



Original Article

## Vaccine hesitancy toward childhood vaccination in the Madinah Region, Saudi Arabia: A cross-sectional study

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### ABSTRACT

**Objectives:** Vaccine hesitancy poses a significant threat to public health and childhood immunization programs globally. Despite high vaccination coverage in Saudi Arabia, limited data exist on parental attitudes toward childhood vaccines in the Madinah region. The objective of the study is to assess the prevalence and determinants of parental vaccine hesitancy toward childhood vaccination in the Madinah region, Saudi Arabia.

**Methods:** A cross-sectional survey was conducted between December 2024 and March 2025 among the parents recruited from five selected healthcare facilities in the Madinah region, with supplementary online participation. Parents of children aged 1–10 years were recruited using convenience sampling.

**Results:** Of 322 participating parents, 89 (27.6%, 95% confidence interval [CI]: 23.0–32.7%) were classified as vaccine hesitant. The mean PACV score was  $38.4 \pm 18.2$ . In multivariate analysis, factors independently associated with vaccine hesitancy included lower parental education (adjusted odds ratio [aOR]: 2.87, 95% CI: 1.52–5.41,  $p = 0.001$ ), unemployment (aOR: 2.14, 95% CI: 1.18–3.89,  $p = 0.012$ ), exposure to anti-vaccine information on social media (aOR: 3.76, 95% CI: 2.08–6.79,  $p < 0.001$ ), and having  $\geq 4$  children (aOR: 1.98, 95% CI: 1.05–3.73,  $p = 0.034$ ). Parents with previous experience of vaccine adverse events were also more likely to be hesitant (aOR: 2.52, 95% CI: 1.31–4.85,  $p = 0.006$ ).

**Conclusion:** More than one-quarter of parents in Madinah demonstrate vaccine hesitancy, with social media exposure and lower education being key modifiable risk factors. Targeted educational interventions and social media monitoring strategies are needed to address parental concerns and maintain high vaccination coverage.

**Keywords:** Childhood vaccination, Cross-sectional study, Madinah, Parents, Saudi Arabia, Vaccine hesitancy

### INTRODUCTION

Vaccination represents one of the most successful public health interventions in history, preventing an estimated 2–3 million deaths annually and contributing to the near-eradication of diseases such as polio and measles.<sup>[1,2]</sup> Despite these achievements, vaccine hesitancy – defined by the World Health Organization (WHO) as the delay in acceptance or refusal of vaccines despite availability – has emerged as one of the top ten threats to global health.<sup>[3]</sup> This phenomenon undermines decades of progress in immunization programs and has been associated with recent outbreaks of vaccine-preventable diseases in various regions.<sup>[4,5]</sup>

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Vaccine hesitancy is a complex and context-specific phenomenon influenced by factors including individual and group influences, vaccine-specific issues, and contextual factors.<sup>[6]</sup> Globally, studies have documented varying rates of vaccine hesitancy, ranging from 10% to over 40% across different populations and settings.<sup>[7,8]</sup> In high-income countries, concerns about vaccine safety, perceived low disease risk, and distrust in pharmaceutical companies have been identified as major drivers of hesitancy.<sup>[9,10]</sup> In low- and middle-income countries, additional barriers such as access to healthcare services, misconceptions about vaccines, and lack of awareness about vaccine-preventable diseases contribute to hesitancy.<sup>[11,12]</sup>

In the Middle East and North Africa region, vaccine hesitancy has been documented with considerable variation across countries. Studies from Turkey have documented parental vaccine refusal and hesitancy, with educational level, misconceptions about vaccine safety, and exposure to anti-vaccine information identified as key predictors.<sup>[13]</sup> Research from Indonesia has highlighted the role of religious beliefs and community leaders in shaping parental vaccination decisions.<sup>[14]</sup> In Central Asian countries such as Kyrgyzstan, studies have identified gaps in parental knowledge about specific vaccines and concerns about adverse events as significant barriers to vaccination acceptance.<sup>[15]</sup>

In Saudi Arabia, the national immunization program has achieved vaccination coverage rates exceeding 95% for most childhood vaccines, reflecting strong governmental commitment and an effective healthcare delivery system.<sup>[16]</sup> However, recent studies have indicated emerging concerns about vaccine confidence among Saudi parents, particularly following the COVID-19 pandemic and increased exposure to misinformation through social media platforms.<sup>[17,18]</sup> Studies from Riyadh and Jeddah have reported vaccine hesitancy rates of 15–20%, with factors such as educational level, previous vaccine experiences, and information sources identified as important determinants.<sup>[19,20]</sup> The Madinah region, as a major pilgrimage destination hosting millions of visitors annually, represents a unique epidemiological context where maintaining high vaccination coverage is particularly critical for public health security.

Understanding the prevalence and predictors of vaccine hesitancy in specific regional contexts is essential for developing targeted interventions and maintaining robust immunization programs. Despite growing global attention to vaccine hesitancy, limited research has been conducted in the Madinah region specifically. Previous studies in Saudi Arabia have primarily focused on major urban centers such as Riyadh and Jeddah or have examined specific vaccines such as the influenza or COVID-19 vaccines.<sup>[19,20]</sup> Furthermore, the evolving landscape of information dissemination through digital media platforms necessitates updated assessments of parental attitudes toward childhood immunization.

This study aimed to assess the prevalence of vaccine hesitancy among parents of children aged 1–10 years in the Madinah region and to identify sociodemographic, behavioral, and informational factors associated with hesitancy. The findings will inform evidence-based interventions to strengthen vaccine confidence and ensure sustained protection against vaccine-preventable diseases in this important region of Saudi Arabia.

## MATERIALS & METHODS

### Study design and setting

This was a cross-sectional survey conducted among the parents recruited from selected healthcare facilities in the Madinah region of Saudi Arabia between December 2024 and March 2025, with supplementary in online participation. The study was conducted in accordance with the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines for cross-sectional studies [Supplementary Material].

### Study population and eligibility criteria

The study targeted parents (mothers or fathers) of children aged 1–10 years residing in Madinah. For the purposes of this study, “residency” was defined as living in the Madinah region for at least six months before the study, regardless of nationality, including both Saudi citizens and non-Saudi residents. Inclusion criteria were (1) parent with at least one child aged 1–10 years, (2) residency in the Madinah region as defined above, (3) attendance at one of the selected healthcare facilities during the study period or receipt of the online questionnaire, (4) ability to read and understand Arabic, and (5) provision of verbal informed consent. Exclusion criteria included (1) non-residents or temporary visitors staying <6 months, (2) parents who declined participation, (3) children with documented medical contraindications to vaccination, and (4) incomplete questionnaire responses.

### Sampling strategy and sample size

Participants were recruited using a convenience sampling technique from five healthcare facilities representing different geographic clusters of Madinah: Al-Salam Primary Health Care (PHC) Center (Central Cluster), Al-Badrani PHC (North Cluster), Al-Hijra PHC (South Cluster), Aldaitha PHC (East Cluster), and the Pediatric Outpatient Clinics at Maternity and Children’s Hospital. Within each facility, parents attending for routine vaccination, pre-school entry examination, or any other clinic visit were approached consecutively by trained research assistants during clinic hours (8:00 am to 2:00 pm, Sunday through Thursday) and invited to participate. All parents meeting the eligibility

criteria who attended during the data collection period were approached until the target sample size was achieved.

The required sample size was calculated using the standard formula for single proportions with a 95% confidence level (CI), 5% margin of error, and an expected prevalence of vaccine hesitancy of 30% based on previous studies in similar settings. This calculation yielded a required sample size of 323 participants. A total of 322 valid responses were collected and analyzed.

### Data collection tool

The study used the validated Arabic version of the parent attitudes about childhood vaccines (PACV) questionnaire. The PACV was originally developed by Opel *et al.*,<sup>[21]</sup> and has been validated in multiple languages including Arabic.<sup>[22,23]</sup> The questionnaire consists of 15 items across three domains: (1) Vaccination behavior (5 items): History of vaccine refusal, delay, or compliance; (2) Beliefs about vaccine safety and efficacy (6 items): Perceptions of side effects, effectiveness, and trust in science; and (3) Trust in healthcare providers (4 items): Confidence in pediatricians and the healthcare system regarding vaccines.

Each item was scored as 0 (non-hesitant response), 1 (intermediate response), or 2 (hesitant response). The total raw score was converted to a 0–100 scale using the formula  $(\text{raw score}/30) \times 100$ . Parents with scores  $\geq 50$  were classified as vaccine hesitant, while those with scores  $< 50$  were considered non-hesitant, following standard PACV scoring guidelines. A supplementary sociodemographic questionnaire captured information on parental age, gender, education level, monthly household income, employment status, number of children, previous adverse events following vaccination, and sources of vaccine information including social media exposure.

### Data collection procedures

Data were collected through both on-site paper-based questionnaires and a secure online platform. Parents attending the selected healthcare facilities were approached by trained research assistants who explained the study purpose and obtained informed verbal consent. Participants could choose to complete the questionnaire immediately using a tablet device or paper form at the facility or to access it later through a secure online link sent to their mobile phones. The online version was hosted on a password-protected survey platform with data encryption. All questionnaires, whether completed on paper or electronically, were reviewed for completeness before acceptance. Paper forms were entered into the electronic database by two independent data entry clerks, with discrepancies resolved through reference to the original

forms. A comparison of responses between paper-based and electronic formats revealed no significant differences in PACV scores ( $p = 0.612$ ) or hesitancy prevalence ( $p = 0.584$ ), indicating no substantial mode effects.

### Statistical analysis

Data was analyzed using IBM Statistical Package for the Social Sciences Statistics version 28.0 (IBM Corp., Armonk, NY, USA). Descriptive statistics including frequencies, percentages, means, and 95% confidence intervals were used to summarize participant characteristics and vaccine hesitancy prevalence. The normality of continuous variables was assessed using the Shapiro–Wilk test and visual inspection of histograms.

Bivariate associations between vaccine hesitancy (dichotomized as hesitant vs. non-hesitant based on PACV score  $\geq 50$ ) and independent variables were examined using Pearson Chi-square tests or Fisher's exact test where appropriate. Variable demonstrating associations with  $p < 0.20$  in bivariate analysis were selected as candidates for inclusion in the multivariate model. Multivariate logistic regression analysis was performed to identify independent predictors of vaccine hesitancy, with adjusted odds ratios (aOR) and 95% CI reported. Statistical significance was set at  $p < 0.05$  for the final model.

Model diagnostics were performed to assess goodness-of-fit using the Hosmer–Lemeshow test ( $p > 0.05$  indicating acceptable fit). Multicollinearity among predictor variables was evaluated using variance inflation factors (VIF), with  $VIF < 5$  considered acceptable. The final model's discriminatory ability was assessed using the area under the receiver operating characteristic curve (AUC-ROC).

### Ethical considerations

The study protocol received approval from the Institutional Review Board of Madinah Health Affairs, which is the officially designated research ethics committee for health research conducted within the Madinah region under the Saudi Ministry of Health (approval number: IRB log No. 24-126, dated December 1, 2024). The study was conducted in accordance with the Declaration of Helsinki and all applicable national and institutional regulations for research involving human participants. Participation was entirely voluntary, and informed verbal consent was obtained from all participants after explanation of the study purpose, procedures, potential risks, and benefits. No personal identifiers were recorded in the dataset, and all data were stored securely with access restricted to authorized research team members only. Participants were informed of their right to withdraw from the study at any time without consequences.

## RESULTS

### Participant characteristics

A total of 356 parents were approached, of whom 322 completed the questionnaire, yielding a response rate of 90.4%. The participant flow is shown in Figure 1. The mean age of participating parents was  $34.8 \pm 6.7$  years (range: 22–52 years). The majority were mothers ( $n = 198, 61.5\%$ ), married ( $n = 314, 97.5\%$ ), and held at least a bachelor's degree ( $n = 187, 58.1\%$ ). Detailed sociodemographic characteristics stratified by vaccine hesitancy status are presented in Table 1.

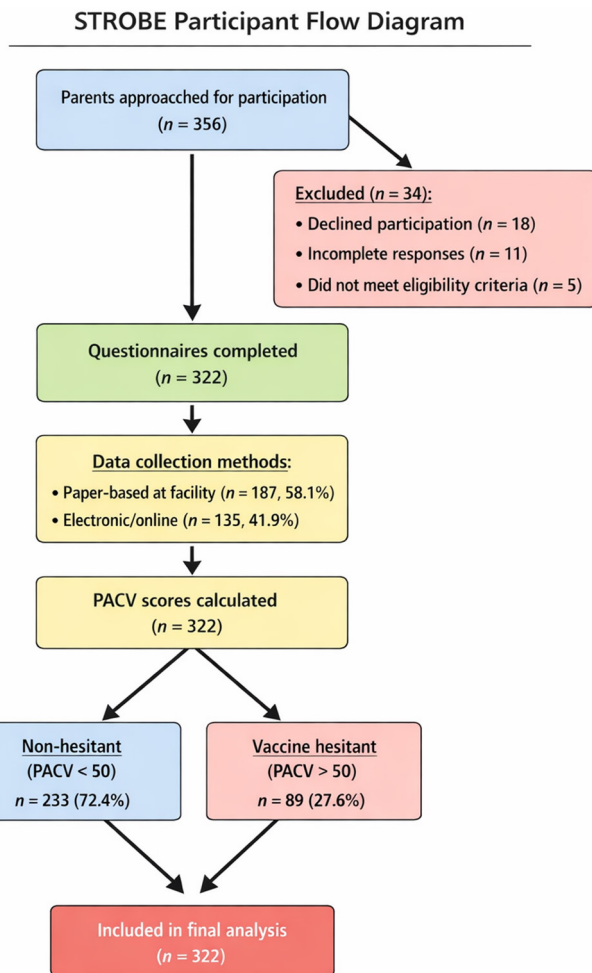
### Prevalence of vaccine hesitancy

Of the 322 parents, 89 (27.6%, 95% CI: 23.0–32.7%) scored  $\geq 50$  on the PACV scale and were classified as vaccine hesitant [Figure 2]. The mean PACV score for the entire sample was  $38.4 \pm 18.2$  (median: 36.7, range: 0–86.7). Among hesitant

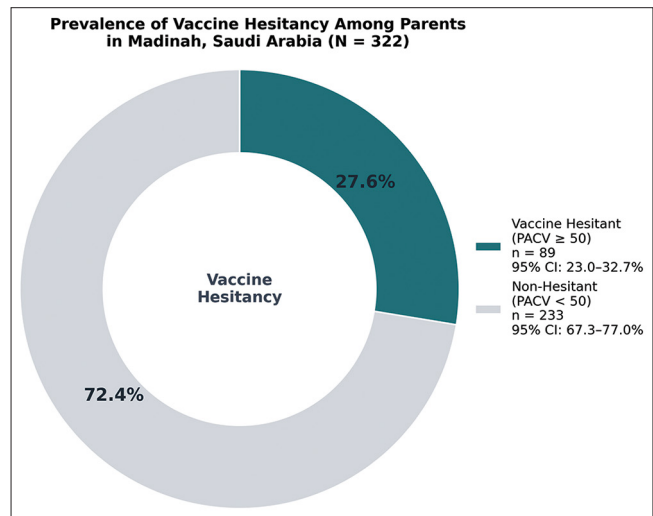
parents, the mean score was  $62.1 \pm 10.4$ , while non-hesitant parents scored  $28.9 \pm 11.8$  ( $p < 0.001$ ). The distribution of PACV scores is illustrated in Figure 3.

### Factors associated with vaccine hesitancy

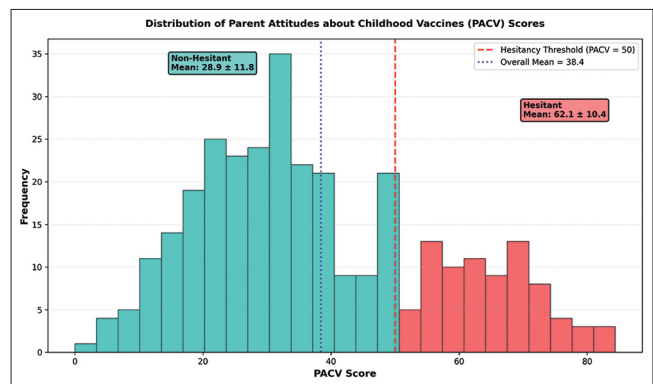
In bivariate analysis, several factors showed significant associations with vaccine hesitancy. Parents with lower educational attainment (high school or below) were significantly more likely to be hesitant compared to those with university education (38.5% vs. 20.9%,  $p = 0.001$ ). Unemployed parents demonstrated higher hesitancy rates than employed parents (35.7% vs. 22.1%,  $p = 0.009$ ). Parents who reported exposure to anti-vaccine information on social media platforms had substantially elevated hesitancy rates



**Figure 1:** Participant flow diagram. Strengthening the reporting of observational studies in epidemiology flow diagram showing participant recruitment, exclusions, and final analysis sample.



**Figure 2:** Prevalence of vaccine hesitancy. Donut chart showing the proportion of vaccine-hesitant (parent attitudes about childhood vaccines [PACV] score  $\geq 50$ ) and non-hesitant (PACV score < 50) parents with 95% confidence intervals (CI).



**Figure 3:** Distribution of parent attitudes about childhood vaccines (PACV) scores. Histogram showing the frequency distribution of PACV scores across the study population, with the hesitancy threshold (PACV score  $\geq 50$ ) clearly marked.

**Table 1:** Sociodemographic characteristics and vaccine hesitancy among parents in Madinah, Saudi Arabia (n=322).

Characteristic	Total (n=322)	Non-hesitant (n=233)	Hesitant (n=89)	p-value*
Age, years (mean±SD)	34.8±6.7	34.6±6.5	35.3±7.2	0.423
Gender				
Mother	198 (61.5)	145 (62.2)	53 (59.6)	
Father	124 (38.5)	88 (37.8)	36 (40.4)	0.668
Education level				
High school or below	135 (41.9)	83 (35.6)	52 (58.4)	
University or above	187 (58.1)	150 (64.4)	37 (41.6)	0.001
Employment status				
Employed	208 (64.6)	162 (69.5)	46 (51.7)	
Unemployed	114 (35.4)	71 (30.5)	43 (48.3)	0.003
Monthly household income				
<5,000 SAR	67 (20.8)	45 (19.3)	22 (24.7)	
5,000–10,000 SAR	132 (41.0)	93 (39.9)	39 (43.8)	
>10,000 SAR	123 (38.2)	95 (40.8)	28 (31.5)	0.216
Number of children				
1–3	239 (74.2)	183 (78.5)	56 (62.9)	
≥4	83 (25.8)	50 (21.5)	33 (37.1)	0.003
Exposed to anti-vaccine information on social media				
Yes	149 (46.3)	87 (37.3)	62 (69.7)	
No	173 (53.7)	146 (62.7)	27 (30.3)	<0.001
Previous adverse events following immunization				
Yes	85 (26.4)	49 (21.0)	36 (40.4)	
No	237 (73.6)	184 (79.0)	53 (59.6)	<0.001

Values are presented as n (%) unless otherwise stated. \*Chi-square test or Fisher's exact test where appropriate. SD: Standard deviation, SAR: Saudi Riyal, p-value <0.05

compared to those without such exposure (44.3% vs. 17.8%,  $p < 0.001$ ).

In addition, parents with four or more children showed higher hesitancy (36.1% vs. 23.4%,  $p = 0.022$ ), as did those reporting previous adverse events following immunization in their children (42.4% vs. 22.0%,  $p < 0.001$ ). Neither parental age, gender, monthly household income, nor child's age group showed significant associations with vaccine hesitancy in bivariate analysis.

### Multivariate analysis

Variables with  $p < 0.20$  in bivariate analysis were entered into the multivariate logistic regression model. The final model demonstrated good fit (Hosmer-Lemeshow  $\chi^2 = 8.34$ ,  $df = 8$ ,  $p = 0.400$ ) and acceptable discrimination (AUC-ROC = 0.78, 95% CI: 0.73–0.83). All VIF values were below 2.0, indicating no problematic multicollinearity.

After controlling for potential confounders, five factors remained independently associated with vaccine hesitancy [Table 2]. Parents with a high school education or below

had nearly three times the odds of being vaccine-hesitant compared to those with a university education (aOR: 2.87, 95% CI: 1.52–5.41,  $p = 0.001$ ). Unemployment was associated with more than double the odds of hesitancy (aOR: 2.14, 95% CI: 1.18–3.89,  $p = 0.012$ ). The strongest predictor was exposure to anti-vaccine information on social media, which increased the odds of hesitancy nearly fourfold (aOR: 3.76, 95% CI: 2.08–6.79,  $p < 0.001$ ). Parents with four or more children had approximately double the odds of being hesitant compared to those with fewer children (aOR: 1.98, 95% CI: 1.05–3.73,  $p = 0.034$ ). Finally, parents who reported previous adverse events following immunization in their children had more than double the odds of vaccine hesitancy (aOR: 2.52, 95% CI: 1.31–4.85,  $p = 0.006$ ).

### Sources of vaccine information

Analysis of vaccine information sources revealed significant differences between hesitant and non-hesitant parents [Table 3]. Healthcare providers were the most commonly cited source overall (78.3%) but were significantly more trusted by

**Table 2:** Multivariate logistic regression analysis of predictors of vaccine hesitancy (*n*=322).

Variable	aOR (95% CI)	p-value
Education level		
University or above	1.00 (reference)	–
High school or below	2.87 (1.52–5.41)	0.001
Employment status		
Employed	1.00 (reference)	–
Unemployed	2.14 (1.18–3.89)	0.012
Number of children		
1–3	1.00 (reference)	–
≥4	1.98 (1.05–3.73)	0.034
Anti-vaccine information on social media		
No	1.00 (reference)	–
Yes	3.76 (2.08–6.79)	<0.001
Previous adverse events		
No	1.00 (reference)	–
Yes	2.52 (1.31–4.85)	0.006

aOR: Adjusted odds ratio, CI: Confidence interval. Model fit: Hosmer-Lemeshow  $\chi^2=8.34$ , *df*=8, *p*=0.400; AUC-ROC=0.78 (95% CI: 0.73–0.83). All variance inflation factors <2.0, indicating no problematic multicollinearity, *p*-value <0.05

**Table 3:** Sources of vaccine information stratified by vaccine hesitancy status (*n*=322).

Information source	Total ( <i>n</i> =322)	Non-hesitant ( <i>n</i> =233)	Hesitant ( <i>n</i> =89)
Healthcare providers (physicians/nurses)	252 (78.3)	199 (85.4)	53 (59.6)
Social media platforms	143 (44.4)	88 (37.8)	55 (61.8)
Government health websites	186 (57.8)	145 (62.2)	41 (46.1)
Family and friends	103 (32.0)	66 (28.3)	37 (41.6)
Television/newspapers	124 (38.5)	89 (38.2)	35 (39.3)
Religious leaders	78 (24.2)	52 (22.3)	26 (29.2)
Internet search engines	167 (51.9)	118 (50.6)	49 (55.1)
Educational materials at clinics	193 (59.9)	151 (64.8)	42 (47.2)

Values are presented as *n* (%). Parents could report multiple sources of information.

non-hesitant parents (85.4%) compared to hesitant parents (59.6%, *p* < 0.001). Social media platforms were used by 62.1% of hesitant parents compared to 37.8% of non-hesitant parents (*p* < 0.001). Television and newspapers were less commonly used, with no significant differences between groups. Notably, family and friends were more frequently consulted by hesitant parents (41.6%) than non-hesitant parents (28.3%, *p* = 0.019).

### PACV domain analysis

Analysis of responses across the three PACV domains revealed distinct patterns [Figure 4]. The behavior domain showed the highest proportion of hesitant responses (32.4%), followed by the safety and efficacy domain (28.9%), and trust in healthcare providers domain (22.7%). Specific vaccine concerns among hesitant parents are detailed in Table 4. Within the safety domain, concerns about vaccine side effects were most frequently cited (45.3% expressing moderate to high concern), followed by doubts about vaccine necessity given low disease prevalence (38.2%), and questions about the number of vaccines given to children (36.0%).

### DISCUSSION

This study provides the first comprehensive assessment of vaccine hesitancy among parents in the Madinah region, revealing that more than one-quarter of parents (27.6%) demonstrate vaccine hesitancy according to the validated PACV instrument. This prevalence is notably higher than the 15–20% reported in recent pre-pandemic studies from other regions of Saudi Arabia,<sup>[19,20]</sup> suggesting a potential increase in hesitancy that may be attributable to the evolving information landscape and the aftermath of COVID-19 vaccine debates. However, it remains lower than rates reported in some Western countries, where vaccine hesitancy has reached 30–40% in certain populations.<sup>[6,7]</sup>

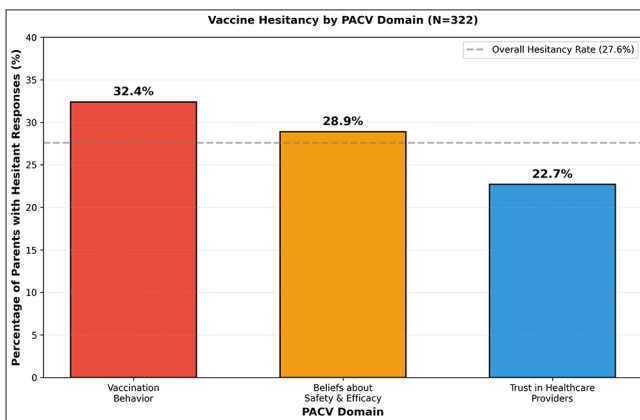
When compared internationally, our findings show similarities and differences with studies from various cultural contexts. In Turkey, studies have reported vaccine refusal and hesitancy rates ranging from 2.9% to 8.5%, considerably lower than our findings.<sup>[13]</sup> However, these Turkish studies focused specifically on vaccine refusal rather than the broader construct of hesitancy, which may explain the difference. A study from Indonesia examining parental rejection of childhood vaccination reported a prevalence of 18.2%, lower than our findings but sharing similar risk factors including educational level and exposure to misinformation.<sup>[14]</sup> Research from Kyrgyzstan examining parental attitudes toward rotavirus vaccination found that 23.4% of parents expressed concerns or hesitancy, comparable to our results.<sup>[15]</sup> Across these diverse settings, common themes emerge including the critical role of health education, the impact of misinformation, and the importance of trust in healthcare providers.

The finding that lower educational attainment is independently associated with increased vaccine hesitancy aligns with the broader literature on health literacy and vaccination behavior.<sup>[24,25]</sup> Parents with higher education levels may possess greater capacity to critically evaluate health information, distinguish credible sources from

**Table 4:** Specific vaccine concerns among vaccine-hesitant parents (n=89).

Specific vaccine concern	Hesitant parents (n=89)	Rank
Concerns about vaccine side effects	67 (75.3)	1
Too many vaccines given at once	58 (65.2)	2
Prefer natural immunity over vaccination	52 (58.4)	3
Doubts about vaccine effectiveness	48 (53.9)	4
Concerns about vaccine ingredients	45 (50.6)	5
Belief that vaccine-preventable diseases are rare	42 (47.2)	6
Religious or cultural concerns	28 (31.5)	7
Negative information from social media	62 (69.7)	—
Bad experience with previous vaccination	36 (40.4)	—
Lack of trust in pharmaceutical companies	38 (42.7)	—

Values are presented as n (%). Parents could report multiple concerns. Ranking based on frequency of concern among hesitant parents (top 6 concerns ranked)



**Figure 4:** Vaccine hesitancy by parent attitudes about childhood vaccines (PACV) domain. Bar chart displaying the percentage of parents expressing hesitant responses across the three domains of the PACV questionnaire: Vaccination behavior, beliefs about safety and efficacy, and trust in healthcare providers.

misinformation, and understand the scientific basis for vaccination recommendations. This relationship underscores the importance of health education initiatives tailored to populations with varying literacy levels, utilizing clear language and culturally appropriate communication strategies.

The strong association between social media exposure to anti-vaccine content and vaccine hesitancy represents a critical finding with immediate implications for public health practice in the Madinah region. With over 90% of Saudi adults actively using social media platforms, the rapid dissemination of vaccine misinformation poses a substantial threat to public health.<sup>[26]</sup> Unlike traditional media, social

media algorithms may create echo chambers that reinforce existing beliefs and amplify emotionally charged content regardless of accuracy. This finding echoes concerns raised by the WHO regarding the “infodemic” accompanying vaccine-preventable disease outbreaks.<sup>[3]</sup> Collaborative efforts between health authorities, social media platforms, and community leaders are needed to counter misinformation and promote evidence-based vaccine information in the Madinah context.

The association between unemployment and vaccine hesitancy may reflect multiple interconnected factors. Economic constraints can limit access to healthcare services and reliable health information. In addition, unemployed parents may experience higher levels of stress and anxiety, potentially influencing their risk perception and decision-making regarding their children’s health.<sup>[27]</sup> Interestingly, household income did not emerge as a significant predictor in the multivariate model despite the association between employment status and hesitancy. This suggests that the relationship between socioeconomic status and vaccine hesitancy is complex and may be mediated more strongly by factors such as access to information, health literacy, and psychosocial stress rather than purely financial resources. In the Saudi context, where healthcare services including vaccinations are provided free of charge through the national health system, financial barriers to vaccination are minimal, which may explain why income itself was not predictive of hesitancy.

The relationship between family size and vaccine hesitancy – with parents of four or more children showing increased hesitancy – may reflect accumulated negative experiences, vaccine fatigue from multiple immunization appointments, or the influence of anti-vaccine narratives encountered during previous vaccination experiences. This finding warrants further qualitative research to understand the mechanisms underlying this association.

Perhaps most concerning is the finding that parents reporting previous adverse events following immunization demonstrate substantially elevated vaccine hesitancy. While serious adverse events following routine childhood vaccines are extremely rare, minor reactions such as fever, injection site pain, or irritability are relatively common and typically self-limited.<sup>[28]</sup> The challenge lies in appropriate risk communication: Healthcare providers must acknowledge and validate parental concerns about adverse events while providing accurate contextualization regarding the risk-benefit balance. Improved reporting systems, transparent communication about adverse event monitoring, and timely follow-up after vaccination may help address this source of hesitancy.<sup>[28,29]</sup>

Given Madinah’s unique status as one of Islam’s holiest cities and a major pilgrimage destination, the role of religious

and cultural factors in shaping vaccine attitudes deserves particular attention. Interestingly, our findings showed that religious or cultural concerns ranked relatively low among the specific concerns cited by hesitant parents (31.5%), and consultation with religious leaders as an information source did not differ significantly between hesitant and non-hesitant groups. This suggests that in this specific setting, religious concerns may not be a primary driver of hesitancy. However, this also presents an opportunity: Religious leaders and institutions in Madinah could serve as powerful allies in promoting vaccine confidence, given the community's trust in religious authority and the Islamic 'tradition's strong emphasis on preserving health and preventing disease. Engaging religious scholars in vaccine promotion efforts and leveraging their influence on counter misinformation could be particularly effective in the Madinah context.

The domain-specific analysis reveals that behavioral hesitancy – actual delays or refusals – is more prevalent than attitudinal hesitancy, suggesting that many parents may hold concerns but ultimately comply with vaccination recommendations. This finding indicates opportunities for intervention at the point of care, where trusted healthcare providers can address specific concerns and strengthen vaccine confidence. The relatively lower levels of distrust in healthcare providers compared to concerns about vaccine safety represent a positive finding that healthcare systems can leverage to combat misinformation.

### Limitations

Several study limitations warrant consideration. The convenience sampling approach and focus on healthcare facility attendees may introduce selection bias. Specifically, parents who are actively disengaged from health services or who completely avoid the healthcare system may be systematically excluded from our study, potentially leading to an underestimation of the true hesitancy prevalence in the general population. Parents who attend healthcare facilities, even if hesitant, demonstrate at least some level of engagement with the health system that non-attendees do not share. Future community-based studies using probability sampling methods would provide more generalizable estimates.

The cross-sectional design precludes the determination of temporal relationships or causal inference. While we identified associations between various factors and vaccine hesitancy, we cannot establish causality or determine whether exposure to anti-vaccine information preceded or followed the development of hesitant attitudes. Social desirability bias may have influenced responses, although the anonymous nature of data collection likely minimized this effect. The study was conducted during a specific four-month period,

and seasonal or temporal variations in vaccine attitudes were not captured.

While our study defined residency as living in the Madinah region for at least 6 months regardless of nationality, the dataset did not systematically capture whether participants were Saudi citizens or non-Saudi residents. This represents a limitation, as non-Saudi residents, including those born and raised locally, constitute an important part of the community and may have different vaccine attitudes shaped by their countries of origin or cultural backgrounds. Future research should specifically examine vaccine hesitancy among non-Saudi residents to provide a more comprehensive understanding of community-level vaccination attitudes and to inform culturally tailored interventions for diverse population subgroups.

Finally, while the PACV has been validated in Arabic, cultural nuances in how questions are interpreted may vary across different regions of Saudi Arabia. Despite these limitations, this study provides valuable insights into vaccine hesitancy in an understudied yet epidemiologically important region of Saudi Arabia.

### Recommendations and future directions

The findings suggest several evidence-based recommendations for the Madinah region. First, targeted health education campaigns should prioritize populations with lower educational attainment, using clear, accessible language and culturally sensitive messaging. Second, healthcare providers require training in effective communication techniques for addressing vaccine concerns, particularly regarding safety and adverse events. Third, collaboration with social media platforms and religious leaders to promote accurate vaccine information and counter misinformation is essential. Fourth, systematic monitoring of vaccine hesitancy trends would enable early detection of declining confidence and timely intervention.

Future research should examine vaccine hesitancy trends longitudinally to assess the effectiveness of interventions and identify emerging concerns. Qualitative studies exploring the nuanced beliefs and experiences underlying hesitancy would provide deeper insights for intervention development. In addition, studies examining the role of religious leaders and cultural norms in shaping vaccine attitudes in the Madinah region, given its unique status as a holy city, would be particularly valuable.

### CONCLUSION

This study identifies significant vaccine hesitancy among parents in Madinah, with more than one-quarter expressing concerns about childhood vaccination. The

findings demonstrate that vaccine hesitancy is associated with exposure to misinformation through social media, educational disparities, and previous adverse event experiences. The identification of social media as the strongest predictor highlights the need for digital health literacy interventions and proactive engagement on social media platforms where misinformation can spread rapidly and reach vulnerable populations.

Educational disparities emerge as another critical modifiable risk factor, underscoring the need for health education programs that are accessible, culturally appropriate, and tailored to diverse literacy levels. The relatively high level of trust in healthcare providers, even among hesitant parents, represents an opportunity for effective intervention through strengthened provider-patient communication, particularly around vaccine safety and adverse events. The Madinah region's unique position as a major pilgrimage destination adds importance to these findings, as maintaining high vaccination coverage is essential not only for protecting local children but also for global health security, given the millions of international visitors annually.

These findings suggest that addressing vaccine hesitancy in Madinah may require a comprehensive, multisectoral approach. Based on the associations identified, potential strategies worth evaluating may include developing accessible and culturally appropriate educational materials, supporting healthcare providers with training in vaccine communication, and exploring collaborative efforts with social media platforms and trusted community voices to promote evidence-based information. Systematic monitoring of vaccine hesitancy trends could help detect changes in parental attitudes over time. However, given the cross-sectional nature of this study, the identified associations cannot establish causality, and the effectiveness of any intervention in this context would need to be assessed through appropriately designed evaluative research. Further longitudinal and interventional studies are needed to determine whether addressing the factors identified here would contribute to strengthening vaccine confidence among parents in the Madinah region.

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