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Maternal Education and Immunization Status Among Children in Kenya

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Abstract Child morbidity and mortality due to infectious diseases continues to be a major threat and public health concern worldwide. Although global vaccination coverage reached 90 % for diphtheria, tetanus and pertussis (DTP3) across 129 countries, Kenya and other sub-Saharan countries continue to experience under-vaccination. The purpose of this study was to examine the association between maternal education and child immunization (12–23 months) in Kenya. This study used retrospective cross-sectional data from the 2008–2009 Kenya Demographic and Health Survey for women aged 15–49, who had children aged 12–23 months, and who answered questions about vaccination in the survey (n = 1,707). The majority of the children had received vaccinations, with 77 % for poliomyelitis, 74 % for measles, 94 % for tuberculosis, and 91 % for diphtheria, whooping cough (pertussis), and tetanus. After adjusting for other covariates, women with primary, secondary, and college/university education were between 2.21 ($p < 0.01$) and 9.10 ($p < 0.001$) times more likely to immunize their children than those who had less than a primary education. Maternal education is clearly crucial in ensuring good health outcomes among children, and integrating immunization knowledge with maternal and child health services is imperative. More research is needed to identify factors influencing immunization decisions among less-educated women in Kenya.

Keywords Child health · Education · Immunization · Kenya · Risk factors

Introduction

Child mortality is one of the most serious problems affecting both developing and developed nations [1]. Its magnitude is recognized by the United Nations' Millennium Development Goal to reduce rate of mortality in children under 5 by two-thirds between 1990 and 2015 [2, 3]. To date, immunization, a primary healthcare preventive measure, remains the most cost-effective public health intervention to reduce child morbidity and mortality attributed to infectious diseases [4]. Worldwide, it prevents more than two million deaths each year [5, 6].

Kenya has focused on immunization in its efforts to reduce child mortality [7]. The 2008–2009 Kenya Demographic and Health Survey (KDHS) conducted by the Kenya National Bureau of Statistics (KNBS) and ICF Macro found that the child mortality rate had dropped to 74 per 1,000 births [8] from 115 per 1,000 births in 2003 [9], a decline of 36 % in the 5-year period. The infant mortality rate dropped by 32 % from 77 per 1,000 births in 2003 to 52 per 1,000 births in 2008–2009 [8, 9]. However, one in

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every 19 children born in Kenya still dies before his or her first birthday, while one in 14 does not survive to age 5 [8].

Paradoxically, the apparent stagnation or rise in the child mortality rate in several East African countries has coincided with expanded immunization coverage, improved access to potable water in rural households, where most children reside, increased use of oral rehydration therapy to treat episodes of diarrhea, and improved female literacy—all social and biomedical changes that would predict decline [2, 10, 11]. Currently, in resource-poor areas around the globe, inadequate levels of immunization against childhood diseases remain a significant public health problem. In September 2011, the Kenyan Ministry of Health (MOH) highlighted a case in Nyanza Province where a 3-year-old boy was found to have polio [12], justifying more research on barriers to immunization in Kenya.

Over the past two decades, studies on developing countries have shown the strong impact of maternal education on infant and child health. On average, each year of a mother's education corresponds to a 7–9 % decline in under-5 mortality [13–19]. Desai and Alva [20] used a fixed-effects model to analyze data from the first round of the Demographic and Health Surveys in 22 developing countries. They examined the effect of maternal education on three markers of child health: infant mortality, height for age, and immunization status. Results showed that maternal education remained statistically significant for children's immunization status in half of the countries even after individual- and community-level factors were included in the model.

Several other studies have shown the effect of maternal education on children's immunization status in resource-deprived urban settlements and slums [17, 21–25] and rural settings [13, 16, 26–33]. Levels of full immunization coverage are lower than expected in informal urban settlements due to rapid population growth and limited community infrastructure [16, 17, 21–25, 34–36]. In Kenya, studies conducted to identify risk factors associated with incomplete vaccination in resource-deprived urban settlements and the extent of full, up-to-date vaccination coverage among children aged 12–23 months living in the slums showed that mother's age, level of education, parity, place of delivery, ethnicity, and household assets were predictors of full vaccination [17, 25].

Mutua et al. [25] conducted a retrospective analysis of a longitudinal maternal and child health study, using data from the Nairobi Urban Health and Demographic Surveillance System (NUHDSS) to determine health-seeking behaviors of women in Nairobi's Korogocho and Viwandani slums. They found that, among other factors, the mother's level of education predicted the child's vaccination status. Specifically, when the oral polio vaccine (OPV) was included, children of mothers who had completed primary education were nearly 1.5 times more likely to have been vaccinated than those whose mothers had no education. The mother's education level also significantly determined immunization coverage among children aged under 5 whose mothers had lived in the Mathare Valley slum in Kenya in the 5 years before the study [17].

In developing countries, non-compliance with vaccination recommendations has been associated with residence in rural areas. Reports cite distance to health services, traditional health practices, and level of maternal education as contributing factors [13, 16, 26, 28–33, 37]. In rural Malawi, non-compliance has also been associated with living in villages with no access to mobile vaccination teams, birth during certain months of the year, and birth at home [33].

Conversely, a study conducted in Kilifi, Kenya, showed that travel time to a healthcare facility did not significantly affect vaccination coverage and timeliness. Instead, it supported the notion that the level of maternal education was the primary factor [28]. It also revealed that immunization coverage increased with maternal education; in the most educated areas, 12-month-olds received three doses of pentavalent vaccine, a combination against diphtheria, tetanus, whooping cough, hepatitis B, and Haemophilus influenza type b (the bacteria that causes meningitis, pneumonia, and otitis) compared to less educated areas [28]. In the Butere-Mumias district in Kenya, a cross-sectional descriptive study found a 35 % immunization rate for children under 5 years of age was significantly associated with a low level of education among mothers [31].

The relatively high infant and child mortality rates in Kenya are an urgent problem. Discovering polio in one child is considered an outbreak and a public health emergency because it means that about 200 people may be carrying and spreading the virus without developing symptoms. Community infrastructure to support maternal education, especially targeting mothers of lower socioeconomic status, must be investigated, improved, and implemented to improve child health. The authors realize that, as the primary if not sole caregivers in the early years of life, Kenyan mothers determine the extent to which their children will be immunized. This paper seeks to determine the association between maternal education and child immunization in Kenya.

Method

Sampling Plan, Data Source, and Study Sample

This cross-sectional study used a multistage, stratified design to analyze data from the 2008–2009 Kenya

Demographic and Health Survey (KDHS 2008–2009). Each household was randomly chosen with equal probability of inclusion from the 400 clusters—133 urban and 267 rural—selected from the national master sample frame for household-based surveys. Design and sampling procedures are described in the survey report [8].

The study sample was limited to women aged 15–49 who responded to questions about child immunization against poliomyelitis, measles, tuberculosis, and diphtheria, pertussis and tetanus (DPT; n = 1,707). For multi-dose vaccinations, the three doses were used to generate a single variable: whether a child did (vaccination date on card, vaccination reported by mother or marked on card) or did not receive vaccination (no record or reports). All data were weighted to control for clustering effects and eliminate over- or underestimation of the standard errors. All data analyses were therefore based on individual-level information [38].

Outcome, Exposure, and Covariates

All four immunization outcomes are dichotomous variables, determined by asking whether the child had received the vaccination for poliomyelitis, measles, tuberculosis, and DPT. The dichotomous variables were generated from the following responses: (1) no; (2) vaccination date on card; (3) vaccination reported by mother; and (4) vaccination marked on hospital card. A "no" response was given a value of 0, and "yes" responses (2, 3, or 4 above) were combined to represent a vaccinated child and given a value of 1.

Education is a categorical variable seeking to measure an individual's formal training. An individual had either less than primary, primary, secondary, or college/graduate education. Stepwise logistic regression analyses and manual selection (important variables based on previous studies) were used in determining the covariates used as controls in this study. They included wealth, immunization knowledge, age, marital status, desired number of children, province, religion, health insurance, and residence.

Data Analysis

The analytical framework used was:

$$\text{svy} : \text{logit}[\Pr(Y_x = 1)] = e^{(Z)}/1 + e^{(Z)};$$
$$z = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \ldots + \beta_k X_k + \varepsilon.$$

The logit is the natural log of the odds of the outcome: ln(e/[1 − e]. Y_x represents the outcomes of interest, that is, vaccinations for poliomyelitis, measles, tuberculosis, or DPT ($Y_x = 1$) or not immunized ($Y_x = 0$). X_1, $X_2 \ldots X_k$ represent the different independent variables; β_0, β_1, $\beta_2, \ldots \beta_k$ represent the corresponding regression coefficients to be estimated, which measure the effect of the independent variable and covariates on the probability of being immunized. The exponential of the coefficients (β_1, $\beta_2, \ldots \beta_k$) gives the odds ratios indicating the likelihood that women with primary, secondary, and university education will differ from those with less than a primary education. ε represents the random error term, which has a normal distribution and a mean that is zero—$E(\varepsilon \mid x) = 0$ [39, 40].

Data analyses for descriptive, bivariate, univariate and multivariate logistic regression analyses were conducted using STATA version 13.1. Bivariate analysis (Chi square test of significance) estimated the prevalence of vaccination against the study's independent variables. Univariate (unadjusted) logistic regression analyses estimated the odds ratio (ORs) of each vaccination outcome and the exposure variable. Multivariate (adjusted) logistic regression analyses estimated the ORs of each vaccination outcome and the exposure variable while controlling for covariates. Results for univariate and multivariate logistic regression are presented with 95 % confidence intervals (CI; $p < 0.05$).

Ethical Approval

The Institutional Review Board (IRB) reviewed and determined exempt status. Data collection procedures were approved by the ORC Macro IRB, supervised in Kenya by KEMRI [8]. Data were approved for use by MEASURE Demographic and Health Surveys (DHS).

Results

Descriptive Analysis

Of the total sample of children aged 12–23 months, 77, 74, 94, and 91 % had received vaccinations for poliomyelitis, measles, tuberculosis, and DPT respectively. Among their mothers aged 15–45, only 14 % had a college/university education, but most (54 %) had undergone primary education, and 25 % reported having secondary education. The majority of the women were aged 20–34 (67 %), 81 % of them were married, and 37 % of them reported that they wanted to have more children after 2 years (see Table 1).

Bivariate Analysis

There was a significant difference between mothers with primary education or above, and those with less than primary or no education. Compared with those with no education, more women with primary education immunized their children for poliomyelitis (77 vs. 50 %, $F_{3,\ 1,038} = 17.6$, $p < 0.001$), measles (75 vs. 64 %, $F_{3,\ 1,072} = 3.29$, $p < 0.05$), tuberculosis (95 vs. 84 %, $F_{3,\ 970} = 6.71$, $p < 0.001$), and

Table 1 Descriptive statistics and bivariate associations between study characteristics and child immunization, 2008–2009 KDHS

Study characteristics	Total	Polio immunization		Measles immunization		BCG[a] immunization		DPT[b] immunization	
		No	Yes	No	Yes	No	Yes	No	Yes
	n (%)	n (%[c])	n (%[c])	n (%[c])	n (%[c])	n (%[c])	n (%[c])	n (%[c])	n (%[c])
Poliomyelitis (n = 1,707)									
Immunized	1,306 (77)	–	–	–	–	–	–	–	–
Measles (n = 1707)									
Immunized	1256 (74)	–	–	–	–	–	–	–	–
BCG (n = 1,707)									
Immunized	1,601 (94)	–	–	–	–	–	–	–	–
DPT (n = 1,707)									
Immunized	1,561 (91)	–	–	–	–	–	–	–	–
Education (n = 1,707)									
Less than primary/none	235 (14)	118 (50)	117 (50)	84 (36)	151 (64)	37 (16)	198 (84)	42 (18)	193 (82)
Primary	915 (54)	211 (23)	704 (77)***	230 (25)	685 (75)*	49 (5)	866 (95)***	65 (7)	850 (93)**
Secondary	412 (25)	58 (14)	354 (86)	99 (24)	313 (76)	11 (3)	401 (97)	26 (6)	386 (94)
Higher/college/graduate	145 (9)	14 (10)	131 (90)	38 (26)	107 (74)	9 (6)	136 (94)	13 (9)	132 (91)
Wealth (n = 1,707)									
Poor	530 (31)	215 (41)	315 (59)	169 (32)	361 (68)	53 (10)	477 (90)	68 (13)	462 (87)
Middle	286 (17)	65 (23)	221 (77)***	65 (23)	221 (77)**	12 (4)	274 (96)[NS]	17 (6)	269 (94)[NS]
Rich	891 (52)	121 (14)	770 (86)	217 (24)	674 (76)	41 (5)	850 (95)	61 (7)	830 (93)
Knowledgeable about immunization (n = 1,707)									
No	240 (14)	82 (34)	158 (66)***	68 (28)	172 (72)[NS]	16 (7)	224 (93)[NS]	22 (9)	218 (91)[NS]
Yes	1,467 (86)	319 (22)	1,148 (78)	383 (26)	1,084 (74)	90 (6)	1,377 (94)	124 (8)	1,343 (92)
Age (n = 1,707)									
15–19	167 (10)	51 (31)	116 (69)	79 (47)	88 (53)	11 (7)	156 (93)	18 (11)	149 (89)
20–24	446 (26)	103 (23)	343 (77)	140 (31)	306 (69)	33 (7)	413 (93)	46 (10)	400 (90)
25–29	381 (22)	75 (20)	306 (80)	89 (23)	292 (77)	22 (6)	359 (94)	28 (7)	353 (93)
30–34	329 (19)	66 (20)	263 (80)*	63 (19)	266 (81)***	13 (4)	316 (96)[NS]	18 (5)	311 (95)[NS]
35–39	233 (14)	63 (27)	170 (73)	47 (20)	186 (80)	19 (8)	214 (92)	24 (10)	209 (90)
40–44	108 (6)	25 (23)	83 (77)	24 (22)	84 (78)	5 (5)	103 (95)	6 (6)	102 (94)
45–49	43 (3)	18 (42)	25 (58)	9 (21)	34 (79)	3 (7)	40 (93)	6 (14)	37 (86)
Marital status (n = 1,707)									
Never married	327 (19)	75 (23)	252 (77)[NS]	94 (29)	233 (71)[NS]	21 (6)	306 (94)[NS]	28 (9)	299 (91)[NS]
Currently married	1,380 (81)	326 (24)	1,054 (76)	357 (26)	1,023 (74)	85 (6)	1,295 (94)	118 (9)	1,262 (91)
Desire for more children (n = 1,707)									
Within 2 years	197 (11)	55 (28)	142 (72)	37 (19)	160 (81)	17 (9)	180 (91)	19 (10)	178 (90)
After 2 years	628 (37)	135 (21)	493 (79)[NS]	211 (34)	417 (66)*	33 (5)	595 (95)[NS]	55 (9)	573 (91)[NS]
Wants but unsure of timing/undecided	169 (10)	50 (30)	119 (70)	45 (27)	124 (73)	14 (8)	155 (92)	20 (12)	149 (88)
No desire, sterilized, infertile	713 (42)	161 (23)	552 (77)	158 (21)	555 (79)	42 (6)	671 (94)	52 (7)	661 (93)
Province (n = 1,707)									
Nairobi	197 (11)	18 (9)	179 (91)	44 (22)	153 (78)	7 (4)	190 (96)	5 (3)	192 (97)
Central	231 (13)	27 (12)	204 (88)	46 (20)	185 (80)	12 (5)	219 (95)	14 (6)	217 (94)
Coast	221 (12)	53 (24)	168 (76)	74 (33)	147 (67)	12 (5)	209 (95)	18 (8)	203 (92)
Eastern	248 (14)	48 (19)	200 (81)***	59 (24)	189 (76)[NS]	10 (4)	238 (96)*	21 (8)	227 (92)[NS]
Nyanza	258 (16)	71 (28)	187 (72)	78 (30)	180 (70)	24 (9)	234 (91)	30 (12)	228 (88)
Rift-Valley	265 (17)	57 (22)	208 (78)	63 (24)	202 (76)	16 (6)	249 (94)	21 (8)	244 (92)
Western	193 (11)	80 (41)	113 (59)	55 (28)	138 (72)	9 (5)	184 (95)	17 (9)	176 (91)
North-Eastern	94 (6)	47 (50)	47 (50)	32 (34)	62 (66)	16 (17)	78 (83)	20 (21)	74 (79)
Religion (n = 1,704)									
Protestant	1,076 (63)	220 (20)	856 (80)	277 (26)	799 (74)	64 (6)	1,012 (94)	87 (8)	989 (92)
Roman catholic	338 (20)	70 (21)	268 (79)**	83 (25)	255 (75)[NS]	12 (4)	326 (96)[NS]	23 (7)	315 (93)[NS]
Muslim	250 (15)	95 (38)	155 (62)	76 (30)	174 (70)	24 (10)	226 (90)	30 (12)	220 (88)
Other religions	40 (2)	14 (35)	26 (65)	13 (32)	27 (68)	4 (10)	36 (90)	4 (10)	36 (90)

Table 1 continued

Study characteristics	Total	Polio immunization		Measles immunization		BCG[a] immunization		DPT[b] immunization	
		No	Yes	No	Yes	No	Yes	No	Yes
	n (%)	n (%[c])	n (%[c])	n (%[c])	n (%[c])	n (%[c])	n (%[c])	n (%[c])	n (%[c])
Health insurance (n = 1,705)									
No	1,583 (93)	395 (25)	1,188 (75)***	423 (27)	1,160 (73)*	102 (6)	1,481 (94)*	137 (9)	1,446 (91)[NS]
Yes	122 (7)	6 (5)	116 (95)	27 (22)	95 (78)	4 (3)	118 (97)	9 (7)	113 (93)
Residence (n = 1,707)									
Urban	571 (33)	86 (15)	485 (85)**	152 (27)	419 (73)[NS]	31 (5)	540 (95)[NS]	43 (8)	528 (92)[NS]
Rural	1,136 (67)	315 (28)	821 (72)	299 (26)	837 (74)	75 (7)	1,061 (93)	103 (9)	1,033 (91)

* $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$; [NS] not significant

[a] Bacille Calmette-Guérin (Tuberculosis)

[b] Diphtheria, Whooping Cough (pertussis), Tetanus

[c] Prevalence

DPT (93 vs. 82 %, $F_{3,\ 999} = 3.74$, $p < 0.01$) (see Table 1). For poliomyelitis in particular, as the level of education rose, so did the percentage vaccinated, although this effect was not seen to the same extent with the other vaccinations.

Univariate Logistic Regression

Associations between education and immunizations were observed. Compared with than those with less than primary or no education, women with primary, secondary, and university education were 2.79 times ($p < 0.001$), 6.20 times ($p < 0.001$), and 6.69 times ($p < 0.001$) more likely, respectively, to immunize their children against poliomyelitis. For measles, women with primary and secondary education were 1.84 ($p < 0.01$) and 2.30 ($p < 0.001$) times more likely, respectively, to immunize their children than those with less than primary or no education. For tuberculosis, women with primary and secondary education were 2.50 ($p < 0.001$) and 6.24 ($p < 0.001$) times more likely, respectively, to immunize their children than those with less than primary or no education. Women with primary and secondary education were 2.49 ($p < 0.001$) and 2.95 ($p < 0.01$) times more likely, respectively, to immunize their children against DPT than those with less than primary or no education (see Table 2).

Multivariate Logistic Regression

After adjusting for other covariates, the odds ratios associating education and immunization for polio and measles were attenuated. Women who had primary, secondary and college or university education were 2.21 ($p < 0.01$), 3.67 ($p < 0.001$) and 2.36 ($p < 0.05$) times more likely, respectively, to immunize their children against polio than those with less than primary or no education. For measles, women who had primary and secondary education were 2.50 ($p < 0.01$) and 2.49 ($p < 0.01$) times more likely, respectively, to immunize their children than those with less than primary or no education. For tuberculosis, they were 5.25 ($p < 0.001$) and 9.10 ($p < 0.01$) times more likely, respectively, to immunize their children than those with less than primary or no education and for DPT, the figures were 2.82 ($p < 0.01$) and 2.86 ($p < 0.05$) (see Table 3).

Other factors associated with the likelihood of immunizing against polio included province (Western and Nyanza) and health insurance. Women from Western and Nyanza province were 74 % ($p < 0.001$) and 73 % ($p < 0.01$) less likely to immunize their children for polio and DPT respectively than those from Nairobi. Those who had health insurance were 8.33 ($p < 0.001$) times more likely to immunize their children than those without (see Table 3).

For measles, wealth, age, desire for more children, and health insurance were associated with increased likelihood of immunization. Women who were wealthier were 2.01 ($p < 0.01$) times more likely to have their children immunized than those in the poorest category. All other age groups were more likely to immunize their children than those aged 15–19, with the highest odds observed among those aged 45–49 (OR 5.83, $p < 0.01$). Women who desired to have more children after 2 years and those who had no desire, were sterilized, or infertile were 65 % ($p < 0.01$) and 63 % ($p < 0.05$) less likely to immunize their children than those who desired to have children within 2 years. Those who had health insurance were 2.03 ($p < 0.05$) times more likely to immunize their children than those without (see Table 3).

For tuberculosis, those who had health insurance were 7.32 ($p < 0.01$) times more likely to immunize their children than those without. For DPT, desire for more children, province and health insurance were associated with increased likelihood of immunization. Compared with those who desired to have children within 2 years, women who desired to have more children after 2 years, wanted to but were unsure and those who had no desire, were sterilized, or infertile were 54 % ($p < 0.05$), 75 % ($p < 0.01$) and 66 % ($p < 0.05$) less likely, respectively to immunize their children. Women from Nyanza province were 73 % ($p < 0.05$) less likely to immunize their children than those from Nairobi. Finally, those who had health insurance were 2.71 ($p < 0.05$) times more likely to immunize their children than those without (see Table 3).

Discussion

The study sought to establish the association between maternal education and child immunization in Kenya using the 2008–2009 KDHS. The descriptive statistics show that polio and measles vaccination rates were generally lower than those for tuberculosis and DPT. Overall, results show that maternal education is an important predictor of child immunization, consistent with previous studies strongly associating the mother's education and the child's health over time [15, 17, 20, 25, 41]. This study supports the hypothesis that maternal education is a significant predictor of child health, specifically child immunization.

The results seem mixed for individual vaccines. However, after adjusting for other factors, the odds of a child being vaccinated against measles were 2.50 and 2.49 higher for those whose mothers had primary and secondary education, than for those of their less-educated counterparts. However, a study by Ettarh et al. [42] examining the relationship between ethnicity and measles vaccination uptake in the Korogocho slums in Nairobi, found that those with a secondary or higher education had relative risk ratios of 0.96 and 0.98 compared with those with no education. Significance was not attained. However, our study used a national sample and Ettarh et al. [42] only examined measles, with education used as a control variable.

Other factors influencing childhood immunization for poliomyelitis, measles, tuberculosis, and diphtheria, pertussis and tetanus include province, health insurance, wealth, age, and desire for more children. The effect of socioeconomic status is a consistent finding in previous studies [20], and this study underscores the importance of resource endowment [43, 44]. We may conclude that wealth is related to a higher education level and more knowledge about immunization, increasing the likelihood that children will be immunized. Previous research found a similar association between parents' health knowledge and children's complete immunization [41, 45, 46]. Formal education is significant because the health knowledge it

Table 2 Unadjusted odds ratios (ORs) and 95 % confidence intervals (CIs) of immunization and education, 2008–2009 KDHS

	Immunization		
	UOR	95 %	CIs
Poliomyelitis (n = 1,707)			
Education			
Less than primary/none	Ref.		
Primary	2.79***	1.84	4.25
Secondary	6.20***	3.70	10.41
University	6.69***	3.23	13.85
Measles (n = 1,707)			
Education			
Less than primary/none	Ref.		
Primary	1.84**	1.19	2.86
Secondary	2.30***	1.40	3.79
University	1.34[NS]	0.66	2.70
BCG[a]; (n = 1,707)			
Education			
Less than primary/none	Ref.		
Primary	2.50***	1.97	6.23
Secondary	6.24***	2.26	17.20
University	1.74[NS]	0.69	4.37
DPT[b] (n = 1,707)			
Education			
Less than primary/none	Ref.		
Primary	2.49***	1.45	4.28
Secondary	2.95**	1.43	6.10
University	1.15[NS]	0.45	2.95

CIs Confidence intervals, *Ref* Reference group

* $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$; [NS]not significant

[a] Bacille Calmette-Guérin (Tuberculosis)

[b] Diphtheria, Whooping Cough (pertussis), Tetanus

imparts to women translates into improved child health [41, 47].

Health insurance was also significantly associated with child immunization, possibly because those who have it are more likely to use health services, and those with young children are therefore more likely to take their children for immunization. We conclude that having health insurance is associated with higher levels of education, higher earning power, and a greater likelihood of seeking child immunization health services. However, despite this higher likelihood, very few women in the study had health insurance (7 %). These findings may underscore the importance of scaling up any type of insurance among women to increase immunization rates in Kenya.

Nyanza (diphtheria, pertussis and tetanus) and Western (polio) provinces were associated with lower likelihood of child immunization compared with Nairobi. This finding

Table 3 Adjusted odds ratios (ORs) and 95 % confidence intervals (CIs) of immunization and study characteristics in a multivariate logistic regression model, 2008–2009 KDHS

Study characteristics	Immunization											
	Polio			Measles			BCG[a]			DPT[b]		
	AOR	95 %	CIs	AOR	95 %	CIs	AOR	95 %	CIs	AOR	95 %	CIs
Education												
Less than primary/none	Ref.			Ref.			Ref.			Ref.		
Primary	2.21**	1.21	4.04	2.50**	1.34	4.65	5.25***	2.31	11.90	2.82**	1.29	6.18
Secondary	3.67***	1.99	6.76	2.49**	1.31	4.75	9.10***	3.45	23.95	2.86*	1.22	6.70
Higher/college/graduate	2.36*	1.02	5.42	0.85^{NS}	0.37	1.92	1.54^{NS}	0.45	5.28	0.79^{NS}	0.26	2.40
Wealth												
Poor	Ref.			Ref.			Ref.			Ref.		
Middle	1.37^{NS}	0.88	2.12	1.58^{NS}	0.98	2.56	1.51^{NS}	0.67	3.38	1.66^{NS}	0.86	3.19
Rich	1.66^{NS}	0.88	3.12	2.01**	1.24	3.26	1.46^{NS}	0.60	3.57	1.53^{NS}	0.71	3.28
Knowledgeable about immunization												
No	Ref.			Ref.			Ref.			Ref.		
Yes	1.26^{NS}	0.86	1.84	0.91^{NS}	0.57	1.45	1.14^{NS}	0.58	2.26	1.00^{NS}	0.52	1.93
Age												
15–19	Ref.			Ref.			Ref.			Ref.		
20–24	0.67^{NS}	0.35	1.30	1.91*	1.10	3.31	0.75^{NS}	0.29	1.95	1.00^{NS}	0.44	2.28
25–29	0.93^{NS}	0.51	1.69	3.25***	1.80	5.86	1.18^{NS}	0.44	3.18	1.08^{NS}	0.45	2.60
30–34	1.18^{NS}	0.56	2.50	3.94***	1.85	8.42	1.34^{NS}	0.41	4.35	1.73^{NS}	0.64	4.69
35–39	0.79^{NS}	0.40	1.55	3.98***	1.98	7.97	0.80^{NS}	0.25	2.56	0.80^{NS}	0.32	2.00
40–44	1.22^{NS}	0.49	3.09	3.45**	1.38	8.64	1.35^{NS}	0.24	7.40	1.79^{NS}	0.44	7.27
45–49	0.78^{NS}	0.29	2.14	5.83**	1.87	18.1	1.20^{NS}	0.23	6.33	1.08^{NS}	0.26	4.53
Marital status												
Never married	Ref.			Ref.			Ref.			Ref.		
Currently married	0.78^{NS}	0.55	1.09	0.89^{NS}	0.62	1.28	0.82^{NS}	0.45	1.51	0.70^{NS}	0.42	1.17
Desire for more children												
Within 2 years	Ref.			Ref.			Ref.			Ref.		
After 2 years	1.06^{NS}	0.57	1.97	0.35**	0.17	0.71	0.91^{NS}	0.37	2.21	0.46*	0.21	0.99
Wants but unsure of timing/undecided	0.73^{NS}	0.34	1.59	0.43^{NS}	0.18	1.06	0.39^{NS}	0.13	1.16	0.25**	0.10	0.63
No desire, sterilized, infertile	0.84^{NS}	0.40	1.76	0.37*	0.16	0.87	0.46^{NS}	0.17	1.20	0.34*	0.14	0.82
Province												
Nairobi	Ref.			Ref.			Ref.			Ref.		
Central	1.50^{NS}	0.58	3.88	1.04^{NS}	0.46	2.33	0.56^{NS}	0.09	3.36	0.46^{NS}	0.09	2.28
Coast	1.12^{NS}	0.52	2.40	0.58^{NS}	0.26	1.31	1.30^{NS}	0.32	5.20	0.49^{NS}	0.15	1.67
Eastern	1.35^{NS}	0.59	3.07	1.05^{NS}	0.46	2.42	1.78^{NS}	0.36	8.73	0.48^{NS}	0.13	1.78
Nyanza	0.73^{NS}	0.35	1.49	0.83^{NS}	0.36	1.91	0.37^{NS}	0.11	1.27	0.27*	0.07	0.99
Rift-Valley	1.26^{NS}	0.53	3.02	1.51^{NS}	0.67	3.39	1.42^{NS}	0.39	5.22	0.65^{NS}	0.18	2.34
Western	0.26***	0.13	0.55	0.80^{NS}	0.37	1.73	1.25^{NS}	0.28	5.6	0.39^{NS}	0.11	1.45
North-Eastern	0.81^{NS}	0.28	2.36	0.97^{NS}	0.31	3.02	0.56^{NS}	0.12	2.75	0.23^{NS}	0.05	1.07
Religion												
Protestant	Ref.			Ref.			Ref.			Ref.		
Roman catholic	1.15^{NS}	0.73	1.81	1.04^{NS}	0.73	1.50	2.11^{NS}	0.95	4.71	1.57^{NS}	0.80	3.10
Muslim	1.04^{NS}	0.54	1.97	1.68^{NS}	0.92	3.07	2.66^{NS}	0.92	7.66	2.54*	1.04	6.21
Other religions	0.27^{NS}	0.07	1.05	0.92^{NS}	0.41	2.07	0.86^{NS}	0.19	3.86	0.81^{NS}	0.19	3.51
Health insurance												
No	Ref.			Ref.			Ref.			Ref.		
Yes	8.33***	2.59	26.83	2.03*	1.02	4.06	7.32**	1.61	33.22	2.71*	1.07	6.88

Table 3 continued

Study characteristics	Immunization											
	Polio			Measles			BCG[a]			DPT[b]		
	AOR	95 %	CIs	AOR	95 %	CIs	AOR	95 %	CIs	AOR	95 %	CIs
Residence												
Urban	Ref.			Ref.			Ref.			Ref.		
Rural	0.78[NS]	0.38	1.57	1.00[NS]	0.56	1.77	1.80[NS]	0.67	4.85	1.50[NS]	0.62	3.63
Number of observations (n)	1,702			1,702			1,702			1,702		

CIs confidence intervals, *Ref* Reference group

* $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$; [NS]not significant

[a] Bacille Calmette-Guérin (Tuberculosis)

[b] Diphtheria, Whooping Cough (pertussis), Tetanus

was similar to those of Ettarh et al. [42] in the Korogocho slums in Nairobi, while another study associated poor health outcomes with Luo children, who live in Nyanza province [48]. The lower rates of immunization in Western Province may be replicating the poor outcomes observed in adjacent Nyanza Province, where the Luhya and Luo tribes originate. Contextual similarities could drive the low immunization coverage observed in Nyanza and Western provinces in this study, and cultural practices that may hinder child immunization and, hence, child health in these two provinces must be further investigated.

The significance of maternal education for child health cannot be overemphasized. Since 2003, Kenya has made great strides in enabling children to access free primary education. Secondary school enrolment has been on the rise as well. There was a government target of increasing primary to secondary transition rate from 47 % in 2003 to 70 % by 2008, although in 2005, only 29.3 % were enrolled in secondary schools [49, 50]. With more children attending both primary and secondary school, we may expect other factors to improve long-term child immunization: improved financing, improved awareness of the importance of secondary school among households, and policies that support secondary education, especially for girls [51].

The integration of other healthcare services with maternal and child health services can also improve child immunization. These would include counseling pregnant women on the importance of immunization, follow-up systems and services, and electronic record-keeping and information-sharing to prevent duplication or misinformed choices.

This study is limited by its cross-sectional nature. Since our measurements of the variables are restricted to one period, we could not assess the impact of maternal education on children's immunization over time. Data on immunization of children were received from mothers who were required to recall the information from when their children were young. Recall of data, especially over a long period, may not be reliable [52, 53]. Our findings are limited to Kenya and cannot be generalized to other African countries.

Overall, our findings have significant policy implications for child immunization and, by extension, child health in Kenya. Increasing maternal education is the key to better health for children. Our study supports the link between education, and in particular, better health knowledge, awareness and understanding and better child health. We suggest incorporating health knowledge in the primary school curriculum [46] and argue that it will enable the vast majority of children to be smarter future parents. While Kenya has made broad efforts to increase educational attainment through free primary education, more should be done to encourage full enrollment of all school-aged children. Adopting a policy of free secondary education would have huge impact on the overall health of the country, enabling children from all economic backgrounds to eventually participate in the economy as well-informed, knowledgeable citizens.

A short-term measure to consider in combating the low immunization uptake could be targeted communication strategies designed to sensitize women to the usefulness of taking their children to health centers for vaccination. The current door-to-door campaigns strategy by the Kenyan government to give booster vaccines should be continued. This strategy has been intensified in the urban informal settlements, which are resource-poor environments and are more likely to be inhabited by a population that has lower levels of education. The government should also pay attention to rural provinces like Nyanza and Western to boost the immunization coverage of children aged 12–23 months. Overall, this study shows that a modifiable factor—the mother's education—is a primary marker of child immunization and, consequently, of child health.

References

1. Nwogu, R., Larson, J. S., & Kim, M. S. (2008). Reducing child mortality in Nigeria. A case study of immunizations and systemic factors. *Social Science and Medicine, 67*(1), 161–164.
2. United Nations Development Program. (n.d.). *Reduce child mortality: Reduce by two thirds, between 1990 and 2015, the under-five mortality rate*. Retrieved from http://www.un.org/millenniumgoals/childhealth.shtml. Accessed 20 Jun 2013.
3. World Health Organization. (2012). *Millennium development goals (MDGs)*. Retrieved from http://www.who.int/mediacentre/factsheets/fs290/en/. Accessed 20 Jun 2013.
4. Black, R. E., Morris, S. S., & Bryce, J. (2003). Where and why are 10 million children dying every year? *Lancet, 361*(361), 2226–2234.
5. World Health Organization/World Bank Working Group on Child Health and Poverty. (2002). *Better health for poor children: A special report*. Geneva: WHO. http://whqlibdoc.who.int/hq/2001/a91061.pdf. Accessed 10 Apr 2013.
6. World Health Organization/Unicef. (2013). *Global immunization data*. http://www.who.int/immunization_monitoring/Global_Immunization_Data.pdf.
7. United Nations (2008). *The millennium development goals report 2008: End poverty millennium development goals 2015, make it happen*. http://www.un.org/millenniumgoals/pdf/The%20Millennium%20Development%20Goals%20Report%202008.pdf. Accessed 05 Dec 2012.
8. Kenya National Bureau of Statistics (KNBS) and ICF Macro. (2010). *Kenya Demographic and Health Survey 2008–09*. Calverton, MD: KNBS and ICF Macro. http://www.unfpa.org/sowmy/resources/docs/library/R313_KNBS_2010_Kenya_DHS_2009_final_report.pdf. Accessed 06 Jan 2012.
9. Central Bureau of Statistics (CBS) [Kenya], Ministry of Health (MOH) [Kenya], and ORC Macro. (2004). *Kenya Demographic and Health Survey 2003*. Calverton, MD: CBS, MOH, and ORC Macro. http://dhsprogram.com/pubs/pdf/FR151/FR151.pdf. Accessed 19 Feb 2012.
10. Brockerhoff, M., & Derose, L. F. (1996). Child survival in East Africa: The impact of preventive health care. *World Development, 24*(12), 1841–1857.
11. Delamonica, E., Minuijin, A., & Guilad, J. (2005). Monitoring equity in immunization coverage. *Bulletin of the World Health Organization, 83*(5), 384–391.
12. Kirimi, S. (2011). *Kenya: Polio outbreak warning issued*. All Africa. http://allafrica.com/stories/201109070469.html. Accessed 15 Dec 2012.
13. Becker, S., Peters, D. H., Gray, R. H., et al. (1993). The determinants of use of maternal and child health services in Metro Cebu, the Philippines. *Health Transition Review, 3*(1), 77–89.
14. Boerma, J. T., Sommerfelt, A. E., & Rutstein, S. O. (1991). *Child morbidity and treatment patterns*. DHS Comparative Studies, No. 4. Columbia, MD: IRD/Macro International, Inc.
15. Cleland, J., & Ginneken, J. (1988). Maternal education and child survival in developing countries. The search for pathways of influence. *Social Science and Medicine, 27*(12), 1357–1368.
16. Hemat, S., Takano, T., Kizuki, M., et al. (2009). Health-care provision factors associated with child immunization coverage in a city center and a rural area in Kabul, Afghanistan. *Vaccine, 27*(21), 2823–2829.
17. Kamau, N., & Esmau, F. (2001). Determinants of immunization coverage among children in Mathare valley, Nairobi. *East African Medical Journal, 78*(11), 590–594.
18. Markland, R., & Durand, D. (1976). An investigation of socio-psychological factors affecting infant immunization. *American Journal of Public Health, 66*(2), 168–170.
19. Marks, J. S., Halpin, T. J., Irvin, J. J., et al. (1979). Risk factors associated with failures to receive vaccinations. *Pediatrics, 64*(3), 304–309.
20. Desai, S., & Alva, S. (1998). Maternal education and child health: Is there a strong causal relationship? *Demography, 35*(1), 71–81.
21. Aaby, P., & Benn, C. S. (2009). Assessment of childhood immunization coverage. *Lancet, 373*(9673), 1428.
22. African Population and Health Research Center (APHRC). (2002). *Population and health dynamics in Nairobi's informal settlements*. Nairobi: APHRC. http://aphrc.org/wp-content/uploads/2014/05/Report-The-Nairobi-Cross-sectional-Slums-Survey-NCSS-2000-1.pdf. Accessed 06 Jan 2013.
23. Atkinson, S. J., & Cheyne, J. (1994). Immunization in urban areas: Issues and strategies. *Bulletin of the World Health Organization, 72*(2), 183–194.
24. Heller, L. R. (2013). Do slums matter? Location and early childhood preventive care choices among urban residents of Bangladesh. *Social Science and Medicine, 94*, 43–55.
25. Mutua, M. K., Kimani-Murage, E., & Ettarh, R. R. (2011). Childhood vaccination in informal urban settlements in Nairobi, Kenya: Who gets vaccinated? *BMC Public Health, 11*, 6. doi:10.1186/1471-2458-11-6.
26. Armstrong Schellenbrg, J. R. M., Mrisho, M., Manzi, F., et al. (2008). Health and survival of young children in Southern Tanzania. *BMC Public Health, 8*, 194. doi:10.1186/1471-2458-8-194.
27. Caldwell, J. C. (1994). How is greater maternal education translated into lower child mortality? *Health Transition Review, 4*(2), 224–229.
28. Moïsi, J. C., Kabuka, J., Mitingi, D., et al. (2010). Spatial and socio-demographic predictors of time-to-immunization in a rural area in Kenya: Is equity attainable? *Vaccine, 28*(35), 5725–5730.
29. Müller, I., Smith, T., Mellor, S., et al. (1998). The effect of distance from home on attendance at a small rural health center in Papua, New Guinea. *International Journal of Epidemiology, 27*(5), 878–884.
30. Odusanya, O. O., Alufohai, E. F., Meurice, F. P., et al. (2008). Determinants of vaccination coverage in rural Nigeria. *BMC Public Health, 8*, 381. doi:10.1186/1471-2458-8-381.
31. Omutanyi, R. M., & Mwanthi, M. A. (2005). Determinants of immunization coverage in Butere-Mumias district, Kenya. *East African Medical Journal, 82*(10), 501–505.
32. Sato, A. (2012). Does socio-economic status explains use of modern and traditional health care services? *Social Science and Medicine, 75*(8), 1450–1459.
33. Vaahtera, M., Kulmala, T., Maleta, K., et al. (2000). Childhood immunization in rural Malawi: Time of administration and predictors of non-compliance. *Annals of Tropical pediatrics, 20*(4), 305–312.
34. Sharma, R., Desai, V., & Kavishvar, A. (2009). Assessment of immunization status in the slums of Surat by 15 clusters multi indicators cluster survey technique. *Indian Journal of Community Medicine, 34*(2), 152–155.
35. Bates, A. S., & Wolinsky, F. D. (1998). Personal, financial and structural barriers to immunization in socioeconomically disadvantaged urban children. *Pediatrics, 101*(4 Pt 1), 591–596.
36. Taffa, N., Chepngeno, G., & Amuyunzu-Nyamongo, M. (2005). Child morbidity and healthcare utilization in the slums of Nairobi, Kenya. *Journal of Tropical Pediatrics, 51*(5), 279–284.
37. Basu, A. M., & Stephenson, R. (2005). Low levels of maternal education and the proximate determinants of childhood mortality: A little learning is not a dangerous thing. *Social Science and Medicine, 60*(9), 2011–2023.
38. StataCorp. (2013). *Stata statistical software: Release 13*. College Station, TX: StataCorp LP.
39. Dupont, W. D. (2002). *Statistical modeling for biomedical researchers*. Cambridge: Cambridge University Press.

40. Wooldridge, J. M. (2006). *Introductory econometrics: A modern approach* (3rd ed.). Mason, OH: Thomson South-Western.
41. Abuya, B. A., Onsomu, E. O., Kimani, J. K., et al. (2011). Influence of maternal education on child immunization and stunting in Kenya. *Maternal and Child Health Journal, 15*(8), 1389–1399.
42. Ettarh, R. R., Mutua, M. K., & Kyobutungi, C. (2012). Ethnicity and delay in measles vaccination in a Nairobi slum. *Tropical Medicine and Health, 40*(2), 59–62.
43. Hanson, K., & Jones, C. (2000). *Social marketing of insecticide treated mosquito nets, Tanzania: End of phase 1 social and economic analysis (Technical assistance to PSI Tanzania, final report)*. London: Malaria Consortium.
44. World Bank. (2012). *Health equity and financial protection report—Kenya*. Washington, D.C.: World Bank. Retrieved from http://www-wds.worldbank.org/external/default/WDSContentServer/WDSP/IB/2012/07/18/000356161_20120718024306/Rendered/PDF/712540WP00PUBL0Country0Report0Kenya.pdf. Accessed 08 Feb 2013.
45. Glewwe, P. (1999). Why does mother's schooling raise child health in developing countries? Evidence from Morocco. *Journal of Human Resources, 34*(1), 124–159.
46. Martin, T. C., & Juuarez, F. (1995). The impact of women's education on fertility in Latin America: Searching for explanations. *International Family Planning Perspectives, 21*(2), 52–57 & 80.
47. Abuya, B. A., Ciera, J., & Kimani-Murage, E. (2012). Effect of mother's education on child's nutritional status in the slums of Nairobi. *BMC Pediatrics, 12*, 80. doi:10.1186/1471-2431-12-80.
48. Magadi, M. (2004). Maternal and child health among the urban poor in Nairobi, Kenya. *African Population Studies, 19*(Suppl B), 179–198.
49. Ngware, M. W., Onsomu, E. N., & Muthaka, D. I. (2007). Financing secondary education in Kenya: Cost reduction and financing options. *Education Policy Analysis Archives, 15*(24), 1–24.
50. United Nations Development Program. (2005). *Human development report 2005*. New York: United Nations Development Program.
51. Ngware, M. W., Onsomu, E. N., Muthaka, D. I., et al. (2006). Improving access to secondary education in Kenya: What can be done? *Equal Opportunities International, 25*(7), 523–543.
52. Beckett, M., DaVanzo, J., Sastry, N., Panis, C., & Peterson, C. (2001). The quality of retrospective data: An examination of long-term recall in a developing country. *The Journal of Human Resources, 36*(3), 593–625.
53. Huber, L. R. B., Lyerly, J. E., Young, A. M., Dmochowski, J., Vick, T. M., & Scholes, D. (2014). Comparison of prospective and retrospective measurements of frequency of sexual intercourse. *Maternal and Child Health Journal, 18*(6), 1293–1299.