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Attitudes & beliefs that influence healthy eating behaviours among mothers of young children in Singapore: A cross-sectional study

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ABSTRACT

Background: Many countries recommend parental involvement to enhance the effectiveness of healthy lifestyle interventions focusing on behavioural modifications that encourage weight management in children. Our study investigates to what extent the different constructs of the Theory of Planned Behaviour (TPB) are influencing healthy eating behaviour among mothers of pre-school and primary school children in Singapore.

Methods: A total of 716 mothers of pre-schoolers, 3–6 years old (N = 358) and primary school students, 7–12 years old (N = 358) were administered a survey to assess healthy eating behaviour using the TPB constructs. Bivariate correlations among TPB constructs were calculated and tested using Pearson's correlation. Multivariate generalized regression was performed to examine the associations between TPB constructs and healthy eating behaviour.

Results: More than 80% of children consumed less than the daily recommended servings of at least 1 glass of dairy,2 servings of fruit and 2 servings of vegetables per day advised by the Singapore Health Board. More primary school children consumed less dairy per day compared to pre-school children (48.9% vs 26.3%; $p < 0.001$). Primary school children's healthy eating behaviours were correlated with mother's perceived behavioural control (PBC) such as adequate discipline ($\beta = 0.40$; $p = 0.001$), self-efficacy ($\beta = 0.35$; $p = 0.01$) and a lower barrier that healthy food does not satisfy hunger ($\beta = -1.16$; $p < 0.001$). Barriers that significantly reduced pre-school children's healthy food intake were lack of motivation among mothers ($\beta = -1.13$; $p < 0.001$) and children ($\beta = -0.49$; $p = 0.02$), lack of satiety ($\beta = -1.06$; $p = 0.02$), difficulty in changing child's eating habits ($\beta = -0.58$; $p = 0.03$), lack of family support ($\beta = -0.62$; $p = 0.03$).

Conclusions: Findings from this study provides a formative foundation for future research and exploration of plausible interventions around improving mother's PBC, self-efficacy and reducing barriers, which could increase mother's engagement in improving their children's healthy eating behaviours in Singapore.

1. Introduction

Early childhood is a period of rapid growth as well as an important phase for developing eating habits since dietary behaviours acquired during the early years could extend to adulthood (De Cosmi, Scaglioni, & Agostoni, 2017; Ramos, Stein, Pediatr, & Rio, 2000). Eating well-balanced diet which is high in intake of fruits and vegetables is also thought to reduce the risk of obesity (Aune et al., 2017). For example, WHO recommends at least 5 portions (5 × 80 g = 400 g) of fruits and vegetables per day (Healthy diet. Available a, 2019). In Singapore, a review of eight anthropometric studies conducted over the past five decades (from 1957 to 2002) found that although the height of pre-schoolers and school age children appeared to have optimised according to their genetic potential, their body mass index (BMI), a tool to assess overweight or obesity, increased over the period of time (Lee et al., 2016).

Without intervention, studies also showed that overweight children were more likely to develop into overweight adults (WHO, 2017; Trends in adult body-mass, 2016; Health Promotion Board). A recent study in Singapore, in 2017 by the Health Promotion Board, showed

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that 7 in 10 children who were overweight at seven years of age were likely to remain overweight as adults which puts them at a greater risk of developing life-threatening cardiovascular diseases or diabetes (Childhood Obesity: Tips f, 2019). This further highlights the importance of addressing the problem early on, as habits formed in childhood may carry on into adolescence or adulthood, influencing the health outcomes later in life.

1.1. Understanding the current dietary practices of children in Singapore

As a measure to encourage healthy eating habits among Singaporeans, Singapore's Health Promotion Board (HPB) developed a healthy eating guide called 'My Healthy Plate' with age-specific recommendations that encourages a variety of foods as part of a balanced diet (Health Promotion Board).

Among the studies on dietary patterns of Singaporeans, a study by Goh DY et al. provided information only on beverage consumption habits of Singaporean children aged 3–10 years old in 2011 (Goh & Jacob, 2011). This study showed that the calcium intake was insufficient among children, which is problematic due to bodily calcium needs for growth. Other published data available includes 2010 National Nutrition survey (NNS) for adults aged 18–69 years old (Health Promotion Board and Singapore, 2010). This survey showed that over half of the respondents did not meet the recommended 2 servings of fruits and 2 servings of vegetables per day i.e. 4 servings per day and nearly half of the adults (46%) did not consume milk/milk-based beverages at all. The adult survey findings further emphasize the importance of establishing healthy dietary practices in childhood including, but not limited to, adequate fruit, vegetables and calcium intake.

However, so far, there is lack of published data to understand the overall dietary patterns of pre-school and primary school children aged 3–12 years in Singapore i.e. understanding healthy eating and drinking habits (fruits, vegetables and dairy consumption). There is also limited research on how to improve children's behaviour in relation to healthy eating and drinking.

1.2. Using the theory of planned behaviour to understand perspectives of mothers' influence on improving children's healthy eating behaviours

Multitude of factors such as genetic, metabolic or hormonal may contribute to childhood obesity. Additionally, one of the important factors influencing children's eating patterns is their mother's attitude and behaviour as it relates to their children's eating behaviours (Scaglioni et al., 2018). Thus, a better understanding of mother's attitude and behaviour could potentially help children achieve a healthier weight with appropriate plausible interventions (Andrews, Silk, & Eneli, 2010) especially in Singapore, where parental involvement is encouraged (Healthy Pre-school Accreditation, 2019).

The Singapore government encourages that weight management in children should emphasize behavioural modifications that influence weight status, e.g. healthy eating habits and regular physical activity, rather than focus on actual weight loss (Lee et al., 2016). Importantly, there is a dearth of studies providing perspectives of mothers of children aged 3–12 (pre-school and primary school) in Singapore, specifically, on how to improve their child's behaviours in relation to healthy eating and drinking.

The Theory of Planned Behaviour (TPB) (Ajzen & Fishbein, 1980), which is an extension of the earlier Theory of Reasoned Action (TRA) (Ajzen & Fishbein, 1980), is amongst the models most commonly used to predict behaviour. According to the TPB, intention is directly driven by three major constructs: attitude, subjective norm and perceived behavioural control (PBC) and stronger the intention, the more likely an individual will perform the behaviour. Besides, the three original constructs, there have been reports on self-efficacy as an independent contributor to eating behaviour (Distinguishing perception, 1304; Armitage & Conner, 2010; Shannon, Bagby, Wang, & Trenkner, 1990). Furthermore, according to the Health Belief Model, perceived barriers are an individual's opinion of the tangible costs of an action or behaviour (Becker, 1974). In addition to health belief model, perceived barriers were also used as a construct to determine how well the TPB predicted fruit and vegetable consumption in adolescents (Lien, Lytle, & Komro, 2002). Additionally, studies have also shown self-efficacy to be an independent contributor to eating behaviour with studies supporting distinction between self-efficacy and PBC when applying TPB to health behaviour (Distinguishing perception, 1304; Shannon et al., 1990; Armitage & Conner, 2001; Terry & O'Leary, 1995). Considering these previous studies, this study expanded the TPB model which incorporated the original constructs of attitude, subjective norm and PBC, as well as two additional constructs, barriers and self-efficacy, to investigate to what extent these different constructs are influencing healthy eating behaviours among mothers of pre-school and primary school children in Singapore. Attitude (positive or negative) is known as the degree to which an individual has a favourable or unfavourable evaluation of the behaviour. Subjective norm (approval or disapproval) measures the importance others hold about performing or not performing a behaviour and one's willingness to comply to those referents. PBC describes the perceived control an individual has for performing a behaviour. It is thought to affect behaviour directly by accounting for factors outside an individual's control and especially for behaviours not under volitional control such as healthy eating (Health Education, 2019). Self-efficacy is defined as an individual's beliefs about their capabilities to produce performance that influence events affecting their lives.

In this framework, an individual will have a higher intention to adopt a certain behaviour if he/she has a favourable attitude towards it (Martens, Assema, & Brug, 2005), perceives that significant others want him/her to perform the behaviour and feels capable of performing it. Hence, testing the theory in the field of healthy eating and drinking would mean delineating the main psychological causes of these behaviours (Fila & Smith, 2006, 2006), as this knowledge will provide valuable information that can be used for predicting and influencing behaviour, for instance in terms of influencing attitudes or making it easier for mothers to engage their children in healthy eating and drinking.

Our study is built upon previous studies to acknowledge the importance of barriers in addition to PBC and self-efficacy, to investigate their effect indirectly through intention, or directly influencing healthy eating behaviour of children through mothers (Fig. 1). Thus, with limited research providing perspectives of mothers of children aged 3–12 (pre-school and primary school) in Singapore, specifically, on how to improve their child's behaviours in relation to healthy eating and drinking, this study will add value to the existing research applying TPB for a specific group (mothers in Singapore). This could eventually help facilitate the development of intervention strategies that could help mothers promote healthy eating behaviours among their children in Singapore.

2. Methods

2.1. Participants

This study was implemented in early 2017. Participants were selected using a multi-stage stratified random sampling method. The total population size of Singapore residents (citizens & permanent residents) aged 0–14 years old was used as the reference for the target population from which we drew the sample of mothers. Proportionate sampling was applied based on gender, ethnicity (Chinese, Malay, Indian and others) and residential area (North, North-east, East, Central, West) in each of the strata using Singapore census data in 2015 (Department of Statistics Singapore, 2015). Such stratification ensured a representative study sample and avoided biases that could occur if sample selection

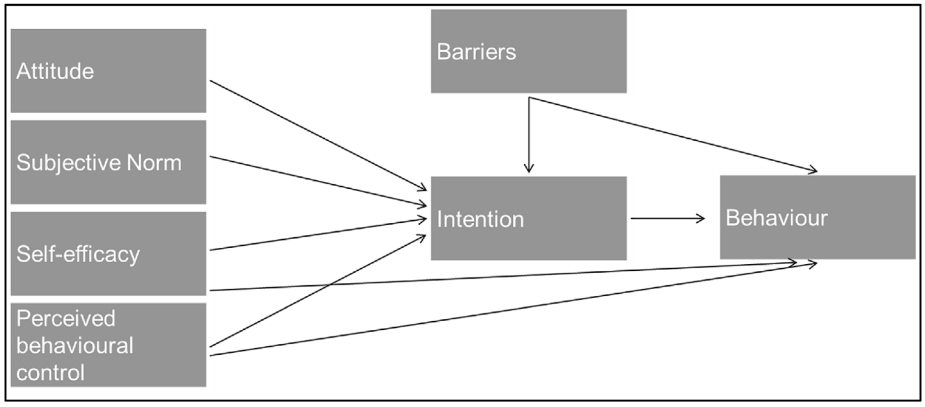

Fig. 1. Study model of healthy eating based on the TPB (Fila & Smith, 2006, 2006).The barriers construct was used as a moderator in the model.

was limited to certain ethnic groups or certain schools or catchment areas. Assuming a total population of 596,164 (resident population aged 0–14 years old) using Department of Statistics Singapore, 2015 census data (Department of Statistics Singapore, 2015) and a 95% confidence interval, a sample size of 700 provided a margin of error of 3.70%. In total, 716 mothers including 358 mothers of pre-schoolers aged 3–6 years old and 358 mothers of primary school students aged 7–12 years old were recruited, for a face-to-face, pen and paper quantitative survey of 30 min and included in the final analyses. Door-to-door or street intercept was performed for recruitment. Mothers were excluded if their children were not citizens or permanent residents of Singapore, attending international schools or special schools with special needs, or having disabilities, chronic illnesses or special dietary conditions, e.g. diabetics, coeliac, phenylketonuria (PKU). National Healthcare Group Domain Specific Review Board of Singapore approved this study. Informed consent was obtained verbally from all participants before the interviews commenced and the consent was recorded by the interviewer. Consent was given verbally as no identifiable information was collected for this study, even during the consent process.

2.2. Measures

The survey was based on a quantitative research method, and all eligible participants were asked to complete the questionnaire. All data were collected using face-to-face paper-based surveys. Data management was conducted to ensure data integrity, as well as data authenticity and confidentiality.

2.2.1. Subject baseline demographics characteristics

Children's age, gender, ethnic group, school and residential area, and mothers' age group, monthly average household income (coded as above median: ≥SGD 8,500, median: SGD 4,500 to < SGD 8,500, and below median: < SGD 4,500), highest educational attainment and employment status were collected and assessed.

2.2.2. Anthropometric measurements

All mothers were asked to self-report their children's height and weight. In randomly selected 30% (N = 298) of the sample, children's actual weight (nearest to 0.1 kg) and height (nearest to 0.1 cm) were collected and measured using an electronic flat scale (Seca 803, Germany) and a portable stadiometer (Seca 213, Germany). Five trained members of the research team were assigned for anthropometric measurements. Each child was measured with light clothing without shoes, heavy objects inside the pockets or hair accessories. The body mass index (BMI) of children was calculated and further categorized into severely underweight, underweight, normal, overweight and obese taking account of children's age and gender according to both local and US Centers for Disease Control and Prevention (CDC) classification guidelines (Supplementary Table S1) (Health Promotion Board, 2014; National Center for Health Statistics & National Center for Chronic Disease Prevention and Health Promotion, 2000; Styne et al., 2017).

2.2.3. Healthy eating and physical activity characteristics

Information on healthy eating and drinking as well as physical activity practice was collected to determine average dairy consumption and daily physical activity level (Supplementary Table S2). The number of glasses of dairy, and the number of servings of fruit and vegetables consumed per day were summed and averaged to measure children's healthy eating behaviours. Definitions and examples of one glass of dairy and one serving of fruit and vegetables were described in the questionnaire to reduce measurement bias (Supplementary Table 3). According to the healthy eating guidelines by Singapore Health Promotion Board (HPB), children should consume at least 2 glasses of dairy, two servings of fruit and two servings of vegetables per day to meet the recommended daily intake of calcium and healthy food respectively (Health Promotion Board). Though Singapore's HPB recommends dairy as the best source of calcium and 500 ml of milk a day to meet the daily requirement for calcium for children aged 3–12, 1 glass of milk (i.e. 250 ml) was considered as the cut-off in this analysis to account for the fact that children may be receiving calcium from other sources in the diet. The adequacy of healthy food intake was coded and analysed as a binary variable, i.e. meeting vs. not meeting the recommended daily healthy food intake, to investigate demographic predictors for inadequate healthy food intake. This composite binary variable allowed for a general measure of adequacy of healthy food intake. Frequency of breakfast that children had in the past week, average number of hours of active play, time spent outdoors under direct sunlight and time spent sitting still in the past week were also collected. Pre-school and primary school children who had physical activities for less than 3 h and 1 h per day, respectively, were identified as not having enough physical activity according to Singapore HPB guidelines (Health Promotion Board, 2012).

2.2.4. TPB constructs measurements for healthy eating

The constructs of the TPB including intention, attitudes, subjective norms, PBC, self-efficacy and barriers related to children's healthy eating behaviours were collected and assessed for all mothers. Questions were slightly adapted from previous studies to ask mothers about e.g. intentions for their children whereas in previous studies the respondent would answer for him or herself. Intention towards healthy eating was measured using a single question asking if mothers would like their children to eat healthily (McDermott et al., 2015). Attitudes were measured using six questions about their perception and opinions of eating healthy food, e.g. “Healthy foods are enjoyable for my child” (Health Survey for England, 2007). Subjective norms were measured

using eight questions asking if their friends, family, people caring for their children, school classmates and teachers, television (TV) programs, newspapers and government authorities thought their children should engage in healthy eating, e.g. “My friends think my child should engage in healthy eating” (McDermott et al., 2015). PBC was measured using three questions about mother's PBC over their willingness, discipline and time to help their children eat healthily (McDermott et al., 2015) e.g. “Do you have enough time to help your child eat healthily? Please rate your answer on a scale of 1–5 where 1 = definitely no and 5 = definitely yes”. Self-efficacy was measured using a single question asking if mothers were confident about improving their children's diet (Health Survey for England, 2007) i.e. “How confident are you about improving your child's diet? Please rate your answer on a scale of 1–5, where 1 = very difficult and 5 = very easy.”

Barriers were measured using fourteen questions concerning both mothers' and children's perceptions about eating healthily including time, expense, cooking ability, the ease of eating food from outside, motivation, the satiety and taste of healthy foods, the ease of changing their children's eating habits and the support from their families, e.g. “Healthy foods costs too much” (Health Survey for England, 2007). All TPB constructs except barriers were evaluated using a five-point Likert response scale. For positively scaled questions responses were coded from 2 to −2 (e.g. strongly agree to strongly disagree), and for negatively scaled questions responses are coded from −2 to 2 (e.g. strongly agree to strongly disagree). Barriers to healthy eating were coded using binary variables (yes or no).

2.3. Statistical analysis

Study participants' demographic characteristics, healthy eating and drinking as well as physical activity behaviours and TPB constructs towards their child's healthy eating were summarized and compared for all participants as well as by age group. Categorical variables were presented as frequency counts with percentages. Continuous variables were presented as mean and standard deviation (SD). Difference between subgroups of interest were examined using Fisher's exact tests for categorical variables and t-tests/ANOVA for continuous variables. Pearson correlation tests were used to determine the bivariate correlation among TPB constructs to healthy eating. Children's healthy eating behaviours were likely to differ in sociodemographic characteristics aside from TPB constructs of attitudes, subjective norms, PBC, self-efficacy and barriers. In addition, there tended to be correlation amongst different TPB constructs. To capture the association between healthy eating behaviour and each of the TPB constructs independently, multivariate linear regression models adjusting for children's age, gender, ethnicity, residential status, BMI category, residential area, mother's age group, household income level, education and employment status were used to control for confounding factors. Multivariate analysis is used to understand each of the items independently at the same level. Multivariate logistic regression models were used to identify significant demographic characteristics for inadequate healthy food intake. Significance was assessed at $p < 0.05$. All statistical analyses were conducted using R version 3.4.0 (R Foundation for Statistical Computing, Vienna, Austria) (R Core Team. R, 2017).

3. Results

Demographic characteristics are summarized in Table 1 for all study participants (N = 716) and by age group. One participant reported an estimated height of 45 cm for her four-year-old boy, which was identified as an outlier according to the international clinical growth charts (National Center for Health Statistics & National Center for Chronic Disease Prevention and Health Promotion, 2000) and was excluded from all BMI-related analyses, resulting in a sample of 715 children with 357 children in the younger age group. The overall prevalence of overweight among children was 24.5%. This was significantly higher among pre-school children (38.1%) compared with primary school children (10.9%; $p < 0.001$; Fig. 2 and Table 1).

Age, an interval/ratio variable, was expressed as mean ± SD and compared using a two-sample independent *t*-test; Nominal variables were expressed as N (%) and compared using Pearson's Chi-square test;

Table 1
Demographics distributions of study participants by age group (n = 716).

Demographics	n (%)			P-value
	Total (n = 716)	**Pre-schoolers (n = 358)**	**Primary school students (n = 358)**	
Children characteristics				
Age (years; mean ± SD)	7.19 ± 2.65	4.90 ± 1.00	9.47 ± 1.60	< 0.001
Gender				
Male	355 (49.6)	175 (48.9)	180 (50.3)	0.76
Female	361 (50.4)	183 (51.1)	178 (49.7)	
Race				
Chinese	481 (67.2)	241 (67.3)	240 (67.0)	0.89
Malay	118 (16.5)	57 (15.9)	61 (17.0)	
Indian	85 (11.9)	42 (11.7)	43 (12.0)	
Others	32 (4.5)	18 (5.0)	14 (3.9)	
Residential status				
Singapore Citizen	677 (94.6)	339 (94.7)	338 (94.4)	1.00
Permanent Resident	39 (5.4)	19 (5.3)	20 (5.6)	
BMI status (N = 715)				
Severely underweight	34 (4.8)	21 (5.9)$_a$	13 (3.6)$_a$	< 0.001
Underweight	28 (3.9)	25 (7.0)$_a$	3 (0.8)$_b$	
Normal	478 (66.9)	175 (49)$_a$	303 (84.6)$_b$	
Overweight	90 (12.6)	64 (17.9)$_a$	26 (7.3)$_b$	
Severely overweight	85 (11.9)	72 (20.2)$_a$	13 (3.6)$_b$	
Residential area				
Central	136 (19.0)	60 (16.8)	76 (21.2)	0.38
East	133 (18.6)	64 (17.9)	69 (19.3)	
North	110 (15.4)	56 (15.6)	54 (15.1)	
North East	152 (21.2)	85 (23.7)	67 (18.7)	
West	185 (25.8)	93 (26.0)	92 (25.7)	
School location				
Central	136 (19.0)	59 (16.5)	77 (21.5)	0.29
East	133 (18.6)	65 (18.2)	68 (19.0)	
North	110 (15.4)	56 (15.6)	54 (15.1)	
North East	154 (21.5)	87 (24.3)	67 (18.7)	
West	183 (25.6)	91 (25.4)	92 (25.7)	
Mothers' characteristics				
Age group				
21–30	146 (20.4)	107 (29.9)$_a$	39 (10.9)$_b$	< 0.001
31–40	432 (60.3)	222 (62)$_a$	210 (58.7)$_a$	
41–49	133 (18.6)	29 (8.1)$_a$	104 (29.1)$_b$	
50–59	5 (0.7)	0 (0.0)$_a$	5 (1.4)$_a$	
Household income				
Above median	181 (25.3)	96 (26.8)	85 (23.7)	0.54
Median	364 (50.8)	180 (50.3)	184 (51.4)	
Below median	167 (23.3)	79 (22.1)	88 (24.6)	
Not willing to disclose	4 (0.6)	3 (0.8)	1 (0.3)	
Education level				
Primary	18 (2.5)	7 (2.0)	11 (3.1)	0.39
Secondary	221 (30.9)	102 (28.5)	119 (33.2)	
Junior College	55 (7.7)	25 (7.0)	30 (8.4)	
Polytechnic/ Diploma	199 (27.8)	106 (29.6)	93 (26.0)	
University and above	222 (31)	117 (32.7)	105 (29.3)	
Refused to answer	1 (0.1)	1 (0.3)	0 (0.0)	
Employment				
Self employed	87 (12.2)	37 (10.3)	50 (14)	0.26
In paid employment	437 (61)	219 (61.2)	218 (60.9)	
Not working	192 (26.8)	102 (28.5)	90 (25.1)	

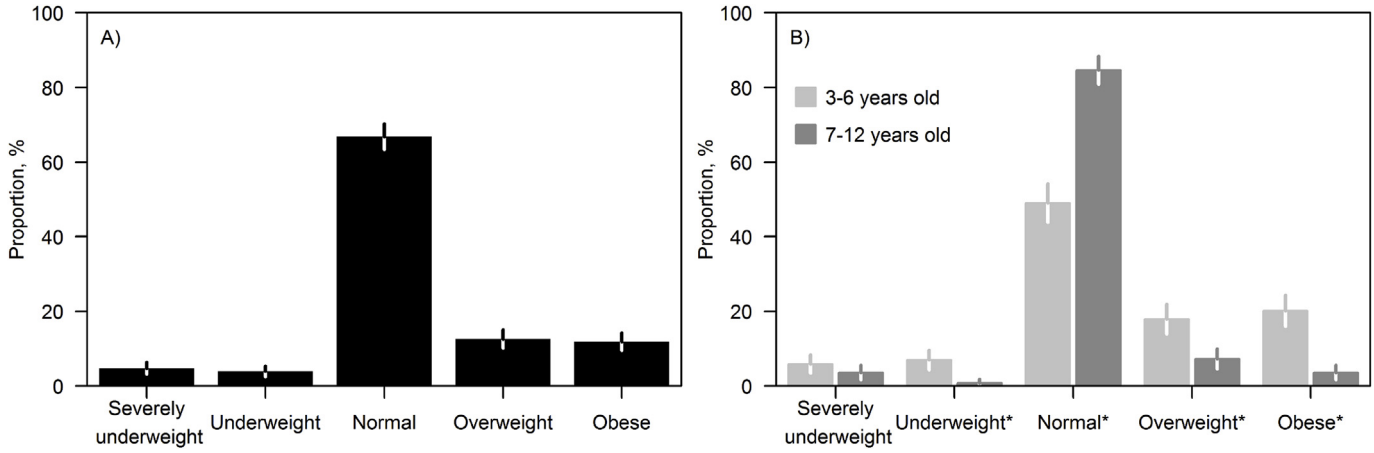

Fig. 2. Distribution of body mass index (BMI) category among all children (A) and by age group (B). Bars represent empirical proportions. In both panels, the whisker on each bar is 95% confidence interval for each empirical proportion. In panel B, significant difference in overall prevalence, between age groups are indicated by an asterisk (*) after the name of the BMI category at the horizontal axis.

Post-hoc pairwise comparisons were conducted for significant nominal variables with more than two levels using the Bonferroni correction; For those variables, values in the same row not sharing the same subscript are significantly different at $p < 0.05$. For example, the number of children who were severely underweight was not significantly different between the two age groups because they shared the same subscript a.

3.1. Children's food intake characteristics

Overall, more than 80% of children did not meet the recommendations for fruits and vegetables i.e. 2 servings of fruits and 2 servings of vegetables, as advised by the Singapore Health Promotion Board. With this, the children also did not meet the WHO recommendation of at least 400 g of fruits and vegetables per day (Healthhub. Fruits and veg, 2019; Healthy diet. Available a, 2019). This proportion was significantly higher among primary school children compared with pre-school children (89.9% vs. 83.8%; $p = 0.02$). A large difference was observed in daily dairy intake where more primary children consumed less than 1 glass of dairy per day compared with pre-school children (48.9% vs. 26.3%; $p < 0.001$; Table 2). Primary school children were also found to have poorer breakfast eating habits. Around 15% of primary school children did not have breakfast every day, compared to only 6% for pre-school children ($p < 0.001$). As presented in Table 2, majority of pre-school children (91%) did not have enough physical activities per day, which was significantly higher compared to primary school children (26.5%; $p < 0.001$). There were also more pre-school children who spent less than 30 min outdoors under direct sunlight per day (13.1%) compared with primary school children (6.7%; $p = 0.01$). Also, more pre-school children (14.6%) spent more than 2 h of sitting still per day compared to the primary school (7.5%) children.

Adequate daily intake of healthy food was associated with household income level in both age groups in the multivariate analyses (Table 3). Children from high income families were more likely to meet recommendations of daily healthy food intake (pre-school children: OR = 0.29, $p = 0.001$; primary school children: OR = 0.13, $p < 0.001$) compared to middle income families. Pre-school children living in the east region of Singapore were also found to be more likely to consume enough healthy food daily (OR = 0.23; $p < 0.001$) compared to those living in the central region of Singapore.

3.2. Behavioural predictors (TPB) & barriers

In the unadjusted bivariate analyses, mothers' intention had a low correlation with children's healthy eating behaviour for the overall study sample (correlation = 0.1; $p = 0.01$; Fig. 3 and Supplementary Table S4). However, no (significant) correlation between intention and healthy eating behaviour was observed among mothers of pre-school children (correlation = 0.03; $p = 0.53$). In the overall study sample, PBC (correlation = 0.31; $p < 0.001$), self-efficacy (correlation = 0.28; $p < 0.001$) and fewer barriers (correlation = 0.24; $p < 0.001$) were significantly correlated with children's healthy eating behaviour. The TPB constructs of attitude (correlation = 0.24; $p < 0.001$), subjective norms (correlation = 0.10; $p = 0.01$), PBC (correlation = 0.40; $p < 0.001$) and self-efficacy (correlation = 0.27; $p < 0.001$), except barriers (correlation = −0.01; $p = 0.84$), were significantly correlated with intention among all mothers. However, subjective norms were not correlated with intention among mothers of pre-school children (correlation = 0.08; $p = 0.14$).

After adjusting for potential confounding effects in the multivariate analyses, mothers' intention was not associated with their children's healthy eating behaviour for both age groups (Table 4). PBC and self-efficacy were not associated with pre-school children's healthy eating behaviour, but both constructs were important for shaping the healthy eating behaviour for primary school children. Particularly, primary school children had significantly better healthy eating behaviour if their mothers had adequate discipline to help their children eat healthily ($\beta = 0.40$; $p = 0.001$) and better self-efficacy ($\beta = 0.35$; $p = 0.01$). Barriers that significantly reduced pre-school children's healthy food intake were lack of motivation in mothers ($\beta = -1.13$; $p < 0.001$), lack of motivation in children ($\beta = -0.49$; $p = 0.02$), lack of satiety ($\beta = -1.06$; $p = 0.02$), difficulty in changing child's eating habits ($\beta = -0.58$; p- = 0.03), lack of family support ($\beta = -0.62$; $p = 0.03$) and other barriers ($\beta = -1.52$; $p = 0.03$). For primary school children, the perception that healthy food does not satisfy hunger was a significant barrier ($\beta = -1.16$; $p = 0.004$).

Descriptive summaries of TPB constructs are presented in Table 5 for all participants and by age group. Almost all mothers (97.9%) had strong intention to have their children eating healthily. Lack of time (31.1%), inconvenience of cooking at home (28.4%) and lack of children's motivation (23.9%) were the top three barriers reported by mothers. Significantly more mothers of primary school children reported that "*They do not have enough time*" (35.8% vs. 26.5%; $p = 0.01$), "*Eating food from outside is more convenient*" (33.0% vs. 23.7%; $p = 0.01$), and "*It is hard to change their children's eating habits*" compared with mothers of pre-school children (21.2% vs. 12.6%; $p = 0.003$).

Table 2
Summary of self-reported healthy eating and physical activity practice among all children and by age group.

	N (%)			
	Total (N = 716)	3–6yrs olds (N = 358)	7–12yrs olds (N = 358)	p-value
Breakfast habit				
No. of children having breakfast everyday (%)	639 (89.6)	335 (94.4)	304 (84.9)	< 0.001
Dairy consumption				
Average no. of glasses consumed daily (mean ± SD)	1.44 ± 1.13	1.82 ± 1.18	1.06 ± 0.93	< 0.001
Not meeting recommendation of daily dairy intake (%)	269 (37.6)	94 (26.3)	175 (48.9)	< 0.001
Fruit consumption				
Average no. of servings consumed daily (mean ± SD)	1.46 ± 0.72	1.47 ± 0.71	1.45 ± 0.72	0.73
Not meeting recommendation of daily fruit intake (%)	574 (80.2)	284 (79.3)	290 (81.0)	0.64
Vegetables consumption				
Average no. of servings consumed daily (mean ± SD)	1.51 ± 0.67	1.46 ± 0.62	1.56 ± 0.71	0.04
Not meeting recommendation of daily vegetables intake (%)	488 (68.2)	248 (69.3)	240 (67)	0.57
Overall healthy food consumption (dairy, fruit and vegetables)				
Consumed less than recommended servings (i.e. any of < 1 glass dairy, < 2 servings of fruit or < 2 servings of vegetables)	622 (86.9)	300 (83.8)	322 (89.9)	0.02
Physical activities				
Not meeting recommendation of daily physical activities	421 (58.8)	326 (91.1)	63 (26.5)	< 0.001
No. of children spending more than 2 h of sitting still per day	79 (11)	52 (14.6)	27 (7.5)	0.003
No. of children spending more than 2 h of sitting still during weekdays	97 (13.6)	60 (16.8)	37 (10.3)	0.01
No. of children spending more than 2 h of sitting still during weekends	256 (35.8)	129 (36)	127 (35.5)	0.94
No. of children having less than 30 min of outdoor play under the direct sunlight per day	71 (9.9)	47 (13.1)	24 (6.7)	0.01
No. of children having less than 30 min of outdoor play under the direct sunlight during weekdays	125 (17.5)	79 (22.1)	46 (12.8)	0.002
No. of children having less than 30 min of outdoor play under the direct sunlight during weekends	151 (21.1)	76 (21.2)	75 (20.9)	1.00

4. Discussion

Our study aimed to address the lack of healthy eating and physical activity data among children aged 3–12 years in Singapore. The strengths are that we ensured our findings were as representative as possible, with our sample aligned to the distribution of Singapore by region/planning area, race and gender. Importantly, this study helps bridge the gaps in current knowledge on the consumption patterns of fruit, vegetables and dairy among children aged 3–12 years in Singapore.

4.1. Daily food intake among children aged 3–12 years in Singapore

The results showed that a high proportion of children aged 3–12 in

Table 3
Multivariate logistic regression analyses of children who did not consume any of the recommended servings of fruit, vegetables (2 servings each), or dairy (1 glass) per day.

Demographic variables	**Total (N =716)**		**3–6yrs olds (N = 358)**		**7–12yrs olds (N = 358)**	
	OR	P-value	OR	P-value	OR	P-value
Age	1.45	0.17	0.98	0.90	1.04	0.75
Male	1.44	0.15	1.21	0.59	2.02	0.08
Ethnicity (reference: Chinese)						
Malay	1.46	0.38	0.86	0.77	3.37	0.26
Indian	2.26	0.11	2.59	0.15	2.65	0.29
Others	2.49	0.19	1.06	0.96	5.76	0.14
Permanent Resident	0.55	0.31	0.83	0.84	0.70	0.70
BMI (reference: Normal)						
Overweight	0.50	0.02	0.34	0.01	–	–
Underweight	1.75	0.33	0.73	0.63	–	–
Residential area (reference: Central)						
East	0.43	0.03	0.23	0.01	0.87	0.84
North	1.35	0.48	1.63	0.44	0.74	0.63
North-east	1.04	0.93	0.64	0.49	1.60	0.58
West	1.11	0.78	1.12	0.83	0.88	0.81
Mother's age group (reference: 21–30yrs)						
31–40yrs	–	–	1.32	0.50	–	–
41–49yrs	–	–	1.55	0.57	–	–
Household income (reference: Median income)						
Above median income	0.21	< 0.001	0.29	0.001	0.13	< 0.001
Below median income	6.62	0.003	17.12	0.01	1.78	0.50
Mother's highest education (reference: University degree and above)						
Pre-University/A-level/Junior College	2.09	0.28	–	–	0.96	0.96
Polytechnic/Diploma	1.40	0.39	–	–	1.121	0.69
Secondary education & below	1.10	0.80	–	–	1.60	0.46
Employed	0.94	0.86	0.76	0.57	1.51	0.46

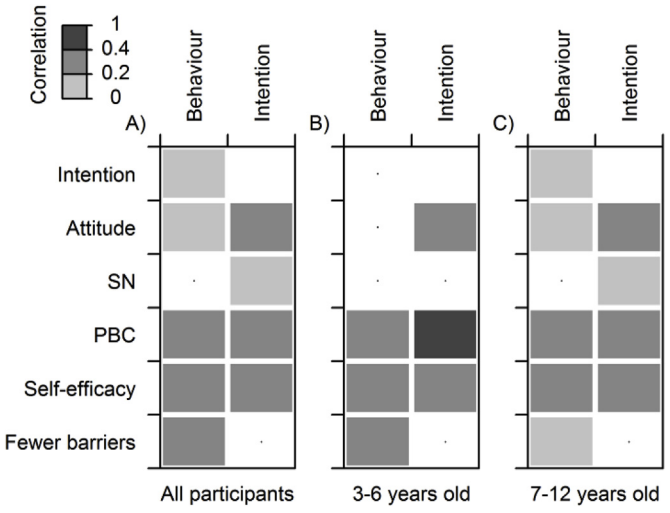

Fig. 3. Unadjusted correlation of theory of planed behaviour (TPB) constructs for all participants (A) and by age group (B: 3–6 years old and C: 7–12 years old). Pearson's correlation test was used to assess the correlation among different TPB constructs. Grey cells represent correlations that are significant at the 5% level. The darker grey colour indicates higher correlation. For example, for the preschool children group (panel B), the correlation between intention and PBC is between 0.4 and 1 indicating by a dark grey colour in row 5 and column 2. Abbreviations: SN, subjective norm; PBC, perceived behaviour control.

Singapore (87%) did not meet the recommended levels of healthy food consumption (Table 2). More than 1 in 3 children did not meet the minimum 1 glass of dairy consumption daily, and it was significantly higher among primary school children (48.9%) compared with pre-school children (26.3%) (Table 2). A previous study carried out in 2011 looking at the dairy consumption patterns of children in Singapore reported similar findings, showing reduced dairy consumption as children get older and 32% of pre-school and 64% of primary school children not meeting the recommended 500 ml of milk per day respectively (Goh & Jacob, 2011). Our study findings are all consistent with other representative health surveys done among different age groups in Singapore, as introduced earlier in this paper (Goh & Jacob, 2011; Health Promotion Board and Singapore, 2010; , Students' Health Survey, 2017) (Table 6). Similarities in the proportion of children not meeting the recommended levels from our study, compared to findings from older age groups suggest that habits formed in childhood may carry on into adolescence and adulthood and further reinforce the importance of establishing healthy habits from young to enhance health outcomes later in life (Birch, Savage, & Ventura, 2007) (Table 6).

4.2. Factors affecting food consumption patterns among children aged 3–12 years

In addition to healthy eating and drinking behaviours, we also looked at other factors affecting weight, e.g. breakfast consumption patterns and physical activity behaviours, time spent in sunlight and time spent sitting still. It is established that children who skip breakfast may be associated with higher BMI, poorer cognitive functioning and poorer nutritional adequacy (Deshmukh-Taskar et al., 2010). Though only a small proportion of mothers reported that their child did not have breakfast every day, it was found that breakfast skipping was more common among primary school children compared to pre-school children (Table 2). Previous research has shown that those who consumed breakfast had higher intakes of carbohydrate, dietary fibre and certain micronutrients if breakfast cereals were included and higher levels of calcium if milk products were included at breakfast (Deshmukh-Taskar et al., 2010; Ortega et al., 1998; Ruxton & Kirk, 1997). Incorporation of fruit, vegetables and dairy products at breakfast might also help children who are not meeting the current levels of intake to improve their consumption of these foods. We also found that a higher proportion of mothers reported that during the weekend, children spent more time sitting still and less time in sunlight compared to weekdays (Table 2). This also highlights the need to plan interventions that encourage parents to promote cultivation of healthy habits outside of school.

In 2016, Singapore's Ministry of Health and Ministry of Education started a programme called 'NurtureSG', aimed at nurturing healthy behaviours among the young in Singapore. One facet of the program was to develop the capacity of parents, caregivers, and teachers to influence positive behavioural change among children in Singapore. This is done through raising awareness and knowledge on how they can improve their child's health and strengthen their capabilities to motivate their children to exhibit these healthy behaviours (NurtureSG,

Table 4
Multivariate regression analysis of healthy eating behaviour. Variables adjusted for in the multivariate regression analyses including children's age, gender, ethnicity, residential status, body mass index (BMI), residential area, mother's age, household income, mother's education and employment status as confounders. Variables that caused multicollinearity were excluded from the multivariate logistic model.

Variables	**Total (N =716)**		**3–6yrs olds (N = 358)**		**7–12yrs olds (N = 358)**	
	β	p-value	β	p-value	β	P-value
Intention	−0.10	0.54	−0.17	0.49	−0.01	0.97
Perceived behaviour control (PBC)						
Willingness to try hard to help my child eat healthily	0.02	0.87	0.12	0.49	−0.01	0.93
Adequate discipline to help my child eat healthily	0.21	0.02	0.03	0.83	0.40	0.001
Adequate time to help my child eat healthily	0.08	0.29	0.12	0.31	0.03	0.78
Self-efficacy	0.26	0.01	0.10	0.45	0.35	0.01
Barriers						
I don't have enough time	0.15	0.31	0.42	0.06	−0.07	0.74
Eating food from outside is more convenient	−0.16	0.26	−0.33	0.12	0.11	0.53
My child is not motivated to	−0.31	0.03	−0.49	0.02	−0.24	0.22
My child does not eat what is given	−0.09	0.58	−0.20	0.41	−0.01	0.97
My child thinks healthy food is not tasty	0.32	0.06	0.18	0.52	0.42	0.06
It is hard to change my child's eating habits	−0.19	0.27	−0.58	0.03	0.03	0.89
I do not have the cooking ability	−0.08	0.68	−0.24	0.35	0.02	0.94
It is very hard to convince my family to eat healthily	−0.12	0.54	−0.62	0.03	0.15	0.57
I am not motivated to/I don't think there is a need to do so	−0.94	< 0.001	−1.13	< 0.001	−0.46	0.10
It costs too much	0.06	0.80	0.04	0.90	−0.12	0.72
I do not think healthy food is tasty	−0.47	0.10	−0.61	0.14	−0.19	0.63
It does not satisfy hunger	−1.14	< 0.001	−1.06	0.02	−1.16	0.004
Others	−0.64	0.22	−1.52	0.03	0.41	0.58

Table 5
Summary of theory of planned behaviour (TPB) constructs for all mothers and by their children's age group.

Variables	No. of rating agree & strongly agree (N, %)			P-value
	Total (N = 716)	**3–6yrs olds (N = 358)**	**7–12yrs olds (N = 358)**	
Intention	701 (97.9)	351 (98.0)	350 (97.8)	1.00
Attitude				
I really care about what my child eats	660 (92.2)	333 (93.0)	327 (91.3)	0.49
Healthy foods are enjoyable for my child	380 (53.1)	213 (59.5)	167 (46.6)	0.001
The tastiest foods are the ones that are bad for my child	250 (34.9)	115 (32.1)	135 (37.7)	0.14
If my child does enough exercise, he/she can eat whatever he/she likes	220 (30.7)	114 (31.8)	106 (29.6)	0.57
I get confused over what's supposed to be healthy and what isn't for my child	100 (14.0)	49 (13.7)	51 (14.2)	0.91
Healthy eating is just another fad	96 (13.4)	47 (13.1)	49 (13.7)	0.91
Overall attitude score (mean ± SD)	0.63 ± 0.52	0.64 ± 0.52	0.63 ± 0.53	0.84
Subjective norms				
My family think my child should engage in healthy eating	556 (77.7)	285 (79.6)	271 (75.7)	0.24
People caring for my child think my child should engage in healthy eating	527 (73.6)	265 (74)	262 (73.2)	0.87
The government authorities think my child should engage in healthy eating	519 (72.5)	258 (72.1)	261 (72.9)	0.87
My child's teachers think my child should engage in healthy eating	455 (63.5)	237 (66.2)	218 (60.9)	0.16
Newspapers I read think my child should engage in healthy eating	441 (61.6)	217 (60.6)	224 (62.6)	0.65
My friends think my child should engage in healthy eating	439 (61.3)	214 (59.8)	225 (62.8)	0.44
TV programs I watch think my child should engage in healthy eating	389 (54.3)	204 (57)	185 (51.7)	0.18
My child's classmates think my child should engage in healthy eating	241 (33.7)	123 (34.4)	118 (33)	0.75
Overall subjective score (mean ± SD)	0.7 ± 0.76	0.7 ± 0.78	0.69 ± 0.74	0.85
Perceived behaviour control (PBC)				
Willingness to try hard to help my child eat healthily	671 (93.7)	338 (94.4)	333 (93)	0.54
Adequate discipline to help my child eat healthily	556 (77.7)	285 (79.6)	271 (75.7)	0.24
Adequate time to help my child eat healthily	509 (71.1)	275 (76.8)	234 (65.4)	0.001
Overall PBC score (mean ± SD)	1.14 ± 0.67	1.22 ± 0.64	1.07 ± 0.69	0.002
Self-efficacy	510 (71.2)	271 (75.7)	239 (66.8)	0.01
Barriers; N (%)				
I don't have enough time	223 (31.1)	95 (26.5)	128 (35.8)	0.01
Eating food from outside is more convenient, e.g. school canteen, hawker centre, food delivery etc.	203 (28.4)	85 (23.7)	118 (33.0)	0.01
My child is not motivated	171 (23.9)	87 (24.3)	84 (23.5)	0.86
My child does not eat what is given	134 (18.7)	67 (18.7)	67 (18.7)	1.00
My child thinks healthy food is not tasty	121 (16.9)	53 (14.8)	68 (19.0)	0.16
It is hard to change my child's eating habits	121 (16.9)	45 (12.6)	76 (21.2)	0.003
I do not have the cooking ability	86 (12)	47 (13.1)	39 (10.9)	0.42
It is very hard to convince my family to eat healthily	80 (11.2)	36 (10.1)	44 (12.3)	0.41
I am not motivated to/I don't think there is a need to do so	67 (9.4)	33 (9.2)	34 (9.5)	1.00
It costs too much	52 (7.3)	28 (7.8)	24 (6.7)	0.67
I do not think healthy food is tasty	32 (4.5)	16 (4.5)	16 (4.5)	1.00
It does not satisfy hunger	29 (4.1)	14 (3.9)	15 (4.2)	1.00
Others	9 (1.3)	5 (1.4)	4 (1.1)	1.00
None	112 (15.6)	64 (17.9)	48 (13.4)	0.12

2016). This ties in with our study findings where mothers reported government materials and advice from health professionals as the most common and most trusted sources of healthy eating and drinking information (results not shown).

4.3. Effect of TPB constructs to assess the maternal influences in the development of children's eating behaviours

We identified specific attributes within each construct that would be important to address for mothers of primary school children vs. pre-school children in influencing healthy eating behaviours.

For mothers of pre-school children, reducing specific barriers, such as lack of mother's and child's motivation, the perception that healthy food does not satisfy hunger, lack of family support and difficulty in changing their child's eating habits would be important in improving the child's healthy eating behaviours. Similar findings were shown in a recent study which showed that lack of support from family, i.e. spouse/partners, acted as a barrier for mothers to promote healthy eating among their children (Parents' barriers and str, 1956). Thus, barriers such as lack of mother's motivation to improve child's eating behaviour could also be associated with lack of family support to promote healthy eating habits. One possible way to address the barrier on lack of family support could be by working together as a family for meal preparation which would help bring the family together and reach consensus in terms of feeding children with healthy foods at home (Parents' barriers and str, 1956). With respect to difficulty in changing the child's eating habits, multitude of factors could interfere with children's eating behaviour. Literature recommends that parents could be well informed on what a healthy diet for children consists of, in order to diversify food options, thus reducing children's picky eating behaviour (Ramos et al., 2000). Other studies have also shown that increasing knowledge, skills and social learning of mothers obtained by the interaction with peers (other mothers), promotes favourable changes in mother's self-efficacy, as well as the health outcomes of their children (Zacarías, Shamah-Levy, Elton-Puente, Garbus, & García, 2019).

For mothers of primary school children, PBC and self-efficacy were important for shaping healthy eating behaviours. Specifically, mothers having adequate discipline and time to help their child eat healthily and having better self-efficacy would lead to improved health behaviours. In addition, there is a need to address the barrier of perception that healthy food does not satisfy hunger. However, no direct association was found between intention to eat healthily and eating behaviour across both age groups. Our findings are consistent with a previous study by Fila and Smith, showing no association between intention and behaviour but association between barriers and PBC with behaviour (Fila & Smith, 2006, 2006), as well as with an Australian study where only PBC and not intention were associated with mothers' perception of

Table 6
Comparison of proportion not meeting the recommended 2 servings of fruit and vegetables daily.

	%				
	Our study (Total)	**Our study (3–6yrs olds)**	**Our study (7–12yrs olds)**	**2012 SHS (12–16 yrs olds)** (, Students' Health Survey, 2017)	**2010 NNS (18–69 yrs old)** (Health Promotion Board and Singapore, 2010)
Not meeting recommendation of daily fruit intake (%)	81	79	81	65	75
Not meeting recommendation of daily vegetable intake (%)	68	69	67	55	69

their child's fruit and vegetable consumption and with unhealthy snacking behaviour (McKee et al., 2019). Studies that have investigated the gap between intention and behaviour (Godin, Conner, & Sheeran, 2005) show factors such as whether intentions are attitudinally vs. morally aligned or whether other moderators exist, e.g. BMI of mother and parent's eating habits. However, another meta-analysis looking at TPB studies showed a significant association between intention, PBC and behaviour (McDermott et al., 2015). This could be due to difference in study populations where studies included in the meta-analysis were self-reporting their eating patterns whereas our study was based on mothers reporting on the child's behaviours subject to varying levels of influence mothers may have in the provision of healthy food to their children.

Previous research has demonstrated the importance of empowering mothers with the right healthy beliefs and attitudes as they are associated with child's belief and intention later on in life (Sumodhee & Payne, 2016). Across both age groups, there is a need to reposition healthy food as filling, through raising awareness on the role of fibre from foods such as fruit and vegetables in satiety and its association with lower rates of overweight children (Kranz, Brauchla, Slavin, & Miller, 2012; Mello, Freitas, Tahan, & Morais, 2010), or educating mothers on how to make informed choices on healthy meals that satisfy hunger.

An additional consideration must be made for households from lower income groups where children were less likely to meet the recommended levels of fruit, vegetables and dairy (Miller et al., 2016). Widely available and affordable healthy options in the society is also vital to encourage healthy eating.

To address the barriers of perceived difficulty in changing child's habits, lack of motivation, time and discipline, further research would be required among mothers in Singapore across income groups and barrier groups to uncover why they have these barriers and to ideate on what would help.

Using previous research done as a proxy, a similar qualitative study on parental feeding behaviours and motivations in the UK showed that parents frequently use strategies to encourage their children to eat more fruit and vegetables by either modifying food preparation methods, presenting food in an attractive way, verbal encouragement, physical encouragement, repetition or exposure to certain foods, or providing a structured feeding environment, e.g. by insisting that the child sits down to eat, or forbidding television while eating (Carnell, Cooke, Cheng, Robbins, & Wardle, 2011). These initiatives were also used to address a similar problem faced by mothers of primary school children, related to time pressures or short-term management of appetite, with some parents applying pressure to ensure that their child ate enough energy to feel full or to prevent hunger until the next meal (Carnell et al., 2011). These could be ideas for planning initiatives aimed at addressing these specific barriers among mothers of Singapore children.

In the Singapore context, it would also be important to consider the role of mothers in the provision of food. A previous study among Singaporean women, aged 30 to 55 showed that there were high numbers of working mothers, that mothers cook infrequently, families eat out frequently, children exert considerable influence on food choices and domestic workers, child-care centers and other proxy caregivers may also play a role in the child's food-related decisions (Wang, Naidoo, Ferzacca, Reddy, & Van Dam, 2014). Separate considerations should be made to motivate and empower mothers to influence healthy eating behaviours through these proxy caregivers in planning of interventions targeted at mothers.

For this study, we selected the TPB as the theoretical framework as it had been successfully applied in children and adolescents, explaining between 50 and 60% of the variance in diet-related intentions, and 6–19% of the variance in behaviours previously (Chan & Tsang, 2011; Fila & Smith, 2006, 2006; McDermott et al., 2015). Previous studies have investigated how well the various constructs of the TPB predict healthy eating behaviour. For example, Chan et al. reported that

behavioural control, attitudes toward healthy eating and subjective norms predicted half of the variance in behavioural intention (Chan & Tsang, 2011), whereas other research showed that availability and taste of foods were the most predictive barriers to healthy eating among children aged 9-18[16]. In another study including high school students, positive attitude and subjective norms were associated with a higher intention to change behaviours of having fruit, high-fat snacks and breakfast (Chan & Tsang, 2011). With respect to subjective norms, family members especially parents have been found to be among the most influential on children's food preferences and health outcomes (Martens et al., 2005). Some studies have also shown that the media, particularly television, is associated with more positive attitudes toward junk food and that peers have a negative influence on healthy eating (Kelly, Turner, & McKenna, 2006). In addition, the TPB has shown to be predictive of parent's or mother's behaviours across healthy eating (Andrews et al., 2010) or health protective behaviours (Amireault, Godin, Vohl, & Pérusse, 2008; Thomson, White, & Hamilton, 2012).

However, TPB construct has its own limitations. It does not take into account the processes responsible for ensuring that intentions are turned into action quickly or effectively, or of how behaviour change is maintained over time (Sheeran, Conner, & Norman, 2001; The Theory of Planned Beh, 2019). In addition, while TPB takes into account normative influences of behaviours, it has weakness in considering critical predictors such as environmental or economic factors that may influence a person's intention to perform a behaviour and these prevents TPB from better predicting one' behavioural intention (Jokonya, 2017). For future studies incorporation of additional cultural constructs in the TPB model, could be considered to increase the explanatory capabilities of the study. As an example, one previous study incorporated Chinese cultural constructs (face consciousness and group conformity) instead of subjective norms and their model improved the explanatory power in the prediction of consumers' green food purchase intentions in a Chinese context (Qi & Ploeger, 2019).

Additionally, some of the other limitations of this study includes: The data is cross-sectional, and no causal associations can be made. Data was collected from mothers and may be subject to recall bias and introduction of inaccuracies. Questions were adapted slightly from the original TPB construct but internal reliability was not measured in the study. Healthy eating behaviour was measured as a binary variable in the current study, and it would be an avenue for future work to understand the association between TPB constructs with healthy eating and drinking behaviours separately. Data was also recorded through face-to-face interviews and respondents may tend to give socially desirable answers to the questions. Although efforts were made to ensure the sample was as representative as possible, there is a possibility of sampling bias of recruiting respondents who lived in or near the town centre and several neighbourhood commercial/shopping centers of each planning area. This was to avoid contacting the schools or enumerating the households which would have PPI (Protected personal information)/data privacy concerns. This study only examined a sample of mothers of Singapore children aged 3–12 and findings may not be true for all mothers in Singapore with children in the same age group. Cultural differences, mother's employment, availability and education level of caregivers or foreign domestic workers, access to healthy foods and knowledge of children could be confounding factors influencing healthy eating behaviour among children and should be considered in future research. Future studies may benefit from using multiple methods of eating behaviour measurements to avoid potential inaccuracies from self-report.

5. Conclusion

Given the limitations outlined, this should be considered as a formative research. In the very least, this effort offers insight into a myriad of factors that are currently inhibiting healthy eating behaviours among children aged 3–12 in Singapore, given the paucity of recent research in this area. Consistent with the HPB's approach of using behavioural insights to positively influence healthy choices for the community (Annual Reports. Health Pr, 2017), this work does provide a foundation for future research and exploration of a range of new interventions around improving mother's PBC, self-efficacy and reducing barriers – e.g. how to incorporate more fruit and dairy in breakfast whether through self or proxy caregivers. Advancements in health promotion have also been public-private partnerships (Kelly et al., 2006), and these should continue in extending the reach of any future initiatives. Strategies could include encouraging mother's as well as other members of the family towards healthy-eating attitudes rather than simply educating them on what to feed their children, recognizing the important influence of parental behaviour on children's healthy eating behaviour. This could help address some of the barriers identified in this study influencing healthy eating behaviour among pre-school and primary school children.

Ethics approval and consent to participate

The study was approved by National Healthcare Group Domain Specific Review Board (NHG DSRB Ref: 2017/00174). Verbal informed consent was obtained prior to the study.

Availability of data and material

The datasets generated and/or analysed during the current study are not publicly available due to data confidentiality but are available from the corresponding author on reasonable request.

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Authors' contributions

Su Lin Lim, Indira Umareddy and Cheryl Teoh conceived the study. Cheryl Teoh managed data collection. Xiahong Zhao and Cheryl Teoh analysed and interpreted the data. Cheryl Teoh and Xiahong Zhao wrote the manuscript. Su Lin Lim, Ilse Khouw, Shikha Satendra Singh and Vince Grillo edited the manuscript critically. All authors read and approved the final manuscript.

Declaration of competing interest

Author Su Lin Lim, declared no conflict of interest related to the authorship of the submitted paper. This study was funded by FrieslandCampina AMEA, Singapore. The analysis was provided by Kantar Health LLC who received funding from FrieslandCampina AMEA, Singapore. At the time the study was conducted, Cheryl Teoh, Indira Umareddy, Xiahong Zhao, Vince Grillo and Shikha Satendra Singh were employees of Kantar Health LLC, and Ilse Khouw was an employee of FrieslandCampina AMEA, Singapore.

List of abbreviations

BMI	Body mass index
CDC	US Centers for Disease Control and Prevention)
HPB	Singapore's Health Promotion Board
NNS	National Nutrition Survey
OR	Odds ratio
PBC	Perceived behavioural control
PKU	Phenylketonuria
SD	Standard deviation
SGD	Singapore Dollar

SHS	Students' Health Survey
TPB	Theory of Planned Behaviour
TRA	Theory of Reasoned Action
UK:	United Kingdom

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.appet.2019.104555.

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