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Prevalence and associated factors of immunization among under-five children in Somalia

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Abstract

Background Children worldwide can live lives free from various illnesses and disabilities due to vaccination. For instance, vaccination has eliminated smallpox, a deformative and frequently fatal illness that claimed an estimated 300 million lives in the twentieth century. However, due to a lack of access to immunization and other health services, 14.3 million infants in 2022 still did not receive their first dose of the Diphtheria-Tetanus-Pertussis (DTP) vaccine, and an additional 6.2 million received only a portion of the scheduled dose. This study aimed to assess prevalence and determinant factors of immunization among under-five children in Somalia using Somalia Health and Demographic Survey (SHDS) Data.

Methods The study design was cross-sectional, utilizing the SHDS 2020 data. A total of 3916 under-five children who fulfilled the inclusion criteria were included in this study. Count regression models were employed to explore factors associated with the number of vaccinations received per child.

Results In this study, 9.14% of children did not receive any vaccination during their childhood. Different candidate count regression models were compared. Using AIC and BIC, the Negative-binomial (NB) regression model was found to be the best fit. From this model, we found that women ages 20–24 (IRR = 1.192, 95% CI: 1.083, 1.313) and 25–29 (IRR = 1.180, 95% CI: 1.068, 1.305) had a higher number of vaccinations per child compared to women in the 15–19 age group. Women who attended primary education (IRR = 1.090, 95% CI: 1.034, 1.150) and secondary education (IRR = 1.157, 95% CI: 1.058, 1.266) had a higher number of vaccinations per child compared to uneducated women) also correlated with increased vaccination Parity (IRR = 1.090, 95% CI: 1.031–1.153), and wealth quantile (IRR = 1.110, 95% CI: 1.012, 1.217) positively influenced vaccination attendance. Regional disparities were also found to be significant, with Togdheer, Sool, Sanaag, Bari, Nugaal, Bay, Bakool, Mudug, Hiiraan and Galgaduud significantly different from Awdal region. In Negative-Binomial, age, region, residence, educational level, wealth quantile, child size at birth, parity and birth order emerged as key predictors, revealing complex determinants of vaccination utilization in Somalia.

Conclusions A large proportion of children did not complete the full vaccination schedule. Socio-demographic factors, such as age, region, residence, educational level, wealth quantile, child size at birth, parity, and birth order, had a significant impact on the number of children vaccinated in Somalia. These findings underscore the importance of targeted interventions for addressing these factors. Implementing initiatives based on these conclusions has the potential to enhance vaccination coverage and child health outcomes.

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Keywords Vaccination, Negative-Binomial Model, Under-five children, Count regression model, Somalia

Background

Vaccination is a simple, safe and dependable approach to protect against infectious diseases prior to the onset of illness. It enhances the immune system and develops resilience against specific infections by utilizing the body's natural defenses [1]. Globally, over 22.7 million children are unable to complete essential vaccinations, which accounts for 17% of children under the age of five [2].

Children worldwide are living free from various illnesses and disabilities due to vaccination. For instance, vaccination has eliminated smallpox, a deformative and frequently fatal illness that claimed an estimated 300 million lives in the twentieth century [3]. However, due to a lack of access to immunization and other health services, 14.3 million infants in 2022 still did not receive their first dose of the Diphtheria-Tetanus-Pertussis (DTP) vaccine, and an additional 6.2 million received only a portion of the scheduled dose [4]. Immunization contributes to 14 of the 17 SDGs and has a direct influence on health (SDG 3) and it has a key role in achieving the anticipated SDGs with a special focus on developing countries where the vaccine coverage is still below from the minimum required coverage [5]. The vaccination coverage in Somalia for DTP3, Measle and Polio vaccination is about 42%, 46% and 47% respectively which showed the coverage remains below regional and global levels due to conflict and population displacement. The coverage for these basic vaccination in the African region is 74%, 39% and 72%, respectively. While the global coverage for the above-mentioned vaccine is 83%, 71% and 83% respectively. These figures showed a disproportion of the vaccine coverage in both the regional and global coverage.

The African countries has made significant progress in increasing access to immunization and reducing child deaths. Despite these achievements, vaccination coverage rates remain stagnant. More than 30 million under-five children still suffer from vaccine-preventable diseases, highlighting the need for improved vaccines and immunization strategies [4].

The COVID-19 pandemic has had a major effect on vaccination rates; in 2022, DTP vaccination rates nearly returned to the 2019 levels. 6.2 million infants were only partially vaccinated, and 14.3 million did not receive the first dose. Furthermore, 21.9 million kids failed to receive their recommended first dose of measles, underscoring the need for increased vaccination rates [6]. Childhood immunization is estimated to prevent three to five million premature deaths among children under the age of five each year [7–9].

The World Health Organization (WHO) support enabled the Expanded Programme on Immunization (EPI) to be launched in Somalia in 1978. However, protracted violence and instability in Somalia left the country with a poor, disjointed, and severely underfunded healthcare system that had an impact on all medical services, including immunization. The program extended its reach to rural and nomadic populations, typically underserved in the country, by utilizing primary healthcare (PHC) networks. Although routine immunization efforts were unsuccessful, mass campaigns significantly enhanced coverage. The civil crisis severely damaged the health infrastructure from 1988 to 1991. Recently, Somalia successfully vaccinated more than 3.2 million children against measles and 3.5 million against polio [10]. However, the goal of complete immunization coverage in Somalia has not yet been achieved. The full immunization coverage remained at only 11% among children aged 11–23 months in 2020, and as a result, many children in Somalia have not received the benefits of full immunization. The country has higher infant and under-five child mortality rates, reaching 106.1 per 1000 live births, compared to other developing countries [11, 12]. Delays to achieving complete vaccination coverage in different settings have been identified and encompass lower education [13, 14], low income [14, 15], place of delivery [16, 17], media exposure [18, 19], household assets and expenditure, ethnicity, age and parity [20] were documented in Asian and African countries. In Somalia, the primary causes of infant mortality, accounting for approximately 80 percent of cases, include preterm birth, hypoxia, birth issues, and infections, such as pneumonia, diarrhea, measles, and neonatal diseases. Furthermore, the access of children in Internally Displaced Persons (IDP) camps to routine immunization is affected by factors such as policy, health system, and social context [20]. The barriers to achieving full immunization coverage among children under-five in Mogadishu include having an older and single caregiver, fathers with low educational level, low monthly family income, child with early birth orders, younger child, unavailability of vaccines at health centers, unaffordability of vaccine-related costs, home deliveries, and caregivers with low knowledge, attitude, and practice regarding child immunization [21]. The educational level and occupation of mothers, waiting time, motivation to return, and level of awareness were found to be statistically significant predictors of children's full immunization [22]. All the above factors were discovered through small-scale investigations.

Regarding the limited research conducted in various regions of Somalia, there is a lack of comprehensive understanding at the national level of societal factors contributing to low vaccination rates and the failure to

utilize immunization services. Hence, the objective of this study was to identify the factors linked to immunization among under-five children in Somalia.

Methodology

Study setting sources of data

The 2020 Somalia Health and Demographic Survey (SHDS) was conducted in sixteen regions namely Togdheer, Woqooyi -Galbeed, Awdal, Sool, Sanaag, Bari, Nugaal, Mudug, Galgaduud, Hiraan, Middle Shabelle, Banadir, Bay, Bakool, Gedo, and Lower Juba. Somalia is one of the sub-Saharan countries in the Horn of Africa, with a population of 18.7 million based on the 2024 national population projection. This study used the 2020 SHDS data and the survey utilized a sampling design based on three stages of cluster allocation. A total of 3916 children who fulfill the inclusion and exclusion criteria and have under-five children for the last five years preceding the survey were included for this study [11, 23].

Survey instrument and administration

The SHDS dataset contained a questionnaire specifically designed for women. This questionnaire collected data on the socio-demographic characteristics of the mothers, their reproductive health and service utilization behaviors, and information about their children. The dataset includes information on all births that occurred within the past five years, from women aged 15 to 49 years. The 2020 SHDS obtained data on vaccination coverage using three methods: (1) recording the vaccination date on the card; (2) gathering information from mothers' verbal accounts; and (3) noting the presence of vaccination marks on the card. If the vaccination cards were accessible, the interviewer transcribed the immunization dates directly into the questionnaire. If the child did not have a vaccination card, or if a vaccine was not documented on the card, the parent was requested to recall the immunization administered to her child. According to the WHO, a child is deemed fully vaccinated after receiving the following: a BCG vaccine for tuberculosis, three doses of the diphtheria, pertussis, and tetanus (DPT) vaccine, at least three doses of the polio vaccine, and one dose of the measles vaccine. The SHDS 2020 survey gathered data on the vaccination coverage for children born within the five years prior to the survey [11].

Study Variables

Response variables

The response variable of this study is denoted by y_i, which indicates the number of vaccinations received among under-five children in Somalia. Thus, y_i takes on values 0, 1, 2… where i denotes the children aged between 0–59 months in the last five years preceding the survey. This study focused on evaluating immunization coverage based on the WHO definition of "fully vaccinated" (basic vaccines) which includes receiving a BCG vaccination, three doses of the DPT vaccine, at least three doses of the polio vaccine, and one dose of the measles vaccine. Therefor the outcome variable is based on these basic vaccines recommended by WHO and to assess overall vaccine uptake across the under-five children in Somalia.

Explanatory variables

The potential risk factors included in this study were mother's education, maternal age, sex of child, region, place of residence, child alive or dead at the time of interview, wealth quantile, parity, media exposure, size of child at birth, place of delivery, birth order, and distance to a medical facility. To assess the effect of media exposure, we considered watching television, listening to radio and reading newspapers at least once a week. The media exposure was then generated by combining the three media sources (television, Radio, and Newspaper) to fully leverage media exposure from these three sources of information and categorized it as Yes if the respondents have media exposure from these media outlets and it is categorized "No" otherwise. The DHS wealth quintile categorization uses a wealth index to estimate household economic status based on data about housing, utilities, and asset ownership, rather than direct income or spending. It's created using a method called Principal Components Analysis (PCA)**,** which analyzes these factors in three steps: first, common indicators are used for both urban and rural areas; second, separate scores are calculated for each area type; and finally, the scores are combined into a national index. This index ranks households from poorest to wealthiest and divides the population into five equal groups, or quintiles.

Statistical analysis

A count regression models were proposed and the Poisson regression model which was initially used, is a conventional model for count data to fit the count response variable. If the count data are characterized by over-dispersion, the appropriate model to be used is the Negative-Binomial (NB) model. The NB distribution is particularly suitable for count data skewed with a heavy right tail, instead of the Poisson distribution. The NB model accounts for over-dispersion by incorporating the dispersion parameter, allowing for increased variability in the count data. Therefore, the Negative-Binomial model provides a more accurate fit for over-dispersed count data compared to the Poisson model. In this study, the NB regression model was found to be the best after careful comparison of candidate models.

The Poisson regression model is commonly used to analyze count data. However, when the data show more variability than expected (a condition known as over-dispersion), the Negative Binomial (NB) model is a better fit. The NB model is particularly well-suited for our data because it accounts for over-dispersion, where the variance (how spread out the data is) exceeds the mean. This is a common limitation of the Poisson model, which assumes that the mean and variance are equal. The NB model handles this extra variability by including an additional parameter, allowing for greater flexibility in modeling the data. In this study, the NB regression model was found to be the best after careful comparison of candidate models [24, 25].

Results

Descriptive data analysis

Table 1 displays the demographic and socioeconomic characteristics of mothers aged 15–49 years who had given birth in the past five years prior to the survey, such as age, region, type of residence, educational level, wealth quintile, distance to health facility, marital status, sex of child, child alive or dead, size of child at birth, parity, birth rank, and place of delivery.

A total of 1,165 (29.75%) mothers were aged between 25 and 29 years old. Additionally, 964 (24.62%) mothers were aged between 20 and 24 years. Moreover, 824 (21.04%) mothers were between 30 and 34 years old. Furthermore, 534 (13.64%) mothers were 35–39 years old. Moreover, 232 (5.92%) mothers were aged between 15 and 19 years. In addition, the age group of the mothers with the second lowest frequency was between 40 and 44 years, with 154 participants, which accounted for 3.93% of the total. Finally, only 43 (1.1%) participants were aged 45–49 years.

Regarding the regional distribution of study participants, the study involved mothers from different parts of Somalia. Most of them, 602 (15.37%), were from Banadir, whereas Sanaag had 394 (10.06%) mothers. Togdheer had 345 (8.81%) and Galgaduud had 276 (7.05%) mothers in the study. 271 (6.92%) of the mothers were came from Bakool, and Woqooyi Galbeed contributed 267 participants (6.82%). Gedo and Middle Shabelle had 217 (5.54%) and 203 (5.18%) mothers respectively. There were 184 participants (4.7%) in Nugaal. Lower Juba had 166 participants (4.24%). Mudug and Hiraan had 161 (4.11%) and 159 (4.06%) mothers, respectively. There were 153 participants (3.91%) in Bari. Bay had 122 participants (3.12%), and Awdal had the fewest participants at 114 (2.91%).

Furthermore, regarding the place of residence of the study participants, 2,196 mothers (56.08%) were urban residents, 1,249 mothers (31.89%) were rural residents, and 471 mothers (12.03%) were nomadic dwellers.

Table 1 Demographic and socioeconomic characteristics of study participants ($n = 3916$)

Variables	Freq	Percent
Age		
15 – 19	232	5.92
20 – 24	964	24.62
25 – 29	1,165	29.75
30 – 34	824	21.04
35 – 39	534	13.64
40 – 44	154	3.93
45 – 49	43	1.1
Total	3,916	100
Region		
Awdal	114	2.91
Woqooyi Galbeed	267	6.82
Togdheer	345	8.81
Sool	282	7.2
Sanaag	394	10.06
Bari	153	3.91
Nugaal	184	4.7
Mudug	161	4.11
Galgaduud	276	7.05
Hiraan	159	4.06
Middle Shabelle	203	5.18
Banadir	602	15.37
Bay	122	3.12
Bakool	271	6.92
Gedo	217	5.54
Lower Juba	166	4.24
Total	3916	100
Residence		
Urban	2,196	56.08
Rural	1,249	31.89
Nomadic	471	12.03
Total	3,916	100
Educational level		
No Education	2,900	74.06
Primary	722	18.44
Secondary	216	5.52
Higher	78	1.99
Total	3,916	100
Wealth quintile		
Lowest	500	12.77
Second	597	15.25
Middle	898	22.93
Fourth	986	25.18
Highest	935	23.88
Total	3,916	100
distance to health facility		
a big problem	2,323	59.32
not big problem	1,593	40.68
Total	3,916	100

Table 1 (continued)

Variables	Freq	Percent
Marital status		
Married	3,582	91.47
Divorced	246	6.28
Widowed	88	2.25
Total	3,916	100
Sex of child		
Male	2,053	52.43
Female	1,863	47.57
Total	3,916	100
Child alive or dead at time of interview		
Alive	3,799	97.01
Dead	117	2.99
Total	3,916	100
Size of child at birth		
Very Large	223	5.69
Larger Than Average	215	5.49
Average	2,545	64.99
Smaller Than Average	257	6.56
Very Small	224	5.72
Don't Know	452	11.54
Total	3,916	100
Parity		
0–3	1,558	39.79
4–7	1,740	44.43
8–15	618	15.78
Total	3,916	100
Birth rank of child		
1	979	25
2	1,619	41.34
+3	1,318	33.66
Total	3,916	100
Place of delivery		
Her home	2,307	58.91
Other home	234	5.98
Health center	1,375	35.11
Total	3,916	100
Media exposure		
No	3,009	76.84
Yes	907	23.16
Total	3,916	100

Moreover, the educational level of the study participants is clarified underneath. 2,900 (74.06%) had no education, 722 (18.44%) had been in primary education, 216 (5.52%) had attended secondary education, and 78 (1.99%) had attended higher education. The wealth quantile of most of the mothers falls in the fourth quintile at 986 (25.18%) mothers. The second-largest number of mothers' wealth quintiles was in the highest quintile at 935 (23.88%). Moving on to the middle quintile, it accounted for 898 (22.93%) of the interviewed mothers. The second quintile represented 597 (15.25%) mothers, while the lowest quintile accounted for the least number of mothers at 500 (12.77%). As we can see, the distribution of wealth is relatively even, with the fourth and fifth quintiles holding the highest percentage of wealth.

The mothers' responses about residential distance from the health facility indicated that 2,323 (59.32%) of the mothers considered that the distance to the health facility poses a significant problem. In comparison, 1,593 (40.68%) participants reported that this was not a significant problem. In addition, 3,582 (91.47%) of the 3,916 participants were married. 246 (6.28%) were divorced and 88 (2.25%) were widowed. According to the table, the children born to the interviewed mothers were mainly 2,053 (52.43%) males, whereas the remaining 1,863 (47.57%) were females. When we examined the number of children alive or dead by the time the mothers were interviewed. 3,799 (97.01%) of the children born to the mothers were alive, while only 117 (2.99%) of the children died. For the child size at birth, 2,545 (64.99%) of the babies were of average size. Additionally, 452 (11.54%) respondents answered with "Do Not Know." about the size of the child at birth, 257 (6.56%) were smaller than the average size at birth and 224 (5.72%) were very small. Finally, 223 (5.69%) children were very large at birth, and 215 (5.49%), which accounted for the lowest percentage, were larger than average.

Based on the descriptive statistics in the table, the total number of children ever born to the mothers' proportions are as follows; 1,558 (39.79%) women had 0–3 children, 1,740 (44.43%) had 4–7 children, and 618 (15.78%) had 8–15 children. These statistics give us a glimpse into the average number of children women have and how they are distributed across groups. The distribution of the birth order of the last child given birth to by the mother is described. Most mothers, 1,619 (41.34%), were on their second child, while the mothers on their third child accounted for 1,318 (33.66%.) and 979 (25%) of the mothers had their first child at the time of the interview. The mother's home accounted for 2,307 (58.91%) deliveries, 1,375 (35.11%) occurred at health centers, and the remaining 234 (5.98%) mothers made delivery at other homes. For this study, mothers who have media exposure are only 23.16% which is about 907 mothers and others don't have any media exposure.

Table 2 displays the number of vaccinations for 3,916 children under the age of five years, ranging from none to eight vaccinations each. Of the 3,916 children, 709 (18.11%) received two vaccines each, with the highest recurrence rate. Moreover, 636 (16.24%) children

Table 2 Number of vaccinations received with its respective percentage among under-five children in Somalia, SHDS 2020

Number of vaccines	Freq	Percent	Cum
0	**358**	**9.14**	**9.14**
1	**636**	**16.24**	**25.38**
2	**709**	**18.11**	**43.49**
3	**469**	**11.98**	**55.46**
4	**388**	**9.91**	**65.37**
5	**290**	**7.41**	**72.78**
6	**343**	**8.76**	**81.54**
7	**476**	**12.16**	**93.69**
8	**247**	**6.31**	**100**
Total	**3,916**	**100**	

Table 3 Summary Statistics for the Number of received vaccinations of children under five years in SHDS, 2020

Observations	Mean	Variance
3,916	3.531	6.078

received one vaccine each, making it the second-highest recurrence. Additionally, 476 (12.16%) children received seven vaccines each. Also, 469(11.98%) children received three vaccines each. Furthermore, 388 (9.91%) children received four vaccines each. In addition, 358 (9.14%) children received 0 vaccines. Similarly, 343 (8.76%) children received six vaccines while 290 children (7.41) received five vaccines. Finally, the least number of children, 247 (6.31%) children to be specific, received eight vaccines each. About 93.69% of under-five children don't receive the full recommended vaccination schedule which shows us it requires a long way to go for full immunization coverage in the country.

Count regression analysis

Table 3 provides summary statistics for the number of vaccinations received by children under-five years old in Somalia, based on the 2020 Somalia Health and Demographic Survey (SHDS). This table includes the mean and variance of the number of vaccines received per child. The mean number of vaccines received per child under-five years old in Somalia was calculated to be approximately 3.531. This value represents the average number of vaccines administered to the children in this age group. This indicates that, on average, children in Somalia receive approximately four (3.531) vaccines as part of their immunization schedule which is much less than the WHO full recommended vaccination schedule. The variance in the number of vaccines received per child was 6.078 and this indicates that there is variability in the number of vaccines children under-five receive in Somalia. Since the variance is larger than the mean, there is an over-dispersion of data, which the Poisson count regression cannot handle. Therefore, a Negative-Binomial Regression was utilized to accommodate this variability.

The SHDS (2020) data on immunizations for children under five years underscores significant issues related to vaccine equity from a public health perspective. The mean number of 3.531 vaccines indicates that each child received roughly 44.14% of the full recommended immunization. The variance (6.078) and slight positive skewness (0.329) indicate disparities, with some children fully immunized and others under served. The kurtosis (1.848) suggests that the majority of children exhibit moderate under-vaccination, rather than being extreme outliers. This disproportionate distribution highlights the necessity for equitable healthcare policies and focused outreach to marginalized groups.

Figure 1 depicted a short dip at zero, indicating that zero outcomes are not abundant. This suggests that a small proportion of children under-five years of age received none of the vaccination. In contrast, observations with larger values (representing a higher number of vaccinations) were more frequent, leading to a close-to-normal distribution. These preliminary analyses indicated that Negative-Binomial Regression is better suited for fitting the data.

We also compared the two count regression models; Negative Binomial and Poisson regressions models using information criteria and confirmed that Negative Binomial regression model performed well for this data. All the analysis and conclusion derived are based on this finally selected model (Table 4).

Table 5 shows the results of incidence risk ratio (IRR) of each risk factor using the proposed Negative-Binomial regression model. The factors associated with the number of vaccinations received per child in the model included maternal age, region, residence, educational level, wealth quantile, child size at birth, parity, and birth order.

Women ages 20–24 (IRR = 1.192, 95% CI: 1.083, 1.313) and 25–29 (IRR = 1.180, 95% CI: 1.068, 1.305) had a higher number of vaccinations per child compared to women in the 15–19 age group. Women who attended primary (IRR = 1.090, 95% CI: 1.034, 1.150) and secondary education (IRR = 1.157, 95% CI: 1.058, 1.266) had a higher number of vaccinations per child than uneducated women. Additionally, women from households categorized under the middle (IRR = 1.094, 95% CI: 1.001, 1.196) and fourth (IRR = 1.110, 95% CI: 1.012, 1.217) wealth quantiles had significantly higher vaccinations per child than the lowest wealth quantile.

Furthermore, Nomadic dwellers had 32.1% less number of vaccinations taken per child compared to rural

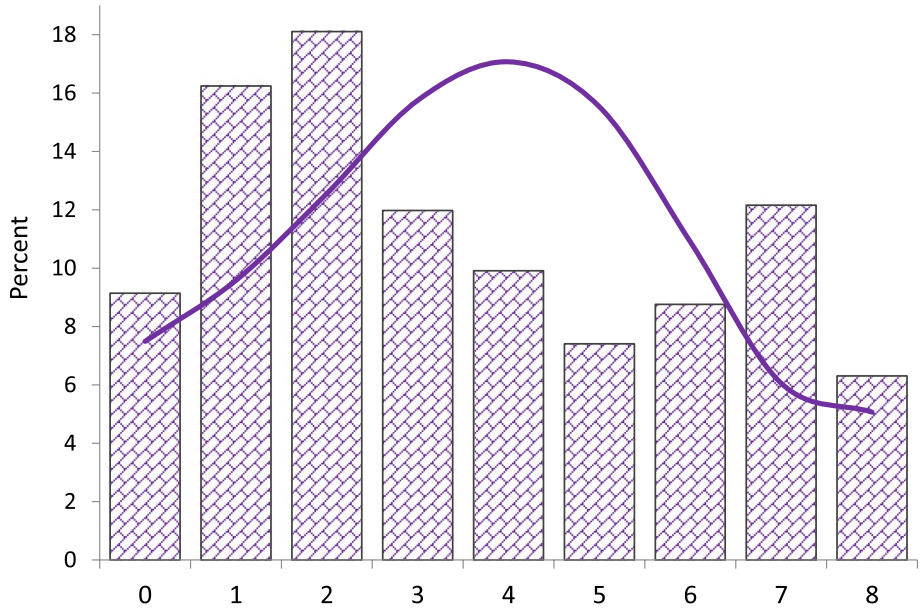

Fig. 1 Number of vaccinations received and percentages for each vaccines among under-five children in Somalia

Table 4 Comparison of Poisson and Negative Binomial regression models

Model Comparison		
Criteria	**Poisson**	**Negative Binomial**
AIC	16,915.7	16,757.35
BIC	17,216.8	17,064.73
log likelihood	−8409.9	−8329.67

dwellers (IRR = 0.679, 95% CI: 0.624, 0.738). Women who had 4–7 children (IRR = 1.090, 95% CI: 1.031, 1.153), and 8–15 children (IRR = 1.113, 95% CI: 1.025, 1.208) had significantly more vaccinations per child as compared to children of women with 0–3 children.

Region-wise, significant variations in vaccination utilization were observed across different regions of Somalia, with Sool (IRR = 1.343, 95% CI: 1.159–1.555), Sanaag (IRR = 1.422, 95% CI: 1.235–1.639), Bari (IRR = 1.307, 95% CI: 1.113, 1.535), Mudug (IRR = 1.246, 95% CI: 1.063, 1.461), Galgaduud (IRR = 1.331, 95% CI: 1.148, 1.544), Hiraan (IRR = 1.301,95%.CI: 1.104,1.533), Bay (IRR = 1.774,95%, Cl:1.503,2.094), and Bakool (IRR = 1.870.95%, Cl:1613,2.168) compared to Awdal as a reference.

Data analysis discussions

This study aimed to examine the factors influencing vaccination coverage among children aged under-five years in Somalia using the Somalia Demographic and Health Survey (SHDS) 2020. The analysis was performed using Negative-Binomial Regression and the number of vaccinations taken by each child was ranked from 0 to 8 vaccinations received. From this study about 9.14% of the children did not receive any vaccinations. From the total children, about 93.69% of children did not complete their immunization schedule. This coverage is significantly higher compared to other East African nations like Kenya (77%), Uganda (57.4%), and Rwanda (56.1%) [17, 26].

Providing the recommended eight doses of vaccines to children under-five years of age is essential for preventing severe infectious diseases, strengthening collective immunity, decreasing death and illness rates, and saving healthcare expenses. It promotes growth, elevates the standard of living, and fosters global health safety through the management of disease outbreaks. Vaccination ultimately safeguards individual health and promotes the overall welfare of the community, rendering it one of the most efficacious public health interventions. This finding indicates that the issue of low vaccination rates in Somalia requires immediate intervention. A similar result was reported by another study conducted in South Sudan [27] compared to the low number of vaccinated children.

One of the key findings of this study is that maternal age is a significant factor in determining vaccination coverage. Mothers aged 20–24 were 1.192 times more likely to vaccinate their children than mothers aged 15–19. This result was also shown by studies conducted in Afghanistan and Myanmar [28, 29] which showed age as a significant variable. A similar previous study revealed that women who were over 19 years old had a significantly

Table 5 Estimation of Parameter for each risk factors using Negative-Binomial Regression

Parameter Estimation of Negative-Binomial Regression					
	IRR	S.E	p-value	UB	LB
Constant	2.4	0.233	< 0.001	1.983	2.904
Maternal age (ref = 15–19)					
20 – 24	1.192	0.059	< 0.001	1.083	1.313
25 – 29	1.18	0.06	< 0.001	1.068	1.305
30 – 34	1.107	0.061	0.066	0.993	1.233
35 – 39	1.146	0.068	0.021	1.021	1.287
40 – 44	1.151	0.086	0.061	0.994	1.333
45 – 49	1.065	0.123	0.585	0.85	1.334
Region (ref = Awdal)					
Woqooyi Galbeed	0.751	0.06	< 0.001	0.642	0.877
Togdheer	0.795	0.061	0.003	0.685	0.924
Sool	1.343	0.101	< 0.001	1.159	1.555
Sanaag	1.422	0.103	< 0.001	1.235	1.639
Bari	1.307	0.107	< 0.001	1.113	1.535
Nugaal	1.139	0.092	0.107	0.972	1.335
Mudug	1.246	0.101	0.007	1.063	1.461
Galgaduud	1.331	0.101	< 0.001	1.148	1.544
Hiraan	1.301	0.109	0.002	1.104	1.533
Middle Shabelle	1.236	0.099	0.008	1.056	1.447
Banadir	0.666	0.05	< 0.001	0.576	0.771
Bay	1.774	0.15	< 0.001	1.503	2.094
Bakool	1.870	0.141	< 0.001	1.613	2.168
Gedo	1.697	0.131	< 0.001	1.459	1.975
Lower Juba	1.454	0.116	< 0.001	1.243	1.701
Residence (rural)					
Urban	1.021	0.027	0.429	0.97	1.075
Nomadic	0.679	0.029	< 0.001	0.624	0.738
Educational level (No education)					
Primary	1.09	0.03	0.001	1.034	1.15
Secondary	1.157	0.053	0.001	1.058	1.266
Higher	1.118	0.087	0.153	0.959	1.303
Wealth quintile (Poor)					
Second	1.011	0.043	0.793	0.93	1.1
Middle	1.094	0.05	0.048	1.001	1.196
Fourth	1.11	0.052	0.027	1.012	1.217
Highest	1.06	0.053	0.245	0.961	1.169
Distance (big problem)					
not big problem	1.003	0.021	0.875	0.962	1.046
Current marital status (Married)					
Divorced	0.979	0.042	0.62	0.899	1.066
Widowed	0.896	0.063	0.118	0.78	1.028
Sex of child (Male)					
Female	0.986	0.02	0.499	0.948	1.026
Child alive or dead (alive)					
Dead	0.962	0.059	0.524	0.852	1.085
Size of child at birth (Very large)					
Larger Than Average	0.869	0.054	0.025	0.769	0.983
Average	1.024	0.046	0.597	0.938	1.118
Smaller Than Average	0.928	0.055	0.207	0.827	1.042
Very Small	0.926	0.056	0.209	0.822	1.044
Don't Know	0.965	0.052	0.509	0.869	1.072
Parity (0–3)					
4–7	1.09	0.031	0.002	1.031	1.153
8–15	1.113	0.047	0.011	1.025	1.208
Birth order (1)					
2	0.956	0.025	0.088	0.907	1.007
+3	0.898	0.027	< 0.001	0.846	0.952
Place of delivery (Her home)					
Other home	0.94	0.042	0.171	0.861	1.027
Health center	1.038	0.025	0.128	0.989	1.088
Media exposure (No)					
Yes	1.027	0.029	0.35	0.971	1.087

higher likelihood, about 10 times, of fully immunizing their children compared to mothers who were under 19 years old. This phenomenon could be attributed to the accumulation of knowledge acquired over a period of time regarding the significance of immunization among mothers who are older than 19 years, along with the adverse consequences experienced by children as a result of not receiving immunization. Two research conducted in Ethiopia provide evidence to support this finding [30–32].

The number of vaccinations received by children varied significantly across regions, with Sanaag, Bari, Bay, Gedo and Bakool regions having a higher likelihood of sufficient vaccination coverage compared to the Awdal region and this finding is supported by a study conducted in Ethiopia [33]. This variation could be due to mothers choosing not to vaccinate their children, especially those from lower socioeconomic backgrounds, while others do so due to cultural and religious beliefs [34]. Another study conducted in Somalia specially North-western regions revealed that national budget distribution is a strong predictor of childhood vaccination rates, indicating that children in regions with higher budgets are more likely to receive vaccinations compared to those in regions with lower budgets [35]. Place of residence was also identified as a significant factor influencing the number of vaccinations received by under-five children in Somalia. The study revealed that children in nomadic areas had approximately 32.1% lower vaccinations than children in rural settlements. This finding is in line with earlier studies conducted in Somalia and North West Ethiopia [34,

36]. Furthermore, earlier research undertaken in several regions of Sub-Saharan Africa (SSA) including Nigeria, Ghana, Ethiopia, Burkina Faso, and Kenya have shown support for the notion that urbanicity is a significant predictor of childhood vaccine coverage [37–43].

Notably, the majority of other countries only have urban and rural populations, whereas Somalia has a substantial proportion of pastoralists that live nomadic lifestyles; approximately 26% of the Somali population consists of nomadic communities [43]. Because these people are generally transient and live in different places, there are less opportunities for them to acquire basic immunizations at a young age. When designing and executing the national expand program for immunization (EPI), the government may take into account methods to enhance immunization delivery to nomadic groups. This could be because Nomadic pastoralists have low awareness of the benefits of vaccinations due to the low access to education and the nomadic non sedentary lifestyle where families move around the wilderness setting up their makeshift homes wherever they find suitable pasture for their animals [35].

Furthermore, the study also revealed that mothers' education level had a substantial impact on the number of vaccinations received per child out of the eight total vaccinations. The number of vaccinations was higher among women attending primary and secondary education than among women with no formal education. This outcome corresponds with findings from other studies [36, 39]. Other studies conducted in Zimbabwe, Uganda and Ethiopia [44–48] have similarly highlighted the significance of maternal education as a key determinant of vaccine uptake. This is because education, adjustments to attitudes, customs, and beliefs, as well as more autonomy and decision-making, all have a direct impact on mothers' health-seeking behaviors. In addition to maternal education, mothers who were well-versed in immunization programs had a higher chance of their kids receiving vaccinations in the district. This study highlighted the influence of the wealth index on the number of vaccinations received by children. Children whose families were classified under the fourth wealth index category had a higher number of vaccinations than those in the poor wealth index category. This result aligns with previous studies that have shown a correlation between wealth index and vaccination utilization [37, 39, 41]. This might be households with greater incomes typically utilize health facilities more effectively and, as a result, are frequently informed about the advantages of childhood vaccination.

The correlation between the birth weight of the child and the number of vaccinations the child received by the age of five was determined to be significant. The study revealed that children of larger than average size at birth received approximately 13.1% fewer vaccinations than children of very large size at birth. This finding is consistent with the results of previous studies [44]. The possible reason for this could be mothers who give birth to average-sized children are more inclined to prioritize their child's health and regularly visit child health care services, including immunization programmes. On the other hand, women who give birth to larger-sized children may face more complications during delivery, which could potentially hinder their utilization of childhood vaccination services [33, 49].

The parity was also observed to have a substantial impact on vaccination. Women who had between 8 and 15 children were 1.113 times more likely to vaccinate their children than women who had between 0 and 3 children, while keeping all other factors constant. This finding is consistent with the results of previous studies [41, 50]. The reason for this could be that parity serves as an indicator of women's previous experience with maternal healthcare facilities, which in turn positively affects their acceptance of full immunization for their children [19, 51].

Birth order was also identified as a significant factor influencing the number of vaccinations for children in Somalia. The study revealed that children with higher birth have less number of vaccine doses compared to the first order child. This finding is consistent with a previous study [38, 42]. This could be explained by many reasons including the mother's experience with unvaccinated children who remaining healthy which leads her to take the vaccinations lightly and the other reason might also being busy taking care of the children and not finding someone to take care of them while she is away, as most Somali fathers do not stay home often, even if they are jobless.

Although this study provides vital insights into the factors that affect vaccination coverage among children under-five years of age in Somalia, it is important to highlight certain limitations. The cross-sectional nature of the Somali Health and Demographic Survey (SHDS) and being the first Health and Demographic Survey data limit the capacity to establish a causal relationship between predictor variables and vaccination uptake. Moreover, dependence on data provided by individuals themselves may lead to a bias in memory recall, which could potentially impact the precision of vaccination reporting.

Additionally, the study's emphasis on socioeconomic and demographic parameters may fail to consider other significant factors that influence vaccination utilization, such as cultural views, availability of healthcare facilities, and competence of vaccination service providers. In addition, while attempts were made to handle

confounding variables, the existence of unmeasured confounders could potentially have influenced the results of the study. The findings of this study may have limited generalizability to populations other than Somalis, as they may not be applicable to environments with distinct healthcare systems and societal norms. Despite these limitations, this study offers useful insights into the complex nature of vaccination usage in Somalia. It also emphasizes areas that require more research and interventions to enhance maternal health care outcomes. This study on vaccination coverage among under-five children in Somalia demonstrates its robustness by meticulously utilizing data from the 2020 Somalia Health and Demographic Survey (SHDS), providing a comprehensive and dependable dataset for analysis. By applying advanced statistical methods such as Negative-Binomial regression, the research effectively tackles the inherent complexities associated with counting data, ensuring the accuracy and validity of its findings. The study's thorough exploration of factors influencing vaccination rates including maternal age, educational attainment, wealth status, and regional disparities provides nuanced, timely, and actionable insights for stakeholders. By leveraging a nationally representative dataset and employing rigorous statistical techniques, the study significantly advances our understanding of vaccination utilization patterns, informing targeted interventions and policy decisions to enhance child health outcomes in Somalia. This rigorous approach strengthens the credibility of the findings and lays a solid groundwork for future research and programmatic efforts focused on improving vaccination coverage in similar contexts globally.

Despite its methodological strengths, this study is constrained by several limitations that deserve consideration. The primary limitation is its cross-sectional design, which restricts the ability to determine causal relationships between predictor variables and vaccination outcomes, underscoring the necessity for longitudinal studies to substantiate findings across time. Furthermore, reliance on self-reported data for vaccination history introduces potential biases, such as recall bias, which may impact the accuracy and reliability of reported vaccination coverage rates. Moreover, the study's narrow focus on socioeconomic and demographic factors may overlook other crucial determinants of vaccination uptake, including cultural beliefs, accessibility of healthcare services, and the quality of vaccination delivery. These limitations underscore the complex nature of vaccination behaviors in diverse contexts like Somalia and emphasize the importance of holistic approaches in future research and intervention strategies to enhance vaccination rates and overall child health outcomes. Addressing these limitations through improved study designs and broader data collection methodologies will be essential in advancing our understanding and effectively enhancing vaccination programs globally.

Conclusions

This study aimed to identify the factors influencing the number of vaccinations received by children under the age of five in Somalia. This was performed by utilizing two count regression models with the SHDS 2020 data. The SHDS, being the first national survey, holds significant value in identifying predominant public health concerns on a nationwide scale. Descriptive statistics revealed that 9.14% of children in Somalia had never received any vaccination, indicating a serious pattern of underutilization of vaccination among children under the age of five. The NB regression model was chosen as the most suitable model for predicting the number of vaccination uptake among under-five children in Somalia, based on the findings of traditional count regression models. This conclusion was made because the NB regression model had the lowest AIC and BIC values among the count regressions, which characterized it as the best fit for the data. The results of the selected NB regression model indicate that age, residence, educational level, wealth quintile, child size at birth, parity, and birth order are statistically significant factors affecting the number of vaccinations received by children under-five years of age in Somalia. Likewise, the region has a significant impact on the number of vaccinations among children under the age of five in Somalia.

Based on these findings, we can understand that there is still a long way to go for increasing the immunization coverage for under-five children and specific interventions should be created and implemented to tackle the factors that affect the vaccinations coverage among under-five children in Somalia.

Improving basic immunization coverage among nomadic populations in Somalia is crucial, as they often face significant barriers to accessing healthcare services. Given their limited access to education and their nomadic lifestyle, these populations may lack awareness of the benefits of vaccination. To address this issue, community outreach programs and mobile vaccination teams, potentially staffed by medical students during university holidays, can be deployed to reach these underserved communities. By implementing targeted strategies and leveraging the expertise of healthcare professionals, it is possible to enhance immunization rates and improve the overall health of nomadic communities in Somalia.

To enhance basic immunization rates in regions with low coverage, the Federal Government of Somalia can increase healthcare budget allocations for these areas, prioritizing distribution of funds. Concurrently, regional

governments can allocate sufficient resources to improve healthcare infrastructure and implement targeted immunization initiatives. These initiatives should include awareness campaigns led by local community and religious leaders to address misconceptions and cultural barriers related to vaccination. The initiatives should prioritize enhancing educational accessibility, particularly for women, strengthening healthcare infrastructure in nomadic regions, and tackling socioeconomic gaps that might hinder access to healthcare services. Furthermore, it is imperative to enhance the capacity of healthcare systems at the regional level in Somalia and guarantee fair and equal access to vaccination services provided by international donors throughout the country.

Abbreviations

PHC	Primary Health Care
UNICEF	United Nations Children's Fund
WHO	World Health Organization
FMoH	Federal Ministry of Health
IDP	Internally Displaced Persons
SHDS	Somali Health and Demographic Survey
EPI	Expanded Programme on Immunization
AIC	Akaike Information Criteria
BIC	Bayesian Information Criteria
IRR	Incidence Rate Ratio
NB	Negative-Binomial

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Authors' contributions
DBB and MIA were involved in performing the data extraction, analyzing, editing, revising, and reviewing the entire manuscript. DC was involved in critically reviewing the manuscript. UAJ contributed to the writing of manuscripts and corrected grammatical errors. All authors have read and approved the final manuscript.

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Data availability
The data used in this study were Somalia Health and Demographic Survey 2020 data (SHDS 2020) and can be obtained or accessed from the Somalia National Bureau of Statistics (SNBS) at https://microdata.nbs.gov.so/index.php/catalog/50. This dataset is publicly available and can be accessed for research purposes. The data were accessed on May 1, 2024.

Declarations

Ethics approval and consent to participate
Not applicable.

Consent for publication
Not applicable.

Competing interests
The authors declare no competing interests.

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