



Vaccine non-receipt and refusal in Ethiopia: The expanded program on immunization coverage survey, 2012

Julia M. Porth^{a,*}, Abram L. Wagner^a, Habtamu Teklie^b, Yemesrach Abeje^c, Beyene Moges^b, Matthew L. Boulton^{a,d}

^a Department of Epidemiology, School of Public Health, University of Michigan, Ann Arbor, MI, USA

^b Ethiopian Public Health Institute, Addis Ababa, Ethiopia

^c Department of Public Health, St. Paul's Hospital Millennium Medical College, Addis Ababa, Ethiopia

^d Department of Internal Medicine, Division of Infectious Disease, University of Michigan Medical School, Ann Arbor, MI, USA



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ABSTRACT

Introduction: Rates of full childhood immunization in Ethiopia are well below the WHO global goal of 90% coverage by 2020. This study explores associations between sociodemographic characteristics and healthcare services utilization with experiences of not receiving a vaccine in Ethiopia.

Methods: This analysis uses data from Ethiopia's 2012 Expanded Program on Immunization Coverage Survey. The relationships between explanatory variables, including sociodemographic and healthcare utilization factors, and various reasons a child was not vaccinated were assessed with Rao-Scott chi-square tests. Multivariable logistic regression analyses examined significant predictors of these experiences.

Results: The sample includes the caregivers of 2,722 children. Experiences of not receiving a vaccine were characterized overall and by type of experience: whether a caregiver ever refused vaccination for their child (2.9%), ever decided to not take their child to a health center for vaccination (3.6%), and ever went to a health facility for vaccination but child was not vaccinated (12.0%). Region of residence, possession of a vaccination card, and the setting of the child's last routine vaccination were predictors of not receiving a vaccine. Caregivers reported negative perceptions of vaccines were among their reasons for refusing a vaccine or declining to take their child to a health facility for vaccination.

Conclusion: Prior experiences with health facilities, such as where a child received their last routine vaccine, play a key role in future vaccination. Vaccine receipt at an outreach event is associated with not bringing a child to a health facility for vaccination, which may indicate an unwillingness to visit or difficulty accessing health centers. Further, negative perceptions of vaccines may result in vaccine refusal or delay. Findings of this study provide public health officials with a better understanding of factors related to vaccination experiences and can inform development of interventions that will improve childhood vaccination rates in Ethiopia.

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1. Introduction

Common vaccine-preventable diseases, including measles, diarrhea, pneumonia, tetanus, and pertussis, cause two to three million childhood deaths worldwide annually, which could be averted through the use of vaccines as a safe and effective public health intervention [1]. Each year nearly twenty million children fail to receive all recommended vaccines and almost two-thirds of these children come from just ten countries, including Ethiopia [2].

Since 1980, the government of Ethiopia has provided select vaccines, for free, to children in Ethiopia through the Expanded Pro-

gram on Immunization (EPI). Under the Ethiopian EPI, a child is considered fully immunized if they have received three doses of the oral polio vaccine (OPV), three doses of the pentavalent vaccine (penta includes diphtheria, tetanus, pertussis [DTP], hepatitis B [HBV], and *Haemophilus influenzae* type b [Hib]), one dose of the Bacille Calmette-Guérin vaccine (BCG, for tuberculosis), one dose of measles-containing vaccine (MCV), three doses of the pneumococcal conjugate vaccine (PCV), and two doses of the rotavirus vaccine (rota), which prevents infant diarrhea [3]. Although vaccines are provided at no cost at public health centers, rates of full immunization in Ethiopia are very low; the national estimate of completion of all recommended vaccines in the EPI series is only 39%, [3] which is well below the World Health Organization (WHO) 2020 goal of 90% coverage in every country [4]. Ethiopia's high childhood

* Corresponding author at: 1415 Washington Heights, Ann Arbor, MI 48109, USA.
E-mail address: jmporth@umich.edu (J.M. Porth).



Fig. 1. Map of Ethiopia.

mortality rates highlight the pressing need to focus efforts on increasing childhood immunization coverage. The neonatal mortality rate in Ethiopia is 29 deaths per 1,000 live births with higher infant (48) and under-five mortality rates (67) [3]. These represent dramatic declines from 2000 levels, but remain much higher than the 2030 mortality rate targets set by the Sustainable Development Goals of 12 and 25 deaths per 1000 live births for neonates and children under five years, respectively [5]. It is imperative that public health officials better understand reasons for continued low vaccination coverage, including vaccination refusal and missed opportunities, in order to inform efforts aimed at increasing immunization coverage and decreasing Ethiopia's high levels of childhood morbidity and mortality (see Fig. 1).

Since 2010, the literature examining predictors of childhood vaccination in low- and middle-income countries, generally, and in Ethiopia, specifically, has increased substantially. Previous research has found vaccination status in Ethiopia varies by sex [6], birth order [7–9], parental educational status [6–14], and family wealth and income [7–9]. Studies of predictors of full vaccination in Ethiopia suggest that low maternal awareness and knowledge of vaccines and vaccine schedules [8,10,15,16], obstacles to immunization such as clinic distance and operating hours [8,10,15], maternal time constraints [6], and maternal fear of adverse outcomes associated with vaccination all play a role in vaccination behavior [8,15]. A few studies have included relatively brief treatments of caregivers' interface with vaccination programs such as the impact of the source of vaccination messaging and the specific messages received have on vaccination status [6,8,11,15].

However, less research has examined reasons for a complete lack of childhood vaccination (i.e. unvaccinated), which may result from parental vaccine refusal, missed opportunities, and/or vaccine supply and access issues. Vaccine refusal occurs when a caregiver rejects or doesn't request available vaccinations for an eligible

child and lies along a continuum from refusing one vaccine to declining all vaccinations [17–19]. Factors such as individual sociodemographic factors (i.e. education, maternal age), caregiver perceptions (i.e. doubts about vaccine safety and necessity), access to (mis)information about vaccines, previous experiences with vaccination and health facility staff, and accessibility of vaccination services are thought to influence vaccine hesitancy and vaccine refusal behaviors [19,20]. While the literature has described vaccine hesitancy and vaccine refusal as closely related and context-specific concepts, it also warns against conflating them, highlighting the importance of separately examining the factors that influence vaccine hesitancy and refusal [18,21]. While one study has examined the effect of vaccine hesitancy on vaccination timeliness in Ethiopia, it did not explore predictors of vaccine hesitancy [22]. Other studies of vaccine hesitancy are either general global reviews [23–28] or have focused on hesitancy in developed countries [29–31] or other African nations [32–34]. To the authors' knowledge, no studies have previously examined predictors for refusing routine vaccinations in Ethiopia.

Additionally, children may not be fully vaccinated due to limited vaccination service supply and access. Access issues would include caregivers residing distant from health facilities and limited clinic operating hours and can prevent children from receiving necessary doses [8,10,15,35]. However, even if a child makes it to a health facility for vaccination, the inability to supply vaccination services due to vaccine stock-outs, cold chain failure, and lack of electricity at the clinic means children may remain unvaccinated due to health system failures [15,35–38]. Personnel supply problems such as no vaccinator being at the health facility during immunization hours, unskilled and unprofessional vaccinators, fear of mistreatment by health workers, and general dissatisfaction with health facility staff also negatively impact a child's vaccination status [10,35,36,38,39].

Even if a caregiver desires vaccination for a child and has access to immunization services, a child may not be fully immunized due to missed opportunities, which occurs when a vaccine-eligible child presents at a health facility but does not receive one or all of the recommended vaccines [40]. Reviews of missed opportunities in immunization in low- and middle-income countries describe myriad reasons for missed opportunities including poor health care provider practices such as failure to review the child's vaccination card, perceived false medical contraindications by the parents or healthcare workers, supply issues including vaccine stock outs or cold chain failure, limited vaccination workers, and poor vaccination awareness among parents and caregivers [35,40].

This study explores if sociodemographic characteristics and healthcare services experiences are associated with various parental experiences of not receiving a dose of vaccine through analysis of the Ethiopian Public Health Institute's 2012 Expanded Program on Immunization Coverage Survey. The results of this analysis will contribute to the literature regarding vaccine non-receipt and refusal in Ethiopia, enabling healthcare workers and public health officials to better understand the reasons children are missing vaccinations and develop more effective public health interventions to improve vaccination coverage.

2. Methods

2.1. Data source

This analysis used data from the 2012 Expanded Program on Immunization (EPI) Coverage Survey, administered by the Ethiopian Health and Nutrition Institute and the Coverage Survey Task Force. The EPI Coverage Survey utilized a cross sectional, multi-stage, stratified clustered design and collected information on EPI vaccine coverage among infants aged 12–23 months. It was determined that a total of 550 clusters (50 from each of Ethiopia's nine regions and the two city-administrations) should be selected to enable an accurate calculation of immunization status at both the national and the regional level. Within each cluster, 14 households were identified, 7 households containing infants aged 12–23 (data used in this analysis) and 7 households containing recently pregnant mothers.

The analysis specifically utilized data from EPI Coverage Survey Form 5: *Child Immunization Questionnaire*, which included questions about EPI vaccines received and reasons a child was not vaccinated (see Form 5 in Appendix). Survey questions and design were based on the Demographic and Health Survey and the Multiple Indicator Cluster Survey tools. Vaccination data were initially collected from childhood vaccination cards and supplemented with information provided by caregivers.

2.2. Variables

Child's age was calculated as the difference between a child's date of birth and the date of interview. The child's immunization status was assessed with two variables. The first variable summed the total number of doses of vaccine a child received. The second contained three categories: the child received all recommended vaccines, the child received some recommended vaccines, or the child did not receive any vaccines.

Some variables were re-coded for the bivariate and multivariate logistic regressions because of small cell sizes in certain categories. Country region was recoded into three groups: central (Addis Ababa, Dire Dawa, Harari, and Oromia), southern (Gambela, Southern Nations Nationalities and Peoples' Region, and Somali), and northern (Tigray, Afar, Amhara, and Benishangul-Gumuz). Occupa-

tion was collapsed into a binary variable of farmers (either sustenance farmers or pastoralists) and other occupations or missing data. Similarly, education level was also condensed into a binary variable, never attended any school and ever attended school or pre-school. Finally, a question that asked whether caregivers ever take their sick children to religious places (places of prayer or places where one can be anointed with holy water) for care was treated as a binary variable.

We analyzed three distinct experiences of not receiving a dose of vaccine: whether a caregiver had ever refused a vaccine for their child when they were already at a health center, whether a caregiver chose to not take their child to a health center to be vaccinated, and whether a caregiver brought their child to a health facility for vaccination but the child was not vaccinated. An additional fourth binary variable was created, which described whether a caregiver did or did not report any of the above experiences. To understand why parents who were already at the health center decided to not accept one or more vaccines, parents were asked if they had ever refused vaccination for their child. Parents were also asked if they had ever decided to not bring their child to the clinic for vaccination. Finally, caregivers were asked if they had ever taken their child to a health facility for vaccination but the child was not vaccinated. Caregivers who responded affirmatively to each of these questions were asked why via an open-ended question without additional probing. As vaccine refusal and missed opportunities for immunization are both complex concepts it would have been preferable to use validated scales to measure them. However, this study was intended to be an exploratory analysis using available data, the results of which may encourage subsequent detailed investigations into vaccine refusal and missed opportunities in Ethiopia.

2.3. Statistical methods

Frequencies and distributions of sociodemographic variables, health service utilization variables, experiences of not being vaccinated, and reasons for not receiving a vaccine were calculated. Rao-Scott chi-square tests were used to describe the relationship between a child's vaccination status and various experiences of not being vaccinated. Rao-Scott chi-square tests were also conducted to elucidate the relationship between sociodemographic and health service utilization factors and not receiving a dose of vaccine. The Holm-Bonferroni method was used to adjust for multiple testing. Four logistic regressions were run, with each of the four vaccination experiences as the outcome. To determine which variables to include in the final multivariate models, bivariate logistic analyses were conducted between each outcome variable and each of the sociodemographic and health service experiences variables. Variables whose association with the outcome yielded a p-value < 0.20 (prior to adjusting for multiple comparisons) were included in the multivariable logistic regression analyses. Variables significant at the 0.05 level in the multivariable logistic regression were deemed significant predictors of vaccine non-receipt. Data were analyzed using *proc surveyfreq* and *proc surveylogistic* in SAS version 9.4 (SAS Institute, Cary, NC, USA) to account for clustering.

2.4. Ethical approval

The University of Michigan Health Sciences and Behavioral Sciences Institutional Review Board approved this analysis. The Ethiopian Health and Nutrition Research Institute, the Central Statistical Agency, and the Interagency Coordination Committee in Ethiopia approved the EPI Coverage Survey protocol.

3. Results

Caregivers of 3,838 children were interviewed and of these, 1,116 participants were removed including 973 excluded because the child's age could not be verified. An additional 159 participants were excluded because their child was younger than 12 months or 24 months or older at the time of interview leaving a final sample of 2,722 children's caregivers (Table 1). There were more male (53.8%) than female children and mothers were the primary caregiver of most children (97.1%). Ethiopian Orthodox (48.2%), Muslim (31.1%), and Protestant (18.8%) were the most common religious affiliations. Many caregivers had never attended school (46.9%) and few received higher than a secondary education (5.7%). Caregivers were mainly employed as subsistence farmers (42.4%) or housewives (29.3%).

Health facilities appeared to be highly utilized; most caregivers first took their sick child to the local health facility (94.9%) and fewer caregivers first took sick children to places of prayer (2.3%), places they could be anointed with holy water (1.5%), or to traditional healers (0.9%, Table 1). Immunization was an important aspect of health facility use; just under half of participants had never been to a health facility for any reason other than immunization (39.7%) and over half of children received their most recent vaccination in a governmental health facility (health centers [31.6%], health posts [28.7%]). Few children had received all recommended vaccines (15.3%); most children had received some, but not all, recommended vaccines (46.1%) or had not received any vaccines (38.6%).

Almost all caregivers had received some messages about vaccines (96.5%) originating from a wide variety of sources including community members (61.2%), health workers at health facilities (60.0%) and at home visits (42.2%), and the radio (27.3%, Table 1). The nature of the information provided was diverse, covering the general importance of vaccines (89.3%), upcoming immunization campaigns (41.9%), and the appropriate age (38.9%) and location (47.6%) for vaccination.

In the sample, 16.5% of caregivers reported not receiving a vaccine for some or all of the reasons including ever refusing vaccination for their child (2.9%), deciding to not take their child to the health center for vaccination (3.6%), and taking their child to a health facility for vaccination but wasn't vaccinated (12.0%, Table 2). Reasons for vaccine refusal were varied with the child's illness, mentioned by 55.1% of caregivers, the most common reason (Table 2). Caregivers also cited dislike of health workers (13.0%), long clinic waiting times (10.1%) and administration of too many shots (8.7%). The most common reasons caregivers gave for deciding to not take their child to a health center to be vaccinated included ill child (35.9%), fear of vaccine side effects (23.6%), perception that vaccines are not important (22.2%), and being too busy (21.4%). Caregivers mentioned no vaccine available (49.7%), no vaccinator present (16.5%), health facility closed when they went (13.6%), and the visit to the health facility was not on the vaccination day (13.0%) as reasons the child did not receive a vaccine when at the health facility.

Each of the experiences of not receiving a vaccine was significantly associated with the child's vaccination status (Table 3). The median number of vaccine doses a child received was lower among caregivers who reported any experiences not receiving a vaccine (5.4 doses vs 6.4 doses), reported vaccines refusal (0.0 doses vs 6.5 doses), and decided to not take their child to a health facility for vaccination (0.0 doses vs 6.5 doses) compared to caregivers who didn't report these experiences. However, the median number of vaccine doses a child received was higher for caregivers who reported going to a health facility for vaccination but their child was not vaccinated (7.2 doses vs 6.0 doses).

Results of the chi-square analysis indicated that only where the child received their last routine immunization was significantly associated with whether a caregiver reported any of the experiences of not receiving a vaccine for their child (Table 4). A variety of both caregiver and health facility use factors were significantly associated with whether a caregiver had ever refused immunization for their child, including religion and occupation of the caregiver, where the child received their last routine vaccination, where a caregiver first took a sick child for care, and the source and content of vaccine messaging received. The results were similar for those situations in which a caregiver declined to take their child to a health facility to be immunized. Region of residence was the only factor significantly associated with whether a caregiver had ever brought their child to a health facility for vaccination but the child did not receive a vaccine.

The bivariate logistic regression indicated that a variety of child factors, caregiver characteristics, and health facility usage variables were related to the various experiences of not receiving a dose of vaccine and were thus included in the multivariate regressions. In the multivariate regression for a caregiver reporting any experience of not receiving a vaccine dose region of residence and occupation were statistically significant (Table 5). Individuals living in the northern regions of Ethiopia were 40% (OR: 0.6, 95% CI: 0.4, 0.8) less likely to report any experience of their child not receiving a vaccine compared to individuals living in the central regions of Ethiopia. Additionally, the odds of reporting this experience were 0.2 (95% CI: 0.1, 0.8) and 0.7 (OR: 0.5, 0.9) times lower for pastoralists and other (or missing) occupations, respectively, compared to subsistence farmers.

Whether a caregiver had ever gone to a health facility for reasons other than vaccination but the child received a vaccine was the only factor significantly associated with vaccine refusal and those caregivers were 28.9 (95% CI: 15.1, 55.2) times more likely to refuse vaccination for their child compared to those who did not report this experience (Table 5). Additionally, caregivers who identified with other religious affiliations (i.e. not Ethiopian Orthodox, not Muslim, and not Protestant) were more likely than caregivers identifying as Ethiopian Orthodox to refuse vaccination (OR: 5.9, 95% CI: 1.5, 23.9).

For caregivers who chose to not take their child to a health facility to be vaccinated, current possession of a vaccination card and where the child received their last routine vaccination were significant predictors (Table 5). Caregivers whose child received their last routine vaccination at an outreach event were 2.3 (95% CI: 1.4, 3.9) times more likely to not bring their child to a clinic for vaccination compared to those whose child received their last routine vaccination at a health facility. The odds of not bringing a child to a clinic to be vaccinated were 50% (OR: 0.5, 95% CI: 0.3, 0.9) lower among caregivers who currently possess a vaccination card or a family health folder compared to caregivers who do not possess this documentation. In addition to healthcare use variables, religion influenced whether a caregiver chose to not bring their child to a clinic for vaccination, though these associations were not statistically significant. Compared to caregivers who identified as Ethiopian Orthodox, caregivers who identified as Muslim (OR: 0.5, 95% CI: 0.3, 1.0) and those who identified with other religious affiliations (OR: 0.7, 95% CI 0.1, 3.7) were less likely to choose to not bring their child to a clinic to be vaccinated.

Finally, only significant predictors of whether a caregiver had ever been to a health facility for vaccination but the child did not receive a vaccine were region of residence and religion (Table 5). The odds of a caregiver reporting this experience were 50% (OR: 0.5, 95% CI: 0.3, 0.8) lower among caregivers who lived in the northern regions of Ethiopia compared to those who lived in the central regions of Ethiopia. Religion influenced whether a caregiver

Table 1
Descriptive statistics of childhood characteristics, caregiver characteristics, health service utilization factors, and vaccination variables, accounting for survey clustering.

Variable	Frequency	Percent
<i>Child characteristics</i>		
Child sex		
Male	1459	53.8
Female	1253	46.2
Birth order ^a		
1	706	25.9
2	514	18.9
3	359	13.2
4 or more	753	27.7
Missing	390	14.3
Region		
Addis Ababa	336	12.3
Afar	100	3.7
Amhara	327	12.0
Benishangu Gumuz	230	8.5
Dire Dawa	271	10.0
Gambela	260	9.6
Harari	258	9.5
Oromia	269	9.9
SNNPR	275	10.1
Somali	63	2.3
Tigray	333	12.2
Region, collapsed		
Central	1134	41.7
Northern	598	22.0
Southern	990	36.4
<i>Caregiver characteristics</i>		
Child's primary caregiver		
Mother	2631	97.1
Father	13	0.5
Other	66	2.4
Religion ^b		
Orthodox	1308	48.2
Muslim	844	31.1
Protestant	510	18.8
Other (Catholic, other Christians, not religious, other)	54	2.0
Caregiver age ^c		
<20	358	13.4
21–25	717	26.7
26–30	874	32.6
31+	733	27.3
Occupation ^d		
Subsistence farming	1125	42.4
Housewife	777	29.3
Business	264	10.0
Employed (formal)	144	5.4
Unemployed	112	4.2
Employed (informal)	102	3.9
Pastoralist	53	2.0
Student	30	1.1
Other	17	0.6
House servant	11	0.4
Other farming	8	0.3
Day labor	6	0.2
House maid	2	0.1
Occupation, collapsed		
Subsistence farming	1125	41.3
Business (any)	264	9.7
Employed (formal or informal)	246	9.0
Pastoralist	53	2.0
Other or missing	1034	38.0
Occupation, collapsed		
Farmer	1178	43.3
Other	1544	56.7
Education		
None	1264	46.9
Pre-school	174	6.5
Primary	733	27.2
Secondary	373	13.8

Table 1 (continued)

Variable	Frequency	Percent
Higher	153	5.7
Education, collapsed		
Ever attended school or pre-school	1429	53.0
Never attended school or pre-school	1269	47.0
<i>Health service utilization factors</i>		
Current possession of immunization card		
Yes	2181	80.8
Child's vaccination status		
Child has received all recommended vaccines	415	15.3
Child has received some recommended vaccines	1256	46.1
Child has not received any vaccines	1051	38.6
Number of doses of vaccines child has received (maximum = 12)	6.2	–
Where child received last routine vaccination		
Health center	861	31.6
Health post	780	28.7
Outreach	503	18.5
Hospital	322	11.8
Other, don't know, missing	224	8.2
Private clinic	32	1.2
Where child received last routine vaccination, collapsed		
Health facility	1995	73.3
Outreach	503	18.5
Other, don't know, missing	224	8.2
Caregiver has ever been to a health facility for a purpose other than vaccination		
Yes	1638	60.3
Caregiver ever gone to health facility for purpose other than vaccination and child received a vaccine		
Yes	97	3.6
Where caretaker first takes a sick child		
Health facility	2560	94.9
Place of prayer	63	2.3
Holy water	39	1.5
Traditional healer	23	0.9
Other	13	0.5
Where the caretaker first takes a sick child, condensed		
Health facility	2560	94.9
Other	138	5.1
Caregiver takes child to a religious place when sick		
Mentioned either holy water or place of prayer	401	14.7
Did not mention either	2303	84.6
Missing	18	0.7
Other places the caretaker takes their sick child (select all that apply)		
Health facility	2639	97.6
Holy water	262	9.7
Place of prayer	184	6.8
Traditional healer	81	3.0
Caregiver heard any messages about vaccines		
No	46	1.7
Yes	2626	96.5
Missing	50	1.8
From whom caregiver received messaging about vaccines (select all that apply)		
Community members	1648	61.2
Health workers at a health facility	1617	60.0
Health workers at a home visit	1139	42.2
Radio	736	27.3
Television	577	21.4
Kebele administrative paper	439	16.3
Other government official	77	2.9
Newspaper	68	2.5
Type of messages received about vaccinations (select all that apply)		
Importance of vaccination	2384	89.3
Where to get vaccination	1271	47.6
About campaigns	1119	41.9
Age to get vaccination	1038	38.9
When to return for next dose	670	25.1
About new vaccines	372	14.0

Note: Percentages reported are the percentage of all respondents who indicated a particular category. Individual with a missing response for that variable are not included in the denominator when calculating percentages, unless otherwise specified.

* Some values are missing for this variable resulting in empty clusters. Fewer than the total 550 clusters were included in this analysis.

Table 2
Descriptive statistics of reasons for not receiving a vaccine, accounting for clustering.

Variable	Frequency	Percent
<i>Reasons for not receiving vaccine</i>		
Reason caregiver provided for child having ever not received a vaccine		
Caregiver only mentioned having ever refused vaccination	35	1.3
Caregiver only mentioned having ever decided to not bring child to health facility for vaccination	55	2.0
Caregiver only mentioned having ever gone to a health facility for vaccination but child not vaccinated	311	11.4
Caregiver reported more than one of the above experiences	48	1.8
Caregiver reported not receiving a vaccine for any of the above reasons	449	16.5
Caregiver has not reported any of the above experiences	2273	83.5
<i>Refusal</i>		
Ever refused vaccination		
Yes	80	2.9
No	2632	96.7
Missing	10	0.4
<i>Reasons for vaccine refusal (select all that apply)</i>		
Child was ill		
Mentioned	38	55.1
Did not mention	31	44.9
Missing	2653	
Did not like health worker		
Mentioned	9	13.0
Did not mention	60	87.0
Missing	2653	
Wait was too long		
Mentioned	7	10.1
Did not mention	62	89.9
Missing	2653	
Too many shots		
Mentioned	6	8.7
Did not mention	63	91.3
Missing	2653	
<i>Decision to not take child to health facility for vaccination</i>		
Ever decided to not take child to health facility for vaccination		
Yes	97	3.6
No	2609	95.9
Missing	16	0.6
<i>Reasons for deciding to not take child to health facility for vaccination (select all that apply)</i>		
Child was ill		
Mentioned	33	35.9
Did not mention	59	64.1
Missing	2630	
Fear of side effects		
Mentioned	21	23.6
Did not mention	68	76.4
Missing	2633	
Not important		
Mentioned	20	22.2
Did not mention	70	77.8
Missing	2632	
Too busy		
Mentioned	19	21.4
Did not mention	70	78.7
Missing	2633	
Place too far		
Mentioned	10	11.4
Did not mention	78	88.6
Missing	2634	
Nobody to take child		
Mentioned	7	7.9
Did not mention	82	92.1
Missing	2633	
Time of visit was inconvenient		
Mentioned	6	6.7
Did not mention	83	93.3
Missing	2633	
Did not know when to take child		
Mentioned	3	3.4
Did not mention	86	96.6

Table 2 (continued)

Variable	Frequency	Percent
Missing	2633	
Did not know where to take child		
Mentioned	1	1.1
Did not mention	88	98.9
Missing	2633	
<i>Went to health facility for vaccination but child not vaccinated</i>		
Ever taken a child to a health facility for vaccination and the child was not vaccinated		
Yes	327	12.0
No	2387	87.5
Missing	14	0.5
<i>Reasons child was not vaccinated when taken to health facility for vaccination (select all that apply)</i>		
No vaccine		
Mentioned	157	49.7
Not mentioned	159	50.3
Missing	2406	
No vaccinator (not closed)		
Mentioned	52	16.5
Not mentioned	264	83.5
Missing	2406	
Health facility closed when they went		
Mentioned	43	13.6
Not mentioned	273	86.4
Missing	2406	
The visit to health facility was not on the vaccination day		
Mentioned	41	13.0
Not mentioned	275	87.0
Missing	2406	
Vaccinator refused because not able to vaccinate (e.g. too busy, NOT no vaccine available)		
Mentioned	19	6.0
Not mentioned	297	94.0
Missing	2406	
Vaccinator refused to vaccinate child		
Mentioned	7	2.2
Not mentioned	309	97.8
Missing	2406	
The caretaker refused the vaccination		
Mentioned	4	1.3
Not mentioned	312	98.7
Missing	2406	

had ever been to a health facility for vaccination but their child was not vaccinated but was not statistically significant.

4. Discussion

Vaccination coverage rates in Ethiopia are exceptionally low, with only 39% of children 12–24 months having received all recommended vaccine doses [3]. This falls far short of the WHO 2020 global goal of 90% coverage for all EPI vaccines in every country [4], and likely translates to insufficient herd immunity against many vaccine preventable diseases. Despite this shortfall, coverage with all recommended vaccine doses has nonetheless almost tripled from 14% in 2000, to 39% in 2016 [3] although the proportion of children lacking all vaccinations has remained static at approximately 17% over that same time period [3].

Well documented obstacles to childhood vaccination including clinic distance, limited operating hours [8,10,15] and maternal time constraints [6] represent common challenges for caregivers in low resource settings. Though these barriers clearly need to be addressed in any comprehensive strategy to improve vaccination levels, consideration should also be given to the changing perceptions of vaccines and reducing or eliminating vaccine refusal, which could serve as a useful starting point for increasing child-

hood immunization coverage in Ethiopia. Our analysis suggests negative perceptions of vaccines, especially fear of side effects and viewing vaccines as unimportant, are key contributors to vaccine refusal. While we found the absolute number of caregivers refusing vaccination is relatively small, it is nonetheless noteworthy. When a caregiver refuses a vaccine or decides not to bring their child to a health facility for vaccination they effectively prevent or delay healthcare workers from providing a safe, cost-effective, and potentially life-saving preventive intervention to that child. Moreover, even small pockets of vaccine refusal could spread and eventually lead to the normalization of refusal behavior, resulting in more susceptible children and greater community vulnerability to disease outbreaks [41,42]. For example, circulating rumors about the safety of the oral polio vaccine led to widespread vaccine refusal in Nigeria in 2003 and 2004 which in turn resulted in substantial increases in polio cases in the country (i.e. 202 cases in 2002 to 1,143 cases in 2006) [43]. Similarly, a review from the United States found vaccine refusal to be associated with an increased risk of contracting measles and pertussis in both vaccinated and unvaccinated individuals, demonstrating the considerable potential for vaccine refusal to impact disease burden and transmission in communities [44]. While the Ethiopian context for vaccine refusal undoubtedly differs, these examples clearly demonstrate the critical need to understand vaccine refusal behav-

Table 3
Descriptive statistics and Rao-Scott Chi-square test of relationship between reasons for not receiving a vaccine and child's overall vaccination status, accounting for survey clustering.

Variable	Rao-Scott Chi-square ^a (p-value)	Yes, reported experience		No, did not report experience	
		Frequency	Percent (Median)	Frequency	Percent (Median)
Didn't receive a dose for any reason	0.2 (0.9)				
Number of vaccine doses child has received (maximum = 12)			(5.4)	345	(6.4)
Child has received all recommended vaccines		70	2.6	1054	12.7
Child has received some recommended vaccines		202	7.4	874	38.7
Child has not received any vaccines		177	6.5		32.1
Refusal	26.7 (<0.0001 [*])				
Number of vaccine doses child has received (maximum = 12)			(0.0)		(6.5)
Child has received all recommended vaccines		4	0.1	411	15.2
Child has received some recommended vaccines		22	0.8	1232	45.4
Child has not received any vaccines		54	2.0	989	36.5
Decision to not take child to health facility for vaccination	50.1 (<0.0001 [*])				
Number of vaccine doses child has received (maximum = 12)			(0.0)		(6.5)
Child has received all recommended vaccines		1	0.04	410	15.2
Child has received some recommended vaccines		25	0.9	1226	45.3
Child has not received any vaccines		71	2.6	973	36.0
Went to health facility for vaccination but child not vaccinated	13.2 (0.001 [*])				
Number of vaccine doses child has received (maximum = 12)			(7.2)		(6.0)
Child has received all recommended vaccines		66	2.4	349	12.9
Child has received some recommended vaccines		166	6.1	1086	40.1
Child has not received any vaccines		95	3.5	946	34.9

^a Rao-Scott Chi-square tests for relationship between whether a caregiver has reported the experience and the child's vaccination status (child has received all, some, or no recommended vaccines).

^{*} significance at the $\alpha = 0.05$ level.

iors and develop programs that can prevent or limit its spread. Negative perceptions of vaccines was another reason caregivers declined to bring their child to a health clinic for vaccination, which may relate less to refusal than delaying vaccination and the inconvenience associated with traveling to a health facility for a service that may not be perceived as important or necessary. Misunderstandings about vaccinations on the part of both caregivers and providers regarding illness as a legitimate contraindication was also mentioned by caregivers. This more likely results in vaccination delay until the child is well rather than refusal but nonetheless demonstrates the importance of education campaigns about vaccinations and child illness to improve vaccination timeliness.

Religion was associated with a child not receiving a vaccine in all four models. Compared to Ethiopian Orthodox caregivers, Muslim caregivers were less likely to refuse vaccination, not go to a clinic for vaccination, and go but not receive vaccination, though none of these were statistically significant. The relationships between not receiving a vaccine and Protestant and "other" (i.e. those following other branches of Christianity or those not religious) caregivers did not follow consistent patterns among the four models and more research is necessary to understand these relationships. The decreased likelihood of Muslims refusing vaccination is consistent with a prior study from northern Ethiopia [11] which found Muslims were more likely to fully vaccinate their children, though, similar to other studies, this association was not significant in final multivariate regressions [7,8]. A study from Guinea found that only 46% of practicing Muslims compared to 80% of religious leaders found vaccination to be acceptable during Ramadan, citing religious prohibitions against such along with concerns that adverse reactions may necessitate breaking their fast [45]. Some Muslim groups in other parts of the world have also raised concerns that certain vaccines are not *halal* [46]. The varying association between religion and vaccination observed in many studies

may be attributable to the differential importance religions attach to childhood vaccination specifically or healthcare utilization more generally. Followers of a given religion may encounter more social pressure from religious peers to vaccinate or may receive greater social support to more fully understand the importance of vaccination and engage in vaccine-seeking behavior. Certain religious groups may also be more reliant on religiously sanctioned or other traditional healing practices and consequently less likely to engage with healthcare institutions and systems.

Previous experiences with health clinics and immunization services appear to exert a lasting effect on caregivers. In our study, some caregivers expressed dislike of health workers and long waits at health clinic as reasons for refusing a vaccine. These results are consistent with other studies that have found immunization service experiences to be important predictors of incomplete vaccination; a vaccinator not being present during immunization hours [10,36], unskilled and unprofessional vaccinators [35], dissatisfaction with health clinic staff [38,39], and vaccine shortages [35–37] have all been related to incomplete vaccination. In this study, decisions to not take a child to a health facility for vaccination were higher among caregivers whose child received their last routine vaccine via an outreach event in the community compared to caregivers whose child received their last routine vaccine in a health facility. However, we are unable to determine whether this was because the caregiver planned to receive the next vaccination at another outreach event due to convenience or previous experiences at health facilities. Further, both vaccine refusal and not taking a child to a health facility for vaccination were less likely among caregivers who initially take their sick child to a health facility compared to those caregivers taking their ill child to other places (i.e. places of prayer, a place to be anointed with holy water, or to a traditional healer), though these were not statistically significant. Previous immunization at a health facility may reflect more ready access to and acceptance of healthcare facilities by

Table 4

Rao-Scott Chi-Square test of relationship between outcome variables and child characteristics, caregiver characteristics, and health service utilization factors, accounting for survey clustering.

Variable	Chi-square	Crude p-value	Adjusted p-value ^a
Didn't receive a dose for any reason			
<i>Child characteristics</i>			
Sex	0.1	0.7	1.0
Birth order	3.4	0.5	1.0
Region of residence, collapsed	6.7	0.03	0.9
<i>Caregiver characteristics</i>			
Primary caregiver	— ^b	— ^b	— ^b
Caregiver age ^c	1.3	0.7	1.0
Religion ^c	5.5	0.1	1.0
Educational level	3.2	0.5	1.0
Ever attended school or pre-school	0.5	0.5	1.0
Occupation	12.0	0.02 *	0.5
Farmer	4.4	0.03	0.9
<i>Health service utilization factors</i>			
Current possession of immunization card	4.9	0.03 *	0.7
Where child received last routine vaccination	20.1	<0.0001 *	<0.004
Caregiver has ever been to a health facility for a purpose other than vaccination	1.8	0.2	1.0
Caregiver ever gone to health facility for purpose other than vaccination and child received a vaccine	— ^b	— ^b	— ^b
Where the caregiver first takes their sick child	5.8	0.02 *	0.5
Caregiver takes child to a religious place when sick	9.0	0.01	0.4
Caregiver takes child to health facility when sick	7.7	0.02 *	0.6
Caregiver takes child to holy water when sick	9.6	0.008 *	0.3
Caregiver takes child to traditional healer when sick	2.1	0.3	1.0
Caregiver takes child to place of prayer when sick	2.6	0.3	1.0
Received vaccine messaging from health workers	7.7	0.02 *	0.6
Received vaccine messaging from media	5.8	0.05 *	1.0
Received vaccine messaging from government (either administrative paper or government official)	6.7	0.04 *	0.9
Received vaccine messaging from community members	4.8	0.09	1.0
Received vaccine messaging from health workers at a health facility	5.3	0.07	1.0
Received vaccine messaging from health workers at a home visit	6.4	0.04 *	0.9
Received vaccine messaging from the radio	5.8	0.05 *	1.0
Received vaccine messaging from the television	8.8	0.01	0.4
Received vaccine messaging from the newspaper	6.2	0.05 *	1.0
Received vaccine messaging from the kebele administrative paper	6.7	0.04 *	0.9
Received vaccine messaging from another government official	1.8	0.4	1.0
Heard any messages about vaccines	9.6	0.008 *	0.3
Heard vaccine messages about campaigns	5.3	0.07	1.0
Heard vaccine messages about importance of vaccines	5.8	0.05 *	1.0
Heard vaccine messages about where to get vaccination	4.9	0.09	1.0
Heard vaccine messages about age to get vaccinations	7.8	0.02 *	0.6
Heard vaccine messages about when to return for next dose	5.6	0.06	1.0
Heard vaccine messages about new vaccines	5.5	0.06	1.0
Heard other vaccine messages	6.1	0.05 *	1.0
Vaccine refusal			
<i>Child characteristics</i>			
Sex	3.3	0.07	0.4
Birth order	6.8	0.1	0.7
Region of residence, collapsed	3.6	0.2	0.7
<i>Caregiver characteristics</i>			
Primary caregiver	— ^b	— ^b	— ^b
Caregiver age ^c	2.9	0.4	0.7
Religion ^c	16.0	0.001 *	0.02 *
Educational level	14.4	0.006 *	0.06
Ever attended school or pre-school	6.3	0.01 *	0.1
Occupation	21.9	0.0002 *	0.004 *
Farmer	19.5	<0.0001 *	<0.004
<i>Health service utilization factors</i>			
Current possession of immunization card	54.5	<0.0001 *	<0.004
Where child received last routine vaccination	69.2	<0.0001 *	<0.004
Caregiver has ever been to a health facility for a purpose other than vaccination	4.3	0.04 *	0.3
Caregiver has ever decided not to take child to be vaccinated	413.8	<0.0001 *	<0.004
Caregiver has taken child to a health facility for vaccination but the child was not vaccinated	1.7	0.2	0.7
Caregiver ever gone to health facility for purpose other than vaccination and child received a vaccine	413.8	<0.0001 *	<0.004
Where the caregiver first takes their sick child	27.7	<0.0001 *	<0.004
Caregiver takes child to a religious place when sick	26.7	<0.0001 *	<0.004
Caregiver takes child to health facility when sick	48.3	<0.0001 *	<0.004
Caregiver takes child to holy water when sick	15.2	0.0005 *	0.008 *
Caregiver takes child to traditional healer when sick	3.2	0.2	0.7
Caregiver takes child to place of prayer when sick	12.0	0.003 *	0.03 *
Received vaccine messaging from health workers	24.2	<0.0001 *	<0.004

(continued on next page)

Table 4 (continued)

Variable	Chi-square	Crude p-value	Adjusted p-value ^a
Didn't receive a dose for any reason			
Received vaccine messaging from media	30.2	<0.0001 [†]	<0.004 [†]
Received vaccine messaging from government (either administrative paper or government official)	13.7	0.001 [†]	0.02 [†]
Received vaccine messaging from community members	18.4	0.0001 [†]	0.004 [†]
Received vaccine messaging from health workers at a health facility	23.3	<0.0001 [†]	<0.004 [†]
Received vaccine messaging from health workers at a home visit	18.4	<0.0001 [†]	<0.004 [†]
Received vaccine messaging from the radio	25.1	<0.0001 [†]	<0.004 [†]
Received vaccine messaging from the television	24.5	<0.0001 [†]	<0.004 [†]
Received vaccine messaging from the newspaper	18.4	<0.0001 [†]	<0.004 [†]
Received vaccine messaging from the kebele administrative paper	13.1	0.002 [†]	0.02 [†]
Received vaccine messaging from another government official	11.0	0.004 [†]	0.05 [†]
Heard any messages about vaccines	38.5	<0.0001 [†]	<0.004 [†]
Heard vaccine messages about campaigns	29.6	<0.0001 [†]	<0.004 [†]
Heard vaccine messages about importance of vaccines	38.8	<0.0001 [†]	<0.004 [†]
Heard vaccine messages about where to get vaccination	30.5	<0.0001 [†]	<0.004 [†]
Heard vaccine messages about age to get vaccinations	31.4	<0.0001 [†]	<0.004 [†]
Heard vaccine messages about when to return for next dose	27.6	<0.0001 [†]	<0.004 [†]
Heard vaccine messages about new vaccines	25.8	<0.0001 [†]	<0.004 [†]
Heard other vaccine messages	7.3	0.03 [†]	0.2
Decision to not take child to be vaccinated	Chi-square	Crude p-value	Adjusted p-value ^a
<i>Child characteristics</i>			
Sex	1.5	0.2	1.0
Birth order	5.5	0.2	1.0
Region of residence, collapsed	9.5	0.009 [†]	0.1
<i>Caregiver characteristics</i>			
Primary caregiver	_b	_b	_b
Caregiver age ^c	2.3	0.5	1.00
Religion ^c	7.5	0.06	0.5
Educational level	19.4	0.0007 [†]	0.02 [†]
Ever attended school or pre-school	13.8	0.0002 [†]	0.005 [†]
Occupation	23.7	<0.0001 [†]	<0.004 [†]
Farmer	20.5	<0.0001 [†]	<0.004 [†]
<i>Health service utilization factors</i>			
Current possession of immunization card	51.8	<0.0001 [†]	<0.004 [†]
Where child received last routine vaccination	103.4	<0.0001 [†]	<0.004 [†]
Caregiver has ever been to a health facility for a purpose other than vaccination	3.0	0.08	0.6
Caregiver has ever refused vaccination	413.8	<0.0001 [†]	<0.004 [†]
Caregiver has taken child to a health facility for vaccination but the child was not vaccinated	0.2	0.7	1.00
Caregiver ever gone to health facility for purpose other than vaccination and child received a vaccine	_b	_b	_b
Where the caregiver first takes their sick child	19.4	<0.0001 [†]	<0.004 [†]
Caregiver takes child to a religious place when sick	23.4	<0.0001 [†]	<0.004 [†]
Caregiver takes child to health facility when sick	16.0	0.0003 [†]	0.007 [†]
Caregiver takes child to holy water when sick	14.4	0.0007 [†]	0.02 [†]
Caregiver takes child to traditional healer when sick	12.5	0.002 [†]	0.04 [†]
Caregiver takes child to place of prayer when sick	10.4	0.006 [†]	0.08
Received vaccine messaging from health workers	20.5	<0.0001 [†]	<0.004 [†]
Received vaccine messaging from media	24.0	<0.0001 [†]	<0.004 [†]
Received vaccine messaging from government (either administrative paper or government official)	12.1	0.002 [†]	0.04 [†]
Received vaccine messaging from community members	13.0	0.002 [†]	0.03 [†]
Received vaccine messaging from health workers at a health facility	27.0	<0.0001 [†]	<0.004 [†]
Received vaccine messaging from health workers at a home visit	14.7	0.0006 [†]	0.01 [†]
Received vaccine messaging from the radio	20.8	<0.0001 [†]	<0.004 [†]
Received vaccine messaging from the television	30.3	<0.0001 [†]	<0.004 [†]
Received vaccine messaging from the newspaper	12.3	0.002 [†]	0.04 [†]
Received vaccine messaging from the kebele administrative paper	12.5	0.002 [†]	0.04 [†]
Received vaccine messaging from another government official	3.8	0.2	0.9
Heard any messages about vaccines	23.4	<0.0001 [†]	<0.004 [†]
Heard vaccine messages about campaigns	9.3	0.01 [†]	0.1
Heard vaccine messages about importance of vaccines	26.1	<0.0001 [†]	<0.004 [†]
Heard vaccine messages about where to get vaccination	9.8	0.007 [†]	0.09
Heard vaccine messages about age to get vaccinations	10.4	0.006 [†]	0.08
Heard vaccine messages about when to return for next dose	12.3	0.002 [†]	0.04 [†]
Heard vaccine messages about new vaccines	6.6	0.04 [†]	0.3
Heard other vaccine messages	0.5	0.8	1.00
Been to health facility for vaccination but child did not receive a vaccine	Chi-square	Crude p-value	Adjusted p-value ^a
<i>Child characteristics</i>			
Sex	1.8	0.2	1.0
Birth order	4.8	0.3	1.0
Region of residence, collapsed	20.9	<0.0001 [†]	<0.004 [†]
<i>Caregiver characteristics</i>			
Primary caregiver	_b	_b	_b
Caregiver age ^c	3.0	0.4	1.0

Table 4 (continued)

Variable	Chi-square	Crude p-value	Adjusted p-value ^a
Didn't receive a dose for any reason			
Religion ^c	7.2	0.06	1.0
Educational level	6.6	0.2	1.0
Ever attended school or pre-school	2.4	0.1	1.0
Occupation	5.0	0.3	1.0
Farmer	0.3	0.6	1.0
<i>Health service utilization factors</i>			
Current possession of immunization card	5.4	0.02*	0.8
Where child received last routine vaccination	1.1	0.6	1.0
Caregiver has ever been to a health facility for a purpose other than vaccination	0.1	0.7	1.0
Caregiver has ever refused vaccination	1.7	0.2	1.0
Caregiver has ever decided not to take child to be vaccinated	0.2	0.7	1.0
Caregiver ever gone to health facility for purpose other than vaccination and child received a vaccine	0.2	0.7	1.0
Where the caregiver first takes their sick child	0.2	0.7	1.0
Caregiver takes child to a religious place when sick	0.01	1.0	1.0
Caregiver takes child to health facility when sick	0.1	0.9	1.0
Caregiver takes child to holy water when sick	0.3	0.9	1.0
Caregiver takes child to traditional healer when sick	1.0	0.6	1.0
Caregiver takes child to place of prayer when sick	0.2	0.9	1.0
Received vaccine messaging from health workers	0.7	0.7	1.0
Received vaccine messaging from media	6.6	0.04*	1.0
Received vaccine messaging from government (either administrative paper or government official)	1.6	0.4	1.0
Received vaccine messaging from community members	0.6	0.8	1.0
Received vaccine messaging from health workers at a health facility	2.1	0.4	1.0
Received vaccine messaging from health workers at a home visit	2.0	0.4	1.0
Received vaccine messaging from the radio	3.9	0.1	1.0
Received vaccine messaging from the television	3.1	0.2	1.0
Received vaccine messaging from the newspaper	1.1	0.6	1.0
Received vaccine messaging from the kebele administrative paper	1.4	0.5	1.0
Received vaccine messaging from another government official	0.1	0.9	1.0
Heard any messages about vaccines	0.7	0.7	1.0
Heard vaccine messages about campaigns	3.5	0.2	1.0
Heard vaccine messages about importance of vaccines	2.0	0.4	1.0
Heard vaccine messages about where to get vaccination	0.3	0.9	1.0
Heard vaccine messages about age to get vaccinations	4.6	0.1	1.0
Heard vaccine messages about when to return for next dose	0.4	0.8	1.0
Heard vaccine messages about new vaccines	4.6	0.1	1.0
Heard other vaccine messages	3.8	0.1	1.0

^a Adjusted for multiple comparisons using Holm-Bonferroni method.

^b At least one cell < 0; unable to calculate Chi-Square statistic.

^c Some values are missing for this variable resulting in empty clusters. Fewer than the total 550 clusters were included in this analysis.

* Significance at the $\alpha = 0.05$ level.

caregivers. A previous positive experience with child vaccination might reasonably lead a caregiver to return to a clinic for future child immunizations while also exhibiting a greater willingness to accept provider recommendations for vaccination. Alternatively, there may be important differences between caregivers whose children received their last routine vaccine via an outreach event versus those who utilized health facilities for previous vaccinations - such as proximity to a health center - that we were unable to capture in this analysis.

4.1. Strengths and limitations

A multi-stage clustered design was employed for this survey, but weights were not available, so we were unable to fully account for the study design in the analysis. While this may not substantially bias sample estimates it likely affected the standard errors, which may account for the large confidence intervals [47]. Further, due to the small sample size and the resulting empty clusters, many analyses used fewer than the total 550 clusters, which may affect the results. Additionally, as this is a cross-sectional study, temporal ambiguity cannot be disregarded, and we are limited in our ability to make any statements about causality. There is also the risk for incorrect recall by caregivers about vaccines received. Additionally, we have no way to ascertain whether these experiences resulted in delayed receipt of the vaccine or the child never receiving the dose since we lacked

detailed information about which doses a child received at campaigns and about specific caregiver vaccine behavior including the impact of distance from vaccination facilities (though only 10 of the 97 caregivers who reported not bringing their child to a clinic mentioned distance as an issue). Social desirability bias may have affected the results in that participants may under-report vaccine refusal behavior. The relatively small number of participants who reported the experiences under study limited our ability to explore how some variables, such as vaccination messaging, predict them. For like reasons, we combined the categories of some variables, which allowed us to examine crude measures of these variables, a more nuanced understanding of how specific regions or occupations affect these experiences would be valuable. We were also unable to determine how key factors that were not collected such as wealth, birth setting, use of antenatal care, or parental knowledge of infectious diseases and vaccines affect these experiences. This study also has many strengths. Probability-proportionate-to-size sampling was utilized to randomly select clusters for the multi-stage clustered study design which helps ensure more accurate estimates at the national and regional level. The EPI Coverage Survey contains questions modified from the validated Demographic and Health Survey and the Multiple Indicator Cluster Survey. Finally, examining different experiences of not receiving a vaccine allows for a more nuanced understanding of vaccination non-receipt and failure to fully immunize.

Table 5
Multivariate logistic regression of outcome variables and child characteristics, caregiver characteristics, and health service utilization factors, accounting for survey clustering.

Variable	Odds ratio	95% confidence interval
Didn't receive a dose for any reason		
Region of residence		
Central	1.0	Reference
Northern	0.6*	(0.4, 0.8)
Southern	0.9	(0.6, 1.2)
Religion		
Orthodox	1.0	Reference
Muslim	0.8	(0.6, 1.1)
Protestant	0.9	(0.6, 1.4)
Other	1.4	(0.5, 3.6)
Occupation		
Subsistence farmer	1.0	Reference
Pastoralist	0.2*	(0.1, 0.8)
Employed (formal or informal)	0.7	(0.5, 1.1)
Business (any)	0.7	(0.5, 1.1)
Other or missing	0.7*	(0.5, 0.9)
Current possession of vaccination card		
Yes	0.9	(0.7, 1.2)
No	1.0	Reference
Where child received last routine vaccine		
Health facility	1.0	Reference
Outreach	1.2	(0.9, 1.6)
Other, don't know, missing	1.7*	(1.1, 2.6)
Ever been to health facility for purpose other than vaccinations		
Yes	1.0	(0.8, 1.2)
No	1.0	Reference
Where caregiver first takes a sick child		
Health facility	0.8	(0.5, 1.2)
Other	1.0	Reference
Caregiver received messaging about vaccines from a health worker at a home visit		
Mentioned	1.0	Reference
Did not mention	1.1	(0.9, 1.5)
Missing	1.7	(0.6, 4.5)
Caregiver heard any messages about vaccines		
Yes	1.0	Reference
No	1.9	(1.0, 3.7)
Missing	1.1	(0.1, 22.1)
Caregiver received messages about age to get routine vaccination		
Mentioned	1.0	Reference
Did not mention	0.8	(0.6, 1.0)
Missing	1.3	(0.1, 24.1)
Caregiver received other messages about vaccination (not about campaigns, importance, age to get vaccination, when to return for next dose, or new vaccines)		
Mentioned	1.0	Reference
Did not mention	0.5	(0.2, 1.1)
Missing	0.8	(0.4, 1.6)
Vaccine refusal		
Child's sex		
Male	1.0	Reference
Female	1.7	(0.9, 3.0)
Birth order		
1	1.0	Reference
2	1.1	(0.4, 3.1)
3	2.2	(0.9, 5.2)
4 or more	1.7	(0.7, 4.0)
Missing	2.4	(0.9, 6.4)
Region of residence		
Central	1.0	Reference
Northern	0.6	(0.3, 1.4)
Southern	1.1	(0.5, 2.3)
Religion		
Orthodox	1.0	Reference
Muslim	0.9	(0.4, 1.9)
Protestant	1.4	(0.6, 3.2)
Other	5.9*	(1.5, 23.9)
Education		

Table 5 (continued)

Variable	Odds ratio	95% confidence interval
Didn't receive a dose for any reason		
Ever attended school or pre-school	1.5	(0.8, 2.8)
Never attended school or pre-school	1.0	Reference
Occupation		
Farmer (subsistence, pastoralist)	1.9	(0.9, 3.8)
Other	1.0	Reference
Caregiver has ever gone to health facility for purpose other than vaccination and child received a vaccine		
Yes	28.9[†]	(15.1, 55.2)
No	1.0	Reference
Current possession of vaccination card		
Yes	0.5	(0.3, 1.0)
No	1.0	Reference
Where child received last routine vaccine		
Health facility	1.0	Reference
Outreach	1.5	(0.8, 2.8)
Other, don't know, missing	1.7	(0.8, 3.7)
Ever been to health facility for purpose other than vaccinations		
Yes	0.9	(0.5, 1.5)
No	1.0	Reference
Where caregiver <i>first</i> takes a sick child		
Health facility	0.5	(0.2, 1.3)
Other	1.0	Reference
Caregiver heard any messages about vaccines		
Yes	1.0	Reference
No	2.4	(0.5, 11.9)
Missing	7.0[†]	(2.0, 24.2)
Decision to not take child to be vaccinated	Odds ratio	95% confidence interval
Region of residence		
Central	1.0	Reference
Northern	1.6	(0.7, 3.6)
Southern	1.4	(0.7, 2.8)
Religion		
Orthodox	1	Reference
Muslim	0.5	(0.3, 1.0)
Protestant	1.0	(0.5, 2.0)
Other	0.7	(0.1, 3.7)
Education		
None	1.0	Reference
Pre-school	1.1	(0.4, 2.6)
Primary	0.6	(0.4, 1.2)
Secondary	0.4	(0.1, 1.3)
Higher	0.6	(0.1, 2.6)
Occupation		
Subsistence farmer	1.0	Reference
Pastoralist	0.3	(0.03, 2.0)
Employed (formal or informal)	1.2	(0.5, 2.9)
Business (any)	0.7	(0.3, 1.8)
Other or missing	0.7	(0.4, 1.2)
Current possession of vaccination card		
Yes	0.5[†]	(0.3, 0.9)
No	1.0	Reference
Where child received last routine vaccine		
Health facility	1.0	Reference
Outreach	2.3[†]	(1.4, 3.9)
Other, don't know, missing	5.1[†]	(2.8, 9.3)
Ever been to health facility for purpose other than vaccinations		
Yes	0.9	(0.6, 1.5)
No	1.0	Reference
Where caregiver <i>first</i> takes a sick child		
Health facility	0.6	(0.3, 1.1)
Other	1.0	Reference
Caregiver heard any messages about vaccines		
Yes	1.0	Reference
No	1.6	(0.5, 4.8)
Missing	2.2	(0.8, 6.3)

(continued on next page)

Table 5 (continued)

Variable	Odds ratio	95% confidence interval
Didn't receive a dose for any reason		
Been to health facility for vaccination but child did not receive a vaccine		
Child's sex		
Male	1.0	Reference
Female	0.9	(0.7, 1.1)
Region of residence		
Central	1.0	Reference
Northern	0.5*	(0.3, 0.8)
Southern	0.8	(0.5, 1.2)
Religion		
Orthodox	1.0	Reference
Muslim	0.8	(0.6, 1.0)
Protestant	0.8	(0.6, 1.3)
Other	0.7	(0.2, 2.2)
Education		
None	1.0	Reference
Pre-school	1.3	(0.8, 2.0)
Primary	1.0	(0.7, 1.4)
Secondary	0.9	(0.6, 1.4)
Higher	1.3	(0.7, 2.4)
Current possession of vaccination card		
Yes	1.3	(0.9, 1.9)
No	1.0	Reference
Caregiver has ever refused vaccination		
Yes	1.8	(1.0, 3.6)
No	1.0	Reference
Caregiver received messaging about vaccines from the media (radio, television, or news)		
Mentioned	1.0	Reference
Did not mention	0.9	(0.7, 1.3)
Missing	2.2	(0.6, 7.2)
Caregiver received messages about vaccination campaigns		
Mentioned	1.0	Reference
Did not mention	1.2	(0.9, 1.6)
Missing	0.7	(0.2, 1.8)
Caregiver received other messages about vaccination (not about campaigns, importance, age to get vaccination, when to return for next dose, or new vaccines)		
Mentioned	1.0	Reference
Did not mention	0.6	(0.2, 1.4)
Missing	0.7	(0.3, 1.7)

* Significance at the $\alpha = 0.05$ level.

4.2. Conclusions

We found that previous experiences with health facilities and negative perceptions of vaccines are important contributors to vaccine non-receipt. Though refusal behaviors were not common in our study population, they are nonetheless important to understand and prevent as they can place the larger community at risk for transmission of infectious diseases. Future studies may improve upon the limitations of this study to further explore immunization non-receipt in Ethiopia by increasing sample size and including additional survey questions about other key variables like wealth and parental knowledge about vaccination. The results of this study can assist health professionals and policy makers better understand the reasons for non-receipt of vaccines which can inform development of interventions that improve childhood vaccination rates in Ethiopia.

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Conflict of interest

Declarations of interest: none.

Authorship

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Appendix A. Supplementary material

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