RESEARCH



Uptake and determinants of routine vaccines among children aged 12–23 months in adansi South district of Ghana. a cross-sectional study

Samuel Sem^{1,2}, Jacob Owusu Sarfo², Mustapha Amoadu² and Thomas Hormenu^{2,3*}

Abstract

Background Routine childhood vaccination (RCV) has demonstrated its effectiveness, saving millions of lives globally and reducing childhood mortality. However, several factors impede mothers from completing their children's vaccination schedule. The purpose of this study was to determine factors influencing RCV among children aged 12–23 months in the Adansi South District (ASD) of Ghana.

Methods A cross-sectional community-based survey with a census approach was conducted involving 3,312 mothers with children aged 12–23 months. Frequency and percentage, bivariate, and hierarchical binary logistic regression analyses were used to identify the factors related to RCV.

Results The number of fully vaccinated children was 56.8% with partially vaccinated being 43.2%, indicating a low full RCV. The factors that influenced RCV included the child's birth order (AOR=0.653, [0.452-0.945], p=0.024), maternal religious affiliation (AOR=1.315, [1.098–1.575], p=0.003), Antenatal care (ANC) contacts (AOR=2.045, [1.315–3.179], p=0.001), number of times ANC contacted (AOR=0.597, [0.502-0.710], p=0.000), and child (AOR=1.842, [1.566–2.166], p=0.000) and mother's age (AOR=2.346, [1.369–4.019], p=0.002). Maternal (AOR=1.461, [1.143–1.866], p=0.002) and spousal income adequacy (AOR=1.590, [1.081–2.337], p=0.018), spouse's income irregularity (AOR=2.292, [1.757–2.987], p=0.000), and if spouse's income is the sole source of livelihood (AOR=1.751, [1.271–2.414], p=0.001), type of material used for house construction (AOR=1.459, [1.046–2.033], p=0.026), and the type of housing for dwelling (AOR=1.570, [1.310–1.881], p=0.000), as well as mothers' perception of vaccines, and vaccination activities (AOR=1.333, [1.137–1.562], p=0.000) influence RCV in the district.

Conclusions The relatively low uptake of RCV is indicative of low herd immunity among these children and posing a potential risk of causing vaccine-preventable diseases (VPD) outbreaks and subsequent health issues among children. The Ghana Health Service should offer flexible scheduling and reminder systems for vaccination appointments in the district. The GHS should prioritise targeted interventions during child welfare clinics (CWC), ANC contacts, and community gatherings to educate mothers on the importance of childhood vaccinations.

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Keywords Routine vaccination, Childhood, Children 12–23 months, Fully vaccinated, Factors, Ghana

Background

Childhood mortality poses a considerable global challenge, particularly in Africa and sub-Saharan Africa [SSA] [1]. In 2019, Africa reported the highest number of childhood deaths, and SSA alone accounted for more than half of the global figures [2]. Despite advancements, Ghana continues to grapple with under-5 mortality rates exceeding the targets outlined in the Sustainable Development Goals (SDGs) [3]. Immunisation has emerged as a key strategy for mitigating childhood mortality, preventing vaccine-preventable diseases [VPDs], and enhancing herd immunities in the community [4, 5].

Routine childhood vaccination (RCV) has demonstrated its effectiveness, annually saving millions of lives [5]. For instance, the increased global coverage of measles vaccination has substantially reduced both measles incidence and related deaths [6]. Ensuring that children receive the recommended vaccination is essential for its effectiveness in protecting them against diseases, disabilities, and mortality [7, 8]. However, several factors impede mothers from completing the vaccination schedule of their children, leading to a compromise in the significant effect of immunisation programmes on reducing childhood morbidity and mortality. Factors such as child's age, child's birth order, number of children, age of the mother, marital status, education, religious belief, antenatal care contacts, place of delivery, parents' parents' occupation and wealth status, type of house for dwelling, mothers' knowledge, perceived attitudes and perception on vaccines and vaccination activities influences utilisation of childhood routine vaccines [9-14, 19, 20, 27, 29-32, 34-44].

Despite support from the World Health Organisation (WHO), Ministry of Health (MOH), Ghana Health Service (GHS), and other partners, some districts in Ghana struggle to achieve high levels of full vaccine uptake for children. Recent studies in the Okaikoi submetro of Greater Accra, Assin North district of the Central Region, and Techiman Municipality in Bono East reported full childhood vaccine uptake rates of 53.3%, 85.4%, and 89.5% respectively [12–14]. The Adansi South District (ASD) of Ghana has consistently failed to reach the target vaccine uptake rate of 95% [15–17]. Furthermore, there is a lack of community-based studies that identify the factors contributing to the low and declining routine childhood vaccine uptake in ASD.

To address this gap, the current study aims to determine routine childhood vaccine uptake (RCVU) and identify the factors that influence levels of RCV in ASD. The study's findings will enhance the understanding of RCV service utilisation and provide extensive information for the GHS to achieve national immunisation targets. It will also serve as a reference for academic purposes, particularly for health education students in Ghana and worldwide. Additionally, the findings will inform policies and interventions to reduce child mortality and morbidity, which is in line with the SDGs for child survival (SDG 3.2).

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Theoretical framework

Andersen's Healthcare Utilisation (AHU) Model, developed in 1968 [18], forms the theoretical base of this study. As shown in Fig. 1, the model suggests that individuals' health-seeking behaviour is influenced by three categories of personal characteristics: predisposing, enabling, and need factors. The assumption is that an individual's actual uptake of health services is a sequential and conditional function of their predisposition to use them, their perceived need for them, and their capacity to obtain and utilise such services. Some of the variables fit into more than one of these categories. Some variables fall into multiple categories, leading to self-categorisation.

Andersen's findings indicate that predisposing factors like the child's age, birth order, number of children, mother's age, mother's religious affiliation, antenatal care (ANC) contacts, number of ANC contacts, place of delivery (healthcare institution or home), and the mother's religious beliefs impact the likelihood of utilising health services. Those who perceive health services as beneficial for disease prevention are more inclined to use them. Enabling factors include family and community resources, such as parental occupation, income, income regularity, and type of housing. The need component considers the knowledge, attitudes, and perceptions of mothers, with those recognising the preventive benefits of health services being more likely to use them [19, 20].



Fig. 1 Theoretical framework adapted from Andersen's Healthcare Utilisation Model (Andersen, 1968)

Methods

Study design/population/sampling procedures

This community-based household study employed a cross-sectional study design and was guided by a quantitative approach. The study utilised a census approach, to include all eligible mothers with children aged 12–23 months in the district, comprising 3,312 mothers [97% of the estimated sample size of 3,408]. Current data suggests that the percentage of children aged 12–23 months constitutes 4% of the total population [21] in the district. Therefore, 4% of a population of 85,200 equals 3,408.

Through the census approach, all households within a cluster underwent screening, and every eligible mother willing and consented was selected for the study. Each residence in each of the 30 clusters in the district was visited to identify households and enrolled all eligible mothers, regardless of the initially estimated target number of respondents per cluster [22]. The study chose the entire population of 3,408 mothers with children aged 12–23 months in the ASD of Ghana due to its well-defined and accessible nature. This approach eliminated potential biases that could occur through the sampling procedure. Furthermore, the question of generalisation does not arise since every member of the population was involved [23, 24].

Data collection tool

Interviewers administered a paper-format survey questionnaire to collect information from mothers of children aged 12–23 months, facilitated by twenty trained research assistants (RAs). Originally in English, the questionnaire underwent translation into Twi (Asante) to accommodate respondents not proficient in English, as Twi (Asante) is the predominant language in ASD. To ensure translation accuracy there was back-to-back translation. The questionnaire employed in this study sought direct responses from participants and included data extraction from the Mother and Child Health Records Book (MCHRB), also known as the home-based record, vaccination card, or weighing card. The MCHRB functions as a home-based health record designed for mothers, newborns, and children, to enhance the continuum of care for maternal and child health [25]. The study focused on the Child Welfare Clinic (CWC) section of the MCHRB, concentrating on reviewing the child's vaccination history to determine their routine vaccine uptake in the district.

Data collection procedures

To ensure consistency in the survey administration, the RAs were well-trained and the training sessions involved using sample questionnaires in English and translated Twi (Asante) version, along with mother and child health record books (MCHRB). RAs were trained in data extraction, questionnaire administration, respondent identification, rapport-developing skills, and encouraging mothers to provide MCHRB. They were paired into ten groups to practice and refine their skills. Eligible mothers who had consented and lived in designated clusters participated as respondents. Data collection took place from morning

to evening to suit their availability. A translated Twi version was provided for those with reading or writing difficulties. RAs also extracted vaccination data from the MCHRB for the questionnaire. Face-to-face administration was preferred for reliability and accuracy, considering literacy levels, particularly in rural areas. Non-literate respondents were assisted through a survey interview, while literate participants completed the questionnaire independently.

The process of collecting data involved visiting all eligible and willing households at their residences in the ASD of Ghana. The focus was on mothers with children aged 12–23 months present during the data collection period. Trained research RAs administered the survey questionnaire to directly gather responses from these eligible mothers after verbal and written informed consents were obtained. Data collection occurred between January 2023 and March 2023, commencing promptly after receiving ethical clearance approval from the Committee on Human Research, Publication and Ethics [CHRPE) at the Kwame Nkrumah University of Science and Technology (KNUST) [on 6/12/2022 with Ref: CHRPE/AP/797/22] for the study and adhering to all necessary protocols. The approved ethical clearance, along with the introductory letter obtained from the District Director of Health Services (DDHS) in ASD, was disseminated to relevant stakeholders, including community elders and opinion leaders in each cluster, to keep them informed about the study. Before participation, informed consents were from mothers, however, mothers below age 18, parental/care givers' informed consents were obtained before their participation. Participation in the study was voluntary.

Statistical analysis

To measure the routine childhood vaccine uptake to determine the vaccination status of children aged 12-23 months in ASD, a descriptive statistic of simple frequencies and percentages were used to report on the proportions of vaccine utilisation among children aged 12-23 months. We also performed a Bivariate correlation with a chi-square test to check if the independent variables (IVs) significantly correlated with the dependent variable (DV). With this, the variables that were significant with *p*-value < 0.05 were retained in the hierarchical binary logistic regression model. Hierarchical binary logistic regression was utilised to identify the unique contribution of each component of Andersen's utilisation model in explaining the variance in vaccination status of children between 12 and 23 months. Only the significant predictor variables in the bivariate analysis were introduced into the hierarchical binary logistic regression model. In Step 1 (Model 1), predisposing variables like the number of children, child's birth order, child's age, age of mother, mother's religious affiliation, antenatal care (ANC)

contacts, number of times ANC contacted, and place of delivery of the eligible child were included. Step 2 (Model 2) included enabling variables such as mother's occupation, income adequacy, income regularity, income sole dependency on income, spouse's occupation, spouse's income adequacy, sole dependency on spouse's income, house construction material, and type of house for dwelling. Finally, Step 3 (Model 3) involved the need variable, comprising mothers' perceptions of vaccines and vaccination activities, as detailed in Table 1.

Results

Description of routine childhood vaccine uptake

A descriptive statistic of simple frequencies and percentages on the proportions of vaccine uptake was used to measure the vaccine uptake and determine the RCVU in ASD.To measure the vaccine uptake to determine the RCVU in ASD. The results are presented in Table 2. Out of the total number of 3,312 captured in the district, fully vaccinated children were 56.8% (n = 1,881) and partially vaccinated 43.2% (n = 1,431) with confidence interval (CI) of -5% [lower limit] or + 5% [upper limit].

Bivariate association

From the bivariate analysis, child's age, child's birth order, number of children, age of the mother, belief acceptance of child vaccination, antenatal care contacts, number of times ANC contacted, place of delivery, mother's occupation, mother's income adequacy, mother's income regularity, mothers income the sole source of household living, spouses occupation, spouses income adequacy, spouses income regularity, spouses income the sole source of living, building material for the house, type of house for dwelling, and mothers perception on vaccines and vaccination activities were strongly related to RCVU. However, mothers' knowledge and mothers' perceived attitudes towards vaccines and vaccination activities were not related to RCVU in the ASD of Ghana (see Table 3).

Multivariate association

In the first model, predisposing variables accounted for 12.7% of the variation in RCVU. In the second model, enabling variables explained 22.3% of the variance in RCVU. Similarly, the third model, incorporating the need variable specific to Ghana's ASD, accounted for 22.8% of the variance in RCVU as indicated in Table 1.

Concerning the predisposing variables, it was revealed that the child's birth order was significant, with thirdborn children [AOR=0.653, (0.452-0.945), p=0.024] less likely to be fully vaccinated compared to first-borns. Additionally, the religious affiliation of mothers was significant, with Muslim mothers [AOR=1.315, (1.098–1.575), p=0.003] more likely to complete childhood vaccination schedules than Christian mothers. Similarly,

 Table 1
 Hierarchical binary logistic regression predictors of routine childhood immunisation status in adansi South district

Variables	Model 1		Model 2		Model 3	
	AOR	95% Cl	AOR	95% Cl	AOR	95% Cl
No. of Children (ref. 1st)	1		1		1	
2nd	.926 ^{NS}	.705-1.216	.876 ^{NS}	.657 – 1.170	.883 ^{NS}	.662-1.178
3rd	1.676**	1.192-2.355	1.306 ^{NS}	.907 – 1.880	1.367 ^{NS}	.948–1.970
4th and above	1.830*	1.100-3.046	1.326 ^{NS}	.776-2.264	1.348 ^{NS}	.789-2.303
Child's birth Order (ref. 1st)	1		1		1	
2nd	1.106 ^{NS}	.838-1.460	1.060 ^{NS}	.789-1.425	1.055 ^{NS}	.785-1.418
3rd	.578**	.411811	.678*	.469980	.653*	.452945
4th and above	.703 ^{NS}	.414-1.193	.799 ^{NS}	.458-1.395	.774 ^{NS}	.443-1.352
Mothers' Religion (ref. Christian)	1		1		1	
Muslim	1.290**	1.087-1.531	1.313**	1.097-1.572	1.315**	1.098–1.575
Traditionalist	1.625*	1.065-2.481	1.403 ^{NS}	.903-2.178	1.392 ^{NS}	.894-2.166
No religion	1.192 ^{NS}	.845-1.682	1.349 ^{NS}	.930-1.956	1.304 ^{NS}	.896-1.896
Belief Accept. of Vac (ref. Yes)	1		1		1	
No	1.114 ^{NS}	.767-1.619	.970 ^{NS}	.656-1.435	.982 ^{NS}	.662-1.457
ANC Contacts (Yes)	1		1		1	
No	2.345***	1.539–3.573	2.064**	1.330-3.202	2.045**	1.315-3.179
No. of ANC Contacts (ref. < 4 contacts)	1		1		1	
4 or more contacts	.414***	.355484	.584***	.491693	.597***	.502710
No contact	.908 ^{NS}	.523-1.576	.917 ^{NS}	.512-1.641	.976 ^{NS}	.542-1.758
Place of Delivery (ref. home)	1		1		1	
Health facility	.930 ^{NS}	.759-1.139	.965 ^{NS}	.777-1.198	.936 ^{NS}	.752-1.164
Child's Age (ref. 12–17 months)	1		1		1	
18–23 months	1.664***	1.428–1.938	1.812***	1.542-2.129	1.842***	1.566–2.166
Mother's Age (ref. < 20 years)	1		1		1	
20–29 years	1.973**	1.185–2.286	2.358**	1.383-4.021	2.346**	1.369–4.019
30–34 years	1.549 ^{NS}	.921-2.607	1.942*	1.125-3.353	1.901*	1.096-3.297
35 years or more	1.888*	1.113-3.201	2.554**	1.467–4.447	2.528**	1.446–4.421
Respondent's Occu. (ref. Gov't)			1		1	
Private work			.789 ^{NS}	.597-1.044	.798 ^{NS}	.603-1.056-
Self-employed			.835 ^{NS}	.632-1.102	.851 ^{NS}	.644-1.124
Unemployment			1.136 ^{NS}	.810-1.593	1.119 ^{NS}	.797-1.571
Is income adequate (ref. Yes)			1		1	
No			1.510	1.183–1.926	1.461	1.143–1.866
Is income regular (ref. Yes)			1 NC		NC	
No			1.079 ^{NS}	.850 – 1.370	1.104	.868-1.403
Spouses' Occupation (ref. Gov't)			1		1	
Private work			.880 ^{NS}	.679-1.141	.883 ^{INS}	.681-1.145
Self-employed			.980 ^{IND}	.756-1.268	.988 ^{IND}	.763-1.281
Unemployment			1.032	.632-1.712	1.058	636-1.759
Spouse's income okay (ref. Yes)] NS		1	
No			1.241	.961-1.601	1.248	.966-1.613
No idea (not certain)			1.568	1.068-2.303	1.590	1.081-2.337
Spouse's income Regular (ref. Yes)			1	4 700 0 005	1	4 757 0 007
No			2.253	1./30-2.935	2.292	1./5/-2.98/
Noidea			.861113	.596-1.243	0.871	.602-1.258
Spouses' income sole source of Living (ref. Yes)			I NS	777 4 6 4 5		707 4 0 4 0
NO			.984'''	.///-1.245	.99/'**	./8/-1.263
No idea			1./89	1.299–2.464	1./51	1.2/1-2.414
Material for Building (ref. Block's house)			1 227*	1000 1 170	1.100 ^{NIS}	004 1 117
BLICK NORSE			1.23/	1.039-1.4/3	1.188'''	.996-1.41/
Type of house for Dwelling (ref. service decided)			1.497	1.070-2.082	1.459 1	1.040-2.033
Type of house for Dwenning (rel. compound rise)			1		I	

Table 1 (continued)

Variables	Model 1		Model 2		Model 3	
	AOR	95% Cl	AOR	95% Cl	AOR	95% Cl
Self-contained House			1.524***	1.274-1.824	1.570***	1.310-1.881
Semi-detached House			1.231 ^{NS}	.946 - 1.600	1.229 ^{NS}	.944-1.599
Mothers' Perception on Immunisation (ref. Poor)					1	
Good perception					1.333***	1.137-1.562
Note: Nagelkerke R Square	0.127		0.223		0.228	
- NE						

Ref: ****p* < 0.001; ***p* < 0.01; **p* < 0.05; ^{NS}*p*>0.05

 Table 2
 Routine childhood vaccine uptake status of children

 12–23 months in ASD of Ghana
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Status	Utilisation	Total (%)		
Fully vaccinated	1,881	56.8		
Partially vaccinated	1,431	43.2		
Total	3,312	100		

mothers' attendance at ANC during pregnancy was significant, with those with no ANC contact [AOR = 2.045,(1.315-3.179), p = 0.001] more likely to fully immunise their children than ANC attendees. Likewise, the frequency of ANC visits during pregnancy strongly predicted vaccination uptake, with those who had 4 or more contacts [AOR = 0.597, (0.502-0.710), *p* = 0.000] less likely to fully vaccinate their children than those with fewer than 4 contacts. The age of both the child and the mother also significantly predicted RCVU. Children aged 18-23 months were [AOR = 1.842, (1.566-2.166), p = 0.000] more likely to be fully immunised than those aged 12-17 months. Similarly, mothers aged 20-29, 30-34, and 35 years and older were [AOR = 2.346, (1.369-4.019), p = 0.002], [AOR = 1.901, (1.096-3.297), p = < 0.022], and [AOR = 2.528, (1.446-4.421), p = 0.001], respectively, more likely to fully complete their children's immunisation schedules than those under 20 years old. However, the number of children [AOR = 0.876, (0.657 - 1.170),p = 0.396], mothers' belief acceptance of childhood immunisation [AOR = 0.970, (0.656 - 1.435), p = 0.928], and place of delivery of the eligible child [AOR = 0.965,(0.777-1.198), p = 0.552 remained statistically nonsignificant in predicting RCVU in the ASD of Ghana as shown in Table 1.

Regarding the enabling variables, factors such as maternal occupation [AOR = 0.798, (0.603-1.056), p = 0 0.114], the regularity of maternal income [AOR = 1.104, (0.868-1.403), p = 0 0.421], and spouses' occupation [AOR = 0.883, (0.681-1.145), p = 0.347] did not exhibit significant influence on RCVU in the ASD of Ghana. However, household income adequacy emerged as a significant determinant. Mothers certain of receiving insufficient income were [AOR = 1.461, (1.143–1.866), p = 0.002], more inclined to complete their children's vaccination schedules than those confident about receiving adequate income. Additionally, mothers uncertain

about their spouse's income adequacy were [AOR = 1.590, (1.081-2.337), p=0.018] more likely to fully utilise vaccination schedules for their children than those certain about their spouses receiving adequate income. Furthermore, mothers certain about their spouse's irregular income were [AOR = 2.292, (1.757–2.987), p = 0.000] more likely to fully utilise vaccination schedules for their children than those certain about their spouse's income regularity. Mothers' perception of whether their spouse's income was the sole source for household living significantly influenced RCVU. Mothers unsure whether their spouse's income was the sole source for household living were [AOR = 1.751, (1.271-2.414), p = 0.001] more likely to fully vaccinate their children than those who were certain about their spouses solely providing for the family. The type of material used for the mothers' houses also significantly predicted RCVU in the ASD of Ghana, with mothers living in mud houses [AOR = 1.459, (1.046-2.033), p = 0.026] being more likely to fully complete their children's immunisation schedules compared to those dwelling in block constructed houses. Additionally, the type of house for household dwelling strongly predicted RCVU, with mothers residing in self-contained houses [AOR = 1.570, (1.310–1.881), *p* = 0.000] being more likely to fully vaccinate their children compared to those living in compound houses as shown in Table 1.

Relating to the need-based factors, mothers' perception of immunisation and immunisation activities significantly influenced RCVU in ASD of Ghana. Mothers with a positive perception [AOR = 1.333, (1.137–1.562), p = 0.000] were more likely to complete their children's vaccination schedules than those with a negative perception, as indicated in Table 1.

Discussion

Routine childhood vaccine uptake

We estimated the routine vaccine uptake among children aged 12–13 months to identify the mother and child predisposing, enabling, and need determinants in ASD of Ghana. Overall, children fully vaccinated were 56.8%, with children partially vaccinated at 43.2%, suggesting a low fully vaccine uptake rate in the district compared to the national target of 95% [16]. This finding indicates a low full RCV rate among children aged 12–23 months old, as found in the prior studies [12–14]. Thus, this outcome suggests that many children aged 12–23 months are not receiving RCV, protects them against various killer diseases and ensures herd immunity. From this finding, more children are likely to be prone to acquiring any of the deadly childhood-preventable diseases that could lead to morbidity, disability, or death.

Determinants

Our study evaluated some mother and child predisposing, enabling, and need factors that determined vaccine uptake in ASD in Ghana.

Predisposing factors

Our study found that the number of children a woman has significantly influences whether they receive recommended vaccinations. Mothers with three or more children are likelier to ensure full vaccination than those with only one child. This trend may be due to the experience and understanding of vaccination benefits gained from previous children [26]. These mothers may have seen the positive effects of vaccination on their older children, leading to a stronger commitment to vaccinate all their children. This finding differs from some previous studies [27] that suggested increased familial responsibilities with more children might reduce the likelihood of subsequent children being vaccinated.

We also found that birth order significantly impacts the likelihood of children being fully vaccinated, with thirdborn children less likely to receive complete vaccination than firstborns. This suggests that as mothers have more children, their motivation to ensure full vaccination diminishes, potentially leaving later-born children vulnerable to preventable diseases. Contributing factors may include less time and attention for each child's healthcare needs and logistical challenges in scheduling appointments [28]. Incomplete vaccination increases the vulnerability to VPDs within households and can strain public health systems, raising healthcare costs and hospitalisations. This outcome aligns with previous studies suggesting firstborn children are more likely to be fully immunised on time [29–32].

Our study further found that maternal religious affiliation significantly influences vaccination completion. Muslim and traditional mothers are more likely to ensure their children complete vaccination schedules compared to christian mothers. Interestingly, a similar study in Nigeria showed muslim mothers as more likely to complete vaccination schedules compared to traditional mothers [33]. However, this study contrasts with a study from Ethiopia which found Christian women more likely than Muslim women to make fewer antenatal care visits [34]. This study outcome may result from Muslim and traditional communities having stronger communal norms around healthcare practices. Also, religious leaders in muslim and traditional communities might actively promote vaccination, framing it as a moral and religious duty to protect children and the broader community.

Interestingly, our study revealed a strong relationship between attending ANC and vaccine utilisation with no ANC contact during pregnancy and was more likely to complete childhood vaccination schedules than those with ANC contacts. Previous studies from Ethiopia do not support this finding, indicating that mothers with no ANC contacts are more likely to default in completing their children's vaccination schedules compared to those with ANC contacts during pregnancy [35-37]. This study outcome may be explained by the fact that mothers lacking ANC access in certain communities may reside in areas with limited healthcare services. Paradoxically, these communities may have better access to vaccination services through outreach programmes or community initiatives, resulting in higher vaccination rates despite lower ANC utilisation. Additionally, some communities prioritise childhood vaccination through communitybased health programmes, independent of ANC attendance, targeting households with unmet ANC needs for vaccination outreach.

Similarly, the relationship between the frequency of ANC contacts and RCVU reveals a significant trend, mothers who had four or more ANC contacts during pregnancy were less likely to ensure full vaccination status for their children than those with three or fewer contacts. This suggests that while ANC visits are important, the number of visits alone may not determine vaccination uptake. This finding aligns with previous research indicating that mothers with at least two ANC followups during pregnancy were more likely to vaccinate their children compared to those without follow-ups [38]. ASD in Ghana is a rural district where most communities are widely dispersed within forested areas. Mothers who face challenges in accessing ANC may also be reluctant to travel for their children's vaccinations, despite being aware of their benefits. While the majority of mothers in the district accept childhood vaccinations, some members of rural communities for unknown reasons reject all forms of vaccination for their children, which could hinder overall vaccine uptake in the district. Another observed trend is that some mothers discontinue child welfare clinic (CWC) visits for vaccinations after their children receive Penta 3 and OPV3, despite having attended ANC, leading to incomplete vaccination schedules.

We found that children aged 18–23 months were significantly more likely to be fully vaccinated compared to those aged 12–17 months. This suggests that as children grow older, mothers' motivation to immunise them fully tends to increase. Factors contributing to this include potential delays in vaccination due to missed appointments, parental concerns, or illness. Additionally, older children have had more time to complete their vaccination schedule, which typically spans the first two years of life, and may have reached the age at which specific vaccines are typically administered. The implications of lower vaccination rates among children aged 12–17 months include an increased risk of VPDs, heightened healthcare costs, and a greater likelihood of hospitalisations, impacting the health of susceptible family members [28].

Mothers' age significantly influenced the likelihood of fully vaccinating their children in this study, with those aged 20 and older more inclined to do so than younger mothers. Similar findings have been observed in Asia, where older maternal age predicts higher immunisation coverage [39, 40]. This is possible because older mothers have more exposure to vaccination information from education, healthcare, and personal experiences. They also benefit from stronger social support networks and a heightened sense of maternal responsibility. Lower vaccination rates among younger mothers can lead to public health risks, including disease outbreaks and increased healthcare costs. Targeted health education campaigns for younger mothers, emphasising vaccine safety and benefits, are vital.

Enabling factors

We found that mothers who are certain about having insufficient income are more likely to ensure their children adhere to vaccination schedules than those confident about having enough income. This suggests that financially stable mothers may be less likely to ensure full vaccination for their children. This contrasts with previous findings that children from the richest wealth quintile are more likely to be fully vaccinated compared to those from the poorest quintile [8, 39]. The current trend may be explained by mothers with uncertain incomes being more inclined to participate in free vaccinations programmes as the case is in the district, recognising their importance in promoting children's health. Additionally, financial insecurity may heighten their awareness of the health risks associated with VPDs, prompting them to prioritise vaccination. These mothers may also prioritise their children's health as a preventive measure and rely more on accessing free vaccination services.

We also found that mothers uncertain about their spouse's income adequacy were more likely to ensure complete vaccination for their children compared to those confident about their spouse's income adequacy. This finding suggests that being financially adequate as a household does not necessarily translate into full vaccination of children, and other factors may be involved. However, this outcome contrasts previous findings noting that financial limitation is the main barrier that hinders childhood vaccination [30, 41], adding that children from the lower wealth quintile are less likely to receive OPV1 vaccine than those from the wealthiest quintile [42]. The current outcome suggests that financial instability may have influenced and disproportionately affected families' ability to prioritise vaccination, potentially exacerbating existing health inequities. Reasons for this trend include uncertain mothers feeling a greater responsibility for their children's health, heightened awareness of vaccination's importance, and proactive efforts to access free vaccination programmes as the case is in Ghana.

We further found that spousal income regularity significantly influenced vaccine uptake, with mothers perceiving their spouse's income as irregular are more likely to fully adhere to vaccination schedules for their children tha those who are certain about their spouse's income regularity. This suggests that mothers certain of their spouse's income regularity may have a higher proportion of their children not fully vaccinated, potentially resulting in weakened immune systems and susceptibility to childhood diseases. Conversely, mothers perceiving irregular income may prioritise vaccination as a preventive measure against financial instability, actively seeking out support services such as free or subsidised vaccination programmes. This phenomenon can exacerbate health inequities, as families with irregular incomes may bear a disproportionate burden of ensuring their children receive essential vaccinations.

Mothers' perceptions of whether their spouse's income was the primary support for their household significantly influenced their children's vaccination uptake in this study. Those uncertain about their spouse's income being the sole source were more inclined to ensure their children were fully vaccinated than those certain about it. This uncertainty seemed to make mothers more aware of potential financial instability, prompting them to prioritise preventive measures like vaccination to safeguard their children's health. Conversely, mothers certain about their spouse's income may assume a level of financial stability, potentially leading to lower vaccination priority or complacency regarding preventive health measures such as vaccination. This disparity could result in lower vaccination coverage rates within communities, increasing susceptibility to VPDs among children.

In the ASD of Ghana, children living in mud houses are more likely to complete their vaccination schedules than those in block-constructed houses. This is surprising given that mud houses are often associated with lower SES, which typically correlates with lower healthcare access and vaccine uptake. However, mothers in mud houses might prioritise vaccinations to compensate for limited medical care access, supported by strong community networks and health awareness. This contrasts with previous research that found that low SES usually leads to poorer health outcomes [43]. The increased vaccination rates among children in mud houses improve overall community health, reducing VPDs, childhood illnesses, hospitalisations, and deaths.

The type of housing strongly influenced the rate of children's complete vaccination uptake, with mothers residing in self-contained houses showing a higher inclination to fully vaccinate their children than those in compound houses. Self-contained houses are typically associated with higher SES than compound houses, suggesting that mothers in such dwellings may possess better education, income, and healthcare knowledge. This enhanced awareness could impact their prioritisation of vaccination for their children, leading to higher vaccination rates. This finding aligns with previous research indicating that individuals with high SES generally exhibit greater uptake of health services and enjoy better health outcomes than those with low SES [43]. However, this outcome also suggests potential vaccination disparities within communities, with children in compound houses being disadvantaged in terms of vaccine coverage. This could increase their vulnerability to VPDs, potentially leading to outbreaks and elevated morbidity and mortality rates among children residing in compound houses.

Need factors

Mothers' perceptions of vaccines and vaccination activities significantly influenced the completion of their children's vaccination schedules in the ASD in Ghana. Those with positive perceptions were more likely to complete the schedules compared to those with negative perceptions. This suggests that mothers who view vaccination positively are more likely to believe in its effectiveness and importance in safeguarding their children from diseases. This belief motivates them to prioritise fully completing the vaccination schedules. Additionally, they are more inclined to trust healthcare providers and public health authorities regarding vaccine safety and efficacy, as seen in prior studies [44]. Higher completion rates among mothers with positive perceptions contribute to improved overall vaccine uptake, leading to better protection against VPDs and reduced illness, hospitalisations, and deaths among children.

Conclusions

Based on our study's findings, we conclude that the full uptake of RCV in the ASD was very low, potentially posing a risk of VPD outbreaks and subsequent health issues among children. Factors like maternal beliefs on childhood vaccination and place of delivery, other predisposing factors such as the number and birth order of children, maternal religious affiliation, attendance and frequency of ANC contacts, and child and maternal age significantly predicted RCV uptake in the ASD of Ghana. Similarly, enabling factors such as maternal and spousal income adequacy, income source, and housing conditions, significantly influenced RCV uptake. However, no link was found between factors like maternal occupation, income regularity, and spouse's occupation and RCV uptake. Moreover, the need factor played a significant role in maternal perception of vaccines and vaccination activities in determining the RCV uptake in ASD in Ghana.

Our research utilised a cross-sectional study design, assessing both vaccine uptake and its determinants simultaneously. This design limited our ability to establish a cause-effect relationship. The exclusion of fathers' perspectives, which could have provided valuable insights into mothers' immunisation practices may limit generalizabilty of the findings. The study exclusively concentrated on the demand side of vaccination services, overlooking the supply side. Incorporating the supply side could have highlighted issues related to vaccine supply and associated services. Also, there is a potential recall bias, as mothers without maternal and child health records for their children were required to recall past events. Furthermore, including too many non-significant variables can lead to overfitting, where the model performs well. The reason for a stepwise or hierarchical logistic regression. The Nagelkerke R-squared values in the models explained only a small proportion of the variance in vaccine uptake (i.e., 12.7-22.8%).

Despite these limitations, our study offers insights into childhood vaccinations in the ASD of Ghana, with findings potentially applicable to similar communities in the districts with similar characteristics. To improve childhood vaccination rates, we recommend a series of comprehensive actions. First, it is essential to prioritise education and counselling on vaccinations during child welfare clinics, antenatal care visits, and community gatherings. To facilitate this, the GHS/DHD should offer flexible schedulingby organising vaccination services at the convenience of the mothers instead of traditional working hours) and employing reminder systems (such as text message, phone calls, community-based surveillance volunteers visting homes, local radio reminder systems) for vaccination appointments is crucial in the district. Additionally, healthcare services should be streamlined to reduce wait times at vaccination clinics. Implementing mobile vaccination clinics in underserved areas is another key strategy. Collaboration among stakeholders must be enhanced to identify and address barriers to vaccination. Mandating school entry vaccines and improving immunisation tracking systems are also necessary steps. The DHD should deploy vaccination teams, establish temporary vaccination centres within densely populated areas to increase accessibility targeting mothers in

compound houses. Encouraging community leaders and religious groups such as local chiefs, imams, pastors, and traditional rulers to publicly receive vaccines and share their experiences, and also discuss the importance of vaccination during sermons, Friday prayers, and community meetings is important to improve vaccine uptake in the district.

The central, local government, and NGOs must address financial barriers to ensure equal vaccination access for all children, regardless of income. Financial counselling and support services should be promoted for families facing income uncertainties, alongside raising awareness of available support services and encouraging proactive health behaviours. The MOH/GHS must ensure targeted health education campaigns to raise awareness about the importance of immunisation and dispel misconceptions. Engaging community leaders, healthcare professionals, and influential figures will help foster positive attitudes toward vaccination and address any doubts within the community.

Abbreviations

GHS Ghana health service

- ASD Adansi South District
- MOH Ministry of health
- RCV Routine childhood vaccination
- VPD Vaccine-preventable diseases

Supplementary Information

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Supplementary Material 1

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Author contributions

S. S., J. O. S., T.H., M.A. conceptualized the idea and designed protocol, S.S. and M. A. collected the data and run the analysis. T.H. and JOS drafted the manuscript and S. S., J. O. S., T.H., M.A. proofread the manuscript. All authors reviewed the manuscript.

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Data availability

Data will be available as soon as the manuscript is accepted for publication.

Declarations

Ethics approval and consent to participate

The ethical clearance with Ref: [CHRPE/AP/797/22] was obtained for this study and the ethical approval was done by the the Committee on Human Research, Publication and Ethics [CHRPE) at the Kwame Nkrumah University of Science and Technology (KNUST). Written and verbal informed consent were obtained from each participants after the purpose of the study have been explained to them. Each participant participated in the study voluntary and were assured to opt out when necessary.

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Consent for publication

Not applicable.

Competing interests

The authors declare no competing interests.

Contribution to literature

There has been consistent decline in the routine immunization of children in certain parts of Ghana. However, the factors influencing the declining immunication was unknown. Based on this research, this manuscript has found the prevalence of routine vaccination, predisposing, enabling and reinforcing factors of routine vaccination. Through this study, the manuscript has found state of routine vaccination of children against vaccine preventablediseases in the study area. The findings would stimulate policy change in line with routine vaccination in the study area.

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