Factors associated with under-5 mortality in three disadvantaged East African districts

Kingsley E. Agho1,*, Osita K. Ezeh2, Akhi J. Ferdous3, Irene Mbugua4 and Joseph K. Kamara5,6

1School of Sciences and Health, Western Sydney University, Locked Bag 1797, Penrith, NSW 2751, Australia; 2International Centre for Diarrhoeal Disease Research, Dhaka, Bangladesh; 3World Vision International, Karen Road, Off Ngong Road, P Box 133 - 00502 Karen, Nairobi, Kenya; 4World Vision International, Southern Africa Regional Office, Mbabane H100, Swaziland; 5School of Social Science and Psychology, Western Sydney University, Locked Bag 1797, Penrith, NSW 2751, Australia

*Corresponding author: Tel: +612 4620 3635; Fax: +612 4620 3792; E-mail: k.agho@westernsydney.edu.au

Received 2 May 2019; revised 20 November 2019; editorial decision 18 September 2019; accepted 3 December 2019

Background: The high rate of avoidable child mortality in disadvantaged communities in Africa is an important health problem. This article examines factors associated with mortality in children <5 y of age in three disadvantaged East African districts.

Methods: Pooled cross-sectional data on 9270 live singleton births from rural districts in Rwanda (Gicumbi), Uganda (Kitgum) and Tanzania (Kilindi) were analysed using logistic regression generalized linear latent and mixed models to adjust for clustering and sampling weights. Mortality outcomes were neonatal (0–30 d), post-neonatal (1–11 months), infant (0–11 months), child (1–4 y) and under-5 y (0–4 y).

Results: The odds of post-neonatal and infant mortality were lower among children delivered by a health professional (adjusted odds ratio [AOR] 0.62 [95% confidence interval [CI] 0.47–0.81] for post-neonatal; AOR 0.60 [95% CI 0.46–0.79] for infant), mothers who had four or more antenatal care (ANC) visits during pregnancy (AOR 0.66 [95% CI 0.51–0.85]) and mothers who initiated breastfeeding within 1 h after birth (AOR 0.60 [95% CI 0.47–0.78]). Neonates not exclusively breastfed had higher mortality (AOR 3.88 [95% CI 1.58–9.52]). Children who lived >6 h away from the nearest health centre (6–23 h: AOR 1.66 [95% CI 1.40–2.0] and ≥24 h: AOR 1.43 [95% CI 1.26–1.72]) reported higher mortality rates in children <5 y of age.

Conclusions: Interventions for reducing deaths in children ≤5 y of age in disadvantaged East African communities should be strengthened to target communities >6 h away from health centres and mothers who received inadequate ANC visits during pregnancy.

Keywords: Disadvantaged communities, East Africa, food security, malnutrition, Under-fives death

Introduction

The disproportionate number of deaths among children <5 y of age between urban and rural dwellers remains a considerable challenge, particularly in sub-Saharan Africa (SSA), including Rwanda, Uganda and Tanzania. The most recent global mortality estimates indicate that the SSA region had the highest mortality rate for children <5 y of age, with most of those deaths occurring in rural areas. More than half of these deaths are preventable or treatable health issues, such as malaria, intrapartum-related complications, diarrhoea, pneumonia and preterm, which contribute to approximately 9, 12, 9, 16 and 13% of these deaths, respectively.

A recent population estimate revealed that the majority of people in Rwanda (84%), Uganda (75%) and Tanzania (70%) live in rural areas. Recent estimates show that the national mortality rates for children <5 y of age for Rwanda, Uganda and Tanzania have been substantially reduced and they are among the few countries in SSA that met the Millennium Development Goal (MDGs) 4 target. Despite this remarkable national decline in mortality rates for children <5 y of age, past evidence suggests that this improvement is boundless, but higher in urban than in rural areas, where there are likely to be a large proportion of households with higher socio-economic status and improved access to high-quality healthcare. In rural areas, however, the Demographic and Health Survey (DHS) reported higher mortality...
rates for children <5 y of age of 70, 75 and 68 deaths per 1000 live births than the national average of 51, 67 and 64 deaths per 1000 live births in Rwanda, Uganda and Tanzania, respectively,\textsuperscript{3,4,7} which may be attributed to socio-economic disparities,\textsuperscript{5} healthcare access and different approaches of intervention coverage.\textsuperscript{9}

Previous studies conducted in Rwanda, Uganda and Tanzania have indicated that child survival is influenced by community, socio-economic and individual (maternal and child) characteristics. For example, Musafiri et al.\textsuperscript{10} measured the impact of place of residence, maternal education attainment and household economic status on neonatal mortality and mortality for children <5 y of age in a national setting of Rwanda. They carried out a survival analysis of live births using national representative data from the Rwanda DHS. This study opined that mothers who have no formal education significantly affect mortality rates for children <5 y of age. A similar study performed by Naseije et al. in 2015\textsuperscript{11} further suggested that being a male child, female-headed household and number of births (one or more births) were significantly related to mortality in children <5 y of age in Uganda. A cross-sectional study conducted in Tanzania by Susuman et al.\textsuperscript{12} on the effect of biodemographic factors on child mortality indicated that birth interval and maternal parity (at least 4) were associated with deaths of children <5 y of age. Additionally, a community-based cross-sectional study on mortality in children <5 y of age in Abim district, Uganda showed that younger mothers (<20 y of age), previous birth interval (<2 y) and access to borehole water were significantly associated with the death of children <5 y of age.\textsuperscript{13} Limitations of these rural community-based or population-based cross-sectional studies are that these studies did not examine factors associated with child mortality in disadvantaged rural communities with similar characteristics and their analyses were not restricted to the most recent singleton live births in order to reduce recall bias. Multiple births were also included in their studies, and past research has shown that multiple births are more than twice as likely to die during infancy compared with singletons.\textsuperscript{14,15} Additionally, studies relating to different age ranges of the first 59 months of life have been limited in Rwanda, Uganda and Tanzania.

This study aimed to identify factors associated with mortality across all age subgroups from 0 to 4 y of age (neonatal, 0–30 d; post-neonatal, 1–11 months; infant, 0–11 months; child, 1–4 y; under-5: 0–4 y) in the three disadvantaged East African districts (Gicumbi, Kilindi and Kitgum). Findings obtained from this study could assist health administrators and public health researchers, as well as government policymakers, to re-evaluate and revitalize existing intervention strategies to accelerate the reduction of mortality in children <5 y of age in these rural communities and other communities with similar characteristics.

Materials and methods

Study area

The Gicumbi district is located in the Northern Province of Rwanda close to the border with Uganda. The Gicumbi district comprises 21 sectors, 109 cells and 630 imigundu (villages). The topography of Gicumbi is mountainous, surrounded by steep ravines with small valleys segmented by multiple swamps. The Kilindi district is one of the eight districts of the Tanganyika Region in Tanzania. The Kilindi district is bordered to the east by the Handeni district, north and west by the Kilimanjaro Region and south by the Morogoro Region. The Kilindi district comprises 16 rural wards, of which World Vision International (WVI) worked in 6, that have 31 villages. The Kitgum district is located in northern Uganda and is bordered by South Sudan to the north. The district has 51 parishes that have 437 village councils. Agriculture is the major economic activity in the districts of Gicumbi (Rwanda), Kilindi (Tanzania) and Kitgum (Uganda).

Previous studies have shown that poverty remains one of the major issues affecting disadvantaged communities in many SSA countries, including Rwanda (Gicumbi district), Uganda (Kitgum district) and Tanzania (Kilindi district). For example, a recent Rwanda National Institute of Statistics report on poverty indicated that the Gicumbi poverty rate ranges from 59 to 77 and is ranked the fifth district with the highest poverty rate in Rwanda between 2010 and 2011.\textsuperscript{16} Similarly, evidence from a recent poverty level survey in the Kilindi district showed that the poverty rate ranged from 60 to 80.\textsuperscript{17} A spatial analysis study on poverty levels that was conducted in Uganda in 2005 revealed that a high geographic concentration of poverty (poverty rate >60) was found in the northern districts, including the Kitgum district.\textsuperscript{18}

Study setting and period

WVI used the ‘7–11’ approach, aimed at preventing maternal and child mortality and morbidity through 7 key interventions for the mother and 11 interventions for the child in disadvantaged East Africa communities. Detailed information about the core interventions for the mothers and children has been reported elsewhere.\textsuperscript{19,20} The baseline, midterm and endline surveys were conducted between July 2011 and June 2016.

Mortality information was extracted from the endline cross-sectional survey of the WVI 7–11 interventions because only the endline survey collected information on child survival. The study was conducted from 21 to 31 January 2016 in the Gicumbi district in Rwanda, Kitgum district in Uganda and Kilindi district in Tanzania, covering 32 villages as part of WVI’s funding service agreement to generate evidence to influence maternal and child health programmes that aimed to reach 36 250 disadvantaged beneficiaries in these East African districts. The study population shared similar characteristics (homogeneous, i.e. all households from a low socio-economic group). The respondents were enrolled in a Maternal Newborn Child Health (MNCH) intervention at the household level, with the specific criteria for household inclusion being the presence of a pregnant woman or breastfeeding mother. The MNCH intervention project aimed to protect and promote mothers’ and children’s health in the region.

Sample design

The survey sample was selected in two stages. In the first stage, a total of 20 villages (clusters) were selected from the cells. In the second stage, 32 households were randomly selected in each of the selected villages (clusters). All selected villages were visited and none was replaced, regardless of the
reason(s) encountered or given. The total sample for the survey consisted of 20 clusters. All 660 (including non-response rate) households completed the mother/caregiver interviews, yielding a response rate of 100%. The high response rate for this survey was because, before conducting the interview, WVI staff in the districts mobilized local leaders, community health workers and team leaders of community health workers for the survey. For reporting district-level results, sample weights were used, and sampling weight was calculated as the product of the reciprocal of the sampling fractions employed in the selection of cells and villages.

**Data management**

The questionnaires used in the survey collected information on household members (usual residents) and mothers/caretakers for all children <5 y of age. The women/caretakers questionnaire included demographic characteristics; antenatal, delivery and postnatal care; breastfeeding and child nutrition. The questionnaires were installed on tablets using the Open Data Kit (ODK). Data were posted daily after fieldwork, enabling a daily review to check for inconsistencies and errors.

**Study outcomes**

The main outcomes used were childhood mortality examined in five different time periods. The time periods were neonatal death (death after birth–30 d of life), post-neonatal death (death of an infant from 1 to 11 months of life) and infant death (death of an infant after birth through 11 months of life). The other two outcomes were child death (death between 1 and 4 y of life) and death of children <5 y of age (death of a child after birth through 4 y of life). We divided the cohorts into five age subgroups based on the Global Burden of Disease Study age classification for the analysis of childhood mortality in the developing world.22

**Potential confounders**

Our choice of potential confounding factors was based on a similar approach adopted by Mosley and Chen23 of factors influencing child survival in developing countries. The outcome variables were examined against all selected potential confounding variables and these variables were organized into four distinct groups: socio-economic and demographic (district, primary caregiver, caregiver education level, sex of the baby, caregiver marital status and household wealth index); child nutrition (exclusively breastfeeding, early initiation of breastfeeding and attended child monthly growth monitoring sessions); maternal and child health services (antenatal care [ANC], quality of care from health services [‘How would you describe the quality of care your sick child receives from the health facility?’], place of delivery, tetanus toxoid [TT] vaccinations during pregnancy, iron and folic acid supplementation, birth attendance and time to health centre) and environmental factors (water available all year, sources of drinking water and type of toilet facility).

The household wealth index variable measures basic household needs for all children 5–18 y of age and these are indicators used by WVI for designing their intervention programmes.24 The household wealth index was constructed by assigning weights to three basic household needs for children 5–18 y of age (i.e. difficulty providing at least two sets of clothes for all children ages 5–18 y living in the household, difficulty providing a pair of shoes for all children ages 5–18 y living in the household and difficulty paying school fees or school contributions for all children ages 5–18 y living in the household) using principal components analysis.25 The household wealth index was divided into three categories (poorest, middle and least poor) and improved and unimproved sources of drinking water and type of toilet facility were categorized based on the World Health Organization and United Nations Children’s Fund Joint Monitoring Programme guidelines.26

**Statistical analysis**

Combined cross-sectional data on 9270 live singleton births in the previous 5 y from Rwanda (Gicumbi district), Uganda (Kitgum district) and Tanzania (Kilindi district) were examined. Mortality rates using a direct method were used to calculated mortality rates for children <5 y of age of all selected characteristics. This was followed by generalized linear latent and mixed models (GLLAMMs) with the logit link and binomial family that adjust for clustering and sampling weights used for univariable and multivariable analyses. We then used multivariable analyses to examine factors associated with each of the study outcomes. As part of the multivariable analyses, a staged modeling technique was employed.

In the multivariable analyses, a four-stage model was carried out. In the first-stage model (model 1), all socio-economic and demographic factors were entered into the model, and this was followed by a manually executed elimination process. Only variables associated with outcome were retained (model 1). In the second-stage model (model 2), the significant factors (p<0.05) in model 1 were added to child nutrition factors, and this was followed by an elimination procedure but retained all the significant factors obtained in model 1. In the third-stage model (model 3), maternal and child health service factors were added and variables with p<0.05 were retained, including all factors obtained in model 2. In the final model (model 4), we added environmental factors to model 3, retained all factors in model 3 and reported the factors that were significantly associated with the outcomes. All statistical analyses were conducted using Stata/MP version 14.1 (StataCorp, College Station, TX, USA) and multilevel models were fitted using Stata survey commands to adjust for the variability of clustering (villages) and sampling weights. The adjusted odds ratios (AORs) and their 95% confidence intervals (CIs) obtained from the adjusted multiple logistics model were used to measure the factors associated with neonatal, post-neonatal, infant, child and under 5 mortality.

**Results**

The distribution of the mortality rate for children <5 y of age and their 95% CIs in three disadvantaged East African districts are presented in Table 1. Mortality rates for children <5 y of...
Table 1. Distribution of under-5 mortality rate and 95% CIs in three disadvantaged East African districts (N=9270)

| Variables                           | Live births, n | Deaths, n | Mortality rate (95% CI) |
|-------------------------------------|----------------|-----------|-------------------------|
| District (country)                  |                |           |                         |
| Gicumbi (Rwanda)                    | 2349           | 418       | 178 (161–195)           |
| Kitgum (Uganda)                     | 4267           | 895       | 210 (196–223)           |
| Kilindi (Tanzania)                  | 2654           | 412       | 155 (140–170)           |
| Caregiver education level (N=9266)  |                |           |                         |
| No schooling                        | 3864           | 668       | 173 (160–186)           |
| Primary                             | 4590           | 919       | 200 (187–213)           |
| Secondary                           | 812            | 137       | 169 (140–197)           |
| Marital status (N=9266)             |                |           |                         |
| Never married                       | 5268           | 668       | 127 (117–136)           |
| Currently married                   | 3789           | 919       | 243 (227–258)           |
| Formerly married                    | 209            | 137       | 655 (545–765)           |
| Household wealth index              |                |           |                         |
| Poorest                             | 4744           | 823       | 173 (162–185)           |
| Middle                              | 2713           | 499       | 184 (168–200)           |
| Least poor                          | 1813           | 403       | 222 (201–243)           |
| Caregiver                           |                |           |                         |
| Mother                              | 8261           | 1535      | 189 (177–195)           |
| Othersa                             | 1009           | 190       | 188 (162–215)           |
| Sex of the baby                     |                |           |                         |
| Male                                | 4552           | 901       | 198 (185–210)           |
| Female                              | 4718           | 824       | 175 (163–187)           |
| Attended child monthly growth monitoring sessions (N=8663) | | | |
| Yes                                 | 6941           | 1317      | 190 (179–200)           |
| No                                  | 1722           | 338       | 196 (175–217)           |
| Water availability all year         |                |           |                         |
| Yes                                 | 7071           | 1345      | 190 (180–200)           |
| No                                  | 2199           | 380       | 173 (155–190)           |
| Sources of drinking water           |                |           |                         |
| Improved                            | 5954           | 1133      | 190 (179–201)           |
| Unimproved                          | 3316           | 592       | 178 (164–193)           |
| Type of toilet facility             |                |           |                         |
| Improved                            | 469            | 93        | 198 (158–239)           |
| Unimproved                          | 8801           | 1632      | 185 (176–194)           |
| Quality of care from health services (N=8170) | | | |
| Very good                           | 1379           | 248       | 179 (157–202)           |
| Good                                | 4857           | 942       | 194 (182–206)           |
| Not good                            | 1934           | 337       | 174 (156–193)           |
| Antenatal care (N=8904)             |                |           |                         |
| Inadequate (<4 visits)              | 2374           | 501       | 211 (193–230)           |
| Adequate (≥4 visits)                | 6530           | 1153      | 177 (166–187)           |
| Place of delivery                   |                |           |                         |
| Government health unit              | 7003           | 1292      | 184 (174–195)           |
| Other                               | 2263           | 433       | 191 (173–209)           |
| Birth attendance (N=9202)           |                |           |                         |
| Non–health professional             | 4292           | 777       | 181 (168–194)           |
| Health professional                 | 4910           | 926       | 189 (176–201)           |
Table 1. Distribution of under-5 mortality rate and 95% CIs in three disadvantaged East African districts (N=9270)

| Variables | Live births, n | Deaths, n | Mortality rate (95% CI) |
|-----------|----------------|-----------|--------------------------|
| Time to health centre (h) (N=7575) | | | |
| <6 | 2055 | 306 | 149 (132–166) |
| 6–23 | 2431 | 486 | 200 (182–218) |
| ≥24 | 3089 | 599 | 194 (178–209) |
| Iron and folic acid supplementation | | | |
| No iron | 2008 | 379 | 189 (170–208) |
| Iron | 7262 | 1346 | 185 (175–195) |
| TT during pregnancy | | | |
| No | 4455 | 990 | 222 (208–236) |
| Yes | 4815 | 735 | 152 (142–164) |
| Fever in the past 2 weeks | | | |
| No | 6003 | 973 | 184 (173–223) |
| Yes | 3267 | 752 | 189 (173–205) |
| Exclusive breastfeeding (N=9169) | | | |
| No | 6202 | 1141 | 184 (173–195) |
| Yes | 2967 | 561 | 189 (173–205) |
| Initiation of breastfeeding | | | |
| Delayed initiation of BF | 2691 | 553 | 205 (188–223) |
| Within the first hour of birth | 6579 | 1172 | 178 (168–188) |

Factors associated with post-neonatal mortality (1–11 months)

Table 3 reported factors associated with post-neonatal mortality in Gicumbi, Kitgum and Kilindi. Post-neonates who lived in the Kilindi district were more likely to die (AOR 1.92 [95% CI 1.25–2.96]) compared with those who lived in the Gicumbi district. Post-neonates from the least poor households were 1.67 times (AOR 1.67 [95% CI 1.18–2.35]) more likely to die compared with those delivered by non-health professionals. Post-neonates who were given iron and folic acid supplementation and who had adequate ANC (four or more visits) during pregnancy were 24% (AOR 0.76 [95% CI 0.59–0.99]) and 34% (AOR 0.66 [95% CI 0.51–0.85]) less likely to die, respectively, compared with post-neonates of mothers not given iron and folic acid supplementation and who had inadequate ANC (less than four visits) during pregnancy. Early initiation of breastfeeding within 1 h after birth was significantly more likely to reduce post-neonatal deaths by 40% (AOR 0.60 [95% CI 0.47–0.78]).

Factors associated with infant mortality (0–11 months)

Table 4 shows factors associated with child mortality. As indicated in the Table 4, infants born to mothers who lived in the Kilindi and Kitgum districts were significantly more likely to report higher infant mortality than infants born to mothers who lived in the Gicumbi district. Infants born to mothers from least poor households (AOR 1.61 [95% CI 1.17–2.12]) had higher odds of...
K. E. Agho et al.

Figure 1. Death rate per 1000 live births with 95% CIs of neonatal, post-neonatal, infant, child and under-5 deaths in the Gicumbi (Rwanda), Kitgum (Uganda) and Kilindi (Tanzania) districts.

Infant mortality than those born in the poorest households. Multivariable analyses indicated infants delivered by health professionals, those whose mothers had adequate ANC and those whose mothers initiated breastfeeding within 1 h after birth were 40%, 27% and 32%, respectively, less likely to die compared with infants who were delivered by non-health professionals, whose mothers had inadequate ANC and whose mothers did not initiate breastfeeding within 1 h after birth.

Factors associated with child mortality (ages 12–59 months)

In Table 5, children between 1 and 4 y of age had a significantly higher risk of child mortality if they lived in the Kitgum and Gicumbi districts. Children whose mothers were from least poor households were also more likely to die (AOR 1.38 [95% CI 1.17–1.62]), as were children whose mothers completed primary education (AOR 1.17 [95% CI 1.01–1.34]). Children whose mothers lived >6 h from the healthcare centre were significantly more likely to die (AOR 1.55 [95% CI 1.38–1.99] for 6–23 h to the healthcare centre; AOR 1.43 [95% CI 1.20–1.72] for ≥24 h to the healthcare centre) compared with children whose mothers lived <6 h from the healthcare centre. Children whose sources of drinking water were unimproved were significantly more likely to die (AOR 1.28 [95% CI 1.06–1.53]) compared with those children whose sources of drinking water were improved. Children who had fever 2 weeks before the survey were 1.30 times more likely to die (AOR 1.30 [95% CI 1.09–1.54]) compared with children with no fever.
Table 2. Factors associated with neonatal mortality

| Variables                        | OR     | (95% CI)     | p-Value | AOR     | (95% CI)     | p-Value |
|----------------------------------|--------|--------------|---------|---------|--------------|---------|
| District (country)               |        |              |         |         |              |         |
| Gicumbi (Rwanda)                 | 1.00   |              |         | 1.00    |              |         |
| Kitgum (Uganda)                  | 0.35   | (0.17–0.70)  | 0.003   | 0.27    | (0.13–0.56)  | <0.001  |
| Kilindi (Tanzania)               | 0.19   | (0.09–0.43)  | <0.001  | 0.71    | (0.29–1.73)  | 0.446   |
| Household wealth index           |        |              |         |         |              |         |
| Poorest                         | 1.00   |              |         | 1.00    |              |         |
| Middle                          | 0.15   | (0.05–0.44)  | 0.001   | 0.13    | (0.04–0.40)  | <0.001  |
| Least poor                      | 2.04   | (1.01–4.12)  | 0.046   | 1.48    | (0.69–3.21)  | 0.316   |
| Exclusive breastfeeding (EBF)    |        |              |         |         |              |         |
| Yes                             | 1.00   |              |         | 1.00    |              |         |
| No                              | 3.42   | (1.59–7.39)  | 0.002   | 3.88    | (1.58–9.52)  | 0.003   |

Table 3. Factors associated with post-neonatal mortality

| Variables                        | OR     | (95% CI)     | p-Value | AOR     | (95% CI)     | p-Value |
|----------------------------------|--------|--------------|---------|---------|--------------|---------|
| District (country)               |        |              |         |         |              |         |
| Gicumbi (Rwanda)                 | 1.00   |              |         | 1.00    |              |         |
| Kitgum (Uganda)                  | 0.78   | (0.58–1.06)  | 0.113   | 1.44    | (0.94–2.19)  | 0.092   |
| Kilindi (Tanzania)               | 1.13   | (0.85–1.49)  | 0.395   | 1.92    | (1.25–2.96)  | 0.003   |
| Household wealth index           |        |              |         |         |              |         |
| Poorest                         | 1.00   |              |         | 1.00    |              |         |
| Middle                          | 0.85   | (0.67–1.07)  | 0.165   | 0.65    | (0.47–0.90)  | 0.009   |
| Least poor                      | 1.20   | (0.89–1.61)  | 0.228   | 1.67    | (1.18–2.35)  | 0.003   |
| Iron and folic acid supplementation |       |              |         |         |              |         |
| No iron                          | 1.00   |              |         | 1.00    |              |         |
| Iron                             | 0.60   | (0.48–0.75)  | <0.001  | 0.76    | (0.59–0.99)  | 0.045   |
| Birth attendance                 |        |              |         |         |              |         |
| Non–health professional          | 1.00   |              |         | 1.00    |              |         |
| Health professional              | 0.65   | (0.52–0.81)  | <0.001  | 0.62    | (0.47–0.81)  | 0.001   |
| Antenatal care                   |        |              |         |         |              |         |
| Inadequate (<4 visits)           | 1.00   |              |         | 1.00    |              |         |
| Adequate (≥4 visits)             | 0.67   | (0.53–0.85)  | 0.001   | 0.66    | (0.51–0.85)  | 0.001   |
| Initiation of breastfeeding       |        |              |         |         |              |         |
| Delayed initiation of BF         | 1.00   |              |         | 1.00    |              |         |
| Within the first hour of birth   | 0.71   | (0.57–0.89)  | 0.003   | 0.60    | (0.47–0.78)  | <0.001  |

Factors associated with under-5 mortality (ages 0–59 months)

In Table 6, the odds of under-5 mortality decreased by 34% in the Kilindi district compared with the Gicumbi district. Children from the least poor households were 1.46 times as likely to die within 59 months of life as compared with those from the poorest households. Multivariable analyses indicated significant associations with under-5 mortality are caregiver education (primary), sex of the baby (female), time to healthcare (6–23 h and ≥24 h), ANC (less than four visits) and fever in the past 2 weeks before the survey (had fever).

Discussion

Our study identified a range of risk factors related to the death of children <5 y of age in the combined information gathered from three rural communities (Gicumbi, Kitgum and Kilindi districts). The risk factors identified vary among the mortality indica-
Table 4. Factors associated with infant mortality

| Variables                     | OR     | (95%CI) | p-Value | AOR     | (95%CI) | p-Value |
|-------------------------------|--------|---------|---------|---------|---------|---------|
| District (country)            |        |         |         |         |         |         |
| Gicumbi (Rwanda)              | 1.00   |         |         | 1.00    |         |         |
| Kitgum (Uganda)               | 0.68   | (0.52–0.91) | 0.007  | 1.26   | (0.85–1.88) | 0.246  |
| Kilindi (Tanzania)            | 0.93   | (0.72–1.19) | 0.549  | 1.67   | (1.13–2.48) | 0.010  |
| Household wealth index        |        |         |         |         |         |         |
| Poorest                       | 1.00   |         |         | 1.00    |         |         |
| Middle                        | 0.74   | (0.59–0.93) | 0.010  | 0.53   | (0.38–0.72) | <0.001 |
| Least Poor                    | 1.29   | (0.99–1.70) | 0.063  | 1.61   | (1.17–2.12) | 0.003  |
| Birth attendance              |        |         |         |         |         |         |
| Non-health professional       | 1.00   |         |         | 1.00    |         |         |
| Health professional           | 0.63   | (0.51–0.77) | <0.001 | 0.60   | (0.46–0.79) | <0.001 |
| Antenatal care                |        |         |         |         |         |         |
| Inadequate (<4 visits)        | 1.00   |         |         | 1.00    |         |         |
| Adequate (≥4 visits)          | 0.72   | (0.58–0.89) | 0.003  | 0.73   | (0.58–0.93) | 0.009  |
| Initiation of breastfeeding    |        |         |         |         |         |         |
| Delayed initiation of BF      | 1.00   |         |         | 1.00    |         |         |
| Within the first hour of birth| 0.82   | (0.66–1.02) | 0.080  | 0.68   | (0.53–0.87) | 0.002  |

Table 5. Factors associated with child mortality

| Variables                      | OR     | (95%CI) | p-Value | AOR     | (95%CI) | p-Value |
|-------------------------------|--------|---------|---------|---------|---------|---------|
| District (country)            |        |         |         |         |         |         |
| Gicumbi (Rwanda)              | 1.00   |         |         | 1.00    |         |         |
| Kitgum (Uganda)               | 1.42   | (1.23–1.65) | <0.001 | 1.33   | (1.07–1.65) | 0.011  |
| Kilindi (Tanzania)            | 0.79   | (0.65–0.97) | 0.024  | 0.72   | (0.53–0.98) | 0.036  |
| Household wealth index        |        |         |         |         |         |         |
| Poorest                       | 1.00   |         |         | 1.00    |         |         |
| Middle                        | 1.33   | (1.15–1.54) | <0.001 | 1.77   | (1.47–2.12) | <0.001 |
| Least poor                    | 1.36   | (1.16–1.59) | <0.001 | 1.38   | (1.17–1.62) | <0.001 |
| Caregiver education level     |        |         |         |         |         |         |
| No schooling                  | 1.00   |         |         | 1.00    |         |         |
| Primary                       | 1.18   | (1.04–1.35) | 0.012  | 1.17   | (1.01–1.34) | 0.036  |
| Secondary                     | 0.94   | (0.74–1.20) | 0.647  | 0.92   | (0.71–1.19) | 0.522  |
| Time to health centre (h)     |        |         |         |         |         |         |
| <6                            | 1.00   |         |         | 1.00    |         |         |
| 6–23                          | 1.63   | (1.36–1.95) | <0.001 | 1.66   | (1.38–1.99) | <0.001 |
| ≥24                           | 1.40   | (1.17–1.67) | <0.001 | 1.43   | (1.20–1.72) | <0.001 |
| Sources of drinking water     |        |         |         |         |         |         |
| Improved                      | 1.00   |         |         | 1.00    |         |         |
| Unimproved                    | 0.91   | (0.79–1.04) | 0.158  | 1.28   | (1.06–1.53) | 0.009  |
| Fever in the past 2 weeks     |        |         |         |         |         |         |
| No                            | 1.00   |         |         | 1.00    |         |         |
| Yes                           | 1.62   | (1.43–1.83) | <0.001 | 1.30   | (1.09–1.54) | 0.003  |

Concerning district location, this study reveals that Kitgum and Kilindi had lower odds of neonatal mortality by 73% and 29%, respectively, during the study period than Gicumbi district. Our

Main finding

Concerning district location, this study reveals that Kitgum and Kilindi had lower odds of neonatal mortality by 73% and 29%, respectively, during the study period than Gicumbi district. Our
Table 6. Factors associated with under-5 mortality

| Variables                                    | N    | OR   | (95% CI)       | p-Value | AOR   | (95% CI)       | p-Value |
|----------------------------------------------|------|------|----------------|---------|-------|----------------|---------|
| District (country)                           |      |      |                |         |       |                |         |
| Gicumbi (Rwanda)                             | 2348 | 1.00 |                |         | 1.00  |                |         |
| Kitgum (Uganda)                              | 3852 | 1.24 | (1.09–1.40)    | 0.001   | 1.10  | (0.93–1.31)    | 0.271   |
| Kilindi (Tanzania)                           | 1098 | 0.84 | (0.72–0.97)    | 0.018   | 0.66  | (0.51–0.86)    | 0.001   |
| Household wealth index                       |      |      |                |         |       |                |         |
| Poorest                                      | 3964 | 1.00 |                |         | 1.00  |                |         |
| Middle                                       | 1626 | 1.07 | (0.94–1.20)    | 0.306   | 1.61  | (1.36–1.91)    | <0.001  |
| Least poor                                   | 1708 | 1.43 | (1.26–1.63)    | <0.001  | 1.46  | (1.26–1.69)    | <0.001  |
| Caregiver education level                    |      |      |                |         |       |                |         |
| No schooling                                 | 2825 | 1.00 |                |         | 1.00  |                |         |
| Primary                                      | 3754 | 1.23 | (1.10–1.37)    | <0.001  | 1.14  | (1.01–1.30)    | 0.024   |
| Secondary                                    | 719  | 0.95 | (0.78–1.16)    | 0.625   | 0.92  | (0.74–1.15)    | 0.384   |
| Sex of the baby                              |      |      |                |         |       |                |         |
| Male                                         | 3554 | 1.00 |                |         | 1.00  |                |         |
| Female                                       | 3744 | 0.86 | (0.77–0.95)    | 0.004   | 0.81  | (0.72–0.91)    | 0.001   |
| Time to health centre (h)                    |      |      |                |         |       |                |         |
| <6                                           | 1989 | 1.00 |                |         | 1.00  |                |         |
| 6–23                                         | 2303 | 1.43 | (1.23–1.68)    | <0.001  | 1.40  | (1.19–1.65)    | <0.001  |
| ≥24                                          | 3006 | 1.38 | (1.19–1.61)    | <0.001  | 1.36  | (1.16–1.59)    | <0.001  |
| Antenatal care                               |      |      |                |         |       |                |         |
| Inadequate (<4 visits)                       | 1952 | 1.00 |                |         | 1.00  |                |         |
| Adequate (≥4 visits)                         | 5346 | 0.80 | (0.71–0.90)    | <0.001  | 0.82  | (0.71–0.94)    | 0.006   |
| Fever in the past 2 weeks                    |      |      |                |         |       |                |         |
| No                                           | 4689 | 1.00 |                |         | 1.00  |                |         |
| Yes                                          | 2609 | 1.49 | (1.34–1.65)    | <0.001  | 1.30  | (1.12–1.51)    | 0.001   |

The findings followed a mortality pattern reported in the three countries’ most recent DHS.

The rates of neonatal, post-neonatal, infant, child and under-5 mortality reported in this study were nearly three times higher than neonatal, post-neonatal, infant, child and under-5 mortality rates reported for northern Rwanda, north central Uganda and northern Tanzania. For instance, in the 2015–16 Tanzania DHS, the reported mortality rate for children <5 y of age in northern Tanzania was significantly lower than that reported in this study (56 vs 155). Similar evidence from the 2016 Uganda DHS also showed that the mortality rate for children <5 y of age residing in north central Uganda was about three times lower compared than the rate reported in this study (74 vs 210), while the mortality rate for children <5 y of age reported in the 2014–15 Rwanda DHS for northern Rwanda was nearly three times more than that reported for the Gicumbi district in this study.

The plausible reasons for the high mortality rate reported in this study may be attributed to a range of factors. First, the number of child deaths in these districts may be over-reported, because WVI staff mobilized local leaders, community health workers and team leaders of community health workers for the surveys. Second, the total number of live births may be very low because the original sample size calculation for this study was based on the number of ANC visits rather than the mortality rate. Lastly, these results could be mainly due to chance, selection bias and potential bias, and may be misleading and could send the wrong message regarding mortality rates in these three districts.

Numerous studies have demonstrated that there are great risks of mortality among neonates whose mothers do not practise exclusive breastfeeding. Our study also found that neonates who were not exclusively breastfed were 3.88 times more likely to die within 28 d after birth than those neonates who were exclusively breastfed. It has been argued that exclusive breastfeeding lowers the risk of infectious diseases such as diarrhoea and pneumonia. Despite the benefits associated with exclusive breastfeeding, prelacteal feeding is still well practised in SSA countries; for example, the prevalence of prelacteal feeding in Uganda is 31%. The plausible explanation for the high risk related to non-exclusive breastfeeding of neonates observed in this study may be linked to cultural beliefs, religious differences and insufficient flow of mother’s breast milk. Cultural beliefs are strong barriers to timely initiation and exclusive breastfeeding in SSA, where studies have found practices such as the squeezing and throwing away of colostrum and administering prelactal food within the first hour of birth instead of initiating breastfeeding.

Post-neonatal mortality

A lower likelihood of post-neonate deaths was associated with mothers who took iron and folic acid supplementation during...
pregnancy compared with mothers that had no iron supplement. This finding is consistent with a cross-sectional study carried out in Indonesia in 2010, which showed a statistically significant reduction in infant death among those whose mothers received iron and folic supplements during pregnancy. A similar cross-sectional study conducted in China also reported a 54% decrease in infant death among those whose mothers received iron and folic supplements. It has been suggested that the intake of iron and folic supplements during pregnancy by mothers could reduce the risk of preterm birth and birth asphyxia. We found children born to mothers living in households with an unimproved source of drinking water had higher odds of child mortality. This finding is consistent with a study conducted in 2014 in Nigeria by Ezeh et al. that indicated children aged 1–4 years exposed to unimproved drinking water had a high mortality risk. Additionally, studies conducted in Eritrea and Egypt also indicated a higher mortality risk for children aged 1–4 years. The possible factors contributing to this may include an inadequate safe water supply and lack of basic sanitation facilities, especially in rural areas, which may impact on child survival. We found that female children had a significantly lower risk of dying during the under-5 period compared with male children. This finding is consistent with previous studies conducted in Nigeria, Indonesia and Bangladesh. The lower risk of female deaths during the under-5 period may be linked to the early development of foetal lung maturity during the first week of life, resulting in a lower incidence of respiratory diseases in female children compared with males.

The current study found that children having a caregiver with primary schooling are at a higher risk of child and under-5 deaths compared with those whose caregivers had no schooling. This finding is inconsistent with past studies that indicated a lower risk of death for children whose mothers had a primary or secondary education. This result could possibly be attributed to educated mothers entrusting postnatal care to other people while the mothers return to work. However, in our analysis we found that children of caregivers with secondary schooling had lower odds of child and under-5 deaths, but it was not statistically significant. Education is an important key determinant of poor child health, because educated mothers/caregivers are more likely to have better knowledge about child health and newer healthcare services. However, children of caregivers with primary schooling in our study had higher odds of dying remains unclear. We also noted that time to the health services centre (6–23 hours or 24 hours) produced significantly higher odds of child and under-5 deaths. The possible contributing factors may include inadequate health facilities, poor public transport system and dilapidated roads typically found in rural communities. Further, we noted that infants and children who had a fever 2 weeks before the survey date had higher odds of death compared with those that had no fever. However, it remains unclear if the reported fever was linked to pneumonia or malaria. Globally, it has been estimated that approximately 920,000 and 306,000 children under 5 years of age died of pneumonia and malaria, respectively, in 2015, and the majority of these deaths occurred in SSA countries. The lack of accessible healthcare facilities, lack of child healthcare services and medical costs may inhibit rural mothers from seeking adequate medical care or treatment for their infants with fever and could be related to the increases in death observed. We also noted a significantly greater mortality risk for age subgroups (post-neonatal, infant, child and under-5) residing in households classified as least poor, similar to those reported in past studies. However, there was a statistically insignificant association between the least poor and neonatal mortality, but 45% greater odds of death was noted. This finding is consistent with a similar study conducted in Nigeria.

This study has several strengths and limitations. First, this was the first study to examine factors associated with child mortality across all age subgroups from 0 to 59 months of life in three disadvantaged rural East African communities. Second, the study has great statistical power because three datasets in disadvantaged rural East African communities that lie within Millennium Development Goals (MDGs) were combined to create a large sample size and to detect statistical differences. Third, our analysis was restricted to singleton live births to reduce maternal recall bias. However, this study also has some limitations. First, the cross-sectional study design limits causal inference. Second, the cause of child death was unknown because a verbal autopsy was not collected. Third, the number of child deaths may have been underestimated or overestimated because only surviving mothers gave an account of their child's birth. Fourth, mobilization of the study participants by WVI staff may affect the generalizability of these findings to other disadvantaged rural communities with similar characteristics. Finally, this study is limited by the fact that some of the WVI 7–11 interventions variables (e.g., immunization, malaria care, paediatric human immunodeficiency virus, immune reconstitution inflammatory syndrome (IRIS), de-worming) were not included in the analysis.

Conclusions

Our analyses examined factors associated with mortality in children under 5 years of age in three disadvantaged East Africa districts. The result reported that least poor households, children who had a fever in the past 2 weeks before the survey and mothers who travelled >6 h to the closest health facility reported higher odds of under-5 mortality. At the household level, educating households about the benefits of healthcare will reduce under-5 mortalities, and at the community level, improving healthcare and improving geographic access to primary healthcare will lower under-5 mortality in many disadvantaged communities. However, the mortality rates reported in this study might be overestimated due to methodological reasons related to either chance of study design and therefore these rates should be interpreted with caution and considered in the context of other much lower child mortality estimates for these three countries over the same period.

Authors’ contributions: KEA and OKE were involved in the conception and design of this study. OKE conducted the literature review, carried out the analysis and drafted the manuscript. OKE, FJA, IM and JKK provided advice on interpretation and revised and edited the manuscript. All authors read and approved the manuscript.

Acknowledgements: The authors would like to acknowledge the support of the district Local Government of Gicumbi, Kiliindi and Kitgum, where these projects were implemented, the community leaders including Community Health Workers in identifying and mobilising eligible
The project was funded by the government of Australia through the Department of Foreign Affairs and Trade and the Australian Agency for International Development as part of the Australian government’s broader Australia Africa Community Engagement Scheme.

Funding: The project was funded by the government of Australia through the Department of Foreign Affairs and Trade and the Australian Agency for International Development as part of the Australian government’s broader Australia Africa Community Engagement Scheme.

Competing interests: None declared.

Ethical approval: Ethical approval was obtained from the Ministries of Health of Kigali, Dar es Salaam and Kampala, and necessary permission was also obtained from the regional health offices and local administrators. Participants signed an informed consent before taking part in the survey, including assurance of anonymity and a description of how the data would be used. For illiterate participants, informed consent information was read aloud and signed. Mothers and children with serious illnesses were referred to nearby health facilities. The data in this article are presented as an aggregate to ensure all respondents’ identification information is obscured.

References
1 UNICEF. WHO. World Bank. UN-DESA Population Division. Levels and trends in child mortality report 2017, 2018. Estimates developed by the UN inter-agency group for child mortality estimation. Available from: https://www.who.int/maternal_child_adolescent/documents/levels_trends_child_mortality_2018/en/ [accessed August 2019].

2 Global Health Observatory (GHO) data. Causes of child mortality, 2017. Available from: http://www.who.int/gho/child_health/cause/mortality/causes/en/ [accessed November 2017].

3 National Institute of Statistics of Rwanda, Ministry of Finance and Economic Planning, Ministry of Health, and ICF International. 2015. Rwanda Demographic and Health Survey 2014–2015. Rockville, MD: ICF International.

4 Economics, Trading. Rural population (% of total population) in Uganda, 2015 Available from: http://www.tradingeconomics.com/uganda/rural-population-percent-of-total-population-wb-data.html [accessed 15 December 2017].

5 Ministry of Health, Community Development, Gender, Elderly and Children [Tanzania], Ministry of Health [Zanzibar], National Bureau of Statistics, Office of the Chief Government Statistician, ICF International. Tanzania Demographic and Health Survey and Malaria Indicator Survey 2015–16. Dar es Salaam: Ministry of Health, Community Development, Gender and Elderly Children. Available from: https://dhsprogram.com/pubs/pdf/FR321/FR321.pdf [accessed 2 September 2017].

6 UNICEF. WHO, World Bank, UN-DESA Population Division. Levels and Trends in Child Mortality, 2015. Geneva: World Health Organization; 2015. Available from: https://www.who.int/maternal_child_adolescent/documents/levels_trends_child_mortality_2015/en/ [accessed December 2017].

7 Uganda Bureau of Statistics, ICF international. Uganda Demographic and Health Survey. 2016. Kampala: Uganda Bureau of Statistics; 2016. Available from: https://dhsprogram.com/pubs/pdf/FR333/FR333.pdf [accessed 8 August 2019].

8 Kazembe L, Mpeketa PMG. Quantifying spatial disparities in neonatal mortality using a structured additive regression model. PLoS One. 2010;5(6):e11180.

9 Becher H, Muller O, Jahn A, Gbangou A, Kynast-Wolf G, Kouyaté B. Risk factors of infant and child mortality in rural Burkina Faso. Bull World Health Org. 2004;82(4):265–273.

10 Musafili A, Essén B, Barbirwia C, Binagwaho A, Persson L-A, Ekholm Selling K. Trends and social differentials in child mortality in Rwanda 1990–2010: results from three demographic and health surveys. J Epidemiol Community Health. 2015;69(9):834–840.

11 Naseeja JB, Mwambi HG, Achia TNO. Understanding the determinants of under-five child mortality in Uganda, including the estimation of unobserved household and community effects using both frequentist and Bayesian survival analysis approaches. BMC Public Health. 2015;15:1003.

12 Sathiya Susumana A, Hamishi HF, Nagarajan R. Bio-demographic factors affecting child loss in Tanzania. Genus. 2016;72:10.

13 Nafiu LA, Okello M, Adiukwu RN. Determinants of under-five mortality in Abim District, Uganda. Pac J Sci Technol. 2016;17(1):223–228.

14 Hong R. Effect of multiple births on infant mortality in Bangladesh. J Paediatr Child Health. 2006;42(10):630–635.

15 Uhthman OA, Uhthman MB, Yahaya I. A population-based study of effect of multiple birth on infant mortality in Nigeria. BMC Pregnancy Childbirth. 2008;8:41.

16 National Institute of Statistics of Rwanda. Poverty trend analysis report 2010/11–2013/14. Available from: http://www.statistics.gov.rw/publication/poverty-trend-analysis-report-201011-201314 [accessed February 2019].

17 Mbonile MJ, Abdullah Mkindi A, Sokoni CH, et al. Mapping poverty, vulnerability and resource rights in Kilindi District, Tanzania. Available from: http://journals.udsm.ac.tz/index.php/jgat/article/viewFile/684/665 [accessed January 2019].

18 World Resources Institute. Poverty rate in Uganda: percentage of rural subcounty population below the poverty line, 2005. Available from: https://www.wri.org/resources/maps/poverty-rate-uganda-percentage-rural-subcounty-population-below-poverty-line-2005 [accessed February 2019].

19 World Vision International. Facilitator’s guide to 7–11 health information. Field test version. Available from: https://www.wvi.org/sites/default/files/Facilitator%27s%20Guide%20to%207-11%20Health%20Information.pdf [accessed March 2018]

20 World Vision. Evaluation of World Vision’s: East Africa Maternal, New born and Child Health Project (EAMNeCH). Available from: http://www.wvi.org/sites/default/files/ENEAMNeCH%20Evaluation%20Final.pdf [accessed January 2018]

21 Hartung G, Anokwa Y, Brunette W, Lere A, Tseng C, Barriello G. Open data kit: tools to build information services for developing regions. In: Proceedings of the 4th ACM/IEEE International Conference on Information and Communication Technologies and Development; 2010, article 18.

22 GBD 2016 Mortality Collaborators. Global, regional, and national under-5 mortality, adult mortality, age-specific mortality, and life expectancy, 1970–2016: a systematic analysis for the Global Burden of Disease Study 2016. Lancet 2016;390(10100):1084–1150.

23 Mosley HW, Chen LC. An analytical framework for the study of child survival in developing countries. Popul Dev Rev. 1984;10(Suppl):25–45.

24 World Vision International. Compendium of indicators for measuring child well-being. Available from: https://www.wvi.org/sites/default/files/Compendium_of_Indicators_for_Child_Well-being_0.pdf [accessed January 2018].

25 Deg F, Pritchett LH. Estimating wealth effects without expenditure data—or tears: an application to educational enrollments in states of India. Demography. 2001;38(1):115–132.

26 World Health Organization, United Nations Children's Fund. Progress on sanitation and drinking-water. 2013 update: Joint Monitoring Programme for Water Supply and Sanitation. Geneva: World Health Organization; 2013.
27 Agho KE, Mukabuter M, Mukazi M, et al. Moderate and severe household food insecurity predicts stunting and severe stunting among Rwandan children aged 6–59 months residing in Gicumbi district. Matern Child Nutr. 2019;15(3):e12767.

28 Biks GA, Berhane Y, Worku A, Gete YK. Exclusive breast feeding is the strongest predictor of infant survival in northwestern Ethiopia: a longitudinal study. J Health Popul Nutr. 2015;33(4):3–13.

29 Sankar MJ, Sinha B, Chowdhury R, et al. Optimal breastfeeding practices and infant and child mortality: a systematic review and meta-analysis. Acta Paediatr. 2015;104(S467):3–13.

30 Natchu UC, Liu E, Duggan C, et al. Exclusive breastfeeding reduces risk of mortality in infants up to 6 months of age born to HIV-positive Tanzanian women. Am J Clin Nutr. 2012;96(5):1071–1078.

31 Boccolini CS, Pérez-Escamilla R, Giugliani ER, de Moraes Mello Boccolin P. Inequities in milk-based prelacteal feedings in Latin America and the Caribbean: the role of cesarean section delivery. J Hum Lact. 2014;31(1):89–98.

32 Fjeld E, Siziya S, Katepa-Bwalya M, Kankasa C, Moland KM, Tylleskär T. ‘No sister, the breast alone is not enough for my baby’ a qualitative assessment of potentials and barriers in the promotion of exclusive breastfeeding in southern Zambia. Int Breastfeed J. 2008;3:26.

33 Agho KE, Ogeleka P, Ogbo FA, Ezeh OK, Eastwood J, Page A. Trends and predictors of prelacteal feeding practices in Nigeria (2003–2013). Nutrients 2016;8(8):462.

34 Ogah AO, Ajayi AM, Akib S, Okolo SN. A cross-sectional study of prelacteal feeding practice among women attending Kampala international university teaching hospital maternal and child health clinic, Bushenyi, Western Uganda. Asian J Med Sci. 2012;4(4):79–95.

35 Khanal V, Adhikari M, Sauer K, Zhao Y. Factors associated with the introduction of prelacteal feeds in Nepal: findings from the Nepal Demographic and Health Survey 2011. Int Breastfeed J. 2013;8:9.

36 Agho KE, Dibley MJ, Odiase JI, Ogbonmwan SM. Determinants of exclusive breastfeeding in Nigeria. BMC Pregnancy Childbirth. 2011;11:2.

37 Alemayehu M, Abreha K, Yebyo H, Zemichael K, Gebremichael H. Factors associated with timely initiation and exclusive breastfeeding among mothers of Axum town, northern Ethiopia. Sci J Public Health. 2014;2(5):394–401.

38 Setegn T, Gerbaba M, Belachew T. Determinants of timely initiation of breastfeeding among mothers in Goba Woreda, south east Ethiopia: a cross-sectional study. BMC Public Health. 2011;11:217.

39 Nankumbi J, Muliria JK. Barriers to infant and child-feeding practices: a qualitative study of primary caregivers in rural Uganda. J Health Popul Nutr. 2015;33(1):106–116.

40 Titaleary CR, Dibley MJ, Roberts CL, Hall J, Agho K. Iron and folic acid supplements and reduced early neonatal deaths in Indonesia. Bull World Health Org. 2010;88(7):500–508.

41 Zeng L, Dibley MJ, Cheng Y, et al. Impact of micronutrient supplementation during pregnancy on birth weight, duration of gestation, and perinatal mortality in rural western China: double blind cluster randomised controlled trial. BMJ. 2008;337:a2001.

42 Ezech OK, Agho KE, Dibley MJ, Hall J, Page AN. The impact of water and sanitation on childhood mortality in Nigeria: evidence from Demographic and Health Surveys, 2003–2013. Int J Environ Res Public Health. 2014;11(9):9256–9272.

43 Waldemicael G. The effects of water supply and sanitation on child mortality in urban Ethiopia. J Biosoc Sci. 2000;32(2):207–227.

44 Ali HA. The effect of water and sanitation on child mortality in Egypt. Working Papers in Economics 112, University of Gothenburg, Department of Economics. Göteborg, Sweden, 2003.

45 Ezech OK, Agho KE, Dibley MJ, Hall J, Page AN. Determinants of neonatal mortality in Nigeria: evidence from the 2008 Demographic and Health Survey. BMC Public Health. 2014;14:521.

46 Titaleary CR, Dibley MJ, Agho K, Roberts CL, Hall J. Determinants of neonatal mortality in Indonesia. BMC Public Health. 2008;8:232.

47 Mondal NI, Hossain K, Ali K. Factors influencing infant and child mortality: a case study of Rajshahi district, Bangladesh. J Hum Ecol. 2009;26(1):31–39.

48 Khoury MJ, Marks JS, McCarthy BJ, Zaro SM. Factors affecting the sex differential neonatal mortality: the role of respiratory distress syndrome. Am J Obstet Gynecol. 1985;151(6):777–782.

49 Ezech OK, Agho KE, Dibley MJ, Hall J, Page AN. Risk factors for post-neonatal, infant, child and under-5 mortality in Nigeria: a pooled cross-sectional analysis. BMJ Open. 2015;5(3):e006779.

50 Abir T, Agho KE, Page AN, Milton AH, Dibley MJ. Risk factors for under-5 mortality: evidence from Bangladesh Demographic and Health Survey, 2004–2011. BMJ Open. 2015;5:e006722.

51 Rahim TM, Chowdhury M, Islam S, Fishman M. The effect of maternal nutrition on the risk of mortality in urban Eritrea. J Biosoc Sci. 2005;26(2):219–246.

52 Galtry J, Callister P. Assessing the optimal length of parental leave for child and parental well-being: how can research inform policy? J Fam Issues. 2005;26(2):219–246.

53 Ogbuanu C, Glover S, Probst J, Liu J, Hussey J. The effect of maternity leave length and time of return to work on breastfeeding. Pediatrics. 2011;127(6):e1414–e1427.

54 Caldwell JC. Education as a factor in mortality decline an examination of Nigerian data. Popul Stud. 1979;33(3):395–413.

55 Guardian Labs. Childhood mortality: six killer diseases and how to stop them. Available from: https://www.theguardian.com/breakthrough-science/ng-interactive/2017/jun/27/childhood-mortality-six-killer-diseases-and-how-to-stop-them [accessed 4 December 2019].