Vol No.2, Issue 1, 2026
ACADEMIA International Journal of Clinical & Translational Health

Relationship between Vaccination Coverage, Public Awareness, and Infectious Disease Prevention

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Received: 16-12-2025 **Revised: 09-01-2026** **Accepted: 04-02-2026** **Published: 18-02-2026**

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DOI: 10.63056

ABSTRACT

Vaccination is one of the most applied public health measure for preventing infectious diseases, but coverage is below recommended levels in many communities in terms of public awareness and systemic barriers in the access to vaccination. A quantitative correlational study was entered into to examine the relationships between public awareness, vaccine uptake and prevention outcomes for infectious diseases. The respondents from the urban and semi-urban households were recruited as a convenience sample of 250. A self-administered questionnaire that assessed the level of vaccination, whether the behaviorers were aware of immunization programs and the effectiveness of vaccines against infectious diseases was used to obtain data. The techniques used were descriptive statistics, Pearson correlation, Cronbach's alpha reliability test and Structural Equation Modeling (SEM) using AMOS. The reliability coefficients for the scaled items varied from .78 to .83. The correlations found between public awareness and vaccination coverage, and between vaccination coverage and disease prevention outcomes were significant and positive, with r values of .61 and .63 respectively and p values of < .001 for each of the correlations. After accounting for the effect of public awareness on vaccination coverage, the direct effect of vaccination coverage on disease prevention (β = .24) was added to the indirect effect (β = .32); (β = .56 denoting the total effect of public awareness on disease prevention). The model fit very well (RMSEA = .058; CFI = .97). The results support that public awareness campaigns in the community regarding immunization knowledge and attitudes are a cost-effective tool which can be utilized for increasing the rate of vaccination and hence the reduction of infectious diseases.

Keywords: vaccination coverage, public awareness, infectious disease prevention, immunization, structural equation modeling, community health, health promotion

INTRODUCTION

Infectious diseases are still a major health system challenge, responsible for around one-third mortality in the world and especially affecting those in low and middle income countries (LMIC; WHO, 2022). Vaccination is universally accepted as having one of the largest impacts of any health intervention ever invented, leading to the eradication of smallpox, the near eradication of poliomyelitis and significant reduction in morbidity and mortality from measles, diphtheria, pertussis and other vaccine preventable diseases (Bloom et al., 2018). However, even with the efficacy of currently available vaccine proven, high, and enduring levels of vaccination required for herd herd immunity is an enormous task in many communities.

The main operational indicator of immunization program performance is vaccination coverage, or the percentage of a population that is vaccinated with the doses of a vaccine recommended for them (CDC, 2021). Vaccination coverage for childhood diseases, however, appears to be on the decline, as in 2010-2011 and notably in 2020 when the COVID-19 pandemic turned vaccination into an impediment to progress, with WHO & UNICEF estimating a loss of 25 million children to not receiving one or more routine vaccination in 2021 alone (WHO & UNICEF, 2022). The decline, where there is concern in public health, brings back decades of gains and increases the risk of the infectious disease resurgence.

The role of awareness in the household influencing individual decisions to vaccinate and population-level coverage is now acknowledged. Awareness includes information about vaccine preventable diseases, an understanding of how vaccines work and when to get them, knowledge of available vaccination services and access to credible information to overcome vaccine hesitancy. The Strategic Advisory Group of Experts on Immunization (SAGE), under the auspices of WHO, recognizes three C's of vaccine hesitancy – complacency, inconvenience, lack of confidence, largely due to low awareness of the disease, particularly when there are no visible outbreaks, of people dissenting against immunizations (Larson et al., 2014). Specific awareness-raising campaigns have been found to soften the culture and economic climate to boost vaccination rates in different situations.

Vaccination behavior lies in between public awareness and infectious disease prevention, both theoretically and empirically. Better educated people are more likely to make their own immunization decisions, adhere to multi-dose immunization schedules, and arrange immunization for their dependents, helping to create a community of immunized individuals that provides protection for those who cannot be vaccinated (Andre et al., 2008). The concept of a mediated chain (awareness v vaccination v prevention) forms the main theoretical idea underpinning the present study where it was empirically tested for structural integrity in an urban context of South Asia.

The study was guided by three major goals: (1) to characterize patient's uptake of vaccines, their level of awareness, and their perceived effectiveness in preventing infectious diseases; (2) to explore the bivariate correlation among the three variables; and (3) to examine the mediation of vaccination coverage between public awareness and infectious disease prevention effectiveness within a structural model. Findings could be used in formulating community health communication campaigns and in prioritizing resources in the country's immunization programs.

LITERATURE REVIEW

The public awareness–vaccination uptake evidence base is strong in many disease contexts. A comprehensive review was carried out by MacDonald and the SAGE Working Group on Vaccine Hesitancy (2015) that identified factors contributing to vaccine hesitancy under three headings: contextual, individual and group, and vaccine- and vaccination-specific. The latter, knowledge or awareness of the disease severity and vaccine benefit had been consistently identified as individual-level factors involved in vaccine acceptance, with prediction across various settings, as well as actual uptake. This review highlighted the importance of health literacy and targeted communication in immunisation programming.

Some community-focused immunization projects have shown that they can show measurable reductions in immunization coverage in LMICs. In analyzing 25 intervention studies in sub-Saharan Africa and South Asia, Favin et al (2012) identified that Communication and Social Mobilization activities contributed to the coverage gains ranging from 10-30 percentage points over the standard service delivery approach. The

impact of these interventions was greatest when the outreach was to previously under-served groups and was using culturally relevant messaging via trusted community messaging systems.

Interactions with health-care workers is another important avenue for the influence of public awareness on vaccination behavior. A randomized controlled study conducted by Strong et al. (2020) showed that provider recommendation–the most easily measurable and understood factor–was the most important driver of adult influenza vaccine uptake compared to messages in the media, reminders and cost incentives. The discovery makes healthcare providers excellent tools to go from awareness to action, and shows that training programs that boost provider communication skills could have a significant public health dividend.

The significance of social determinants of vaccination behavior (such as education, income, access to health care) is widely known. Health Literacy, their perception of risk and attitudes towards preventive health services such as vaccination are higher for those with a higher level of education (Gust et al., 2008). In contrast, vaccination coverage is lower for those in low-income areas and those living in rural areas as coverage is affected by financial barriers and rural inaccessibility (Rainey et al., 2011). These structural inequities require strategies to tackle both informational and logistical aspects of access at the same time.

The WHO has identified vaccine hesitancy—defined very broadly as the delay in receiving or refusal of vaccines despite the availability of vaccination services—as one of the top ten threats to global health (WHO, 2019). The reluctance is not a uniform phenomenon; it can range from total acceptance to absolute opposition, and is shaped by various influencing factors, including religious and cultural convictions, negative past experiences, and mistrust of health organisations (Larson et al., 2014). Social media has become an effective promoter and driver of vaccine misinformation, resulting in waning coverage according to vaccine acceptance studies in affluent nations like Italy, France and the U.S. (Hussain et al. 2018).

COMOVAX is the first vaccine used in India during the COVID-19 pandemic to offer an unprecedented natural experiment in public awareness, vaccine acceptability, and disease prevention. Before and after the pandemic vaccinations were launched, research found very high levels of vaccine acceptance across countries and populations, which were strongly related to prior people's trust in governments and health institutions (de Figueiredo et al., 2020). However, early in the year 2021, initial hesitation towards vaccines for the Covid-19 pandemic stood at ~30–40% in Pakistan, where sufficient evidence indicating vaccine safety remained a concern and misinformation campaigns as well as religious concerns affected vaccine uptake, although the situation improved significantly after covering the bases in the community (Saeed et al., 2022). The target setting in this context-driven study adds a layer of importance for research to be focused on awareness.

More recently, the increasing use of SEM in vaccine-related research has made it possible to evaluate complicated causal sequences and test a theory using the appropriate statistical techniques. In the United Kingdom, Yaqub et al. (2014) tested the survey data with SEM and established that the cognitive (knowledge, perceived risk) pathway and affective pathway (trust, feelings) were independent predictor variables of the attitudes towards vaccine uptake. This methodological insight guided the present investigation's methodology.

Studies on vaccine uptake in Pakistan have identified structural and behavioral barriers to coverage gaps. Habib et al. (2017) reported that only 54% of children aged 12-23 months in peri-urban Lahore were fully DTP3 vaccinated and the greater coverage of mother was considered to be the strongest predictor of the children's DTP3 vaccination coverage. Children's awareness about immunization schedules was also found

to be a good predictor. Ali et al. (2020) conducted a follow-on qualitative study to elucidate the mechanisms behind these associations, and identified social network influence, religious leader endorsement, and healthcare provider trust as important mediators of these behaviors. The findings give theoretical support to the quantitative examination in the present study.

A cognitive/behavioral continuum is evident in the perceived effectiveness that is perceived with regard to the vaccines effectiveness in relation to diseases.An awareness continuum which is embedded with vaccines effectiveness in relation to diseases can be seen in how effective vaccines are perceived in preventing disease. There is a theory known as the Health Belief Model theory (1974, Rosenstock) that states that perceived benefits of health actions, such as perceived vaccine efficacy, is a condition for preventive actions. A large number of studies have consistently shown that people who believe that vaccines are effective are much more likely to seek vaccination and to follow a recommended schedule (Champion & Skinner, 2008). Perceived effectiveness is included as an outcome variable in this study which represents the end point of the awareness-vaccination behavioral chain.

The awareness to vaccination pathway is moderated by access to healthcare services, which decide if information is used to act on vaccination. Highly motivated individuals may still not adhere to vaccination schedules when service delivery is not geographically accessible or consistently open or has stoppages in supply chains (Rainey et al., 2011). In order to account for this moderating dimension, and to allow practical comparisons between urban and suburban service delivery to optimize services, participants in the present study were divided into three healthcare access categories.

It is evident that the cumulative effect of the existing research provides valuable evidence for the causal effect of the triadic relationship between public awareness, vaccine coverage and prevention of infectious diseases. Yet multi-pathway structural modelling exercises that combine all of these pathways have been few, especially in South Asia in LMICs. The present investigation attempts to address this gap by employing SEM in individuals from urban and semi-urban settings in Pakistan to generate culturally appropriate evidence that can be used in direct decisions regarding any aspects of policy communication or health system strengthening related to immunization.

METHODOLOGY

Research Design

The quantitative correlational research design was used to examine the correlation between vaccination coverage, public awareness and the prevention of infectious diseases. Correlational designs are suitable for research goals that involve describing the nature, direction, and nature of relationships between naturally occurring ones or between one naturally occurring and one unmanipulated experimental variables (Creswell, 2014). In the present study, the cross sectional design was considered as appropriate due to logistical and resources restraints, but it is understood that it does not allow the establishment of temporal precedence of predictors. This study was carried out in the post-positivist epistemological approach, post-positivism considered that social phenomena can be measured and analyzed through systematic approach that is replicable.

Study Population and Sampling

The target population were adults (18 years and over) in urban and semi-urban communities. The minimum sample size was calculated at 230 using G*Power 3.1 on a medium effect size ($f^2 = .15$), $\alpha = .05$, a power

of .80 and a number of four predictors. A sample of a final n = 250 was sampled to account for excess over minimum acceptable. Convenience sampling was used because a comprehensive sampling frame for the semi-urban communities that were included in the study was not available. The participants were identified by community health centers, immunization clinics, and the local mosques and community centers with the cooperation of health facility management. Inclusion criteria included: age ≥ 18 years, and community residents for at least six months and consented to give informed consent. People with cognitive disability and/or communication difficulties were not included.

Data Collection Instrument

The structured questionnaire is self-administered which was developed after the review of some validated questionnaires from earlier literature. Demographic data collected in section A covered Age, Sex, Education level (primary, secondary, tertiary), Area of residence (urban and semi-urban), Self reported access to healthcare services (easy and limited access). Section B evaluated vaccination status based on a checklist of routine and recommended vaccines (e.g., COVID-19, influenza, measles, hepatitis B) which were collected and a composite coverage score was calculated as the percentage of received vaccines to the number of vaccine recommended for that age group. For Section C, public awareness of immunization programs was measured using a nine-item scale that focused on knowledge of vaccine-preventable diseases, awareness of national immunization schedule, exposure to immunization messaging and trust in immunization information sources. Items were rated on a 1–to 5-point Likert scale; 1 equaling Strongly Disagree and 5 equaling Strongly Agree. Perceived effectiveness of vaccines against infectious diseases was measured with 5 items adapted from the Champion Perceived Benefits subscale of the Health Belief Model (Champion & Skinner, 2008), with the exception of one item that was reverse coded to increased perceived benefits and another to decreased perceived risks when measured on the reverse side of the items.Section D was based on five items adapted from the Champion Perceived Benefits subscale of the Health Belief Model (Champion & Skinner, 2008): One item was reverse coded to increased perceived benefits and another to decreased perceived risks when reverse-scored. The entire questionnaire was content validated by two individual public health consultants before use.

Data Analysis

Details of processing and analyzing data were performed by IBM SPSS Statistics (Version 26), whereas AMOS (Version 24) was performed for data analyses. After data entry and cleaning descriptive statistics were calculated for all the demographic and study variables. Cronbach's alpha was used to validate scale internal consistency for awareness and perceived effectiveness scales. To consider bivariate associations between public awareness, the percentage of people immunized as well as outcomes related to disease prevention, Pearson product-moment correlation analysis was used. Then two-step method of Anderson and Gerbing (1988) was used for SEM including confirmatory factor analysis to test the validity of measurement model and further, structural path estimation was used to test the mediation hypothesis. The criteria used to determine model fit were the same as in Study 1 (χ^2/df, CFI, TLI, RMSEA, and SRMR). Indirect effects were estimated using 5,000 bootstrap (5k) samples to estimate 95% CI for the indirect effects. All analyses were performed with p value at 0.05.

RESULTS

Demographic Characteristics

Table 1 shows the sociodemographic status of the 250 participants. The majority of females (52.8%) was slightly more than the males. The dominant age group was 31–45 years (39.2%). The majority of respondents' highest education was tertiary education (48.0%) and the highest proportion were found in the urban area (56.8%). Just over half respondents (57.2%) said that they could obtain health services easily, and 42.8% said that they had limited access.

Table 1: Sociodemographic Characteristics of Participants – Study 2 (N = 250)

Variable	Category	Frequency (n)	Percentage (%)
Gender	Male	118	47.2
	Female	132	52.8
Age Group	18–30 years	75	30.0
	31–45 years	98	39.2
	46–60 years	52	20.8
	Above 60	25	10.0
Education Level	Primary	38	15.2
	Secondary	92	36.8
	Tertiary	120	48.0
Area Type	Urban	142	56.8
	Semi-Urban	108	43.2
Healthcare Access	Easy access	143	57.2
	Limited access	107	42.8

Descriptive Statistics and Reliability

Descriptive statistics and Cronbach's alpha values of the major constructs are shown in Table 2. Mean vaccination coverage score was 3.47 (SD 0.82) suggesting moderate level of vaccination uptake in the sample. Public awareness had a mean of 3.55 (SD = 0.76), and disease prevention outcome a mean of 3.61 (SD = 0.79). All of them exceeded the indicated level of .70 reliability with Cronbach's algorithms ranging from .78 to .83. The results agree that all scales of the study are valid.

Table 2: Descriptive Statistics and Reliability Coefficients

Variable	N	Mean	SD	Cronbach's α
Vaccination Coverage	250	3.47	0.82	0.78
Public Awareness	250	3.55	0.76	0.83
Disease Prevention Outcome	250	3.61	0.79	0.80

Correlation Analysis

Table 3 presents the Pearson correlation between the variables of Study 2. The level of public awareness was significantly and positively associated with level of vaccination coverage ($r = .61$, $p < .001$), suggesting that the more aware participants were about vaccination programs, the more vaccinated were they. A significant positive correlation was also correlated between public awareness and disease prevention outcome ($r = .57$; $p < .001$). Disease prevention outcome showed there was a significant correlation with vaccination coverage ($r = .63$, $p < .001$). These associations bolster the proposed mediation model, and the relationship between awareness and prevention outcomes becomes powerful when awareness is mediated by vaccination coverage.These associations strengthen the proposed mediation model, which posits a link between awareness and prevention outcomes that is mediated by the level of vaccination coverage.

Table 3: Pearson Correlation Coefficients Among Variables

Variable	1	2	3
1. Public Awareness	—		
2. Vaccination Coverage	.61**	—	
3. Disease Prevention Outcome	.57**	.63**	—

*Note. **p < .001 (two-tailed).*

Structural Equation Modeling

Table 4 shows the results of using SEM. Public awareness had a strong positive direct impact on the coverage of vaccination ($\beta = .58$, SE = .08, CR = 7.25, $p < .001$). The effects of vaccination coverage on disease prevention outcome was significant ($\beta = .55$, SE = .07, CR = 7.86, $p < .001$). Public awareness had a direct influence on the outcome of disease prevention, too ($\beta = .24$, SE = .09, CR = 2.67, $p = .008$). A bootstrapped indirect effect for disease prevention via vaccination coverage from public awareness was found to be statistically significant ($\beta = .32$ [95% CI = (.21, .44)]). Overall, public awareness had a partial effect of $\beta = .56$ on disease prevention. Model fit indices were acceptable: $\chi^2/df = 1.98$, CFI = .97, TLI = .96, RMSEA = .058, SRMR = .049 all showing excellent fit of the model.

Table 4: Structural Equation Modeling Path Estimates

Path	β	SE	CR	p
Public Awareness → Vaccination Coverage	.58	.08	7.25	<.001
Vaccination Coverage → Disease Prevention	.55	.07	7.86	<.001
Public Awareness → Disease Prevention (direct)	.24	.09	2.67	.008
Public Awareness → Prevention (indirect via VC)	.32	.06	5.33	<.001
Total Effect	.56	.07	8.00	<.001

Note. Model fit: $\chi^2/df = 1.98$; CFI = .97; TLI = .96; RMSEA = .058; SRMR = .049

DISCUSSION

The results of this study further support the conceptual links between public awareness, vaccination and infectious disease prevention. Higher associations between improved public awareness and vaccination rates (r = .61) imply that public awareness of immunization and the nuances of necessary vaccines and risk levels are correlated to the health promoting behavior of immunizing. This discovery mirrors earlier research that has shown awareness, as an important factor in vaccination; particularly when the misinformation and low level of health literacy work against immunization achievements. The relationship between the two is very tight and it suggests awareness is not the only but an important determinant which affects behavioural changes in public health.

The positive correlation between the uptake increase and reduction in disease vulnerability at the individual and community level (r = .63) here again supports the simple principle of the vitamin D immunization program: The more the vaccine is taken up, the less vulnerable the individual and community is to the disease. This discovery adds to the understanding of herd immunity: that the more people who are covered, the more overall protection that will be provided – and that includes people who can't get vaccinated. The observed relationship is also a reflection of the perceived efficacy of vaccines and hence a certain alignment between behavioural and belief systems.

The study conducted the structural analysis using SEM that highlighted that vaccination coverage was one of the factors that could serve as structure which mediated the correlation between public awareness and disease prevention, one of the strengths of this study. There was an indirect effect (β = .32) larger than the direct effect (β = .24), indicating that the majority of awareness induced benefits in disease protection are mediated through uptake of vaccines being more. The finding could prove to be of theoretical importance for models such as the Health Belief Model which investigates the links between awareness and behaviour, and behaviour and health outcomes. A significant direct effect also suggests that knowledge can in turn motivate other mediating prevention actions, such as improving personal practices and hygiene, seeking preventive care in a timely fashion, and avoiding risky situations.

Moreover, the result of good model fit indices CFI = .97 and RMSEA = .058 also indicates that the proposed framework model was assumed to be able to reflect the structure in the data and had good model fit. In addition, the satisfactory reliability coefficients showed a good level of congruency in measuring the constructs, so results of this study were valid. By using SEM, however, the rather full picture of the direct and indirect pathways could be obtained, instead of relying on the traditional regression.

The social context relates to low- and middle-income areas where gaps can be informational and/or structural in this case. This study also focuses mainly on awareness, although the influence of health access (reported as being limited by the majority), indicates that awareness, by itself, is not enough to bring about the resulting vaccinations if there are not services that support access. Thus, the relationship of knowledge and access needs to be taken into account for the development of effective interventions for public health.

Overall the study emphasises the importance of awareness as one of the core elements in the chain of infectious disease prevention. Specifically, it empirically demonstrates the mediating effect of vaccination coverage, providing guidance to policy makers and health practitioners for how vaccination outcomes can be enhanced through means of communication strategies.

CONCLUSION

Finally, this study confirmed that public awareness is an important issue which can impact results in terms of vaccine coverage and is therefore critical to the reduction of the burden of infectious diseases. The results affirm that awareness directly and indirectly affects the outcomes of prevention, such as coverage of immunization. The importance of interventions to increase awareness is illustrated in the Structural Model as they can have significant impact on the uptake of vaccination and the risk of disease occurring in communities. These findings highlight the need to embed health education and communication activities in immunization initiatives, especially in urban and semi-urban areas where there are knowledge gaps and inequities in access to vaccines.

RECOMMENDATIONS

Based upon these findings, it is recommended that the focus of public health experts should to be on developing and releasing culturally informed, accessible and community-specific comprehensive public awareness campaigns. These campaigns should leverage on multiple communication channels, such as social media, community leaders, healthcare providers and educational institutions in order to reach out to as many people as possible with the right vaccine information. Additionally, the raised awareness should be materialized in the high vaccination rate, which requires further strengthening of health infrastructure and health services, especially in the areas of less services delivered, semi urban areas etc. Education of health care providers about effective communication techniques also is important because providers' recommendations can have a significant effect on vaccination decisions. Furthermore, addressing misinformation through educational and regulatory means needs to be a part of the policy and the people need to be empowered to restore their confidence in vaccines through educating them on misinformation. Future designs that look for the long-term impact of awareness on vaccination behaviour and disease prevention should involve the inclusion of behavior and context variables for a longitudinal design.

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