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Effect of maternal nutritional education and counselling on children's stunting prevalence in urban informal settlements in Nairobi, Kenya

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Abstract

Objective: To determine whether the prevalence of stunting differed between an intervention group and a control group and to identify factors associated with the children's linear growth.

Design: This was a follow-up study of mother–child pairs who participated in a 2012–2015 cluster randomised controlled trial. Linear mixed effects models were performed to model the children's linear growth and identify the determinants of child linear growth.

Setting: The study was conducted in two slums in Nairobi. The intervention group received monthly nutrition education and counselling (NEC) during pregnancy and infancy period.

Participants: A birth cohort of 1004 was followed up every 3 months after delivery to the 13th month. However, as a result of dropouts, a total of 438 mother–child pairs participated during the 55-month follow-up. The loss to follow-up baseline characteristics did not differ from those included for analysis.

Results: Length-for-age z-scores decreased from birth to the 13th month, mean –1·42 (SD 2·04), with the control group (33·5 %) reporting a significantly higher prevalence of stunting than the intervention group (28·6 %). Conversely, the scores increased in the 55th month, mean –0·89 (SD 1·04), with significantly more males (16·5 %) stunted in the control group than in the intervention group (8·3 %). Being in the control group, being a male child, often vomiting/regurgitating food, mother's stature of <154 cm and early weaning were negatively associated with children's linear growth.

Conclusions: Home-based maternal NEC reduced stunting among under five years; however, the long-term benefits of this intervention on children's health need to be elucidated.

Keywords
Stunting
Maternal nutrition education and counselling
Urban slums
Community health workers
Kenya

In low- and middle-income countries, approximately one child in every thirteen dies before his or her fifth birthday, unlike in high-income countries (one child in every 189)[1]. Nearly half of these deaths are associated with malnutrition in the first 1000 d. Worldwide, about 165 million under-fives are stunted[1], with the majority of these children originating from low- and middle-income countries. In sub-Saharan Africa, approximately 40 % (56 million) of under-fives are stunted[2].

Stunting, a growth impairment determined by length/height-for-age z (LAZ/HAZ) score of < –2 SD, is a chronic public health problem because most of the affected countries have not made substantial advances in reducing or eliminating it. Its effects are highly correlated with the short- and long-term adverse health effects on the affected children. Stunting hinders optimal growth and development and prevents maximum brain development, causing poor cognitive abilities later in life, cascading poor

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school performance, and reduced potential for a nation's development[3].

Multiple risk factors have been identified as determinants of stunting. Fenske *et al*.[4] and Goudet *et al*.[5] report a comprehensive analysis of these risk factors and present conceptual frameworks showing the determinants of stunting and child undernutrition, respectively. Factors such as low birth weight as a result of premature birth or intra-uterine growth restriction[6], poor hygienic practices, child morbidity[5], inadequate infant and young child feeding practices through the first 2 years of life, among other predicting factors[4] have been associated with stunting. Notably, food insecurity may influence inappropriate feeding practices in poor urban settings[5]. Moreover, caregivers' inappropriate complementary feeding behaviour due to lack of nutrition, knowledge on optimal feeding practices, inadequate awareness of the frequency of feeding, and the amount of food to be fed to the child, what constitutes a balanced diet and cultural beliefs are modifiable factors that can contribute to the deterioration of a child's nutritional status[7]. Consequently, various nutrition-specific and nutrition-sensitive interventions were proposed by the WHO to improve maternal and young child health/nutrition status in developing countries[8].

For the period 2008/2009 to 2014, Kenya reported a significant reduction in the prevalence of stunting, from 35 % to 26 %[9,10]. This success is attributed to extensive implementation of maternal and child health-related interventions and strategies. These include breast-feeding campaigns and personalised nutrition education and counselling (NEC) geared towards the improvement of exclusive breast-feeding and complementary feeding practices[11,12]. However, the evidence supporting this hypothesis is limited, while the results of the few studies thus far conducted in urban informal settlements in Kenya and other low- and middle-income countries on the effect of maternal nutrition counselling on stunting have been inconclusive.

For instance, previous systematic reviews have reported the effect of providing nutrition counselling, with or without nutritional support, on child's growth and development[13,14]. A nutrition education intervention delivered through the health centre in low-income shanty towns in Peru reports a greater proportion of stunting among the control group than the intervention group[15]. However, a similar study conducted in poor urban slums in Mumbai through household visits reports the effectiveness of nutrition counselling alone on increasing child energy intake but no significant improvement on children's length and weight gain[16]. A recent systematic review reporting the effects of different forms of nutrition interventions revealed inadequate effects of those interventions on child nutrition outcomes in the context of urban slums[17]. These contradictory findings are likely to emanate from differences in the duration and intensity of the nutrition counselling provided, the different set-ups for delivering education messages (health centre *v.* home-based), the mode of delivering nutrition education messages and differences in food security status in the study areas among others[15–17]. On the other hand, underlying conditions such as poverty, illiteracy, poor environmental factors and inadequate resources explain the lack of behaviour change in these settings[18]. Given this paradox, this study aimed to evaluate the difference in children's stunting among a community who received home-based NEC through the involvement of community health workers (CHW) and to identify the determinants of the child's linear growth.

Methodology

Study design

This was a follow-up study of a mother–child cohort who initially participated in a cluster randomised controlled trail[19]. The initial study was conducted under the Maternal Infant and Young Child Nutrition (MIYCN) project by the African Population and Health Research Center from 2012 to 2015. The experimental intervention involved personalised, home-based nutritional counselling of pregnant women from the time of recruitment until the baby attained 1 year. The objective of the initial study was to assess the effectiveness of personalised, home-based nutrition counselling of women during pregnancy as well as its effect on infant feeding practices, morbidity and nutrition outcomes within 1 year after delivery. Follow-up data from this cohort were collected in 2018. The main focus of this follow-up study was to assess the effect of NEC on children's linear growth while considering factors that may have been influenced by the initial study such as exclusive breast-feeding, complementary feeding practices and hygienic practices. Details on the initial cluster randomisation and recruitment of the study participants were published in the trial protocol[19], and the effects of the intervention on exclusive breast-feeding practices have been published elsewhere[20].

Study setting

This study was nested within the Nairobi Urban Health and Demographic Surveillance System (NUHDSS) run by the African Population and Health Research Center. The NUHDSS follows about 80 000 residents of two highly populated urban informal settlements (slums), Viwandani (52 583/km^2) and Korogocho (63 318/km^2), in Nairobi, Kenya, since 2003[21]. The initial study (first to fourth follow-up) was conducted in 2012–2015, while the fifth follow-up data collection was done in 2018 in these two slums. These slums are located 7 km from each other and comprise fourteen villages in total. Seven villages from both slums were exposed to NEC, while the other seven to the control group. The study area is characterised by food

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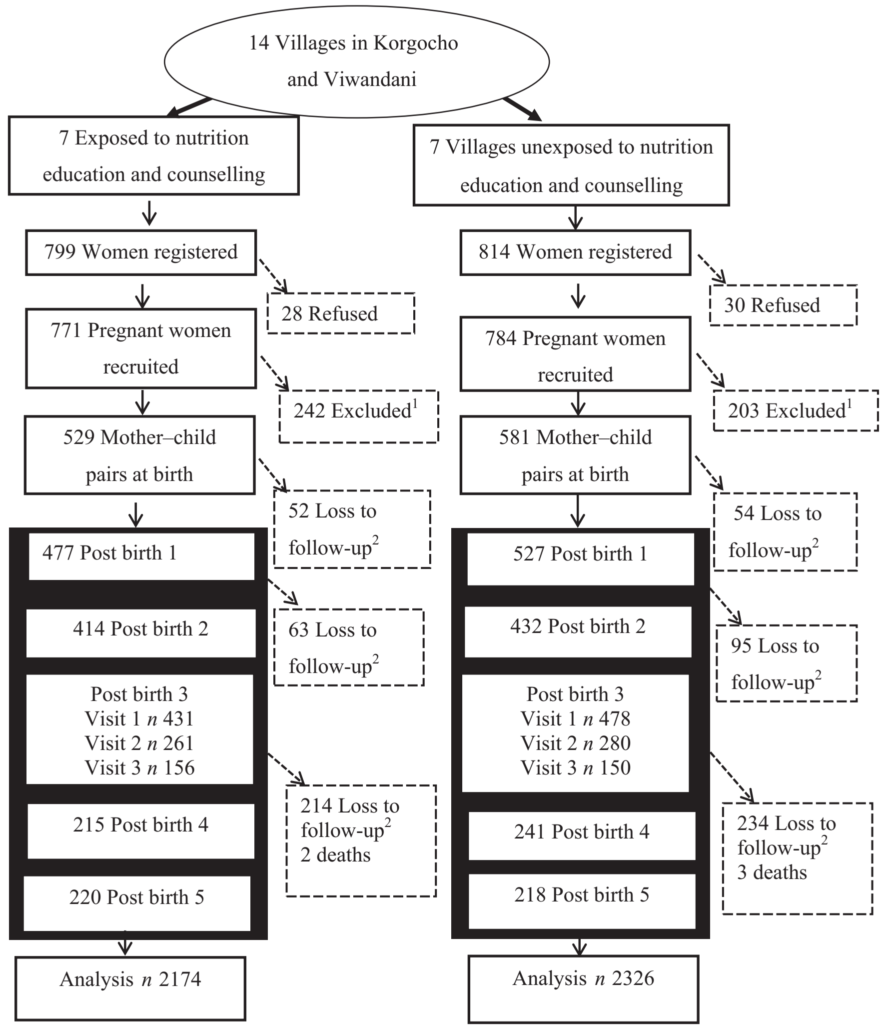

Fig. 1 Flow diagram of study participants included in the analysis. [1]Excluded or dropped due to loss to follow-up during pregnancy, migration or death of mother, giving birth before receiving the intervention and pregnancy loss (miscarriage/abortion or still birth). [2]Lost to follow-up after giving birth due to out migration, untraced cases, death of mother or the baby and exit from study

insecurity, poor sanitation and hygiene, poor housing, poor child nutrition indicators and poor child feeding practices[22].

Study population

This was a cohort of pregnant women recruited during pregnancy and followed-up quarterly with their children until the 13th month after delivery and at the 55th month. The initial study's inclusion criteria involved women of reproductive age, registered in the NUHDSS, who became pregnant in the year between 2012 and 2014, who voluntarily agreed to participate in the study. As a result, a total of 529 mother–child pairs who were exposed to NEC and 581 in the control group (not exposed) were available at birth for follow-up. However, at the 13th month after delivery, only 215 and 221 mother–child pairs in the intervention and control groups, respectively, were followed up as some were lost to follow-up or not traced, Fig. 1.

The mother–child pairs who were still residing in the Korogocho and Viwandani slums, registered within the NUHDSS, and voluntarily agreed to participate, provided written informed consent and were included in the fifth follow-up. The exclusion criteria were: mother–child pairs who participated in the initial study but migrated out of the study area, presence of chronic diseases, hearing and vision disabilities and/or death of the index child. A total of 220 mother–child pairs in the exposed (intervention group) and 218 in the unexposed (control group) were traced, and data were collected from them, Fig. 1.

Participants with missing information on child length/height were excluded from the data analysis. There were few cases (2·1 %) of missing data regarding the outcome variable from the 2012–2015 follow-up and no cases of missing data in the 2018 follow-up. Baseline characteristics of children who dropped out during the study period did not differ with those analysed in this study.

Description of the exposed and unexposed groups

Details on the intervention and control group were published previously[19,20]. Thirty CHW with basic standard training from the government and a minimum of primary school education were selected from the fourteen villages. The CHW in the intervention group received additional intensive training on top of the standard training. The training was conducted by the African Population and Health Research Center for personalised, home-based nutrition counselling of mothers using a package on Community Infant and Young Child Feeding adopted from the Kenyan Government, Ministry of Health[23]. The trained CHW passed down this information to the mothers, fathers and caregivers in the intervention group with the aid of coloured counselling cards with illustrations that depicted the key infant and young child feeding concepts. Counselling was initiated as soon as the woman was recruited during pregnancy and continued on a monthly basis until the baby turned 1-year-old. The intervention group CHW had a counselling work schedule and specific messages from MIYCN to be shared with the intervention group during each visit as highlighted in the counselling schedule online supplementary material, Supplemental Table S1. For example, during prenatal visits, they informed the pregnant women on adequate diet, reminders to attend antenatal care clinics, the value of immunisation and taking Fe and folate supplements. Seven nutrition counselling sessions were offered during pregnancy. The first four sessions were conducted once every 4 weeks until the 34th week of gestation, whilst the other three sessions were done on a weekly basis until delivery, see online supplementary material, Supplemental Table S1.

After delivery, the intervention group mothers were visited, their child's health checked and counselled weekly during the first month and on a monthly basis until the infant turned 1-year-old. Weekly counselling was conducted when the child was 5 months to prepare mothers for complementary feeding. A total of seventeen counselling sessions were held after delivery. Key messages were imparted for exclusive breast-feeding and continued breast-feeding until the child was 2 years old, feeding infants an adequate and well-balanced diet, practicing responsive feeding, advocacy on postnatal clinic attendance for periodic immunisation, proper hygienic practices, weight monitoring and vaccination of their children among others, see online supplementary material, Supplemental Table S2.

The control group received the usual antenatal care practices such as home-based counselling from the CHW on usual care (antenatal care, family planning, skilled delivery and immunisation), MIYCN reading materials. These CHW were not participating in the intervention and were not given any form of training on MIYCN[20]. The CHW visits to the control group households are a standard practice specified under the community health strategy of the Kenyan Government, Ministry of Health and are defined by the mother's need. This study was blinded by the fact that CHW in both study arms were to visit the mothers monthly. The CHW were allocated women within their village of residence to visit. However, they did not know whether their village was an intervention or control group. The cluster randomisation in the allocation of the villages to the study arm by a data analyst who was not part of the study team reduced the chances of contamination of the control group.

Data sources

The baseline data were collected during recruitment, and then the pre-birth data during the third trimester of pregnancy. Thereafter, the follow-up data were collected every 3 months from post birth one to post birth four. This was followed by a single observation in May 2018 (fifth follow-up) when the majority of the children were four and a half years old. Post birth three had three surveys at intervals of 2 months. Hence, data from the mother–child pairs were collected post birth when the mean age (SD) of the child was 1·4 (SD 2·4), 4·4 (SD 1·9), 7·3 (SD 1·9), 9·5 (SD 1·9), 11·0 (SD 1·6), 13·5 (SD 1·7) and 55·9 (SD 5·3). Data used for the analysis of child health characteristics consist of 4062 observations of repeated measures from birth until the infant turned 1 year for both the exposed (intervention group) and unexposed (control group) and 438 during the fifth follow-up as described in Fig. 1. A total of 4043 observations of the outcome variable were available for analysis.

The fifth follow-up data collection

Eight trained interviewers (four in the intervention group and four in the control group) were accompanied by two CHW, who participated in the initial study and who were still residing in the same village. Households that participated in the initial study and those who might have changed their residence were identified using existing household identification numbers issued during the quarterly surveillance by the NUHDSS. Others were identified by CHW and interviewers who participated in the initial study.

The recruited mothers confirmed that they had participated in the initial study and received a detailed explanation of the study details before giving written informed consent. Data were collected one village at a time from each mother–child pair using a handheld android tablet containing a semi-structured pretested questionnaire installed in SurveyCTO collect software version 2.50. The questionnaire consisted of three parts: a general questionnaire for sociodemographic and socio-economic information of the households and caregivers, previous breast-feeding, and complementary feeding practices of the index child, health practices such as vaccination, morbidity experience of the child, maternal and child anthropometric measurements.

Measurements

Anthropometric measurements were taken by experienced interviewers who received training on anthropometric measurements based on guidelines recommended by the Centers for Disease Control and Prevention. During infancy, a length board was used to take two measurements of the infant's recumbent length to the nearest 0·1 cm while the infant was lying in a supine position. Subsequently, during the fifth follow-up, a height board was used to collect the child's height to the nearest 0·1 cm while the child was standing. The infant's mother and the CHW in charge of the village assisted the interviewer in positioning the child as advised by the interviewer to ensure measurement reliability and validity.

An average of the two readings for length/height was used to compute the length/height-for-age *z* scores at each measurement point to assess stunting using the WHO growth reference standards by the z anthro command in STATA. This LAZ/HAZ score index is an indicator of linear growth with cut-off points to assess retardation and cumulative growth deficits in children. The WHO cut-offs were used to determine child nutrition status. Children with a LAZ/HAZ score of <–2 SD were considered stunted[24].

An SECA stadiometer was used to take two readings of the mother's height to the nearest 0·1 cm, while an electronic scale (SECA876; SECA) was used to take the mother's weight to the nearest 0·1 kg. From the two readings, an average value was computed and used as the weight and height of the mother to reduce the measurement error. The mother's BMI was calculated using her weight divided by her squared height (kg/m^2). Their nutrition status was categorised as underweight, normal, overweight or obese based on the WHO cut-off values[25].

Study variables

The primary outcome was children's stunting prevalence (LAZ/HAZ score of <–2 SD). The predictor variable was study group (intervention or control), while the covariates were infant breast-feeding and responsive feeding practices, child characteristics (term birth weight, weight for age, sex, morbidity experience) and maternal characteristics (village of residence, total income, level of education, occupation, household size, parity, marital status and hygiene practices) as guided by existing literature and conceptual frameworks[4,5].

Statistical analysis

Child linear growth from the first to the 13th month was analysed separately with the 55-month follow-up because of the big time lag. There were a few cases of missing data (<2·1 %) regarding the outcome variable, Table 2; therefore, imputation of the missing data was not performed. Descriptive statistics (proportions for categorical and means for continuous variables using χ^2 and *t* tests, respectively) were used to report maternal and child characteristics between the study arms at different follow-ups. Correlation coefficients were checked for covariates. A linear mixed effects model was used to fit LAZ/HAZ scores, as it takes account of correlations among repeated measures from the same child/household[26]. The subject (child) was modelled as a random effect, while the study group was modelled as a fixed parameter. Child birth weight, breast-feeding, age at weaning, child feeding and maternal height, among others were added as fixed covariates of the child linear growth model. Model building involved several steps, and the selected covariates in the final model were based on existing literature, results of the regression outputs and testing for collinearity. Different regression diagnostics were performed to assess the model goodness of fit and multicollinearity. Generalised linear model using generalised estimating equations were used to compare the findings of the linear mixed effects models, see online supplementary material, Supplemental Table S3. Preterm children were excluded from the final model. Statistical analysis was conducted using IBM SPSS version 24. Statistical significance was considered at $P < 0·05$.

Results

General characteristics of the mothers

There were no statistical differences observed between the control group and the intervention group regarding their socio-economic and demographic characteristics at baseline and at the fifth follow-up, except for ethnicity, Table 1. However, a change was observed in age group, school attendance, parity, occupation, weight, height and BMI of the women when the baseline and the fifth follow-up sociodemographic characteristics were compared. The mean (SD) weight of the mothers increased from 63·5 (SD 10·7) kg at baseline to 68·9 (SD 14·7) kg during the fifth follow-up. A mean height difference of 2 cm was observed between the baseline, 158·6 (SD 8·0) cm, and the fifth follow-up, 160·4 (SD 5·6) cm, probably as a result of 16 % women aged <18 years, with a range of 12–49 years old, during baseline data collection or technical measurement error.

Child health characteristics, responsive complementary feeding and caregivers' hygiene practices

Child health characteristics after birth are reported in Table 2. During the first follow-up after birth, mothers in the intervention group reported having delayed the introduction of complementary foods by 19 d as compared with those in the control group. Moreover, significantly higher proportions of mothers positively encouraging the child to finish food were reported in the intervention group than in the control group (58·0 % *v.* 42 %) during the

Table 1 General characteristics of the mothers by study group

	Baseline at enrolment (2012)					5th follow-up (2018)				
	Control (*n* 770)		Intervention (*n* 760)			Control (*n* 218)		Intervention (*n* 220)		
Variable category	*n*	%	*n*	%	*P*-value	*n*	%	*n*	%	*P*-value
Age group (years)										
14–20	222	28·8	223	29·3		5	2·3	1	0·5	
21–30	446	57·9	458	60·3	0·218	116	53·2	131	59·5	0·135
31–50	102	13·3	79	10·4		97	44·5	88	40·0	
School attendance										
Preschool	131	17·0	119	15·6		13	6·0	5	2·2	
Primary	450	58·4	429	56·5		132	60·6	119	54·1	
Secondary	171	22·3	186	24·5	0·131	66	30·3	84	38·2	0·055
College	18	2·3	26	3·4		7	3·1	12	5·5	
Occupation										
Unemployed	561	72·8	544	71·6		85	39·0	86	39·1	
Casual labour	95	12·4	97	12·8	0·345	79	36·3	72	32·7	0·532
Own business	92	12·0	95	12·4		46	21·0	50	22·7	
Salaried	22	2·8	24	3·2		8	3·7	12	5·5	
Marital status										
Married	639	83·0	606	79·7	0·431	157	72·0	180	81·8	0·067
Unmarried	131	17·0	154	20·3		61	28·2	40	18·2	
Religion										
Christian	701	91·0	700	92·2		192	88·0	210	95·4	
Muslim	65	8·5	40	5·2	0·631	23	10·6	7	3·2	0·081
Other	4	0·5	20	2·6		3	1·4	3	1·4	
Ethnicity										
Kikuyu	200	26·0	217	28·6		67	30·7	61	27·7	
Luhya	159	20·7	133	17·5		44	20·2	34	15·5	
Luo	111	14·4	125	16·5	0·180	29	13·3	57	25·9	0·002
Kamba	156	20·2	148	19·4		42	19·3	36	16·4	
Others	144	18·4	137	18·0		36	16·5	32	14·5	
Maternal BMI (kg/m^2)										
<18·5	10	1·3	10	1·3		7	3·3	5	2·3	
18·5–24·9	405	52·6	406	53·4	0·172	76	34·7	84	38·1	0·845
25·0–29·9	279	36·2	244	32·2		87	39·9	83	37·6	
30 and more	76	9·9	100	13·1		48	22·1	48	22·0	
Parity										
0–1 child	516	67·0	537	70·7		51	23·4	40	18·2	
2 children	127	16·5	119	15·6	0·268	66	30·3	82	37·3	0·213
3 or more	127	16·5	104	13·7		101	46·3	98	44·5	
Total monthly income in Kenyan Shilling										
<4000	136	17·7	170	22·4		52	23·8	43	19·5	
4000–6999	223	29·0	214	28·2	0·722	47	21·6	44	20·0	0·423
>7000	411	53·3	376	49·4		119	54·6	133	60·5	

post-infancy period (18 months' follow-up). During the third follow-up, a significantly higher proportion (61·1 % *v.* 56·2 %) of mothers in the control group reported stopping feeding their child once they refused to eat; a similar trend was observed post infancy, with 55·5 % of mothers in the control group *v.* 46·7 %. Besides, significantly more mothers in the control group (32·6 % *v.* 28·2 %) reported changing the texture of the food. In addition, significantly more children (13·4 %) in the control group than the intervention group (8·8 %) experienced food regurgitation/vomiting during feeding. Data on responsive feeding were not collected during the fifth follow-up as most of the children could feed by themselves, Table 2.

Good sanitation and hygiene practices were not common among the control group. For example, during the third and post-infancy follow-ups, the proportion of mothers who reported disinfecting utensils used for feeding their children was significantly higher in the intervention group (56·8 % and 32·1 %, respectively) than in the control group (44·8 % and 21·2 %), respectively. The proportion of mothers who reported using a cup/bowl and spoon to feed the child was also significantly higher in the intervention group (61·0 %) than in the control group (56·2 %). Only 6·5 % of the women reported using their palms/hands to feed their children, with more reported in the control group (8·2 %) than in the intervention group (4·8 %). During the fifth follow-up, about 44·5 % of the study participants paid a fee to use a toilet facility (35·3 % in the control and 53·6 % in the intervention), while 90·9 % paid for drinking water, with the majority (60·0 %) buying it from a tap water kiosk. Significantly more mothers in the intervention group reported to often (47·3 %) and

Table 2 Child health-related characteristics and feeding practices by study group and follow-up

	Follow-up first to fourth†				Fifth follow-up			
	Control (*n* 2108)		Intervention (*n* 1954)		Control (*n* 218)		Intervention (*n* 220)	
Variable‡	Mean	SD	Mean	SD	Mean	SD	Mean	SD
GA at birth in weeks	38·1	3·9	38·6	3·8*	38·4	3·0	38·7	4·2
Mean birth weight (kg)	3·2	0·5	3·2	0·5	3·3	0·6	3·2	0·6
Low birth weight								
n	35·0		12·0		13		7·0	
%	6·7		2·5*		6·0		3·2	
Infant sex, male								
n	1081		961		126		102	
%	51·3		49·2		57·8		46·4	
EBF (self-reported)								
n	1096		938		186		190	
%	52·0		48·0		85·3		86·4	
Age of CF for those not EBF	5·21	2·5	5·47	5·8	3·0	1·5	3·4	1·6
Common morbidity§	*n* 1775		*n* 1692					
Cough								
n	290		235		67		61	
%	16·3		13·9*		30·7		27·7	
Fever								
n	194		144		42		51	
%	10·9		8·5*		19·3		23·2	
Diarrhoea								
n	174		165		45		28	
%	9·8		9·8		16·1		12·7	
Mother wash hands before handling food *n* (%)	185	10·4	418	24·7**	90	41·5	104	47·5*
Mother wash hands before feeding child *n* (%)	–		–		45	20·7	64	29·2*
Pace of child feeding *n* (%)‖	*n* 1037		*n* 976					
Fast pace								
n	80		50		–¶		–	
%	7·7		5·1		–		–	
Moderate pace								
n	595		695		–		–	
%	57·4		71·2***		–		–	
Slow pace								
n	362		231		–		–	
%	34·9		23·7		–		–	
Child often vomits/regurgitates food *n* (%)‖	139	13·4	85	8·8**	–		–	
Encourages baby to finish food positively *n* (%)‖	372	35·9	434	44·5**	–		–	
Promise baby a reward if they finish food *n* (%)‖	50	4·8	88	9·0**	–		–	
Refocus baby's attention with play *n* (%)‖	326	31·4	346	35·4*	–		–	

GA, gestational age; EBF, exclusive breast-feeding; CF, complementary feeding.
**P* < 0·05, ** *P* < 0·01, ****P* < 0·001.
†Observations at 1, 4, 7, 9, 11 and 13 months old.
‡Continuous variables are presented as mean and SD; categorical variables are presented as numbers and percentages.
§Data were collected when the child was 1, 4, 7, 9 and 11 months old.
‖Data were collected when the child was 7, 9, 11 and 18 months old.
¶Information was not collected as the children could feed themselves.

sometimes (41·4 %) practice proper infant feeding practices as taught by CHW as compared with 21·6 % and 44·5 %, respectively, in the control group.

Child linear growth and prevalence of stunting

The LAZ scores decreased from birth to the 13th month, a mean (SD) of –1·42 (SD 2·04), with significantly higher stunting prevalence in the control group (33·5 %) than the intervention group (28·6 %). Moreover, male children were significantly stunted in comparison with the female children. Conversely, the scores increased in the 55th month, a mean (SD) of –0·89 (SD 1·04), with 13·9 % stunting prevalence in the control group and 11·1 % in the intervention group and significantly more males were stunted in the control group (16·5 %) than the intervention group (8·3 %). At the age of 7 and 13 months, children in the intervention group were reported to be taller by 0·47 cm and 0·72 cm, respectively, compared with the children in the control group, while the boys were reported to be slightly taller throughout the follow-ups. A significantly higher (–10 %) difference in stunting was observed between the intervention and control groups at the 9 months' visit. Consecutively, at 13 months, a higher proportion of

Table 3 Child mean length, length/height-for-age *z* (LAZ/HAZ)-score and prevalence of stunting by follow-up and study group

	Control			Intervention				
Variable*	Mean or *n*	SD or %	Total *n*	Mean or *n*	SD or %	Total *n*	95 % CI	*P*-value
LAZ (1–13 months)	−1·51	2·09	1868	−1·31	1·96	1737	−0·03, −0·07	0·003
Male stunted	432	40·0	949	301	31·4	853	–	<0·001
Female stunted	275	26·8	919	257	25·9	884	–	0·359
Total stunted	707	33·5	1868	558	28·6	1737	–	0·001
Missing	28	1·5		50	2·8		–	
HAZ (55 months)	−0·83	1·03	218	−0·73	1·06	220	−0·12, 0·33	0·361
Male stunted	21	16·5	126	8	8·3	102	–	0·045
Female stunted	9	9·9	92	16	14·3	118	–	0·386
Total stunted	30	13·9	218	24	11·1	220	–	0·226
Mean (SD) length and height in cm								
1 month	53·54	4·32	527	54·04	5·33	477	−1·13, 0·17	0·145
% stunted	142	27·0		112	23·4			0·126
4 months	60·62	4·21	432	60·63	3·81	414	−0·62, 0·54	0·892
% stunted	121	28·0		117	28·1			0·493
7 months	64·98	4·38	478	65·45	3·91	431	−1·07, 0·13	0·122
% stunted	162	33·9		127	29·5			0·116
9 months	67·56	3·98	280	67·95	3·46	261	−1·01, 0·24	0·228
% stunted	112	40·1		78	30·0			0·009
11 months	69·12	3·93	150	69·43	2·90	156	−1·11, 0·47	0·429
% stunted	57	37·9		49	31·3			0·148
13 months	71·32	3·51	241	72·04	2·72	215	−7·41, 4·74	0·638
% stunted	109	45·4		75	34·5			0·015
55 months	103·90	4·73	218	103·44	4·73	220	−0·43, 1·34	0·314

*Continuous variables are presented as mean and SD and CI; categorical variables are presented as numbers and percentages.

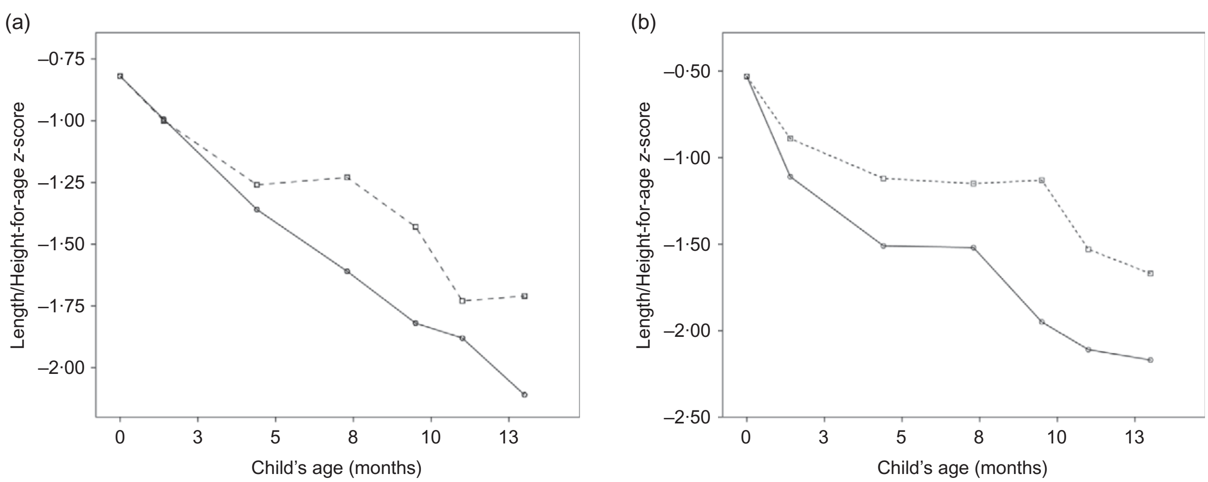

Fig. 2 Variation of child length/height-for-age *z*-score for (a) study group and (b) gender, from birth to 13th month. (a) --------, intervention; ———, control; (b) --------, female; ———, male

children were stunted in the control group than in the intervention group, Table 3. Figure 2 shows the LAZ/HAZ scores plotted against their age to show their growth pattern considering the study group and sex.

Factors associated with children's linear growth in mixed effects models

A fully adjusted linear mixed effects model was fitted for all the children with LAZ/HAZ scores from the first to the fifth follow-up, Table 4. Children in the control group, those living in the Korogocho informal settlements, were less likely to grow taller than were those in the intervention group and Viwandani informal settlements. Child factors such as being male, often regurgitating/vomiting food after feeding, being introduced to complementary foods before 6 months and maternal factors such as shorter stature were associated with lower LAZ/HAZ scores. However, term children born with normal birth weight (>2·5 kg), fed slowly or at a moderate pace, and breastfed longer, were more likely to grow taller than their counterparts.

Table 4 Factors associated with children's linear growth from linear mixed-effects model

Fixed effect parameters	Coefficient (β)	SE	95% CI	P-value
Intercept	–0·82	0·201	–1·22, –0·43	<0·001
Study group (ref. intervention)				
Control group	–0·21	0·096	–0·39, –0·02	0·031
Study site (ref. Viwandani)				
Korogocho	–0·73	0·181	–0·11, –0·30	0·001
Child sex (ref. female)				
Male child	–0·52	0·095	–0·71, –0·33	<0·001
Full-term birth weight (ref. LBW)	0·68	0·240	0·14, 1·08	0·011
Child is still BF above 1 year old	1·07	0·438	0·21, 1·93	0·015
Early weaning, before 6 months*	–0·48	0·071	–0·63, –0·35	<0·001
Usual pace of child feeding (ref. fast)				
Slow	0·49	0·206	0·09, 0·89	0·016
Moderate	0·81	0·197	0·42, 1·20	<0·001
Child often vomits/regurgitates food (ref. no)	–0·66	0·148	–0·95, –0·73	0·001
Caregiver washes hands before handling baby food (ref. no)	0·34	0·146	0·14, 0·53	0·001
Mother's height (ref. > 163 cm)				
<154·5 (<25th percentile)	–0·69	0·138	–0·63, –0·16	0·001
154·5–163 (50th percentile)	–0·13	0·115	–0·36, 0·10	0·272

LBW, low birth weight; BF, breastfeeding, CF, complementary feeding.
*Early weaning was defined as the introduction of complementary foods before 6 months.

Interestingly, a positive association was found between women who reported washing their hands before handling their child's food and the child's linear growth.

Discussion

Child stunting patterns and factors associated with their linear growth were assessed in this follow-up study of children born between 2012 and 2014 in two of Nairobi's urban informal settlements. A high prevalence of stunting at 1-year-olds was observed. However, a vast improvement was observed during the fifth year of follow-up when the average age of the children was four and a half years. This stunting pattern is common among children under five in low- and middle-income countries, with many studies reporting the highest stunting rates at 2 years of age[27,28]. Using new WHO standards on a sample of 1000–47 000 children from fifty-four countries measured from birth, Victora *et al.*[28] reported that the child's length/height falters dramatically until 24 months and increases slightly after 24 months, with bumps at 36 and 48 months. Moreover, a recent publication[29] whose participants were children born earlier (2007–2012) in the two study sites (Korogocho and Viwandani) reported significantly more children were stunted in Korogocho and maximum growth faltering in length at 2 years, after which a modest recovery was observed up to 5 years of age.

Significantly, more stunting prevalence was observed in the control group than in the intervention group throughout the follow-up period. Consequently, personalised, home-based NEC of pregnant and lactating women by trained CHW improved maternal nutrition status during pregnancy and after delivery, reduced low birth weight and preterm delivery of the children in the intervention group as reported in another publication based on the initial study[30], reduced their morbidity, created awareness on appropriate infant feeding practices and promoted proper hygiene practices. Moreover, more children were reported to have the minimum meal frequency in the intervention group than the control group as already published[31]. Previous studies have reported comparable findings[15,32,33]. For instance, a study in Pakistan reported a lower prevalence of growth faltering among the intervention group following nutrition counselling of mothers by trained health workers[34]. A study conducted in India[35] reported that intensive NEC of caregivers can increase meal frequency and improve the quality of food fed to children living in the urban slums of Mumbai. Therefore, on the basis of these previous studies, the likelihood exists to improve infant feeding practices and their nutrition status through the provision of maternal nutrition education interventions by trained CHW[14,36].

Although the difference in stunting proportions between the control and intervention groups was significantly higher in the first four follow-ups, a reduction in the prevalence of stunting during the 55th month follow-up was observed with a significant difference between the study arms observed among the male children. This finding is similar to the most recent (2019) prevalence of stunting (14·5 %) among children observed up to 5 years old in these slums[29] and a prevalence of 17 % for children under five in the whole of Nairobi based on 2014 KHDS[10]. The reduction in the prevalence of stunting during the fifth follow-up may be explained by the fact that maximum stunting rates are achieved at 2 years old after which the child tries to recover their height up to the age of 5 years[29]. Faye *et al.* reported an incidence of 45 %

stunting recovery among children from these slums[37]. Another possible explanation is that the African Population and Health Research Center implemented a project in 2015 of giving vouchers (to subsidise the cost of taking their child to a day care facility) to mothers with children aged 1–3 years old in the control and intervention groups[38]. This could have resulted in improved child feeding and their nutrition status because their mothers had time to engage in some income-generating activities. Hence, the majority of the mothers were either in casual employment or undertaking small business activities and their monthly income increased[38] as also evidenced in the occupation status during the fifth follow-up as compared with the baseline.

Various factors identified to be negatively or positively associated with LAZ/HAZ score have been reported in other studies. For example, studies in Indonesia reported LBW as the leading cause of stunting[6]. Low birth weight may result from intra-uterine growth restriction, which emphasises the need to initiate interventions prenatally to address child malnutrition. In the same paper and previous publications, boys are more likely to be stunted than girls, which also compares with the KDHS findings with higher levels of stunting among boys than girls[10]. Biologically, it is well known that girls tend to grow faster than boys during early childhood and they require fewer nutrients[39]. Notably, a significant difference in stunting between the two study groups was observed among boys but not among the girls. An exploration of already published[40] baseline qualitative data on breast-feeding from the initial study has probable explanatory responses. Mothers reported introducing complementary feeds to boys earlier than 6 months and could not practice continued breast-feeding up to 2 years like they do for girls due to a common belief that boys breastfeed 'a lot' and 'weaken' their mothers[40]. However, some studies have recommended exclusive breast-feeding and continued breast-feeding as a predictor of better linear growth[29,41] because it is a protective factor against child morbidity such as diarrhoea cough or wheeze, and vomiting[42]. In addition, previous studies that included child responsive feeding messages in the nutrition education package reported women in the intervention group actively encouraged their children to eat at 9 and 18 months. As a result, a positive effect of the intervention on children's dietary intake and growth was reported[15,43,44]. However, the independent effect of responsive feeding was not determined in these studies. Besides, maternal short stature is a known cause of child linear growth retardation[4], while good hygiene practice like washing hands before handling child food[45] is documented as a preventive measure against common illnesses in children such as diarrhoea and vomiting which causes nutrient loss and is associated with deteriorating child's linear growth if it recurs[46].

Strengths/limitations

The strengths of this study are that the initial study was a large and well-organised and monitored randomised controlled study, the CHW were well trained and supervised, and the data were well managed, thereby increasing their reliability. Moreover, to the best of our knowledge, it is the first randomised controlled trial of a personalised, home-based nutrition education intervention for maternal and young child nutrition and complementary feeding practices in urban informal settlements in Kenya. Additionally, this study is the first follow-up to assess and report the effect of NEC on stunting prevalence among this population after 5 years of study completion.

The limitations include: the study population is an urban informal settlement, which to some extent limits the generalisation of the results to the whole country; however, generalisation to similar impoverished settings is possible. Second, there was a high loss to follow-up. This trend is noted in most studies conducted in urban slums owing to high out-migration. However, the loss to follow-up baseline characteristics did not differ from those included for analysis. Third, the intervention group was routinely visited according to the counselling schedule, while the control group was routinely visited by the interviewers for measurements as for those in the intervention group. Moreover, CHW also visited the control group according to the usual practice specified within the community strategy. Therefore, it is not possible to rule out a potential for Hawthorne effect and contamination across the study participants given the nature of the intervention which involved knowledge transfer. However, since both mothers were visited by CHW, the cluster randomisation and blinding effect reduced the chances of contamination of the controls. Fourth, mothers might have given desired answers concerning child feeding practices due to social desirability in the context of an intervention. Conversely, the interviewers asked a lot of questions longitudinally regarding child feeding practices and were trained on probing to justify the answers given. Last, child's linear growth between 13 and 55 months was not assessed as height measurements were not taken.

Conclusion

According to this study's findings, providing maternal NEC during pregnancy and 1 year after delivery reduced stunting prevalence in the first and fifth year of life, with significantly lower rates of stunting observed among boys in the intervention group as compared with the control group. This could have resulted because of better responsive feeding practices, good hygiene practices and less morbidity among children born to mothers in the intervention group than among those born in the control group.

Further scale-up of household-based NEC needs to be evaluated by governments in urban informal settlements or similar high-risk areas.

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Supplementary material

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References

1. World Health Organization (2015) Joint child malnutrition estimates. Global Database on Child Growth and Malnutrition. http://www.who.int/nutgrowthdb/estimates2014/en/ (accessed May 2019).
2. Ahmed T, Hossain M & Sanin KI (2012) Global burden of maternal and child undernutrition and micronutrient deficiencies. *Ann Nutr Metab* **61**, Suppl. 1, 8–17.
3. Victora CG, Adair L, Fall C *et al.* (2008) Maternal and child undernutrition: consequences for adult health and human capital. *Lancet* **371**, 340–357.
4. Fenske N, Burns J, Hothorn T *et al.* (2013) Understanding child stunting in India: a comprehensive analysis of socio-economic, nutritional and environmental determinants using additive quantile regression. *PloS One* **8**, e78692.
5. Goudet SM, Kimani-Murage EW, Wekesah F *et al.* (2017) How does poverty affect children's nutritional status in Nairobi slums? A qualitative study of the root causes of undernutrition. *Public Health Nutri* **20**, 608–619.
6. Aryastami NK, Shankar A, Kusumawardani N *et al.* (2017) Low birth weight was the most dominant predictor associated with stunting among children aged 12–23 months in Indonesia. *BMC Nutr* **3**, 16.
7. Black RE, Victora CG, Walker SP *et al.* (2013) Maternal and child undernutrition and overweight in low-income and middle-income countries. *Lancet* **382**, 427–451.

8. Christian P, Mullany LC, Hurley KM *et al.* (2015) Nutrition and maternal, neonatal, and child health. *Semin Perinatol* **39**, 361–372.
9. Kenya National Bureau of Statistics (KNBS) & ICF Macro (2010) *Kenya Demographic and Health Survey 2008–09*. Calverton, MD: KNBS and ICF Macro. https://dhsprogram.com/pubs/pdf/fr229/fr229.pdf (accessed April 2019).
10. Kenya National Bureau of Statistics (KNBS) & ICF Macro (2014) *Kenya Demographic and Health Survey 2008–09*. Calverton, MD: KNBS and ICF Macro. https://dhsprogram.com/pubs/pdf/fr308/fr308.pdf (accessed April 2019).
11. Bakibinga P, Ettarh R, Ziraba AK *et al.* (2014) The effect of enhanced public–private partnerships on maternal, newborn and child health services and outcomes in Nairobi–Kenya: the PAMANECH quasi-experimental research protocol. *BMJ Open* **4**, e006608.
12. Kimani-Murage EW, Norris SA, Mutua MK *et al.* (2015) Potential effectiveness of Community Health Strategy to promote exclusive breastfeeding in urban poor settings in Nairobi, Kenya: a quasi-experimental study. *J Dev Orig Health Dis* **7**, 172–184.
13. Dewey KG & Adu-Afarwuah S (2008) Systematic review of the efficacy and effectiveness of complementary feeding interventions in developing countries. *Matern Child Nutr* **4**, 24–85.
14. Imdad A, Yakoob MY & Bhutta ZA (2011) Impact of maternal education about complementary feeding and provision of complementary foods on child growth in developing countries. *BMC Public Health* **11**, Suppl. 3, S25.
15. Penny ME, Creed-Kanashiro HM, Robert RC *et al.* (2005) Effectiveness of an educational intervention delivered through the health services to improve nutrition in young children: a cluster-randomised controlled trial. *Lancet* **365**, 1863–1872.
16. Bhandari N, Bahl R, Nayyar B *et al.* (2001) Food supplementation with encouragement to feed it to infants from 4 to 12 months of age has a small impact on weight gain. *J Nutr* **131**, 1946–1951.
17. Goudet S, Bogin B, Madise N *et al.* (2019) Nutritional interventions for preventing stunting in children (birth to 59 months) living in urban slums in low- and middle-income countries (LMIC). *Cochrane Database of Syst Rev* **6**, CD011695.
18. Davis R, Campbell R, Hildon Z *et al.* (2015) Theories of behaviour and behaviour change across the social and behavioural sciences: a scoping review. *Health Psychol Rev* **9**, 323–344.
19. Kimani-Murage EW, Kyobutungi C, Ezeh AC *et al.* (2013) Effectiveness of personalised, home-based nutritional counselling on infant feeding practices, morbidity and nutritional outcomes among infants in Nairobi slums: study protocol for a cluster randomised controlled trial. *Trials* **14**, 445–445.
20. Kimani-Murage EW, Griffiths PL, Wekesah FM *et al.* (2017) Effectiveness of home-based nutritional counselling and support on exclusive breastfeeding in urban poor settings in Nairobi: a cluster randomized controlled trial. *Global Health* **13**, 90.
21. Beguy D, Elung'ata P, Mberu B *et al.* (2015) Health & demographic surveillance system profile: The Nairobi Urban Health and Demographic Surveillance System (NUHDSS). *Int J Epidemiol* **44**, 462–471.
22. Emina J, Beguy D, Zulu EM *et al.* (2011) Monitoring of health and demographic outcomes in poor urban settlements: evidence from the Nairobi Urban Health and Demographic Surveillance System. *J Urban Health* **88**, 200–218.
23. World Health Organization (2006) *Infant and Young Child Feeding Counselling: An Integrated Course*. Geneva: WHO Document Production Services. https://apps.who.int/iris/bitstream/handle/10665/43567/9789241594776_eng.pdf;sequence=4 (accessed June 2019).
24. WHO (2006) Child Growth Standards based on length/height, weight and age. *Acta Paediatr Suppl* **450**, 76–85.
25. WHO (1995) Physical status: the use and interpretation of anthropometry. Report of a WHO Expert Committee. *World Health Organ Tech Rep Ser* **854**, 1–452.
26. Ware JH (1985) Linear models for the analysis of longitudinal studies. *Am Stat* **39**, 95–101.
27. Svefors P, Rahman A, Ekström E-C *et al.* (2016) Stunted at 10 years: linear growth trajectories and stunting from birth to pre-adolescence in a rural Bangladeshi cohort. *PLoS One* **11**, e0149700–e0149700.
28. Victora CG, de Onis M, Hallal PC *et al.* (2010) Worldwide timing of growth faltering: revisiting implications for interventions. *Pediatrics* **125**, e473–e480.
29. Faye CM, Fonn S, Levin J *et al.* (2019) Analysing child linear growth trajectories among under-5 children in two Nairobi informal settlements. *Public Health Nutri* **22**, 2001–2011.
30. Nyamasege CK, Kimani-Murage EW, Wanjohi M *et al.* (2018) Determinants of low birth weight in the context of maternal nutrition education in urban informal settlements, Kenya. *J Dev Orig Health Dis* **10**, 237–245.
31. Macharia TN, Ochola S, Mutua MK *et al.* (2018) Association between household food security and infant feeding practices in urban informal settlements in Nairobi, Kenya. *J Dev Orig Health Dis* **9**, 20–29.
32. Shi L, Zhang J, Wang Y *et al.* (2009) Effectiveness of an educational intervention on complementary feeding practices and growth in rural China: a cluster randomised controlled trial. *Public Health Nutri* **13**, 556–565.
33. Mistry SK, Hossain MB & Arora A (2019) Maternal nutrition counselling is associated with reduced stunting prevalence and improved feeding practices in early childhood: a post-program comparison study. *Nutr J* **18**, 47.
34. Zaman S, Ashraf RN & Martines J (2008) Training in complementary feeding counselling of healthcare workers and its influence on maternal behaviours and child growth: a cluster-randomized controlled trial in Lahore, Pakistan. *J Health Popul Nutr* **26**, 210–222.
35. Palwala M, Sharma S, Udipi SA *et al.* (2009) Nutritional quality of diets fed to young children in urban slums can be improved by intensive nutrition education. *Food Nutr Bull* **30**, 317–326.
36. Sunguya BF, Poudel KC, Mlunde LB *et al.* (2013) Effectiveness of nutrition training of health workers toward improving caregivers' feeding practices for children aged six months to two years: a systematic review. *Nutr J* **12**, 66.
37. Faye CM, Fonn S & Levin J (2019) Factors associated with recovery from stunting among under-five children in two Nairobi informal settlements. *PLoS One* **14**, e0215488.
38. Clark S, Kabiru CW, Laszlo S *et al.* (2019) The impact of childcare on poor urban women's economic empowerment in Africa. *Demography* **56**, 1247–1272.
39. Galloway T (2007) Gender differences in growth and nutrition in a sample of rural Ontario schoolchildren. *Am J Hum Biol* **19**, 774–788.
40. Wanjohi M, Griffiths P, Wekesah F *et al.* (2017) Sociocultural factors influencing breastfeeding practices in two slums in Nairobi, Kenya. *Int Breastfeed J* **12**, 5.
41. Kramer MS & Kakuma R (2012) Optimal duration of exclusive breastfeeding. *Cochrane Database Syst Rev* Cd003517. doi: 10.1002/14651858.CD003517.
42. Popkin BM, Adair L, Akin JS *et al.* (1990) Breast-feeding and diarrheal morbidity. *Pediatrics* **86**, 874–882.

43. Bhandari N, Mazumder S, Bahl R *et al*. (2004) An educational intervention to promote appropriate complementary feeding practices and physical growth in infants and young children in rural Haryana, India. *J Nutr* **134**, 2342–2348.
44. Bentley ME, Wasser HM & Creed-Kanashiro HM (2011) Responsive feeding and child undernutrition in low- and middle-income countries. *J Nutr* **141**, 502–507.
45. Rah JH, Cronin AA, Badgaiyan B *et al*. (2015) Household sanitation and personal hygiene practices are associated with child stunting in rural India: a cross-sectional analysis of surveys. *BMJ Open* **5**, e005180.
46. Guerrant RL, Oriá RB, Moore SR *et al*. (2008) Malnutrition as an enteric infectious disease with long-term effects on child development. *Nutr Rev*. **66**, 487–505.