the most commonly used screen device and contributed the longest viewing time. In addition, children spent more than half an hour per day on handheld devices. These results were consistent with previous findings (15, 31) from this cohort and other existing evidence among children aged 3 years and below (34, 36). In the present study, no clear threshold across SVT levels were observed and we instead found a dose-response relationship where estimated daily time spent in LPA and MVPA decreased while SB time increased. These findings suggest that even small amounts of daily screen use could have negative effects on health behaviours, supporting recent recommendations from the UK (3) and France (4).According to previous research in the GUSTO cohort, only 5.5% of Singaporean children aged 5.5 years met integrated 24-Hour Movement Guidelines, which is comparable to other Asian countries (15). The low adherence to integrated movement guidelines is concerning, because meeting the integrated guidelines for all movement behaviours is associated with the lowest risk of obesity and other non-communicable diseases when compared with meeting only one or none of the individual guidelines (33). Strategies to promote movement-related behaviours comprehensively represent an important public health target. Our findings illustrate that such strategies should include elements to reduce SVT early in life.

Strengths of this study include its longitudinal design, objective assessment of movement behaviours and the use of 24-h accelerometer data rather than a combination of approaches to measure all behaviours. In addition, the application of Dirichlet regression approach took the compositional nature of movement data into consideration. We also assessed exposure to different types of screen devices to reflect the recent digital revolution. However, our study also has several limitations. First, parent-reported screen viewing data may be susceptible to recall bias. However, SVT was measured at ages 2 and 3 years and the average was included in analysis. Thus, such error might have been reduced. Second, this study did not control for other baseline health behaviours (e.g., diet, sleep or PA at 2 years) or environmental factors (e.g. time spent in childcare centre) due to a lack of relevant data, which could result in residual confounding. To partly address this concern we performed additional sensitivity analyses that further included outdoor PA and non-screen-based SB at 2 years, and the findings were similar. Third, although the use of wrist-worn accelerometers in young children has important advantages (37), particularly in the monitoring of movement behaviours across a 24-hour period, we acknowledge that the raw acceleration cut-points are not validated in our study population. However, such cut-offs have been validated in other populations and to the best of our knowledge, there are no other cut-points developed for preschool-aged children. Fourth, Dirichlet regression may have limitations when analysing movement behaviour data given its assumption that the compositions are independent except for the simplex constraint. However, presented results were similar when compared to those from the CoDA approach in the sensitivity analysis. Last, the GUSTO cohort does not represent the entire Singaporean population. For instance, Malay and Indian families were overrepresented purposely at inclusion; recruited mothers were also less likely to hold a university degree than the women from the general population of the same age range (21). Generalizing our results should therefore be done with caution.

**CONCLUSION**

Our study, using analyses accounting for compositional time use, suggests that higher engagement in SVT in toddlerhood in Singapore is associated with longer SB and shorter MVPA, LPA in later childhood. Such findings demonstrate that the displacement of PA by screen-based SB could already occur during the early years. Considering the substantial amount of SVT at ages 2-3 years and its negative impact on movement behaviours and health later in life, strategies to reduce SVT during the early years are needed to address this important public health threat. Further research into the potentially longitudinal effects of screen viewing on movement behaviours is warranted, to confirm and extend our findings.

**DECLARATIONS**

**Abbreviations**

PA: physical activity; SB: sedentary behaviour; LPA: light physical activity; MVPA: moderate-to-vigorous physical activity; SVT: screen viewing time; GUSTO: Growing Up in Singapore Towards healthy Outcomes; CoDA: compositional data analysis

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**Authors’ contributions**
KHT, FY, YSC, LS, KMG and SYC conceived and designed the cohort study; BC, JYB, JGE CST and FMR designed the present work; NP, SC and SMS contributed to data collection; BC, JYB, NP, YN, CL, CST and FMR contributed to data analysis and interpretation; BC drafted the manuscript, and JYB, YN, SC, KMG, SMS, SYC, JGE, CST and FMR added important intellectual content; all authors read and approved the final manuscript.

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**Availability of data and materials**

The dataset supporting the conclusions of this article can be made available upon request, and after approval by the GUSTO Executive Committee.

**Ethics approval and consent to participate**

All participating pregnant women signed written informed consent for themselves and on behalf of their offspring at enrolment. The study received ethical approval from the National Healthcare Group Domain Specific Review Board and the SingHealth Centralised Institutional Review Board.

**Consent for publication**

Not applicable.

**Competing interests**

KMG and YSC report receiving reimbursement for speaking at conferences sponsored by companies selling nutritional products. KMG and YSC report being part of an academic consortium that has received research funding from Abbott Nutrition, Nestle and Danone. All other authors have no conflict of interest to declare.

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