

Original Research Article

Application of the 5C model in understanding adult vaccine hesitancy among medical students: a cross-sectional study

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ABSTRACT

Background: Adult vaccination is an important component of preventive health care, but vaccine hesitancy can limit uptake even when vaccines are available. Medical students represent future health professionals and may influence vaccination decisions in the community. The 5C model provides a multidimensional framework encompassing confidence, complacency, constraints, calculation, and collective responsibility.

Methods: A cross-sectional study was conducted among undergraduate medical students in a tertiary-care teaching institution, Puducherry. A total of 386 medical students from first year through internship were included. Data were collected using a self-administered, pre-tested structured questionnaire containing sociodemographic variables and assessment of adult vaccine hesitancy and the five dimensions of the 5C model. Data were analyzed using IBM SPSS. Categorical variables were expressed as frequency and percentage, and associations were assessed using Pearson's chi-square test. Pearson's correlation coefficient was used to assess correlations between the five 5C dimensions.

Results: Among 386 participants, 216 (56.0%) were classified as vaccine hesitant and 170 (44.0%) as non-hesitant. Age and religion were not significantly associated with vaccine hesitancy ($p=0.851$ and $p=0.495$, respectively). Significant associations were observed with gender ($p<0.001$) and year of study ($p<0.001$). The five 5C dimensions demonstrated statistically significant positive correlations with one another. Correlation coefficients ranged from 0.581 between calculation and collective responsibility to 0.699 between confidence and calculation (all $p<0.001$).

Conclusions: Adult vaccine hesitancy was prevalent among the medical students studied. Gender and year of study were significantly associated with hesitancy, while the five psychological antecedents measured by the 5C model demonstrated significant interrelationships.

Keywords: Adult vaccination, Vaccine hesitancy, Medical students, 5C model, Immunization, Preventive medicine

INTRODUCTION

Vaccination is one of the most effective public health interventions for preventing infectious diseases and reducing associated morbidity and mortality. Immunization programs have traditionally focused on childhood vaccination; however, vaccination across the life course is increasingly recognized as an important component of comprehensive preventive health care. The Immunization Agenda 2030 emphasizes immunization

across the life course and highlights communication, advocacy, monitoring, and accountability as important components of successful immunization programs.¹

Despite the availability of safe and effective vaccines, vaccination uptake may remain suboptimal because of vaccine hesitancy. The Strategic Advisory Group of Experts on Immunization (SAGE) defines vaccine hesitancy as a delay in acceptance or refusal of vaccination despite the availability of vaccination services. It is considered to be complex and context-

specific, varying across time, place, and vaccine.² Vaccine hesitancy should therefore be distinguished from complete refusal, as hesitant individuals may accept some vaccines while delaying or declining others.³

Vaccine hesitancy is influenced by multiple individual, social and contextual factors. These include confidence in vaccines and healthcare systems, perceived disease risk, accessibility and convenience, information-seeking behaviour and concerns regarding vaccine safety and effectiveness.⁴⁻⁷ Studies have demonstrated substantial heterogeneity in the prevalence and determinants of vaccine hesitancy across populations and settings.⁸⁻¹⁰

Healthcare professionals have an important role in influencing vaccination decisions. Their knowledge, confidence and communication practices can affect vaccine acceptance among patients and the wider community.¹¹ Medical students constitute an important population because they are future healthcare providers and will subsequently be involved in counselling patients regarding preventive health measures, including vaccination. Evidence from studies among medical students indicates that vaccine hesitancy may occur even among individuals with medical training.¹²⁻¹⁵

The COVID-19 pandemic further highlighted the importance of understanding vaccine hesitancy among healthcare workers and students. Studies among medical students have reported varying levels of hesitancy and identified concerns regarding vaccine safety, efficacy, information sources and trust as important factors.^{12,16-18} A systematic review of COVID-19 vaccine hesitancy among medical students reported considerable variation between studies, indicating the influence of population and contextual factors.¹⁹

Traditional approaches to vaccine hesitancy have frequently emphasized confidence. However, vaccine decision-making is multidimensional. The 5C model proposed by Betsch et al conceptualizes five psychological antecedents of vaccination: confidence, referring to trust in vaccine safety and effectiveness and the system delivering vaccines; complacency, reflecting low perceived disease risk or perceived lack of need for vaccination; constraints, referring to structural and psychological barriers; calculation, reflecting extensive information seeking and weighing of vaccination risks and benefits; and collective responsibility, referring to the willingness to protect others through vaccination.²⁰ The 5C scale was developed and validated to provide a multidimensional assessment of these psychological antecedents.^{20,21}

The 5C framework has subsequently been applied in different populations and vaccine-related contexts.²²⁻²⁵ Indian research has also demonstrated the relevance of multidimensional assessment of adult vaccine hesitancy, including the use of the 5C framework.²⁶ A recent validation study among Hindi-speaking adults in

Northern India further supports the applicability of the five-domain framework for assessment of adult vaccine hesitancy in the Indian context.²⁶

Although several studies have examined vaccine hesitancy related specifically to COVID-19, fewer studies have assessed adult vaccine hesitancy more broadly among undergraduate medical students using a multidimensional framework. Understanding the magnitude of hesitancy and the characteristics associated with it can help inform medical education and communication strategies.

Therefore, the present study was undertaken to assess adult vaccine hesitancy among medical students and to examine its association with selected sociodemographic characteristics and the interrelationships among the five dimensions of the 5C model.

The aim of the study is to assess the prevalence of adult vaccine hesitancy and its association with sociodemographic characteristics and the dimensions of the 5C vaccine hesitancy model among medical students. The objectives of the study are to estimate the prevalence of adult vaccine hesitancy among medical students, assess the association between selected sociodemographic characteristics and adult vaccine hesitancy, and assess the correlation among the five dimensions of the 5C vaccine hesitancy model confidence, calculation, constraints, complacency, and collective responsibility among medical students.

METHODS

A cross-sectional study was conducted among undergraduate medical students studying in a tertiary-care teaching institution in Puducherry, India, during March - May 2026. The study population comprised undergraduate medical students from first year through internship. Students enrolled in the undergraduate medical programme during the study period who provided informed consent and completed the study questionnaire were eligible for participation. Students who did not provide consent or submitted incomplete responses were excluded from the study.

The sample size was calculated using the single-proportion formula.

$$n = Z^2 pq/d^2$$

Where: n = required sample size; Z = 1.96 for 95% confidence level; p = expected prevalence of vaccine hesitancy; q = 1 – p; d = absolute precision.

A prevalence of 50% was assumed based on a previous study by Kalra et al with a 95% confidence level and 5% absolute precision.²⁷ The minimum required sample size was calculated to be 384.16, which was rounded up to 385. A total of 386 medical students were included in the

study. Participants were recruited using convenience sampling from the eligible undergraduate medical student population, with students from first year, second year, third year, fourth year and internship included in the study.

Data were collected using a self-administered, structured and pre-tested questionnaire. The questionnaire included sociodemographic characteristics such as age, gender, religion and year of study. Adult vaccine hesitancy was assessed using a 15-item questionnaire based on the five dimensions of the 5C model, namely confidence, complacency, constraints, calculation and collective responsibility, with three items under each dimension. Each item was rated on a seven-point Likert scale. The scores of all 15 items were summed to obtain an overall score, with a possible score range of 15–105. The mean total score observed in the study population was 72, which was used as the operational cut-off for classification. Participants with a total score greater than 72 were classified as having adult vaccine hesitancy, whereas those with a score of 72 or less were classified as non-hesitant. The questionnaire was pre-tested before the main data collection to assess its comprehensibility and feasibility. Participants were informed about the purpose of the study, and confidentiality of the information provided was maintained.

The collected data were entered and analysed using IBM SPSS Statistics version 25. Categorical variables were summarized using frequencies and percentages. The prevalence of adult vaccine hesitancy was calculated as the proportion of participants classified as hesitant among the total study population. The association between selected sociodemographic characteristics and vaccine hesitancy was assessed using the Pearson chi-square test. Pearson's correlation coefficient was used to assess the correlation between the five dimensions of the 5C model. All correlation tests were two-tailed, and a $p < 0.05$ was considered statistically significant.

Ethical approval was obtained from the Institutional Ethics Committee (Human Studies) of Sri Lakshmi Narayana Institute of Medical Sciences, Puducherry (IEC approval No. IEC/C-P/5/2025), dated 08 February 2025. Written informed consent was obtained from all participants before enrolment. Participation was voluntary, and confidentiality and privacy of the participants were maintained throughout the study.

RESULTS

A total of 386 medical students were included in the analysis.

Sociodemographic characteristics

Among the 386 participants, 205 (53.1%) belonged to the 22–25-year age group, followed by 152 (39.4%) aged 18–21 years and 29 (7.5%) aged 26–29 years. There were 208 (53.9%) female and 178 (46.1%) male participants.

The majority of participants were Hindu (243; 63.0%), followed by Christian (75; 19.4%), Muslim (60; 15.5%) and other religions (8; 2.1%). With respect to year of study, 92 (23.8%) were first-year students, 61 (15.8%) second-year students, 78 (20.2%) third-year students, 42 (10.9%) fourth-year students and 113 (29.3%) were interns (Table 1).

Prevalence of adult vaccine hesitancy

Among the 386 participants, 216 (56.0%) were classified as having adult vaccine hesitancy, while 170 (44.0%) were classified as non-hesitant (Table 2 and Figure 1). Thus, the prevalence of adult vaccine hesitancy in the study population was 56.0% (95% CI: 50.9%–61.0%).

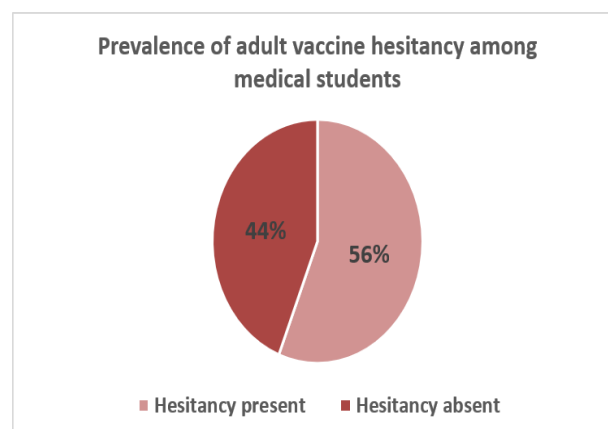


Figure 1: Prevalence of adult vaccine hesitancy.

Association between sociodemographic characteristics and vaccine hesitancy

Age group was not significantly associated with vaccine hesitancy ($p=0.851$). Among participants with vaccine hesitancy, 87 (40.3%) were aged 18–21 years, 114 (52.8%) were aged 22–25 years and 15 (6.9%) were aged 26–29 years. A statistically significant association was observed between gender and vaccine hesitancy ($p < 0.001$). Among participants with hesitancy, 82 (38.0%) were male and 134 (62.0%) were female. Among those without hesitancy, 96 (56.5%) were male and 74 (43.5%) were female. Religion was not significantly associated with vaccine hesitancy ($p=0.495$). A statistically significant association was observed between year of study and vaccine hesitancy ($p < 0.001$). Among students with hesitancy, 84 (38.9%) were first-year students, 39 (18.1%) were second-year students, 56 (25.9%) were third-year students, 4 (1.9%) were fourth-year students and 33 (15.3%) were interns (Table 3).

Correlation between dimensions of the 5C model

All five dimensions of the 5C model demonstrated statistically significant positive correlations with one another ($p < 0.001$ for all correlations). The strongest correlation was observed between confidence and calculation ($r=0.699$), followed by calculation and

constraints ($r=0.690$), confidence and collective responsibility ($r=0.675$), confidence and complacency ($r=0.671$), and constraints and complacency ($r=0.664$). The weakest correlation was observed between calculation and collective responsibility ($r=0.581$). Other

correlations were 0.646 between confidence and constraints, 0.632 between constraints and collective responsibility and 0.626 between calculation and complacency (Table 4).

Table 1: Sociodemographic characteristics of medical students included in the study (n=386).

Characteristics	Frequency (N)	Percentage (%)
Age group (years)		
18-21	152	39.4
22-25	205	53.1
26-29	29	7.5
Gender		
Male	178	46.1
Female	208	53.9
Religion		
Hindu	243	63.0
Christian	75	19.4
Muslim	60	15.5
Others	8	2.1
Year of study		
First year	92	23.8
Second year	61	15.8
Third year	78	20.2
Fourth year	42	10.9
Interns	113	29.3

Table 2: Prevalence of Adult vaccine hesitancy among medical students (n=386).

Vaccine hesitancy status	Frequency (N)	Percentage (%)
Hesitancy present	216	56.0
Hesitancy absent	170	44.0
Total	386	100.0

Table 3. Association between sociodemographic characteristics and vaccine hesitancy

Sociodemographic characteristic	Adult vaccine hesitancy present, N (%)	Adult vaccine hesitancy absent, N (%)	P value
Age group (in years)			
18-21	87 (40.3)	65 (38.2)	0.851
22-25	114 (52.8)	91 (53.5)	
26-29	15 (6.9)	14 (8.2)	
Gender			
Male	82 (38.0)	96 (56.5)	<0.001*
Female	134 (62.0)	74 (43.5)	
Religion			
Hindu	130 (60.2)	113 (66.5)	0.495
Christian	44 (20.4)	31 (18.2)	
Muslim	36 (16.7)	24 (14.1)	
Others	6 (2.8)	2 (1.2)	
Year of study			
First year	84 (38.9)	8 (4.7)	<0.001*
Second year	39 (18.1)	22 (12.9)	
Third year	56 (25.9)	22 (12.9)	
Fourth year	4 (1.9)	38 (22.4)	
Interns	33 (15.3)	80 (47.1)	

Note: Values are presented as n (%). P values were obtained using the Pearson chi-square test. * $p<0.05$ was considered statistically significant

Table 4: Pearson correlation between the dimensions of the 5C vaccine hesitancy scale among medical students (n=386).

Variables	Confidence	Calculation	Constraints	Complacency	Collective responsibility
Confidence	1	0.699**	0.646**	0.671**	0.675**
Calculation	0.699**	1	0.690**	0.626**	0.581**
Constraints	0.646**	0.690**	1	0.664**	0.632**
Complacency	0.671**	0.626**	0.664**	1	0.656**
Collective responsibility	0.675**	0.581**	0.632**	0.656**	1

Note: Values represent Pearson's correlation coefficient. **p<0.001, two-tailed (n=386)

DISCUSSION

The present study assessed adult vaccine hesitancy among undergraduate medical students using a multidimensional approach based on the 5C framework. More than half of the participants, 56.0%, were classified as vaccine hesitant. Significant associations were observed with gender and year of study, whereas age and religion were not significantly associated with hesitancy. In addition, all five 5C dimensions showed statistically significant positive correlations with each other.

The prevalence observed in the present study indicates that vaccine hesitancy remains relevant even among individuals undergoing formal medical education. This finding is consistent with the broader understanding that vaccine hesitancy is not restricted to the general population and may occur among healthcare professionals and students.^{28,29} In an Indian multi-centre study conducted among medical students during the COVID-19 vaccination programme, 10.6% were hesitant specifically toward COVID-19 vaccination.¹² Differences between that finding and the present prevalence may reflect differences in the outcome being measured. The earlier study focused specifically on COVID-19 vaccine hesitancy during the initial vaccination period, whereas the present study assessed adult vaccine hesitancy more broadly. Therefore, the two estimates should not be interpreted as directly equivalent.

A study of healthcare providers and their family members in Delhi reported considerable hesitancy towards several adult vaccines, including pneumococcal, influenza, varicella, human papillomavirus and zoster vaccines.²⁷ The authors identified concerns regarding adverse effects, lack of awareness and absence of clear adult immunization guidance as important issues.²⁷ These findings highlight that adult vaccination involves a different decision-making context from routine childhood immunization.

The significant association between gender and vaccine hesitancy in the present study is noteworthy. Female students constituted a larger proportion of the hesitant group, whereas males constituted a larger proportion of the non-hesitant group. However, the cross-sectional

design does not establish why this difference was observed. Gender-related differences in vaccine attitudes have been reported in some studies, but findings are not uniform across settings.^{16,30} Such associations may be influenced by differences in risk perception, information sources, vaccine-specific concerns and social or cultural factors.

Year of study was also significantly associated with vaccine hesitancy. The distribution showed a particularly high proportion of hesitant participants among first-year students, while interns constituted a larger proportion of the non-hesitant group. The association may indicate differences in exposure to clinical teaching, preventive medicine education and experience with patient counselling; however, this interpretation remains hypothetical because the present study did not directly measure these factors. A previous 5C-based study among medical students also reported that academic year and gender were among factors associated with psychological antecedents of vaccination.³¹

The absence of a significant association between age and vaccine hesitancy may partly reflect the relatively narrow age distribution of undergraduate medical students. Similarly, religion was not significantly associated with hesitancy in the present study. These findings suggest that demographic characteristics alone may not sufficiently explain vaccine decision-making among medical students.

The 5C analysis demonstrated statistically significant positive correlations among all five dimensions. The strongest correlation was between confidence and calculation ($r=0.699$), while the weakest was between calculation and collective responsibility ($r=0.581$). The original 5C model recognizes these dimensions as conceptually distinct but related psychological antecedents of vaccination.^{20,21} Therefore, correlations between the dimensions are expected. However, the presence of correlations should not be interpreted as demonstrating that one-dimension causes another.

The positive correlations observed in the present study may indicate that students who engage with vaccination-related information and decision-making also tend to demonstrate related attitudes across other domains.

Nevertheless, the present analysis does not permit determination of the direction or causal nature of these relationships. Further studies using multivariable modelling and validated scoring approaches may help clarify which psychological domains are independently associated with vaccine hesitancy.

The use of the 5C framework is particularly relevant because vaccine hesitancy is multidimensional. Confidence, complacency, constraints, calculation and collective responsibility represent different pathways through which vaccination decisions may be influenced.²⁰ The framework therefore provides a broader conceptual basis than approaches focusing solely on confidence or knowledge.

Indian research has increasingly demonstrated the importance of understanding adult vaccine hesitancy.^{26,27} The validation of the 5C questionnaire among Hindi-speaking adults in Northern India supports the applicability of this multidimensional construct in the Indian setting.²⁶ However, differences in language, population, vaccine type and healthcare context should be considered when comparing results between studies.

The findings have implications for undergraduate medical education. Medical students are future healthcare providers and may subsequently serve as trusted sources of vaccine information. Studies have shown that healthcare-provider recommendation and communication are important components of vaccine acceptance.^{32,33} Strengthening undergraduate education on adult immunization, vaccine safety communication, risk perception and management of vaccine concerns may therefore be useful.

The study has several strengths. First, it included students across all years of the undergraduate medical curriculum, including interns. Second, it assessed adult vaccine hesitancy using a multidimensional conceptual framework rather than focusing only on a single vaccine. Third, the sample size was adequate for the planned descriptive and bivariate analyses.

However, several limitations should be considered. The cross-sectional design prevents assessment of temporal relationships and causality. Convenience sampling from a single medical institution limits generalizability to medical students in other institutions or regions. Self-reported responses may also be affected by reporting and social desirability biases. In addition, the present analysis did not include multivariable modelling; therefore, the observed associations with gender and year of study should be regarded as unadjusted associations. Finally, the correlations between 5C dimensions do not establish causal relationships or identify independent predictors of vaccine hesitancy.

CONCLUSION

Adult vaccine hesitancy was observed in 56.0% of the medical students included in this study. Gender and year of study were significantly associated with vaccine hesitancy, whereas age and religion were not. The five dimensions of the 5C model demonstrated significant positive correlations with each other, supporting the multidimensional nature of vaccine-related attitudes. Medical education provides an opportunity to strengthen future healthcare professionals' understanding of adult immunization and their ability to communicate effectively about vaccine benefits, risks and uncertainties. Further multicentric studies using representative sampling and multivariable analysis are warranted to identify independent factors associated with adult vaccine hesitancy among medical students.

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