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Original Paper

Predictors of HIV Screening among Florida Students: An Application of Multilevel Logistic Regression

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Abstract

Objectives: To explore the predictors of Human Immune Virus (HIV) screening among Florida high school students using a multilevel logical regression.

Methods: We used data of 5,394 high school students in grade level 8 to 12 from the Youth Risk Behavior Survey (YRBS) 2019. In addition to univariate analysis, multilevel logistic regression models were used to examine the association of selected predictors and HIV screening.

Results: Students aged 17 years and above were more likely to test for HIV than students 16 years or less (OR=1.928, 95% CI 1.413 – 2.630). Compared to students who did not have A's or B's, students who had A's and B's were 47% less likely to screen for HIV (OR =0.530, 95% CI 0.381 - 0.736). Discussing HIV with adults and parents (OR= 1.417, 95% CI 1.029 -1.952) and healthcare experts (OR=3.923, 95% CI 2.838 -5.423) was associated with increased odds of screening.

Conclusions: Multilevel approaches to examine HIV screening predictors have tremendous potential to provide more insight into class level factors that influence public health programs. This is important especially in situations where there may not be enough state or departmental funding to implement a comprehensive screening program.

Keywords

HIV Screening, Multilevel regression modelling, Adolescents

1. Introduction

Human Immunodeficiency Virus (HIV) is a significant public health problem among youth in the United States. HIV disproportionately affects adolescents and young adults compared to the general population (Bekker & Hosek, 2015). The Centers for Disease Control and Prevention (CDC) reports that in 2018, individuals aged 13 to 24 made up 21% of the 37,832 new HIV diagnoses in the United States (US) and dependent areas (CDC, 2020). This rate is higher than the rate in Florida, as young people in the age bracket of 13-24 make up 17.3% of new HIV cases (AIDSVu, 2020). These recent cases represent missed opportunities for early diagnosis, treatment, and reduction in the number of new HIV transmissions.

Early screening is gaining traction as it provides an opportunity for HIV eradication and represents a pathway toward HIV care (Branson et al., 2006). The CDC advises routine HIV screening of adults, adolescents, and pregnant women in healthcare settings in the US at least once as part of routine healthcare (Branson et al., 2006). These recommendations also call for reducing barriers to HIV testing (Branson et al., 2006). The United States Preventive Services Task Force (USPSTF) recommends that clinicians screen for HIV infections among individuals aged 15 to 65, as both adolescents and older adults are at an increased risk of HIV infection (USPSTF, 2016). The significance and importance of early HIV testing/screening are many. People living with HIV who are aware of their status can access HIV treatment and benefit from early Antiretroviral Treatment (ART) (Cohen et al., 2016). Treatment with ART lowers HIV viral load, reduces HIV-associated diseases, and facilitates undetectable viral load (Cohen et al., 2016). Early testing also enables people to adapt their risky behaviors to protect themselves from HIV (May 2017). It enables an infected person to become aware of their disease status and adapt their behavior to avoid transmitting the disease to others (Burnside & Rietmeijer, 2017).

Understanding HIV screening and testing predictors among Florida high school students are essential in developing targeted, culturally relevant public health intervention programs. Adolescence and early adulthood are a period of transition and exploration as young people develop an increased interest in sex and risky sexual behaviors like condomless sex (Hallfors et al., 2016). A high sense of invulnerability and increased propensity to take risks is prevalent during this period (Greenwald et al., 2018). Studies have shown that low perception of HIV risk behavior, risky sexual behaviors like a high number of sexual partners, and lack of motivation because of perceived lack of risk are predictors of HIV testing (More, 2013; More, 2017). Another study using the Youth Risk Behavior Survey (YRBS) found that HIV testing was positively associated with HIV-related risk behaviors despite low screening (22%) between 2005 and 2011, even for those engaging in risk behaviors (Coeytaux et al., 2014). Other studies demonstrate that age (Denison et al., 2014; Thomas et al., 2008), sex (Gillen, & Markey, 2014), and race (Ebrahim, 2004), being taught about AIDS or HIV in school (Voetsch et al., 2009) and comprehensive knowledge of HIV either from parents, home or school (Okumu, 2017) are predictors of HIV screening/testing.

Prior studies of the predictors of HIV testing typically focus on individual-level predictors that cannot simultaneously examine the role of group-level factors. Only a few studies have used multilevel modeling to capture group-level effects. HIV risk determinants also show wide variability by group-level characteristics, which may be a marker for mixing patterns (Diez & Aiello, 2005). For example, group prevalence of sexual behaviors is known to be associated with disease transmission and may be influenced by factors like group norms and peer pressure, like the kind seen in high schools (Bauermeister, 2009). Specifically, the prevalence of infectious diseases can also vary by group-level properties that should be accounted for through multilevel modeling (Diez & Aiello, 2005). High school students in different grade levels are different in their probability of adopting risky behaviors and HIV testing (Coeytaux et al., 2014). This study, therefore, aims to fill this gap by examining the predictors of HIV testing among Florida adolescents in their class context using a sample of students from grades 9 to 12 in Florida schools. Specifically, this study aims to determine the probability of HIV screening in a typical class, determine the variation in HIV screening rates across classes, and examine the relationship between individual and class-level predictors and the likelihood of HIV testing.

2. Method

The 2019 Florida High School Youth Risk Behavior Survey (FHSYRBS) data was used for this research. The Youth Risk Behavior Survey (YRBS) is a statewide, school-based confidential survey of Florida's public high school students (FDH, 2019). The purpose of the YRBS is to monitor priority health-risk behaviors that contribute substantially to the leading causes of death, disability, and social problems among youth, which contribute to patterns in adulthood (CDC, 2015). The FHSYRBS is based on a two-stage cluster probability sample design. First, a random sample of public high schools is selected for participation in the survey. Second, within each selected school, a random sample of classrooms is selected, and all students in those classes are invited to participate in the survey. The responses of the survey participants are weighted to be representative of all Florida public high school students (FDH, 2019). Parental and child consents were obtained before the survey form was administrated. A detailed description of the sampling methods and response rates has been described in detail elsewhere (FDH, 2019).

The study sample included 5,394 students and statistical analyses were completed in 2021.

2.1 Study Variables

Outcome variable: A single item was used to ascertain the HIV testing status. Respondents were asked, "Have you ever tested for HIV in the last 3 months (not counting tests done if they donated blood)?". The responses were recorded as "Yes" or "No".

Predictors: Independent variables considered in this analysis were age (16 years or less, 17 years and above), Sex (male or female), Race/Ethnicity (Whites and Non-whites), being taught about HIV/AIDS in school ("yes" and "No), talked about HIV with adults/parents ("yes" and "no"), discussed with a healthcare provider about HIV ("yes" and "no"), and school grades mostly A's and B's ("Yes" and "no").

2.2 Statistical Analysis

The analysis of this data was completed in two steps. First, a bivariate analysis followed by multilevel logistic regression. Pearson's chi-square test and *p*-values were used to test for the significance of predictors in bivariate analysis. A multilevel logistic regression was then used to model the association of the predictors with HIV testing. The predictors that were finally considered were the age of the child, talking/discussing about HIV with adults/parents, being taught about HIV in school, discussing with healthcare providers about HIV/AIDS, and having grades A's and B's. Race was not statistically significant in the bivariate analysis and was not included in the final multilevel model.

In the YRBS, children are nested within classes, and classes are nested within schools. For this analysis, children have been nested within their grade level (used as a class in this analysis) representing students in grades 9, 10, 11, and 12. To properly account for this hierarchy, the class level is the level-2 variable under which the students are nested. The level 1 variables in this analysis that represent individual-level variables were age, talking about HIV with adults/parents at home, discussing with healthcare workers about HIV/AIDS, and having grades A's and B's. Being taught HIV in school was selected as a level 2 variable (class level variable). Given that the outcome variable is binary, we used a binary distribution and logit link function to compute the odds of having the response (Austin & Merlo, 2017).

The multilevel logistic regression model can be represented at 2 levels as described by Snijders & Bosker (2011). Suppose that there are one level-1 explanatory variable and one level-2 explanatory variable (like this study), then the level-1 equation of the model is described as (Snijders & Bosker, 2011):

$\text{Log}\left[P_{ij} / (1-P_{ij})\right] = \beta_{0j} + \beta_{1j} X_{1ij}$ ....equation 1

While the level 2 equations are

$$\beta_{0j} = \gamma_{00} + \gamma_{01} W_{1j} + U_{0j}$$

$\beta_{1j} = \gamma_{10} + \gamma_{11} W_{1j} + U_{1j}$ …………………………………………equation 2

where both the level-1 random intercept β_{0j} and random slope β_{1j} are treated as linear functions of level-2 explanatory variable w_{1j}.

Thus, the combined model follows:

$\log (P_{ij} / 1 - P_{ij}) = \gamma_{00} + \gamma_{01} W_{1j} + \gamma_{10} X_{1ij} + \gamma_{11} X_{1ij} W_{1j} + (U_{0j} + U_{1j} X_{1ij})$ …. equation 3

Where $\gamma_{00} + \gamma_{01} W_{1j} + \gamma_{10} X_{1ij} + \gamma_{11} X_{1ij} W_{1j}$ are fixed effects

and $(U_{0j} + U_{1j} X_{1ij})$ are random effects. Equation 3 gives the log odds when fitted to data.

The predicted probability of the event of interest (e.g. HIV testing =" Yes") can be calculated using the following formula (Ene et al., 2014): $PP = e^{\beta} / (1 + e^{\beta})$.

PROC GLIMMIX in SAS 9.4 (Cary, NC) was used to fit the logistic distribution with the logit link function specified. For model diagnostics, candidate models were constructed and compared based on -2 log likelihood criteria, AIC, and BIC.

2.3 Model Building and Model Selection

The random intercept model is fitted with only the intercept represented in model 1. Model 2 comprised of model 1 with individual level variables added (age, talking about HIV with adults/parents at home, discussing with healthcare workers about HIV/AIDS and having grades A's and B's). Model 3 consist of model 2 plus class level variable (HIV education in school). Interaction among the predictors in model 3 was not statistically significant.

3. Results

3.1 Bivariate Analysis

Of the 5,394 children included in this study, 52.6% were females and 47.4% were males. Fourteen percent tested for HIV in the last 3 months. Table 1 presents cross-tabulation of prevalence of HIV testing (frequency and percentages) by predictors for high school children in the state of Florida. Students were nested in 4 classes corresponding to their grade levels. Overall, 30% of the students were in Grade 9, 26% were in Grade 10, 25% were in grades 11 and 19% were in grade 12. Rao-chi-square test for association shows that the class level is statistically significantly associated with HIV testing ($\chi^2 = 65.51$, $p < 0.001$), indicating that the prevalence of HIV screening varies by class level of student.

Table 1. Descriptive Characteristics of Study Population

		No HIV testing (n=4722)		**HIV testing (n=672)**		
	Total sample (%)	**N**	**%**	**N**	**%**	**Chisq *p*-Value***
Age of Child,						
≤16 years	65.76	3199	90.29	344	9.71	<0.001
≥17 years	34.24	1519	82.33	326	17.67	
Sex						
Female	52.63	2489	88.17	334	11.83	
Male	47.37	2208	86.89	333	13.11	0.1581
Taught about HIV/AIDS in class						
Yes	65.64	2868	85.59	483	14.41	
No	34.36	1612	91.90	142	8.10	<0.001
Talked about HIV/AIDS with adults/parents						
Yes	41.28	1746	82.87	361	17.13	
No	58.72	2733	91.19	264	8.80	<0.001
Discussed with healthcare provider about HIV						
Yes	33.29	1158	75.93	367	24.07	

No	66.71	2863	93.68	193	6.32	<0.001
Grades mostly As and B's						
Yes	73.26	3425	88.89	428	11.11	
No	26.74	1182	84.07	224	15.93	<0.001
Class level (level 2)						
Grade 9 (class ID= 1)	30.03	1481	91.42	139	8.58	
Grade 10 (class ID= 2)	25.95	1254	89.57	146	10.43	
Grade 11 (class ID=3)	25.03	1149	85.11	201	14.89	
Grade 12(class ID=4)	18.98	838	81.84	186	18.16	<0.001

3.2 Multivariate Analysis

Table 2 shows the fitted models along with the estimated effects and their standard errors. Laplace estimation has been used to enable model comparisons. The use of Laplace estimation as a linearization method in this study is to fit discrete data models like this one in which joint distribution is difficult to ascertain, thereby allowing many random effects to be estimated in the model (Schabenberger, 2005). The last row of Table 2 shows the *p*-values for the deviance test based on Chi-square statistic.

Table 2. Estimates for Two Level Logistic Model of Predictors and Outcome

	Model 1	Model 2	Model 3
Fixed Effects			
Intercept	-1.9398(0.194) *	-2.666 * (0.1125)	-2.8225* (0.1309)
Age		0.6807 * (0.0972)	0.6564 * (0.0976)
Grades mostly A's &B's		-0.6255* (0.1032)	-0.6334 * (0.1034)
Talked about HIV with adults/parents		0.3897* (0.0099)	0.3489* (0.1006)
Discussed about HIV with healthcare provider		1.3933* (0.1014)	1.3669* (0.1018)
Taught about HIV in school			0.2911 (0.1143)
Error variance			
Intercept	0.1439(0.1233) *		
ICC	0.0419		
Model Fit			
-2LL	4006.49	2931.08**	2923.58**
AIC	4010.49	2941.08	2935.58
BIC	4009.26	2938.02	2931.90

Note. Entries in the table are estimated effects while the standard errors are reported in the parenthesis.

*Level of significance at $p < 0.05$.

**Significant LR test; ICC = 0.0419. PROC GLIMMIX in SAS 9.4 with Laplace estimation method was used.

Three models were considered in this analysis, and they are presented in table 2. The models are nested within each other (i.e., model 1 is nested in model 2 and model 2 is nested in model 3). This allows for comparison based on -2LL. Model 3 (model with the level 2 effect – "HIV taught in school") was the best model out of the 3 models because of a statistically significant Likelihood Ratio Test (LRT) compared to model 2 and a smaller AIC and BIC. Model 2 showed a significant fall in -2LL (LRT: $p < 0.001$) from model 1 and is the second-best model. Therefore model 3 will be used to answer our research hypotheses.

For the first research hypothesis about the HIV testing rate at a particular class, this is represented by the value of the intercept in the null model (β= -1.9398, $p < 0.05$). The estimated effects in Table 2 (Model 1) are the log-odds of successful HIV testing with typical background characteristics (null model). The odds of successful HIV test at a typical class level was 14% [exp (-1.9398)]. This odd is used to estimate the predicted probability of HIV testing of a student in a typical class. The estimated probability is 0.126 [exp (-1.9398)/1 + exp (-1.9398)].

The second hypothesis tests if the likelihood of HIV testing varies across the grade level. This represents the estimated covariance parameter for class level and is 0.1439 ($p < 0.05$). Thus, there exist a statistically significant variation across class for the likelihood of getting a HIV test. More so, the Intra-Class correlation was calculated as 0.0419 and indicates that 4.2 % of the total variation the probability of getting a HIV test is due to variation among the classes. Hence, the remaining 96% variability is due to the variation within the students and other unknown factors.

For the final hypothesis, model 3 is used to explain the relationship between the predictors and likelihood of HIV testing. Model 3 has four significant covariates (student age, students who talked about HIV to adults or parents, students who discussed about HIV with their healthcare provider and students who mostly got A's and B's). There was a significant effect of age (β = 0.66, $p < 0.05$), students talking to adults or parents about HIV (β = 0.35, $p < 0.05$), discussing about HIV with their healthcare provider (β = 1.37, $p < 0.05$) and having mostly A's and B's (β = -0.63, $p < 0.05$). Being taught about HIV in school, have statistically significant effect on the likelihood of HIV screening (β=0.2911, $p > 0.05$). The calculated odds ratio of the predictors in Table 3 shows the estimated odds ratio and 95% Confidence Interval (CI) and enable for easier interpretation of the predictors. People aged 17 years and above were more likely to screen for HIV than people who are 16 years or less (*OR*=1.928, *95% CI* 1.413 – 2.630). Compared to students who did not have A's or B's, students who had A's and B's were 42% less likely to screen for HIV (*OR* =0.530, *95% CI* 0.381 -0.736). Discussing about HIV with adults and parents (*OR*= 1.417, *95% CI* 1.029 -1.952) and healthcare experts (*OR*=3.923, *95% CI* 2.838 -5.423) was associated with increased odds of screening. While students who were taught HIV were 33.8% more likely to get a test when compared to students who were not taught about HIV, it was not statistically significant (*OR*= 1.338, *95% CI* 0.930 -1.925).

Table 3. Estimated Odds Ratio and 95% CI for Multilevel Logistic Regression of Predictors against HIV Testing

Predictor	Model 2	Model 3
Age		
≤16 years	Ref	Ref
≥17 years	1.975 (1.450 – 2.691)	1.928 (1.413 – 2.630)
Grades mostly A's &B's		
No	Ref	Ref
Yes	0.535 (0.385 – 0.743)	0.530 (0.381 -0.736)
Talked about HIV with adults/parents		
No	Ref	Ref
Yes	1.476 (1.076 -2.027)	1.417 (1.029 -1.952)
Discussed about HIV with healthcare provider		
No	Ref	Ref
Yes	4.028 (2.917 – 5.562)	3.923 (2.838 -5.423)
Taught about HIV in school		
No		Ref
Yes		1.338 (0.930 -1.925)

4. Discussion

Multilevel models result in more accurate estimates of model parameters because they adjust for clustering effects. In samples where individuals cluster in higher-order social groupings (a department, a school, or some other type of organization), simple random sampling does not hold because people clustered in groups are similar in various ways. For example, children in the same grade level are less likely to be identical to students in another grade level. Ignoring clustering in the analysis could introduce a bias in estimating model parameters. In this situation, the goal would be to investigate the random variability in intercepts and slopes across the sample of higher-level units.

Our analysis is vital for public health professionals and policymakers in Florida. Uniform class level-based efforts that target increased HIV screening may have limited impact if they cannot account for the nuances that multilevel modeling can detect. Thus, multilevel approaches to examining HIV screening predictors have tremendous potential to provide more insight into school grade levels that may need the most attention, especially in situations where there may not be enough funding.

The findings of this study agree with extant literature that examined the predictors of HIV testing in school children (Denison et al., 2014; Thomas et al., 2008; Voetsch et al., 2009; Okumu et al., 2017). We found that students 17 years and above were twice as likely to have screened for HIV compared to those 16 years or fewer. Indeed, the prevalence of HIV testing increases with age. Patel et al. (2020) reported the prevalence of being tested for HIV as higher in older age groups than in younger age groups, with a significantly increasing trend. A reason for this could be that increasing age is associated with increased sexual activity, and sexual activity, in turn, is a known predictor of HIV testing (Banson et al., 2006).

We also found a significant association between academic performance and HIV screening. Students with A's and B's have lower odds of HIV screening in our study. Our result agrees with Rasberry et al. (2019). They found that students with mostly A's and primarily Bs had significantly lower prevalence estimates for most health-related risk behaviors, including all substance use, sexual risk, violence-related, and suicide-related behaviors. It is also possible that individual choices of students with A and B grades differ from those of other students. However, further studies to explain this association are warranted.

HIV discussion with adults or parents in the home was also statistically significant in this study. Parental communication positively influences HIV-related behaviors, including getting tested for HIV (Boyd et al., 2020). Findings from Boyd et al. (2020) showed that parents with positive attitudes about sex and who communicate these attitudes, had children who were twice as likely to get tested for HIV, highlighting the need for positive communication skills in future HIV-related adolescent interventions.

In addition, we found a positive association between HIV testing and provider communication. Previous studies have found that a physician's recommendation for HIV testing affects patients' HIV testing behaviors (Baumman et al., 2018). Baumman et al. (2018) reported that a physician's recommendation was the top reason for patients' acceptance of getting an HIV test. A prior national survey by the Kaiser Family Foundation (2012) reported physician recommendation as a significant reason for getting a HIV test in one-third of participants (Kaiser Family Foundation, 2012).

Our study is not without limitations. First, we did not check for the normality assumptions of homogeneity of variance because of the categorical nature of the variables used in this analysis. Categorical data are not from a normal distribution, which is continuous or at least interval data. Our study was underpowered, with about four times more non-screeners than screeners. Underpowered studies can increase p-value and lead to statistically insignificant results when there is a substantial effect. Underpowered studies could also potentially have model convergence issues; however, our analysis did not run into these issues. We used school grade level to represent class level in our analysis. School grade level is not entirely homogenous and there may exist other sublevels/classes among students at the same grade level. While the low ICC (4.2%) suggests low intra-class variability and argues against multilevel modeling, authors have argued that any form of nesting within data warrants multilevel modeling, even if when ICC is low (Nezlek, 2008). Further, the cross-sectional nature of this study does not show a causal relationship between the predictors and the outcome of interest.

In conclusion, to achieve the Healthy People's aim and the Florida Department of Health HIV initiative, routine HIV screening of adolescents should continue to be accessible and emphasized, and school HIV screening should continue to be encouraged. Routine HIV screening is a critical part of HIV prevention and understanding the risk factors associated with screening/testing will ensure a more targeted approach to intervention.

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