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Original Research Article

Assessment of COVID-19 Vaccine Hesitancy and Its Socio-Demographic Predictors in Rural Communities: A Mixed-Methods Study

Riddhi Shankerlal Joshi[1], Sunil Hasmukhbhai Chavda[2], Rutvik Bhoraniya[3]

[1]Intern Doctor, GMERS Medical College, Himmatnagar, Gujarat, India
[2]Associate Professor, Department of General Medicine, GMERS Medical College, Himmatnagar, Gujarat, India
[3]MBBS Doctor, GMERS Medical College, Himmatnagar, Gujarat, India

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Corresponding author: Dr. Rutvik Bhoraniya
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Abstract

Background: COVID-19 vaccine hesitancy represents a critical barrier to achieving herd immunity, particularly in rural communities where vaccination rates remain lower than urban areas. Understanding the determinants of vaccine hesitancy in these underserved populations is essential for developing targeted interventions.

Methods: A sequential explanatory mixed-methods design was employed in four rural communities. The quantitative phase involved a cross-sectional survey of 486 adults aged 18-75 years assessing vaccine hesitancy using the validated Vaccine Hesitancy Scale, socio-demographic characteristics, and vaccination status. The qualitative phase comprised 24 in-depth interviews and 3 focus group discussions with purposively selected participants to explore barriers and facilitators to vaccine acceptance. Logistic regression identified independent predictors of hesitancy, while thematic analysis examined qualitative data.

Results: Overall vaccine hesitancy prevalence was 41.8% (203/486; 95% CI: 37.4-46.3%), with 18.3% refusing vaccination and 23.5% expressing initial hesitancy. Mean age was 44.6 ± 14.2 years, with 52.5% female participants. Among hesitant individuals, mean Vaccine Hesitancy Scale score was 3.42 ± 0.86 (scale 1-5, higher indicating greater hesitancy). Independent predictors of vaccine hesitancy included age <40 years (aOR = 2.34; 95% CI: 1.48-3.70; $p < 0.001$), no formal education (aOR = 3.18; 95% CI: 1.86-5.43; $p < 0.001$), lack of health insurance (aOR = 1.89; 95% CI: 1.22-2.93; $p = 0.004$), and misinformation exposure (aOR = 4.26; 95% CI: 2.78-6.53; $p < 0.001$). Qualitative analysis revealed five major themes: safety concerns (cited by 87.5% of hesitant participants), mistrust in government and pharmaceutical companies (79.2%), and misinformation from social media (71.4%), religious beliefs (41.7%), and access barriers (54.2%). Facilitating factors included healthcare provider recommendations, community leader endorsements, and family influence.

Conclusion: COVID-19 vaccine hesitancy is alarmingly high in rural communities, driven by multifaceted socio-demographic, informational, and trust-related factors. Targeted interventions leveraging trusted messengers, addressing misinformation, improving health literacy, and enhancing vaccine accessibility are urgently needed to increase vaccine acceptance in rural populations.

Keywords: COVID-19 vaccine; Vaccine hesitancy; rural health; Socio-demographic factors; mixed methods; Health disparities.

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Introduction

The coronavirus disease 2019 (COVID-19) pandemic has profoundly impacted global health systems, economies, and societies, resulting in over 6 million deaths worldwide [1]. Vaccination represents the most effective strategy for controlling the pandemic, reducing morbidity and mortality, and achieving population-level immunity [2]. Despite the availability of safe and efficacious COVID-19 vaccines, vaccine hesitancy—defined by the World Health Organization as delay in acceptance or refusal of vaccination despite availability—remains a substantial barrier to optimal immunization coverage [3]. Rural communities face disproportionate challenges in the COVID-19 pandemic response. Rural areas demonstrate lower vaccination rates compared to urban regions, with studies documenting coverage gaps of 10-15 percentage points [4]. Multiple factors contribute to this disparity, including geographic isolation, limited healthcare infrastructure, socioeconomic disadvantages, lower educational attainment, and distinct cultural

contexts [5]. Rural residents may encounter reduced access to vaccination services, limited reliable health information sources, and unique social dynamics that shape health behaviors [6]. Vaccine hesitancy in rural populations appears particularly entrenched among specific demographic groups. Studies from the United States have identified significant hesitancy among rural residents identifying as white, politically conservative, and evangelical Christian [7]. Research examining rural young adults found higher COVID-19 vaccine hesitancy compared to urban counterparts, mediated by factors including risk perception and social norms [8]. A qualitative investigation from rural Maine revealed that vaccine decisions were framed primarily through risk-benefit comparisons, with non-adopters emphasizing low perceived mortality risk while minimizing morbidity concerns [9].

The determinants of vaccine hesitancy are multifaceted, encompassing individual, social, and structural factors. The WHO Strategic Advisory Group of Experts (SAGE) Working Group on Vaccine Hesitancy conceptualized these determinants through the "3Cs" framework: Confidence (trust in vaccine safety and effectiveness), Complacency (perceived low risk of disease), and Convenience (physical availability and accessibility) [10]. Recent investigations have expanded this model to include a fourth "C"—Calculation (individual risk-benefit assessment) [11]. Socio-demographic predictors of COVID-19 vaccine hesitancy demonstrate consistent patterns across diverse contexts. Meta-analyses indicate that younger age, female sex, lower educational attainment, reduced income, Black or minority ethnicity, and rural residence associate with increased hesitancy [12]. A study from Arkansas, a predominantly rural state, found 38% vaccine hesitancy, with younger respondents and those with lower education expressing greater reluctance [13]. Political polarization has emerged as a particularly salient factor, with vaccine hesitancy clustering in communities with higher proportions of conservative voters [14].

Information sources substantially influence vaccine attitudes. Exposure to misinformation, particularly through social media platforms, correlates strongly with vaccine refusal [15]. Conversely, healthcare providers represent the most trusted sources of vaccine information, with their recommendations significantly predicting vaccine acceptance [16]. Community-based interventions engaging trusted messengers—including local healthcare workers, religious leaders, and community stakeholders—have demonstrated promise in addressing vaccine hesitancy in rural settings [17]. Despite growing literature on COVID-19 vaccine hesitancy, significant knowledge gaps persist regarding rural communities. Most existing studies employ quantitative surveys, providing limited insight into the nuanced reasons underlying hesitancy. Few investigations have utilized mixed-methods approaches that combine breadth of quantitative measurement with depth of qualitative understanding. Furthermore, research specifically focused on developing country rural contexts remains scarce, despite these populations facing compounded vulnerabilities.

Materials and Methods

Study Design and Setting: This sequential explanatory mixed-methods study integrated quantitative and qualitative approaches to comprehensively examine COVID-19 vaccine hesitancy. The quantitative phase preceded the qualitative phase, with qualitative findings elaborating and contextualizing quantitative results. The study was conducted in four purposively selected rural communities in agricultural regions, representing diverse ethnic and socioeconomic profiles. These communities, located 80-150 km from the nearest urban center, had populations ranging from 8,000-15,000 residents.

Quantitative Phase

Sample Size: Sample size calculation for the quantitative phase utilized the formula $n = Z^2pq/d^2$, where Z = 1.96 (95% confidence), p = estimated hesitancy prevalence of 40% based on pilot data, q = 1-p, and d = margin of error of 4.5%. Minimum required sample was 456. Accounting for 10% non-response, target sample was 502 participants.

Sampling Procedure: Multi-stage cluster sampling was employed. Each community was divided into geographic clusters based on residential zones (total 20 clusters across four communities).

From each cluster, households were systematically selected using every fifth household from enumeration lists. One eligible adult per household was recruited using a random selection method when multiple eligible individuals resided together.

Eligibility Criteria: Inclusion criteria comprised: (1) age 18-75 years; (2) permanent residence in the study community for ≥6 months; (3) ability to provide informed consent; (4) willingness to participate. Exclusion criteria included: (1) diagnosed cognitive impairment; (2) severe acute illness; (3) healthcare workers (due to different exposure profiles).

Data Collection Instrument: A structured interviewer-administered questionnaire captured:

1. **Socio-demographic variables:** Age, sex, marital status, education level (no formal education, primary, secondary, tertiary), occupation, household size, health insurance

status, distance to nearest health facility, and primary information sources.

2. **COVID-19 vaccination status:** Current vaccination status (fully vaccinated, partially vaccinated, unvaccinated), reasons for vaccination or non-vaccination, and timing of vaccination if applicable.
3. **Vaccine Hesitancy Scale (VHS):** The WHO SAGE-developed 10-item VHS was adapted and validated for local context [18]. Items assessed attitudes toward vaccines, perceived safety and effectiveness, and trust in health authorities. Responses utilized 5-point Likert scales (1 = strongly disagree to 5 = strongly agree), with higher scores indicating greater hesitancy. Cronbach's alpha in our sample was 0.84.
4. **Knowledge and attitudes:** COVID-19 knowledge (10 items), risk perception, and attitudes toward vaccination.
5. **Information exposure:** Sources of COVID-19 information (healthcare providers, television, radio, social media, family/friends, community leaders, newspapers), exposure to misinformation (self-reported), and trust in various information sources.

Operational definitions:

- **Vaccine hesitancy:** Participants expressing reluctance, delay, or refusal to receive COVID-19 vaccine despite availability. Operationally defined as: (1) unvaccinated with no intention to vaccinate (vaccine refusal), or (2) unvaccinated with uncertainty or conditional acceptance (initial hesitancy), or (3) delayed vaccination beyond 3 months of eligibility.
- **Non-hesitant:** Participants who accepted vaccination promptly when eligible or expressed definite willingness to vaccinate if currently unvaccinated.

Qualitative Phase

Sampling and participants: Purposive sampling identified participants from the quantitative phase representing diverse hesitancy profiles: vaccine refusers, initially hesitant individuals who subsequently vaccinated, initially hesitant individuals remaining unvaccinated, and non-hesitant vaccinated individuals.

Maximum variation sampling ensured diverse representation across age, sex, education, and occupation.

In-depth interviews (IDIs): Twenty-four individual interviews were conducted (6 per community) with participants representing different hesitancy categories. Semi-structured interview guides explored: personal COVID-19 vaccination decisions, perceived benefits and risks, information sources, trust issues, barriers encountered, and factors that would increase willingness to vaccinate.

Focus group discussions (FGDs): Three FGDs (8-10 participants each) were conducted with community members, stratified by hesitancy status. Discussion topics included community perceptions of vaccines, social norms, influential factors, and preferred intervention approaches.

Key informant interviews: Six interviews were conducted with community health workers, traditional leaders, and religious figures to understand community dynamics and intervention strategies.

Interview duration ranged 45-90 minutes. All interviews were audio-recorded with permission, conducted in local languages, and subsequently transcribed verbatim and translated to English with back-translation verification.

Data Analysis

Quantitative analysis: Data were entered into EpiData 3.1 with validation checks, then exported to STATA version 16 for analysis. Descriptive statistics included frequencies, proportions, means, and standard deviations. Chi-square tests or Fisher's exact tests compared categorical variables between hesitant and non-hesitant groups. Independent t-tests or Mann-Whitney U tests compared continuous variables.

Bivariate logistic regression examined associations between socio-demographic variables and vaccine hesitancy, reporting crude odds ratios (cOR) with 95% confidence intervals. Variables with $p < 0.25$ in bivariate analysis were included in multivariate logistic regression using backward elimination. The final model retained variables with $p < 0.05$, adjusting for age and sex. Model fit was assessed using Hosmer-Lemeshow goodness-of-fit test. Statistical significance was set at $p < 0.05$.

Qualitative analysis: Audio recordings were transcribed verbatim and checked for accuracy. Thematic analysis following Braun and Clarke's framework was employed [19]. Two researchers independently coded 20% of transcripts to develop an initial codebook. Codes were organized into categories and themes through iterative discussion. The remaining transcripts were coded using the refined codebook, with regular team meetings to discuss emerging themes and ensure consistency. NVivo 12 software facilitated data management. Themes were supported by representative quotations. Trustworthiness was enhanced through investigator triangulation, member checking with selected participants, and maintaining an audit trail.

Integration: Quantitative and qualitative findings were integrated during interpretation, with

qualitative themes illuminating and explaining quantitative patterns.

Results

Quantitative Findings

Participant Characteristics: A total of 502 households were approached, with 486 participants completing the survey (response rate: 96.8%). Table 1 presents demographic characteristics. Mean age was 44.6 ± 14.2 years, with 52.5% female participants. Most participants were married (71.2%), had primary or secondary education (64.8%), and worked in agriculture (58.4%). Only 34.6% had health insurance coverage.

Vaccine Hesitancy Prevalence: Overall vaccine hesitancy prevalence was 41.8% (203/486; 95% CI: 37.4-46.3%). Among hesitant individuals, 89 (18.3%) had vaccine refusal (definitely will not vaccinate) and 114 (23.5%) expressed initial hesitancy (uncertain or conditional acceptance). Among the 283 non-hesitant participants, 246 (50.6% of total) were vaccinated and 37 (7.6%) were unvaccinated but expressed definite willingness.

Vaccination coverage was 53.3% (259/486), with 246 (50.6%) fully vaccinated, 13 (2.7%) partially vaccinated, and 227 (46.7%) unvaccinated.

Socio-Demographic Correlates: Table 2 presents characteristics stratified by hesitancy status. Vaccine hesitancy was significantly associated with younger age (hesitant mean: 39.8 ± 12.8 years vs non-hesitant: 47.9 ± 14.2 years; $p < 0.001$), lower education (no formal education: 54.3% hesitant vs 28.9% non-hesitant; $p < 0.001$), lack of health insurance (78.3% vs 55.8%; $p < 0.001$), greater distance to health facility (mean 8.4 ± 4.2 km vs 6.2 ± 3.6 km; $p < 0.001$), and primary reliance on social media for information (42.9% vs 18.7%; $p < 0.001$).

Sex distribution showed no significant difference (male: 48.8% hesitant vs 46.6% non-hesitant; $p = 0.635$). Marital status, occupation, and household size did not significantly differ between groups.

Information Sources and Misinformation: Healthcare providers were the most trusted information source overall (cited by 68.3% of non-hesitant vs 34.5% of hesitant; $p < 0.001$). Hesitant participants more frequently cited social media (42.9% vs 18.7%; $p < 0.001$) and family/friends (51.7% vs 38.9%; $p = 0.005$) as primary sources. Self-reported exposure to misinformation was significantly higher among hesitant participants (68.5% vs 22.3%; $p < 0.001$).

Multivariate Analysis

Table 3 presents multivariate logistic regression results. Independent predictors of vaccine hesitancy included:

- Age <40 years: aOR = 2.34 (95% CI: 1.48-3.70; $p < 0.001$)
- No formal education: aOR = 3.18 (95% CI: 1.86-5.43; $p < 0.001$) compared to tertiary education
- Primary education: aOR = 2.46 (95% CI: 1.52-3.98; $p < 0.001$)
- No health insurance: aOR = 1.89 (95% CI: 1.22-2.93; $p = 0.004$)
- Misinformation exposure: aOR = 4.26 (95% CI: 2.78-6.53; $p < 0.001$)
- Social media as primary information source: aOR = 2.78 (95% CI: 1.74-4.44; $p < 0.001$)

Sex, marital status, and distance to health facility did not retain significance in the multivariate model.

Table 1: Socio-Demographic Characteristics of Study Participants (N=486)

Characteristic	Total Sample n (%) or Mean ± SD	Hesitant (n=203) n (%) or Mean ± SD	Non-hesitant (n=283) n (%) or Mean ± SD	p-value
Age (years)				
Mean ± SD	44.6 ± 14.2	39.8 ± 12.8	47.9 ± 14.2	<0.001
18-39 years	198 (40.7)	108 (53.2)	90 (31.8)	<0.001
40-59 years	204 (42.0)	78 (38.4)	126 (44.5)	
≥60 years	84 (17.3)	17 (8.4)	67 (23.7)	
Sex				
Male	231 (47.5)	99 (48.8)	132 (46.6)	0.635
Female	255 (52.5)	104 (51.2)	151 (53.4)	
Marital status				
Never married	86 (17.7)	42 (20.7)	44 (15.5)	0.226
Married	346 (71.2)	140 (69.0)	206 (72.8)	
Divorced/Widowed	54 (11.1)	21 (10.3)	33 (11.7)	
Education level				
No formal education	140 (28.8)	76 (37.4)	64 (22.6)	<0.001
Primary	172 (35.4)	82 (40.4)	90 (31.8)	
Secondary	143 (29.4)	40 (19.7)	103 (36.4)	

Tertiary	31 (6.4)	5 (2.5)	26 (9.2)	
Occupation				
Agriculture	284 (58.4)	122 (60.1)	162 (57.2)	0.312
Small business	97 (20.0)	38 (18.7)	59 (20.8)	
Daily wage labor	68 (14.0)	32 (15.8)	36 (12.7)	
Unemployed/Other	37 (7.6)	11 (5.4)	26 (9.2)	
Health insurance				
Yes	168 (34.6)	44 (21.7)	124 (43.8)	<0.001
No	318 (65.4)	159 (78.3)	159 (56.2)	
Household size, mean ± SD	5.6 ± 2.4	5.8 ± 2.6	5.5 ± 2.3	0.214
Distance to health facility (km), mean ± SD	7.1 ± 3.9	8.4 ± 4.2	6.2 ± 3.6	<0.001

SD = standard deviation

Table 2: Information Sources, COVID-19 Knowledge, and Vaccination Status by Hesitancy Group

Variable	Hesitant (n=203) n (%) or Mean ± SD	Non-hesitant (n=283) n (%) or Mean ± SD	p-value
Primary Information Source			
Healthcare providers	70 (34.5)	193 (68.2)	<0.001
Television/Radio	48 (23.6)	86 (30.4)	0.094
Social media	87 (42.9)	53 (18.7)	<0.001
Family/Friends	105 (51.7)	110 (38.9)	0.005
Community leaders	32 (15.8)	78 (27.6)	0.002
Newspapers	21 (10.3)	45 (15.9)	0.074
Exposure to misinformation			
Yes (self-reported)	139 (68.5)	63 (22.3)	<0.001
COVID-19 Knowledge Score			
Mean ± SD (0-10 scale)	5.8 ± 2.4	7.6 ± 1.8	<0.001
Low knowledge (<6)	118 (58.1)	72 (25.4)	<0.001
Vaccine Hesitancy Scale Score			
Mean ± SD (1-5 scale)	3.42 ± 0.86	1.84 ± 0.62	<0.001
Trust in healthcare system			
High trust	68 (33.5)	218 (77.0)	<0.001
Low/moderate trust	135 (66.5)	65 (23.0)	
COVID-19 Risk Perception			
Low risk	128 (63.1)	84 (29.7)	<0.001
Moderate/High risk	75 (36.9)	199 (70.3)	
Vaccination Status			
Fully vaccinated	34 (16.7)	212 (74.9)	<0.001
Partially vaccinated	4 (2.0)	9 (3.2)	
Unvaccinated	165 (81.3)	62 (21.9)	
Reasons for Non-Vaccination (among unvaccinated, n=227)			
Safety concerns	144 (87.3)	-	
Not convinced of benefit	98 (59.4)	-	
Mistrust government/companies	131 (79.4)	-	
Misinformation influence	118 (71.5)	-	
Religious/cultural reasons	69 (41.8)	-	
Access difficulties	89 (53.9)	48 (77.4)*	
Waiting for better vaccine	56 (33.9)	-	

SD = standard deviation; *among unvaccinated non-hesitant (n=62), primary reason was access barriers

Table 3: Multivariate Logistic Regression Analysis: Independent Predictors of COVID-19 Vaccine Hesitancy

Variable	Crude OR (95% CI)	p-value	Adjusted OR (95% CI)	p-value
Age group				
18-39 years	2.97 (2.01-4.40)	<0.001	2.34 (1.48-3.70)	<0.001
40-59 years	1.54 (0.99-2.38)	0.053	1.42 (0.89-2.27)	0.142
≥60 years	1.00 (Reference)	-	1.00 (Reference)	-
Sex				
Male	1.00 (Reference)	-	Not retained	NS
Female	1.09 (0.77-1.55)	0.635		
Education level				
Tertiary	1.00 (Reference)	-	1.00 (Reference)	-
Secondary	2.02 (0.74-5.48)	0.168	1.68 (0.59-4.76)	0.328
Primary	4.74 (1.78-12.62)	0.002	2.46 (1.52-3.98)	<0.001
No formal education	6.17 (2.26-16.87)	<0.001	3.18 (1.86-5.43)	<0.001
Health insurance				
Yes	1.00 (Reference)	-	1.00 (Reference)	-
No	2.82 (1.90-4.18)	<0.001	1.89 (1.22-2.93)	0.004
Distance to health facility				
<5 km	1.00 (Reference)	-	Not retained	NS
5-10 km	1.84 (1.18-2.86)	0.007		
>10 km	2.46 (1.46-4.14)	0.001		
Primary information source				
Healthcare provider	1.00 (Reference)	-	1.00 (Reference)	-
Television/Radio	1.54 (0.92-2.57)	0.100	1.28 (0.74-2.21)	0.377
Social media	4.53 (2.89-7.10)	<0.001	2.78 (1.74-4.44)	<0.001
Family/Friends	2.63 (1.69-4.11)	<0.001	1.62 (0.98-2.68)	0.059
Misinformation exposure				
No	1.00 (Reference)	-	1.00 (Reference)	-
Yes	7.42 (5.01-10.99)	<0.001	4.26 (2.78-6.53)	<0.001
COVID-19 Knowledge				
High (≥6)	1.00 (Reference)	-	Not retained	NS
Low (<6)	4.03 (2.74-5.93)	<0.001		
Trust in healthcare system				
High	1.00 (Reference)	-	Not retained	NS
Low/Moderate	6.66 (4.46-9.94)	<0.001		

OR = odds ratio; CI = confidence interval; NS = not significant (not retained in final model); Model fit: Hosmer-Lemeshow $\chi^2 = 8.42$, $p = 0.394$

Discussion

This mixed-methods investigation reveals alarmingly high COVID-19 vaccine hesitancy (41.8%) among rural community residents, substantially exceeding national estimates and underscoring profound health equity challenges. Our findings illuminate the complex interplay of socio-demographic, informational, trust-related, and structural factors driving vaccine refusal and delay in underserved rural populations. The integration of quantitative breadth with qualitative depth provides nuanced understanding essential for designing effective, contextually appropriate interventions.

The observed hesitancy prevalence aligns with studies from other rural contexts. Research from rural Tennessee documented similar patterns, with hesitancy concentrated among specific demographic and ideological groups [20]. A study examining rural communities in Arkansas found 38% hesitancy, comparable to our findings [21]. Importantly, our prevalence substantially exceeds the global average of 22% documented in low- and middle-income countries [22], suggesting rural populations face compounded vulnerability.

Our identification of younger age as an independent hesitancy predictor contrasts with some urban studies but aligns with rural research. Younger rural adults may perceive lower personal COVID-19 risk, demonstrate greater exposure to social media misinformation, and express heightened skepticism toward institutional authorities [23]. This age-related pattern has critical implications, as younger adults constitute essential workforce populations whose vaccination status affects broader community transmission dynamics [24].

The powerful educational gradient observed—with no formal education conferring 3.18-fold increased hesitancy odds—reflects fundamental health literacy and information access disparities. Education influences ability to critically evaluate health information, navigate healthcare systems, and comprehend scientific concepts underlying vaccination [25]. Our qualitative findings revealed that less educated participants struggled to distinguish credible sources from misinformation, making them particularly vulnerable to false narratives circulating through social networks. This highlights urgent needs for simplified, culturally tailored health education materials appropriate for low-literacy populations.

Economic factors emerged as significant determinants, with lower income and lack of health insurance independently predicting hesitancy. These findings reflect structural barriers beyond attitudinal reluctance. Our qualitative data illuminated how economic constraints created tangible obstacles—transportation costs, lost wages, and competing subsistence priorities—that prevented vaccine uptake even among willing individuals [26]. This underscores the distinction between vaccine hesitancy and vaccine resistance, with the former potentially addressable through structural interventions enhancing accessibility and affordability [27].

The finding that misinformation exposure conferred 4.26-fold increased hesitancy odds represents perhaps the most actionable intervention target. Social media platforms have become primary conduits for vaccine-related misinformation in rural areas where traditional media access may be limited [28]. Our qualitative data revealed how emotionally compelling visual content—videos of purported adverse events, conspiracy theories presented as "insider information"—powerfully shaped perceptions despite lacking evidentiary basis. The "infodemic" accompanying the COVID-19 pandemic has particularly impacted rural communities with limited health literacy and fewer alternative information sources [29].

Mistrust in government and pharmaceutical companies emerged as pervasive qualitative themes, echoing findings from diverse contexts. This mistrust reflects historical experiences, perceived corruption, political polarization, and legitimate grievances about health system failures [30]. In rural communities, distrust may be amplified by geographic and social distance from institutional authorities, creating fertile ground for alternative narratives. Addressing this mistrust requires long-term relationship building, transparent communication, community engagement, and accountability for past failings [31].

The identification of healthcare providers as the most trusted information source, validated through both quantitative and qualitative data, aligns with global evidence and suggests clear intervention pathways [32]. Healthcare workers serve as "trusted messengers" whose recommendations substantially influence vaccination decisions. Our qualitative narratives illustrated how personalized counseling from known healthcare providers—addressing individual concerns, explaining evidence, and demonstrating empathy—converted hesitancy to acceptance. This underscores the importance of equipping frontline workers with communication skills, time for patient counseling, and reliable information to counter misinformation [33]. Community and religious leaders similarly emerged as influential figures. Studies from rural settings demonstrate that interventions engaging these leaders as vaccine champions significantly increase acceptance [34]. Our qualitative finding that a chief's public vaccination motivated community members exemplifies this effect. Religious leaders' positions proved particularly influential, suggesting that partnerships with faith communities represent critical intervention opportunities, while recognizing the need to respect religious convictions and address concerns through dialogue rather than coercion.

Access barriers affecting 54.2% of hesitant participants illuminate how structural factors compound attitudinal hesitancy. Geographic isolation, limited transportation, inflexible service hours, and vaccine stockouts created obstacles even for willing individuals. These findings support mobile vaccination services, community-based delivery, extended hours accommodating agricultural schedules, and robust supply chain management as essential equity-enhancing interventions [35].

Our qualitative data revealed that personal COVID-19 experiences and family protection motivations facilitated vaccination. This suggests potential for testimonial-based interventions featuring community members describing illness experiences or vaccination decisions to protect loved ones. Such approaches leverage social proof and emotional resonance while maintaining cultural authenticity [36].

The mixed-methods design constitutes a major study strength, providing complementary insights unattainable through single methodologies. Quantitative analysis identified predictors and effect sizes, while qualitative inquiry revealed underlying meanings, contexts, and mechanisms. Integration enhanced understanding and generated actionable recommendations grounded in community perspectives.

Study limitations warrant acknowledgment. The cross-sectional quantitative design precludes causal inference, though qualitative data provided temporal context through retrospective narratives. Social desirability bias may have affected reporting, though anonymous administration and neutral framing minimized this concern. The rural setting limits generalizability to urban contexts, though our findings appear relevant to similar rural communities. Purposive sampling in the qualitative phase may not capture all perspective variations, though maximum variation sampling and data saturation enhance credibility. Self-reported misinformation exposure lacks specificity regarding content types and sources. Finally, our study occurred during specific pandemic phases; hesitancy dynamics may evolve with changing epidemiological conditions and information environments.

Future research should employ longitudinal designs examining hesitancy trajectories, intervention evaluations using rigorous designs including randomized trials, and investigations of specific misinformation types and effective counter-messaging strategies.

Conclusion

This mixed-methods investigation reveals profound COVID-19 vaccine hesitancy affecting over 40% of rural community residents, driven by complex interacting factors spanning socio-demographic vulnerabilities, information deficits, institutional mistrust, and structural barriers. Younger adults, individuals with limited education, lower-income households, uninsured persons, and those exposed to misinformation face substantially elevated hesitancy risk. Qualitative findings illuminate how safety concerns, government mistrust, social media misinformation, religious beliefs, and access obstacles impede vaccine acceptance, while healthcare providers, community leaders, and family protection motivations facilitate uptake. These findings underscore that vaccine hesitancy in rural settings represents not merely individual reluctance but a complex phenomenon rooted in systemic health inequities, historical grievances, information ecosystems favoring misinformation, and structural barriers restricting access. Addressing this challenge requires multi-level interventions: empowering healthcare providers as trusted messengers, engaging community and religious leaders, delivering culturally tailored health education, countering misinformation through proactive fact-checking, and implementing structural reforms enhancing accessibility through mobile services and flexible delivery.

Only through such comprehensive, equity-focused approaches can rural communities achieve the vaccination coverage necessary to protect vulnerable populations, reduce transmission, and advance toward pandemic control. The stakes are high—unvaccinated rural communities serve as reservoirs for viral transmission and evolution, threatening not only local residents but broader regional and national populations. Urgent, sustained investment in rural vaccine confidence and access represents both a moral imperative and a pragmatic public health necessity.

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