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Operational Readiness of Medical Interns in Immunization Services: A Cross-Sectional Study at a Tertiary Care Hospital in Dakshina Kannada, Karnataka

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ABSTRACT

Introduction: Globally vaccination is one of the most cost-effective public health interventions, averting millions of deaths annually. Adequate operational knowledge in various thematic areas among providers is mandatory to achieve best immunisation outcomes. Posting of medical interns to vaccination centre is a golden opportunity to acquire operational knowledge and skill to roll out as confident and competent doctors to provide quality vaccination services to the beneficiaries.

Objectives:

1. To assess the operational readiness of medical interns in immunization services.
2. To evaluate knowledge of medical interns related to key operational aspects of immunization.
3. To identify factors associated with operational readiness among medical interns.

Methods: A cross-sectional study was conducted among medical interns posted in the vaccination clinic of a tertiary care teaching hospital in Dakshina Kannada, Karnataka, between 2024 and 2026. A validated semi-structured questionnaire based on Universal Immunization Programme guidelines was administered to interns. Descriptive statistics were used for data summarization, and associations were evaluated using the chi-square test with odds ratios and 95% confidence intervals.

Results: A total of 261 interns participated in the study. Overall operational readiness was low, with only 64 (24.5%) interns demonstrating adequate readiness, 104 (39.8%) moderate readiness, and 93 (35.6%) inadequate readiness. Domain-wise readiness was highest for National Immunization Schedule (75%), while readiness was lower for cold chain and VVM (53.3%), open vial policy (40.6%), and Dose, route and site (37.5%). Interns who had independently administered vaccines were significantly more likely to be operationally ready

(OR = 4.4; 95% CI: 2.56–7.55; p < 0.001). Interns who had received on the job expert immunization instructions showed a positive but non-significant association with readiness (OR = 1.62; 95% CI: 0.94–2.78).

Conclusion: Operational readiness of medical interns in immunization services was suboptimal. The study findings highlight the need for structured immunization training during internship to strengthen practical competencies in vaccination services.

Keywords: Immunization training; Medical interns; Operational readiness; Universal Immunization Programme; Competency-based medical education.

INTRODUCTION

Vaccination is widely recognized as one of the most cost-effective public health initiatives.[1] According to the WHO, vaccination prevents an estimated 3.5 to 5.0 million deaths annually from illnesses like influenza, tetanus, and measles.[1] According to a recent WHO/Lancet analysis, vaccination campaigns have prevented 154 million deaths worldwide over the last 50 years, among which the great majority were in infants. Vaccines are considered among the most impactful public health innovations, having led to the eradication of smallpox and near eradication of polio.[2] These achievements highlight vaccination as a vital and cost-effective investment in public health, offering better health and longevity for both adults and children. India has the world's most extensive vaccination program, and the scale of immunization is vast. By conducting over 9 million sessions with the assistance of 27,000 cold-chain locations and 150,000 auxiliary nurses, the Universal Immunization Programme (UIP) hopes to reach approximately 27 million infants each year.[3]

An efficient health work force is critical for realizing the full benefits of immunization programs. WHO's immunization agenda and global health strategies highlight strengthening human resources as a key priority.[4]Training of medical professionals is essential to ensure competent care and to address vaccine hesitancy and build public trust.[5] Various controlled studies show that applied pre-service education (e.g. realistic vaccine clinics or simulations) substantially improves trainees' immunization knowledge, skill, confidence and attitudes. It is noteworthy that a competent immunization workforce is widely recognized as a key determinant of vaccine acceptance and uptake within communities.[6]Poorly prepared personnel risk undermining vaccination targets. Thus, global policy calls for immunization curriculum and competency-based training for all health workers.

It is crucial to emphasize that gaps persist despite increase in routine immunization coverage. According to latest estimates, India's estimated coverage for the third dose of diphtheria–pertussis–tetanus vaccine (DPT3) was approximately 94%, representing a substantial improvement from the earlier level of 72%.[7] Therefore, all levels of the health system, including front-line employees, are essential to success in India. The program's spokespersons, health care professionals (HCPs), offer family counselling and oversee the appropriate handling of vaccines.[8]Research indicates that immunization program failures have been associated with deficiencies in HCP knowledge or attitudes (e.g., regarding vaccine storage or AEFI).[9]

In this context, medical interns – who often rotate through pediatrics and community medicine – are a crucial group. Interns typically participate directly in immunization clinics, pediatric wards and outreach sessions, and play a key role in vaccine administration and safety surveillance. Their understanding of the national schedule, cold-chain practices, dosing and adverse-event management will directly affect service quality. Recent surveys suggest that even among interns and students there are significant gaps in immunization knowledge

and practice, highlighting the need for better training.

Despite this, the operational readiness of medical interns for routine immunization services has been little studied. There is a lack of comprehensive data on how well interns understand and can apply immunization guidelines in the Indian setting. Given their pivotal role, it is important to assess intern readiness and identify any training needs. Therefore, this study was undertaken to evaluate the operational knowledge and preparedness of medical interns in immunization services at a tertiary care hospital**.** The findings will help inform targeted educational interventions to strengthen the immunization workforce.

MATERIALS & METHODS

This hospital-based cross-sectional study was conducted among medical interns posted in the vaccination clinic of the Department of Community Medicine at a tertiary care teaching hospital. The study was carried out over a 2year period from 2024 to 2026.A total population sampling strategy was done for interns attending vaccination clinic on a rotational basis during the study period. A total of 261 interns who fulfilled the inclusion criteria and provided consent were enrolled into the study on a consecutive basis. Interns who did not provide consent, or who returned incomplete or near-empty questionnaires, were excluded from the analysis.

Questionnaire

Data were collected using a validated, semi-structured, self-administered questionnaire designed to assess operational readiness in immunization services. The questionnaire was prepared based on the Universal Immunization Programme (UIP) guidelines, national immunization schedule, and relevant literature on immunization training and knowledge assessment. The instrument covered key operational domains including National Immunization Schedule, Vaccine dose, route and site of administration, Cold chain, vaccine vial monitor (VVM), Open vial policy and immunization safety.

Content validity of the questionnaire was assessed by a panel of experts consisting of faculty members from Community Medicine, Paediatrics, and Immunization program experts. The experts evaluated the items for relevance, clarity, and representativeness of the operational domains of immunization services. The questionnaire was pilot tested among a small group of medical interns (n=20) who were not included in the final study sample. Participation was voluntary and confidentiality was maintained. Subjectively all agreed that the questions were relevant and wished to know more about the programme.

Each correct response was awarded one mark, and a composite knowledge score was calculated. The total score was converted into a percentage, and operational readiness was categorized as adequate (>75%), moderate (50–75%), and inadequate (<50%).

Statistical Analysis

Data were entered into Microsoft Excel and analyzed using Statistical Package for the Social Sciences (SPSS). Descriptive statistics were used to summarize the data. Categorical variables were presented as frequencies and percentages. Continuous variables were summarized using mean, standard deviation (SD), median, interquartile range (IQR), minimum, and maximum values. For domain-wise analysis, the categories of adequate and moderate readiness were combined and considered as operational readiness.

Inferential statistics were applied to assess associations between operational readiness and selected variables such as prior expert immunization instructions received and independent vaccine administration experience. Information regarding prior expert immunization instructions was obtained from the participants. In this study, prior immunization instructions received refers to those given by an expert during their postings. For analytical purposes, interns

scoring in the adequate and moderate readiness categories were combined and classified as operationally ready. Chi-square test was used to test for association. Odds ratios (OR) with 95% confidence intervals (CI) were calculated to estimate the strength of associations. A p value <0.05 was considered statistically significant.

RESULT

A total of 261 medical interns were assessed. Overall operational readiness was low (Table 1). Only 64 interns (24.5%) scored "adequate," 104 (39.8%) "moderate," and 93 (35.6%) "inadequate." The mean knowledge score was 33.1 ± 13.0 (median 33.0, interquartile range 19.0–41.0, range 15–56) (Table 2).

Operational readiness varied across different immunization domains. For domain-wise comparison, interns with adequate and moderate readiness were grouped together and classified as operationally ready. Highest level of operational readiness was observed in the national immunization schedule (75%). Moderate readiness was observed for cold chain maintenance and vaccine vial monitor (VVM) interpretation, with 139 interns (53.3%) demonstrating readiness. Lower readiness levels were observed for open vial policy, where 106 interns (40.6%) were ready. The lowest readiness was noted for the dose, route and site, with only 98 interns (37.5%) demonstrating readiness (Table 3).

We also examined factors associated with readiness. Among interns who received on-the-job expert immunization instructions, 69/97 (71.1%) were ready versus 99/164 (60.4%) without training; this difference was not statistically significant (χ^2=3.1, P≈0.08, OR=1.62, 95% CI 0.94–2.78) (Table 4). By contrast, interns who had independently administered vaccines were much more likely to be ready: 125/162 (77.2%) versus 43/99 (43.4%) of those without such experience (χ^2=29.5, P<0.001, OR=4.4, 95% CI 2.56–7.55) (Table 5).

Table 1. Overall operational readiness of interns in immunization services (N=261).

Operational readiness category	Number	Percentage
Adequate (>=75%)	64	24.5%
Moderate (>=50 to 74%)	104	39.8%
Inadequate (<50%)	93	35.6%
Total	261	100

Table 2. Descriptive statistics of immunization knowledge scores.

Statistic	Value
Mean	33.09
SD	13.03
Median	33.0
25th percentile	19.0
75th percentile	41.0
Minimum	15
Maximum	56

Table 3. Operational readiness across immunization domains* (N = 261).

Domain	Readiness n (%)
National immunization schedule	195 (75.0)
Cold chain & VVM	139 (53.3)
Open vial policy	106 (40.6)
Dose, route and site	98 (37.5)

*** Readiness includes both adequate and moderate readiness categories for domain wise comparison**

Table 4. Association between on-the-job expert immunization instructions and operational readiness (N=261).

Expert instructions	Ready n (%)	Not ready n (%)	Total
Received	69 (71.1)	28 (28.9)	97
Not received	99 (60.4)	65 (39.6)	164
Total	168	93	261

$\chi^2 = 3.10$; $P = 0.082$. Odds ratio (OR) = 1.62 (95% CI: 0.94–2.78).

Table 5. Association between independent vaccine administration and operational readiness (N=261).

Administered independent vaccination	Ready n (%)	Not ready n (%)	Total
Yes	125 (77.2)	37 (22.8)	162
No	43 (43.4)	56 (56.6)	99
Total	168	93	261

$\chi^2 = 29.5$; $P < 0.001$. Odds ratio (OR) = 4.4 (95% CI: 2.56–7.55).

DISCUSSION

In this study, among 261 medical interns, we found that only 24.5%(n=64) achieved "adequate" operational readiness in immunization, while 35.6%(n=93) were "inadequate." The mean knowledge score was low (mean±SD≈33.1±13.0), indicating substantial gaps. Also, we found that specific immunization domains were weak. These results are consistent with existing literature suggesting that, although medical trainees acknowledge the importance of vaccination, deficiencies persist in their operational and programmatic knowledge. For example, Thiagarajan et al. found that only ~65% of Indian interns correctly knew a key infant vaccine schedule detail, underscoring incomplete schedule knowledge.[10] Liu et al. likewise reported that while Chinese medical students largely favored vaccination, significant knowledge gaps remained and a formal vaccine curriculum was needed.[11]

Our study showed that interns who had received informal on-the-job immunization training demonstrated higher odds of operational readiness (OR=1.62; 95% CI: 0.94–2.78), although the association did not achieve statistical significance (P≈0.08). In contrast, independent vaccine administration showed a strong and statistically significant association with readiness (OR=4.4; 95% CI: 2.56–7.55; P<0.001). Shalansky et al., found that implementation of a pilot immunization curriculum improved residents' knowledge, with correct response rates increasing from 49% to 67%, highlighting the importance of structured immunization training. [12] The important finding of 4.4-fold increase in readiness odds associated with independent vaccine administration provides empirical support for the shift toward Competency-Based Medical Education (CBME), which was introduced in India in 2019 and revised in 2024. The CBME paradigm emphasizes "performances" and "outcomes" over merely attending lectures.[13-14] Many current medical students are still at the "Know How" or "Show How" (simulated environment) vaccination stages in Miller's Pyramid of clinical competence.[15]Through autonomous performance in actual clinical settings, the internship offers the rare and essential chance to advance to the "Does" level.

The introduction of CBME has also led to the establishment of clinical skills laboratories in most medical colleges, which provide opportunities for simulation-based learning and repeated practice of clinical procedures in a controlled environment. Simulation-based medical education has been shown to significantly improve clinical competence, confidence, and preparedness for clinical practice.[16] In the context of immunization services, incorporating structured vaccination training modules within existing skill laboratories may help strengthen interns' operational readiness. Simulation-based vaccination training programs and structured procedural workshops have been shown to improve learners' confidence and technical proficiency in vaccine administration and related practices.[17]

Global evidence suggests that when students are actively involved in vaccination

campaigns - such as the IUSM Medical Student Volunteer Vaccinator program in Indiana, USA - they contribute thousands of hours and deliver tens of thousands of doses, resulting in marked increases in their clinical judgment and community engagement.[18] The transition from "Show How" to "Performance" must be institutionalized.The findings suggest that incorporating a "Certified Immunization Skills Logbook" into the Compulsory Rotatory Medical Internship (CRMI) could be a useful strategy for the National Medical Commission to strengthen immunization-related competencies.

Strengths and Limitations

This study's strengths include its total population sampling of all the interns attending the vaccination clinic on a consecutive basis and use of a validated semi-structured questionnaire covering key operational domains. We assessed real-world competencies (schedule, immunization safety, etc.) relevant to clinical practice. Also, questions pertaining to open vial policy and waste management were added based on the findings of the pilot study. However, this was a single-center study in one teaching hospital, which may limit generalizability to other regions or private settings. Data were based on a written test, which may not perfectly capture hands-on skills or actual performance in clinics. We also excluded interns who did not consent or fully complete the survey, which could introduce selection bias. Despite these limitations, the consistency of our findings with other reports supports their validity.

CONCLUSION

This study is a pioneer evaluation on medical interns' operational preparedness in the field of vaccination services. It identifies specific areas for improvement by assessing domain-specific knowledge and determining predicting factors. By connecting readiness—not merely attitude or basic knowledge—with real-world training experience, it contributes to the body of literature. Additionally, it would be beneficial to track interns over time to see if readiness increases with experience and to witness actual immunization practice (beyond written examinations). The results emphasize the need for structured hands-on immunization training workshops, integrated within existing CBME skill laboratory activities, to improve the competency of future physicians in vaccination services.

Declaration by Authors

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