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Determinants of low birth weight in the context of maternal nutrition education in urban informal settlements, Kenya

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Abstract

Inadequate knowledge in maternal nutrition is one of the determinants of low birth weight. However, little evidence is available on whether maternal nutrition counselling alone can influence birth weight among women from low socioeconomic households. This study assessed the effect of prenatal maternal nutritional counselling on birth weight and examined the related risk factors. A cluster randomized controlled trial was conducted to assess the effectiveness of home-based maternal nutritional counselling on nutritional outcomes, morbidity, breastfeeding, and infant feeding practices by the African Population and Health Research Center in two urban informal settlements of Nairobi. The intervention group received monthly antenatal and nutritional counselling from trained community health volunteers; meanwhile, the control group received routine antenatal care. A total of 1001 participants were included for analysis. Logistic regression was applied to determine associations between low birth weight and maternal characteristics. A higher prevalence of low birth weight was observed in the control group (6.7%) than in the intervention group (2.5%; $P < 0.001$). Logistic regression identified significant associations between birth weight and intervention group (adjusted odds ratio (AOR) = 0.26; 95% confidence interval (CI), 0.10–0.64); maternal height <154.5 cm (AOR = 3.33; 95% CI, 1.01–10.96); last antenatal care visits at 1st or 2nd trimesters (AOR = 9.48; 95% CI, 3.72–24.15); pre-term delivery (AOR = 3.93; 95% CI, 1.93–7.98); maternal mid-upper arm circumference <23 cm (AOR = 2.57; 95% CI, 1.15–5.78); and cesarean delivery (AOR = 2.27; 95% CI, 1.04–4.94). Nutrition counselling during pregnancy reduced low birth weight and preterm births, which was determined by women of short stature, early stoppage of antenatal visit, and cesarean delivery.

Introduction

Over 20 million infants worldwide (15.5% of all births) are born with low birth weight (LBW), that is, weight of less than 2.5 kg within the first hours of life.[1] The majority of LBWs (95.6%) are reported from low and middle-income countries.[2] Low birth weight has a negative impact on child survival, causing 40% to 80% of neonatal deaths owing to related complications,[3] stunted growth, disabilities, deficits in neurological development, and long-term health-related chronic diseases such as diabetes as well as cardiovascular diseases.[4]

More than 43 factors have been reported to play an important role in influencing an infant's birth weight.[5] These factors are linked to the mother, the infant, or the social and physical environments. Most of these risks and causal factors such as premature delivery, poor maternal nutritional status, inadequate nutritional knowledge, teenage pregnancy, teenage maternal height, morbidity during pregnancy, psychosocial status, antenatal care practices, lifestyle, low education, exposure to toxins, and socioeconomic level are modifiable through interventions. For example, women with inadequate gestational weight gain (<1 kg per month in the last 2 trimesters) have a higher risk of intrauterine growth restriction (IUGR), which is a main cause of LBW; thus, adequate pregnancy weight gain can alleviate the effects on the fetus.[6] Conversely, the biological/genetic constitution of the parents, sex of the fetus, multiple pregnancies, and ethnicity among others are unalterable even with interventions in place.

Therefore, many interventions have been put in place to improve mothers' prenatal health and newborn birth outcomes. For instance, nutrition education and counselling (NEC), an interactive supporting process focusing on the need for diet modification, is a widely used strategy in health facilities to improve the nutritional status of women during pregnancy. It is based on the World Health Organization's (WHO) recommendations on healthy eating and antenatal care for good pregnancy outcomes.[7] Third trimester nutrition education coupled with food supplementation was demonstrated to have a positive impact on the nutrition knowledge of pregnant women and led to an improvement in gestational weight gain and neonatal birth weight among low and middle income populations.[8–10] However, Nair *et al.* in a recent publication did not report significant findings in a similar randomized study of low-income women in India.[11] Moreover, to the best of our knowledge, no similar study of the effect of nutrition counselling on LBW has been conducted in Kenya.

Hence, more research still needs to be conducted to increase certainty on the effect of NEC offered to pregnant women living in urban informal settlements on their newborns' birth weight. Besides this, it has been reported that people rarely change their behavior on the basis of telling alone[12] and that societal and environmental factors confound nutrition and behavior change.[13] Consequently, this study aimed at examining the effect of personalized home-based nutrition counselling of pregnant women on birth weight. This study also examined LBW-related risk factors and elucidated the combined effect of living in low socioeconomic households challenged with poverty, illiteracy, inadequate resources, and limited access to adequate nutrition.

Methods

Study design and population

This study was embedded into a larger cluster randomized controlled trial, Maternal Infant and Young Child Nutrition (MIYCN), by the African Population and Health Research Center (APHRC) from 2012 to 2015. The primary outcome of the umbrella study was the effectiveness of personalized, home-based nutrition counselling of pregnant and postnatal women on the prevalence of exclusive breastfeeding.[14] Hence, the effect of the intervention on birth weight was tested in this study. The study participants were residents of two densely populated slums (Korogocho, 63, 318/km^2 and Viwandani, 52, 583/km^2) located 7 km apart from each other. The Korogocho slum is the fourth largest informal settlement in Nairobi. It is located 11 km from the capital city. Majority of Viwandani residents are mobile youth migrants seeking jobs in nearby industries unlike Korogocho residents who rarely migrate. Residents of both slums have limited access to formal health care and education, live in highly insecure places with inadequate infrastructure, poor housing, polluted environment, high unemployment rates, and poor health indicators.[15] The APHRC runs systematic quarterly collection of demographic data under the Nairobi Urban Health and Demographic Surveillance System (NUHDSS), which covers most of the residents of the two slums.[15] The NUHDSS collects and records vital demographic events of all household members such as pregnancies, deaths, births, morbidity, in/out migration, and household assets.

Recruitment of the study participants took place from September 2012 to February 2014. There were 14 villages in the two slums. A computer-generated cluster-randomization system was used to allocate seven villages into the intervention group and the other seven into the control group. Both slums were represented in both the intervention and the control groups. The clusters were stratified using the total number of women of reproductive age registered in the NUHDSS and slum of residence. Pregnant women were prospectively included throughout the trimesters. To recruit most of the pregnant women, the NUHDSS register of quarterly collected data from households was used to identify pregnant women. Other pregnant women were identified by antenatal care (ANC) providers and community health volunteers (CHVs). The inclusion criteria for each pregnant woman were that she resided in the Korogocho or the Viwandani slum, was aged 12 to 49 years, was registered within the NUHDSS, and provided informed consent. The exclusion criteria from the study were women of reproductive age who were to deliver before the intervention started. Sample size calculation of the umbrella study took into consideration the cluster randomized study design. Up to delivery, there were 529 mothers remaining in the intervention and 581 women remaining in the control group. In the current study, we analyzed 480 and 521 mother-infant pairs in the intervention group and control group, respectively, with the information on birth weight and related variables. Sample size was justified based on a 0.11 kg-effect size, a mean birth weight difference in the intervention and control, as reported in a systematic review by Girard *et al.*[16] of similar studies from low- and middle-income countries. To achieve a power of 80%, at an alpha value of 0.05 and a beta value of 0.2 for a two-sided t-test, a variance of 0.76 was used. Thus, a calculated sample size of 806 (403 mother and infant pair from each study arm) was necessary to detect a significant difference. More details on the umbrella study can be seen in a previous paper describing the trial protocol.[14] A consort flowchart is available in a publication by Kimani *et al.*[17]

Intervention and control

The intervention group received nutritional counselling from trained CHVs. These CHVs were recruited from the community units. Community units (CUs) as defined by the national community health strategy were used as clusters. The CUs are geographically defined units with an approximate population of 5,000 people. Within each CU, a CHV provides primary health care services to people.[18]

The CHVs had a minimum of primary school education and basic primary health care training from the Kenyan ministry of health. They were further trained using the community Infant and Young Child Feeding (IYCF) training package developed by United Nations Children's Fund (UNICEF)/WHO in 2006 and adopted by the government of Kenya. The trained CHVs passed down this information to the mothers primarily, but also to the fathers or other caregivers where possible in the intervention group. Counselling was initiated as soon as the mother was recruited, as early as possible during pregnancy, and then continued monthly till after one year following delivery. A total of seven home-based, personalized nutrition-counselling sessions were offered during pregnancy to each pregnant woman in the intervention group. The first 4 sessions were conducted once in every fourth week till the 34th week of gestation, while the other three sessions were done weekly till the mother gave birth. Key messages were adopted from the training package and highlighted in brightly colored IYCF counselling cards. These cards were used by the CHVs during counselling. The specific maternal nutrition education key messages included importance of adequate diet during pregnancy, attending ANC, and taking iron and folate

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supplements. Other maternal health-related key messages were on seeking early treatment for infections and how to prevent them, encouraging the use of good hygienic practices, avoiding alcohol, smoking, and nonprescription drugs, and good antenatal care.[19] The counselling schedule for CHVs is published in supplementary material by Kimani *et al.*[17] The control group received the usual ANC services, reading materials on MIYCN, and counselling visits on basic health care by the CHVs. The CHVs home visits are defined by the needs of the pregnant woman as a common practice specified under community health promotion strategies.[18] These CHVs did not receive the additional training on MIYCN as the CHVs in the intervention group did.[14]

Data collection and measurements

Data collection was done at household level using semi-structured questionnaires. Fifteen trained and experienced field interviewers (independent from the CHVs) with a minimum of secondary school education collected data from the participants. The questionnaires were subdivided into recruitment, baseline, anthropometry, pre-birth, household food security, and cohort follow-up questionnaires. The pregnant woman's anthropometrics and self-reported morbidity experience were taken every four months during the follow-up period between 2012 and 2015, depending on when she joined the cohort. Hence, the variables necessary for our study were taken twice, at baseline and pre-birth. Mid-upper arm circumference (MUAC) tapes were used to take the circumference of the mother's straightened arm. The MUAC thresholds of <23.0 cm were applied to identify malnourished women who were at higher risk of delivering LBW babies.[20] The MUAC cut-off point for normal was 23 to 32 cm and for overweight and obese, >33 cm. The MUAC was preferred for analysis in this study since it reflects the nutritional status of the mother only, the measurements have a narrow range of cut-off values, it has been identified to have a strong association with LBW in previous studies, and it is rather insensitive to changes such as presence of edema, which is common in pregnant women.[20] Additionally, the MUAC has been reported to be highly correlated with body mass index (BMI), and researchers suggest it can be used in place of BMI.[21]

The height quartiles were used as cut-offs for maternal stature, although the WHO classifies <145 cm as short stature. The short stature cut-off (<154.5 cm) in this study is comparable to a range of 146 to 157 cm for women of short stature, which can be used to identify risk of LBW, as reported in a literature review by Ververs *et al.*[20,22] Blood pressure was measured using a blood pressure gauge. Cut-off points for elevated blood pressure, diastolic (>80 mmHg) blood pressure, and systolic (>120 mmHg) blood pressure were used. The field interviewers recorded the majority of the birth weight data from the mother's clinic booklet given to all pregnant women visiting ANC in Kenya. However, some of the mothers self-reported birth weight since they could not trace the clinic booklet.

Statistical analysis

The differences between the intervention and the control groups were tested in regard to the maternal baseline socioeconomic and demographic characteristics (maternal age, education levels, ethnicity, occupation, parity, nutritional status); follow-up ANC practices including the number of ANC visits; services offered such as personnel who assisted during delivery; place of delivery; morbidity during pregnancy (hypertension, anemia, malaria, fever, gestational diabetes, nausea, and vomiting); and nutrient supplementation, among others. This analysis was conducted using the chi-square test, which was adjusted for village-based clustering and reported in proportions and *P*-values. Student's independent *t*-test was used to test differences between two means for the independent continuous variables (age, height, BMI, MUAC, and systolic and diastolic blood pressure). The mean birth weight and LBW proportions among the available maternal factors[5] were reported in the univariate analysis. The outcome variable (birth weight) was grouped into LBW (<2.5 kg) and normal birth weight (≥2.5 kg) in the categorical analysis.

Univariate analysis was performed to test for associations between LBW and possible risk factors. Logistic regression analysis was conducted to determine associations between LBW and maternal factors that were significant at $P < 0.10$ by univariate analysis. Linear regression was also performed with birth weight as a continuous variable for some covariates. Interactions and multicollinearity were tested among variables in the final model. The strength of association between LBW and the covariates was reported using adjusted ORs and their 95% confidence intervals. Statistical significance was set at $P < 0.05$ and analyses were carried out using the Statistical Package for the Social Sciences (SPSS) version 24, IBM New York.

Results

Baseline information of the women by study group, at enrollment

The control group had a slightly higher number of participants (n = 521) than did the intervention group (n = 480). The baseline nutritional status and the socioeconomic and demographic characteristics were comparable between the study groups except for occupation and parity (Table 1). All the women were aged between 14 and 45 years. Most of the women in both study groups had attended up to elementary school, were unemployed, and were having either their first or second child. Maternal mean (SD) height and BMI was similar in both the intervention and the control groups, 158.7 (8.8) cm and 25.2 (4.6) kg/m^2, respectively.

Almost a quarter of the women (22.5%; n = 400) were taking nutritional supplements at baseline, which was slightly more in the intervention (23.9%) than in the control group (21.3%) but did not meet the level of significance. However, even though at baseline a level of significance was not achieved, during follow-up, more women (30.5%; n = 400) reported using nutritional supplements with an increased proportion in the control group (31.5%) as compared with the intervention group (29.3%). Very few women (0.6%) consumed alcohol during pregnancy. On the other hand, 30.8% had pica (eating stones or soil) during the baseline period (Table 1). Conversely, during the follow-up, the proportion of those with pica decreased significantly ($P < 0.001$) in the intervention group from 30.5% at baseline to 19.2% as compared with the control group, in which pica increased slightly from 31.1% to 32.2%.

Follow-up antenatal check, nutritional status, pregnancy-related morbidity, and infant deliveries

The mean (SD) birth weight was 3.2 (0.52) kg (range, 1–5.8 kg) (Table 2). Male infants weighed slightly more than female infants. Slightly more female infants than male infants were also born

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Table 1. Baseline characteristics of the women by study group (at enrollment)

Variable	Control n = 521	Intervention n = 480	P-value
Age group	n(%)	n(%)	
14–19	88 (16.9)	80 (16.6)	
20–24	212 (40.7)	209 (43.5)	0.112
25–29	127 (24.4)	127 (26.4)	
30–45	94 (18.0)	64 (13.5)	
Highest level of education			
Less than primary	84 (16.1)	67 (14.1)	
Completed primary	303 (58.3)	272 (56.6)	0.276
Secondary school	114 (21.8)	119 (24.8)	
College/university	20 (3.8)	22 (4.5)	
Occupation			
Unemployed	481 (92.3)	406 (84.7)	
Self-employed	22 (4.2)	38 (7.9)	0.023
Casual labor	13 (2.5)	22 (4.5)	
Salaried	5 (1.0)	14 (2.9)	
Marital status			
Married/living together	433 (83.2)	383 (79.8)	
Single	60 (11.6)	65 (13.5)	
Separated/divorced	18 (3.5)	17 (3.6)	0.235
Widowed	2 (0.5)	3 (0.6)	
Missing	6 (1.2)	12 (2.5)	
Ethnicity			
Kikuyu	136 (26.0)	137 (28.6)	
Luhya	108 (20.7)	84 (17.5)	0.180
Luo	75 (14.4)	79 (16.5)	
Kamba	105 (20.2)	93 (19.4)	
Others	97 (18.7)	87 (18.0)	
Maternal height, cm			
< 154.5 cm (25th percentile)	136 (26.2)	119 (24.8)	
154.5–163.0 cm (50th percentile)	278 (53.3)	252 (52.4)	0.845
> 163 cm (75th percentile)	107 (20.6)	109 (22.8)	
Mid-upper arm circumference, cm			
Lower (<23 cm)	83 (15.9)	75 (15.6)	
Normal (23–32 cm)	415 (79.7)	394 (82.1)	0.108
Overweight and obese (>33 cm)	23 (4.4)	11 (2.3)	

Table 1. (*Continued*)

Variable	Control n = 521	Intervention n = 480	P-value
Time in weeks of the 1st ANC visit			
First trimester (<13 weeks)	39 (7.5)	47 (9.8)	
Second trimester (13–28 weeks)	424 (81.4)	387 (80.6)	0.331
Third trimester (>28 weeks)	58 (11.1)	46 (9.6)	
History of stillbirth			
Yes	70 (13.4)	61 (12.8)	0.215
No	451 (86.6)	419 (87.2)	
Parity			
0	183 (35.2)	194 (40.5)	
1	162 (31.2)	148 (30.8)	0.025
2 and more	176 (33.6)	138 (28.7)	
Infant's sex			
Male	270 (51.8)	241 (50.2)	0.151
Female	251 (48.2)	239 (49.8)	
Taking nutrient supplements			
Yes	111 (21.3)	115 (23.9)	0.135
No	410 (78.7)	365 (76.1)	
Consumed soil/mineral stones (pica)			
Yes	162 (31.1)	146 (30.5)	0.421
No	359 (68.9)	334 (69.5)	
Previous cases of under 5 child deaths	**n = 61**	**n = 54**	
<2 children	53 (86.5)	47 (87.2)	
2–3 children	8 (12.4)	6 (11.5)	
>4 children	1 (1.1)	1 (1.3)	

Data are presented as a number and percentage with *P*-values based on the chi-square test, which accounts for clustering at the village level.
ANC, antenatal care.

with LBW, but the difference was not significant. A higher prevalence of LBW (6.7%; n = 35) was observed in the control group than in the intervention group (2.5%; n = 12, $P < 0.001$).

Most of the pregnant women (90.5%) attended ANC, with a mean (SD) number of visits of 3.62 (1.6) (median 4). The intervention group reported an almost comparable mean (SD) number of ANC visits 3.67 (1.6) as the control group's mean (SD) 3.54 (1.5). Both study groups received similar types of antenatal care services such as an HIV test, blood pressure measurements, ultrasound scans, iron supplementation, antimalarial tablets, deworming tablets, mosquito nets, tetanus vaccination during the

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Table 2. Follow-up health information collected during the last home visit before infant delivery

Variable	Control n = 521	Intervention n = 480	*P*-value
Average number of ANC visits	n (%)	n (%)	
3 or less times	254 (48.8)	230 (48.0)	
4–5 times	232 (44.4)	191 (39.8)	0.003
6 or more	35 (6.8)	59 (12.2)	
Time of last antenatal visit, weeks			
1st and 2nd trimester (<28 weeks)	27 (5.1)	13 (3.0)	
3rd trimester (≥28 weeks)	494 (94.9)	466 (97.0)	0.030
MUAC, cm			
At risk of LBW (<23 cm)	64 (12.3)	50 (10.4)	
Normal (23–32 cm)	414 (79.5)	422 (88.0)	< 0.001
Overweight and obese (≥33 cm)	43 (8.2)	8 (1.6)	
Delivery personnel			
Doctor/clinical officer	277 (53.1)	169 (35.3)	
Nurse/midwife	228 (43.7)	281 (58.6)	<0.001
Others[a]	16 (3.2)	20 (6.1)	
Mode of delivery			
Spontaneous vertex delivery	425 (81.6)	388 (80.8)	0.407
Cesarean	96 (18.4)	92 (19.2)	
Place of delivery			
Health facility	513 (98.5)	473 (98.6)	0.132
Home	8 (1.5)	7 (1.4)	
Birth weight distribution			
LBW (<2.5 kg)	35 (6.7)	12 (2.5)	
Normal (2.5–3.9 kg)	444 (85.2)	430 (89.6)	< 0.001
Macrosomia (≥4 kg)	42 (8.1)	38 (7.9)	
Mean gestation age at birth, weeks			
Preterm births (<37 weeks)	144 (27.6)	111 (23.2)	0.003
Term and post term births (≥37 weeks)	377 (72.4)	369 (76.8)	

[a]relative, neighbor, friend, self, traditional birth attendant.
ANC, antenatal care; MUAC, mid-upper arm circumference; LBW, low birth weight.

first antenatal care check, and weight monitoring at every visit. The proportions of the services received did not differ significantly between the intervention group and the control group. Moreover, significantly more women in the intervention group attended ANC during the third trimester (Table 2).

The prevalence of women at risk of delivering LBW babies was significantly reduced in the intervention group as compared with that in the control group by examination of their mid-upper arm circumferences (MUAC <23 cm). In addition, during follow-up, there were more overweight and obese women in the control group, MUAC mean (SD) 26.56 (4.5) cm, than in the intervention group, MUAC mean (SD) 25.68 (2.8) cm. The mean (SD) for MUAC was similar to the mean (SD) BMI in both study groups (Table 2).

At enrollment, the systolic blood pressure reading was normal (91–120 mmHg) in 83.3% of the pregnant women, less than 90 mmHg in 11.1%, and above 120 mmHg in 5.6%. The diastolic blood pressure reading was normal (61–79.9 mmHg) in 72.8% of the pregnant women, 60 mmHg or below in 19.1%, and above 80 mmHg in 8.1%. The observed measurements for the systolic and diastolic blood pressures were almost similar at baseline and late pregnancy, and no statistical differences were observed between the study groups.

At baseline, the prevalence of women in the control group who reported having experienced severe nausea and vomiting (48.5%), malaria (17.7%), and fever (27.7%) was significantly higher ($P = 0.001$) than that in the intervention group (39.8%, 11.9%, and 14.4%, respectively). Comparisons of the baseline and follow-up data showed slight but not significant reductions in malaria, anemia, bleeding, spotting, severe nausea, and vomiting in the intervention group, but no changes in the control group. During pregnancy, elevated blood pressure was experienced by only 2.5% of the women; bleeding or spotting by 3.8%; and anemia, by 6.5%. The difference between the intervention and the control group was not statistically significant. Other pregnancy-related medical conditions were swollen legs (14.2%), depression (2.4%), fainting (2.8%), varicose veins (1.3%), and gestational diabetes (0.8%) (Table 3). When these conditions were tested for association with birth weight, none of the morbidities of the mother had a significant association.

Most of the women (98.6%) from both study groups delivered in the health facility, with 95.4% of these deliveries being assisted by skilled personnel (doctor, nurse, midwife or clinical officer). The majority (92.4%) of the babies were weighed at birth. The mean (SD) gestational age at birth was 38.6 (10.9) weeks. The women in the control group and the intervention group had similar mean (SD) gestational age at birth, 38.54 (12.5) weeks and 38.58 (8.8) weeks, respectively. Slightly more female infants were born earlier, mean (SD) 38.14 (7.9) weeks, than male infants, 38.97 (13.19) weeks. Similar proportions (18.2%) of women delivered via cesarean section (CS) in both study groups. Significantly more (27.6%) preterm babies were born in the control than in the intervention group (23.2%). However, the mean (SD) gestation age at birth for CS deliveries was 38.58 (8.80) weeks and 38.54 (12.40) weeks in the intervention group and the control group, respectively; the difference was not statistically significant (Table 2).

Regression analysis for low birth weight risk factors

Variables for which a significance of $P < 0.10$ was obtained in the univariate analysis were tested using logistic regression. None of the baseline variables other than parity and mother's height had any significant associations with birth weight (Table 4). Women in the intervention group had a lower risk of LBW (OR = 0.36; 95% confidence interval (CI), 0.18–0.69). Women with short stature, first time delivery, MUAC of less than 23 cm, doctor-assisted delivery, teenage mothers, preterm births (<37 weeks), events of fever during pregnancy, MUAC < 23 cm, and discontinued ANC

Table 3. Maternal self-reported morbidity during pregnancy

	Enrollment (Baseline information)			After Intervention (Pre-Birth Data)[a]		
Morbidity Experience (n, %)	Control n = 521	Intervention n = 480	*P*-value	Control n = 521	Intervention n = 480	*P*-value
High blood pressure						
Yes	14 (2.6)	12 (2.5)	0.548	9 (1.8)	14 (3.0)	0.943
No	507 (97.4)	468 (97.5)		512 (98.2)	466 (97.0)	
Gestational diabetes						
Yes	3 (0.6)	4 (0.8)	0.474	3 (0.6)	4 (0.8)	0.510
No	518 (99.4)	476 (99.2)		518 (99.4)	476 (99.2)	
Malaria						
Yes	92 (17.7)	57 (11.9)	0.001	41 (7.9)	47 (9.7)	0.001
No	429 (82.3)	423 (88.1)		480 (92.1)	433 (90.3)	
Fever						
Yes	145 (27.7)	69 (14.4)	0.001	153 (29.4)	69 (14.3)	< 0.001
No	376 (72.3)	411(85.6)		368 (70.6)	411 (85.7)	
Anemia						
Yes	45 (8.6)	37 (7.7)	0.300	39 (7.5)	26 (5.4)	0.422
No	476 (91.4)	443 (92.3)		482 (92.5)	454 (94.6)	
Severe nausea and vomiting (morning sickness)						
Yes	253 (48.5)	191 (39.8)	0.001	212 (40.6)	179 (37.2)	0.002
No	268 (51.5)	289 (60.2)		309 (59.4)	301 (62.8)	

[a]Majority (73.7%) were in the third trimester during data collection and there was no statistical difference among the group.

visits in the second trimester had higher odds of delivering LBW babies.

The factors confirmed with multiple logistic regression analysis as significant were intervention (AOR = 0.26; 95% CI, 0.10–0.64); maternal MUAC <23 cm (AOR = 2.57; 95% CI, 1.15–5.78); delivery via CS (AOR = 2.27; 95% CI, 1.04–4.94); maternal height <154.5 cm (AOR = 3.33; 95% CI, 1.01–10.96); last antenatal care visits at 1st or 2nd trimesters (AOR = 9.48; 95% CI, 3.72–24.15); mothers' age (AOR = 2.26; 95% CI, 1.02–4.99), parity (AOR = 3.55; 95% CI, 1.37–9.15), and pre-term delivery (AOR = 3.93; 95% CI, 1.93–7.98). Multiple linear regression also confirmed that mother's maternal MUAC ($\beta = 0.12$; 95% CI, 0.01–0.031), study group ($\beta = 0.07$; 95% CI, 0.01–0.15), mode of delivery ($\beta = 0.11$; 95% CI, 0.05–0.22), gestational age at birth ($\beta = 0.18$; 95% CI, 0.02–0.03), and time of last visit to ANC ($\beta = 0.08$; 95% CI, 0.00–0.01), were significantly associated with LBW after controlling for other variables (Table 5).

Discussion

The findings of this study demonstrated an association between birth weight and pregnant women's participation in a nutrition education program. This study had similar findings to a previous study conducted in Burkina Faso among low-income women.[9] Akter *et al.* and Jahan *et al.*[8,23] reported in separate studies that women who received third trimester nutrition counselling on pregnancy weight gain added 1.73 kg and 3.22 kg, respectively, more than women in the control group. In addition, babies born to these women weighed 0.44 kg and 20% more, respectively. However, their intervention had a food supplement (khichuri), unlike this study's intervention.

Overall, Kenya showed a slight increase in the prevalence of LBW from 6% to 8%, as reported in 2009 and 2014, respectively, by the Kenya Demographic and Health Survey (KDHS).[24,25] The prevalence of LBW among infants in the control group was similar to recent findings reported by Mutual *et al.*[26] for Nairobi's Viwandani and Korogocho slums.

Therefore, home-based nutrition counselling may have informed pregnant women in the intervention group on recommended antenatal care, which translated to adoption of good nutrition and adequate ANC practices. This is evidenced by positive changes in some of the maternal variables, such as more ANC visits and better nutrition status among women in the intervention group than among those in the control group. In addition, the number of their ANC visits was slightly higher than those of the control group, and slightly more women attended up to the third trimester. Moreover, the prevalence of undernutrition and over nutrition in the intervention group was reduced, as revealed by the comparison of the baseline and follow-up (pre-birth) MUAC measurements. However, some studies have argued that MUAC does not change during pregnancy. Conversely, Lopez *et al.*[27] in their cohort study conducted in Argentina reported a MUAC mean increase of 1.7 cm among 1000 pregnant

Table 4. Logistic regression for low birth weight determinants, controlling for maternal characteristics

Variable categories	OR (95% CI)	*P*-value	AOR (95% CI)[a]	*P*-value
Study group				
Intervention	0.36 (0.18–0.69)	0.002	0.26 (0.10–0.64)	0.010
Control	ref			
Mode of delivery				
Cesarean	1.70 (0.88–3.29)	0.104	2.27 (1.04–4.94)	0.039
Normal/SVD	ref			
Pregnancy MUAC				
< 23 cm	2.10 (1.05–4.19)	0.036	2.57 (1.15–5.78)	0.022
23–32 cm	0.57 (0.12–2.59)	0.465	1.71 (0.37–7.85)	0.488
33 >	ref			
Time of last ANC visit				
1st and 2nd trimester	9.73 (4.37–21.65)	< 0.001	9.48 (3.72–24.15)	< 0.001
3rd trimester	ref			
Mothers' height				
< 154.5 (<25th percentile)	3.42 (1.09–10.67)	0.034	3.33 (1.01–10.96)	0.043
154.5–163 (50th percentile)	2.59 (0.88–7.58)	0.115	1.92 (0.62–5.98)	0.257
> 163 (>75th percentile)	ref			
Mothers' age				
14–24	2.19 (1.12–4.29)	0.021	2.26 (1.02–4.99)	0.044
25–45	ref			
Gestation age at birth				
Preterm (<37 weeks)	4.45 (2.32–8.55)	< 0.001	3.93 (1.93–7.98)	< 0.001
Term	ref			
Parity				
0–1 child	3.61 (1.41–9.21)	0.007	3.55 (1.37–9.15)	0.009
2 and above	ref			

[a]AOR-adjusted odds ratio, adjusted for doctor assisted delivery, infant sex, and fever during pregnancy.
SVD, spontaneous vaginal delivery; MUAC, mid upper arm circumference; ANC, antenatal care.

women between the 16th and 38th gestational week. Moreover, Lopez *et al.* reported means (SD) of MUAC similar to the BMI at baseline and follow-up. Cooley *et al.* and Sultana *et al.*[21,28] reported significant correlations (r = 0.836) between the MUAC and BMI and suggested that BMI can be directly estimated from the following equation: BMI = MUAC ± 2. Previous studies also reported a significant association between MUAC and birth weight, with women who gave birth to LBW infants reporting low MUAC values.[29] Although some studies have reported that overweight and obese women are at risk of delivery of macrosomic infants,[30] a slightly higher prevalence of LBW infants was also shown in women with higher MUAC measurements in this study. In addition, the control group had more underweight and overweight/obese women than did the intervention group. This could be the cause of LBW due to preterm delivery since Aly *et al.*[31] reported obese women to be more likely to deliver prematurely owing to increased risk of gestational diabetes, pre-eclampsia, and anemia.

Women in the intervention group had a reduction in consumption of soil and mineral stones, which is a form of pica caused by micronutrient deficiency, mostly iron deficiency.[32] Soil consumption pica may increase the transmission of soil helminths such as hookworms, which may lead to anemia and later LBW,[33] however, in our study, hemoglobin was not measured hence not enough evidence to conclude. The women in the control group had a higher intake of nutrient supplements during the follow-up, which could be a result of supplementation recommendation stemming from nutrient deficiency.[34]

In addition, maternal height and antenatal characteristics such as parity, time at which the pregnant woman stopped seeking ANC, and mode of delivery, which are significantly associated with LBW, were consistent with those found in similar studies of

Table 5. Multiple linear regression analysis for possible determinants of low birth weight

Variable categories	Standardized Beta Coefficients[a]	95% CI	P-value
Study group	0.07	(0.01–0.15)	0.036
Mode of delivery	0.11	(0.05–0.22)	0.002
Mother's pregnancy MUAC	0.12	(0.01–0.03)	<0.001
Child sex	−0.04	(−0.11–0.02)	0.198
Gestation age at birth	0.18	(0.02–0.03)	<0.001
Time of last visit to ANC, weeks	0.08	(0.00–0.01)	0.020

[a]Was standardized with adjustment of mother's age, fever, taking nutrient supplements and personnel who assisted with delivery.
MUAC, mid upper arm circumference; ANC, antenatal care.

predictors of LBW.[30,31,35,36] For instance, some studies have reported that few ANC visits is associated with LBW because of inadequate ANC services such as nutrition counselling, low micronutrient intake, and reduced chances of identifying risks such as pregnancy-related morbidity and other risks that might lead to IUGR and preterm births.[37]

The proportion of deliveries by cesarean was almost similar to the proportion of Nairobi (20.7%) county as reported in the 2014 KDHS.[24] Deliveries by cesarean section may have led to LBW since some births take place before term owing to miscalculated gestational age or planned early deliveries. In addition, medical complications associated with LBW such as eclampsia may increase the demand for cesarean delivery; hence, the baby is born before reaching term. This study findings are consistent with those in a study by Coutinho *et al.*[38] who reported that infants born via cesarean were 1.4 times more likely to have a LBW than were those born via vaginal delivery.

The study participants exhibited low socioeconomic and education levels, which is a characteristic of slum dwellers.[39] No significant associations were observed between LBW and most of the socioeconomic and demographic characteristics such as maternal education levels and marital and employment status. In contrast, previous studies from other developing countries, but not restricted to slum populations, have reported significant associations.[36] The discrepancy may have resulted from the fact that most women living in slums do not have significant differences in their socioeconomic and demographic statuses. Similar findings were reported by Mogire *et al.*[40] in a study conducted in a Pumwani maternity hospital in Nairobi, which is attended mostly by women from low socioeconomic households.

The strength of this study is that it was a large and well-organized randomized controlled study, with good data management, increasing the reliability of the data. In addition, to the best of our knowledge, it may be the first study reporting the effect of nutrition education offered in Kenyan slums on newborns' birth weight.

However, the study has some limitations. The intervention focused on increasing awareness for pregnant women to exclusively breastfeed for up to six months. Hence, not so much emphasis was laid on information needed for promoting birth weight. In addition, pregnancy-related medical conditions were self-reported, which could have led to reporting bias while multiple pregnancies were not specified hence not controlled for during analysis. Lastly, the study population is an urban informal settlement, which to some extent limits the generalizability of the results to the whole country; however, generalization to similarly impoverished low-income households is possible. Moreover, some of the study findings on antenatal care maternal baseline characteristics closely correspond to those reported in the 2014 KDHS for low-income settings.

Conclusion

Home-based nutrition counselling during pregnancy reduces low birth-weight and preterm deliveries. This is evidenced by improvement in the pregnant women's nutritional status and more use of ANC services in the intervention group as compared with the control group. We have identified LBW risk factors. We recommend the government and other health care providers to focus on modifiable risk factors that include improvement of pregnant women's nutritional status through offering nutrition counselling and promoting maximum use of ANC services. Moreover, this study has provided fundamental evidence that offering monthly home-based individual counselling to pregnant women by CHVs can essentially improve maternal nutrition and newborn birth weight. A number of risk factors for LBW were identified, therefore, the government and other health care providers should focus on improvement of pregnant women's nutritional status through offering nutrition counselling and promoting maximum use of ANC services especially in slum areas.

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