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Analysis of Pedagogical Approaches to the Vaccination Module in the Instituts Supérieurs des Techniques Médicales (ISTM), Kinshasa, Democratic Republic of the Congo

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Abstract

Introduction: The quality of immunization services depends largely on the competencies of frontline healthcare professionals. In the Democratic Republic of the Congo (DRC), the *Instituts Supérieurs des Techniques Médicales* (ISTM)—**Higher Institutes of Medical Techniques—in Kinshasa** play a central role in preparing personnel involved in the implementation of the Expanded Program on Immunization (EPI). However, the pedagogical organization of the vaccination module and its alignment with operational requirements remain insufficiently documented. This study aimed to analyze the pedagogical approaches used in teaching the vaccination module and to identify factors associated with students' level of knowledge. **Methods:** A cross-sectional observational study with descriptive and analytical components was conducted between March and July 2024 in nine ISTMs in Kinshasa. A proportionate stratified probabilistic sampling method was used to include 555 students. Data were collected using a structured questionnaire assessing pedagogical approaches, institutional barriers, and vaccination knowledge level, measured through a composite score. Pedagogical variables, including the availability of practical training and teaching materials, were assessed primarily based on students' self-reported perceptions. These variables were not systematically verified through institutional documents or direct observation, which may introduce information bias. Associations were examined using the chi-square test, multivariable logistic regression, and multilevel analysis to account for institutional-level effects. Statistical significance was set at $p < 0.05$.

Results: Among participants, 44.3% demonstrated a high level of knowledge, 41.3% a moderate level, and 9.2% a low level. The main barriers identified were lack of teaching resources (80.7%) and insufficient regular practical sessions (78.4%). In multivariable analysis, the availability of practical training (adjusted OR = 2.03; 95% CI: 1.27 - 3.23; p = 0.003) and adequate teaching materials (adjusted OR = 1.80; 95% CI: 1.09 - 2.96; p = 0.022) were significantly associated with a high level of knowledge. Multilevel analysis showed that approximately 11.3% of the variance in knowledge level was attributable to differences between institutions in the empty model, decreasing to 7.6% after adjustment. **Conclusion**: Pedagogical approaches—particularly practical training and the availability of teaching materials—are key determinants of students' knowledge of vaccination. Strengthening the structural organization of the vaccination module and harmonizing curricula across ISTMs appear to be strategic levers for sustainably improving the quality of paramedical training and enhancing the performance of the EPI in the DRC.

Keywords

Pedagogical Approaches, Vaccination, Student Knowledge, Paramedical Training, Practical Training, Teaching Resources

1. Introduction

Vaccination is one of the most effective public health interventions for preventing infectious diseases, reducing child mortality, and improving life expectancy. According to joint estimates from the World Health Organization (WHO) and the United Nations Children's Fund (UNICEF), immunization prevents between 3.5 and 5 million deaths each year from diseases such as diphtheria, tetanus, pertussis, measles, and influenza [1]. It constitutes a fundamental pillar of universal health coverage and health system strengthening [2].

Despite these advances, persistent inequalities in vaccination coverage remain, particularly in low- and middle-income countries. Global estimates indicate that a substantial number of children remain under-immunized or unvaccinated, exposing certain regions to recurrent outbreaks of vaccine-preventable diseases [1]. The global resurgence of measles observed in recent years highlights the fragility of immunization gains [3].

In the Democratic Republic of the Congo (DRC), the Expanded Program on Immunization (EPI) serves as the national strategic framework for implementing vaccination activities. However, the country continues to experience recurrent outbreaks of measles and other vaccine-preventable diseases, reflecting persistent challenges related to accessibility, quality of services, and overall health system performance [3]. Beyond logistical and financial constraints, the quality of vaccination services is closely dependent on the competencies of frontline healthcare professionals [4].

The scientific literature indicates that healthcare providers' knowledge, atti-

tudes, and skills significantly influence both the quality of vaccination services and public confidence in immunization programs [5] [6]. Healthcare professionals are, in fact, the most influential source of information in patients' vaccination decisions. Insufficiently structured training may limit mastery of vaccination protocols, the management of adverse events following immunization, and effective communication in addressing vaccine hesitancy [7].

In health sciences education, the acquisition of professional competencies follows a progressive pathway integrating theoretical knowledge, practical skills, and performance in real-life situations. Miller's framework distinguishes the levels "knows", "knows how", "shows how", and "does", illustrating the progression of clinical competence [8]. Applied to vaccination, this approach implies a coherent pedagogical structure combining up-to-date theoretical content, practical training, clinical placements, and qualified supervision.

The *Instituts Supérieurs des Techniques Médicales* (*ISTM*)—**Higher Institutes of Medical Techniques—in Kinshasa** play a strategic role in preparing frontline healthcare providers. In Kinshasa, the main hub for paramedical training in the DRC, the rapid expansion of ISTMs, particularly in the private sector, raises important concerns regarding curriculum harmonization and the quality of pedagogical approaches used in key modules such as vaccination. The global strategy on human resources for health emphasizes that health system performance depends on initial training that is aligned with national priorities and supported by harmonized standards [4].

To date, few studies have empirically examined the pedagogical organization of the vaccination module in Congolese paramedical training institutions and its alignment with the operational requirements of the EPI and the objectives of the Immunization Agenda 2030 [2].

In this context, it is essential to analyze the pedagogical approaches used in teaching the vaccination module within ISTMs in Kinshasa in order to better understand their organization, identify potential gaps, and assess their capacity to adequately prepare future healthcare professionals for the demands of national immunization programs.

2. Materials and Methods

2.1. Study Design and Setting

A descriptive and analytical cross-sectional study was conducted between March and July 2024 in nine *Instituts Supérieurs des Techniques Médicales* (ISTM) in Kinshasa, Democratic Republic of the Congo (DRC). These institutions provide initial training for mid-level healthcare professionals who are expected to deliver primary healthcare services, including the implementation of vaccination activities under the Expanded Programme on Immunization (EPI).

The nine ISTMs included in this study were selected based on their operational status during the 2023-2024 academic year and their involvement in training mid-level health professionals in Kinshasa. These institutions represent a subsample of

the eligible ISTMs in Kinshasa, selected to ensure diversity in institutional characteristics (public vs. private) and student population size. However, they may not fully represent all paramedical training institutions in the city, which should be considered when interpreting the generalizability of the findings.

The study aimed to analyze the pedagogical approaches used in the vaccination module and to examine their association with students' level of knowledge, while accounting for variability across institutions.

2.2. Participants

The target population consisted of students enrolled during the 2023–2024 academic year in the selected ISTMs who had either completed or were currently undertaking the vaccination module.

Students were eligible if they were officially enrolled in the institution and had provided written informed consent. Those absent during data collection or who submitted incomplete questionnaires (less than 80% of items completed) were excluded from the final analysis.

2.3. Sample Size and Sampling Procedure

The minimum sample size was calculated using Schwartz's formula, commonly applied in cross-sectional studies:

$$n = \frac{Z^2 \times p(1-p)}{d^2}$$

Assuming a 95% confidence level (Z = 1.96), an expected proportion of 50% (a conservative estimate maximizing sample size), and a precision of 5%, the minimum required sample size was 384 students. To account for potential non-response and ensure adequate statistical power, a 30% increase was applied, resulting in a final target sample size of 555 students.

A proportionate stratified random sampling method was used. Each of the nine institutions constituted a stratum. Participants were allocated proportionally based on the estimated student population in each institution, out of an overall population of approximately 5,800 students. Within each institution, students were selected through simple random sampling using official academic lists.

2.4. Study Variables

2.4.1. Dependent Variable

The primary outcome variable was the level of knowledge on vaccination, categorized into three levels (low, moderate, high) based on a composite score derived from multiple-choice questions.

For regression analyses, this variable was dichotomized (high vs. moderate/low) to identify factors associated with a high level of knowledge.

2.4.2. Independent Variables

The explanatory variables included:

- **Pedagogical approaches** (existence of a structured module, availability of teaching materials, organization of practical sessions, clinical placements, teaching methods);
- **Institutional characteristics** (public vs. private management);
- **Sociodemographic characteristics** (age, sex, academic level);
- **Institutional constraints and perceived needs**.

2.5. Data Collection Instrument and Procedure

Data were collected using a structured self-administered questionnaire developed based on:

- World Health Organization recommendations on immunization training [4];
- existing literature on vaccine confidence and healthcare provider-related determinants [5] [6].

The questionnaire comprised four main sections:

1) sociodemographic characteristics;
2) pedagogical organization of the vaccination module;
3) assessment of vaccination knowledge;
4) institutional constraints and perceived needs.

Data collection was conducted face-to-face under the supervision of trained research assistants to ensure standardized administration and minimize information bias.

2.6. Measurement of Knowledge

Vaccination knowledge was assessed using a composite score based on multiple-choice questions covering:

- general principles of immunization;
- the national vaccination schedule;
- cold chain management;
- adverse events following immunization.

Each correct answer was awarded one point, and the total score was converted into a percentage.

Knowledge levels were classified as follows:

- **High:** ≥ 75%
- **Moderate:** 50% - 74%
- **Low:** < 50%

The 75% threshold was selected in line with commonly accepted academic standards in health sciences education.

Non-responses and "don't know" answers were coded as incorrect responses (score = 0) to avoid overestimation of knowledge levels.

2.7. Validity and Reliability

Although internal consistency of the knowledge scale was acceptable (Cronbach's alpha = 0.82), a full psychometric validation was not conducted. Specifically, the

study did not assess: item difficulty indices, discrimination indices, criterion validity against standardized national examinations, such as those of the Expanded Programme on Immunization (EPI).

In addition, the threshold of 75% used to define a "high level of knowledge" was based on commonly used academic standards but lacks empirical validation in the specific context of vaccination training in the DRC. Future research should aim to develop and validate standardized assessment tools adapted to local training and evaluation frameworks.

2.8. Statistical Analysis

Data were entered and analyzed using SPSS version 26.

Descriptive statistics included means and standard deviations for quantitative variables, and frequencies and percentages for qualitative variables.

Bivariate associations between explanatory variables and knowledge level were assessed using Pearson's chi-square test. Variables with $p < 0.20$ in bivariate analysis were included in a multivariable logistic regression model to identify factors independently associated with a high level of knowledge.

Model goodness-of-fit was assessed using the Hosmer-Lemeshow test. Multicollinearity was evaluated using the variance inflation factor (VIF), with an acceptable threshold of $VIF < 2$.

Given the hierarchical structure of the data (students nested within institutions), a two-level multilevel logistic regression model was applied to account for clustering and estimate institutional-level random effects. The intraclass correlation coefficient (ICC) was calculated to estimate the proportion of variance attributable to differences between institutions. Statistical significance was set at $p < 0.05$.

For regression analysis, knowledge levels were dichotomized into high versus moderate/low. This approach was adopted to facilitate interpretation of results and to identify factors associated with achieving a competency threshold relevant for clinical practice. After excluding missing data (n = 29), the regression analysis was conducted on a final sample of n = 526 participants.

3. Results

3.1. Univariate Analysis

3.1.1. Participant Characteristics

A total of 555 students were included in the analysis. Their distribution across the nine participating institutions is presented in Table 1.

Table 1. Distribution of participants by institution (n = 555).

Institution	N	%
ISTM Croix-Rouge	187	33.7
ISTM Kinshasa	158	28.5

Continued

ISTM UFA	47	8.5
ISETEM Makala	42	7.6
ISTM CEPROMAD	40	7.2
ISTAM Kinkole	34	6.1
ISTM Matete	31	5.6
ISTM Ngiri-Ngiri Kimbanguiste	16	2.9
Total	**555**	**100**

More than 60% of participants were drawn from ISTM Croix-Rouge and ISTM Kinshasa, reflecting the larger enrollment capacity of these institutions. The proportionate stratified sampling strategy ensured institutional representation consistent with student population size.

3.1.2. Sociodemographic Characteristics

Sociodemographic characteristics are presented in Table 2.

Table 2. Sociodemographic characteristics of participants (n = 555).

Variable	N	%
Age		
18 - 24 years	262	47.2
25 - 34 years	244	44.0
≥ 35 years	49	8.8
Sex		
Male	280	50.5
Female	275	49.5
Marital status		
Single	431	77.7
Level of study		
Undergraduate level	420	75.7

Most participants were under 35 years of age (91.2%), and the sex distribution was nearly balanced. The majority were enrolled at the undergraduate level.

3.1.3. Knowledge Levels and Perceptions

The distribution of vaccination knowledge levels is shown in Table 3.

Table 3. Level of vaccination knowledge (n = 555).

Knowledge level	n	%
Low	51	9.2
Moderate	229	41.3
High	246	44.3
Missing data	29	5.2

Overall, 44.3% of students demonstrated a high level of knowledge, 41.3% a moderate level, and 9.2% a low level. In addition, 73.0% of participants considered that the benefits of vaccination outweigh potential risks, indicating an overall favorable perception of immunization.

3.1.4. Reported Pedagogical Constraints and Institutional Needs

Institutional constraints reported by participants are presented in Table 4.

Table 4. Reported pedagogical constraints.

Constraint	N	%
Insufficient teaching resources	448	80.7
Inadequate teacher training	373	67.2
Lack of practical sessions	300	54.1
Curriculum overload	97	17.5

The most frequently reported constraint was insufficient teaching resources (80.7%), followed by inadequate teacher training (67.2%). Limited or absent practical sessions were also commonly reported.

Specific challenges related to the vaccination module are summarized in Table 5.

Table 5. Pedagogical challenges related to the vaccination module.

Challenge	n	%
Absence of a structured module	434	78.2
Lack of regular practical sessions	435	78.4
Limited access to teaching materials	302	54.4

More than three-quarters of students reported the absence of a formally structured vaccination module and insufficient practical sessions, suggesting organizational weaknesses in curriculum implementation.

Priority needs expressed by students are presented in Table 6.

Table 6. Priority needs expressed by students.

Need	n	%
Collaboration with the Expanded Programme on Immunization (EPI)	494	89.0
Standardized teaching materials	477	86.0
Practical training/internships	430	77.5
Teacher training	428	77.1

Students emphasized the need to strengthen collaboration with the EPI (89.0%) and to provide standardized teaching materials (86.0%).

3.2. Factors Associated with a High Level of Knowledge

3.2.1. Bivariate Analysis

The results of the bivariate analysis are presented in Table 7.

Table 7. Bivariate analysis of factors associated with a high level of knowledge.

Variable	Crude OR	95% CI	p-value
Availability of practical training	2.24	1.45 - 3.46	0.002
Adequate teaching materials	2.10	1.33 - 3.30	0.008
Adequate teacher preparation	1.88	1.22 - 2.90	0.014
Male sex	1.09	0.78 - 1.53	0.410
Private vs. public institution	0.91	0.59 - 1.40	0.705

The availability of practical training, adequate teaching materials, and sufficient teacher preparation was significantly associated with a high level of knowledge in the bivariate analysis. Sex and type of institution were not significantly associated.

3.2.2. Multivariable Logistic Regression

The results of the multivariable analysis are presented in Table 8.

Table 8. Multivariable logistic regression of factors associated with a high level of knowledge.

Variable	Adjusted OR	95% CI	p-value
Availability of practical training	2.03	1.27 - 3.23	0.003
Adequate teaching materials	1.80	1.09 - 2.96	0.022
Adequate teacher preparation	1.49	0.93 - 2.38	0.084

After adjustment, the availability of practical training and adequate teaching materials remained significantly associated with a high level of knowledge. Teacher preparation was no longer statistically significant in the adjusted model.

Model diagnostics indicated good fit (Hosmer-Lemeshow $\chi^2 = 6.84$; $p = 0.553$). The Nagelkerke pseudo R^2 was 0.18, indicating that 18% of the variance in high knowledge level was explained by the model. No significant multicollinearity was detected (VIF < 2).

3.2.3. Multilevel Analysis

Given the hierarchical structure of the data (students nested within institutions), a two-level multilevel logistic regression model was applied (Table 9).

Table 9. Null multilevel model (random intercept by institution).

Parameter	Estimate
Between-institution variance ($\sigma^2 u$)	0.42
Intraclass correlation coefficient (ICC)	11.3%

The ICC value of 11.3% indicates that a notable proportion of the variance in knowledge level is attributable to differences between institutions. Adjusted multilevel model is presented in Table 10).

Table 10. Adjusted multilevel model.

Variable	Adjusted OR	95% CI	p-value
Availability of practical training	2.18	1.34 - 3.54	0.002
Adequate teaching materials	1.92	1.14 - 3.21	0.015
Adequate teacher preparation	1.41	0.88 - 2.27	0.139
Random effect	**Estimate**		
Between-institution variance (σ^2u)	0.27		
ICC after adjustment	7.6%		

After introducing pedagogical variables into the model, between-institution variance decreased from 0.42 to 0.27, and the ICC dropped to 7.6%, indicating that differences in pedagogical organization partially explain institutional variability in knowledge levels.

4. Discussion

This study examined the pedagogical organization of the vaccination module in the *Instituts Supérieurs des Techniques Médicales* (ISTM) in Kinshasa and its association with students' knowledge levels. The findings reveal substantial organizational constraints and show that the availability of practical training and pedagogical resources is independently associated with higher knowledge levels. In addition, the multilevel analysis identified a significant institutional effect, indicating that part of the variability in knowledge is attributable to differences between training institutions.

4.1. Knowledge Levels and Educational Gaps

Although nearly half of the students (44.3%) demonstrated a high level of knowledge, a comparable proportion (41.3%) remained at a moderate level, suggesting incomplete acquisition of vaccination-related competencies. The generally favorable perception of vaccination observed in this study—where 73% of participants considered the benefits to outweigh the risks—is consistent with findings reported among health professional students globally [3] [4]. However, positive attitudes alone do not guarantee adequate technical competence.

Previous studies in health professions education have highlighted gaps between theoretical knowledge and practical performance, particularly in areas such as cold chain management and the handling of adverse events following immunization [1] [5]. In this context, the moderate proportion of students achieving high knowledge levels in our study underscores the need to strengthen pedagogical approaches beyond theoretical instruction [6] [7].

4.2. Central Role of Practical Training

The availability of practical training emerged as the strongest factor associated with a high level of knowledge, both in multivariable analysis (adjusted OR = 2.03) and in multilevel modeling (adjusted OR = 2.18). This finding is consistent with competency-based education frameworks, particularly Miller's model, which describes the progression from knowledge acquisition ("knows") to application in real-life settings ("does") [8] [9].

Practical exposure promotes experiential learning, reinforces theoretical knowledge, and supports long-term retention of skills. The high proportion of students reporting insufficient practical sessions (78.4%) suggests that experiential learning components are not adequately integrated into current curricula. This gap may partly explain why a substantial proportion of students remain at an intermediate level of knowledge.

The persistence of this association in the multilevel model further indicates that the effect of practical training is robust and not merely explained by institutional clustering.

4.3. Importance of Pedagogical Resources

Access to adequate pedagogical resources was also independently associated with higher knowledge levels. Educational tools such as updated guidelines, standardized manuals, and structured teaching materials are essential for ensuring consistency in training and alignment with national immunization policies [10].

Limited access to such resources may lead to fragmented learning and variability in educational quality across institutions. The strong demand expressed by students for standardized materials (86%) further highlights the need for harmonized and well-structured teaching supports.

4.4. Institutional Variability and Multilevel Findings

The multilevel analysis showed that 11.3% of the variance in knowledge levels was attributable to differences between institutions in the null model. Although this proportion decreased to 7.6% after adjustment for pedagogical factors, a residual institutional effect remained.

This finding suggests that differences between institutions are not fully explained by measured pedagogical variables alone and may reflect broader structural factors, including academic governance, supervision quality, infrastructure, and institutional culture. The observed reduction in variance after adjustment indicates that strengthening pedagogical components—particularly practical training and access to resources—could help reduce disparities between institutions.

However, the persistence of residual variability highlights the importance of systemic approaches, including regulatory frameworks and curriculum standardization, to ensure more uniform training quality.

4.5. Model Performance and Interpretation

The multivariable model explained 18% of the variance in high knowledge levels. Although modest, this level of explained variance is consistent with findings in educational and behavioral research, where outcomes are influenced by multiple interacting factors. The absence of multicollinearity and the satisfactory model fit support the internal validity of the analysis.

Nevertheless, the cross-sectional design limits causal inference. While the observed associations are consistent and theoretically plausible, causal relationships cannot be definitively established.

4.6. Implications for Immunization Workforce Development

In a setting characterized by recurrent outbreaks of vaccine-preventable diseases, strengthening pre-service immunization training represents a strategic investment in health system resilience. The findings suggest that structured vaccination modules integrating practical training and standardized pedagogical materials could significantly improve knowledge acquisition among paramedical students.

Given the identified institutional effect, harmonizing vaccination curricula across ISTMs and strengthening collaboration with the Expanded Programme on Immunization (EPI) may help reduce inter-institutional disparities and enhance workforce preparedness.

5. Limitations

This study has several limitations. First, knowledge was assessed using a self-administered questionnaire, which may be subject to reporting bias and may not accurately reflect actual competencies. Moreover, this approach captures theoretical knowledge only and does not allow for direct evaluation of clinical or practical skills. In line with Miller's pyramid of clinical competence, the assessment in this study is limited to the "knows" level and does not address higher levels such as "shows how" and "does", which are essential for safe and effective vaccine administration. Future studies incorporating objective structured clinical examinations (OSCEs) or direct observation of practice would provide a more comprehensive assessment of students' competencies in immunization.

Second, pedagogical variables, including the availability of practical training and teaching materials, were based on students' self-reported perceptions and were not independently verified through institutional records or direct observation, which may have introduced information bias.

Third, although multilevel modeling accounted for institutional clustering, the relatively small number of clusters may have reduced the precision of random-effect estimates.

6. Conclusions

This study provides empirical evidence on the pedagogical organization of the

vaccination module within the *Instituts Supérieurs des Techniques Médicales* in Kinshasa. Although a substantial proportion of students demonstrated satisfactory knowledge levels and a generally favorable perception of vaccination, significant structural and pedagogical gaps were identified.

The availability of practical training and access to adequate teaching resources were independently associated with higher knowledge levels, even after accounting for institutional clustering effects. Multilevel analysis also indicated that part of the observed variability in knowledge levels is attributable to differences between institutions, underscoring the importance of the organizational context in shaping educational outcomes.

Strengthening structured vaccination training based on a competency-based approach—particularly through the systematic integration of practical sessions and the use of standardized teaching materials—could enhance the preparedness of future healthcare professionals involved in vaccination services. Harmonizing curricula across institutions and aligning them with national immunization priorities also represent key strategic opportunities to improve the quality and consistency of paramedical training in the Democratic Republic of the Congo.

Future longitudinal or interventional studies are needed to assess whether the proposed pedagogical reforms translate into improved practical competencies and measurable gains in the performance of vaccination services.

7. Study Contribution

This study provides one of the first empirical assessments of the pedagogical organization of the vaccination module within the *Instituts Supérieurs des Techniques Médicales* (ISTM) in Kinshasa. By examining both educational practices and student knowledge outcomes, it offers original evidence on the determinants of learning in vaccinology within paramedical training in the Democratic Republic of the Congo.

The findings highlight the critical role of practical training and access to pedagogical resources in shaping students' knowledge levels, while also demonstrating the influence of institutional context through multilevel analysis. This dual analytical approach contributes to a better understanding of how both individual and institutional factors interact to influence educational outcomes.

In addition, the study identifies concrete gaps in current training practices and proposes actionable directions for strengthening competency-based education in vaccination. These results may inform curriculum reforms, support the harmonization of training standards across institutions, and contribute to improving the preparedness of the future immunization workforce.

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Authors' Contributions

All authors contributed to the conception and design of the study. Data collection and approved the final version for publication.

Conflicts of Interest

The authors declare that they have no conflicts of interest related to the design, conduct, analysis, or publication of this study.

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