

# Didactic-Pedagogical Modeling of the Acquisition of Preventive Skills Related to Combined HIV Prevention among Key Populations in Kinshasa

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## Abstract

**Background:** Combined HIV prevention is recognized as an effective approach for reducing new HIV infections among key populations. However, the sustainable acquisition of preventive skills depends not only on access to information, but also on the quality and relevance of the didactic and pedagogical strategies used during health education interventions. **Objective:** This study aimed to develop a didactic-pedagogical model of the determinants associated with the acquisition of preventive skills related to combined HIV prevention among key populations in Kinshasa. **Methods:** A longitudinal analytical study was conducted from 2022 to 2024 among 844 participants belonging to key populations in Kinshasa. Data were collected using a structured 64-item questionnaire assessing knowledge related to combined HIV prevention, perceived didactic-pedagogical strategies, motivation, self-efficacy, and environmental factors. Generalized estimating equations (GEE) were used to identify factors associated with the acquisition of preventive skills. Generalized additive models (GAM) and linear mixed models (LMM) were also explored to assess predictive performance. **Results:** Among the 844 participants, 618 (73.2%) demonstrated satisfactory acquisition of preventive skills, while 226 (26.8%) demonstrated insufficient acquisition. Participatory discussions, practical demonstrations, audiovisual materials, individualized feedback, intrinsic motivation, and self-efficacy were significantly associated with the acquisition of preventive skills ( $p < 0.05$ ). Sociodemographic factors independently associated with the outcome included marital status, residential district, and occupation. Among the predictive models examined, the GAM showed the best reported discriminative performance (AUC = 0.87), followed

by the GEE (AUC = 0.81) and the LMM (AUC = 0.79). **Conclusion:** The results suggest that the acquisition of preventive skills among key populations is influenced by the interaction between knowledge, active pedagogical strategies, motivation, self-efficacy, and the social and health environment. The proposed MIDCAP-HIV model provides a contextualized framework for strengthening competency-based health education and combined HIV prevention programs in the Democratic Republic of the Congo.

## Keywords

HIV/AIDS, Combined HIV Prevention, Preventive Skills, Didactic-Pedagogical Modeling, Key Populations, Kinshasa, Self-Efficacy, Health Education

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## 1. Introduction

Human immunodeficiency virus (HIV) infection remains a major public health problem worldwide, despite considerable progress in antiretroviral treatment, testing, and prevention. In 2024, approximately 1.3 million new HIV infections were still estimated worldwide, demonstrating the persistence of major gaps in prevention. Sub-Saharan Africa continues to bear a major share of the global HIV burden, while inequalities in access to prevention, testing, and treatment services remain concerning [1] [2].

In the Democratic Republic of the Congo (DRC), the HIV epidemic presents a heterogeneous profile and remains influenced by individual, social, economic, and structural determinants. Key populations, particularly female workers in high-risk occupations, men who have sex with men (MSM), trans. people (TG), and people who inject drugs (PWID), are particularly exposed groups. International surveillance data show that marginalization, stigma, discrimination, and, in some contexts, criminalization contribute to increasing the vulnerability of these populations to HIV and limiting their access to essential services [2] [3]. Available data for the DRC also show the persistence of structural and social barriers that may compromise the effectiveness of prevention programs among key populations [4].

The World Health Organization (WHO) recommends a combined HIV prevention approach based on the combination of biomedical, behavioral, and structural interventions. This approach includes, in particular, the promotion and correct use of condoms, HIV testing, pre-exposure prophylaxis (PrEP), post-exposure prophylaxis (PEP), access to antiretroviral treatment, as well as interventions aimed at reducing stigma, discrimination, and social and structural barriers to access to care [3] [5]. WHO recommendations particularly emphasize that the needs of key populations cannot be effectively addressed without simultaneously acting on individual, community, and structural factors that influence access to and use of health services.

However, access to information alone does not guarantee the adoption and maintenance of preventive behaviors. Knowledge of HIV transmission modes or prevention methods must be transformed into concrete abilities that enable

individuals to make decisions, communicate with their partners, negotiate condom use, access testing and prevention services, and correctly use available biomedical tools. Evidence from the literature shows that educational interventions can improve knowledge and certain behavioral determinants, particularly self-efficacy and condom use, but that their effects strongly depend on the techniques used, their intensity, and their ability to promote the implementation and maintenance of preventive behaviors [6] [7].

This distinction between information and competence is particularly important among key populations, for whom preventive behaviors are influenced not only by individual knowledge, but also by stigma, social relationships, community norms, the healthcare environment, and conditions of access to services. A recent systematic review of behavioral interventions among key populations also highlights the complexity of their effects and the need to better consider the contextual and behavioral dimensions of prevention [8].

From the perspective of educational sciences, several theoretical frameworks help clarify the process through which knowledge can be transformed into competence. Chevallard's theory of didactic transposition highlights the transformation of scientific knowledge into teachable and appropriable knowledge, making it possible to examine how knowledge related to HIV prevention is selected, organized, and adapted to the characteristics of key populations [9].

Houssaye's pedagogical triangle, for its part, highlights the dynamic relationships between knowledge, the teacher, and the learner. Applied to preventive education, this framework makes it possible to consider the learner not as a simple recipient of information, but as an actor engaged in a learning process in which teaching methods and pedagogical interactions can influence the acquisition of skills [10].

Paulo Freire's critical pedagogy adds another dimension by emphasizing dialogue, participation, conscientization, and learner empowerment. In the context of HIV prevention, these principles are particularly relevant for populations that may face stigma and various forms of marginalization. A participatory approach can therefore promote the expression of experiences, the identification of barriers, and the collective development of solutions adapted to lived realities [11].

Furthermore, Bandura's social cognitive theory gives a central role to self-efficacy, defined as a person's belief in their ability to organize and carry out the actions necessary to achieve a goal. In the field of HIV prevention, this dimension is particularly important because knowledge of preventive behavior does not necessarily mean that the individual feels capable of effectively implementing it in a concrete situation [12]. Recent evidence on prevention interventions further confirms the importance of techniques aimed at intention formation, barrier identification, practice, and strengthening self-efficacy [2].

In HIV prevention programs targeting key populations in Kinshasa, educational interventions primarily aim to provide information on transmission modes, prevention methods, and the use of available services. However, the literature shows that educational approaches do not necessarily produce the same effects

when they remain focused on the transmission of knowledge or when they incorporate mechanisms promoting practice, autonomy, self-efficacy, dialogue, and the resolution of behavioral barriers [6] [8].

There is therefore a need to better understand **how didactic-pedagogical, psychological, behavioral, and environmental determinants interact in the process of acquiring preventive skills** among key populations. This gap is important because international recommendations recognize the need for approaches centered on key populations and adapted to their social, community, and health contexts, whereas the educational mechanisms that make it possible to transform knowledge into sustainable preventive skills remain insufficiently modeled in the context of Kinshasa [3] [5].

It is therefore necessary to develop a contextualized didactic-pedagogical model capable of simultaneously integrating educational, psychological, behavioral, and environmental determinants likely to influence the acquisition of preventive skills related to combined HIV prevention.

The present study falls within this perspective. It combines contributions from educational sciences, particularly didactic transposition, the pedagogical triangle, critical pedagogy, and social cognitive theory, with the analysis of behavioral and environmental determinants and longitudinal statistical modeling. It thus aims to **develop and evaluate a didactic-pedagogical model of the determinants associated with the acquisition of preventive skills related to combined HIV prevention among key populations in Kinshasa.**

#### **Research question**

What are the didactic-pedagogical, psychological, and environmental factors associated with the acquisition of preventive skills related to combined HIV prevention among key populations in Kinshasa?

#### **General objective**

To model the didactic-pedagogical, psychological, and environmental determinants associated with the acquisition of preventive skills related to combined HIV prevention among key populations in Kinshasa.

#### **Specific objectives**

- 1) To describe the sociodemographic characteristics of the participants;
- 2) To assess knowledge related to combined HIV prevention;
- 3) To identify the didactic-pedagogical strategies associated with the acquisition of preventive skills;
- 4) To analyze the role of motivation and self-efficacy in the acquisition of preventive skills;
- 5) To develop and evaluate an explanatory and predictive model of the acquisition of preventive skills.

## **2. Methods**

### **2.1. Study Setting**

The study was conducted in Kinshasa, the capital and administrative province of

the Democratic Republic of the Congo (DRC). This large urban agglomeration is characterized by a high population density as well as significant social, economic, and health disparities that may influence access to HIV prevention services and the acquisition of preventive skills.

Participants were recruited from several health districts of Kinshasa, notably Funa, Lukunga, Mont Amba, and Tshangu. The selection of these areas aimed to ensure diverse geographical coverage and to take into account the different recruitment contexts of key populations.

## **2.2. Study Design and Period**

This was a longitudinal analytical study with an explanatory and predictive purpose, conducted over a period of 36 months, from January 2022 to December 2024.

The longitudinal nature of the study aimed to assess changes in preventive skills over time and to analyze the relationships between didactic-pedagogical, psychological, behavioral, sociodemographic, and environmental factors and the level of acquisition of preventive skills.

The study followed an interdisciplinary approach combining educational sciences, epidemiology, and statistical modeling. This approach aimed to develop a contextualized explanatory and predictive model of the acquisition of preventive skills related to combined HIV prevention among key populations in Kinshasa.

## **2.3. Study Population**

The study population consisted of people belonging to the main key populations at increased risk of HIV infection in Kinshasa.

The groups concerned were:

- female workers in high-risk occupations;
- men who have sex with men (MSM);
- trans. people (TG);
- people who inject drugs (PWID).

These groups were selected because of their importance in HIV prevention programs and the existence of individual, behavioral, social, and structural vulnerability factors likely to influence access to prevention services as well as the acquisition and implementation of preventive skills.

## **2.4. Eligibility Criteria**

### **2.4.1. Inclusion Criteria**

Participants were eligible if they:

- were at least 15 years old;
- belonged to one of the predefined key population groups;
- had resided in Kinshasa for at least six months;
- voluntarily agreed to participate in the study;
- had provided informed consent in accordance with the established ethical

procedures.

#### 2.4.2. Exclusion Criteria

Participants were excluded if they:

- were unable to answer the questionnaire because of severe communication or comprehension difficulties;
- refused to participate in the study or withdrew their consent;
- had insufficient data to allow assessment of the main study variables.

#### 2.5. Sample Size Determination

The minimum theoretical sample size was estimated using the Cochran formula applicable to the estimation of a proportion:

$$n_0 = Z^2 \times p(1 - p) / d^2$$

where  $Z = 1.96$  for a 95% confidence level,  $p = 0.50$  corresponding to the assumption of maximum variability, and  $d = 0.05$  corresponding to a precision of 5%.

This formula resulted in a theoretical minimum sample size of 384 participants. To account for the sampling design and potential correlation between observations, a design effect of 2 was applied, increasing the theoretical minimum sample size to 768 participants.

The final sample consisted of 844 participants. This sample size was considered sufficient for the planned multivariate analyses and statistical modeling, while allowing for potential missing data and constraints related to longitudinal follow-up.

#### 2.6. Sampling and Recruitment Procedure

Participant recruitment was carried out using a strategy adapted to the characteristics of key populations, which are populations that are difficult to reach through conventional sampling methods.

A geographical organization of recruitment was implemented in the selected health districts, notably Funa, Lukunga, Mont Amba, and Tshangu. For populations without a comprehensive sampling frame, the **Respondent-Driven Sampling (RDS)** method was used.

The RDS procedure was based on the identification of initial participants, referred to as “seeds,” selected from the different key population groups. These initial participants received a controlled number of invitations intended to recruit eligible individuals from their social network. The process continued through successive recruitment waves.

This strategy aimed to improve access to populations that are difficult to identify through conventional survey systems and to reduce reliance on exclusively institutional or convenience-based recruitment. Information relating to recruitment chains was documented during data collection to allow description of the recruitment structure and assessment of its potential effects on sample composition.

## 2.7. Data Collection Instrument

Data were collected using a structured questionnaire comprising **64 items**, developed based on the study objectives, the theoretical constructs involved, and the relevant dimensions of combined HIV prevention.

The questionnaire covered the following main dimensions:

- 1) sociodemographic characteristics;
- 2) knowledge related to combined HIV prevention;
- 3) didactic-pedagogical strategies;
- 4) motivation and self-efficacy;
- 5) environmental factors and access to services;
- 6) acquisition of preventive skills.

Knowledge related to combined prevention included, in particular, condom use, HIV testing, antiretroviral treatment, pre-exposure prophylaxis (PrEP), post-exposure prophylaxis (PEP), and treatment as a means of prevention.

The didactic-pedagogical strategies assessed included participatory discussions, practical demonstrations, role-playing activities, the use of audiovisual materials, individualized feedback, and learner involvement.

The motivational and psychological dimension included motivation to adopt preventive behaviors, self-efficacy, confidence in applying prevention measures, the ability to negotiate safer sexual practices, and perceived control over preventive decisions.

Environmental factors included, in particular, accessibility and availability of HIV prevention services, social support, stigma, and certain structural barriers.

Attitudinal items were mainly assessed using a five-point Likert scale ranging from “Strongly disagree” to “Strongly agree”.

The questionnaire was administered by previously trained interviewers according to a standardized procedure. Particular attention was paid to confidentiality, neutrality in administering the questions, and respect for participants’ rights.

## 2.8. Instrument Validation

Before being used in the main analysis, the data collection instrument underwent a validation procedure aimed at assessing its relevance to the constructs studied and the internal consistency of its different dimensions.

The relevance of the items was examined in relation to the study objectives and the theoretical concepts involved. The internal consistency of the questionnaire dimensions was assessed using appropriate reliability indicators.

This procedure aimed to verify that the items grouped within the same dimension measured the corresponding construct with sufficient consistency. Any adaptations made to the questionnaire were completed before the main data collection.

## 2.9. Study Variables

### 2.9.1. Dependent Variable: Acquisition of Preventive Skills

The acquisition of preventive skills related to combined HIV prevention constituted

the main dependent variable.

It was measured using **10 items corresponding to questions 45 to 54 of the questionnaire**. These items addressed, in particular, condom use, HIV testing, knowledge and access to PrEP and PEP, recognition of risk situations, participation in prevention activities, application of acquired knowledge, and decision-making favorable to HIV prevention.

Each item was assessed using a five-point Likert scale:

1 = “Strongly disagree”;

2 = “Disagree”;

3 = “Neither agree nor disagree”;

4 = “Agree”;

5 = “Strongly agree”.

A **composite preventive skills acquisition score** was calculated as the mean of the responses to the ten items. The score therefore ranged from 1 to 5, with higher values corresponding to a higher level of acquisition of preventive skills.

For analyses requiring a categorical variable, the score could be grouped into three levels: low (1.00 - 2.33), moderate (2.34 - 3.66), and high (3.67 - 5.00). When longitudinal or predictive analyses required a quantitative variable, the continuous score was retained in order to preserve, as much as possible, the information contained in the original responses.

### 2.9.2. Independent Variables

The independent variables included sociodemographic, educational, psychological, and environmental factors.

Sociodemographic variables included, in particular, age, sex, educational level, marital status, occupation, income, and residential district.

Didactic-pedagogical factors included, in particular, exposure to participatory strategies, practical demonstrations, educational materials, feedback, and activities promoting learner involvement.

Psychological factors mainly included motivation and self-efficacy.

Environmental factors included access to prevention services, service availability, social support, stigma, and structural barriers.

### 2.10. Organization of Longitudinal Follow-Up

Within the longitudinal framework of the study, data relating to preventive skills and explanatory factors were collected according to the follow-up schedule defined in the protocol.

The initial measurement constituted the reference time point ( $M_0$ ). Repeated measurements conducted during the follow-up period made it possible to establish a longitudinal data structure suitable for analyzing individual changes in the level of skills.

Available observations at several time points for the same participant were taken into account in the statistical analyses in order to account for dependence between repeated measurements.

**Important methodological note:** clinical visits, serological testing, and viral load measurements should only be mentioned in this section if they were actually performed as part of the present study protocol and if their data were incorporated into the analyzed database. Otherwise, these elements should be removed to avoid inconsistency between the protocol, the variables analyzed, and the results presented.

### 2.11. Data Collection and Data Management Procedure

The interviewers were trained on the study objectives, standardized administration of the questionnaire, respect for confidentiality, and data collection procedures.

Participants were informed about the study objectives, participation procedures, and their right to refuse or discontinue their participation without consequence.

Completed questionnaires underwent quality control, after which the data were entered, cleaned, and verified before statistical analysis. Data allowing direct identification of participants were not used in the statistical analyses.

### 2.12. Statistical Analysis

Data were entered, cleaned, and verified using Microsoft Excel, and then analyzed using SPSS version 27 and R software for advanced statistical analyses.

#### 2.12.1. Descriptive Analysis

Descriptive analysis was used to characterize the study population. Categorical variables were presented as frequencies and percentages. Quantitative variables were described using the mean and standard deviation when their distribution allowed it, or using appropriate descriptive statistics otherwise.

#### 2.12.2. Analysis between Explanatory Variables and Preventive Skills

Associations between explanatory variables and levels of acquisition of preventive skills were examined using statistical tests appropriate to the nature of the variables.

Pearson's Chi-square test was used to analyze associations between categorical variables when its assumptions were met. Fisher's exact test was used when the expected frequencies were insufficient.

The statistical significance threshold was set at  $p < 0.05$ .

#### 2.12.3. Longitudinal Modeling Using GEE

Given the longitudinal structure of the data and the presence of repeated measurements among some participants, **generalized estimating equations (GEE)** were used to account for within-subject correlation of observations.

GEE models were used to estimate the association between explanatory factors and changes in the level of acquisition of preventive skills while accounting for the dependence between repeated measurements.

The results were presented as adjusted coefficients or measures of association,

together with their 95% confidence intervals and  $p$ -values, according to the model specification.

#### 2.12.4. Generalized Additive Models

**Generalized additive models (GAM)** were used to examine the possibility of nonlinear relationships between certain explanatory variables and the level of acquisition of preventive skills.

This approach made it possible not to impose a priori a strictly linear relationship between continuous explanatory variables and the dependent variable.

#### 2.12.5. Linear Mixed Models

**Linear mixed models (LMM)** were also explored to account for the longitudinal structure of observations and, where appropriate, inter-individual variability.

Fixed effects represented the explanatory factors of interest, while random effects made it possible to account for the dependence between observations originating from the same participant.

#### 2.12.6. Model Validation and Comparison

Model performance was assessed using indicators appropriate to their objective and the nature of the dependent variable.

When discrimination analysis was applicable, predictive performance was assessed in particular using the area under the ROC curve (AUC).

The AUC values obtained were **0.81 for the GEE model, 0.87 for the GAM, and 0.79 for the LMM**. These results indicated high discriminative ability for the GAM, which showed the best performance among the models compared.

Model comparison was interpreted jointly with the available fit indicators and considerations regarding their suitability for the data structure.

The statistical significance threshold was set at 5%, with 95% confidence intervals when appropriate.

### 2.13. Ethical Considerations

The study was conducted in accordance with the ethical principles applicable to research involving human subjects and the principles of the **Declaration of Helsinki**.

The required ethical approval was sought from the competent ethics committee of the **National AIDS and STI Control Program (PNLS)** as well as from the relevant institutional authorities before the beginning of data collection.

Before inclusion, participants were informed about the study objectives, data collection procedures, the voluntary nature of their participation, potential benefits and risks, and the measures taken to ensure the confidentiality of the information collected.

Informed consent was obtained before participation in the study, in accordance with applicable ethical procedures.

The data were anonymized or coded and handled confidentially. No information allowing the direct identification of participants was included in the

analytical database or presented in the results. The data were used exclusively for scientific purposes.

### 3. Results

#### 3.1. Sociodemographic Characteristics

A total of 844 participants were included in the study.

Participants aged 15 to 24 years constituted the largest age group, with 564 participants (66.8%). Men accounted for 508 participants (60.2%), while women accounted for 336 (39.8%).

Regarding educational level, 102 participants (12.1%) had no formal education, 50 (5.9%) had primary education, 346 (41.0%) had secondary education, and 346 (41.0%) had university or higher education.

The largest proportion of participants came from Tshangu (40.4%), followed by Mont Amba (31.3%), Funa (14.7%), and Lukunga (13.6%). See **Table 1**.

**Table 1.** Sociodemographic characteristics of participants (N = 844).

| Variable                    | n   | %    |
|-----------------------------|-----|------|
| <b>Age group (years)</b>    |     |      |
| 15 - 24                     | 564 | 66.8 |
| 25 - 34                     | 216 | 25.6 |
| 35 - 44                     | 42  | 5.0  |
| ≥45                         | 22  | 2.6  |
| <b>Sex</b>                  |     |      |
| Male                        | 508 | 60.2 |
| Female                      | 336 | 39.8 |
| <b>Educational level</b>    |     |      |
| No formal education         | 102 | 12.1 |
| Primary                     | 50  | 5.9  |
| Secondary                   | 346 | 41.0 |
| University/higher education | 346 | 41.0 |
| <b>Residential district</b> |     |      |
| Funa                        | 124 | 14.7 |
| Lukunga                     | 115 | 13.6 |
| Mont Amba                   | 264 | 31.3 |
| Tshangu                     | 341 | 40.4 |

#### 3.2. Knowledge of Combined HIV Prevention

The majority of participants (87.4%) had already heard about combined HIV prevention.

Knowledge of correct condom use was reported by 81.9% of participants, while 78.7% knew the importance of regular HIV testing.

Knowledge of new biomedical prevention approaches was lower. PrEP was known by 52.5% of participants, and 58.1% knew about the preventive effect of antiretroviral treatment. See **Table 2**.

**Table 2.** Knowledge indicators of combined HIV prevention.

| Knowledge indicator                        | Yes, n (%) | No, n (%)  |
|--------------------------------------------|------------|------------|
| Knowledge of combined HIV prevention       | 738 (87.4) | 106 (12.6) |
| Knowledge of correct condom use            | 691 (81.9) | 153 (18.1) |
| Knowledge of the importance of HIV testing | 664 (78.7) | 180 (21.3) |
| Knowledge of PrEP                          | 443 (52.5) | 401 (47.5) |
| Knowledge of the preventive effect of ARVs | 490 (58.1) | 354 (41.9) |

### 3.3. Perceived Didactic-Pedagogical Strategies

Practical demonstrations were the most appreciated strategy (87.0%), followed by participatory discussions (83.2%), audiovisual materials (81.6%), individualized feedback (78.0%), and role-playing activities (72.9%). See **Table 3**.

**Table 3.** Perceived didactic-pedagogical strategies.

| Educational strategy      | Agree, n (%) | Disagree, n (%) |
|---------------------------|--------------|-----------------|
| Participatory discussions | 702 (83.2)   | 142 (16.8)      |
| Role-playing activities   | 615 (72.9)   | 229 (27.1)      |
| Practical demonstrations  | 734 (87.0)   | 110 (13.0)      |
| Audiovisual materials     | 689 (81.6)   | 155 (18.4)      |
| Individualized feedback   | 658 (78.0)   | 186 (22.0)      |

### 3.4. Motivation and Self-Efficacy

A large proportion of participants reported confidence in their ability to adopt preventive behaviors.

Self-efficacy regarding correct condom use was reported by 85.4% of participants, while 71.4% reported being able to negotiate safer sexual practices See **Table 4**.

**Table 4.** Motivation and self-efficacy indicators.

| Indicator                            | Agree, n (%) | Disagree, n (%) |
|--------------------------------------|--------------|-----------------|
| Ability to use condoms correctly     | 721 (85.4)   | 123 (14.6)      |
| Ability to negotiate protected sex   | 603 (71.4)   | 241 (28.6)      |
| Motivation for regular HIV testing   | 677 (80.2)   | 167 (19.8)      |
| Ability to apply the advice received | 694 (82.2)   | 150 (17.8)      |

### 3.5. Acquisition of Preventive Skills

Based on the composite preventive skills score, 618 participants (73.2%) demonstrated satisfactory acquisition of preventive skills, while 226 (26.8%) demonstrated insufficient acquisition. See **Table 5**.

**Table 5.** Level of acquisition of preventive skills.

| Acquisition level | n          | %            |
|-------------------|------------|--------------|
| Satisfactory      | 618        | 73.2         |
| Insufficient      | 226        | 26.8         |
| <b>Total</b>      | <b>844</b> | <b>100.0</b> |

### 3.6. Bivariate Analysis

Several factors were significantly associated with the acquisition of preventive skills, including educational level, marital status, residential district, knowledge of PrEP, participatory discussions, practical demonstrations, educational feedback, and self-efficacy. See **Table 6**.

**Table 6.** Bivariate associations with the acquisition of preventive skills.

| Variable                  | $\chi^2$ | <i>p</i> |
|---------------------------|----------|----------|
| Educational level         | 18.42    | <0.001   |
| Marital status            | 22.75    | <0.001   |
| Residential district      | 11.36    | 0.010    |
| Knowledge of PrEP         | 29.84    | <0.001   |
| Participatory discussions | 34.21    | <0.001   |
| Practical demonstrations  | 41.67    | <0.001   |
| Educational feedback      | 27.53    | <0.001   |
| Self-efficacy             | 45.18    | <0.001   |

### 3.7. Multivariate Analysis Using Generalized Estimating Equations

The GEE model identified several independent predictors of the acquisition of preventive skills. See **Table 7**.

**Table 7.** Sociodemographic predictors of the acquisition of preventive skills.

| Variable          | Adjusted $\beta$ | 95% CI            | <i>p</i> |
|-------------------|------------------|-------------------|----------|
| Age               | 0.0019           | −0.0020 to 0.0050 | 0.225    |
| Sex               | 0.0425           | −0.0455 to 0.1304 | 0.344    |
| Educational level | 0.0274           | −0.0104 to 0.0653 | 0.155    |
| Marital status    | 0.0691           | 0.0305 to 0.1076  | <0.001   |

**Continued**

|                      |        |                   |        |
|----------------------|--------|-------------------|--------|
| Residential district | 0.0876 | 0.0110 to 0.1641  | 0.025  |
| Occupation           | 0.0750 | 0.0369 to 0.1131  | <0.001 |
| Monthly income       | 0.0511 | −0.0050 to 0.1073 | 0.075  |

**3.8. Didactic-Pedagogical and Psychological Predictors**

Participatory discussions, practical demonstrations, audiovisual materials, individualized feedback, self-efficacy, and intrinsic motivation were significantly associated with the acquisition of preventive skills. See **Table 8**.

**Table 8.** Didactic-pedagogical predictors of the acquisition of preventive skills.

| Variable                  | Adjusted $\beta$ | 95% CI           | <i>p</i> |
|---------------------------|------------------|------------------|----------|
| Participatory discussions | 0.1124           | 0.0641 - 0.1607  | <0.001   |
| Role-playing activities   | 0.0417           | −0.0068 - 0.0902 | 0.092    |
| Practical demonstrations  | 0.1489           | 0.0973 - 0.2005  | <0.001   |
| Audiovisual materials     | 0.0836           | 0.0342 - 0.1330  | 0.001    |
| Individualized feedback   | 0.1261           | 0.0728 - 0.1794  | <0.001   |
| Self-efficacy             | 0.1715           | 0.1186 - 0.2244  | <0.001   |
| Intrinsic motivation      | 0.1398           | 0.0865 - 0.1931  | <0.001   |

**3.9. Predictive Performance**

The reported predictive performance was highest for the GAM, followed by the GEE and the LMM. See **Table 9**.

**Table 9.** Predictive performance of statistical models.

| Model | AUC  | Interpretation |
|-------|------|----------------|
| GEE   | 0.81 | Good           |
| LMM   | 0.79 | Acceptable     |
| GAM   | 0.87 | Very good      |

The GAM had the highest AUC (0.87), suggesting better predictive performance within the modeling framework used.

**3.10. Summary of the Main Findings**

The main findings can be summarized as follows:

- 73.2% of participants demonstrated satisfactory preventive skills;
- knowledge regarding biomedical prevention methods, particularly PrEP, remained limited;
- active educational strategies were significantly associated with the acquisition of preventive skills;
- self-efficacy was the most important predictor among the educational and

psychological variables studied;

- intrinsic motivation was also strongly associated with the acquisition of preventive skills;
- the GAM demonstrated the best reported predictive performance.

These results support the hypothesis that the quality of didactic-pedagogical interventions contributes significantly to the acquisition of preventive skills related to combined HIV prevention.

## **4. Discussion**

### **4.1. Interpretation of Preventive Skills Acquisition**

This study aimed to develop a didactic-pedagogical model explaining the determinants associated with the acquisition of preventive skills related to combined HIV prevention among key populations in Kinshasa.

Overall, 73.2% of participants demonstrated satisfactory acquisition of preventive skills, compared with 26.8% who demonstrated insufficient acquisition. This finding suggests that a substantial proportion of key populations possess the capacities needed to mobilize prevention knowledge and resources, but that a considerable proportion remains vulnerable in terms of education and behavior. This situation is particularly important in the context of key populations, among whom social, structural, economic, and service-access barriers may limit the translation of knowledge into effective preventive practices [1] [2].

The fact that more than one quarter of participants demonstrated insufficient acquisition shows that exposure to information alone does not guarantee operational mastery of preventive skills. Combined prevention relies on the integration of several components, including biomedical, behavioral, and structural measures, as well as individuals' ability to access services and effectively use available tools [1]. Thus, knowledge of condoms, HIV testing, PrEP, or PEP must be accompanied by skills that enable their appropriate use in concrete situations.

This finding reinforces the importance of competency-based educational approaches that go beyond the simple transmission of knowledge and prioritize active learning, practice, interaction, feedback, empowerment, and the learner's ability to address real-life situations. Peer education interventions have notably shown favorable effects on knowledge and certain preventive behaviors among populations at risk of HIV [3] [4].

From this perspective, the acquisition of preventive skills should be considered a dynamic process in which the learner progressively transforms information into know-how and then into autonomous capacity for action. This conception is consistent with current WHO recommendations, which call for interventions adapted to key populations that are accessible, acceptable, and incorporate the community and structural dimensions of prevention [1].

### **4.2. Knowledge Related to Combined HIV Prevention**

General knowledge regarding HIV prevention was relatively high, particularly

concerning condoms and HIV testing. However, knowledge of PrEP was considerably lower.

This situation is important because PrEP is now a recognized component of combined HIV prevention for people at substantial risk of acquiring HIV [5]. WHO recommendations emphasize the need to diversify and simplify access to PrEP in order to improve its initiation, persistence, and effective use [5]. Limited knowledge of this method may therefore represent an early stage in an incomplete prevention cascade.

Our findings are consistent with the international literature showing that, despite the demonstrated effectiveness of PrEP, awareness and particularly use remain uneven among vulnerable populations. A systematic review and meta-analysis notably showed that PrEP use remained relatively low in several subgroups of key populations and that culturally appropriate approaches were needed to reduce these disparities [6]. Other studies have highlighted that lack of knowledge, stigma, risk perception, mistrust, and difficulties accessing services constitute important barriers to PrEP use [7].

Understanding of the preventive effect of antiretroviral treatment was also insufficient among a substantial proportion of participants. Strengthening communication about treatment as a means of prevention and the principle of “Undetectable = Untransmittable” therefore appears particularly relevant. Education on this dimension may simultaneously contribute to improving knowledge, promoting the use of services, and reducing certain misconceptions about HIV.

These findings indicate that prevention education programs should progressively move from an approach centered on traditional prevention methods toward an integrated approach presenting the entire prevention continuum: condoms, testing, PrEP, PEP, antiretroviral treatment, prevention of injection-related risks, vaccination when relevant, and prompt use of health services. This orientation is consistent with international recommendations promoting combined prevention centered on the needs of key populations [1] [5].

#### **4.3. Role of Didactic-Pedagogical Strategies**

One of the main findings of this study was the strong association between active educational strategies and the acquisition of preventive skills.

Practical demonstrations showed a strong association with the outcome (adjusted  $\beta = 0.1489$ ;  $p < 0.001$ ). This finding suggests that learning preventive skills does not rely solely on exposure to educational messages, but also on the opportunity for learners to observe, experiment, reproduce, and correct a practice.

This observation is particularly relevant for skills related to condom use, access to PrEP or PEP, HIV testing, and the prompt seeking of care following exposure to risk. Interactive teaching methods may facilitate the transformation of declarative knowledge into operational skills.

Available evidence on peer education reinforces this interpretation. A meta-analysis involving 60 studies and 96,484 participants showed that peer education

was associated with a reduction in HIV risk among high-risk groups [3]. Another meta-analysis conducted in developing countries observed an association between peer education, better HIV knowledge, and increased condom use [4]. These findings support the value of educational approaches that place the learner and their community at the center of the process.

Chevallard's concept of didactic transposition provides a relevant framework for interpreting this finding. Biomedical and scientific knowledge must be transformed into knowledge that is teachable, understandable, and applicable within the learner's social and cultural context. In HIV prevention, this transformation involves moving from abstract scientific content to concrete situations: how to correctly use a prevention method, where to obtain PrEP, when to seek PEP, how to get tested, and how to make a preventive decision in a real-life situation.

Houssaye's pedagogical triangle also makes it possible to interpret these findings through the relationships between the learner, educator, and knowledge. Preventive education appears more likely to produce skills when the learner is actively involved in the educational process rather than being considered solely as a recipient of information.

Freire's critical pedagogy complements this interpretation by emphasizing dialogue, participation, conscientization, and empowerment. In the context of key populations, this approach is particularly relevant because interventions must take into account lived experiences, power relations, stigma, and barriers to accessing services.

The significant association observed for participatory discussions and individualized feedback is consistent with the same perspective. It suggests that educational effectiveness may depend not only on the content delivered, but also on how this content is constructed, discussed, practiced, and adapted to the needs of each participant.

However, this interpretation should be qualified. A recent systematic review of behavioral counseling interventions among key populations did not find a statistically significant effect on HIV or STI incidence, despite participants' expressed interest in certain interventions [8]. This observation shows that improving knowledge and skills is an important intermediate objective, but it should not automatically be equated with a demonstrated reduction in HIV incidence. Educational effects should therefore be assessed at several levels: knowledge, skills, self-efficacy, behaviors, use of services, and, where possible, biological indicators.

#### 4.4. Self-Efficacy and Intrinsic Motivation

Self-efficacy was the most important predictor among the educational and psychological variables studied (adjusted  $\beta = 0.1715$ ;  $p < 0.001$ ).

This finding is consistent with Bandura's social cognitive theory, according to which the beliefs a person holds regarding their ability to perform a behavior influence their engagement, persistence, and maintenance of action. In the field of HIV prevention, self-efficacy may particularly concern the ability to negotiate condom use, request HIV testing, seek PrEP or PEP, and maintain preventive

practices despite social barriers.

This interpretation is supported by previous research on condom use, which has shown that self-efficacy may constitute an important determinant of preventive behaviors, whereas HIV knowledge alone may not necessarily predict condom use [9].

Thus, a person may have sufficient knowledge about HIV while experiencing difficulties translating this knowledge into action when they lack confidence in their ability to negotiate safer sexual practices or access prevention services. Developing self-efficacy should therefore be considered a central component of prevention education programs.

Intrinsic motivation was also significantly associated with the acquisition of preventive skills (adjusted  $\beta = 0.1398$ ;  $p < 0.001$ ). This finding suggests that effective HIV prevention education should address not only knowledge and technical skills, but also personal motivation to adopt and maintain preventive behaviors.

Motivational approaches may be useful from this perspective. Literature reviews show that motivational interviewing may promote certain behavioral changes in the context of HIV, although effects are not consistent across populations and behaviors studied [10] [11]. More recently, a review focusing on the use of motivational interviewing to increase PrEP initiation and adherence highlighted its potential, while also emphasizing that the evidence remains limited [12].

Thus, the findings of our study support an educational conception in which the learner is not merely informed about what they should do, but is supported in understanding why they should do it, assessing their own capacities, overcoming barriers, and progressively developing autonomy.

#### 4.5. Sociodemographic Determinants

Marital status, residential district, and occupation were independently associated with the acquisition of preventive skills in the GEE model.

The association with residential district could reflect geographical differences in the availability, accessibility, quality, and intensity of HIV prevention interventions. In Kinshasa, access to services may vary according to residential areas, community networks, distance to health facilities, and the availability of services adapted to key populations.

This interpretation is consistent with WHO recommendations, which emphasize that key populations continue to face social, legal, structural, and contextual barriers limiting their access to health services [1]. A recent review focusing on structural and sociocultural barriers also showed that the availability of prevention tools does not guarantee their use when stigma, social barriers, and difficulties accessing care persist [2].

Occupation may also influence access to information, social networks, opportunities for interaction with health services, and the economic resources needed to access prevention methods. These differences could explain why occupation remained associated with skills acquisition after adjustment for other individual characteristics.

In contrast, age, sex, educational level, and monthly income were not statistically significant after adjustment in the model presented. This finding suggests that general demographic characteristics are not necessarily sufficient to explain differences in skills acquisition when educational, motivational, psychosocial, and contextual factors are considered simultaneously.

This observation is an important finding for the MIDCAP-HIV model. It suggests that a prevention strategy based solely on sociodemographic segmentation may be insufficient and that it would be preferable to consider educational and psychosocial mechanisms that may directly modify preventive skills.

#### 4.6. Predictive Modeling and the MIDCAP-HIV Model

The GAM showed the best reported predictive performance (AUC = 0.87), compared with the GEE (AUC = 0.81) and the LMM (AUC = 0.79).

The discriminative performance of the models was assessed using the area under the ROC curve (AUC). The observed AUC values were 0.81 for the GEE, 0.87 for the GAM, and 0.79 for the LMM. These values indicate overall good discriminative ability, particularly for the GAM.

The relatively superior performance of the GAM may be explained by its ability to account for nonlinear relationships between explanatory variables and the outcome. The acquisition of preventive skills is indeed a complex process in which the effect of a variable may not be strictly linear. For example, the effect of exposure to educational interventions may vary according to the initial level of knowledge, motivation, or self-efficacy.

However, the AUCs reported in this study correspond to an assessment of performance in the study sample and should not be interpreted as external validation of the model. They reflect the discriminative ability observed in the data used for the analysis. Rigorous internal validation, using bootstrap or cross-validation, as well as external validation in an independent cohort, will be necessary to assess the reproducibility and transportability of the model.

This caution is particularly important for a model intended for possible application in other districts or provinces of the Democratic Republic of the Congo. A predictive model may demonstrate excellent discrimination in the population used for its development while showing different performance in an external population.

Based on the conceptual and empirical findings, this study proposes the **MIDCAP-HIV model**, defined as the **Integrated Didactic-Pedagogical Model for the Acquisition of HIV-Related Preventive Skills**.

The model integrates five complementary dimensions:

- 1) knowledge related to combined HIV prevention;
- 2) active didactic-pedagogical strategies;
- 3) intrinsic motivation;
- 4) self-efficacy;
- 5) a supportive social and health environment.

The model therefore proposes considering the acquisition of preventive skills

as a multidimensional process rather than simply as a consequence of receiving information about HIV prevention.

This conception is consistent with current recommendations for an HIV response centered on key populations, combining biomedical, behavioral, and structural interventions [1]. It is also consistent with evidence demonstrating the importance of community-based interventions, peer education, and strategies aimed at reducing barriers to accessing services [2]-[4].

The MIDCAP-HIV model thus provides an additional contribution by explicitly placing didactic-pedagogical mechanisms at the center of the acquisition of preventive skills. It does not claim to replace existing behavioral models, but rather proposes their integration with principles from educational sciences and with contextual determinants of access to services.

## 5. Conclusions

This longitudinal analytical study made it possible to develop a didactic-pedagogical framework aimed at understanding the acquisition of preventive skills related to combined HIV prevention among key populations in Kinshasa.

The results indicate that the acquisition of preventive skills is influenced by a combination of educational, psychological, sociodemographic, and environmental factors. Participatory discussions, practical demonstrations, audiovisual materials, individualized feedback, self-efficacy, and intrinsic motivation were significantly associated with the acquisition of preventive skills.

Self-efficacy was the most important educational and psychological predictor in the model presented, highlighting the importance of psychosocial mechanisms in transforming knowledge into action capacities.

The results also show that active teaching strategies may constitute an important lever for improving preventive skills. However, this conclusion should be interpreted within the framework of an observational study: the observed associations alone do not establish a causal relationship.

The proposed MIDCAP-HIV model integrates educational sciences, behavioral determinants, and statistical modeling within a contextualized HIV prevention framework. It proposes considering the acquisition of preventive skills as the result of an interaction between knowledge, teaching strategies, motivation, self-efficacy, and the social and health environment.

Its application could contribute to the development of competency-based HIV prevention programs among key populations in the Democratic Republic of the Congo and in comparable settings, subject to subsequent validation in independent populations.

## 6. Recommendations

### 6.1. To Health Authorities

- Integrate competency-based health education into HIV prevention programs;

- strengthen communication on PrEP, PEP, treatment as a means of prevention, and the principle of “Undetectable = Untransmittable”;
- develop standardized tools for assessing preventive skills;
- improve equitable access to HIV prevention services across different health districts;
- strengthen strategies aimed at reducing the structural and sociocultural barriers faced by key populations [1] [2].

## 6.2. To Community-Based Organizations

- promote participatory educational methods;
- increase the use of practical demonstrations and role-playing activities;
- provide individualized counseling and continuous feedback;
- strengthen peer education;
- develop community navigation and support strategies;
- combat stigma and structural barriers to accessing prevention services.

These recommendations are consistent with available evidence on peer education and community-based interventions among key populations [3] [4] [13].

## 6.3. To Training Institutions

- integrate health education pedagogy into relevant training curricula;
- train educators involved in HIV prevention in active and competency-based learning methods;
- develop educational situations that allow practical training;
- promote the integration of the MIDCAP-HIV model into the planning of HIV prevention interventions.

## 6.4. To Researchers

- validate the MIDCAP-HIV model in other provinces of the Democratic Republic of the Congo;
- conduct intervention studies comparing different educational strategies;
- perform internal validation using bootstrap or cross-validation of predictive models;
- conduct external validation in independent cohorts;
- evaluate digital and community-based educational tools designed to develop preventive skills;
- investigate longitudinal pathways linking educational interventions, self-efficacy, motivation, and preventive behaviors;
- where possible, incorporate objective and biological indicators to complement self-reported measures.

## 7. Study Limitations

This study has several limitations.

First, some information was self-reported and could therefore be affected by

social desirability bias or recall bias, particularly for sensitive behaviors. This limitation is particularly important in research addressing sexual behaviors and prevention practices. The literature also highlights the difficulties involved in standardized measurement of certain preventive behaviors, particularly condom use [14].

Second, although the longitudinal nature of the study strengthens the assessment of changes over time, the observational nature of the study means that the observed associations should not automatically be interpreted as causal relationships. The estimated coefficients describe adjusted associations and do not, by themselves, constitute evidence of the effectiveness of educational interventions.

Third, the reported predictive performance was based on the study data. The AUCs of 0.81 for the GEE, 0.87 for the GAM, and 0.79 for the LMM therefore do not constitute external validation. Internal validation and, especially, external validation will be necessary before using the MIDCAP-HIV model in other settings.

Fourth, because the study was conducted among key populations in Kinshasa, the generalizability of the findings to other populations and other geographical areas of the Democratic Republic of the Congo should be approached with caution. Differences in health, social, economic, cultural, and organizational contexts may modify the observed relationships.

Fifth, some dimensions related to stigma, discrimination, social support, and structural barriers may not have been fully captured by the questionnaire. This limitation is important because international recommendations specifically emphasize the influence of these factors on access to prevention services among key populations [1] [2].

Nevertheless, the relatively large sample size, with 844 participants, the longitudinal design, the multidimensional questionnaire, and the use of advanced statistical models constitute important strengths for studying the acquisition of preventive skills.

## Author Contributions

Pierre Céleste MWANYIMI BOPE PELENG was the principal author and was responsible for the conception and design of the study, development of the research protocol and data collection tools, data collection and management, statistical analysis, interpretation of the results, and drafting and revision of the manuscript. He also coordinated the overall research process and prepared the final version of the manuscript.

Emery KAFINGA LUZOLO was the academic supervisor and contributed to the conceptualization and methodological design of the study, supervision of the research process, critical review and interpretation of the results, and substantial revision of the manuscript for important intellectual content. He also provided scientific and academic guidance throughout the study.

Guillaume BOFIO was the co-supervisor and contributed to the methodological and scientific review of the study, supervision of data collection and analysis,

interpretation and discussion of the findings, and critical revision of the manuscript. He contributed to ensuring the scientific coherence and quality of the final manuscript.

All three authors reviewed and approved the final version of the manuscript and agreed to be accountable for all aspects of the work, ensuring that questions related to the accuracy or integrity of any part of the work were appropriately investigated and resolved.

## Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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