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# Factors associated with non-vaccination among nomadic pastoralists and under-vaccination among settled pastoralists in Lagdera, Kenya

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Global Epidemiology

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By

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B.S., University of Notre Dame, 2013

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# Abstract


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**Introduction:** Despite vaccines being widely accepted as one of the most cost-effective and successful public health interventions to prevent child death, the World Health Organization estimates that 1.5 million deaths among children under 5 years annually are due to vaccine-preventable diseases. For a country like Kenya, with a national under-5 mortality rate of 49 per 1,000 births, vaccination marks a key opportunity to improve early childhood survival. Settled and nomadic pastoralists are two groups within Kenya that are historically underserved and improving vaccination services to these groups is of critical public health importance.

**Methods:** A cross-sectional interview survey was conducted among households in settled and nomadic pastoralist settlements in Lagdera sub-district of Garissa Country, Kenya. 235 settled mothers, representing 354 children under five years, and 302 nomadic mothers, representing 405 children under five years, were included in this survey. Multivariate logistic regression was used to assess the association of various factors to receipt of at least one vaccination among nomadic pastoralists and age- appropriate vaccination among settled pastoralists.

**Results:** Only 41% (95% CI 21-36) of nomadic children surveyed had ever received a vaccination, while 36% (95% CI 29-44) of settled children had either incomplete vaccination for age or no vaccination. The main factors associated with partial vaccination among nomads were maternal phone ownership, positive maternal views of vaccine safety, and maternal knowledge of past campaign. For settled children, the main factors associated with age-appropriate vaccination were possession of a vaccination card and positive view of vaccine importance.

**Conclusion:** The findings of this study indicate that nomadic and settled pastoralists face meaningfully different obstacles in securing childhood vaccinations. For both groups, physical distance to vaccination sites alone does not fully explain vaccination outcomes. These groups both require tailored vaccination programs that account for their unique barriers in order to achieve basic levels of vaccination coverage.

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**Table of Contents**

## **Chapter I:** Background/Literature Review

*Pastoralism*

Pastoralism is broadly defined by the use of extensive grazing areas for the production of livestock and is the major economic activity in arid and semi-arid lands (ASAL) of the globe (1). There are approximately 20 million pastoralists in the Horn of Africa alone (2). Despite these significant numbers and important economic productivity in challenging environments, pastoralists suffer from strong biases, political marginalization, and false narratives (3). These negative perceptions often equate pastoralism with poverty, economic inefficiency, violence and a failure to adapt to modern developments. While pastoralists are often omitted form formal policy documents, one exception is the 2010 African Union's Policy Framework for Pastoralism in Africa, which calls to dispel these long held myths about pastoralism and instead work to adapt basic services to this livelihood (4). This policy framework recognizes the significant economic activity, estimated at over $1 billion annually in livestock trade alone, which occurs in some of the most inhospitable regions of the world. A key difference between false and informed narratives about pastoralists is that those who understand pastoralism recognize this livelihood is actually highly responsive to market demands and environmental changes, but ASAL severely limit the range of sustainable economic activities (3).

Pastoralism is not one uniform way of life, but instead an array of related lifestyles centered on livestock production. Pastoralists may have many or few animals, different species of animals, different levels of engagement with markets, and different opportunities to achieve livelihood diversification (3). The most common differentiator among pastoralists is the degree of movement associated with livestock rearing and this ranges from highly nomadic

to fully settled pastoralists (1). Pure nomads move in irregular patterns in search of pasture resources that vary from year to year. Settled pastoralists, on the other hand, maintain permanent residences and often supplement their livestock production with crop production and may or may not be more closely involved in market activities. Although livestock are still highly valued property, settled pastoralists tend to have smaller herds on average than other pastoralist types. Between settled pastoralism and nomadism is transhumance, which is the regular movement of herds between fixed points in response to seasonal fluctuations in pasture resources. The differences between these forms of pastoralists are meaningful, but even these categories are a simplification. Pastoral mobility must be seen on a continuum from highly mobile nomadism to permanently settled households, where individuals can move from one lifestyle to another in response to pressures or opportunities (5).

The form of pastoralism that a particular community or household practices substantially impacts the social, health and economic dynamics of that group. A series of studies in northern Kenya looked at five different pastoralist communities, including both nomadic and settled groups, and found that settled communities suffered greater short-term and long-term malnutrition as well as a greater incidence of diarrheal and respiratory illness when compared to nomadic communities (6, 7). The differences in nutrition were attributed to protein deficiencies among the settled communities due to the decreased milk consumption and increased reliance on grain (6, 7). And while all the pastoralists suffered from a high burden of malaria, the settled communities had greater access to clinics and health services, which led to reduced mortality from the condition. Due to meaningful differences like these between different pastoral groups, programs must be tailored to properly align with the specific needs and considerations of a given pastoralist community. A program aimed at reducing childhood diarrheal and respiratory diseases might have a relatively limited impact

among a nomadic pastoralists group, while being hugely impactful in their settled pastoralists neighbors living within the same geographic area.

As a result of their geographic isolation and political marginalization, pastoralist communities often suffer from a lack of basic services and a significant delay in new policy initiatives in their areas (8). In general, pastoralist areas have far fewer basic services such as education, electricity, and healthcare when compared to non-pastoralists regions (2). The per capita cost of almost all service provision in pastoralist areas is higher as a direct result of the low population density and remoteness of these regions, which makes any service provision difficult even under ideal political circumstances (3). The provision of educational services to Kenyan pastoralists is an illustrative example of the challenges faced in the expansion of basic services to pastoralists. To understand the context, two key points must be recognized. First, demand for education among Kenya pastoralists is rapidly increasing and second, previous education programs for pastoralists have been based on a simple adaptation of sedentary models and have failed to reach enrollment and educational outcome goals (9). A major reason these programs have been ineffective is because their design forces pastoralists to decide either to enroll their children in traditional formal classroom education, most commonly in boarding schools, or to keep their children at home where they can assist in herding and learn informal lessons about their own culture, society, and economy. In a sense, the choice has been between pastoralism *or* education. As a result, these programs are by definition incompatible with pastoralist society, so low uptake and weak educational outcomes among pastoralists could have been predicted. Historically, however, policymakers and non-pastoralists blame this poor performance on a lack of pastoralist demand and used these results to justify not expanding services to pastoralists. This is a gross mischaracterization since pastoralists reject the mode of delivery, not the product.

However, the Ministry of Education and the Ministry of Northern Kenya recently proposed a new National Commission on Nomadic Education in Kenya to adapt educational programs to fit within pastoral society and allow for distance learning outside of the traditional classroom. This innovative program will use radio broadcasts to reach pastoralists; children and mobile field staff to periodically check in with students and conduct program monitoring and evaluation. Evidence supports this change in approach, as the rare examples where educational programs for pastoralists have succeeded are characterized by their sympathy and support of pastoralism (10). This alternative approach in Kenya has the opportunity to do just that and fundamentally shift the way education is provided to pastoralists.

*Health care access and utilization among pastoralists*

While some studies have found rates of health care utilization and health knowledge to be extremely low among nomadic and settled pastoralists (11, 12), there is considerable inconsistency in the operational definition used for these groups and a general lack of research that carefully separates the many forms of pastoralism (13). Although the health disparities of pastoralists have been widely acknowledged, previous efforts to expand services to pastoralists more broadly, and nomadic pastoralists in particular, have proved to be more costly than equivalent programs for non-pastoralists groups and occasionally quite ineffective (14, 15). Effective efforts to increase health service utilization among pastoralists have often either not been sustained or not expanded to other countries and regions (16, 17). Such constraints to real health care access impact pastoralists with a high burden of vaccine preventable diseases (VPD) among other conditions (18).

Health care access among pastoralist groups is often framed as an issue of geographic distance and physical barriers. However, evidence suggests that social, economic and cultural barriers play an important role in health care access for pastoralists as well and that proximity to a health facility or a sedentary lifestyle is not always enough to overcome these non-physical barriers (19). The critical implication of this conclusion is that dealing only with issues of mobility and distance will not necessarily result in improved access, as evident in pastoralist education programs mentioned previously. Health programs that have been designed with pastoralism dynamics in mind, such as combined human and animal vaccinations, have seen lower costs, higher utilization, and positive perception among the target community (16). Also, programs that have high community engagement and allow for community adaptation have been shown to be highly successful among pastoralists, even when the pastoralists themselves must commit significant time and resources to the project (20, 21). Overall, the evidence suggests that the expansion of health care access to pastoralist communities must take a multidisciplinary approach and be sensitive to the values and priorities of these communities, but if these steps are taken, meaningful access is possible.

*Vaccination*

Despite vaccines being widely accepted as one of the most cost effective and successful public health interventions to prevent child death, the World Health Organization (WHO) estimates that 1.5 million deaths among children under 5 years annually are due to vaccine preventable diseases, representing about 17% of the global under-5 mortality (22). For a country like Kenya, with a national under-5 mortality rate of 49 per 1,000 births, vaccination marks a key opportunity to improve early childhood survival (23). Although the WHO estimates 89% of eligible children in Kenya have received three doses of diphtheria,

pertussis, and tetanus vaccine (DPT3), only 35% of districts in Kenya report DPT3 coverage above 80% (24). This discordance between national and district level vaccination coverage reveals an intense non-uniform distribution of both population and vaccination services, which leaves underrepresented populations, such as pastoralist communities, particularly vulnerable.

Children must overcome two distinct steps to be fully protected from VPD. First, they must receive their first dose of a given vaccine, then they must receive all subsequent doses in accordance with the Kenya Expanded Program on Immunization's (KEPI) recommended schedule. Based on how many of these steps they have completed, all children fall into one of three categories: unvaccinated, partially vaccinated, or up-to-date for age. Previously, four broad explanatory themes have been identified as reasons for unvaccinated and partially vaccinated children: immunization system factors, communication and information, family characteristics, and parental attitudes and knowledge (25). Although these themes are imperfect and some factors do not fit perfectly into a single category, they are useful categorizations from a program recommendations perspective. While non-vaccination and under-vaccination do share some common associations, there are considerable and meaningful differences as well, which may require separate programmatic interventions (26). A review of over 200 peer-reviewed papers found that non-vaccination is more commonly associated with factors related to parental attitudes and knowledge while under-vaccination is more closely connected to immunization system factors (26). However, this research did not differentiate between the settings of these studies or the populations being considered. This is particularly of interest since analysis of survey data from 95 countries found that the factors associated with non-vaccination and under-vaccination were highly country dependent and meaningful overall trends were difficult to identify (27). Reviews of grey

literature also found high variation between countries (28). Far more studies have looked at partial vaccination compared to non-vaccination, which indicates a need to better understand the factors associated with non-vaccination. The research gap on unvaccinated children is especially relevant in groups that have consistently had low rates of any vaccination, such as pastoralist communities.

## Chapter II: Manuscript

# Factors associated with non-vaccination among nomadic pastoralists and under-vaccination among settled pastoralists in Lagdera, Kenya

**Michael R. Diaz**


## Abstract

**Introduction:** Despite vaccines being widely accepted as one of the most cost-effective and successful public health interventions to prevent child death, the World Health Organization estimates that 1.5 million deaths among children under 5 years annually are due to vaccine-preventable diseases. For a country like Kenya, with a national under-5 mortality rate of 49 per 1,000 births, vaccination marks a key opportunity to improve early childhood survival. Settled and nomadic pastoralists are two groups within Kenya that are historically underserved and improving vaccination services to these groups is of critical public health importance.

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Despite vaccines being widely accepted as one of the most cost-effective and successful public health interventions to prevent child death, the World Health Organization (WHO) estimates that 1.5 million deaths among children under 5 years annually are due to vaccine-preventable diseases, representing about 17% of the global under-5 mortality (22). For a country like Kenya, with a national under-5 mortality rate of 49 per 1,000 births, vaccination marks a key opportunity to improve early childhood survival (23). Although the WHO estimates 89% of eligible children in Kenya have received three doses of diphtheria, pertussis, and tetanus vaccine (DPT3), only 35% of districts in Kenya report DPT3 coverage above 80% (24). This discordance between national and district level vaccination coverage reveals an intense non-uniform distribution of both population and vaccination services, which leaves underrepresented populations, such as pastoralist communities, particularly vulnerable.

There are approximately 20 million pastoralists in the Horn of Africa and pastoralism is the primary livelihood for a majority of the people living in the arid or semi-arid regions of northern Kenya (29-31). Kenyan pastoralists can be further described as nomadic pastoralists and settled pastoralists, which must be viewed as related, but distinct groups. Nomadic pastoralism is defined by the periodic migration in pursuit of scarce resources, predominantly pasture and water, for both livestock and humans with no permanent residence (20). Settled pastoralism, on the other hand, still rely on livestock for the majority of their livelihood, but have a defined year-round residence and often have a highly diversified livelihoods not solely reliant on livestock (30). The form of pastoralism a particular community or household practices substantially impacts the social, health and

economic dynamics of that group (6, 7). Due to these differences, programs must be tailored to properly align with the specific needs and considerations of a given pastoralist community.

While some studies have found rates of health care utilization and health knowledge to be extremely low among nomadic and settled pastoralists (11, 12), there is considerable inconsistency in the operational definition used for these groups and a general lack of research that carefully separates these two livelihoods (13). Although the health disparities of pastoralists have been widely acknowledged, previous efforts to expand services to pastoralists more broadly, and nomadic pastoralists in particular, have proved to be more costly than equivalent programs for non-pastoralists groups and occasionally quite ineffective (14, 15). Effective efforts to increase health service utilization among pastoralists have often either not been sustained or not expanded to other countries and regions (16, 17). Such constraints to real health care access, impact pastoralists with a high burden of vaccine preventable diseases (VPD) among other conditions (18).

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category, they are useful categorizations from a program recommendations perspective. While non-vaccination and under-vaccination do share some common associations, there are considerable and meaningful differences as well, which may require separate programmatic interventions (26).

## Methods

### *Study Design*

A cross-sectional interview survey was conducted among households in settled and nomadic pastoralist settlements. The sampling frames for both groups were developed from the most up-to-date polio micro plans and were validated using key informant interviews. The final sampling frame included 148 seasonal temporary (nomadic) locations and 135 settled villages. Settled clusters were selected using probability proportional to estimated size sampling and temporary settlements were sampled using a simple random sample with replacement for clusters that were uninhabited due to the season. Temporary settlements were not selected using probability proportional to estimated size because an estimated population size for the nomadic pastoralists was unavailable. Instead, a random walk methodology was used to select temporary households. For both settled and temporary settlements, 25 clusters with 12 households per cluster were included in the survey focused on demographic characteristics, economic indicators, maternal knowledge attitudes and practices regarding vaccination and vaccine preventable diseases, and the vaccination status of all biological children under 5 years of age.

### *Study Population*

This study was conducted in Lagdera sub-district of Garissa County in Northeastern Kenya in February, 2015. Lagdera is a large arid region of 8,390 $km^2$ primarily inhabited by

pastoralists with a population of 92,636 in the 2009 national census. Both settled and nomadic pastoralist mothers with children between the ages of 0-59 months were included in this study. In order to be eligible for enrolment in this study, mothers had to live in Lagdera, raise animals, have at least one child between the ages of 0-59 months and provide informed consent.

*Study Procedure*

Trained data collectors administered the survey using an Open Data Kit (ODK) application on an android tablet, which also recorded GPS locations of each household. The geospatial coordinates of markets and health facilities providing vaccination services in the area were collected separately. The ODK application was preprogramed with skip patterns based on respondent's answer choices and allowed for real-time and retrospective data quality checks. Thus the respondents' answers determined the number of questions answered; the maximum number of questions would have been 120 if a mother reported for three children. Vaccination cards were used when available to determine vaccination status, and maternal recall was used as a substitute when cards were not available.

*Outcomes of Interest*

Previous analysis of these populations revealed a substantial number of completely unvaccinated nomadic pastoralists and relatively few unvaccinated settled pastoralists [1]. For this reason, each type of pastoralists had a different outcome of interest to account for their meaningful differences in vaccination coverage. The outcome of interest for nomadic pastoralists was receipt of one or more vaccinations and this analysis can help to determine opportunities to reduce non-vaccination among nomadic pastoralists. For the settled pastoralists, the outcome of interest was full vaccination for age in accordance with the

Kenya Expanded Program on Immunization schedule. This outcome can help to determine opportunities to reduce under-vaccination among settled pastoralists.

*Variable Designation*

The explanatory variables considered were divided into four categories (1) immunization system factors (2) communication and information (3) family characteristics and (4) parental attitudes and knowledge. Maternal age, child age, mobile phone ownership, maternal Islamic education, number of biological siblings under 5 years, birth order among children under 5 years, presence of co-wives, and wealth index were considered under family characteristic. Each household estimated the number of cattle, donkey, sheep, goat, camel, and fowl (chicken and ducks) owned at the time of the survey. We conducted a principal components analysis and created a wealth score from the factor weights of the first principal component. This wealth index score was then divided into wealth quintiles. Principal components analysis is commonly used to construct wealth indices from asset ownership, and previous studies have included animal ownership in these analyses [2].

For the parental attitudes and knowledge category, maternal knowledge of polio symptoms (those who identified at least some symptoms versus none), maternal knowledge of the age of first measles vaccination, maternal views of vaccine safety, and maternal view of the importance of vaccines were considered. To quantify the relationship between the immunization system and the receipt of vaccination, Euclidean distance to the nearest health facility offering vaccination, maternal receipt of tetanus toxoid vaccine and past animal vaccination were included in the analysis. Euclidean distance to nearest vaccination health facility was calculated using QGIS version 2.14.3 with the household and health facility coordinates collected at the time of the survey. It is important to note that for nomadic

households this measure only captures the distance to the nearest health facility and this distance is likely to fluctuate significantly throughout the year. Households were categorized based on the median distance to the nearest health facility within their pastoralist group. Among the settled pastoralists, possession of a vaccination card was also considered, but could not be assessed in nomadic because not having a vaccination card was perfectly correlated with non-vaccination. Finally, knowledge of the 2014 polio vaccination campaign in the area and maternal perceptions of treatment by health staff were included to understand the impact of communication and information on vaccination.

*Data Analysis*

Institutional review board (IRB) exemption was obtained through Emory University IRB. Data were analyzed using Statistical Analysis Software (32) version 9.4. The data were cleaned, outliers and extreme values identified and data entry errors flagged and removed from the analysis, if appropriate. Univariate summary statistics were produced for all included variables to identify distributions and assess preliminary data trends. Subsequently, all variables of interest were analyzed to determine the bivariate associations with the outcome of interest using a multilevel logistic regression to control for clustering at both the village and household level. Odds ratios with 95% confidence intervals were used to assess associations with the outcome of interest. Variables that appear to be at least marginally associated with the outcome of interest were included in a multivariate logistic regression model, again controlling for both village and household level clustering. Separate bivariate and multivariate models were constructed for nomadic and settled pastoralists due to the sampling design of the survey.

**Results**

A total of 275 settled and 302 nomadic households were approached for inclusion in this study, of which 17 did not provide informed consent and 62 either did not have children under five years or did not raise animals (Figure 1). This left a total of 235 settled pastoralists and 263 nomadic pastoralists households that were included in the survey. Among the 263 nomadic mothers surveyed, the vast majority were married (98%) and received no government education (99%) (Table 1). A majority of mothers were between 20 years and 39 years old and a majority had at least some Islamic education (65%). These mothers reported a total of 405 biological children under 5 years with slightly more males (52%) than females. The median distance to the nearest health facility was almost 13km for nomadic households.

Settled pastoralists mothers shared similar basic demographic information with their nomadic counterparts, with comparable rates of marriage, age distribution and very low overall rates of government education. It is important to note that settled mothers had higher rates of Islamic education (82%). The 235 settled mothers reported 354 biological children under 5 years and more male offspring (57%) than female. For number of children, the majority of both settled (63%) and nomadic (66%) households had only one child. Far more settled mothers had received tetanus toxoid vaccination during pregnancy (83%) compared to nomadic mothers (37%). Settled households, on average, lived much closer to vaccination health facilities with a median distance of just under 1km.

For the outcome of interest among the nomadic pastoralists group, 59% (95% CI 48-70) were never vaccinated, and 41% (95% CI 21-36) had received at least one vaccination. As past results from these populations suggested (33), the settled pastoralists had a substantially

different distribution. In this group, 63.8% (95% CI 56.2-70.8) were up-to-date for their age, and 36.2% (95% CI 29.2-43.8) had either incomplete vaccination for age or no vaccination.

The bivariate association of nomadic family characteristics, maternal attitudes and knowledge, immunization system, and community and information factors with partial vaccination found noteworthy association among all four categories of factors (Table 2). Maternal phone and radio ownership, Islamic education, disease knowledge, history of tetanus vaccination, and awareness of past campaigns were among the strongest associated factors with partial vaccination. Older mothers and those without opinions on health staff were strong negative indicators of partial vaccination. Other family demographic features such as birth order, family wealth quintile, number of siblings and the presence of co-wives did not appear to have a meaningful relationship with the outcome of interest. Children whose mothers reported that vaccines were "somewhat" or "very" important were 15.20 times more likely to have received at least one vaccination compared to children whose mothers reported that vaccines were "not very" important or did not have an opinion about vaccinations (cOR 15.20; 95%CI 5.89-39.19). Proximity to health facility did appear to have a slight impact on receipt of vaccination as well with those living under the median distance being 1.93 times more likely to have received at least one vaccination (cOR 1.93 95%CI 0.82-4.54). Special attention must be paid to maternal views of vaccine safety due to high estimates of association with the outcome and wide confidence intervals as a results of small cell counts. These estimates strongly suggest a positive association between viewing vaccines as "somewhat safe", "safe" or "very sage" and receipt of vaccine. However, the very wide confidence intervals make it difficult to make any conclusive statement about the exact magnitude of association.

Among settled pastoralists, many of the factors associated with receipt of at least one vaccination among nomadic pastoralists were also associated with complete vaccination for age among settled pastoralists, namely: Islamic education, polio symptom knowledge, history of tetanus vaccination, and awareness of past campaigns (Table 3). However, mobile phone ownership and maternal age did not show meaningful associations with complete vaccination, which was seen for partial vaccination in nomadic households. Again, positive maternal view of vaccination showed the largest crude association with the outcome of interest. Children whose mothers reported that vaccines were "somewhat" or "very" important were 9.32 times more likely to have received all recommended vaccinations for their age compared to children whose mothers reported that vaccines were "not very" important or did not have an opinion about vaccinations (cOR 9.32; 95%CI 2.57-33.76). Although maternal views of vaccine safety were considered, the association with the outcome could not be considered due to a lack of variation in responses.

The multivariate logistic regression model for nomadic pastoralists found a meaningful relationship between maternal phone ownership, positive maternal views of vaccine safety, and maternal knowledge of past campaigns and the outcome of one or more vaccinations. Distance to health facility, history of tetanus vaccination, and positive maternal views about vaccination also appeared to be at least marginally associated with childhood vaccination. In addition, not having an opinion about health staff was strongly negatively associated with vaccination, while other sentiments did not show clear relationships. Of note, both polio disease and measles vaccination schedule knowledge went from strong positive association in the crude analysis to null associations in the adjusted estimate. Radio ownership also showed no meaningful relationship in the adjusted estimate of association. Again, interpretation of the exact magnitude of association for maternal views of vaccine safety is

difficult due to the high estimates of association with the outcome and wide confidence intervals as a results of small cell counts.

For age-to-date vaccination among settled pastoralists, the multivariate logistic regression analysis showed strong associations with possession of a vaccination card and positive view of vaccine importance as well as moderate associations with history of tetanus vaccination and maternal knowledge of measles vaccination schedule (Table 5). While possession of a vaccination card was associated with our outcome, it is also possible that mothers of children without cards may have underreported total vaccination, which would also lead to the observed association. Other factors such as distance to health facility, awareness of past campaigns, and polio disease knowledge show no meaningful relationship. Older children tended to be more associated with age-to-date vaccination, while those who were first born were generally more vaccinated than those who were third born. Only those who reported "always" being treated nice by health staff showed an increased association with age-to-date vaccination.

**Discussion**

The findings of this study indicate that nomadic and settled pastoralists face meaningfully different obstacles in securing childhood vaccinations. The strongest evidence of these differences is the overall estimates of partial and age-appropriate vaccination among these two groups. Substantial efforts must be made to address non-vaccination among nomadic pastoralists in order to catch them up to their settled pastoralist neighbors, while those settled pastoralists also need focused programs to increase age-appropriate vaccination.

*Partial Vaccination among Nomadic Pastoralists*

Negative attitudes and a lack of knowledge about vaccines have previously been flagged as a potential driver for non-vaccination (26), however, our results suggest views on vaccine safety may have the strongest impact on vaccine receipt and other attitudes and knowledge factors may play a secondary role among this study population. Programmatically, this would indicate that vaccine safety must be given special attention among outreach campaigns to nomadic communities.

Although animal wealth was not associated with the outcome, mobile phone ownership maintained a strong association with partial vaccination even after controlling for other factors. This is especially interesting because radio ownership did not maintain a strong association after controlling for other factors, which suggests mobile phone ownership may not just be an indicator of asset ownership. This result has important implications for innovation. Mobile phones have long been viewed as a useful tool in expanding health services among hard to reach population in low resource settings (34). Mobile phone ownership in Kenya has already been shown to be highly heterogeneous and non-randomly distributed, especially among rural communities (35), and our results show that, among nomadic pastoralists, phone ownership is already associated with health care utilization. For these reasons, programs aimed at increasing health care utilization among nomadic pastoralists by using existing phone ownership may only engage those already more likely to use health services.

Finally, these results suggest that reported contact with the vaccination system, in any manner, appears to be associated with vaccination. Knowledge of past polio campaigns is one of the strongest indicators of vaccination and having "no opinion" about health staff

shows an overall slightly negative association with vaccination. If contact with the vaccination system occurred randomly and physical distance were the main barrier to the uptake of health services, we would expect those living closer to health facilities and older children to have more vaccination than the young and far away. However, the results do not support this theory. Distance to the nearest health facility offering vaccination is not one of the strongest associated factors with vaccination and age is not consistently associated with vaccination among this group. These results together suggest that physical distance alone does not explain the low rates of vaccination among nomadic pastoralists. Greater consideration must be paid to the social, cultural and economic barriers that appear to also play a role, as previous research has suggested (19). Outreach to previously unreached nomadic pastoralists is critical, but that this outreach must be focused on more than just physical access and distance.

*Age-Appropriate Vaccination among Settled Pastoralists*

The overall greater access and utilization of health services, as indicated by vaccination coverage, among settled compared to nomadic pastoralists is consistent with previous results (7). While knowledge of polio symptoms did not associate with the outcome of interest, knowledge of the measles vaccination schedule did show a marginal association. This result suggests that not all knowledge leads to complete vaccination and that programs designed to encourage childhood vaccination need to carefully consider the content provided to parents.

Distance to the nearest health facility offering vaccination showed almost no meaningful association with age-appropriate vaccination, which contradicts the common narrative about pastoralists and access to health services (3, 13). In general, it appears competing priorities may be a major factor in under-vaccination, as suggested by the strong positive association

of age-appropriate vaccination with maternal views of vaccine importance and the negative association of age-appropriate vaccination with birth order. Vaccination programs need to take this into consideration and design programs that reduce conflict between vaccination and other responsibilities.

Unlike partial vaccination among nomadic pastoralists, it appears contact with the vaccination system is not strongly associated with age-appropriate vaccination and instead positive interactions are valuable. This is supported by the lack of association with knowledge of the previous polio campaign and the presence of an association between positive view of health staff and the outcome.

*Strengths and Limitations*

This study provides valuable and actionable information about critically underserved and misunderstood communities. These pastoralist communities are particularly vulnerable to vaccine-preventable diseases due to their low vaccination coverage and mark a distinct threat to global elimination and eradication efforts. Part of the reason these groups are misunderstood is that pastoralist communities are inherently difficult to study due to the remote and low-population density areas in which they live and their mobility. These challenges may introduce selection bias into survey sampling and reduce how representative study participants are of the broad population. This is particularly relevant in this analysis as accurate sampling weights could not be calculated for these observations because exact population counts were unavailable. As a result, these samples are treated as self-weighting. However, this study reduced these biases by independently sampling nomadic and settled pastoralists and working with community members to expand the sampling frame as much as possible. And while there are concerns related to the generalizability of these results to the

broader populations being studied, these results provide an initial indication of associations in these populations, which can be refined and strengthened moving forward. In addition, as this is a cross-sectional study, we are unable to assess temporality of exposures or make conclusions regarding overall causality. Despite these limitations, the approach of this study provides valuable information due to the dearth of information on these populations and the necessity for evidence to inform program activities.

*Conclusions*

Based on the results of this cross-sectional survey of nomadic and settled pastoralists, several programmatic steps can be taken to increase childhood vaccination among these groups. Separate and additional efforts must be made to specifically target nomadic pastoralists for vaccination as they have far lower estimates of vaccine coverage. For both groups, physical distance to vaccination sites does not fully explain the variations seen in vaccination outcomes. Among nomadic pastoralists, a complex array of factors appear to influence initial vaccination, but self-reported previous contact with vaccination services may be the best indicator of vaccine receipt. For settled pastoralists, under-vaccination may be most related to competing priorities. Efforts to reach pastoralists communities should consider these results and differences to better enable vaccine uptake among these underserved communities.

**References**


1. Blench, R., *'You Can't Go Home Again': Pastoralism in the New Millennium*. 2001: Overseas Development Institute London.
2. Humanitarian Policy Group, *Pastoralism demographics, settlement and service provision in the Horn and East Africa Transformation and opportunities*. 2010.
3. Catley, A., J. Lind, and I. Scoones, *Pastoralism and development in Africa: dynamic change at the margins*. 2013: Routledge.
4. African Union, *Policy Framework for Pastoralism in Africa*, D.o.R.E.a. Agriculture, Editor. 2010.
5. Spencer, P., *The pastoral continuum: The marginalization of tradition in East Africa*. 1998: Clarendon Press.
6. Fratkin, E. and E.A. Roth, *As pastoralists settle: social, health, and economic consequences of the pastoral sedentarization in Marsabit District, Kenya*. Vol. 1. 2006: Springer Science & Business Media.
7. Nathan, M.A., et al., *Health and Morbidity among Rendille Pastoralist Children*, in *As Pastoralists Settle*. 2005, Springer. p. 193-208.
8. Devereux, S. and K. Tibbo, *Social protection for pastoralists*. Pastoralism and Development in Africa: Dynamic Change at the Margins, 2013: p. 215.
9. Siele, D., J. Swift, and S. Krätli, *Reaching Pastoralists With Formal Education*, in *Pastoralism and development in Africa: Dynamic change at the margins*. 2012. p. 206-214.
10. Krätli, S., *Education provision to nomadic pastoralists*. 2001: Institute of Development Studies (IDS).
11. El-Shiekh, B. and A.v.d. Kwaak, *Factors influencing the utilization of maternal health care services by nomads in Sudan*. Pastoralism: Research, Policy and Practice, 2015. **5**(23).
12. Bezunesh, D., et al., *Knowledge of mothers on poliomyelitis and other vaccine preventable diseases and vaccination status of children in pastoralist and semi-pastoralist areas of Ethiopia. (Special issue on contributing towards polio eradication in Ethiopia.)*. Ethiopian Medical Journal, 2013. **51**(Suppl. 1): p. 59-66.
13. Omar, M.A., *Health care for nomads too, please*. World Health Forum, 1992. **13**(4): p. 307-10.
14. Imperato, P.J., *Nomads of the West African sahel and the delivery of health services to them*. Social Science & Medicine, 1974. **8**(8): p. 443-57.
15. Aliou, S., *What health system for nomadic populations?* World Health Forum, 1992. **13**(4): p. 311-4.
16. Schelling, E., et al., *Human and animal vaccination delivery to remote nomadic families, Chad*. Emerging Infectious Diseases, 2007. **13**(3): p. 373-9.
17. Ndiaye, S.M., et al., *Polio outbreak among nomads in Chad: outbreak response and lessons learned. (Special Issue: The final phase of polio eradication and endgame strategies for the post-eradication era.)*. Journal of Infectious Diseases, 2014. **210**(Suppl. 1): p. S74-S84.
18. Zinsstag, J., M. Ould Taleb, and P.S. Craig, *Editorial: health of nomadic pastoralists: new approaches towards equity effectiveness*. Trop Med Int Health, 2006. **11**(5): p. 565-8.
19. Hampshire, K., *Networks of nomads: negotiating access to health resources among pastoralist women in Chad*. Social Science & Medicine, 2002. **54**(7): p. 1025-37.
20. Sheik-Mohamed, A. and J.P. Velema, *Where health care has no access: the nomadic populations of sub-Saharan Africa*. Tropical Medicine & International Health, 1999. **4**(10): p. 695-707.

21. Akogun, O.B., et al., *Nomadic Fulani communities manage malaria on the move.* International Health, 2012. **4**(1): p. 10-9.
22. World Health Organization. *Immunization surveillance, assessment and monitoring.* Vaccine-preventable diseases 2017 [cited 2017 February 20]; Available from: http://apps.who.int/immunization_monitoring/diseases/en/.
23. UN Inter-agency Group for Child Mortality Estimation, *Child Mortality Estimates.* 2015.
24. World Health Organization, *WHO vaccine-preventable diseases: monitoring system. 2016 global summary*. 2016.
25. Hadler, S., et al., *Immunization in developing countries.* Vaccines. 5th ed. Philadelphia: Saunders Elsevier, 2008: p. 1541-1571.
26. Rainey, J.J., et al., *Reasons related to non-vaccination and under-vaccination of children in low and middle income countries: findings from a systematic review of the published literature, 1999-2009.* Vaccine, 2011. **29**(46): p. 8215-21.
27. Bosch-Capblanch, X. *Assessment of determinants of unreached children in immunization, analyses of surveys data.* 2009. SAGE meeting (Geneva). Geneva, Switzerland: WHO.
28. Favin, M., et al., *Why children are not vaccinated: a review of the grey literature.* International Health, 2012. **4**(4): p. 229-238.
29. MINISTRY OF PUBLIC HEALTH AND SANITATION, *COMPREHENSIVE MULTI YEAR PLAN 2013-2017* 2013.
30. Schrepfer, N. and M. Caterina, *On the Margin: Kenya's Pastoralists–From displacement to solutions, a conceptual study on the internal displacement of pastoralists.* Internal Displacement Monitoring Centre: Geneva Switzerland. ht tp://www. internal-displacement. org/assets/publications/2014/201403-af-kenya-on-the-margin-en2. pdf, 2014.
31. Ginetti, J. and T. Franck, *Assessing drought displacement risk for Kenyan, Ethiopian and Somali pastoralists-Technical Paper.* Genève: Internal Displacement Monitoring Centre and Norwegian Refugee Council). Disponible à l'adresse: http://www. internaldisplacement. org/publications/2014/assessing-drought-displacement-risk-for-kenyanethiopian-and-somali-pastoralists, consulté le, 2014. **20**(05): p. 2014.
32. Adedire, E.B., et al., *Immunisation coverage and its determinants among children aged 12-23 months in Atakumosa-west district, Osun State Nigeria: a cross-sectional study.* BMC Public Health, 2016. **16**(1): p. 905.
33. Unshur, A., G. Kikuvi, and M. Karama, *Determinants of vaccination coverage among pastoralists in north eastern Kenya.* East African Medical Journal, 2016. **93**(8): p. 333-334.
34. United Nations Foundation, *mHealth for development: the opportunity of mobile technology for healthcare in the developing world.* 2009.
35. Wesolowski, A., et al., *Heterogeneous Mobile Phone Ownership and Usage Patterns in Kenya.* PLOS ONE, 2012. **7**(4): p. e35319.

## Tables

| **Table 1**. Description of study household and child characteristics in Lagdera sub-district of Garissa County, Kenya, 2015 | | |
|---|---|---|
| Characteristic | Nomadic N (%) | Settled N (%) |
| **Household Level Variables** | | |
| **Number of Households** | 263 | 235 |
| **Mother's Age** | | |
| >20 | 10 (4) | 5 (2) |
| 20-29 | 108 (41) | 89 (38) |
| 30-39 | 115 (44) | 115 (49) |
| >=40 | 30 (11) | 26 (11) |
| **Mother's Marital Status** | | |
| Married | 259 (98) | 229 (97) |
| Single | 4 (2) | 6 (3) |
| **Mother's Islamic Education** | | |
| No | 92 (35) | 42 (18) |
| Yes | 171 (65) | 193 (82) |
| **Mother's highest level of Government education** | | |
| Lower primary | 1 (<1) | 5 (2) |
| Upper primary or above | 0 | 3 (1) |
| No government education | 401 (99) | 225 (96) |
| *Missing* | *1 (<1)* | *2 (1)* |
| **Maternal tetanus toxin vaccination while pregnant** | | |
| Yes | 151 (37) | 295 (83) |
| No | 248 (61) | 57 (16) |
| Don't Know | 6 (2) | 2 (1) |
| **Median distance to nearest health facility** | 12.76km | .93km |
| **Child Level Variables** | | |
| **Number of Children** | 405 | 354 |
| **Gender** | | |
| Male | 211 (52) | 201 (57) |
| Female | 194 (48) | 152 (43) |
| **Number of biological siblings under 5 years** | | |
| 1 or more | 266 (66) | 224 (63) |
| None | 139 (34) | 130 (37) |

| | | |
|---|---|---|
| **Child's Age** | | |
| 0-5 months | 40 (10) | 44 (12) |
| 6-11 months | 26 (6) | 30 (9) |
| 12-23 months | 77 (19) | 73 (21) |
| 24-59 months | 260 (65) | 206 (58) |

**Table 2**. Bivariate associations of family characteristics, maternal attitudes and knowledge, immunization system, communication and information factors on partial vaccination among nomadic pastoralists in Lagdera sub-district of Garissa County, Kenya, 2015

| | Crude OR | 95% CI | |
|---|---|---|---|
| Characteristic | Nomadic | | |
| **Family Characteristics** | | | |
| **Mother's Age** | | | |
| 20-29 | (Ref.) | | |
| >20 | 0.39 | 0.10 | 1.59 |
| 30-39 | 0.75 | 0.42 | 1.35 |
| >=40 | 0.25 | 0.09 | 0.64 |
| **Child's Age** | | | |
| 0-5 months | (Ref.) | | |
| 6-11 months | 1.22 | 0.48 | 3.13 |
| 12-23 months | 2.10 | 0.61 | 7.17 |
| 24-59 months | 0.75 | 0.33 | 1.69 |
| **Wealth Index**[a] | | | |
| Moderate wealth | (Ref.) | | |
| Poorest | 1.65 | 0.70 | 3.89 |
| Poorer | 0.85 | 0.38 | 1.94 |
| Wealthier | 0.66 | 0.29 | 1.49 |
| Wealthiest | 0.64 | 0.27 | 1.53 |
| **Mother owns radio** | | | |
| No | (Ref.) | | |
| Yes | 2.68 | 1.29 | 5.58 |
| **Mother owns mobile phone** | | | |
| No | (Ref.) | | |
| Yes | 3.88 | 1.98 | 7.57 |
| **Mother's Islamic Education** | | | |
| No | (Ref.) | | |
| Yes | 2.40 | 1.14 | 5.08 |
| **Number of biological siblings under 5 yrs** | | | |
| None | (Ref.) | | |

| | | | |
|---|---|---|---|
| 1 or more | 1.21 | 0.70 | 2.11 |
| **Birth order among biological siblings under 5 yrs** | | | |
| First born | (Ref.) | | |
| Second born | 1.18 | 0.71 | 1.98 |
| Third born | 2.16 | 0.66 | 7.03 |
| **Number of co-wives** | | | |
| 0 | (Ref.) | | |
| 1 or more | 1.12 | 0.48 | 2.62 |
| **Attitudes and Knowledge** | | | |
| **Mother correctly identified some or all polio symptoms** | | | |
| No | (Ref.) | | |
| Yes | 4.20 | 2.28 | 7.72 |
| **Mother correctly identified age of measles vaccination** | | | |
| No | (Ref.) | | |
| Yes | 4.22 | 1.97 | 9.03 |
| **Mother's view of vaccine safety** | | | |
| Not safe | (Ref.) | | |
| Somewhat safe | 27.53 | 3.15 | 240.92 |
| Safe | 107.14 | 12.28 | 934.93 |
| Very Safe | 87.58 | 10.12 | 758.17 |
| **Mother's view of vaccine importance** | | | |
| Don’t know/Not very important | (Ref.) | | |
| Somewhat/very important | 15.20 | 5.89 | 39.19 |
| **Immunization System** | | | |
| **Euclidean distance to health facility offering vaccination** | | | |
| Over 13km | (Ref.) | | |
| Under 13km[b] | 1.93 | 0.82 | 4.54 |
| **Maternal tetanus toxoid vaccine while pregnant** | | | |
| No | (Ref.) | | |
| Yes | 6.13 | 3.44 | 10.90 |
| **Past animal vaccination** | | | |
| No | (Ref.) | | |
| Yes | 0.53 | 0.22 | 1.25 |
| **Communication and Information** | | | |
| **Mother aware of 2014 polio campaign** | | | |
| No | (Ref.) | | |

| | | | |
|---|---|---|---|
| Yes | 9.49 | 4.06 | 22.19 |
| **Treatment by health staff** | | | |
| "They are rude" | (Ref.) | | |
| Don't know/No opinion | 0.09 | 0.02 | 0.46 |
| "They are sometimes nice" | 2.61 | 0.62 | 10.89 |
| "They are always nice" | 2.12 | 0.51 | 8.73 |

[a]Wealth index based on total animal ownership

[b]Median distance among nomadic pastoralists

**Table 3**. Bivariate associations of family characteristics, maternal attitudes and knowledge, immunization system, communication and information factors on age-appropriate vaccination among settled pastoralists in Lagdera sub-district of Garissa County, Kenya, 2015

| | Crude OR | 95% CI | |
|---|---|---|---|
| Characteristic | Settled | | |
| **Family Characteristics** | | | |
| **Mother's Age** | | | |
| 20-29 | (Ref.) | | |
| >20 | 0.36 | 0.04 | 2.91 |
| 30-39 | 1.04 | 0.60 | 1.82 |
| >=40 | 1.83 | 0.70 | 4.81 |
| **Child's Age** | | | |
| 0-5 months | (Ref.) | | |
| 6-11 months | 2.67 | 1.12 | 6.38 |
| 12-23 months | 2.14 | 0.72 | 6.32 |
| 24-59 months | 1.75 | 0.85 | 3.62 |
| **Wealth Index**[a] | | | |
| Moderate wealth | (Ref.) | | |
| Poorest | 0.62 | 0.26 | 1.52 |
| Poorer | 0.69 | 0.28 | 1.66 |
| Wealthier | 0.43 | 0.18 | 1.00 |
| Wealthiest | 1.14 | 0.46 | 2.81 |
| **Mother owns radio** | | | |
| No | (Ref.) | | |
| Yes | 2.36 | 1.30 | 4.28 |
| **Mother owns mobile phone** | | | |
| No | (Ref.) | | |
| Yes | 1.02 | 0.59 | 1.75 |
| **Mother's Islamic Education** | | | |
| No | (Ref.) | | |

| | | | |
|---|---|---|---|
| Yes | 2.05 | 0.98 | 4.29 |
| **Number of biological siblings under 5yrs** | | | |
| None | (Ref.) | | |
| 1 or more | 1.10 | 0.65 | 1.87 |
| **Birth order among biological siblings under 5 yrs** | | | |
| First born | (Ref.) | | |
| Second born | 0.80 | 0.48 | 1.34 |
| Third born | 0.24 | 0.07 | 0.85 |
| **Number of co-wives** | | | |
| 0 | (Ref.) | | |
| 1 or more | 1.75 | 0.73 | 4.21 |
| **Attitudes and Knowledge** | | | |
| **Mother correctly identified some or all polio symptoms** | | | |
| No | (Ref.) | | |
| Yes | 1.84 | 1.08 | 3.16 |
| **Mother correctly identified age of measles vaccination** | | | |
| No | (Ref.) | | |
| Yes | 3.71 | 2.07 | 6.65 |
| **Mother's view of vaccine importance** | | | |
| Don’t know/Not very important | (Ref.) | | |
| Somewhat/very important | 9.32 | 2.57 | 33.76 |
| **Immunization System** | | | |
| **Euclidean distance to health facility offering vaccination** | | | |
| Over .9km | (Ref.) | | |
| Under .9km[b] | 2.01 | 1.11 | 3.64 |
| **Possession of vaccination card** | | | |
| No | (Ref.) | | |
| Yes | 2.84 | 1.62 | 4.98 |
| **Maternal tetanus toxin vaccine while pregnant** | | | |
| No | (Ref.) | | |
| Yes | 2.78 | 1.34 | 5.75 |
| **Past animal vaccination** | | | |
| No | (Ref.) | | |
| Yes | 1.17 | 0.65 | 2.13 |
| **Communication and Information** | | | |
| **Mother aware of 2014 polio campaign** | | | |

| | | | |
|---|---|---|---|
| No | (Ref.) | | |
| Yes | 2.01 | 1.14 | 3.56 |
| **Treatment by health staff** | | | |
| "They are rude" | (Ref.) | | |
| Don't know/No opinion | 0.89 | 0.18 | 4.54 |
| "They are sometimes nice" | 1.93 | 0.49 | 7.71 |
| "They are always nice" | 3.83 | 1.06 | 13.81 |
| [a]Wealth index based on total animal ownership | | | |
| [b]Median distance among settled pastoralists | | | |

**Table 4**. Multivariate associations of family characteristics, maternal attitudes and knowledge, immunization system, communication and information factors on partial vaccination among nomadic pastoralists in Lagdera sub-district of Garissa County, Kenya, 2015

| | aOR* | 95% CI | |
|---|---|---|---|
| Characteristic | Nomadic | | |
| **Family Characteristics** | | | |
| **Mother's Age** | | | |
| 20-29 | (Ref.) | | |
| >20 | 0.25 | 0.04 | 1.52 |
| 30-39 | 1.24 | 0.57 | 2.71 |
| >=40 | 0.46 | 0.15 | 1.44 |
| **Child's Age** | | | |
| 0-5 months | (Ref.) | | |
| 6-11 months | 1.05 | 0.34 | 3.26 |
| 12-23 months | 3.14 | 0.75 | 13.12 |
| 24-59 months | 0.82 | 0.30 | 2.24 |
| **Mother owns radio** | | | |
| No | (Ref.) | | |
| Yes | 1.77 | 0.71 | 4.45 |
| **Mother owns mobile phone** | | | |
| No | (Ref.) | | |
| Yes | 3.18 | 1.30 | 7.74 |
| **Mother's Islamic Education** | | | |
| No | (Ref.) | | |
| Yes | 0.51 | 0.19 | 1.39 |
| **Attitudes and Knowledge** | | | |
| **Mother correctly identified some or all polio symptoms** | | | |
| No | (Ref.) | | |

| | | | |
|---|---|---|---|
| Yes | 0.80 | 0.35 | 1.82 |
| **Mother correctly identified age of measles vaccination** | | | |
| No | (Ref.) | | |
| Yes | 0.81 | 0.29 | 2.25 |
| **Mother's view of vaccine safety** | | | |
| Not safe | (Ref.) | | |
| Somewhat safe | 10.94 | 0.72 | 165.51 |
| Safe | 31.52 | 1.91 | 519.62 |
| Very Safe | 27.94 | 1.89 | 412.92 |
| **Mother's view of vaccine importance** | | | |
| Don’t know/Not very important | (Ref.) | | |
| Somewhat/very important | 1.86 | 0.45 | 7.66 |
| **Immunization System** | | | |
| **Euclidean distance to health facility offering vaccination** | | | |
| Over 13km | (Ref.) | | |
| Under 13km[b] | 2.43 | 0.91 | 6.48 |
| **Maternal tetanus toxin vaccine while pregnant** | | | |
| No | (Ref.) | | |
| Yes | 1.94 | 0.90 | 4.18 |
| **Communication and Information** | | | |
| **Mother aware of 2014 polio campaign** | | | |
| No | (Ref.) | | |
| Yes | 6.23 | 1.95 | 19.96 |
| **Treatment by health staff** | | | |
| "They are rude" | (Ref.) | | |
| Don’t know/No opinion | 0.25 | 0.03 | 1.89 |
| "They are sometimes nice" | 1.92 | 0.30 | 12.44 |
| "They are always nice" | 0.62 | 0.10 | 3.99 |

*Adjusted Odds Ratio-Adjusted for all other factors listed in table

[a]Wealth index based on total animal ownership

[b]Median distance among nomadic pastoralists

**Table 5**. Multivariate associations of family characteristics, maternal attitudes and knowledge, and immunization system factors on age-appropriate vaccination among settled pastoralists in Lagdera sub-district of Garissa County, Kenya, 2015

| | aOR* | 95% CI | |
|---|---|---|---|
| Characteristic | Settled | | |
| **Family Characteristics** | | | |
| **Child's Age** | | | |
| 0-5 months | (Ref.) | | |
| 6-11 months | 3.85 | 1.27 | 11.67 |
| 12-23 months | 1.97 | 0.52 | 7.48 |
| 24-59 months | 3.28 | 1.07 | 10.05 |
| **Mother owns radio** | | | |
| No | (Ref.) | | |
| Yes | 1.04 | 0.49 | 2.21 |
| **Mother's Islamic Education** | | | |
| No | (Ref.) | | |
| Yes | 0.47 | 0.18 | 1.23 |
| **Birth order among biological siblings under 5 yrs** | | | |
| First born | (Ref.) | | |
| Second born | 0.68 | 0.35 | 1.33 |
| Third born | 0.22 | 0.04 | 1.16 |
| **Attitudes and Knowledge** | | | |
| **Mother correctly identified some or all polio symptoms** | | | |
| No | (Ref.) | | |
| Yes | 0.92 | 0.45 | 1.87 |
| **Mother correctly identified age of measles vaccination** | | | |
| No | (Ref.) | | |
| Yes | 1.99 | 0.83 | 4.80 |
| **Mother's view of vaccine importance** | | | |
| Don’t know/Not very important | (Ref.) | | |
| Somewhat/very important | 5.43 | 1.02 | 28.91 |
| **Immunization System** | | | |
| **Euclidean distance to health facility offering vaccination** | | | |
| Over .9km | (Ref.) | | |
| Under .9km[b] | 0.87 | 0.37 | 2.05 |
| **Possession of vaccination card** | | | |
| No | (Ref.) | | |

| | | | |
|---|---|---|---|
| Yes | 4.95 | 2.23 | 10.99 |
| **Maternal tetanus toxin vaccine while pregnant** | | | |
| No | (Ref.) | | |
| Yes | 2.01 | 0.75 | 5.36 |
| **Communication and Information** | | | |
| **Mother aware of 2014 polio campaign** | | | |
| No | (Ref.) | | |
| Yes | 1.68 | 0.81 | 3.46 |
| **Treatment by health staff** | | | |
| "They are rude" | (Ref.) | | |
| Don’t know/No opinion | 1.73 | 0.22 | 13.68 |
| "They are sometimes nice" | 1.97 | 0.41 | 9.43 |
| "They are always nice" | 3.92 | 0.93 | 16.52 |
| *Adjusted Odds Ratio-Adjusted for all other factors listed in table | | | |
| [a]Wealth index based on total animal ownership | | | |
| [b]Median distance among settled pastoralists | | | |

## Figures

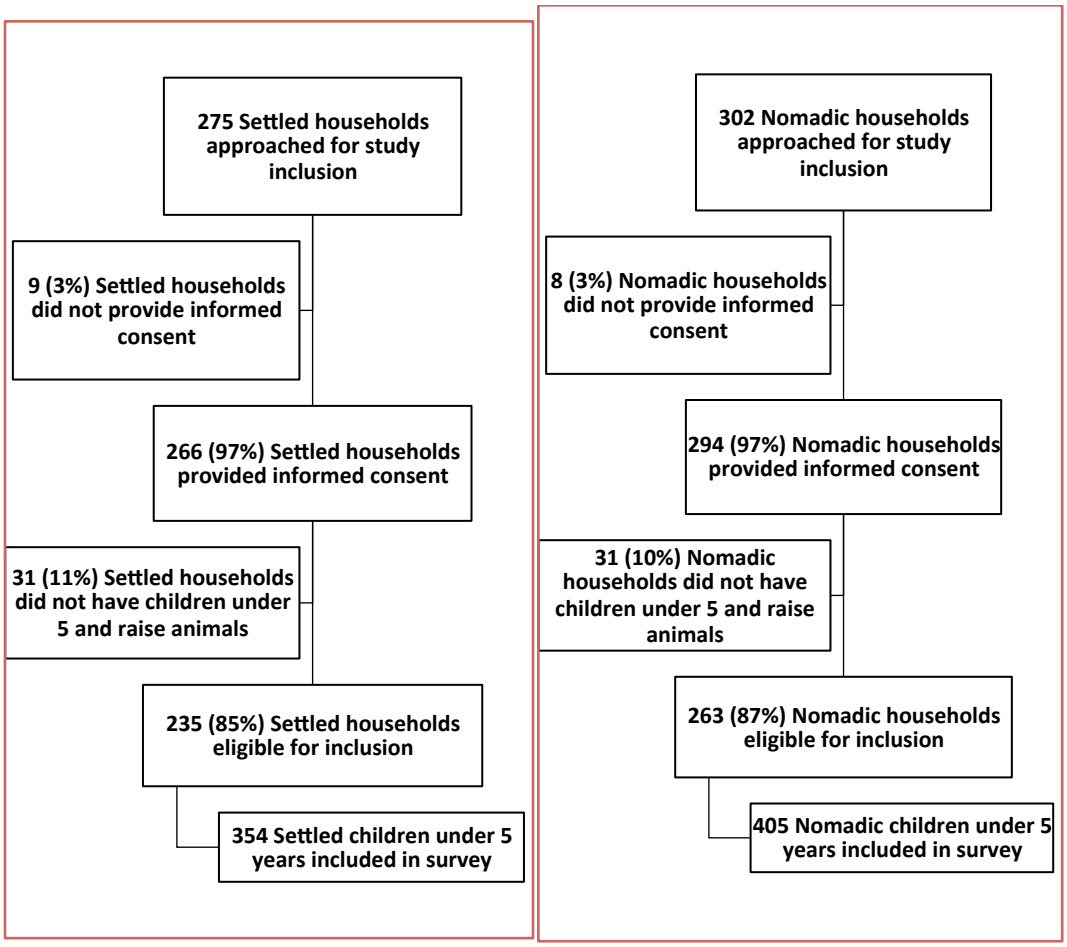


**Figure 1. Selection of study participants.**

## Chapter III: Summary, Public Health Implications, and Possible Future Directions

Based on the results of this cross-sectional survey of nomadic and settled pastoralists, several programmatic steps can be taken to increase childhood vaccination among these groups. Separate and additional efforts must be made to specifically target nomadic pastoralists for vaccination as they have far lower estimates of vaccine coverage. For both groups, physical distance to vaccination sites does not fully explain the variations seen in vaccination outcomes. Among nomadic pastoralists, a complex array of factors appear to influence initial vaccination, but self-reported previous contact with vaccination services may be the best indicator of vaccine receipt. For settled pastoralists, under-vaccination may be most related to competing priorities. Efforts to reach pastoralists communities should consider these results and differences to better enable vaccine uptake among these underserved communities.

While these results can have an immediate impact on public health decision-making, more rigorous evaluation of pastoralists' lifestyle and vaccination is clearly warranted. In particular, research that continues to systematically characterize the meaningful differences within pastoralists groups and assesses the impact of the differences on health seeking behavior is critical. One such area would be looking at different migration patterns among nomadic pastoralists over time and determining if there is a connection to the use of health services. While research into these populations is challenging and resource intensive, the opportunity to meaningfully improve health outcomes among these communities more than justify the work.