Vaccine 32 (2014) 6699–6704

Contents lists available at ScienceDirect

Vaccine

journal homepage: www.elsevier.com/locate/vaccine

Demographic, socio-economic and geographic determinants of seasonal influenza vaccine uptake in rural western Kenya, 2011 ☆

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ARTICLE INFO

Article history:
Received 25 April 2013
Received in revised form
12 September 2013
Accepted 26 October 2013
Available online 22 January 2014

Keywords:
Vaccine uptake
Determinants
Seasonal influenza
Children

ABSTRACT

Influenza-associated acute lower respiratory infections cause a considerable burden of disease in rural and urban sub-Saharan Africa communities with the greatest burden among children. Currently, vaccination is the best way to prevent influenza infection and accompanying morbidities.

We examined geographic, socio-economic and demographic factors that contributed to acceptance of childhood seasonal influenza vaccination among children living in a population-based morbidity surveillance system in rural western Kenya, where influenza vaccine was offered free-of-charge to children 6 months–10 years old from April to June, 2011. We evaluated associations between maternal and household demographic variables, socio-economic status, and distance from home to vaccination clinics with family vaccination status.

7249 children from 3735 households were eligible for vaccination. Of these, 2675 (36.9%) were fully vaccinated, 506 (7.0%) were partially vaccinated and 4068 (56.1%) were not vaccinated. Children living in households located >5 km radius from the vaccination facilities were significantly less likely to be vaccinated (aOR = 0.70; 95% CI 0.54–0.91; $p = 0.007$). Children with mothers aged 25–34 and 35–44 years were more likely to be vaccinated than children with mothers less than 25 years of age (aOR = 1.36; 95% CI 1.15–1.62; $p < 0.001$; and aOR = 1.35; 95% CI 1.10–1.64; $p = 0.003$, respectively). Finally, children aged 2–5 years and >5 years of age (aOR = 1.38; 95% CI 1.20–1.59; $p < 0.001$; and aOR = 1.41; 95% CI 1.23–1.63; $p < 0.001$, respectively) and who had a sibling hospitalized within the past year (aOR = 1.73; 95% CI 1.40–2.14; $p < 0.001$) were more likely to be vaccinated.

Shorter distance from the vaccination center, older maternal and child age, household administrator's occupation that did not require them to be away from the home, and having a sibling hospitalized during the past year were associated with increased likelihood of vaccination against influenza in western Kenya. These findings should inform the design of future childhood seasonal influenza vaccination campaigns in rural Kenya, and perhaps elsewhere in Africa.

1. Introduction

An estimated 28,000–111,500 children younger than five years old died worldwide in 2008 due to causes attributable to influenza-associated acute lower respiratory infections (ALRI), and 99% of these deaths occurred in developing countries [1]. While the burden of influenza has traditionally been assumed to be minor in Africa with respect to other causes of severe disease, global concerns surrounding influenza A (H5N1) and pandemic preparedness provided resources to support surveillance systems that have better characterized the epidemiology of influenza in Africa [2].

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http://dx.doi.org/10.1016/j.vaccine.2013.10.089

Surveillance reports from the Cote d' Ivoire, Democratic Republic of Congo, Gabon, Gambia, Kenya, Madagascar, and Senegal all indicate that influenza circulates annually in Africa, causing regular epidemics [3]. Many other countries in Africa including Ghana, Egypt and Morocco, also have some limited data on influenza circulation [4]. A trivalent influenza vaccine is commercially available in Kenya. However in this country of 37 million people, the Government does not yet routinely procure influenza vaccine, as influenza vaccination is not covered by Kenya's Expanded Programme on Immunization. Fewer than 40,000 doses are sold annually within the private sector [5].

Vaccination is currently the most cost-effective intervention to reduce hospitalization and treatment costs due to influenza [6]. While the Expanded Programme on Immunization successfully led the eradication of smallpox [7] and has made immense public health gains by reducing the burden of poliomyelitis, measles, diphtheria and pertussis, influenza remains prevalent in developing countries. The World Health Organization's Strategic Advisory Group of Experts (SAGE) on immunization recommends that children aged 6 months–5 years be vaccinated against influenza annually [8], and that immunologically naive children be given two doses of vaccine. SAGE further stresses the prioritization for vaccination based on burden of disease, cost-effectiveness, feasibility and other appropriate considerations. Influenza is found in 10% of Severe Acute Respiratory Illness (SARI) cases in Africa and children aged less than 5 years old account for approximately half of all influenza-like illness (ILI) and SARI cases [9]. Furthermore, surveillance data in Kenya suggest ALRI cause a considerable burden of disease in rural and urban communities, with the greatest burden among children [10].

Although routine vaccination is a major tool in the primary prevention of influenza [11,12], a significant proportion of the population is reluctant to receive vaccines [13,14]. We examined demographic, socio-economic and geographic factors that contributed to acceptance of childhood seasonal influenza vaccination among families in rural western Kenya. Existing literature from other countries suggest important determinants of childhood vaccine uptake [15–20]. Analyses from demographic and surveillance systems (DSS) have found different socio-demographic factors associated with childhood vaccination; In Bangladesh, diphtheria–tetanus–pertussis and oral polio vaccination were independently associated with higher maternal age, lower maternal education and birth order of the child [15]. In Malawi, maternal education was found to be among major determinants of the immunization status of the child [16], Moreover, findings from DSS in Ghana showed positive relationship between socio-economic status and vaccination status [17].

Cross-sectional surveys have similarly suggested important determinants of childhood vaccination; a survey in Khartoum State of Sudan observed an increased vaccination rate with an increase in the age of the children and the education level of the mother, subsequently children of older mothers were more likely to have had the correct vaccinations [18]. A survey in Ghana found distance to be the most important factor that influences the utilization of health services [19]. Moreover, a survey in Kenya found that immunization rate ratios were reduced with every kilometer of distance from home to vaccine clinic [20]. Researches on factors associated with vaccination among children in Africa have focused on vaccinations covered by EPI programs. None of these studies, however, draws attention on the issue raised in our work and to best of our knowledge determinants of childhood vaccination in the context of influenza vaccination remains an ignored expedition for sub-Saharan Africa. Understanding the determinants of children's vaccine uptake in Kenya is therefore important for guiding future immunization policies.

2. Materials and methods

2.1. Study site and population

The CDC's International Emerging Infections Program in collaboration with KEMRI has conducted population-based infectious disease surveillance (PBIDS) in Asembo Division, Siaya County since late 2005 [21]. Asembo has an area of 200 km^2 and lies northeast of Lake Victoria in Nyanza Province in western Kenya. The PBIDS area comprises approximately 100 km^2 with an overall population density of about 325 persons per square kilometer. The surveillance population includes approximately 25,000 persons living in 33 villages. All study participants must have resided permanently in the area for 4 calendar months and have been registered into the KEMRI/CDC Health and Demographic Surveillance System (HDSS) [22]. The population is predominantly subsistence farmers and fishermen belonging to the Luo ethnic group. Rain falls year-round, but is usually heaviest between March and May, with a second smaller peak in October and November [23]. The area has high child mortality; in 2009, it had a mortality ratio of 180.5 per 1000 live births in children under age five [24]. At the time of the vaccination campaign, Asembo still had no paved roads, except on its northern border. Few public transport vehicles serviced the area and walking was the most common mode of transport.

KEMRI/CDC established the HDSS in 2001 with an objective of providing an infrastructure for future evaluation of population-based public health interventions [22]. Data generated by the HDSS stratified by age, sex, socio-economic status (SES), educational level, and geographic location can be used to generate hypotheses and address the causes of morbidity and mortality in subgroups of the population. The SES score is derived using multiple component analysis (MCA) [25], for all households under HDSS. The MCA is generated based on household assets, namely occupation of household head, primary source of drinking water, main source of cooking fuel, in-house possession (lantern lamp, sofa, radio bicycles and TV) and livestock ownership (goats, cattle, donkeys, pigs and sheep). All houses in the HDSS area were mapped using a differential global positioning system (GPS) as part of the insecticide treated net malaria trial [26], and maps are updated at least annually to take account of new construction.

We implemented a seasonal influenza vaccination campaign from April 4 to June 24, 2011, offering free trivalent inactivated influenza vaccine to children aged 6 months–10 years old who are participants of the population-based morbidity surveillance in rural western Kenya. The trivalent vaccine included a pandemic influenza A (H1N1) 2009 component, an influenza A (H3N2) component and an influenza B component. Children aged 6 months–8 years, and those that were vaccine naive, were scheduled to receive 2 doses while those aged 9–10 years old were scheduled to receive only one dose. The two doses were administered 4 weeks apart. Influenza vaccines were administered from three designated health facilities; St. Elizabeth Lwak Mission Hospital, Mahaya Health Center and Ong'ielo Sub-district Hospital. These three health facilities are spread within the surveillance area to allow ease in access to healthcare. The vaccines were available at the facilities on weekdays from 9 am to 3 pm.

Community members, hired and trained by KEMRI/CDC on standardized and consistent messages conducted a community sensitization campaign one month prior to vaccine administration through door-to-door mobilization of all households with eligible children; fliers were left behind in homes where parents were away at the time of mobilization. We also held meetings with community members and distributed posters and fliers at market places, schools and health facilities within the surveillance area. Mobilization messages included signs and symptoms of seasonal influenza, ways of preventing and controlling influenza, benefits of seasonal influenza vaccine and designated clinics for seasonal influenza vaccination. Mobilization continued throughout the vaccination administration period. Data on vaccination were collected at 3 vaccination clinics by use of netbooks.

2.2. Statistical analysis

We used existing geo-codes mapped by the HDSS to calculate radial distances from homesteads to each of the three health facilities in order to evaluate the impact of distance from residence to the nearest vaccination center on vaccination status. Demographic and socio-economic variables were analyzed as covariates through linkage to the HDSS database. Bivariate and multivariate associations between the independent variables and a three-level dependent variable of vaccination uptake (fully, partially and not vaccinated) were evaluated. Fully vaccinated children were defined as having received all of the required doses of the influenza vaccine. Partially vaccinated children were defined as children receiving only one dose of vaccine when two doses were required. Non-vaccinated children did not receive any doses of influenza vaccine. Data were analyzed using SAS version 9.2 (SAS Institute, Cary, NC, USA) software package.

In our initial bivariate analyses, independent variables were compared with the three levels of child vaccination status. Independent variables included maternal and household demographic variables (maternal and child age, maternal education, household occupation, sibling death and hospital admission reported within one year prior to vaccination), socio-economic status, and radial distance in kilometers from home to the nearest vaccination clinic. We considered the occupation of the household administrator in the family to be the household occupation. Household administrator was defined as the member of the household who makes the day-to-day decisions in the household and manages it in the absence of or on behalf of the head of the household. We also classified household occupations into two categories: those that required the administrator of household to be away from home during vaccination clinic hours of operation (such as teaching, nursing and fishing) and those that did not require the administrator of household to be away from home (such as local subsistence farming or agricultural work, local small business operations, or no occupation). Associations between independent variables and vaccination status were interpreted using odds ratios (OR) and their 95% confidence intervals (CI), the OR presented were common for fully, partially and non-vaccination statuses. Following bivariate analyses, logistic regression analyses (with an ordinal outcome of fully, partially and non-vaccinated statuses of the children) were performed using the GENMOD procedure, taking into account the clustering of fully, partially, and unvaccinated children within families and households. Variables that were significant at $p < 0.2$ in the bivariate analyses were included in the multivariable model. Findings were considered statistically significant if the p-value was <0.05 in the multivariable model.

2.3. Ethical clearance

The study protocol was reviewed and approved by the institutional review boards of KEMRI (Nairobi, Kenya) and CDC (Atlanta, GA). Written informed consent was obtained for linkage of participants' vaccination data with the health and demographic surveillance system database.

3. Results

A total of 7249 children from 3735 households were targeted for vaccination. Of these, 2264 children (31.2%) were aged 2–4 years old, 2120 (29.3%) children were aged 5–8 years old and 1917 (26.5%) children were above 8 years (Table 1). Only 948 (13.1%) children were below 2 years old. The mean age of the children was 5.7 years, with a range of 6 months–10.9 years.

Table 1
Demographic characteristics of study population, Kenya, 2011.

	n	%
Maternal age (N = 3735)		
<25 years	965	25.8
25–34 years	1589	42.5
35–44 years	889	23.8
>44 years	292	7.8
Maternal education (N = 3735)		
No education	83	2.2
Primary education	2819	75.5
Secondary/high school education	769	20.6
Post secondary/high school education	64	1.7
Children's age (N = 7249)		
<2 years	948	13.1
2–5 years	2264	31.2
>5 years	4037	55.7
Occupation of household administrator (N = 7249)		
Business owner (duka, kiosk, jua-kali)	233	3.2
Commercial farming	52	0.7
Fisher	199	2.8
Housewife	42	0.6
Not working	34	0.5
Other	85	1.2
Salaried worker (teacher, nurse, office)	501	6.9
Skilled labor (carpenter, tailor)	581	8.0
Small business (sell maize)	933	12.9
Subsistence farming	3894	53.7
Unskilled labor (Shamba, construction)	695	9.6

Demographic data were analyzed for 3735 mothers (Table 1). The mean maternal age was 32 years (range 15–57 years). Overall, 2819 (75.5%) mothers had a primary level of education, 83 (2.2%) mothers reported no education. The median distance traveled by parents/caretakers to the nearest vaccination clinic was 2.5 km with a range of 0.02–6.19 km. 6711/7249 (92.6%) children lived within a 5 km radius from the nearest vaccination facility. The majority of the household administrators were subsistence farmers (3894/7249, 53.7%) (Table 1). Seventy-six of 7249 (1.0%) household administrators did not have any occupation, while for 85 persons (1.2%) occupation was not classified. Of the 7249 children eligible for vaccination, 2675 (36.9%) were fully vaccinated, 506 (7.0%) were partially vaccinated and 4068 (56.1%) were not vaccinated.

Bivariate analyses of demographic variables indicated that mothers with post-secondary education, younger mothers, and mothers of younger children were significantly less likely to bring their children for vaccination (Table 2). With regard to socio-demographic and geographic variables, bivariate analyses indicated that children from households with fewer children (median = 2; range, 1–6), children from households that were located more than 5 km from the nearest vaccination facility, and children from households who had a household administrator whose occupation required them to be away from home were less likely to be vaccinated. Children with siblings who had been hospitalized in the past year were more likely to be vaccinated (Table 2).

Multivariate analyses (Table 3) indicated that children living >5 km from the nearest vaccination site remained significantly less likely to be vaccinated [aOR = 0.70; 95% CI 0.54–0.91; $p = 0.007$). In addition, children of household administrators whose occupation required them to be away from home were less likely to be vaccinated than those who came from households where the household administrator did not work or whose nature of work did not require that they be away from home (aOR = 0.84; 95% CI 0.72–0.99; $p = 0.032$) (Table 3). Children with mothers aged 25–34 and 35–44 years were more likely to be vaccinated than children

Table 2
Bivariate analysis: demographic, geographic and socio-economic variables by influenza vaccine uptake, 2011.

	Fully vaccinated (*N* = 2675) *n* (%), median (range)	Partially vaccinated (*N* = 506) *n* (%), median (range)	Non-vaccinated (*N* = 4068) *n* (%), median (range)	Crude OR (95% CI)	*p*-Value
Age of child					
<2 years	211 (22.3)	164 (17.3)	573 (60.4)	Ref	
2–5 years	823 (36.3)	174 (7.7)	1267 (56.0)	1.39 (1.21, 1.59)	<0.001
>5 years	1641 (40.6)	168 (4.2)	2228 (55.2)	1.53 (1.34, 1.74)	<0.001
Age of mother in years					
<25 years	393 (27.7)	143 (10.1)	883 (62.2)	Ref	
25–34 years	1377 (38.7)	249 (7.0)	1933 (54.3)	1.46 (1.24, 1.72)	<0.001
35–44 years	731 (39.6)	105 (5.7)	1012 (54.7)	1.47 (1.22, 1.77)	<0.001
≥45 years	174 (41.1)	9 (2.1)	240 (56.7)	1.44 (1.10, 1.89)	0.008
Mother's level of education					
None	60 (40.0)	8 (5.3)	82 (54.7)	Ref	
Primary	2115 (37.5)	406 (7.2)	3124 (55.3)	0.94 (0.60, 1.48)	0.792
Secondary	478 (35.0)	90 (6.6)	798 (58.4)	0.84 (0.52, 1.33)	0.453
Post-secondary	22 (25.0)	2 (2.3)	64 (72.7)	0.46 (0.21, 0.98)	0.044
Distance in km to the nearest vaccination site					
Live within 5 km radius of clinic	2515 (37.5)	467 (7.0)	3729 (55.5)	Ref	
Live outside 5 km radius of clinic	160 (29.7)	39 (7.3)	339 (63.0)	0.73 (0.56, 0.94)	0.015
Socio-economic status (SES) in quintiles					
Quintile 1 (poorest)	238 (34.2)	47 (6.8)	411 (59.0)	Ref	
Quintile 2	362 (36.3)	77 (7.7)	558 (56.0)	1.12 (0.85, 1.47)	0.412
Quintile 3	483 (38.5)	98 (7.8)	675 (53.7)	1.23 (0.94, 1.59)	0.128
Quintile 4	674 (37.6)	136 (7.6)	981 (54.8)	1.18 (0.92, 1.50)	0.187
Quintile 5 (least poor)	918 (36.6)	148 (5.9)	1443 (57.5)	1.08 (0.86, 1.37)	0.507
Occupation[a]					
Not working or nature of work does not require that they are away from home	1986 (37.5)	404 (7.6)	2908 (54.9)	Ref	
Nature of occupation requires that they are away from home	655 (35.1)	96 (5.1)	1115 (59.8)	0.85 (0.73, 0.99)	0.036
Sibling death					
No death reported within 1 year prior to vaccination	2594 (36.7)	496 (7.0)	3983 (56.3)	Ref	
Death reported within 1 year prior to vaccination	81 (46.0)	10 (5.7)	85 (48.3)	1.42 (0.94, 2.16)	0.100
No. of children within a household	2 (1–6)	2 (1–6)	1 (1–6)	1.07 (1.02, 1.13)	0.004
Sibling hospital admission					
No hospital admission reported within 1 year prior vaccination	2294 (35.5)	441 (6.8)	3735 (57.7)	Ref	
Hospital admission reported within 1 year prior to vaccination	381 (48.9)	65 (8.3)	333 (42.8)	1.78 (1.45, 2.20)	<0.001

[a] 85 cases with household job not specified were dropped.

with mothers <25 years of age (aOR = 1.36; 95% CI 1.15–1.62; $p < 0.001$; and aOR = 1.35; 95% CI 1.10–1.64; $p = 0.003$, respectively).

Children aged 2–5 years and >5 years of age were more likely to be vaccinated compared with those below two years of age (aOR = 1.38; 95% CI 1.20–1.59; $p < 0.001$; and aOR = 1.41; 95% CI 1.23–1.63; $p < 0.001$, respectively). Finally, children that had a sibling hospitalized within one year prior to vaccine campaign were more likely to be vaccinated than children from households with no hospitalizations reported within one year prior to the campaign (aOR = 1.73; 95% CI 1.40–2.14; $p < 0.001$) (Table 3).

4. Discussion

Influenza is a vaccine-preventable cause of medically attended illness, hospitalizations and death each year in Kenya [10]. Despite the free distribution of influenza vaccine to children, we observed a vaccine uptake of 37% for fully vaccinated children. While this compares favorably to the 33% uptake of seasonal vaccine observed in the United States during the 2004–2005 influenza season when vaccine was first recommended for young children [27], much room for improvement remains. While economic considerations are critical to future vaccine campaigns in Africa, behavioral determinants for seeking immunization are also among the myriad challenges to improving influenza immunization rates in Africa. These factors are therefore important to consider in the implementation of future influenza vaccines campaigns.

Multiple factors influence healthcare utilization at clinics, including cost, distance, quality of care, and severity of illness [28–31]. In the HDSS in western Kenya, many ill persons do not utilize free high-quality referral clinics; in 2009 only 30–40% of ill participants sought care at any clinic and only a half of those went to designated PBIDS referral clinics [22]. Accessibility to vaccination services in terms of walking time to the nearest place of vaccination, the child's age, age of the mother, and the mother's education have been cited as some of the determinants of vaccination in children in Africa [18]. Distance to the nearest vaccination facility, the child's age and age of the mother clearly also played an important role in the use of fixed vaccination sites in this Kenyan context.

In this study, as well as previous studies in developing countries [32,33], greater distance to primary health care facilities was negatively associated with vaccine uptake. In addition to longer transit distances that must be covered by participants from peripheral villages, the poor state of roads, especially during rainy seasons [21], may have hindered participants' access to vaccination clinics; the vaccines were delivered in March–June, which is the primary rainy season in Kenya. Other studies in developing countries have also

Table 3
Multivariate analysis: demographic, geographic and socio-economic variables associated with seasonal influenza vaccine uptake, 2011.

	Crude OR (95% CI)	*p*-Value	Adjusted OR[a] (95% CI)	*p*-Value
Distance in km to the nearest vaccination site				
Live within 5 km radius of clinic	Ref		Ref	
Live outside the 5 km radius of clinic	0.73 (0.56, 0.94)	0.015	0.70 (0.54, 0.91)	0.007
Age of child				
<2 years	Ref		Ref	
2–5 years	1.39 (1.21, 1.59)	<0.001	1.38 (1.20, 1.59)	<0.001
>5 years	1.53 (1.34, 1.74)	<0.001	1.41 (1.23, 1.63)	<0.001
Age of mother				
<25 years	Ref		Ref	
25–34 years	1.46 (1.24, 1.72)	<0.001	1.36 (1.15, 1.62)	<0.001
35–44 years	1.47 (1.22, 1.77)	<0.001	1.35 (1.10, 1.64)	0.003
≥45 years	1.44 (1.10, 1.89)	0.008	1.30 (0.97, 1.74)	0.075
Mother's level of education				
None	Ref		Ref	
Primary	0.94 (0.60, 1.48)	0.792	0.95 (0.60, 1.52)	0.834
Secondary	0.84 (0.52, 1.33)	0.453	0.89 (0.55, 1.44)	0.632
Post-secondary	0.46 (0.21, 0.98)	0.044	0.52 (0.24, 1.13)	0.097
Occupation[a]				
Not working or nature of work does not require that they are away from home	Ref		Ref	
Nature of occupation requires that they are away from home	0.85 (0.73, 0.99)	0.036	0.84 (0.72, 0.99)	0.032
Sibling death				
No death reported within 1 year prior to vaccination	Ref		Ref	
Death reported within 1 year prior to vaccination	1.77 (0.90, 3.47)	0.100	1.48(0.74, 2.96)	0.263
No. of children within a household	1.07 (1.02, 1.13)	0.004	1.03 (0.98, 1.08)	0.213
Sibling hospital admission				
No hospital admission reported within 1 year prior vaccination	Ref		Ref	
Hospital admission reported within 1 year prior to vaccination	1.78 (1.45, 2.20)	<0.001	1.73 (1.40, 2.14)	<0.001

[a] 85 cases whose house hold occupation could not be classified were dropped, thus $N = 7164$ for the adjusted model.

suggested that walking or traveling time and distance are key factors that influence the utilization of healthcare services [33,34]. Our findings are consistent with evidence that most people will not travel further than 5 km to basic preventive and curative care [35].

We found that younger maternal age was negatively associated with children's influenza vaccine uptake, findings that have been described in the uptake of other vaccines [18,36]. Studies have suggested that older mothers, independent of their educational level, may be influenced more by memories of the benefits of past vaccination [37], and less by current controversies over vaccinations [38].

Other studies from Africa have found a positive relationship between socio-economic status and vaccination status [17,20]. Children belonging to the wealthiest households have higher vaccination rates for routine childhood vaccines that are given only once (BCG and measles vaccinations). However, socio-economic status does not as strongly affect probabilities of children receiving complete coverage with other vaccines that are required to be given in multiple doses (polio3, DTP3 and HepB3) [39]. In this study, socio-economic status was not a significant predictor for vaccination. This could be attributed to a lack of variability in this factor in the study region with overall low socio-economic status [28], and may also be influenced by the fact that many children required multiple doses of influenza vaccine.

In our study, the nature of the administrator of household's occupation was an important factor associated with the vaccination uptake, children who came from homes where the household administrator did not work or, had an occupation that did not require them to work away from home, were more likely to vaccinate their children. This is not surprising, given that people who work away from home may need to take time off work to get their children vaccinated, or to seek medical care. Other studies have also suggested that parental occupations that keep parents away from home may reduce the likelihood of parents to seek immunization for their children [40,41].

Recent studies of influenza vaccine uptake in young children have shown associations of vaccine uptake with the age of child. Lower rates of influenza immunization have been observed in children younger than two years of age in Canada and the United States of America [42,43]. These findings are consistent with our observation that children aged <2 years were less likely to be vaccinated. This could be attributed to parental concern that children in this age group receive too many vaccines [44].

This study had several limitations. Information on paternal education was not sufficient to evaluate the relationship between paternal education and vaccination status. Additionally we defined household occupational status based on the occupation of the household administrator who is a single individual rather than a composite measure based on the roles of adult household members. Moreover, we did not examine vaccination-related attitudes and knowledge as determinants of vaccine uptake despite existing literature emphasizing on their role as key determinants of vaccination decisions neither did we collect information on which parent nor guardian brought the child for vaccination. However, a supplementary survey is currently underway to help understand the role of fathers or other male household decision-makers as well as vaccine-related attitudes in influenza vaccine uptake. Despite the considerable burden of influenza disease from existing literature, the cost or opportunity cost for an introduction of an influenza vaccine is yet to be defined and analyses are currently underway to describe these costs. Finally, there was potential for misclassification regarding occupations that do or do not result in lots of time away from home. While further validation of the occupational categories is warranted, misclassification in this variable would likely place a conservative bias on the observed association.

5. Conclusion

We found that demographic, geographical and educational characteristics of mothers and families were important determinants of vaccine uptake among children during a seasonal influenza vaccine campaign in Kenya. Future vaccination campaigns will need to consider ways to adapt vaccination schedules and locations to accommodate parents who work outside the home. Finally, mobilization efforts may also need to more extensively target more children below two years of age since they bear greatest burden of influenza and respiratory diseases, and who often require multiple doses of vaccine.

Acknowledgements

We thank seasonal influenza vaccine effectiveness study participants and study team members for their participation in the study, MoPHS, DDSR for technical oversight during study implementation, John Williamson of CDC – Kenya for his statistical advice, Sanofi Pasteur for donation of influenza vaccine, and the director for KEMRI for permission to publish these data.

The findings and conclusions in this report are those of the authors and do not necessarily represent the views of the Centers for Disease Control and Prevention.

Author contributions: Conception and design of the study: NAO, JAM. Acquisition of data: NAO, EL, JAM, BN, GE, AA. Analysis and interpretation of data: NAO, JAM, BN, GE, AA. Drafting the article or revising it critically for important intellectual content and final approval of the version to be submitted: NAO, JAM, BN, GE, EL, AA, MW, PM, GB, RFB, RO, DB, MAK, DKS.

References

[1] Nair H, Brooks WA, Katz M, Roca A, Berkley JA, Madhi SA, et al. Global burden of respiratory infections due to seasonal influenza in young children: a systematic review and meta-analysis. Lancet 2011;378(9807):1917–30.
[2] Breiman RF, Nasidi A, Katz M, Kariuki NM, Vertefeuille J. Preparedness for highly pathogenic avian influenza pandemic in Africa. Emerg Infect Dis 2007;13(10) www.cdc.gov/eid
[3] Yazdanbakhsh M, Kremsner PG. Influenza in Africa. PLoS Med 2009;6(12), http://dx.doi.org/10.1371/journal.pmed.1000182, e1000182.
[4] FluNet. Global influenza surveillance and response system (GISRS); 2013 www.who.int/flunet [accessed 12.09.13].
[5] Mwaingi M. Nairobi, Kenya: Sanofi Pasteur; 2010.
[6] Salo H, Kilpi T, Sintonen H, Linna M, Peltola V, Heikkinen T. Cost-effectiveness of influenza vaccination of healthy children. Vaccine 2006;24(23):4934–41.
[7] Peter G. Childhood immunizations. N Engl J Med 1992;327:1794–800.
[8] http://www.who.int/influenza/vaccines/SAGE_information/en [accessed 16.05.12].
[9] Duque J. Influenza surveillance in 15 countries in Africa, 2006–2010: the ANISE network. In: Proceedings of the 3rd Annual African Network for Influenza Surveillance and Epidemiology (ANISE) Meeting, February 1–3. 2012.
[10] Katz MA, Lebo E, Emukule G, Njuguna H, Aura B, Cosmas L, et al. The epidemiology, seasonality and burden of influenza and influenza-like illness in urban and rural Kenya, 2007–2010. J Infect Dis 2012;206:S53–60.
[11] Cox NJ, Subbarao K. Influenza. Lancet 1999;354:1277–82.
[12] Santibanez TA, Santoli JM, Bridges CB, Euler GL. Influenza vaccination coverage of children aged 6 to 23 months: the 2002–2003 and 2003–2004 influenza seasons. Pediatrics 2006;118:1167–75.
[13] Borràs E, Domínguez A, Fuentes M, Batalla J, Cardeñosa N, Plasencia A. Parental knowledge of paediatric vaccination. BMC Public Health 2009;9:154.
[14] Oria PA, Arunga G, Lebo E, Emukule G, Otieno NA, Katz M, et al. Assessing parents' knowledge and attitudes towards seasonal influenza vaccination of children before and after a seasonal influenza vaccination effectiveness study in low-income urban and rural Kenya, 2010–2011. BMC Public Health 2013;13:391.
[15] Breiman RF, Streatfield PK, Phelan M, Shifa N, Rashid M, Yunus M. Effect of infant immunisation on childhood mortality in rural Bangladesh: analysis of health and demographic surveillance data. Lancet 2004;364:2204–11.
[16] Munthali AC. Determinants of vaccination coverage in Malawi. Evidence from the demographic and health surveys. Malawi Med J 2007;19:79–82.
[17] INDEPTH NETWORK. Measuring health equity in small areas: findings from demographic surveillance system. Health inequalities in the Kassena-Nankana District in Northern Ghana. England: Ashgate; 2005. p. 45–65.
[18] Ibnouf AH, Van den Borne HW, Maarse JAM. Factors influencing immunisation coverage among children under five years of age in Khartoum State, Sudan. S Afr Fam Pract 2007;49(8):14.
[19] Buor D. Analysing the primacy of distance in the utilization of health services in the Ahafo-Ano South district, Ghana. Int J Health Plann Manag 2003;18:293–311.
[20] Ndiritu M, Cowgill KD, Ismail A, Chiphatsi S, Kamau T, Fegan G, et al. Immunization coverage and risk factors for failure to immunize within the Expanded Programme of Immunization in Kenya after the introduction of *Haemophilus* influenza type b and hepatitis b virus antigens. BMC Public Health 2006; 6:132.
[21] Feikin DR, Audi A, Olack B, Bigogo GM, Polyak C, Burke H, et al. Evaluation of the optimal recall period for disease symptoms in home-based morbidity surveillance in rural and urban Kenya. Int J Epidemiol 2010;39:450–8.
[22] Adazu K, Lindblade KA, Rosen DH, Odhiambo F, Ofware P, Kwach J, et al. Health and demographic surveillance in rural western Kenya: a platform for evaluating interventions to reduce morbidity and mortality from infectious diseases. Am J Trop Med Hyg 2005;73:1151–8.
[23] Phillips-Howard PA, Wannemuehler KA, Ter Kuile FO, Hawley WA, Kolczak MS, Odhacha A, et al. Diagnostic and prescribing practices in peripheral health facilities in rural western Kenya? Am Soc Trop Med Hyg 2003; 68(Suppl. 4):44–9.
[24] Hamel MJ, Adazu K, Obor D, Sewe M, Vulule J, Williamson JM, et al. A reversal in reductions of child mortality in western Kenya, 2003–2009. Am J Trop Med Hyg 2011;85(4):597–605.
[25] Booysen F, van der Berg S, Burger R, von Maltitz M, du Rand G. Using an asset index to assess trends in poverty in seven Sub-Saharan African countries: Brasilia, Brazil; 2005.
[26] Hightower AW, Ombok M, Otieno R, Odhiambo R, Oloo AJ, Lal AA, et al. A geographic information system applied to a malaria field study in western Kenya. Am J Trop Med Hyg 1998;58:266–72.
[27] Childhood Influenza Vaccination Coverage, United States, 2004–05 Influenza Season; 2012. http://www.cdc.gov/mmwr/preview/mmwrhtml/mm5539a1.htm [accessed 29.08.12].
[28] Feikin DR, Nguyen LM, Adazu K, Ombok M, Audi A, Slutsker L, et al. The impact of distance of residence from a peripheral health facility on pediatric health utilisation in rural western Kenya. Trop Med Int Health 2009;14:54–61.
[29] Armstrong Schellenberg JR, Adam T, Mshinda H, Masanja H, Kabadi G, Mukasa O, et al. Effectiveness and cost of facility-based Integrated Management of Childhood Illness (IMCI) in Tanzania. Lancet 2004;364:1583–94.
[30] Bhattarai A, Ali AS, Kachur SP, Mårtensson A, Abbas AK, Khatib R, et al. Impact of artemisinin-based combination therapy and insecticide-treated nets on malaria burden in Zanzibar. PLoS Med 2007;4:e309.
[31] Hayes JA. Hedging opportunities in health care. Health Care Strategy Manag 1990;8:12–4.
[32] Torun SD, Bakirci N. Vaccination coverage and reasons for non-vaccination in a district of Istanbul. BMC Public Health 2006;6:125–32.
[33] Muller J, Smith T, Mellor S. The effects of distance from home on attendance at a small rural health centre in Papua New Guinea. Int J Epidemiol 1998;27(5):878–84.
[34] Wilson JB, Collison AH, Richardson D, Kwofie G, Senah KA, Tinkorang EK. The maternity home waiting concept: the Nsawam, Ghana experience. Int J Gynaecol Obstet 1997;59(Suppl. 2):165–72.
[35] Evers DB. Teaching mothers about childhood immunizations. Am J Matern Child Nurs 2001;26:253–6.
[36] Casiday R, Cresswell T, Wilson D, Panter-Brick C. A survey of UK parental attitudes to the MMR vaccine and trust in medical authority. Vaccine 2006;24:177–84.
[37] Antai D. Rural–urban inequities in childhood immunisation in Nigeria: the role of community contexts. Afr J Prim Health Care Fam Med 2011;3(1) [Art. #238], 8 pp.
[38] Prislin R, Dyer JA, Blakely CH, Johnson CD. Immunization status and sociodemographic characteristics: the mediating role of beliefs, attitudes and perceived control. Am J Public Health 1998;88:1821–6.
[39] Ndirangu J, Bärnighausen T, Tanser F, Tint K, Newell ML. Levels of childhood vaccination coverage and the impact of maternal HIV status on child vaccination status in rural KwaZulu-Natal, South Africa. Trop Med Int Health 2009;14(11):1383–93.
[40] Antai D. Inequitable childhood immunization uptake in Nigeria: a multilevel analysis of individual and contextual determinants. BMC Infect Dis 2009; 9:181.
[41] Mitchelle S, Andersson N, Ansari NM, Omer K, Soberanis JL, Cockcroft A. Equity and vaccine uptake: a cross-sectional study of measles vaccination in Lasbela District, Pakistan. BMC Int Health Hum Rights 2009;9(Suppl. 1):S7.
[42] Campitelli MA, Inoue M, Calzavara AJ, Kwong JC, Guttmann A. Low rates of influenza immunization in young children under Ontario's Universal Influenza Immunization Program. Pediatrics 2012;129(6):e1421–30.
[43] Santibanez TA, Fiore A, Singleton JA, Centers for Disease Control and Prevention (CDC). Influenza vaccination coverage among children aged 6–23 months – United States, 2007–08 influenza season. Morb Mortal Wkly Rep 2009;58(38):1063–6.
[44] Dempsey AF, Schaffer S, Singer D, Butchart A, Davis M, Freed GL. Alternative vaccination schedule preferences among parents of young children. Pediatrics 2011;128(5):848–56.