Estimating Unhealthy Food Effects on Childhood Overweight in Malawi Using an Observational Study

Halima S. Twabi[1,*], Samuel O. M Manda[2], Dylan S. Small[3]

[1] Department of Mathematical Sciences, University of Malawi,

[2] Department of Statistics, University of Pretoria, Pretoria, South Africa

[3] Department of Statistics, University of Pennsylvania, Philadelphia, USA

*Correspondence to Halima S. Twabi. Email: htwabi@unima.ac.mw

Abstract

Introduction: Consumption of unhealthy foods in children contributes to high levels of childhood obesity globally. In developing countries there is paucity of empirical studies on the association. This study employed propensity-score methods to evaluate the effect of unhealthy foods on overweight among children in Malawi using observational data.

Methods: Data on 4625 children aged 6 to 59 months from the 2015-16 Malawi Demographic and Health Survey (MDHS) were analyzed. A multivariable logistic regression model of unhealthy foods (yes or no) on purported confounders of childhood overweight was used to obtain a child's unhealthy food propensity score. The propensity scores were then used to form matched sets of healthy and unhealthy fed children. The association between unhealthy foods and childhood overweight was assessed using the conditional logistic regression model.

Results: The prevalence of overweight (body mass index (BMI) z-score > 2 standard deviations) was estimated at 4.5% (3.8%, 5.3%). The proportion of children who consumed unhealthy foods was estimated at 14.6% (95% CI: 13.1%, 16.2%). Our propensity score matching achieved a balance in the distribution of the confounders between children in the healthy and unhealthy food groups. Children fed unhealthy foods were significantly more likely to be overweight than those fed healthy foods (OR = 2.5, 95% CI: (1.2, 5.2)).

Conclusion: The findings suggest the adverse effects of unhealthy foods on childhood overweight in Malawi. Thus, efforts to reduce unhealthy food consumption among children should be implemented and supported to address the problem of childhood overweight in Malawi and the sub-Saharan African region.

Keywords: Propensity score; Child feeding; BMI; Overweight; Unhealthy foods; Observational studies

Significance

Childhood overweight is an emerging public health issue in Sub-Saharan Africa. Sustaining appropriate child feeding practices is a challenge in the region due to poverty and urbanization children are fed ready-made processed foods. There is scarcity of randomized controlled trials within the region that assess the impact of consumption of unhealthy foods on childhood overweight/obesity. Most data available on feeding practices have used observational studies. To determine the effect of consumption of unhealthy foods on childhood overweight, we use propensity-score methods that balance potential confounders for observational studies. Consumption of unhealthy foods had an adverse effect on childhood overweight.

Introduction

The increase in the consumption of unhealthy diets, such as salty, sugary, and saturated fatty foods, among children, has been associated with high childhood overweight/obesity levels in sub-Saharan Africa (SSA) (Kalimbira & Gondwe, 2015; Biadgilign et al., 2017;Tuyet et al., 2019). This has led to an increase in obesity-related health conditions such as type-2 diabetes mellitus, cardiovascular disease, asthma, and respiratory diseases within the region (Sahoo et al.,2015; Kansra et al., 2020). Globally, approximately 38 million under-five children were at least overweight/obese in 2018, and a quarter was in sub-Saharan Africa (Biadgilign et al., 2017; WHO, 2018). As regards child feeding practices, the World Health Organisation (WHO) recommends feeding children aged 6 to 24 months appropriate complementary foods (World Health Organization, 2008). This type of recommendation is often not sustained in low-income countries, for example, in SSA, where the children are often fed food that is commercially processed and has high energy content and low nutrients (Rousham et al., 2022).

Previous studies and reviews have highlighted the inconclusive and conflicting evidence on the effect of unhealthy food consumption on higher Body Mass Index (BMI) in children(English et al., 2019; Pries, Filteau, et al., 2019; Pries, Rehman, et al., 2019; Min et al., 2021; Rousham et al., 2022). Most of these studies have been conducted in high-income countries (English et al., 2019; Pries, Filteau, et al., 2019) . Ascertaining a true effect of unhealthy foods on childhood overweight would require a randomized controlled trial (RCT); however, this could be subject to ethical issues. A recent systematic review and meta-analysis found only two studies that were RCT (Rousham et al., 2022). In addition, for most of these observational studies, the analysis was done using standard statistical techniques. Observational studies could be challenging for evaluating effects due to the problem of confounder imbalance between unhealthy and healthy food groups. Statistical methods that are used to balance the confounders between the two food groups for these observational studies have been developed (Austin, 2011; Rosenbaum & Rubin, 1983; Rubin & Thomas, 1996). In particular, propensity-score based methods can be used to estimate the effect of treatment exposure (unhealthy foods) on the outcome (childhood overweight). This study aimed to use the Malawi Demographic and Health Survey (MDHS) data to assess the effect of unhealthy food diets on childhood overweight using a covariate adjustment method based on the propensity score.

Materials and methods

Study Data and Design

The data was obtained from the 2015-16 Malawi Demographic Health Survey (MDHS), implemented by the National Statistical Office of Malawi in conjunction with the Ministry of Health and Malawi's Community Health Services Unit. The sampling procedure and design can be obtained from the 2015-16 MDHS report (NSO, 2017). The study analyzed data on 4625 children aged 6 to 59 months for whom weight (in kilograms) and height (in centimeters) were measured as per described in the 2015-16 MDHS report.

Childhood overweight and associated confounders

A child was categorized as overweight if his/her weight by height (body mass index) z-score was above 2 standard deviations from the median of the reference child population (WHO, 2006). Our analysis excluded children who had missing or "Flagged cases" for the weight by height z-scores. Covariates identified within the MDHS as potential confounders were categorized as child or parent-related. These included the following: parent-related; maternal education, mother's age, antenatal visits, and mother's employment status. Child-related; history of diarrhea, whether a child had fever, household wealth, child's age, sex of a child, place of residence, and birth weight.

Child unhealthy foods

Following WHO/UNICEF (World Health Organization, 2008;World Health Organization, 2019), a child is fed unhealthy foods if their diet contains the following food items: sugar-sweetened foods and beverages such as juices, soft drinks (fizzy drinks), chocolates, sweets, pastries, and cakes; foods with oils, butter, saturated fats; processed foods such as cheese, yogurt, and other milk products.

Statistical methods

The propensity score was obtained as the probability of a child being fed unhealthy foods given the measured confounders. This was done by fitting a multivariable logistic regression on child unhealthy feeding (yes/no).We implemented the propensity score matching using one-to-one matching (Gu & Rosenbaum, 1993; Austin & Mamdani 2006).The effect of unhealthy foods on childhood overweight was estimated using a conditional logistic regression model on the matched sample.

Results

Summary information about characteristics of feeding practices and prevalence of overweight for the 4625 children aged 6–59 months is presented in Table 1. Out of the 4625 children, 4.5% (95% CI: (3.8%, 5.3)) were overweight. Of these, 764 children (15.6%) (95% CI: (14.1%, 17.4)) were fed unhealthy foods while 3861 (84.4%) were fed healthy foods. The common dietary food given to the children was grain (12.1%) followed by legumes and nuts (10.0%) and then diary (9.8%). Out of the 4625 children, 600 (12.5%) (95% CI: (11.1%, 13.9)) children had sugar-sweetened foods and beverages and 243 (4.9%) (95% CI: (4.1%, 5.9)) had saturated fatty and oily foods.

Table 1. Characteristics of child feeding and overweight among the 5110 under-five children, 2015-16 MDHS

Characteristic	Freq.	Percent	(95% CI)
Overweight	203	4.5%	(3.8, 5.3)
Type of complementary			
Healthy	3861	84.4	(82.6, 85.9)
Unhealthy	764	15.6	(14.1, 17.4)
Type of food			
Diary	441	9.8	(8.6, 11.2)
Grain	557	12.1	(10.8, 13.5)
Legumes and nuts	497	10.0	(8.7, 11.5)
Meat	314	6.6	(5.7, 7.6)
Eggs	142	3.0	(2.4, 3.9)
Fruits and vegetables	74	1.4	(0.9, 2.3)
Sugar-sweetened food and beverages			
Yes	600	12.5	(11.1, 13.9,)
No	4025	87.5	(86.1, 88.9)
Fatty and oily foods			
Yes	243	4.9	(4.1, 5.9)
No	4382	95.1	(94.1, 96)

Freq – Frequency; 95% CI – 95% Confidence Interval

Propensity score estimation

We modelled the probability of unhealthy feeding by a child as a function of potential confounders namely, mother's age, child's age, child's sex, household wealth, mother's education, antenatal care visits, place of residence, birth weight, history of diarrhoea, mother's employment status and whether a child had fever. The results of the association between the confounders and log odds of eating unhealthy foods are presented in Table 2. In the univariate analysis, a child's age (25–59 months) (Coef.=-2.11, 95% CI: -2.3, -1.9), rural residence (Coef.=-0.8, 95% CI:-1.1,-0.4); a mother's secondary/post-secondary education (Coef.=0.7, 95% CI:0.2, 1.2); antenatal visits (2–3 times) (Coef.=0.8, 95% CI:0.5, 1.3), (4 visits and above) (Coef.=0.7, 95% CI:0.4, 1.2); children who had diarrhea (Coef.=0.6, 95% CI:0.4, 0.8), and children with mothers who were rich (Coef.=0.4, 95% CI: 0.2, 0.7) were associated with unhealthy feeding. For the multivariate analysis, children aged 25–59 months, children with mothers who had secondary or post-secondary education and those from rich families were more likely to have unhealthy foods. While children residing in rural areas were less likely to have been given unhealthy foods.

Table 2. Association (on log-odds scale) between diet type and confounders of obesity, 2015-16 MDHS

Variable	Frequency	Univariate Coef. (95% CI)	Adjusted Coef. (95% CI)
Residence			
Urban	740 (12.8%)	ref	ref
Rural	3885 (87.2%)	-0.76(-1.1,-0.4)	-0.59 (-1.0, -0.1)
Mother's Education			
None	580 (13.1%)	ref	ref
Primary	3018 (66.0%)	0.18(-0.2,0.6)	-0.1 (-0.5, 0.4)
Secondary/Post-Secondary	1027 (20.9%)	0.70(0.2, 1.2)	0.36(-0.2, 0.9)
Had diarrhoea last 2 weeks			
No	3631 (78.5%)	ref	ref
Yes	994 (21.5%)	0.60(0.4,0.8)	0.2 (-0.1, 0.4)
Wealth			
Poor	2045 (47.2%)	ref	ref
Medium	904 (19.2%)	0.20(-0.1, 0.5)	0.18 (-0.2, 0.5)
Rich	1676 (33.6%)	0.44(0.2, 0.7)	0.36(0.1, 0.7)
Mothers age			
15–24 years	1636(36.6%)	1.00	ref
25–34 years	2103 (45.1%)	-0.3(-0.5, -0.02)	-0.1(-0.40, 0.2)
35–49 years	886 (18.3%)	-0.3(-0.6,0.1)	0.1(-0.3,0.5)
Child's age			
6–24 months	1682 (35.8%)	ref	ref
25–59 months	2943 (64.3%)	-2.1 (-2.3, -1.9)	1.95(1.6,2.4)
Antenatal visits			
0–1	137 (4.0%)	ref	ref
2–3	1603 (44.3%)	0.8(0.5,1.3)	0.1(-0.5, 0.7)
4 above	1868 (51.7%)	0.7(0.4,1.2)	0.1(-0.5, 0.7)
Birth weight			
Normal weight	4176 (90.2%)	ref	ref
Low birth weight	449 (9.8%)	-0.2(-0.6,0.2)	-0.04(-0.5,0.4)
Fever			
No	3209 (68.7%)	ref	ref
Yes	1416 (31.3%)	0.2(-0.03,0.4)	0.3(-0.01,0.5)
Mother's employment			
Not employed	1330 (28.0%)	ref	Ref
Employed	3295 (72.0%)	-0.1(-0.4,0.2)	0.07(-0.2,0.4)
Sex of child			
Male	2275 (48.3%)	ref	Ref
Female	2350 (51.7%)	-0.02(-0.2, 0.2)	0.05(-0.2,0.3)

Coef – Coefficient, 95% CI– 95% Confidence Interval

The Hosmer and Lemeshow goodness-of-fit test was performed to check if the propensity score model fit the data well. A p-value of 0.4719 was obtained indicating that the model fit the data reasonably well. Besides, a classification accuracy analysis test was done to check the percentage of children correctly specified into the unhealthy fed group. We observed that 92.1% of the children were correctly specified to either unhealthy feeding or not. The propensity of a child being fed unhealthy food was then calculated from the estimates obtained from the fitted multivariable logistic regression model.

Table 3. Distribution of characteristics before and after matching

	Before Matching			After Matching		
	Unhealthy (n = 764)	**Healthy (n = 3861)**		**Unhealthy (n = 584)**	**Healthy (n = 584)**	
Characteristic	**N (%)**	**N (%)**	**p-value**	**N (%)**	**N (%)**	**p-value***
Age of child						
6–24 months	591 (76.2)	1091(28.3)		434(74.3)	416(71.2)	
25–59 months	173(23.8)	2770(71.7)	<0.001	150(25.7)	168(28.8)	0.483
Sex of child						
Male	382(48.9)	1893(48.2)		292(48.1)	292(49.6)	
Female	382 (51.1)	1968(51.8)	0.775	292(51.9)	292(50.4)	0.359
Residence						
Urban	162(21.4)	578(11.3)		135(22.5)	128(20.4)	
Rural	602(78.6)	3283(88.7)	<0.001	449(77.5)	456(79.7)	0.882
Mothers' Education						
None	72(10.4)	508(13.8)		51(9.5)	38(6.3)	
Primary	472(60.3)	2546(66.9)		351(59.2)	365(64.1)	
Secondary & Post-Secondary	220(29.3)	807(19.3)	<0.001	182(31.4)	181(29.7)	0.783
History of diarrhoea						
No	533(68.9)	3098(79.2)		362(60.6)	361(60.8)	
Yes	231(31.0)	763(20.8)	<0.001	222(39.4)	223(39.2)	0.353
Birth weight						
Normal weight	700(91.8)	3476(89.9)		553(91.3)	544(93.9)	
Low birth weight	64(8.2)	385(10.1)	0.237	51(8.7)	40(6.1)	0.117
Wealth						
Poor	287(40.4)	1758(48.7)		209(39.3)	218(40.7)	
Medium	149(18.7)	755(19.1)		112(19.0)	114(17.0)	
Rich	328(40.8)	1348(32.3)	0.004	263(41.7)	252(42.3)	0.311
Had Fever						
No	503 (65.2)	2706 (69.3)		355 (59.0)	347 (57.7)	
Yes	261 (34.8)	1155 (30.7)	0.084	229 (41.0)	237 (42.3)	0.052
Mother's Employment status						
Not employed	218 (29.7)	1112(27.7)		168 (29.6)	168 (26.6)	
Employed	546 (70.3)	2749(72.3)	0.481	416 (70.4)	416 (73.4)	0.572
Maternal Age						
15–24 years	337(41.5)	1299(34.2)		269 (44.5)	269 (47.0)	
25–34 years	319(42.1)	1784(46.4)		235(40.1)	233 (39.7)	
35–49 years	108(16.4)	778(19.4)	0.036	80 (15.4)	82 (13.3)	0.071

i) * p–values calculated using McNemar's test for dichotomous variables and Marginal homogeneity test for covariates with more than two categories for n=275

ii) N − Number (frequency)

iii) p − p–value

Distribution of confounders and balance assessment

Table 3 presents the distribution of the studied confounder variables before and after matching. Before matching the children based on their propensity scores, we assessed the balance of the confounders between the feeding groups. Out of the 4625 children, 764 were fed unhealthy foods, and 3861 were fed healthy foods. Of the 764 children given unhealthy foods, 382 (48.9%) of the males were fed unhealthy foods, while 1893 (48.2%) males were fed healthy foods. Out of the 4625 children, 162 (21.4%) from the urban areas were fed unhealthy foods, while 11.3% were fed healthy foods. Most children aged 6–24 months were fed unhealthy foods (76.2%), while 28.3% were fed healthy foods. Of the children from rich households, 40.8% were fed unhealthy foods, and 32.3% had healthy foods. For children who had mothers with secondary or post-secondary education, 29.3% had unhealthy foods, and 19.3% had healthy foods. Place of residence, child's age, household wealth index, mothers' educational status, history of diarrhea, and mothers' age were distributed differently between children who had unhealthy and healthy foods ($P < 0.05$), see Table 3. We further assessed the systematic differences of the confounders using an absolute standardized difference. A standardized difference of 0.1 (10%) was used to denote meaningful balance between children given unhealthy and healthy foods across the measured confounders (Normand et al., 2001; Austin, 2009).The absolute value of the standardized difference of the covariates before matching was greater than 0.1 for mother's education, child's age, mother's age (35 years above), place of residence, mother's wealth status, antenatal visits (4 times above) and if a child had diarrhea.

We performed both the one-to-one (1:1) and the four-to-one (4:1) nearest neighbor matching algorithm with an acceptable difference between the scores of 0.2. A comparison of the matching algorithms between the groups was done and the 4:1 matching algorithm did not produce better balance between the scores as compared to the 1:1 matching. The analysis was done using the matched sample obtained using the 1:1 matching algorithm.

We assessed the balance on the matched sample by checking that there was no difference between the exposure groups across the observed confounders using a McNemar's Bowker's test for categorical variables (Bowker, 1948). After PS matching on the confounders, 584 children who had unhealthy foods were matched to 584 children given unhealthy foods. We analyzed the matched sample to assess the difference in baseline characteristics as shown in Table 3. No significant difference was observed in the covariates between children given unhealthy foods and those given healthy foods. Furthermore, the absolute standardized difference were less than 0.1 implying homogeneity in the distribution of all the covariates between children who had unhealthy foods and those who had healthy foods ($P > 0.05$) in the matched sample, see Table 4.

Table 4. Absolute Standard Differences and p-values Before and After Matching

	Before		After	
Confounders	**Abs. Std. Difference**	**p-values**	**Abs. Std. Difference**	**p-values**
Sex of a child				
Male	0.019	0.624	0.000	1.000
Female	0.019	0.624	0.000	1.000
Mothers' education				
None	0.127	0.008	0.084	0.153
Primary	0.100	0.026	0.049	0.400
Secondary/ Post-Secondary	0.199	<0.001	0.004	0.950
Child's age				
6–24 months	1.130	<0.001	0.010	0.161
25–59 months	1.130	<0.001	0.000	1.000
Residence				
Urban	0.176	<0.001	0.029	0.624
Rural	0.176	<0.001	0.029	0.624
Had diarrhoea				
No	0.341	<0.001	0.004	0.952
Yes	0.341	<0.001	0.004	0.952
Fever				
No	0.127	0.004	0.028	0.633
Yes	0.127	0.004	0.028	0.633
Wealth				
Poor	0.159	0.001	0.032	0.585
Medium	0.010	0.824	0.009	0.882
Rich	0.166	<0.001	0.038	0.517
Mothers' age				
15–24 years	0.263	<0.001	0.000	1.000
25–34 years	0.113	0.024	0.007	0.905
35 years above	0.190	<0.001	0.010	0.866
Birth weight				
Low birth weight	0.026	0.174	0.070	0.231
Normal birth weight	0.026	0.174	0.070	0.231
Mother's Employment status				
Not employed	0.006	0.882	0.000	1.000
Employed	0.006	0.882	0.000	1.000
Antenatal visit				
0–1 times	0.009	0.845	0.206	0.257
2–3 times	0.002	0.961	0.047	0.724
4 above	0.006	0.902	0.035	0.953

Abs. Std. Diff – Absolute Standardized Differences

Estimation of unhealthy effect on childhood overweight

For the unmatched sample, the ordinary logistic regression model was used to assess the association between unhealthy feeding and childhood overweight, accounting for the potential confounders. As shown in Table 5, the effect of unhealthy foods on childhood overweight was not significant ((OR = 1.0, 95% CI: (0.6, 1.8)).

Table 5. Association between unhealthy feeding and overweight before matching

Characteristics	Overweight for height
	OR (95% CI)
Type of foods	
Healthy	1.00
Unhealthy	1.0 (0.6, 1.8)
Gender	
Male	1.00
Female	0.7 (0.5, 1.1)
Mothers' education	
None	1.00
Primary	0.8 (0.3, 2.1)
Secondary/Post-Secondary	0.5 (0.2, 1.5)
Child's age	
6–24 months	1.00
25–59 months	0.5 (0.3, 0.9)
Residence	
Urban	1.00
Rural	2.2 (1.1, 4.5)
Had diarrhoea	
No	1.00
Yes	0.4 (0.3, 0.8)
Fever	
No	1.00
Yes	0.6 (0.4, 1.0)
Wealth	
Poor	1.00
Medium	1.2 (0.7, 2.2)
Rich	1.6 (0.9, 2.7)
Mothers' age	
15–24 years	1.00
25–34 years	1.2 (0.7, 2.0)
35 years above	0.6 (0.3, 1.4)
Birth weight	
Low birth weight	1.00
Normal birth weight	1.5 (0.6, 4.0)
Mother's Employment status	
Not employed	1.00
Employed	1.0 (0.6, 1.5)
Antenatal visit	
0–1 times	1.00
2–3 times	0.5 (0.2, 1.1)
4 above	0.5 (0.2, 1.2)

Table 6. The effect of unhealthy foods on childhood obesity, Malawi 2015-16

Indicators	Overall	Urban	Rural
	OR (95% Conf. Int)	**OR (95% Conf. Int)**	**OR (95% Conf. Int)**
Overweight	2.5 (1.2, 5.2)	3.4 (0.7, 16.7)	2.2 (1.0, 5.2)

i) The odds ratio and 95% confidence interval were obtained by the conditional logistic regression analyses (n=368)

ii) AOR – Adjusted odds ratio

iii) Approp. – Appropriately complementary fed

iv) OR – Odds ratio

v) Conf.Int – Confidence Interval

However, in using the propensity score matching methods, a child fed unhealthy foods was more likely to be overweight (OR = 2.5, 95% CI: (1.2, 5.2)) compared to those who had healthy foods. Children in urban areas who were fed unhealthy foods were significantly more likely to be overweight (OR = 3.4, 95% CI: (0.7, 16.7)). However, this was not the case for rural children (OR = 2.2, 95% CI: (1.0, 5.2)), (Table 6). A number of variables had missing data. We performed basic imputations and re-run the analysis. The estimated effects of unhealthy foods were hardly affected.

Sensitivity analysis

In the application of the propensity score matching, there is a need to consider the possible influence of unmeasured confounders on the estimated effects (Rosenbaum, 2005; Rosenbaum & Small, 2017). This was done using the Mantel Haenszel's sensitivity test (Aakvik, 2001; Rosenbaum, 2005)). We found that possibility of unmeasured confounders would not greatly affect the estimated effect of unhealthy foods on child overweight.

Breastfeeding duration is an important confounder of child feeding and growth (Martin, 2001; Haider & Saha, 2016; Lang Morović & Musić Milanović, 2019). Thus, we also re-run the analyses for only children with breastfeeding duration. There was no major differences in the estimation of the effect between unhealthy foods and childhood overweight.

Discussion

Childhood overweight is an emerging public health problem in SSA, where most children are given unhealthy food. Evidence on the impact of unhealthy foods on childhood overweight is conflicting due to the paucity of RCTs within the region. This study used observational data to determine the association between the consumption of unhealthy foods and childhood overweight in Malawi. The propensity score matching was used to balance the confounder distribution between children fed unhealthy foods and those fed healthy foods. Multivariate logistic regression was used to model a child's dietary food as a function of measured confounders to obtain the propensity of eating unhealthy foods using the 2015-16 MDHS. The results showed that children fed unhealthy foods were more likely to be overweight than those provided healthy foods.

Several studies have also found a significant impact of consuming unhealthy snacks and sugar-sweetened beverages on childhood overweight (O'Connor et al., 2006; Jimenez-Cruz et al., 2010). On the contrary, some studies have found no association between consuming foods high in fats, sugars, and unprocessed and being overweight among children aged 6 to 23 months, particularly among countries with a low prevalence of childhood overweight (Budree et al., 2017; Pries, Filteau, et al., 2019). The possible reason for these differences might be different feeding practices among under-five children by country, differences in socioeconomic status, cultural differences in feeding preferences, and different nutrition assessment methods (Min et al., 2021; Otitoola et al., 2021).

Malawi has programs such as the Malawi National Multi-Sector Nutrition Policy 2018–2022 that ensure that under-five-year-old children have optimal feeding (Ministry of Health, Malawi, 2018). However, the implementation and adoption of these policies tend to be challenging among the poor and rural households. The lack of access to quality healthy foods among the poor and with the rise in urbanization, children are mostly fed locally-made processed foods, which are a major source of unhealthy eating (Kalimbira & Gondwe, 2015; Casari et al., 2022). Evidence from this study support recent alarms made by public health specialist on the growing prevalence of unhealthy eating which is resulting in high childhood overweight in SSA. There is a need to intensify interventions that promote appropriate child feeding practices in Malawi and the region and to ensure the uptake of the guidelines at all socio-economic levels.

Findings in this study are subject to constraint in that there was no temporal association between unhealthy feeding and being overweight. Even though we did not have temporality, our study provides more robust findings than other studies that have used observational studies because we used covariate adjustment methods based on the propensity score. There is a possibility that other unmeasured factors would have to be controlled in terms of the propensity score matching. However, our sensitivity analysis showed that the estimated effect could not have been affected by the unmeasured factors. Another limitation was that unhealthy foods were based on self-reported information and a 24-hour recall of the type of dietary food a child was given which may result in recall bias.

Conclusions

The findings from this study revealed the adverse effect of unhealthy feeding on child overweight. Child feeding interventions in sub-Saharan African should been encouraged and supported to reduce the consumption of unhealthy foods to address the problem of child overweight in the region.

Data Availability

The data that support the findings of this study are available upon request from the Demographic and Health Survey (DHS) website. Upon approval, full access is granted to all unrestricted survey datasets.

Acknowledgements

We acknowledge the DHS team for making the MDHS data available for use. Special thanks to South Africa Medical Research Council for hosting and supporting my research visits.

Funding

This work was supported through the DELTAS Africa Initiative, Sub-Saharan Africa Consortium for Advanced Biostatistics Training (SSACABT). The DELTAS Africa Initiative is an independent funding scheme of the African Academy of Sciences (AAS)'s Alliance for Accelerating Excellence in Science in Africa (AESA) and supported by the New Partnership for Africa's Development Planning and Coordinating Agency (NEPAD Agency) with funding from the Wellcome Trust [SSACABT] and the UK government. The views expressed in this publication are those of the author(s) and not those of AAS, NEPAD Agency, Wellcome Trust or the UK government. This work was further supported by the L'Or'al-UNESCO for Women in Science Sub-Saharan Africa Young Talents Programme.

Ethics approval and consent to participate

The Malawi Health Research Committee determined that ethical approval was not deemed necessary in this study considering the fact that the study used data from a research study already approved by an ethical research committee. According to the 2015-16 MDHS report [11], the MDHS study was ethically approved by Malawi Health Research Committee, Institutional Review Board of ICF Macro, and Centre for Disease and Control (CDC) in Atlanta, GA, USA and Prevention IRB. Informed consent was obtained from all eligible persons.

Conflict of interest

The authors declare that they have no conflict of interest.

References

Aakvik, A. (2001). Bounding a matching estimator: the case of a Norwegian training program. *Oxford Bulletin of Economics and Statistics*, *63*(1), 115–143

Austin, P. C. (2009). Balance diagnostics for comparing the distribution of baseline covariates between treatment groups in propensity-score matched samples. *Statistics in Medicine*, *28*(25), 3083–3107

Austin, P. C. (2011). An Introduction to Propensity Score Methods for Reducing the Effects of Confounding in Observational Studies. *http://i%3E/10.1080/00273171.2011.568786*.https://doi.org/10.1080/00273171.2011.568786

Austin, P. C., & Mamdani, M. M. (2006). A comparison of propensity score methods: a case-study estimating the effectiveness of post-AMI statin use. *Statistics in Medicine*, *25*(12), 2084–2106

Biadgilign, S., Mgutshini, T., Haile, D., Gebremichael, B., Moges, Y., & Tilahun, K. (2017). Epidemiology of obesity and overweight in sub-Saharan Africa: a protocol for a systematic review and meta-analysis. *British Medical Journal Open*, *7*(11), https://doi.org/10.1136/BMJOPEN-2017-017666

Bowker, A. H. (1948). A Test for Symmetry in Contingency Tables. *Journal of the American Statistical Association*, *43*(244), 572–574. https://doi.org/10.1080/01621459.1948.10483284

Budree, S., Goddard, E., Brittain, K., Cader, S., Myer, L., & Zar, H. J. (2017). Infant feeding practices in a South African birth cohort-A longitudinal study. *Maternal & Child Nutrition*, *13*(3), https://doi.org/10.1111/MCN.12371

Casari, S., Paola, M., Di, Banci, E., Diallo, S., Scarallo, L., Renzo, S., Gori, A., Renzi, S., Paci, M., de Mast, Q., Pecht, T., Derra, K., Kaboré, B., Tinto, H., Cavalieri, D., & Lionetti, P. (2022). Changing Dietary Habits: The Impact of Urbanization and Rising Socio-Economic Status in Families from Burkina Faso in Sub-Saharan Africa. *Nutrients 2022*, *14*(9), 1782. https://doi.org/10.3390/NU14091782. *14*

English, L. K., Obbagy, J. E., Wong, Y. P., Butte, N. F., Dewey, K. G., Fox, M. K., Greer, F. R., Krebs, N. F., Scanlon, K. S., & Stoody, E. E. (2019). Types and amounts of complementary foods and beverages consumed and growth, size, and body composition: a systematic review. *The American Journal of Clinical Nutrition*, *109*(Suppl_7), 956S–977S. https://doi.org/10.1093/ajcn/nqy281

Gu, X. S., & Rosenbaum, P. R. (1993). Comparison of multivariate matching methods: Structures, distances, and algorithms. *Journal of Computational and Graphical Statistics*, *2*(4), 405–420

Haider, R., & Saha, K. K. (2016). Breastfeeding and infant growth outcomes in the context of intensive peer counselling support in two communities in Bangladesh. *International Breastfeeding Journal*, *11*(1), 18. https://doi.org/10.1186/s13006-016-0077-6

Jimenez-Cruz, A., Bacardi-Gascon, M., Pichardo-Osuna, A., Mandujano-Trujillo, Z., & Castillo-Ruiz, O. (2010). Infant and toddlers' feeding practices and obesity amongst low-income families in Mexico. *Asia Pacific Journal of Clinical Nutrition*, *19*(3), 316–323

Kalimbira, A., & Gondwe, E. (2015). Consumption of sweetened beverages among school-going children in a densely populated township in Lilongwe, Malawi. *Malawi Medical Journal: The Journal of Medical Association of Malawi*, *27*(2), 55–59. https://doi.org/10.4314/mmj.v27i2.5

Kansra, A. R., Lakkunarajah, S., & Jay, M. S. (2020). Childhood and Adolescent Obesity: A Review. *Frontiers in Pediatrics*, *8*, 581461. https://doi.org/10.3389/fped.2020.581461

Lang Morović, M., & Musić Milanović, S. (2019). Breastfeeding Duration as a Predictor of Childhood Lifestyle Habits, Overweight and Obesity in Second- and Third-Grade Schoolchildren in Croatia. *Acta Clinica Croatica*, *58*(3), 481–490. https://doi.org/10.20471/acc.2019.58.03.12

Martin, R. M. (2001). Commentary: Does breastfeeding for longer cause children to be shorter? *International Journal of Epidemiology*, *30*(3), 481–484. https://doi.org/10.1093/ije/30.3.481

Min, K., Wang, J., Liao, W., Astell-Burt, T., Feng, X., Cai, S., Liu, Y., Zhang, P., Su, F., Yang, K., Sun, L., Zhang, J., Wang, L., Liu, Z., & Jiang, Y. (2021). Dietary patterns and their associations with overweight/obesity among preschool children in Dongcheng District of Beijing: a cross-sectional study. *Bmc Public Health*, *21*(1), 223. https://doi.org/10.1186/s12889-021-10240-x

Normand, S. L. T., Landrum, M. B., Guadagnoli, E., Ayanian, J. Z., Ryan, T. J., Cleary, P. D., & McNeil, B. J. (2001). Validating recommendations for coronary angiography following acute myocardial infarction in the elderly: a matched analysis using propensity scores. *Journal of Clinical Epidemiology*, *54*(4), 387–398

NSO (2017). *Malawi Demographic and Health Survey 2015-16 Report*

O'Connor, T. M., Yang, S. J., & Nicklas, T. A. (2006). Beverage intake among preschool children and its effect on weight status. *Pediatrics*, *118*(4), https://doi.org/10.1542/peds.2005-2348

Otitoola, O., Oldewage-Theron, W., & Egal, A. (2021). Prevalence of overweight and obesity among selected schoolchildren and adolescents in Cofimvaba, South Africa. *South African Journal of Clinical Nutrition*, *34*(3), 97–102. https://doi.org/10.1080/16070658.2020.1733305

Pries, A. M., Filteau, S., & Ferguson, E. L. (2019). Snack food and beverage consumption and young child nutrition in low- and middle-income countries: A systematic review. *Maternal and Child Nutrition*, *15*(S4), https://doi.org/10.1111/mcn.12729

Pries, A. M., Rehman, A. M., Filteau, S., Sharma, N., Upadhyay, A., & Ferguson, E. L. (2019). Unhealthy Snack Food and Beverage Consumption Is Associated with Lower Dietary Adequacy and Length-for-Age z-Scores among 12-23-Month-Olds in Kathmandu Valley, Nepal. *The Journal of Nutrition*, *149*(10), 1843–1851. https://doi.org/10.1093/JN/NXZ140

Rosenbaum, P. R. (2005). Sensitivity Analysis in Observational Studies. *Statistics Reference Online*, *4*, 1809–1814

Rosenbaum, P. R., & Rubin, D. B. (1983). The central role of the propensity score in observational studies for causal effects. *Biometrika*, *70*(1), 41–55. https://doi.org/10.1093/biomet/70.1.41

Rosenbaum, P. R., & Small, D. S. (2017). An adaptive Mantel–Haenszel test for sensitivity analysis in observational studies. *Biometrics*, *73*(2), 422–430

Rousham, E. K., Goudet, S., Markey, O., Griffiths, P., Boxer, B., Carroll, C., Petherick, E. S., & Pradeilles, R. (2022). Unhealthy Food and Beverage Consumption in Children and Risk of Overweight and Obesity: A Systematic Review and Meta-analysis. *Advances in Nutrition (Bethesda, Md.)*. https://doi.org/10.1093/advances/nmac032

Rubin, D. B., & Thomas, N. (1996). Matching using estimated propensity scores: relating theory to practice. Biometrics, 249–264

Sahoo, K., Sahoo, B., Choudhury, A. K., Sofi, N. Y., Kumar, R., & Bhadoria, A. S. (2015). Childhood obesity: causes and consequences. *Journal of Family Medicine and Primary Care*, *4*(2), 187–192. https://doi.org/10.4103/2249-4863.154628

Tuyet, L. T., Thu, N. T. T., Hoai, N. T. T., Huong, N. T. L., Dung, L. T. T., & Khanh, D. N. (2019). Double Burden of Nutrition and some Eating Habits Characteristics of Preschool Children in Nam Hong Commune, Dong Anh district, Hanoi, 2018. *VNU Journal of Science: Medical and Pharmaceutical Sciences*, *35*(2), 68–77. https://doi.org/10.25073/2588-1132/VNUMPS.4175

World Health Organization. (2019). UNICEF-WHO low birthweight estimates: levels and trends 2000-2015 (No. WHO/NMH/NHD/19.21). World Health Organization.

WHO (2006). *WHO Child Growth Standards based on length/height, weight and age WHO MULTICENTRE GROWTH REFERENCE STUDY GROUP*. https://doi.org/10.1080/08035320500495548

WHO, I (2018). *Obesity and overweight*

World Health Organization (2008). *Young Child Feeding Global Strategy for Infant and*. http://apps.who.int/iris/bitstream/10665/42590/1/9241562218.pdf