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Nutritional characterisation of low-income households of Nairobi: socioeconomic, livestock and gender considerations and predictors of malnutrition from a cross-sectional survey

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Abstract

Background: In sub-Saharan Africa, urban informal settlements are rapidly expanding, leading to overcrowding and constituting challenging environments for food and water supplies, health and nutrition. The study objectives were to characterise and compare two low-income areas of Nairobi according to socioeconomic (including livestock and gender) indicators and the nutritional status of non-pregnant women of reproductive age and 1 to 3 year-old children; and to investigate socioeconomic predictors of malnutrition in these areas.

Methods: In this cross-sectional survey 205 low-income households in deprived areas of Dagoretti and Korogocho (Nairobi) were randomly selected. Socioeconomic data were collected via an interviewer-administered questionnaire. Maternal and child dietary data were collected by a 24-h dietary recall. Maternal and child anthropometric and haemoglobin measurements were taken. Chi-square, *t*-test and Wilcoxon-Mann-Whitney test were used to compare groups and multivariable linear regression to assess predictors of malnutrition.

Results: Dagoretti consistently showed better socioeconomic indicators including: income, education and occupation of household head, land ownership, housing quality and domestic asset ownership. Animal ownership was more than twice as high in Dagoretti as in Korogocho (53.0 % vs 22.9 % of households; *p*-value < 0.0001). A double burden of malnutrition existed: 41.5 % of children were stunted, and 29.0 % of women were overweight. In addition, 74.0 % of the children and 25.9 % of the women were anaemic, and were at risk of inadequate intakes for a number of micronutrients. Nutritional status and nutrient intakes were consistently better in Dagoretti than Korogocho; height-for-age (0.47 Z-scores higher; *p*-value = 0.004), the minimum dietary diversity (80.0 % vs 57.7 % in children, *p*-value = 0.001) and intakes of several nutrients were significantly higher. Positive predictors of maternal nutritional status were income, age and not having a premature delivery. Positive predictors of child nutritional status were area, household head education, mother not being married, female animal ownership and child's sex (female).

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Conclusions: Malnutrition is prevalent in these settings, which could be partly due to low nutrient intakes, and to socioeconomic factors (including poverty), thus requiring comprehensive approaches that include increased accessibility and affordability of nutrient-dense foods. This study indicates that differences among low-income areas may need consideration for prioritisation and design of interventions.

Keywords: Gender, Socioeconomic status, Malnutrition, Informal settlements

Abbreviations: BMI, Body mass index; Ca, Calcium; DHS, Demographic and health survey; EAR, Estimated average requirement; FAO, Food and Agriculture Organization of the United Nations; FCT, Food composition tables; Fe, Iron; GPS, Global positioning system; HAZ, Height/length-for-age Z-scores; Hb, Haemoglobin; ILRI, International Livestock Research Institute; IMAPP, Intake monitoring, assessment and planning programme; KEMRI, Kenya Medical Research Institute; KES, Kenyan shillings; SD, Standard deviation; TLH, Total livestock holding; TLU, Tropical livestock units; UL, Upper intake level; WDDS, Women dietary diversity score; WHO, World Health Organization; WHZ, Weight-for-height Z-scores; Zn, Zinc

Background

Although the proportion of underweight children globally decreased from 28 to 17 % between 1990 and 2013 [1], progress has been uneven among countries. In sub-Saharan Africa, more than half of the countries were seriously or moderately off target for achieving the Millennium Development Goal on underweight reduction at the end of 2015 [2]; thus nutrition remains a priority within the Post-2015 Sustainable Development Goals [3]. Malnutrition levels in sub-Saharan Africa are high and the prevalence of stunting is highest in the East Africa sub-region where 42 % of children are stunted [4]. Such high rates of stunting are a concern since undernutrition in early life can have long-term consequences on health and cognitive development, which in turn have impact on the physical, intellectual and social capacity of the individual and society as a whole [4]. The causes of malnutrition are fairly well understood [5] and effective nutrition-specific interventions have been identified [6]. However, the results achieved by these interventions depend on (unaddressed) structural factors such as education, sanitation, health, or the food environment [4, 7], emphasising the need to understand the multiple pathways to adequate nutrition in different settings. Further, the investigation of indirect predictors and gender disaggregation of data can also help improve our understanding of how to tackle undernutrition in a given context.

In Kenya, the dwellers of Nairobi informal settlements (also known as ‘slums’ [8]), which are defined as urban areas heavily populated and “characterised by substandard housing and squalor” [9], often have very poor health indicators, including a high prevalence of stunting compared with nationwide estimates [10]. According to the 2014 Demographic and Health Survey (DHS), 26.0 % of children under 5 were stunted nationwide [11] whereas above 40 % were stunted according to surveys in poor settlements in Nairobi between 2008 and 2010 [12–14]. Since 60 % of Nairobi’s population

lives in informal settlements [9] and these urban settlements are expanding rapidly [15], these high levels of stunting (>40 %) represent a serious public health issue. Underlying factors for these stunting rates may be: i) direct factors relating to food security and safety, and infant feeding practices [16, 17], diseases [18], and inadequate water supply and sanitation [19]; and, ii) indirect factors such as socioeconomic status, and women’s participation in household decision-making [20]. Maternal social characteristics can influence child-care practices and result in reduced stunting in poor settings [4]. For example, in Korogocho and Viwandani, two Nairobi informal settlements, maternal education, marital status or health seeking behaviour were associated with breastfeeding and complementary feeding practices [17] and with stunting [12]. A better understanding of the social factors associated with nutrition in these fast growing urban populations is necessary to effectively reduce malnutrition.

The role of women (both consumers and providers of care and nutrition in the household) as agents of change is complex. Priorities on food and non-food resource allocation often differ between women and men, and women’s empowerment is likely to improve the household’s wellbeing [21]. Maternal decision-making capacity and empowerment are needed to use nutrition information effectively and improve child nutrition and care practices [21, 22]. Increasing women’s control over assets can also contribute positively to child nutrition [23]. Specifically, the control of animal assets (livestock) is relevant because they can have a positive impact in nutrition, by increasing availability of nutrient-rich animal-source foods, consumed in limited amounts among urban poor consumers [24], or as a source of income [25]. Yet, to tackle undernutrition, context-specific differences in the benefits of gender-equality specific mechanisms and livestock ownership may need to be ascertained.

In this study, a survey was conducted in two low-income areas of Nairobi, Korogocho and deprived areas

of Dagoretti. The overall aim was to develop and test a framework to study, in poor urban environments, the associations among consumers' access to and use of different animal-source foods and livestock value chains, and maternal and child nutrition. This paper presents a description of socioeconomic status of the populations living in these areas, particularly related to livestock ownership and gender indicators, and their associations with nutritional outcomes in women and children. This study also provides updated baseline data and new dietary intake data to inform the design of further research, to develop and evaluate strategies aiming to address malnutrition in informal settlements.

Methods

Study population

The study was conducted in two low-income areas of Nairobi county: Korogocho, located in Kasarani sub-county and officially classified as an informal settlement, and 5 locations in Dagoretti (now divided into two sub-counties, Dagoretti North and South), namely Kawangware, Ruthimitu/Uthiru, Waithaka, Mutuini and Riruta. Higher-income areas in the east of Dagoretti were excluded from the survey. The location of the study areas is shown in Fig. 1. Although they have relatively stable

populations, both areas receive migrant populations from all regions in the country. Korogocho is densely populated with 63,318 inhabitants per square km [17], while Dagoretti population density is lower, varying substantially among areas (with a maximum density in Kawangware, with 30,411 inhabitants per square km [26]). The study areas were selected purposely by the study team based on previous studies showing they had high rates of malnutrition (Korogocho [12]) and high density of livestock (Dagoretti [27]). Most houses in these locations are tin-roofed structures, with limited access to piped water, sanitation and electricity [10, 28].

Study design

A cross-sectional survey was conducted between December 2013 and February 2014 in 205 low-income households. The time period overlapped with the end of the short rainy season (November and December). This sample size allowed estimation of at least 10 % prevalence of a condition to within ± 5 % (95 % confidence interval) and assuming a design effect of 1.5. A sampling strategy stratified by area was used, in which Global Positioning System (GPS) points were randomly selected in each of the two areas. Once the GPS point was identified, the closest household to the right when facing north was selected. If the first

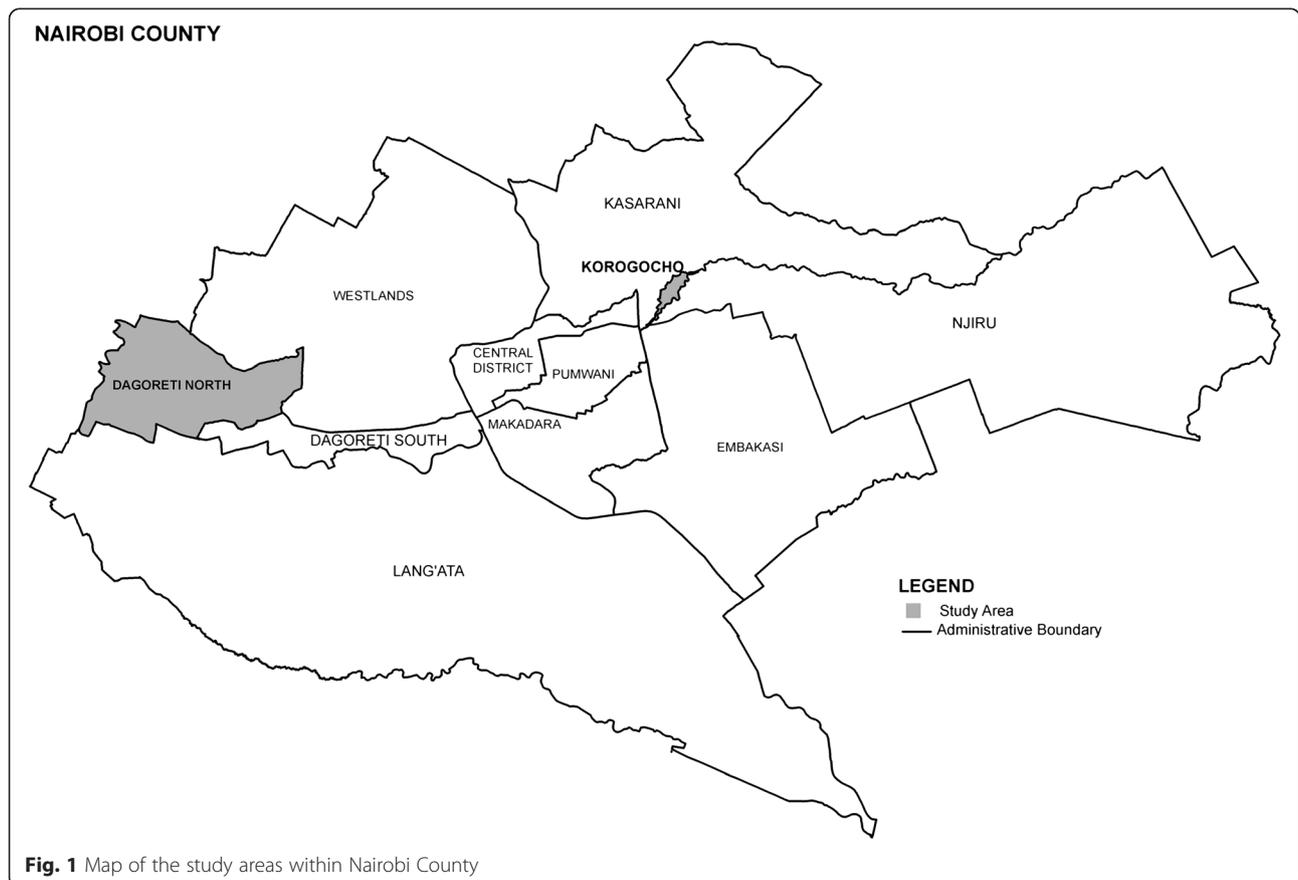


Fig. 1 Map of the study areas within Nairobi County

household was not eligible, then the next one on the right was selected. Eligibility criteria were: informal housing (temporary) structures; households with low monthly income (below 20,000 Kenyan Schillings (KES), i.e. \$US230) according to estimated incomes for manual workers; presence of at least one child between 1–3 years of age; and, a non-pregnant woman of reproductive age (15–45 years). However, none of households visited with informal housing was found to have an annual income > 20,000 KES.

Data collection

Questionnaire

Socioeconomic, demographic and health data were collected by means of a structured questionnaire administered by trained interviewers in Swahili. The questions were developed based on ILRI's 'Gender, livestock and livelihoods indicators guidelines' [29] and included details on household structure, housing characteristics, decision-making and gender dynamics, ownership of land, and household assets (domestic and animal). Questions on infant feeding practices (e.g. breastfeeding) and health (e.g. vaccines, iron supplementation) were also included. The responses were captured electronically in Android tablets with the open-source tool Open Data Kit (ODK Collect).

Dietary assessment

The dietary intakes of women and children were assessed using a four-pass 24-h recall [30]. Data were collected on a staggered schedule to avoid a day of the week bias, with an interruption during Christmas and New Year festivities to avoid a bias associated with festive food intakes. Portion sizes (served and left-overs) were estimated using food models, which were weighed (kitchen scale Salter 1036 Slim; precision ± 1 g) and recorded. Conversion factors were developed to convert the weight of the food models into the weights of food consumed [30]. For some foods, portion sizes were estimated using Kenyan-specific photo books developed by the Kenya Medical Research Institute (KEMRI). For composite cooked dishes, participants were asked for information on the quantity of each ingredient used in the recipe. For these cooked dishes, standard recipes were prepared locally to: i) establish the conversion factors to convert the weight of the food models used to estimate the total recipe weight and the portion of the dish eaten by participants; and ii) estimate standard ingredient proportions to use when the recipe composition could not be obtained directly from the participant. Averaged conversion factors across cooks for the same dish were used.

Anthropometric and biochemical assessment

Duplicate measurements were made by trained anthropometrists. Recumbent length (children 12–24 months

of age) was measured to the nearest 1.0 cm with a UNICEF wooden baby/infant length/height board and height (mothers and children >24 months of age) was similarly measured with a Seca 213 portable stadiometer and the UNICEF wooden board respectively. Maternal and child weight was measured to the nearest 0.1 kg with a Seca 877 weight scale. Maternal and child haemoglobin levels were measured from finger prick blood samples with an HemoCue 201+ B-Haemoglobin analyser, using standardised procedures.

Data analysis

A 'gender disparity score' was calculated as the proportion of female members (total number of female family members divided by the total number of family members). Adults were defined as an individual above 16 years of age. Data on asset ownership were used to calculate a 'household domestic asset index', where each of the assets was assigned a weight according to ILRI's 'Gender, livestock and livelihoods indicators guidelines' [29], adapted from an analysis recommended by the Bill and Melinda Gates Foundation for development projects [29]. To calculate this index, non-animal assets (household assets such as cookers/stoves, refrigerators, radios, televisions, mobile phones and mosquito nets; and transport assets such as motorcycles, bicycles and carts) were also assigned a weight according to their depreciation value. A 'gender asset disparity ratio' (Women Domestic Asset Index/ Men Domestic Asset Index) and a 'livestock contribution to the household asset base' (Livestock Asset index / Household Asset Index $\times 100$) were also calculated from the data [29]. In female-headed households without males, a value of 1 was given. A score on 'quality of housing' was calculated, adapted from CASHPOR House index used by the Grameen Bank. This score merges housing conditions such as roof and wall building materials, ownership of the housing and number of rooms, as a proxy for poverty [29]. The Total Livestock Holding (TLH) was calculated for each household, by weighting the number of heads of livestock by a species- and age-specific exchange ratio, and expressed in Tropical Livestock Units (TLU). This index describes livestock biomass across species with a single indicator and summarises the total amount of livestock present at a household [29].

The dietary data were entered in the 'Census and Survey Processing System' to convert food model weights to grams of food consumed and calculate individual energy and nutrient intakes. (CSPro <https://www.census.gov/population/international/software>). A food composition table (FCT) compiled for a previous survey in Kenya was used [31]. For foods not available in this database, composition values were obtained from the HarvestPlus FCT for Uganda [32] or from the closest food in the Kenyan FCT. The nutrients assessed were: energy, protein, fat, carbohydrates, calcium (Ca), iron (Fe), zinc (Zn), vitamin A, thiamine (B1), riboflavin

(B2), niacin (B3), vitamin B6, folate, vitamin B12, and vitamin C. Since breastmilk intakes could not be estimated, children were stratified into a breastfeeding and a non-breastfeeding group to estimate dietary adequacy. The percentage of women and non-breastfeeding children “at risk” of inadequate nutrient intakes, was determined using the Estimated Average Requirement (EAR) fixed cut-off approach for all nutrients except iron; and the full probability approach for iron. These analyses were done with the software IMAPP (World Health Organisation (WHO) Intake Monitoring, Assessment and Planning Programme, <http://www.side.stat.iastate.edu/imapp.php>); and the internal variance ratios based on 2002/2003 NHANES data were used. For breastfed children the WHO recommended nutrient densities of complementary foods were used to identify nutrients that may be low in their diets [33]. In addition dietary diversity scores were estimated to assess dietary quality using the Women Dietary Diversity Score (WDDS), according to Food and Agriculture Organization of the United Nations (FAO) guidelines, [34]; and the WHO Child Minimum Dietary Diversity Score [35]. The percentage of children consuming ≥ 4 food groups was calculated.

Z-scores for height- or length-for-age (HAZ) and weight-for-height (WHZ), for children, were calculated using WHO 2006 growth standards [36]. Stunting and wasting were defined as a HAZ < -2 SD and a WHZ < -2 SD, respectively, and severe conditions below -3 SD. For women, Body Mass Index (BMI) was calculated as weight (kg)/height² (m²), and classified according to the International classification [37], in which values under 18.5 kg/m² denote underweight and above 25 kg/m² denote overweight (or obesity for values above 30 kg/m²). Anaemia was defined using the WHO classification: i.e., a cut-off for haemoglobin of <11 g/dL was used for children and <12 g/dL for women [38].

Statistical analysis

Stata 11.0 was used for the statistical analysis. The distributions of all variables were visually examined and mathematical transformations were done to normalise any non-normal distribution before any analyses were done.

Descriptive statistics

Means and standard deviation or medians and inter-quartile ranges were calculated, for normally and non-normally distributed continuous variables, respectively. Inter-group comparisons were done using Chi-square test and *t*-test for categorical and continuous variables respectively, and Wilcoxon-Mann-Whitney test was used for non-normally distributed variables.

Unconditional associations

A subset of data elements collected was chosen for consideration as predictors of the outcomes of interest, based on their biological plausibility, existing literature, the study’s aim to evaluate factors associated with female empowerment and animal ownership and the completeness of the data. The analysis of associations between socioeconomic predictors and the main health and growth outcomes was guided by the causal diagram in Fig. 2. Outcomes included three measurements made on the selected child (height-for-age-Z-scores, weight-for-height-Z-scores, and haemoglobin (Hb) level) as well as two maternal measurements (BMI and Hb). The normality of each of these outcomes was evaluated graphically and, when non-normality was observed, a variety of transformations considered with the transformation that did the best job of normalizing the distribution being selected. For all continuous predictors, the linearity of the association with each outcome of interest was evaluated using a lowess plot with a quadratic term being created

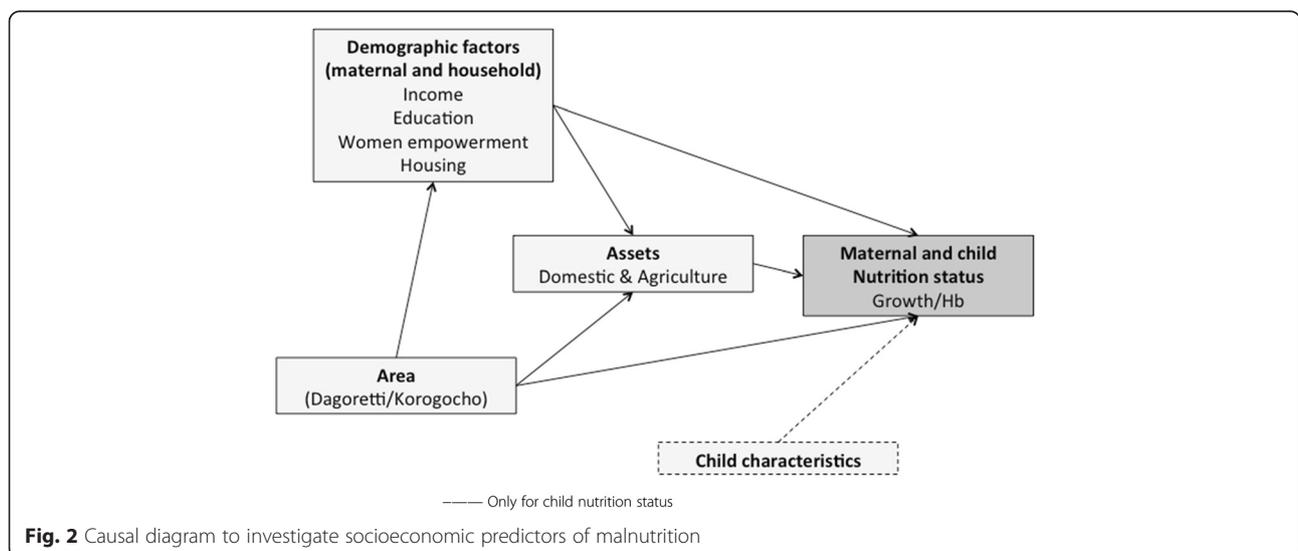


Fig. 2 Causal diagram to investigate socioeconomic predictors of malnutrition

if there was evidence of curvature in the relationship. The quadratic term was only retained if it showed statistical significance in the unconditional (univariable) models of association. Categorical predictors with small numbers of observations in some categories were recoded to produce the variables used in the analyses (as shown in Table 3). Unconditional associations were assessed for each predictor using simple linear regression models. Variables significant at $P < 0.15$ were retained for evaluation in multivariable models.

Multivariable models

In the multivariable models, two confounders (area and maternal age) were considered to be potentially important and were included into all models. Other variables selected from the unconditional models were assessed in a manual backwards elimination with variables being retained if they were significant at $P < 0.1$ or if they appeared to have an important confounding effect. Final models were evaluated through the use of normal probability plots of standardised residuals, scatter plots of residuals vs. predicted values and examining individual records with standardised residuals below -3 or above $+3$.

Results

Descriptive statistics of socioeconomic variables (including a comparison of informal settlements) are presented in Table 1. Descriptive statistics for growth and nutrition parameters are presented in Table 2. Unconditional associations of selected variables are presented in Table 3, and the final multivariable models are presented in Table 4.

Socioeconomic characterisation

Demographics

Income was below 5,000 KES (<60\$) per month in over half (53.2 %) of the households; households in Korogocho had significantly lower incomes than those in Dagoretti (p -value < 0.0001) (Table 1). A quarter of the households (24.9 %) were female-headed, with no significant differences between areas; however, female-headed households had significantly lower incomes than male-headed household (p -value = 0.006) (differences in socioeconomic characteristics by sex of head of household are shown in the Additional file 1: Table S1). The majority of mothers were married (78.1 %); although there was a significantly higher number of single or widowed mothers (p -value = 0.03) in Korogocho than in Dagoretti. The women generally had either primary education (63.9 %) or secondary and above (34.2 %); few women had not attended school (2.0 %). The women in Dagoretti had a higher level of education than in Korogocho

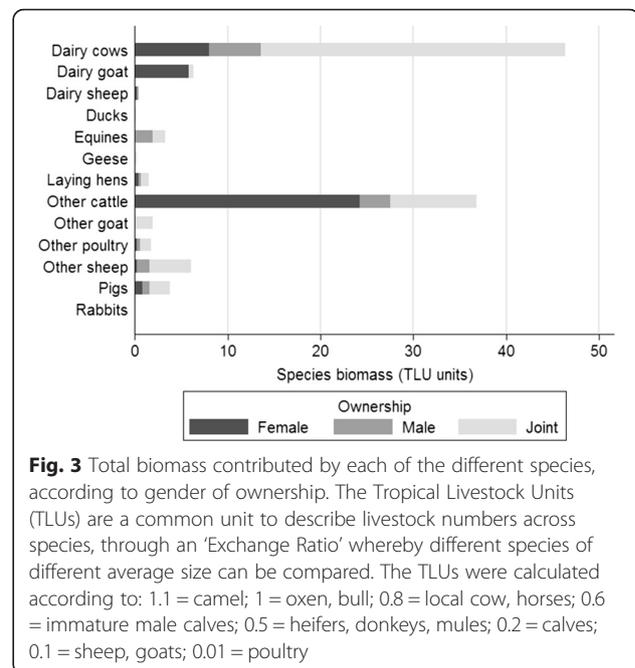


Fig. 3 Total biomass contributed by each of the different species, according to gender of ownership. The Tropical Livestock Units (TLUs) are a common unit to describe livestock numbers across species, through an 'Exchange Ratio' whereby different species of different average size can be compared. The TLUs were calculated according to: 1.1 = camel; 1 = oxen, bull; 0.8 = local cow, horses; 0.6 = immature male calves; 0.5 = heifers, donkeys, mules; 0.2 = calves; 0.1 = sheep, goats; 0.01 = poultry

(p -value < 0.001). Overall 43.0 % of women in the households had some kind of paid employment, and this proportion was significantly higher in Korogocho than in Dagoretti. Also, all households had at least one person generating some type of income: in 36.3 % of the households it was a male only, in 10.5 % it was a female only, and in the remainder of the households there were at least two people contributing to household income, with 39.5 % of the cases being one male and one female together. In 53.5 % of households, decision-making on income expenditure was reported to be made jointly by male and female adults (87.0 % of these households were male-headed), while in 22.8 % of households a female made the decisions (26.1 % of these households were male-headed) and in 21.3 % it was a male. Decisions on the use of money were taken independently by the woman and the man in 2.5 % of the households. Higher level of education of the head of household was associated with higher income (p -value = 0.015) and with type of occupation (p -value = 0.001). The dwellings had an average number of rooms of 1.5 (SD = 0.9 rooms, min. = 1, max. = 5), which varied by area (p -value = 0.028), income (p -value = 0.003) and number of family members (p -value < 0.001). The average number of members per household was 4.8 (SD = 1.9, min. = 2, max. = 13), with 2.5 (SD = 1.4, min. = 1, max. = 7) children under 16 years of age.

Assets

The roofs of all households were made of iron sheets. Walls made from iron sheets were more frequent in Dagoretti than Korogocho (p -value < 0.0001) and in

Table 1 Socioeconomic characteristics of participant households, by area

	Dagoretti (n = 100)	Korogocho (n = 105)	N
Income [%]			
Less than 1,000 KES (<11.5\$)	3.0	9.5***	
1,001–5,000 KES (11.5–58\$)	33.0	60.0	205
5,001–10,000 KES (58–116\$)	40.0	25.7	
10,001–20,000 KES (116–231.5\$)	24.0	4.8	
Income expenditure decision [%]			
Household male	18.6	23.8	
Household female	18.6	26.7	202
Joint (male and female)	62.8	49.5	
Female contribution to income [%]			
0 female	30.7	42.9	193
1 female	58.0	44.8	
2–3 female	11.3	12.3	
HH head sex [%]			
Female	43.1	56.8	205
HH head age [Mean (SD)]	34.2 (9.1)	30.9 (9.0)*	184
HH head religion [%]			
Christian	98.0	92.4	205
Muslim	2.0	7.6	
HH head education [%]			
Never went to school	2.5	1.3*	
Primary school	42.5	61.5	160
Secondary school	41.3	34.6	
College	13.8	2.6	
HH head occupation [%]			
Unemployed	2.4	0.0**	
Farm related	5.9	1.2	
Labourer	38.8	65.9	167
Private enterprise	29.4	14.6	
Civil servant	8.2	1.2	
Own business	15.3	17.1	
Maternal status [%]			
Married	85.0	71.4*	205
Single	10.0	21.9	
Widowed/Divorced/Separated	5.0	6.7	
Maternal education [%]			
None	3.0	1.0***	205
Primary	49.0	78.1	
Secondary and above	48.0	21.0	
Maternal occupation [%]			
No	63.0	51.4*	205
Yes	37.0	48.6	
# HH members [Mean (SD)]	4.7 (1.9)	4.9 (2.0)	199
Proportion of female members (#females/#members) [Mean (SD)]	0.5 (0.2)	0.5 (0.2)	199

Table 1 Socioeconomic characteristics of participant households, by area (Continued)

	Dagoretti (n = 100)	Korogocho (n = 105)	N
# HH children (<15y) [Mean (SD)]	2.3 (1.4)	2.6 (1.5)	200
Land ownership [%]			
No land	52.6	91.3***	200
0–5000 m ²	28.9	3.9	
>5000 m ²	18.5	3.9	
Land usage [%]			
No land	89.6	96.2	200
0–5000 m ²	2.1	2.9	
>5000 m ²	8.3	1.0	
Home owned [%]	17.0	12.4	205
# rooms [%]			
1 room	60.0	76.7*	202
2–3 rooms	32.3	21.4	
>3 rooms	7.1	1.9	
Walls material [%]			
Iron sheets	100.0	63.8***	205
Earth/mud	0.0	36.2	
Quality of housing score [%]			
Poor (0–10)	82.8	80.3***	202
Moderate (11–20)	17.2	9.7	
Good (21–30)	0	0	
Domestic asset index [%]			
0–25	70.0	97.2***	
25–50	15.0	1.0	205
50–75	10.0	0.0	
75–100	4.0	1.0	
>100	1.0	1.0	
Men domestic asset index [Md (Q ₁ –Q ₃)]	5.0 (2.9–24.3)	2.9 (0.8–5.0)***	205
Women domestic asset index [Md (Q ₁ –Q ₃)]	5.7 (3.0–20.4)	3.4 (2.0–5.8)***	205
Gender asset disparity [Md (Q ₁ –Q ₃)] (women/total domestic asset index)	0.8 (0.5–0.9)	0.7 (0.5–1.0)	204
Animal ownership [%] ^a	53.0	22.9***	205
Livestock contribution to HH asset [Md (Q ₁ –Q ₃)] (livestock/total assets)	0.0 (0.0–0.7)	0.0 (0.0–0.0)***	204
Livestock contribution to women asset [Md (Q ₁ –Q ₃)] (women livestock/total female assets)	0.0 (0.0–0.8)	0.0 (0.0–0.0)***	196
Total livestock holding [%] ^b			
0 TLU equivalents	54.0	87.6***	
0.1–2 TLU equivalents	32.0	10.5	205
2.1–4 TLU equivalents	13.0	1.0	
>4 TLU equivalents	1.0	1.0	
Female livestock holding [%] ^b			
0 TLU equivalents	63.0	90.5	205
>0 TLU equivalents	37.0	9.52	

The data were collected between 02–20/12/13 and 7–16/01/14 in Dagoretti, and between 21/01/14 and 21/02/14 in Korogocho
 HH household, KES Kenyan schillings, Md median, n sample size, Q₁ quartile 25 %, Q₃ quartile 75 %, SD standard deviation, TLU tropical livestock unit
 *p-value ≤0.05; **p-value ≤0.01; ***p-value ≤0.001

^aThis includes both livestock and non-livestock animals; ^bThe TLUs are calculated according to: 1.1 = camel; 1 = oxen, bull; 0.8 = local cow, horses; 0.6 = immature male calves; 0.5 = heifers, donkeys, mules; 0.2 = calves; 0.1 = sheep, goats; 0.01 = poultry

Table 2 Nutritional indicators of participant children and women in poor households of Nairobi, by area

	CHILDREN 1–3 YEARS				WOMEN REPRODUCTIVE AGE				
	BREASTFEEDING		Non-BREASTFEEDING		NON-PREGNANT				
	Dagoretti (n = 35)	Korogocho (n = 42)	Dagoretti (n = 65)	Korogocho (n = 62)	Dagoretti (n = 100)	Korogocho (n = 104)			
Age [months/years] [Mean (SD)]	17.8 (4.0)	18.5 (5.2)	25.4 (5.9)	25.9 (7.1)	26.7 (6.3)	25.6 (5.9)			
Child female [% (CI)]	48.6 (31.5–65.6)	34.9 (20.2–49.5)	44.6 (32.3–56.9)	45.2 (32.6–57.8)	-	-			
Child prematurity [% (CI)]	11.4 (0.6–22.3)	11.6 (1.8–21.5)	4.7 (–0.6–10.0)	8.2 (1.2–15.2)	-	-			
HAZ [Z-scores] [Mean (SD)]	–1.34 (1.07)	–2.23*** (0.98)	–1.70 (1.27)	–1.90 (1.17)	-	-			
WHZ [Z-scores] [Mean (SD)]	–0.15 (1.34)	–0.45 (1.17)	0.07 (1.46)	–0.14 (1.09)	-	-			
BMI [kg/m ²] [Mean (SD)]	-	-	-	-	24.2 (4.6)	23.3 (3.8)			
Haemoglobin [g/dL] [Mean (SD)]	10.1 (1.1)	10.2 (1.3)	10.2 (1.3)	9.8 (1.7)	12.7 (1.8)	12.8 (1.8)			
Prevalence of: [% (CI)]									
Stunting (<–2Z-score)	25.7 (10.5–40.9)	53.5* (38.0–69.0)	38.5 (26.3–50.6)	45.2 (32.4–57.9)					
Wasting (<–2Z-score)	2.9 (–0.3–8.7)	11.6 (1.6–21.6)	1.5 (–0.2–4.6)	3.2 (–0.1–7.7)					
BMI <18.5 kg/m ² (underweight)	-	-	-	-	7.0 (1.9–12.1)	9.5 (3.8–15.2)			
BMI >25 kg/m ² (overweight)	-	-	-	-	22.2 (13.9–30.6)	16.3 (9.1–23.6)			
BMI >30 kg/m ² (obese)	-	-	-	-	12.1 (5.6–18.7)	7.7 (2.5–12.9)			
Anaemia (<11 g/dL // <12 g/dL) [% (CI)]	85.7 (73.5–97.9)	65.1 (50.3–80.0)*	70.8 (59.4–82.1)	77.4 (66.7–88.1)	26.0 (17.3–34.7)	25.7 (17.2–34.2)			
MDD ^a [% (CI)]	74.3 (59.4–89.2)	52.4*(36.8–67.9)	83.1 (73.8–92.4)	61.3** (48.9–73.6)	-	-			
WDDS ^b [Mean (SD)]	-	-	-	-	4.4 (1.1)	4.1* (1.4)			
Intake of: [Mean (SD)]	Complementary food intake	WHO 2002 recommended intake ^c (12–23 months)	Total intake	Total % at risk of inadequacy ^d	Total intake	Total% at risk of inadequacy ^d			
Energy [kcal/d]	898.4 (572.9)	703.5 (399.0)	-	1255.7 (441.2)	1009.9** (514.5)	-	1928.7 (725.5)	1768.1 (822.4)	-
Carbohydrates [g/d]	154.4 (104.3)	124.0 (69.4)	-	206.2 (75.6)	171.8 (86.3)*	-	320.5 (119.2)	295.8 (137.5)	-
Protein [g/d]	22.4 (15.2)	17.6 (11.2)	-	33.1 (14.2)	24.1*** (15.4)	6.1	47.9 (22.0)	42.9 (25.5)	30.6
Fats [g/d]	22.7 (19.3)	17.0 (14.1)	-	35.6 (17.6)	27.0** (19.5)	-	53.1 (30.9)	48.5 (33.41)	-
Calcium [mg/d]	265.8 (189.8)	222.4 (188.4)	500	481.6 (257.3)	343.7** (242.2)	52.4	597.9 (328.7)	461.4*** (299.4)	93.8
Iron [mg/d]	5.4 (4.1)	4.1 (2.9)	5.8	7.7 (3.9)	5.7** (4.0)	98.7	13.0 (7.5)	11.8 (7.4)	19.6
Zinc [mg/d]	3.2 (1.9)	2.4 (1.4)	4.1	4.8 (2.4)	3.3*** (1.9)	7.7	7.1 (3.1)	6.1* (3.5)	61.3
Vitamin A [µg RE/d]	676.4 (825.0)	495.1 (687.2)	400	770.9 (675.4)	561.2 (629.5)	11.5	1575.3 (1620.3)	1409.7 (1516.9)	6.9
Vitamin B1 [mg/d]	0.5 (0.4)	0.4 (0.3)	0.5	0.7 (0.4)	0.5** (0.5)	22.6	1.1 (0.7)	1.0 (0.6)	32.3

Table 2 Nutritional indicators of participant children and women in poor households of Nairobi, by area (Continued)

Intake of: [Mean (SD)]	CHILDREN 1–3 YEARS						WOMEN REPRODUCTIVE AGE		
	BREASTFEEDING			Non-BREASTFEEDING			NON-PREGNANT		
	Complementary food intake	WHO 2002 recommended intake ^c (12–23 months)		Total intake	Total % at risk of inadequacy ^d		Total intake	Total% at risk of inadequacy ^d	
Vitamin B2 [mg/d]	0.6 (0.5)	0.4 (0.3)	0.5	0.8 (0.4)	0.6*** (0.5)	18.8	1.0 (0.5)	0.9* (0.5)	49.7
Vitamin B3 [mg/d]	5.8 (3.8)	4.1 (3.9)*	6	7.4 (3.5)	5.3*** (3.2)	33.5	10.3 (4.4)	9.2 (5.3)	70.0
Vitamin B6 [mg/d]	0.9 (0.6)	0.7 (0.6)	0.5	1.2 (0.7)	0.8*** (0.5)	8.9	1.5 (0.8)	1.3* (0.8)	22.9
Folate [µg DFE/d]	209.9 (232.6)	122.9* (116.7)	160	303.4 (244.7)	220.1*(206.8)	18.9	468.1 (411.7)	359.8*(317.5)	33.1
Vitamin B12 [µg/d]	5.2 (7.3)	4.8 (5.4)	0.9	7.4 (9.7)	4.8 (6.5)	8.8	14.9 (17.7)	16.9 (17.9)	-
Vitamin C [mg/d]	55.7 (44.7)	57.3 (55.4)	30	80.9 (59.5)	70.9 (68.7)	3.2	131.5 (92.8)	123.4 (104.6)	6.3

n for child intake = 204; *n* for women intake = 204

The data were collected between 02–20/12/13 and 7–16/01/14 in Dagoretti, and between 21/01/14 and 21/02/14 in Korogocho

BMI body mass index, *CI* confidence interval, *DFE* dietary folate equivalents, *HAZ* height-for-age Z-scores, *n* sample size, *N/A* not available, *RE* retinol equivalents, *RNI* recommended nutrient intake, *SD* standard deviation, *WHZ* weight-for-height Z-scores

p*-value ≤ 0.05; *p*-value ≤ 0.01; ****p*-value ≤ 0.001

^aMinimum Dietary Diversity (MDD) for infants: proportion of children 6–23 months of age who received foods from 4 or more food groups (on a 7-point food group scale proposed by WHO for children 6–23 months, here used up to 36 months) [35]; ^bWomen's Dietary Diversity Score (WDDS) for women: 9-point food group score proposed by FAO [34]; ^cAccording to WHO 2002 intakes [33]; ^dPrevalence of inadequacy calculated by IMAPP software, based on EAR cut-off point

// difference in indicator or units for children and women

higher-income than lower-income households (p -value = 0.04). The composite quality of housing score was 6.5 on average (SD = 2.3, min. = 1, max. = 7) which is considered as 'poor' [29], and there were significant differences by area (p -value < 0.001) and by household income (p -value = 0.003). Most households (94.1 %) had a cooker, but different types of fuels were used: most commonly kerosene/gas (72.2 %), followed by charcoal/wood (27.3 %), and one household had electricity/battery. Only two households had a refrigerator. The majority of households (88.8 %) had at least one mobile phone in the household, 66.3 % had at least one mosquito net, 56.1 % had a radio and 48.3 % had a television. Only 9.3 % of the households had a bicycle, 3.4 % a motorbike and 1.5 % a cart.

Livestock

Livestock were kept by 29.3 % of households (Fig. 3 shows the animal species) and of these, two households had animals that they kept for others. Poultry was the most frequent species kept; local bird breeds were kept by 22.9 % of the households and only one household owned exotic poultry. Cattle were the second most commonly kept livestock (14.6 % of the households). The livestock biomass contributed by different species is shown in Fig. 3, as well as the ownership by gender. The percentage of households owning animals increased with income (p -value = 0.001) and in Dagoretti was more than double of Korogocho. The total livestock holding was also significantly higher in Dagoretti (mean = 0.67, SD = 1.17) compared to Korogocho (mean = 0.28, SD = 2.35) (p -value < 0.001). The livestock contribution to the total household asset base across all households was 18.2 %. Of the households reporting they had one or more livestock species, 61.6 % reported to have animals mainly for subsistence, 53.3 % reported to have species which were mainly for selling, 13.3 % had horses, donkeys or cattle for the purpose of draft and other work, and one household reported to have cattle for bull fighting. Also, amongst livestock-keeping households, 62.7 % kept their animals outside the urban area, 33.9 % kept their livestock in structures attached to their household and 3.4 % kept their animals elsewhere within the urban area. The specific livestock contribution to the asset base for women was 52.4 %. Animals were mostly said to belong to the household and not to any specific member of the family. When attributed to a specific member, they were more often attributed to female than to male members, although the sample size was too small to test for a true difference.

Maternal and child nutrition

Children 1–3 years

Overall, 8.3 % of the children were reported to be premature at birth. At the time of the survey, 43.4 % of

children were still breastfeeding, although only 37.3 % were reported to have consumed breastmilk on the previous day. Of the 55.6 % of children who were not breastfeeding, 99 % were reported to have been breastfed earlier in life, with a mean duration of 17.1 months (SD = 5.5 months). Just over half the children (54.5 %) were reported to have been exclusively breastfed up to 6 months of age and the introduction of liquids took place on average at 4.1 months (SD = 2.4 months) and of solid food at 5.4 months (SD = 1.9 months), with no statistical differences by gender. A majority of children (82.0 %) was reported to have taken vitamin A capsules over the previous 6 months. Three of the children had been in a therapeutic feeding programme during the last three months, one of whom was still in the programme; one child had been in a supplementary feeding programme. None of the children was reported to have positive HIV status but only 51.2 % had been tested. It was reported that 22.9 % of children had been sick within the past 24 h, with cough (9.2 %), fever (8.3 %), diarrhoea (5.9 %) or vomiting (2.9 %) as the most common symptoms.

Table 2 summarises the dietary and nutritional indicators of breastfeeding and non-breastfeeding children by area (child sex differences are shown in the Additional file 1: Table S2). Breastfeeding children were significantly younger (p -value < 0.0001) but did not differ in other nutritional indicators. Total prevalence of acute malnutrition was 4.4 %, with 1.0 % severely wasted and no cases of oedema reported; total stunting was 41.5 %, with 14.2 % of cases severe stunting. The mean height-for-age Z-scores was lower in Korogocho than Dagoretti (0.47 SD lower, p -value = 0.004) and in boys than girls (0.38 SD, p -value = 0.02). Anaemia was found in 74.1 % of children, with 2.4 % of cases severe anaemia. Among the wasted children 66.7 % were also stunted (the β coefficient of the linear regression between height-for-weight and height-for-age was 0.164, p -value = 0.031) and 88.9 % were also anaemic (the β coefficient of the linear regression between height-for-weight and haemoglobin levels was 0.155, p -value = 0.016). There was no association between height-for-age and haemoglobin levels.

It was reported that 13.2 % of children had lower total dietary intakes than usual on the day prior to the survey. The estimated energy and nutrient intakes, the percentages at risk of inadequate nutrient intakes (non-breastfed children and women only), and the percentage of children with a dietary diversity score \geq four food groups are also shown in Table 2 (differences by sex in Additional file 1: Table S2). The energy and nutrient intake data for breastfeeding children was from complementary foods alone (i.e. not including intakes from breastmilk). Overall, more than a third of non-breastfed children were at risk of inadequate intakes of calcium, iron or niacin (up to 98.7 % in

the case of iron); whereas the percentage of children at risk of inadequate intakes of zinc and vitamins B6, B12 and C were low (<10 %). Just over two thirds of the children (i.e., 68.6 %) were consuming diets that had the recommended foods from 4 or more food groups, although this percentage was significantly lower in Korogocho than Dagoretti (80.0 % vs 57.7 %, *p*-value = 0.001); the difference between boys and girls was not significant. On the 24-h recall day, over 50 % of children consumed foods from the staples (starchy tubers and grains), green leaves, other vegetables (mostly tomato) and dairy products; whereas less than 30 % and 10 % consumed flesh foods and eggs, respectively (Fig. 4). Iron intake was not found to be associated with haemoglobin levels in any of the groups.

Women of reproductive age

The mean age was 26.2 years (SD = 6.1 years). Night blindness was reported by 6.3 % of women. None of the women were taking iron supplements at the time of the survey, however, 41.0 % reported to have taken iron supplements during their last pregnancy, of whom 86.3 % reported taking them seven days a week over an average length of 4.9 weeks (SD = 6.7 weeks), and 15.2 % of women took iron supplements for 12 weeks or more. Relatively few women reported being HIV-positive (i.e., 6.3 %).

Not having enough food for the family ‘occasionally’ (less than 15 times a year) was reported by 28.8 % of women, and ‘often’ (above 15 times a year) by 29.8 %. Women’s nutrition and dietary indicators by area are summarised in Table 2 (and by sex of head of household, in the Additional file 1: Table S2). Less than 10 % of women were under-weight (BMI < 18.5 kg/m²), whereas close to

30 % were over-weight or obese (BMI > 25 kg/m²) of which 9.9 % were obese (BMI > 30 kg/m²). The BMI was not associated with HIV status. The prevalence of anaemia was 25.9 %: 1.5 % of cases were severe, 14.2 % moderate and 10.2 % mild. No differences in nutritional status were detected between areas or depending on the sex of the household head. Lower than normal dietary intakes on the day prior to the survey was reported by 11.2 % of women and 5.4 % had been sick, mostly due to head or other body pain. Over a third of the women were at risk of inadequate intakes of calcium, zinc, riboflavin, niacin and folate (up to 93.8 % in the case of calcium); whereas fewer than 20 % were at risk of inadequate intakes of iron. Dietary iron intakes and reported length of iron supplementation were not associated with haemoglobin levels among these women. The average percentage of contribution to energy intake was slightly low for protein (9.6 % vs recommended 10–35 %), normal for fat (23.5 % - recommended 20–35 %) and high for carbohydrates (68.1 % vs recommended 45–65 %). The women dietary diversity score was 0.2 points lower in Korogocho (*p*-value = 0.04) and the food groups consumed are shown in Table 4. As for children, over 50 % of women consumed over the last 24 h staples, green leaves, other vegetables and dairy products; whereas less than 30 % and 10 % consumed flesh foods and eggs, respectively (Fig. 4).

Predictors of malnutrition

The direction and statistical significance of the unconditional linear regression models for predictors of interest of nutritional outcomes are shown in Table 3 (the β-coefficients are shown in the Additional file 1: Table S3). The β-coefficients of the statistically significant variables

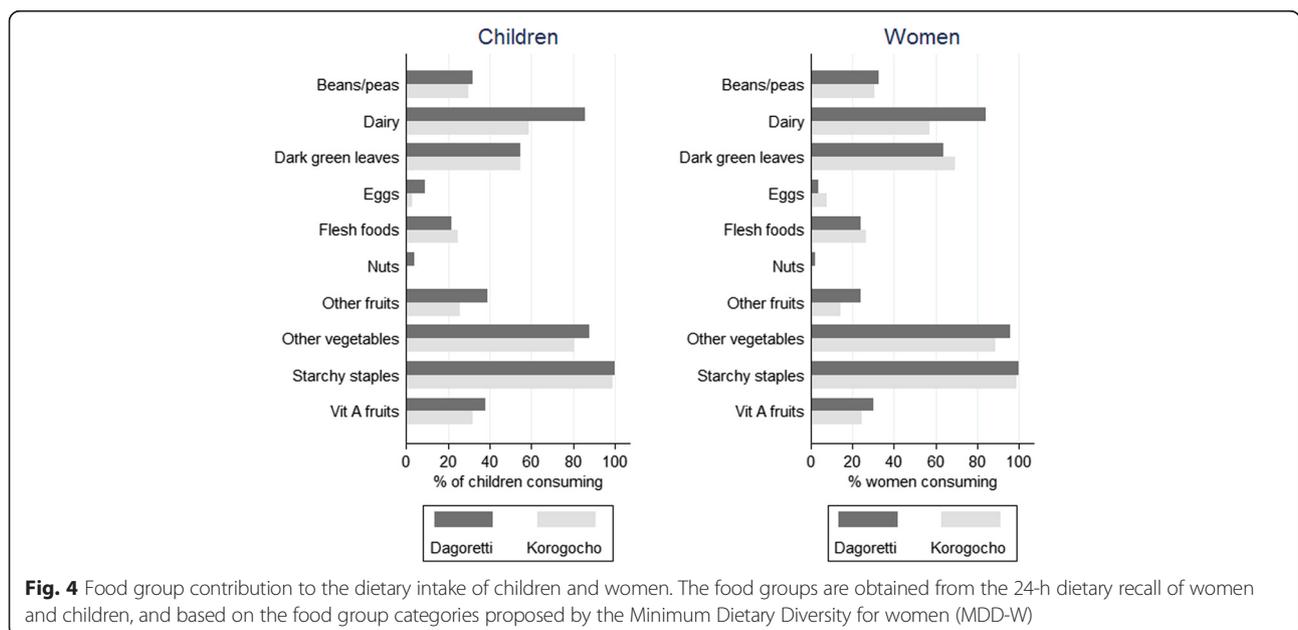


Table 3 Univariable regression analysis for predictors of interest of nutritional outcomes

Description	Categories	n	β HAZ	β WHZ	β Ch Hb	β M BMI ^b	β M Hb ^c
Area	0 = Dagoretti; 1 = Korogocho	100/104	- ***	-	-	- *	+
Household income	1 = <1 K;	12	Base	Base*	Base **	Base***	Base
	2 = 1 K-5 K;	96	-	-	+	-	+
	3 = 5 K-10 K;	67	-	-	-	+	+
	4 = 10 K-20 K	29	+	-	+	+	+
Income expenditure decision	1 = Female	45	Base	Base	Base	Base	Base
	2 = Male	43	+	+		-	+
	3 = Joint	113	-	+		+	+
Female contribution to income	0 = No; 1 = Yes	72/120	-	-	-	+ **	+
HH head sex	0 = Male; 1 = Female	154/51	+	-	+	-	+
HH head education	0 = None or 1 st ly; 1 = Secondary+	113/83	+ ***	-	+	-	-
Maternal status	0 = Not married; 1 = Married	44/160	- *	+	-	-	- *
Maternal education	0 = None or 1 st ly; 1 = Secondary+	134/70	+ *	-	+	+	- *
Maternal occupation	0 = None, student; 1 = All other	118/86	-	-	-	+	+ *
# HH children (<15y)	1 = 1; 2 = 2; 3 = > 3	54/68/77	-	+	-	+	-
Quality of housing score	0 = 4-6; 1 = 8-16	163/38	+ *	+	+ *	+ **	+
Domestic asset index	-	203	+	+ *	+	+ **	+
Women domestic asset index	-	203	+ ***	+	+	+ **	+
Domestic livestock asset index	-	203	-	+ ***	+	+ **	+
Women livestock asset index	0 = 0; 1 = >0	158/46	+	+ **	-	+ ***	- **
Total livestock holding	0 = 0; 1 = >0	145/59	+	+ *	+	+ **	- *
Female livestock holding	0 = 0; 1 = >0	157/47	+ **	+ **	+	+ ***	- *
Maternal age [yrs]	-	204	quad ^a	+	+	+ ***	+
Child age [months]	-	204	- **	+	+ **	+	+
Child sex	0 = Male; 1 = Female	116/88	+ ***	-	+	-	-
Prematurity	0 = No; 1 = Yes	186/16	-	- **	+	+	- **

Regression coefficients are not presented because the parameters were measured on different scales. These values are presented in the Additional file 1: Table S3. The sign (+/-) indicates the direction of the relationship and the ***indicated the statistical significance (* p -value ≤ 0.15 , ** p -value ≤ 0.1 , *** p -value ≤ 0.05 ; Ch = child; HH = household; M = mother; n = sample size

^aquadratic function with peak at approximately 30 years

^bmother's BMI was log transformed to improve normality of distribution

^cmother's Hb was transformed as $(Hb^3)/1000$ to improve normality of distribution

in the multivariable regression analysis are shown in Table 4. The factors significantly associated with nutritional status were: for child height-for-age, living in Dagoretti, being a girl and having a non-married mother were associated with better Z-scores and the household head's education was marginally associated. For weight-for-height, living in Dagoretti and female ownership of livestock were positively associated (marginally in the case of female livestock holding) while income was negatively associated. Regarding maternal nutrition, BMI was positively associated with age and negatively associated with income; whereas hemoglobin levels were marginally associated with prematurity of child at birth.

Finally simple linear regression showed an association between certain nutritional indicators of a child and those of their mothers/caregivers: haemoglobin levels of

woman and child had a β -coefficient of 0.152 (p -value = 0.006), child weight-for-height and woman BMI had a β -coefficient of 0.614 (p -value = 0.014), and child height-for-age and women height had a β -coefficient of 0.030 (p -value = 0.032).

Discussion

This paper documents socioeconomic and nutrition characteristics of two areas of informal settlements in Nairobi, Kenya. Even though Dagoretti's deprived areas are urban by definition, they have a peri-urban character, with lower population density and more agriculture activities, than Korogocho, which is a shanty-town inside the city. The levels of malnutrition and risk of inadequate intakes were high, highlighting that pockets of malnutrition exist in poor urban areas of Nairobi.

Table 4 Multivariable regression analysis for predictors of interest of nutritional outcomes

Description	Categories	<i>n</i>	β HAZ (<i>p</i> -val)	β WHZ (<i>p</i> -val)	β Ch Hb (<i>p</i> -val)	β M BMI ^a (<i>p</i> -val)	β M Hb ^b (<i>p</i> -val)
Area	0 = Dagoretti; 1 = Korogocho	100/104	-0.427 (0.014)	-0.392 (0.045)	-0.239 (0.219)	-0.004 (0.893)	0.021 (0.849)
Household income	1 = <1 K	12		base (0.009) ^c		base (0.019) ^c	
	2 = 1 K-5 K	96		-0.140 (0.714)		-0.065 (0.226)	
	3 = 5 K-10 K	67		-0.682 (0.087)		-0.007 (0.899)	
	4 = 10 K-20 K	29		-0.929 (0.037)		0.051 (0.409)	
HH head education	0 = None or 1 ^{ary} ; 1 = Secondary+	113/83	0.313 (0.076)				
Maternal status	0 = Not married; 1 = Married	44/160	-0.427 (0.045)				
Female livestock holding	0 = 0; 1 = >0	157/47		0.426 (0.054)			
Maternal age [yrs]	-	204	0.000 (0.973)	0.010 (0.479)	0.017 (0.299)	0.007 (<0.0001)	-0.002 (0.833)
Child age [months]	-	204	-0.021 (0.082)				
Child sex	0 = Male; 1 = Female	116/88	0.332 (0.050)				
Prematurity	0 = No; 1 = Yes	186/16					-0.344 (0.098)

B-coefficients and *p*-values (*p*-val) are presented. *Ch* child, *HH*, household, *M* mother, *n* sample size

^amother's BMI was log transformed to improve normality of distribution

^bmother's Hb was transformed as (Hb³)/1000 to improve normality of distribution

^coverall *P*-value for variable

Nevertheless, the women and children residing in Dagoretti clearly showed better socioeconomic and nutrition status than in Korogocho, and so might be a better model for informal development. The data show that even among low-income households in Nairobi there can be a wide range of variability and hence the importance of stratifying data in urban areas in research and policy design. Some socioeconomic indicators, including livestock ownership, were found to be associated with nutritional outcomes, which is of relevance for policy and intervention design.

Socioeconomic characterisation

The data (income and family size) indicate that majority of households, in this study live under the World Bank international poverty line set at 1.25\$ per day per person [39]. Female-headed households had significantly lower incomes than male-headed households; whereas they were similar comparing other socioeconomic indicators. These results may reflect a misclassification bias. We could not distinguish between female headed households with an absent male-head versus those with no male head. The first named might receive financial support from a husband living away, which could attenuate differences between female and male headed households.

The quality of housing was mostly classified as 'Poor' (i.e. scores ≤ 10), with only a few households being 'Average' (i.e. scores between 11 and 20). All indicators related to ownership of land, domestic assets and animals were better in Dagoretti. Gender disaggregation of asset ownership including livestock is important to identify

gender disparities and track potential inequity reduction resulting from targeted interventions. Ownership of assets by women increases the decision power and thus has been associated with positive outcomes in health and education [40]. Assets like livestock can have specific impacts on food access and availability [41, 42]. The median gender asset disparity was 0.7, relatively high, indicating female ownership was important. This could be due to the relative presence in the sample of female-headed households (one in four households). In addition, the concept of 'ownership' of assets might need further exploration. For example, respondents might say that assets belong to the household and thus to all of its members, but this might not be the case when a couple divorces. In such situations gender disparity could raise, with women losing important assets. A different question formulation could be investigated in this respect in further studies, to obtain more accurate information and assess capacity of women to respond to 'household internal shocks' [43].

In this study, 29.3 % of households owned livestock, which is comparable to other African urban settings [44]. Animals are particularly important assets, contributing in multiple ways to household economy, in particular to either income generation and/or the household's own food consumption [44, 45]. The number of heads and species owned can be highly informative to the household's socioeconomic characterisation, and be strongly related to productivity, income and welfare in some rural settings of developing countries. While in rural areas the majority of household keep livestock, the less well-off are more likely

to keep livestock [44]. In urban areas livestock ownership is generally less common due to space and other restrictions, but the same trend seems to apply [44]. However, these trends can also be context-specific, and African countries such as Malawi or Tanzania have shown that rural wealthier households were likely to own more livestock [44, 46]. The households keeping livestock in Dagoretti (and an animal biomass (TLH) more than double that of Korogocho) might contribute to a diverse livelihood portfolio, and improve resilience, and dietary quality. However animal concentration can also increase the zoonotic pathogen load in the household. In this study, income was positively associated with animal ownership; this increased income could be either the result of the small-scale livestock production and/or the reason for investment in livestock. Importantly, livestock was reported to be owned predominantly by the household (i.e. not by male members), and also sometimes by women. This deviates from findings in rural poor settlements and may be due to urban context where men can often have a job outside the household and are less involved in livestock. Again there can be differences in the understanding of the term 'ownership,' since other work in Dagoretti (among richer dairy households) quoted people as saying "everything with blood in the house belongs to the man", while finding that women dominated decisions about cattle milk, manure and the day-to-day care of cattle [27]. The absence of refrigerators in both areas could pose a challenge to food preservation and food safety, particularly for foods of animal origin (i.e. meat, milk).

Maternal and child nutrition

The areas under study, like other urban low-income ones, showed the presence of a double burden of malnutrition in which high levels of chronic malnutrition (stunting) co-exist with high levels of maternal overweight/obesity [13]. In this study, 4 in 10 children between 1 and 3 years were stunted and almost one third of their mothers were overweight or obese [14]. Anaemia was also an issue of concern, especially among children, and almost all non-breastfed children were at risk of inadequate iron intakes. The quality of diets was low. Over 50 % of non-breastfed children were at risk of inadequate intakes of iron and calcium; and over 50 % mothers were at risk of inadequate intakes of calcium, zinc, riboflavin and niacin. These nutritional profiles suggest that micronutrient-dense food must be promoted, rather than calorie dense foods, to prevent stunting and reduce overnutrition and its related diseases such as diabetes type II or heart disease. These chronic diseases are becoming prevalent in urban poor settings [47]; and will place an economic burden on health care systems, which might well justify a resource investment in the food production system and in education. Interventions at the food

system level may contribute to economic activity as well as prevent long-term reduction in human welfare. Low intakes of essential micronutrients and high rates of stunting and child anaemia justify the promotion of nutrient-dense foods such as animal-source foods. In follow-up research, some related issues were addressed to explore the economic and sociological drivers of animal-source food demand, including price elasticities (Cornelsen L, Dominguez-Salas P, et al. Price and other drivers of demand for animal source foods in peri-urban Nairobi, Kenya. Forthcoming. 2016). These studies also analysed the characteristics of the Nairobi livestock value chains supplying these low-income dwellers, in order to assess associated limitations, challenges, upgrading opportunities and risks (Alarcon P, Fèvre EM, et al. Mapping of the beef, sheep and goat source food systems in Nairobi associated to markets and large processing companies. 2016. Forthcoming).

Children

Prevalence of stunting above 40 % was 'very high' according to the WHO Classification for assessing severity of child malnutrition, and compared to national levels. This probably reflects long-term problems of food insecurity, poor diets and child feeding practices, micronutrient deficiency, infectious disease load and/or enteropathy, inadequate water and sanitation, among others [16, 17, 48]. Almost one in four children had recently been sick, which might be due to poor food and environmental hygiene and the effect of the rainy season. Malnutrition has consequences for the individual's mental (cognitive) and psychomotor development, and the high prevalence of stunting observed in this study is expected to have serious long-term impact on the development and wellbeing of the Kenyan society as a whole. Tackling stunting in these settings can be challenging, but fostering prevention strategies must be a high priority. Conversely a 'low' level of wasting (<5 %) was found, which suggests dietary energy intakes were adequate. We observed a sex difference in the prevalence of stunting; however, this was not supported by differential intake in our data. A comparative advantage in girls has been reported in other studies and the reasons could be both biological (response to environmental stress) and cultural (differential access to food, care, or physical activities) [13, 49, 50]. Also, the difference in prevalence between Dagoretti and Korogocho could be related to differences in the general sanitation, population density, and environmental conditions between these two areas. The number of wasted children was not high, but our data showed coexistence of wasting and stunting and an association between them. Both conditions are associated with increased mortality, especially when they co-exist, and infectious diseases contribute to both of them, as do inflammation and gut health (via the effects of

chronic inflammation, malabsorption and/or appetite effects) [51–53]. There is also evidence that weight and length at birth determine later linear (and potentially ponderal) growth, and therefore women should be targeted via maternal (and pre-maternal) health and nutrition support. In children below five years, stunting, severe wasting and intrauterine growth restriction together are estimated to contribute 21 % of total global disability-adjusted life-years (DALYs), which constitutes the largest risk factor in this group [54]. Child anaemia prevalence was above the 40 % WHO anaemia threshold considered as a ‘severe public health problem’ [38], and does not seem to have improved from data from the latest comprehensive survey on anaemia prevalence in 1999, which was 69.0 % for preschool-age children countrywide [55].

Breastfeeding practices recorded were better than previously reported for these settings [17]; however, the follow up methodology in that study was different: focusing on younger children and with feeding practices being longitudinally recorded in detail. The nutrient intake of children surveyed in Korogocho was consistently lower than those in Dagoretti for all nutrients and child groups, but was only statistically significant in non-breastfeeding children (with the exception of vitamins A, B12 and C), probably due to the relative sample sizes. B12 was abnormally high in this population probably due to the national mandatory fortification of refined maize flour for the key staple ‘ugali’. An increased blood level of vitamin B12 due to high intake is unlikely, as only small amounts of vitamin B12 can be absorbed and the rest is removed in the urine. Therefore, no tolerable upper intake level (UL) has been set [56]. Doses as high as 2000 µg have not shown significant side effects [57]. Lower intakes in Korogocho could be due to lower income among the households, although anecdotal observation indicates that food prices are also lower in Korogocho. Also, the access to nutrient-rich value chains could differ among areas. The minimum dietary diversity score was high in Dagoretti compared to studies from other sub-Saharan countries, probably due to the urban nature of the population [58, 59], but was significantly lower in Korogocho. In these settings, there is a need to assess if the right quantity and quality of food to ensure dietary requirements can be met with local diets, and thus enable children and women to reach their optimal weight, heights and cognitive capacity. The lack of association between the individual haemoglobin levels and iron intakes might be due to the absence of repeated day intake measurement and inherent measurement error associated with estimating dietary intake, as well as other factors such as parasite infestation. Despite the existence of a programme distributing sprinkles to children under 5, no household

reported consumption of sprinkles within the 24-h recall.

Women

The prevalence of 29.1 % overweight (9.9 % obese) in women was lower than previously reported in Korogocho and Viwandani from a sample of older women [60], and coexisted with 7.4 % of women being too thin. The key risk factors for obesity in these areas deserve further investigation and could be related to high intakes of carbohydrates and oil, and to lack of physical activity. The prevalence of anaemia in non-pregnant women was low compared to children but in line with the national prevalence in women of reproductive age (25 %) [61]. Yet, it would still be classified as a ‘moderate public health problem’; also, Nairobi has low malaria prevalence. In any case, health policies on anaemia prevention and control introduced by the Ministry of Health over recent years to address the high rates of anaemia need to be formally monitored and evaluated. Taking iron supplements during pregnancy was reported by almost half of the women, although the compliance period was relatively short. Night blindness was also lower than the 6.8 % reported in the 2008/09 demographic and health survey [62] although it is not fully comparable since that study referred to both sexes and to different areas. This was in turn higher than the 4.3 % found in that same survey for rural populations, indicating that dwellers of poor urban areas could have a more limited access to vitamin A rich foods. Nutrient intakes were consistently lower for all nutrients except for vitamin B12 and iron in Korogocho women than in Dagoretti ones, but these differences were only significant for calcium, zinc, riboflavin, vitamin B6 and folate. The significantly higher intake of calcium and riboflavin in Dagoretti could be due to higher fresh milk intakes in this area, possibly facilitated by a higher presence of livestock. Women’s dietary diversity indicators were also lower in Korogocho and were in line with previous findings [63]. Ethnicity was not included in the questions to avoid potential sensitivity but it should be explored in the future since dietary practices and patterns have been observed to differ among ethnic groups [64]. A double burden of malnutrition was identified among women, and better nutrition of the woman and child assessed seemed to be associated within households. In addition, higher weight may be related in this population to higher caloric intake from commonly used fried street foods such as ‘mandazi’ (a sort of doughnut) and oil, and not to good quality foods, thus not preventing stunting or anaemia.

Predictors of malnutrition

Some factors related to poverty have been identified in previous studies as associated with suboptimal nutrition [65]. Among the sociocultural predictors explored, the best

predictors of stunting in this study were lower education of the head of the household, sex of the child (with girls having lower stunting rates), and marital status (with married women having more stunted children). Lower education and not being married have been previously identified as risk factors for stunting [12] and breastfeeding cessation [17]. Higher education is likely to be associated with higher knowledge, higher income and more positive health and nutrition practices. Surprisingly, contrary to the previous study, in this sample children of married women were more likely to present lower height-for-age than children of single or divorced women. Although this study includes a different setting (Dagoretti), with a different socioeconomic reality than Korogocho and Viwandani, this finding requires further investigation. Weight-for-height showed positive relationship with female livestock ownership expressed as number of tropical livestock units, suggesting a beneficial effect of women owning animals as regards wasting in these settings, although this association was only marginally significant and would require further study. Evidence so far has shown that animal ownership may relate to better nutrition at household level [45, 66–68]; this has been reported for stunting in rural populations, and the pathways are still unclear. The lack of association of stunting with animal assets in this sample might thus be due to different dynamics of animal use and expenditure patterns in these urban areas compared to rural ones. In poor urban settings, direct pathways contributing to own consumption of animal-source foods could be affected due to animals being kept far from households (in this sample, households with higher number of animals i.e. >5 heads of ruminants or >10 heads of poultry were kept mostly outside the urban area) and therefore contribution to daily intakes might be limited, or alternatively to fewer animals kept. Indirect pathways of income generation to purchase food might also be affected due to a higher number of competing priorities for money expenditure. In addition, animals in overcrowded areas could contribute more easily to zoonotic disease via environmental contamination, potentially contributing to malnutrition. Therefore, the interaction with animals in these settings could be substantially different to rural areas and deserves further investigation. The association found with wasting rather than with stunting could be due to the sale of animal-source foods to buy caloric foods (staples, oil, etc.) rather than for own consumption. The negative association of income with weight-for-height and maternal BMI was unexpected. It is important to note that the difference between income categories is limited, and households may have varied among income category each month, as incomes were often irregular. Again, this finding might be related to expenditure dynamics: when additional income was obtained in a month, it might have been diverted to other household needs, reducing intakes. The fact that it was not associated with longer-term

indicators such as height-for-age is reasonable when income differences are not related to higher level of education or knowledge, as adequate height-for-age at young age does not only rely on sufficient quantity of intake but also on quality of diet and good weaning food practices. Anaemia was not strongly related to any of the factors, and the effect of other factors such as intestinal parasites might be more important. The lack of association of nutrition with domestic assets might be related to the choice of assets, whose ownership might not be meaningful enough in these settings as to characterise different types of households (for example, in an urban area certain assets such as second-hand radio or a cooker might be easier to obtain at an affordable price; so which might be the best indicators for this type of context deserves attention).

Limitations

The households visited were relatively homogeneous in terms of socioeconomic parameters, and the range restriction might make it more difficult to establish differences. It must be noted that levels of acute malnutrition and BMI could substantially differ throughout the year, where different food availability, prices and access, and ultimately intake, as well as a different pattern of diseases are likely. Specifically, this study took place at the end of the short rainy season and weight could have been lower due to increased infections (respiratory infection, diarrhoea, etc., particularly in children) resulting, for example, from poor structures for water and sanitation and associated flooding. Also, as noted, part of the data was collected prior to Christmas festivities and part after, when purchase power may be lower. Although there was a two-week interruption to ensure a wash out period, weight might have been affected by festivities, when trips to rural areas are frequent (potentially with access to more diverse foods), as well as having relatives visiting for celebrations, and better meals and higher intakes. Data collection throughout the year would help obtain a better picture of the nutrition situation and capture seasonal variations. In any case, dietary data are subject to bias arising from recall, the error introduced by FCTs, and both respondent's under-reporting and over-reporting, which are expected to balance out on average, but may be important at individual level. Also, more than one day of observation would have been preferable to capture the intra-individual variation. A specific difficulty in a setting where food is often sold in small repacked portions is the misclassification of certain foods (e.g. flour composition, oil type). Finally the limited sample size might have prevented detection of statistically significant small differences and association. The necessary division between breastfed and non-breastfed children reduced further the sample size in some of the child comparisons.

Conclusions

This study presents useful information on socioeconomic and nutrition characteristics in two low-income urban areas of Nairobi. It highlights several key points: a) the two low-income areas investigated (Dagoretti, urban area with lower population density and more agriculture activities, and Korogocho, a shanty town inside the city) differed substantially, with Dagoretti showing consistently better indicators. This suggests that Dagoretti might represent a better model for informal development where, for example, the high proportion of households keeping livestock in Dagoretti could be contributing to a more diverse livelihood portfolio and to improved resilience. In any case, differences among low-income areas need to be considered when planning and prioritising interventions; b) there is evidence of triple burden of malnutrition, with 4 in 10 children stunted, 3 in 10 mothers obese, and high prevalence of anaemia, emphasising the need to target nutrition interventions and to address quality as well as quantity; c) livestock keeping was not found to be associated with stunting, which contrasts the results from recent studies that showed that livestock keeping in rural areas is associated with better stunting reduction; it was however marginally associated with wasting. This suggests that the livestock path to nutrition may be different in urban and rural contexts. Therefore, to improve nutrition during the first 1000 days in these settings, market based interventions may be more promising than interventions targeting livestock production. Upscaling of food value chain interventions could potentially contribute to ensure an affordable nutrient-dense food supply for healthy and sustainable diets. Interventions also need to incorporate women's empowerment and gender equality as a cross-cutting issue. Particularly for some gender indicators, such as women ownership of livestock and decision-making, further research is needed in this setting, including qualitative research. Given that urban populations are expected to expand in the coming years, these low-income settings will require further investigation to inform and develop policies and interventions with positive impact on maternal and child nutrition.

Additional file

Additional file 1: Table S1. Socioeconomic characteristics of participant households, by sex of household-head. Table S2: Nutritional indicators of participant children and women in poor households of Nairobi, by gender characteristics. Table S3: Coefficients of the univariable regression analysis for predictors of interest of nutritional outcomes. (DOCX 51 kb)

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Availability of data and materials

Data and analysis codes are available from the authors upon request and will be deposited in ILRI's publicly available repository at the end of the study.

Authors' contributions

The authors' responsibilities were as follows: PA, KC, EF, EF, DG, BH and JR conceived the study; PA, SA, KC, PD-S, EF, EF, DG, BH, EWK-M and JR contributed to the study protocol; PD-S conducted the data collection; ID and PD-S performed the statistical analysis; and PD-S drafted the manuscript. All authors reviewed and approved the final manuscript.

Competing interests

The authors declare that they have no competing interests.

Consent for publication

No individual participant data is published.

Ethics approval and consent to participate

Ethical approval was granted by the International Livestock Research Institute Institutional Research Ethics Committee (ILRI-REC2013-14), recognised by Kenyan authorities as competent to provide ethical clearance for human research in Kenya, and the Royal Veterinary College Ethics Committee (URN2013 0093H) in the United Kingdom. Informed written consent was obtained from all respondents after health authorities approval at the community level.

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