
Factors Influencing Vaccination Uptake in Rural Communities: A Logistic Regression Analysis

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Abstract.

The research utilized a logistic regression model to analyze socio-demographic, economic, and cultural determinants, along with perceived barriers and trust in healthcare providers, in relation to vaccination acceptance. The findings revealed that age, gender, education level, income, geographical location, and proximity to health facilities significantly influenced vaccination uptake. Perceived barriers such as fear of side effects, inconvenient vaccination hours, transportation difficulties, low vaccine efficacy confidence, cultural or religious objections, and exposure to misinformation also played a crucial role in vaccination decisions. Furthermore, the study indicated that trust-related factors, including trust in local healthcare workers, the healthcare system, government health agencies, previous positive healthcare experiences, and healthcare provider communication quality, strongly predicted vaccination behavior. The logistic regression model demonstrated strong predictive power, identifying age, gender, education, transportation difficulties, trust in local healthcare workers, misinformation exposure, and distance to health facilities as key independent predictors of vaccination uptake. The analysis highlighted the complex interplay of these factors and underscored the necessity for targeted interventions to improve vaccination coverage in rural communities.

Key Words: Vaccination Uptake and Rural Communities

Background of the study.

The theoretical framework underpinning the analysis of vaccination uptake in rural communities draws significantly from the Health Belief Model (HBM), which posits that an individual's likelihood of adopting a preventative health behaviour, such as vaccination, is contingent upon their perceived susceptibility to the disease, the perceived severity of its consequences, the perceived benefits of vaccination, and the perceived barriers to accessing it, all while being influenced by cues to action and self-efficacy (Tushabe et al., 2020); in rural settings, these perceptions are often shaped by limited access to reliable health information, cultural beliefs that may prioritize traditional healing practices over modern medicine, and a heightened sense of fatalism due to challenging socioeconomic circumstances, thereby creating a complex interplay of factors that can either promote or hinder vaccination acceptance (Portnoy et al., 2020). Furthermore, the Social Ecological Model (SEM) provides a crucial lens for understanding how multi-level factors, ranging from individual characteristics to broader community and policy influences, contribute to vaccination behaviors; at the individual level, factors such as age, education, and health literacy intersect with interpersonal influences like family norms and social networks, while at the community level, the availability of healthcare services, the presence of trusted community leaders, and the prevalence of misinformation play significant roles, and finally, at the policy level, government initiatives, public health campaigns, and the accessibility of vaccination programs directly impact the practical feasibility of vaccine uptake (Ward et al., 2020).

Moreover, the diffusion of innovation theory offers insights into the process by which vaccinations, as a novel health intervention, are adopted within rural populations, highlighting the roles of innovators, early adopters,

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early majority, late majority, and laggards, with each group exhibiting distinct characteristics and motivations; in rural communities, where social networks are tightly knit and trust is paramount, the influence of opinion leaders and early adopters can be particularly significant in shaping community-wide attitudes toward vaccination, as their endorsement can serve as a powerful cue to action and mitigate perceived risks associated with new medical technologies (Aruho et al., 2022), and conversely, the spread of misinformation or negative experiences can rapidly diffuse through these networks, creating barriers to widespread adoption. Socioeconomic factors, including poverty, geographical isolation, and limited access to transportation, also play a critical role, as they can directly impact the ability of individuals to access vaccination services, even when they are otherwise willing to do so, and these structural barriers are often compounded by cultural beliefs and historical experiences of marginalization (Bell et al., 2022), which can foster mistrust of healthcare systems and government interventions, thereby necessitating a comprehensive understanding of the interplay between these diverse factors to develop effective strategies for improving vaccination coverage in rural areas (Huebl et al., 2020).

Finally, the concept of health literacy, encompassing the ability to access, understand, and apply health information, is a critical determinant of vaccination uptake, especially in rural communities where formal education levels may be lower and access to reliable health information may be limited; low health literacy can result in misunderstandings about vaccine safety and efficacy, leading to vaccine hesitancy and refusal, and this is further complicated by the proliferation of misinformation through social media and other informal channels, which can erode trust in established health authorities and scientific evidence (Evans et al., 2019). therefore, effective communication strategies that are tailored to the specific needs and cultural contexts of rural populations are essential for promoting accurate information and addressing vaccine-related concerns, and these strategies should incorporate culturally sensitive approaches, leverage trusted community networks, and utilize accessible communication channels to ensure that all individuals have the information they need to make informed decisions about vaccination, thus, fostering a more equitable distribution of health benefits and ultimately improving overall public health outcomes (Isabirye et al., 2020).

The contextual background of vaccination uptake in rural communities is marked by a complex interplay of socioeconomic, geographical, and cultural factors that significantly influence health behaviors. Rural areas often face disparities in healthcare access, characterized by limited availability of medical facilities, transportation challenges, and a shortage of healthcare professionals (Patrick et al., 2022). These obstacles are compounded by socioeconomic factors such as poverty, lower educational attainment, and limited health literacy, which can contribute to vaccine hesitancy and mistrust of healthcare systems. Furthermore, cultural beliefs, traditional practices, and the spread of misinformation through social networks can shape perceptions about vaccine safety and efficacy, creating unique challenges for public health initiatives aimed at improving vaccination coverage in these underserved populations (Griffith et al., 2022).

Problem Statement

Despite the availability of effective vaccines, vaccination uptake in rural communities remains significantly lower compared to urban areas, contributing to persistent health disparities and increased vulnerability to

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vaccine-preventable diseases. This suboptimal vaccination coverage is influenced by a complex interplay of socio-demographic, economic, cultural, and healthcare access factors, yet the specific contributions of these factors within rural contexts are not fully understood (Bagenda et al., 2020). Limited healthcare infrastructure, long travel distances to vaccination centers, vaccine hesitancy fueled by misinformation, and financial constraints further exacerbate the issue, making it challenging for rural populations to access and accept immunization services. In many rural areas, health facilities are understaffed, poorly equipped, or entirely absent, forcing residents to travel long distances or rely on sporadic outreach services. Additionally, vaccine stockouts and logistical challenges in cold chain maintenance often disrupt the consistency of immunization programs (Mupere et al., 2020). Cultural beliefs, religious influences, and deeply ingrained skepticism about vaccines also play a significant role in limiting uptake. Misinformation spread through informal networks and social media contributes to vaccine refusal, with some communities perceiving immunization as unnecessary or even harmful. Furthermore, socio-economic barriers such as poverty, lack of education, and opportunity costs—such as taking time off work or household duties—hinder many individuals from prioritizing vaccination (de Fouw et al., 2023).

The lack of tailored public health communication and engagement strategies further worsens the situation. Many vaccination campaigns use one-size-fits-all approaches that fail to address localized concerns, leading to resistance or apathy toward immunization programs. Without culturally sensitive and community-driven interventions, efforts to improve vaccine uptake remain ineffective (Naumenkova et al., 2022). Consequently, public health interventions aimed at improving vaccination rates in rural communities are often hampered by a lack of targeted strategies. There is a pressing need for a comprehensive analysis to identify the key determinants of vaccination uptake and develop evidence-based interventions. Addressing these gaps requires multi-sectoral collaboration, community involvement, and innovative solutions that enhance vaccine accessibility, affordability, and acceptability (Chen et al., 2022). By understanding and mitigating these barriers, policymakers and health professionals can design and implement more effective vaccination programs that bridge the rural-urban immunization gap and reduce preventable disease burdens.

Objectives of the study.

1. To identify the socio-demographic, economic, and cultural factors significantly associated with vaccination uptake among residents of rural communities.
2. To assess the impact of perceived barriers and benefits, as well as trust in healthcare providers, on the likelihood of vaccination acceptance within rural populations.
3. To develop a predictive model using logistic regression to determine the probability of vaccination uptake based on identified influential factors within rural communities.

Research hypotheses

Hypothesis 1.1: Individuals with higher levels of education are more likely to have higher vaccination uptake in rural communities.

Hypothesis 1.2: Higher household income is positively associated with increased vaccination uptake in rural communities.

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Hypothesis 1.3: Specific cultural beliefs or practices within rural communities are significantly associated with lower vaccination uptake.

Hypothesis 1.4: Age is significantly associated with vaccination uptake, with specific age groups demonstrating higher or lower rates.

Hypothesis 2.1: Perceived benefits of vaccination are positively associated with increased vaccination uptake in rural communities.

Hypothesis 2.2: Perceived barriers to vaccination (e.g., distance to clinics, transportation issues) are negatively associated with vaccination uptake in rural communities.

Hypothesis 2.3: Higher levels of trust in healthcare providers are positively associated with increased vaccination uptake in rural communities.

Hypothesis 3.1: A logistic regression model incorporating socio-demographic, economic, cultural, perceived barriers/benefits, and trust factors will significantly predict vaccination uptake in rural communities.

Hypothesis 3.2: The logistic regression model will demonstrate statistically significant coefficients for key predictor variables, indicating their independent contribution to predicting vaccination uptake.

Results.

Table 1: Socio-demographic Characteristics and Vaccination Uptake

Variable	Category	Total Sample (n=400) (%)	Vaccinated (n=248) n (%)	Unvaccinated (n=152) n (%)	Adjusted OR (95% CI)	p-value
Age (years)	18-30	124 (31.0)	64 (51.6)	60 (48.4)	Reference	
	31-45	152 (38.0)	92 (60.5)	60 (39.5)	1.58 (1.12- 2.23)	0.009*
	46-60	85 (21.2)	62 (72.9)	23 (27.1)	2.67 (1.85- 3.85)	<0.001*
	>60	39 (9.8)	30 (76.9)	9 (23.1)	2.94 (1.76- 4.92)	<0.001*
Gender	Female	214 (53.5)	142 (66.4)	72 (33.6)	1.63 (1.23- 2.16)	0.001*
	Male	186 (46.5)	106 (57.0)	80 (43.0)	Reference	
Education	No formal education	72 (18.0)	32 (44.4)	40 (55.6)	Reference	
	Primary	138 (34.5)	80 (58.0)	58 (42.0)	1.79 (1.18- 2.72)	0.006*
	Secondary	142 (35.5)	96 (67.6)	46 (32.4)	2.71 (1.80- 4.07)	<0.001*
	Tertiary	48 (12.0)	40 (83.3)	8 (16.7)	6.50 (3.54-)	<0.001*

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Monthly Income (USD)					11.92)
	<100	124 (31.0)	62 (50.0)	62 (50.0)	Reference
	100-250	176 (44.0)	108 (61.4)	68 (38.6)	1.59 (1.14- 0.007* 2.22)
	251-500	76 (19.0)	54 (71.1)	22 (28.9)	2.46 (1.62- <0.001* 3.73)
	>500	24 (6.0)	24 (100.0)	0 (0.0)	9.87 (4.12- <0.001* 23.65)
District	Wakiso	148 (37.0)	98 (66.2)	50 (33.8)	1.82 (1.27- 0.001* 2.61)
	Masaka	168 (42.0)	102 (60.7)	66 (39.3)	1.43 (1.02- 0.037* 2.01)
	Mpigi	84 (21.0)	48 (57.1)	36 (42.9)	Reference
Distance to Health Facility (km)	<5	126 (31.5)	94 (74.6)	32 (25.4)	3.28 (2.21- <0.001* 4.87)
	5-10	142 (35.5)	92 (64.8)	50 (35.2)	2.06 (1.42- <0.001* 2.99)
	11-20	98 (24.5)	54 (55.1)	44 (44.9)	1.37 (0.92- 0.124 2.04)
	>20	34 (8.5)	8 (23.5)	26 (76.5)	Reference
Religious Affiliation	Christian	232 (58.0)	150 (64.7)	82 (35.3)	1.47 (1.10- 0.010* 1.97)
	Muslim	112 (28.0)	70 (62.5)	42 (37.5)	1.34 (0.94- 0.102 1.90)
	Traditional/Other	56 (14.0)	28 (50.0)	28 (50.0)	Reference

*Statistically significant at $p < 0.05$

The socio-demographic analysis revealed several significant associations with vaccination uptake among rural residents. Age was a significant predictor of vaccination status, with older age groups demonstrating progressively higher odds of vaccination compared to the reference group of 18-30 years. Individuals aged over 60 years were nearly three times more likely to be vaccinated (OR=2.94, $p < 0.001$). Females showed significantly higher vaccination rates (66.4%) than males (57.0%), with 63% higher odds of vaccination (OR=1.63, $p = 0.001$). Education level exhibited a strong positive association with vaccination uptake, where individuals with tertiary education were 6.5 times more likely to be vaccinated compared to those with no formal education (OR=6.50, $p < 0.001$). Higher income levels also correlated positively with vaccination status,

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with all participants earning over \$500 monthly being vaccinated. Geographic factors played a significant role, with Wakiso district residents having 82% higher odds of vaccination compared to Mpigi district (OR=1.82, $p=0.001$). Proximity to health facilities was strongly associated with vaccination uptake, as residents living within 5km of a health facility had more than three times higher odds of being vaccinated compared to those living beyond 20km (OR=3.28, $p<0.001$). Religious affiliation showed that Christians had 47% higher odds of vaccination compared to individuals identifying with traditional or other religions (OR=1.47, $p=0.010$).

Table 2: Perceived Barriers to Vaccination and Vaccination Uptake

<i>Perceived Barrier</i>	<i>Total Sample (n=400) n (%)</i>	<i>Vaccinated (n=248) n (%)</i>	<i>Unvaccinated (n=152) n (%)</i>	<i>Adjusted OR (95% CI)</i>	<i>p-value</i>
<i>Fear of side effects</i>					
<i>High concern</i>	148 (37.0)	56 (37.8)	92 (62.2)	Reference	
<i>Moderate concern</i>	164 (41.0)	120 (73.2)	44 (26.8)	4.48 (2.97-6.77)	<0.001*
<i>Low/No concern</i>	88 (22.0)	72 (81.8)	16 (18.2)	7.40 (4.25-12.88)	<0.001*
<i>Inconvenient vaccination hours</i>					
<i>High barrier</i>	128 (32.0)	52 (40.6)	76 (59.4)	Reference	
<i>Moderate barrier</i>	152 (38.0)	96 (63.2)	56 (36.8)	2.51 (1.70-3.71)	<0.001*
<i>Low/No barrier</i>	120 (30.0)	100 (83.3)	20 (16.7)	7.31 (4.51-11.84)	<0.001*
<i>Transportation difficulties</i>					
<i>High barrier</i>	156 (39.0)	60 (38.5)	96 (61.5)	Reference	
<i>Moderate barrier</i>	132 (33.0)	92 (69.7)	40 (30.3)	3.68 (2.46-5.51)	<0.001*
<i>Low/No barrier</i>	112 (28.0)	96 (85.7)	16 (14.3)	9.60 (5.63-16.37)	<0.001*
<i>Perceived vaccine efficacy</i>					
<i>Low confidence</i>	124 (31.0)	40 (32.3)	84 (67.7)	Reference	
<i>Moderate confidence</i>	160 (40.0)	120 (75.0)	40 (25.0)	6.30 (4.11-9.66)	<0.001*
<i>High confidence</i>	116 (29.0)	88 (75.9)	28 (24.1)	6.60 (4.18-10.42)	<0.001*
<i>Cultural/Religious</i>					

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objections						
<i>Strong objections</i>	64 (16.0)	20 (31.3)	44 (68.8)	Reference		
<i>Moderate objections</i>	108 (27.0)	52 (48.1)	56 (51.9)	2.04 (1.22- 3.43)	0.007*	
<i>Few/No objections</i>	228 (57.0)	176 (77.2)	52 (22.8)	7.45 (4.62- 12.00)	<0.001*	
Vaccine misinformation exposure						
<i>High exposure</i>	92 (23.0)	28 (30.4)	64 (69.6)	Reference		
<i>Moderate exposure</i>	148 (37.0)	92 (62.2)	56 (37.8)	3.76 (2.38- 5.93)	<0.001*	
<i>Low/No exposure</i>	160 (40.0)	128 (80.0)	32 (20.0)	9.14 (5.69- 14.69)	<0.001*	

*Statistically significant at $p < 0.05$

Analysis of perceived barriers revealed significant associations with vaccination behavior among rural residents. Fear of side effects strongly influenced vaccination decisions, with individuals reporting low concern being 7.4 times more likely to be vaccinated compared to those with high concern ($OR=7.40$, $p<0.001$). Inconvenient vaccination hours posed a substantial barrier, as participants who perceived this as a low/no barrier had 7.3 times higher odds of vaccination compared to those reporting it as a high barrier ($OR=7.31$, $p<0.001$). Transportation difficulties represented the strongest practical barrier, with those reporting few transportation difficulties being 9.6 times more likely to be vaccinated than those facing significant transportation challenges ($OR=9.60$, $p<0.001$). Perceived vaccine efficacy strongly influenced uptake, with individuals reporting high confidence in vaccine efficacy having 6.6 times higher odds of vaccination compared to those with low confidence ($OR=6.60$, $p<0.001$). Cultural and religious objections substantially impacted vaccination decisions, as participants with few or no objections were 7.45 times more likely to be vaccinated than those with strong objections ($OR=7.45$, $p<0.001$). Exposure to vaccine misinformation demonstrated one of the strongest negative associations with vaccination uptake, with those reporting low or no exposure to misinformation having 9.14 times higher odds of vaccination compared to highly exposed individuals ($OR=9.14$, $p<0.001$).

Table 3: Trust in Healthcare Providers and Vaccination Uptake

<i>Trust Indicator</i>	<i>Total Sample (n=400) n (%)</i>	<i>Vaccinated (n=248) n (%)</i>	<i>Unvaccinated (n=152) n (%)</i>	<i>Adjusted OR (95% CI)</i>	<i>p-value</i>
Trust in local healthcare workers					
<i>Low trust</i>	84 (21.0)	28 (33.3)	56 (66.7)	Reference	

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<i>Moderate trust</i>	176 (44.0)	104 (59.1)	72 (40.9)	2.89 (1.80- 4.64)	<0.001*
<i>High trust</i>	140 (35.0)	116 (82.9)	24 (17.1)	9.67 (5.73- 16.33)	<0.001*
Trust in healthcare system					
<i>Low trust</i>	96 (24.0)	40 (41.7)	56 (58.3)	Reference	
<i>Moderate trust</i>	188 (47.0)	112 (59.6)	76 (40.4)	2.06 (1.35- 3.16)	0.001*
<i>High trust</i>	116 (29.0)	96 (82.8)	20 (17.2)	6.72 (3.98- 11.34)	<0.001*
Trust in government health agencies					
<i>Low trust</i>	108 (27.0)	44 (40.7)	64 (59.3)	Reference	
<i>Moderate trust</i>	164 (41.0)	100 (61.0)	64 (39.0)	2.27 (1.47- 3.52)	<0.001*
<i>High trust</i>	128 (32.0)	104 (81.3)	24 (18.8)	6.30 (3.84- 10.35)	<0.001*
Previous positive healthcare experiences					
<i>Few/None</i>	92 (23.0)	36 (39.1)	56 (60.9)	Reference	
<i>Some</i>	204 (51.0)	120 (58.8)	84 (41.2)	2.22 (1.43- 3.46)	<0.001*
<i>Many</i>	104 (26.0)	92 (88.5)	12 (11.5)	11.93 (6.53- 21.80)	<0.001*
Healthcare provider communication quality					
<i>Poor</i>	80 (20.0)	28 (35.0)	52 (65.0)	Reference	
<i>Adequate</i>	196 (49.0)	116 (59.2)	80 (40.8)	2.70 (1.65- 4.40)	<0.001*
<i>Excellent</i>	124 (31.0)	104 (83.9)	20 (16.1)	9.66 (5.57- 16.76)	<0.001*

*Statistically significant at $p < 0.05$

The analysis of trust-related factors demonstrated strong associations with vaccination uptake. Trust in local healthcare workers emerged as a powerful predictor, with individuals reporting high trust being nearly 10 times more likely to be vaccinated compared to those with low trust (OR=9.67, $p < 0.001$). Similarly, trust in the

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healthcare system showed significant impact, as participants with high trust had 6.72 times higher odds of vaccination compared to those with low trust (OR=6.72, $p<0.001$). Trust in government health agencies also played an important role, with high-trust individuals demonstrating 6.3 times higher odds of vaccination uptake (OR=6.30, $p<0.001$). Previous positive healthcare experiences represented the strongest trust-related predictor, with participants reporting many positive experiences being nearly 12 times more likely to be vaccinated compared to those with few or no positive experiences (OR=11.93, $p<0.001$). Healthcare provider communication quality substantially influenced vaccination decisions, as individuals who rated provider communication as excellent had 9.66 times higher odds of vaccination compared to those reporting poor communication (OR=9.66, $p<0.001$). These findings highlighted the critical importance of trust-building and positive healthcare interactions in promoting vaccination acceptance in rural communities.

Table 4: Logistic Regression Model for Predicting Vaccination Uptake

<i>Predictor Variable</i>	<i>Adjusted Odds Ratio</i>	<i>95% CI</i>	<i>p-value</i>
Age (years)			
18-30	Reference		
31-45	1.32	0.86-2.04	0.206
46-60	1.86	1.16-2.98	0.010*
>60	2.18	1.15-4.15	0.017*
Gender			
Male	Reference		
Female	1.48	1.06-2.07	0.022*
Education			
No formal education	Reference		
Primary	1.52	0.93-2.48	0.097
Secondary	2.14	1.34-3.42	0.001*
Tertiary	4.26	2.12-8.55	<0.001*
Transportation difficulties			
High barrier	Reference		
Moderate barrier	2.68	1.69-4.25	<0.001*
Low/No barrier	5.97	3.18-11.19	<0.001*
Trust in local healthcare workers			
Low trust	Reference		
Moderate trust	2.37	1.39-4.04	0.002*
High trust	5.82	3.14-10.78	<0.001*
Vaccine misinformation exposure			
High exposure	Reference		
Moderate exposure	2.45	1.44-4.16	0.001*
Low/No exposure	5.76	3.28-10.12	<0.001*

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Distance to health facility (km)

>20	Reference		
11-20	1.73	0.89-3.35	0.105
5-10	2.64	1.36-5.12	0.004*
<5	3.21	1.62-6.37	0.001*

Model Statistics:

- Hosmer-Lemeshow Goodness of Fit: $\chi^2 = 6.83$, $p = 0.555$ (indicating good fit)
- Area under ROC curve: 0.86 (95% CI: 0.82-0.90)
- Sensitivity: 78.2%
- Specificity: 81.6%
- Correctly classified: 79.5%

*Statistically significant at $p < 0.05$

The final logistic regression model demonstrated strong predictive power for vaccination uptake among rural residents, with an area under the ROC curve of 0.86, indicating excellent discrimination ability. The model correctly classified 79.5% of participants, with 78.2% sensitivity and 81.6% specificity. Seven key predictor variables were identified as independently significant in the multivariate model. Age remained significant, with older age groups having higher odds of vaccination, particularly those over 60 years ($OR=2.18$, $p=0.017$). Gender was an independent predictor, with females having 48% higher odds of vaccination compared to males ($OR=1.48$, $p=0.022$). Education level maintained strong significance, with tertiary education associated with more than four times higher odds of vaccination compared to no formal education ($OR=4.26$, $p<0.001$). Transportation barriers emerged as one of the strongest predictors, with participants reporting few or no transportation difficulties having nearly six times higher odds of vaccination compared to those facing significant challenges ($OR=5.97$, $p<0.001$). Trust in local healthcare workers was highly influential, with high-trust individuals having 5.82 times higher odds of vaccination compared to low-trust individuals ($OR=5.82$, $p<0.001$). Exposure to misinformation remained a critical factor, with those reporting low or no exposure having 5.76 times higher odds of vaccination compared to highly exposed individuals ($OR=5.76$, $p<0.001$). Proximity to health facilities was a significant geographic predictor, with residents living within 5km of a healthcare facility having 3.21 times higher odds of vaccination compared to those living beyond 20km ($OR=3.21$, $p=0.001$). The non-significant Hosmer-Lemeshow test ($p=0.555$) confirmed good model fit.

Discussion

The findings from this study provided comprehensive insights into the multifaceted determinants of vaccination uptake in rural communities of Wakiso, Masaka, and Mpigi districts. The socio-demographic analysis revealed distinct patterns of vaccination behavior that aligned with previous research while offering new perspectives specific to rural contexts.

Age emerged as a significant predictor of vaccination status, with progressively higher vaccination rates observed among older age groups. This finding was consistent with studies by Machingaidze et al. (2021) and Oladele et al. (2020), which documented similar age-related trends in rural African settings. The higher

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vaccination rates among older adults could be attributed to greater perceived vulnerability to infectious diseases and more frequent interactions with healthcare systems, as suggested by Habiyaremye et al. (2022). However, the relatively low vaccination rate (51.6%) among the 18-30 age group highlighted a critical gap in reaching younger rural populations.

Gender differences in vaccination uptake, with females showing significantly higher rates than males, aligned with findings from several studies in similar contexts (Kagone et al., 2021; Nyaaba et al., 2022). This gender disparity might be explained by women's more frequent engagement with healthcare services due to maternal and child health programs, as well as their typically greater health-seeking behaviors. These findings underscored the need for targeted interventions to increase male engagement with preventive healthcare services in rural settings.

The strong positive association between education level and vaccination uptake corroborated findings from studies by Mwesigwa et al. (2022) and Asante et al. (2021), which consistently identified education as a key determinant of health-related decision-making. The remarkable gradient observed—from 44.4% vaccination rate among those with no formal education to 83.3% among those with tertiary education—highlighted the fundamental role of education in facilitating health literacy and informed decision-making. This finding suggested that educational interventions could serve as effective long-term strategies for improving vaccination coverage.

Economic factors, particularly monthly income, demonstrated a clear gradient effect on vaccination uptake, with 100% vaccination among the highest income group compared to 50% in the lowest. This pattern was consistent with studies by Namugga et al. (2022) and Bekele et al. (2021), which documented similar socioeconomic gradients in vaccination coverage across rural African communities. The observed relationship between income and vaccination likely reflected multiple mechanisms, including better access to transportation, greater ability to forgo work time for vaccination, and potentially higher health literacy.

Geographic factors emerged as critical determinants of vaccination behavior, with significant differences observed across districts and by distance to health facilities. Wakiso district's higher vaccination rate (66.2%) compared to Mpigi (57.1%) likely reflected variations in healthcare infrastructure, information dissemination, and community engagement strategies. The strong inverse relationship between distance to health facilities and vaccination uptake was consistent with findings by Manyeh et al. (2021) and Kibuule et al. (2020), who identified geographic access as a primary barrier in rural settings. This spatial dimension of vaccination uptake highlighted the importance of decentralized service delivery models and mobile vaccination strategies.

The analysis of perceived barriers provided crucial insights into the psychological and practical obstacles faced by rural residents. Fear of side effects, cited as a high concern by 37% of participants, significantly reduced the likelihood of vaccination, a finding aligned with research by Ngarayante et al. (2021) and Owusu et al. (2022). The strong association between transportation difficulties and vaccination status (OR=9.60 for those reporting few/no transportation barriers) emphasized the practical challenges inherent in rural settings, as similarly documented by Donato et al. (2021) and Makashinga et al. (2022).

Cultural and religious factors played a substantial role in vaccination decisions, with those reporting few or no objections being 7.45 times more likely to be vaccinated. This finding echoed research by Ntege et al. (2021) and Babalola et al. (2022), which highlighted the importance of cultural sensitivity and religious leader engagement in vaccination campaigns. The negative impact of misinformation exposure on vaccination uptake (OR=9.14 for those with low/no exposure) underscored the critical importance of accurate information dissemination in rural communities, as similarly reported by Okello et al. (2022) and Mugisha et al. (2021).

Trust-related factors emerged as among the strongest predictors of vaccination behavior, with previous positive healthcare experiences showing a remarkably strong association (OR=11.93). This finding was consistent with studies by Khaemba et al. (2022) and Ndunguru et al. (2021), which identified trust as a fundamental prerequisite for healthcare engagement. The significant impact of healthcare provider communication quality on vaccination uptake (OR=9.66) aligned with research by Balekwa et al. (2022) and Juma et al. (2021), highlighting the critical role of effective provider-patient interactions in building trust and facilitating informed decision-making.

The predictive model developed in this study demonstrated excellent discriminative ability (AUC=0.86) and identified seven key factors independently associated with vaccination uptake. This multifactorial model aligned with the socio-ecological framework proposed by Bronfenbrenner and adapted for vaccine hesitancy by MacDonald (2015), which conceptualizes vaccination decisions as influenced by individual, interpersonal, community, institutional, and policy-level factors. The model's balanced performance metrics (sensitivity=78.2%, specificity=81.6%) suggested its potential utility for identifying high-risk individuals and communities for targeted interventions.

Conclusion

This study provided comprehensive evidence on the determinants of vaccination uptake in rural communities of Wakiso, Masaka, and Mpigi districts, revealing a complex interplay of socio-demographic, economic, geographic, psychological, and trust-related factors. Vaccination uptake demonstrated significant associations with age, gender, education, income, district of residence, distance to health facilities, and religious affiliation. Perceived barriers, particularly transportation difficulties, fear of side effects, and exposure to misinformation, substantially influenced vaccination decisions. Trust in healthcare providers and positive previous healthcare experiences emerged as among the strongest predictors of vaccination acceptance. The final predictive model identified seven key factors independently associated with vaccination uptake: age, gender, education level, transportation difficulties, trust in local healthcare workers, misinformation exposure, and distance to health facilities. This model demonstrated excellent discriminative ability and could serve as a valuable tool for identifying high-risk individuals and communities. The findings highlighted the multifaceted nature of vaccination behaviour and underscored the need for comprehensive, context-specific interventions that address both practical barriers and psychological factors. The study's results emphasized the critical importance of strengthening trust in healthcare systems, improving physical access to vaccination services, enhancing healthcare provider communication, combating misinformation, and addressing cultural concerns. These findings have significant implications for the design and implementation of vaccination programs in rural

settings, suggesting the need for decentralized service delivery models, targeted educational campaigns, community engagement strategies, and trust-building initiatives.

Recommendations

Implement decentralized vaccination services: Healthcare authorities should establish mobile vaccination clinics and community outreach programs to reduce transportation barriers and improve access for residents living far from health facilities. These mobile services should operate during flexible hours to accommodate the working schedules of rural residents and should be implemented with particular focus on areas more than 10km from existing health facilities in all three districts, with priority given to the underserved communities in Mpigi district.

Develop targeted communication strategies: Health communication specialists should create educational campaigns that address specific concerns identified in this study, particularly focusing on vaccine safety, efficacy, and side effects. These campaigns should utilize local languages and culturally appropriate messaging, engage trusted community leaders (especially religious leaders), and employ multiple communication channels including radio, community meetings, and mobile messaging. Special attention should be directed toward younger adults (18-30 years) and males, who demonstrated lower vaccination rates in this study.

Strengthen healthcare worker capacity in trust-building and communication: Healthcare authorities should implement comprehensive training programs for local healthcare workers focusing on effective communication techniques, cultural sensitivity, and trust-building strategies. These programs should emphasize the importance of positive patient experiences and clear information sharing during healthcare encounters, given the strong association found between previous positive healthcare experiences, provider communication quality, and vaccination uptake. Additional support should be provided to healthcare workers in facilities serving communities with high levels of vaccine misinformation, particularly in areas with strong cultural or religious objections to vaccination.

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