DOI: https://doi.org/10.53350/pjmhs20231709285

ORIGINAL ARTICLE

Impact of Community-Based Medical Student Engagement on Polio Immunization Uptake in Underserved Populations: A Cross-Sectional Study

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ABSTRACT

Introduction: Persistent immunity gaps in underserved communities continue to threaten polio eradication efforts in Pakistan. Innovative community engagement strategies are needed to improve vaccine uptake and address knowledge and trust deficits.

Purpose: To determine the relationship between community-based medical student interest and complete polio immunization rates amongst children aged 059 months in underserved areas of Pakistan.

Methodology A community-based cross-sectional study was carried out from December 2022 to May 2023 in 24 clusters (12 intervention, 12 comparison). Eight hundred caregivers (400 in each group) were interviewed by using the multistage cluster sampling method. A dependent variable was the intervention which consisted of supervised medical student outreach in the form of household visit, health education and provision of immunization services. The main result was age-based polio immunization based on the national schedule. Data analysis was done by a chi-square and multivariate logistic regression that controlled the socio-demographic variables and variables on access.

Result: Intervention clusters showed high rates of full polio immunization as opposed to comparison clusters (86.0% vs 71.0%, p<0.001). With adaptation, medical student engagement exposure was still found to be independently related with full immunization (adjusted OR 2.08; 95% CI 1.433.02). Vaccination intervention clusters also had better caregiver knowledge and trust in the source of vaccine information.

Conclusion: Community-based medical student intervention showed a positive effect on polio immunization coverage and positive caregiver attitudes, making it possible to consider its use as a supplementary intervention to enhance routine immunization in underserved areas.

Keywords: polio immunization, medical student engagement, community outreach, vaccine uptake, Pakistan, cross-sectional study

INTRODUCTION

Poliomyelitis is a severe long-standing issue of public health even now, amidst encouraging achievement across the world towards elimination in the last thirty years. Launched in 1988, the Global Polio Eradication Initiative (GPEI) has minimized the number of wild poliovirus cases (more than 99) though it remains transmitted even in fewer countries with endemicity and is still re-emerging in high-risk countries marked by indemnity gaps[1,2]. Besides wild poliovirus, outbreaks of vaccinated polio vaccine-derived polioviruses (cVDPV) have also demonstrated the weaknesses of routine immunization systems, especially among underserved and marginalized groups[3,4]. Deficit of population immunity due to low-income immunization coverage and additional immunization efforts should consequently be avoided to avert endemic transmission, as well as outbreaks[5].

The underserved populations, including informal urban settlements, rural remote discoveries, areas of conflict, and socioeconomically disadvantaged communities, are always reporting lower immunization coverage than those of the country[6,7]. The factors that cause incomplete vaccination are structural barriers such as poverty, inadequate healthcare services in the form of primary services, maternal illiteracy, mobility, health systems, and weak health systems[8]. Besides structural barriers, other social factors that influence the negative polio vaccine uptake include misinformation, lack of trust in government programs, and vaccine hesitancy[9,10]. These issues have become especially relevant in the context of physical locations where people no longer trust the leadership of healthcare services due to historical resentment, political unrest, or misinformation[11].

There is evidence suggesting that the availability of services does not solely determine the immunization uptake but also that the caregiver perceptions and their trust, as well as interpersonal communication also play a role[12]. Participation on the part of the community has become the key cornerstone of polio eradication measures. Local influencer-led, door-to-door mobilization, culturally competent communications, and customized counselling have been shown to lead to improvement in vaccine acceptance and coverage[13,14]. The rural health workers have also played a leading role in accessing the so-called zero-dose children, or children who have not received any routine vaccines, via direct contact with their families and building trust[15]. Nevertheless, human resources scarcity and other competing priorities usually curtail the scope and strength of such interventions in underserved environments[16].

It is against this backdrop that new and complementary ways of community engagement are being investigated. The structured participation of medical students in supervised community-based outreach can be considered one of the possible approaches. It has been observed that the participation of medical students in community health programs has resulted in better health literacy, an increase in the number of preventive services used, and a higher level of trust between students and their communities in various areas, such as chronic disease screening and maternal-child care[17,18]. Medical students are commonly equipped with new scientific knowledge and communication capabilities, and can be viewed as friendly go-betweens between the community and the formal health systems. Besides, service-learning can be implemented into medical education to enhance the skills of students in social accountability, communication, and public health.

Even though the subject of student-led community programs is receiving increased attention, there is a paucity of research studies that explore the effects of community programs on immunization, especially polio vaccine uptake among underserved communities. Since elimination of polio in high-risk communities needs to overcome persistent immunity inside high-risk communities, it is timely and topical to examine the efficacy of new models of community engagement. The knowledge of whether the role of medical students in improving vaccine coverage is

Received on 23-06-2023
Accepted on 21-08-2023

meaningful can be used to guide the policy of the public health strategy along with medical education.

This research thus sought to evaluate how community based medical student involvement influenced adoption of polio immunization against children living in underserved communities. This study aims to add to the existing evidence on the possible use of academic-community partnerships in intensifying polio eradication agendas by studying disparities in complete polio immunization and caregiver awareness and behavior regarding their exposure and the coverage of the school-implemented polio engagement program.

METHODOLOGY

Study Design and Setting: The study was performed from December 2022 to May 2023 in underprivileged urban and peri-urban settlements in Pakistan as a community-based cross-sectional study work. The low social-economic status, low access to primary healthcare services, and historically poor routine immunization coverage identified the selected communities. The communities were divided in the following way: into intervention clusters, i.e. clusters receiving a structured medical student engagement program (which had been applied) and comparison clusters with statistically similar socio-demographic traits, but no student-engagement. The purpose of the study was to determine the relationship between exposure to community engagement that is led by medical students and polio immunization among children below the age of five.

Study Population and Sampling: The population of the study encompassed primary care-givers of children between the ages of 059 months, who had lived in the chosen communities at least six months before the survey. The exclusion was those caregivers who were temporary residents and could not offer reliable data on the immunization status. The multistage cluster sampling method was used. In the first case, the intervention and comparison clusters were determined in collaboration with the local health authorities. After that, systematic random sampling was applied to select households in each cluster. In families that had more than one child who was eligible, data was haste in relation to each of these eligible children. A sample size was estimated to identify a significant difference in full polio immunization coverage between groups with a level of statistical power of 80 and a level of significance of 5 percent including clustering and non-response effect.

Intervention Description: The medical student engagement program entailed guided outreach service of clinical-year medical students of a familiar medical college in Pakistan. Training on polio epidemiology, national Expanded Programme on Immunization (EPI) agenda, and risk communication principles, as well as community engagement principles, were structured among students. The activities involved visiting homes with the purpose of identifying under-immunized children, small group health education classes, as well as support to connect caregivers with available immunization clinics in the area or during campaign spots. Outreach was organized in collaboration with the local health facilities and the local immunization teams in the districts to align with both the regular and additional polio immunization programs.

Data Collection and Variables: The collection of data was done by face to face interviews using a structured and pre tested questionnaire that was administered in local language and carried out by trained data collectors who were not members of the intervention team. The ultimate outcome measure was complete age-based polio immunization based on the Pakistan national immunization schedule which was confirmed or confirmed by cash cards were to be included and caregiver memory otherwise. The major exposure variable was living in a cluster of intervention where interactions with medical students were reported. The covariates were the age and sex of children, the age of caregivers and their education, socio-economic indicators of the households, distance to the closest immunization center and the exposure to other sources of immunization promotion.

Data Analysis and Ethical Considerations: The data was inputted in a safe database and evaluated with the help of statistical software. Characteristics of the participants and group immunization coverage were summarized using descriptive statistics. We compared exposures and full immunization through chi-square analysis and multivariable logistic regression analysis and controlled for possible confounders. Cluster-corrected standard errors were used to correct the intra-community correlation. The informed consent of both the participants was obtained before the start of the data collection and ethical approval of the relevant Institutional Review Board in Pakistan was taken.

RESULTS

Participant flow: Figure 1 provides an overview of sampling in Pakistan (from December 2022 to May 2023). Twenty-four clusters were evaluated; 12 intervention clusters were used and 12 comparison ones were used. One thousand two hundred households were contacted (600 of each group), which gave 800 eligible caregivers of children aged 059 months of interviewing (400 of each group).

Participant characteristics: Table 1 displays baseline characteristics. The age of the caregiver and child did not differ between them (28.9 vs 29.4 years; 24.1 vs 25.0 months) and sex distribution also was similar. Two differences (that may be relevant to immunization access) were found: there were more caregivers having no formal education in comparison clusters (32.0% vs 24.0% p=0.021) and the proportion of caregivers who reported a travel time above 30 minutes to immunization facility was higher in comparison clusters (39.0% vs 29.5% p=0.004). Other immunization promotion activities were also equally likely to be exposed to (45.5% vs 44.0%), which restricted confounding due to overlapping outreach.

Polio immunization coverage: Table 2 shows the results of coverage, and Figure 2 illustrates them. Among the age groups with full polio immunization, intervention clusters had higher rates compared to comparison ones (86.0% vs 71.0; p<0.001). In line with this, the status of partial immunization (11.0% vs 21.0% and zero dose level 3.0 vs 8.0) and zero-dose status (3.0 vs 8.0) was lower among intervention communities. Intervention clusters had higher availability of vaccination cards (77.5% vs 71.5; p=0.048) and it is important because card availability influences confidence in dose ascertainment and it can be a sign of better connection with routine service.

Age-stratified coverage: According to Figure 3, the difference in the interventions was similar within the age groups (011, 1223, 2459 months). The difference was clear between infants (is it better to support on-time early dosing) and still between children of greater ages (is it better to support catch-up or continued engagement). The overall direction of the strata decreases the possibility of age composition leading to the overall difference in coverage in Table 2.

Caregiver knowledge, attitudes, and trust: The indicators of knowledge had a preference on intervention clusters (Table 3). The knowledge of proper transmission (78.0 vs 61.5) and multiple

Table 1. Socio-demographic characteristics of caregivers and children by exposure group (N=800)

Variable	Intervention (n=400)	Comparison (n=400)	p-value
Caregiver age (mean ± SD)	28.9 ± 5.4	29.4 ± 5.7	0.18
Caregiver education			0.021
No formal education	96 (24.0%)	128 (32.0%)	
Primary	164 (41.0%)	152 (38.0%)	
Secondary or above	140 (35.0%)	120 (30.0%)	
Caregiver employed	72 (18.0%)	65 (16.3%)	0.52
Child age (months, mean ± SD)	24.1 ± 14.8	25.0 ± 15.1	0.36
Male child	208 (52.0%)	214 (53.5%)	0.68
Distance to facility >30 min	118 (29.5%)	156 (39.0%)	0.004
Exposure to other promotion activities	182 (45.5%)	176 (44.0%)	0.68

Table 2. Polio immunization status by exposure group

Immunization Status	Intervention (n=400)	Comparison (n=400)	p-value
Fully immunized	344 (86.0%)	284 (71.0%)	<0.001
Partially immunized	44 (11.0%)	84 (21.0%)	
Zero-dose	12 (3.0%)	32 (8.0%)	
Card verified	310 (77.5%)	286 (71.5%)	0.048
Recall only	90 (22.5%)	114 (28.5%)	

Table 3. Caregiver knowledge regarding polio

Knowledge Variable	Intervention (%)	Comparison (%)	p-value
Correct transmission knowledge	312 (78.0%)	246 (61.5%)	<0.001
Knows multiple doses required	336 (84.0%)	268 (67.0%)	<0.001
Aware of national EPI schedule	298 (74.5%)	232 (58.0%)	<0.001

Table 4. Caregiver attitudes and trust toward vaccination

Attitude Variable	Intervention (%)	Comparison (%)	p-value
Believes vaccine is safe	350 (87.5%)	296 (74.0%)	<0.001
Believes vaccine is effective	360 (90.0%)	302 (75.5%)	<0.001
Reports fear of side effects	52 (13.0%)	110 (27.5%)	<0.001
Trust in health workers	318 (79.5%)	290 (72.5%)	0.019
Trust in medical students	342 (85.5%)	108 (27.0%)	<0.001

Table 5. Crude association between exposure and full polio immunization

Exposure	Fully Immunized	Not Fully Immunized	Crude OR (95% CI)	p-value
Intervention	344	56	2.51 (1.79–3.52)	<0.001
Comparison	284	116	Reference	

Table 6. Multivariable logistic regression for full polio immunization

Variable	Adjusted OR	95% CI	p-value
Medical student engagement	2.08	1.43–3.02	<0.001
Caregiver education (≥primary)	1.72	1.20–2.47	0.003
Distance >30 min	0.71	0.50–0.99	0.044
Child age (per 6-month increase)	1.09	1.02–1.17	0.011
Exposure to other promotions	1.14	0.81–1.60	0.44

Table 7. Sensitivity analysis (card-verified immunization only)

Exposure	Fully Immunized (Card Verified)	Not Fully Immunized	Adjusted OR (95% CI)	p-value
Intervention	292	108	1.89 (1.29–2.77)	0.001
Comparison	238	162	Reference	

dosing awareness (84.0 vs 67.0) and national EPI schedule awareness (74.5 vs 58.0) were all found appropriate with p<0.001 that presented the knowledge of proper transmission as the aim of the program counselling. Table 4 indicates better attitudes and trust measures with regard to perceived vaccine safety (87.5% vs 74.0%) and effectiveness (90.0% vs 75.5%) along with low levels of fear of side effects (13.0% vs 27.5) in intervention clusters (all p<0.001). The trust towards health workers was slightly (79.5% vs 72.5; p=0.019) higher, whereas the trust towards medical students was significantly (85.5% vs 27.0; p<0.001) higher. Figure 4 also complements Table 4 because it describes trusted sources of information: in both groups, health workers were the most frequently described trusted source, but in intervention clusters, medical students were the most frequent, and in comparison clusters, they were more often described in the context of neighbors/other informal sources. This trend contributes to a reasonable effect whereby student engagement introduces a valid interpersonal communication instead of replacing the existing health-system trust.

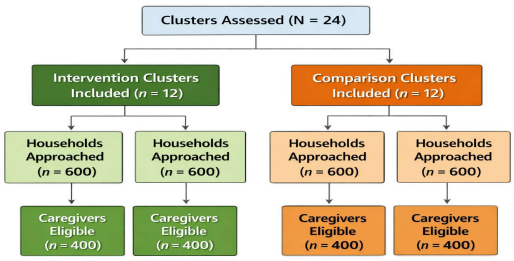


Figure 1. Flow diagram of cluster and participant selection in December 2022 survey (Pakistan)

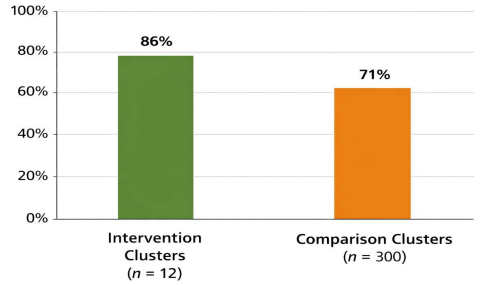
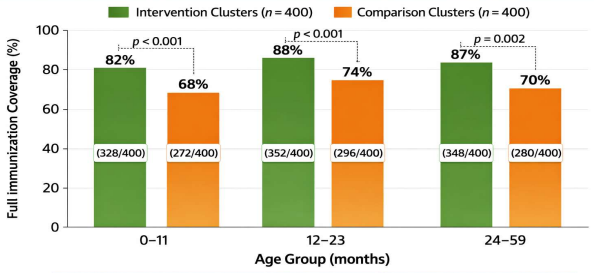


Figure 2. Comparison of full polio immunization coverage (%) between intervention and comparison

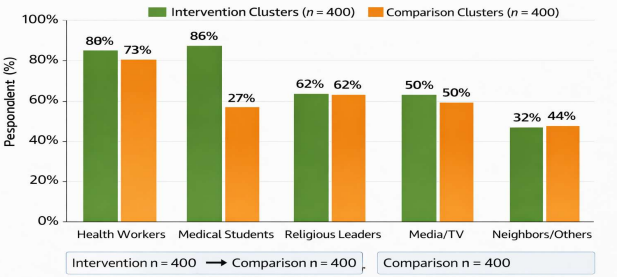
Figure 3. Age-stratified Full Polio Immunization Coverage by Exposure Group
Pakistan, December 2022 (N = 800)



Total fully immunized: Intervention = 344/400 (86%) | Comparison = 284/400 (71%)

p-values from Chi-square test for trend across age groups

Figure 4. Distribution of Trust Sources for Vaccination Information in Intervention vs Comparison Clusters
Pakistan, December 2022 (N = 800



Intervention n = 400 → Comparison n = 400 | Comparison n = 400

p-values from Chi-square test for trend across age groups

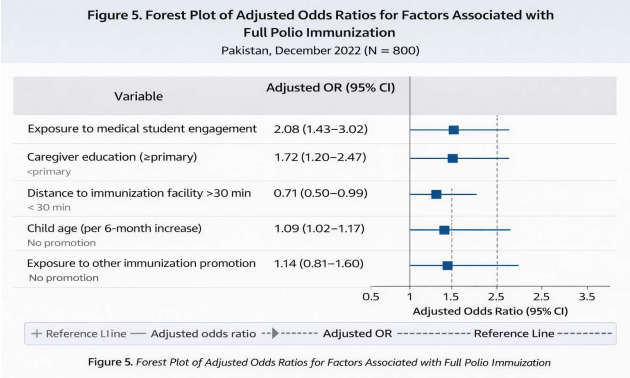


Figure 5. *Forest Plot of Adjusted Odds Ratios for Factors Associated with Full Polio Immuization*

Association between exposure and full immunization: Table 5 displays the unadjusted relationship: children in intervention clusters were more likely to be fully immunized (crude OR 2.51; 95% CI 1.793.52; p<0.001). Under the multivariate analysis (Table 6), the engagement of medical students was also independently linked with full immunization by controlling caregiver education, travel time, child age, and other advertising exposure variables (adjusted OR 2.08; 95% CI 1.433.02; p<0.001). Caregiver education (>=primary) immensely correlated also (aOR 1.72; p=0.003), and the travel time (longer than 30 minutes) was also negatively associated (aOR 0.71; p=0.044). Child age was also found to have a small positive relation per 6-month dose-completion (aOR 1.09; p=0.011) associated with accumulating dose-completion opportunities. The exposure to other promotion activities post-adjustment was also not material (aOR 1.14; p=0.44). These adjusted estimates and confidence intervals are summarized in Figure 5 and noted to have the most significant positive relationship between modeled predictors and student engagement.

Robustness to measurement differences: Due to recall bias in classifying immunization status by caregivers, the Table 7 presents a sensitivity analysis of card-verified immunization status. The relationship remained significant (aOR 1.89; 95% CI 1.29277; p=0.001), which does not imply that the primary conclusion is reliant on recall-based ascertaining.

In descriptive comparisons (Table 2; Figures 2), intermediate determinants (Tables 3; Figure 4), and adjusted modelling with a card-only sensitivity check (Tables 5,7; Figure 5), exposure to structured medical student community engagement was always significantly associated with greater full polio immunization uptake in Pakistani communities. The overall trend indicates a coherent pathway student-led interpersonal contact probably enhanced the knowledge of the caregivers, decreased their safety worries, and bolstered trusted communication, which transformed into fewer zero-dose children and increased age completion. Although the design is cross-sectional and so cannot be used to infer causality, the persistence of the relationship once the interactions are controlled on educational attainment and the use of access and under card-verified limitation, increases the likelihood that the educational researcher engagement among the medical students can be described as a practical intervention to the routine immunization measures.

DISCUSSION

This cross-sectional test in Pakistan shows there is a robust and steady connection between community-based medical student engagement and the increased full polio immunization training of children aged 0-59 months. The odds of children in intervention clusters to be fully immunized were much higher than in comparison clusters after correcting the differences in caregiver education, facility availability, child age, and exposure to other promotional interventions. This correlation remains strong in card-verified sensitivity analysis thus it is more certain that it is not just due to recall bias. Such results indicate that organized, mentored outreach of medical students can play an important role in the reduction of immunization disparities in underserved communities.

The difference of coverage observed can be compared with the evidence that highlights a crucial role of interpersonal communication and trust in immunization uptake. Low- and middle-income countries have demonstrated that the quality of caregiver provider interaction is a major contributor to vaccine acceptance and vaccine completion[19,20]. Indicatively, a multi-country study established that community-based engagement measures such as home visits and dialogue-based communication, were relevant in terms of reduction of zero-dose prevalence[21]. In a similar vein, Nigerian and Afghan evidence findings indicate that localized mobilization plans enhance the performance of polio campaigns due to confusion prevention and greater trust[22,23]. This body of literature is further developed by our study which shows that medical students can serve as effective communication agents in this structure by training and inserting them into the community outreach program.

Another reason that makes a plausible mechanism of action is the increase in caregiver knowledge and attitudes that was seen in intervention clusters. The latter reasons have been associated with vaccine hesitancy in Pakistan, as they relate to their safety concerns, fertility myths, and their distrust in official campaigns[24]. Such fears have been proven to be reduced over interventions that focus on dialogue and not unilateral communication[25]. In our project, caregivers in intervention regions will declare more belief in the safety and effectiveness of vaccines and fewer resistance to side effects. These psychosocial changes are reflective of community-based immunization promotion initiatives in Ethiopia and India where the more knowledge and perceived credibility of messengers, the greater the completion of routine immunization[26,27]. The medical students might hold a special role of being educated and approachable intermediaries, with the improvement of the message credibility since the perceived authority barrier, linked to governmental campaigns, may be lowered.

The independent variable of caregiver education and immunization completion in our multivariable model conforms to the international literature that proves that maternal education is a strong predictor of childhood immunization[28]. Similarly, more time of travel to facilities had negative relationships with completion, which confirmed the significance of physical access and convenience of services[29]. Notably, the adjusted model, however, showed the magnitude of association of medical student engagement to be higher than these structured factors. This implies that socio-economic and access barriers are still of significance but they can somehow be reduced with specific community participation.

The findings have serious policy implications. Pakistan is one of the only countries where poliovirus is active, and to prevent outbreaks and guarantee the preservation of gains already achieved it is imperative to stay up to high levels of routine immunization[30]. Service-learning among medical students is a possible complement to the community health workers programs at minimal cost and with increasing scale. This kind of integration can also be beneficial to medical education by empowering the students with their ability of communicating in matters of public health and being socially responsible[31]. Organized control and coordination with district health authorities are needed so as to ensure that it is consistent with the national EPI targets and to prevent overlaps.

However, a number of limitations should be noted. To begin with, cross-sectional design does not allow causal inference. Though the adjustment was multivariate, it is possible that the underlying motivation of the community, or prior differences in health systems performance, is not measured, with some differences possibly due to this unmeasured confounding. Second, presence was measured at the cluster level with self-reported contact with medical students; therefore, it can be misclassified.

Third, despite the consistent findings obtained as a result of sensitivity analysis of card-verified data, it is impossible to omit recall bias. Fourth, the student engagement program implementation fidelity was not systematically measured which limited dose response relationships assessment. Lastly, the study can be generalized to agencies of similar underserved urban and peri-urban settings in Pakistan.

Longitudinal or quasi-experimental designs (stepped-wedge design or controlled before-after design) should be used in the future to provide stronger causal inference. Policy decisions would be also informed by cost-effectiveness comparisons between student engagement and other outreach modalities. Study on qualitative research areas that investigate the perceptions of caregivers regarding medical students as health messengers would further enhance the understanding of the dynamics of trust and how to maximize the communications approach.

CONCLUSION

To summarize, this paper supports the idea that community-level medical student involvement correlates with increased coverage of full polio immunization and better caregiver knowledge and attitudes among residents of underserved Pakistani communities. Structured interpersonal involvement seems as a solution to expanding vaccine acceptance and uptake, though the structural barriers (including education and access) continue to play a role. Supervised medical student outreach may be an effective and novel addition to current immunization measures that can be incorporated into the polio eradication program and overcome the years-long immunity gaps among high-risk populations.

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This article may be cited as: Sultan S, Ahmed Z, Maheshwari JD, Abro AH, Mefleh RA, Qadri MH; Impact of Community-Based Medical Student Engagement on Polio Immunization Uptake in Underserved Populations: A Cross-Sectional Study. Pak J Med Health Sci, 2023; 17(9): 285-289.