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Educational quality and oral health promotion in Brazilian schools: a multilevel analysis of national data

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Abstract: The aim of this study was to investigate whether educational quality is associated with schools' potential support for oral health promotion in Brazil, using a multilevel model. An ecological study was carried out using data from 940 public schools (school level) from the 27 Brazilian state capitals (city-level). The explanatory variable was educational quality, measured by the Basic Education Development Index (IDEB) for each city, and the four dependent variables referred to the Oral Health Promotion School Environment (OHPSE) indicator and its dimensions: Dimension 1 (In-school aspects), Dimension 2 (Aspects of the school surroundings), and Dimension 3 (Prohibitive policies at school). The OHPSE was developed using categorical principal components analysis (CATPCA) of data from the 2015 National Adolescent School-Based Health Survey (PeNSE). Covariates were human development index and oral health care coverage of cities. Multilevel Poisson regression models with robust variance were undertaken ($p < 0.05$). Bivariate associations were found between the IDEB and each Total OHPSE and OHPSE-Dimension 1 (In-school aspects: sale of foods with added sugar and health promotion actions/programs). After adjustment, IDEB (PR: 1.38, 95%CI: 1.01–1.90; $p = 0.045$) and oral health care coverage (PR: 1.01; 95%CI: 1.00–1.02; $p = 0.001$) remained associated with the OHPSE Dimension 1. It was concluded that educational quality measured by the IDEB was associated with schools' potential support for oral health promotion regarding the sale of foods with added sugar and health promotion actions/programs in schools.

Keywords: Adolescent; Schools; Educational Measurement; Multilevel Analysis.

Introduction

Social determinants of health include social, economic, and physical environment factors. Among them, education is strongly associated with life expectancy and most overall health outcomes.[1-4] Previous studies that analyzed the relationship between education-related variables and oral health included individual variables such as the students' academic performance,[5-7] level of education,[8-11] and parents' schooling,[9,10,12,13] as well as contextual variables.[12,14-21]

The school environment plays an essential role in promoting oral health in children and adolescents. Schools that promote oral health have characteristics (curricular, procedural, and structural) that can stimulate the development of skills and competencies favorable to oral health.[15-19,22,23]

A link between educational aspects of schools and students' oral health outcomes is therefore expected. In Brazil, the educational quality of public elementary schools has been assessed by the national government through the Basic Education Development Index (IDEB) since 2005.[24] A previous study showed an association between higher IDEB scores in 2013 and lower self-reported impact of oral conditions on the quality of life of 12-year-old students in a sample of schools of an inner Brazilian city.[14]

To our knowledge, no previous studies investigated the relationship between oral health promotion in schools and the Brazilian IDEB or other educational quality indicators in other countries. The present study explores this possible association using data from the National Adolescent School-Based Health Survey (PeNSE)[25] and from the IDEB.[26] The multilevel approach was used to simultaneously analyze contextual factors at different levels (cities and schools), seeking a broader understanding of the relationships between education and oral health promotion.[27]

The aim of this study was to investigate, using a multilevel model, whether cities' educational quality is associated with schools' potential support for oral health promotion in Brazil. The hypothesis was that Brazilian state capitals with higher educational quality would have public schools with more favorable environment for promoting oral health.

Methodology

An ecological cross-sectional study was carried out using multilevel analysis of data from 940 public schools (school level) from the 27 Brazilian state capitals (city-level). Data were from four sources: IDEB[26] (explanatory variable), PeNSE[25] (dependent variables), Atlas of Human Development in Brazil[28], and Ministry of Health[29] (covariates).

The independent explanatory variable was the educational quality measured by the average IDEB indicator of the schools for each city in 2015.[26] The IDEB of each school was based on information about student performance or school flow (approval) and performance in standardized exams in Portuguese and mathematics, with grades ranging from zero to ten.[24]

The dependent variables were four outcomes related to the schools' oral health promotion potential, using data from the PeNSE 2015 data. This is a national survey carried out periodically in Brazil since 2009 by the Ministry of Health (MH) and the Brazilian Institute of Geography and Statistics (IBGE) to investigate the health status and behaviors of adolescents in school, as well as factors in the school environment that can influence their health.[25]

In the PeNSE 2015 survey design, the total sample was stratified in two stages: schools (primary units) and classes (secondary units). First, a sample calculation was performed to define the number of students involved, considering a maximum relative error of 3%, a prevalence of 50% for the different health conditions of adolescents and 95% confidence intervals (CI). The sample of schools was defined from the number of students, which were randomly selected, considering representativeness, according to geographic strata. The project was approved by the National Research Ethics Council (Nº. 1,006,467/2015). The schools involved were not identified. Additional methodological information is available in previous publications.[25,30]

The four outcomes of the study were dichotomous indicators from the Oral Health Promotion School Environment indicator (Total OHPSE, OHPSE D1, OHPSE D2, and OHPSE D3), which refer to the potential support of the school environment for oral health promotion. These indicators were developed for the present analysis using data from the PeNSE and the categorical principal components analysis (CATPCA), based on a previous study.[20] CATPCA is a method similar to principal component analysis (PCA), applicable to categorical variables. A greater number of variables is reduced to a few unrelated dimensions with the least possible loss of information. Scores are then generated for each dimension. The contribution of the variables to the total variance of the data (explanation percent) is expressed by the sum of the factor loads (eigenvalues) resulting in the analysis.[31]

For this calculation, 11 variables from the PeNSE 2015 questionnaire were selected, which refer to characteristics of the school environment with possible influence on the students' oral health: "sale of soft drinks in the cafeteria", "sale of other beverages with added sugar in the cafeteria", "sale of sweets and other delicacies in the cafeteria", "sale of soft drinks at alternative points", "sale of other beverages with added sugar at alternative points", "sale of sweets and other delicacies at alternative points", "the school has a health group or committee", "the school joined the *Programa Saúde na Escola* (PSE – Health in School Program)", "the school develops actions in partnership with the Primary Health Units (PHU)", "the school prohibits tobacco consumption" and "school prohibits alcohol consumption". Each variable's yes/no answers were assessed to ensure that the direction expressed positive support for health promotion.

The CATPCA technique generated partial scores referring to the three resulting dimensions for each school, which were summed up, resulting in a general score. To facilitate the interpretation of these results, the four OHPSE scores were dichotomized by the median to indicate schools with high or low potential support for oral health promotion.

Covariates were socioeconomic data of the capital cities: Human development index (HDI) in 2010[28] (year closest to 2015 with this available data), and "oral health care coverage" (percentage of population covered by oral health teams in the family health strategy in 2015[29]).

The HDI is composed of population indicators of education, longevity, and income. A higher HDI indicates higher human development. The "oral health care coverage" is one of the indicators used by the Ministry of Health in the planning and monitoring of oral healthcare actions. It indicates the estimated population covered by the Family Health Strategy (FHS) oral health teams. It is assumed that this variable is related to the studied outcomes since most of the actions related to oral health promotion in Brazilian schools involve partnership with local oral health teams.[32]

The SPSS for Windows version 23.0 was used for descriptive analyses. Multilevel analyses were performed in the STATA version 14.0. Multicollinearity of independent variables was previously verified. Four multilevel Poisson regression models with robust variance adjustment using fixed-effect models with random intercept were carried out to assess associations between the independent explanatory variable (IDEB – city-level) and each of the four outcomes (Total OHPSE and OHPSE D1, D2 and D3 – school level). The associations were adjusted by covariates (HDI and "oral health care coverage" – city-level). Prevalence ratios (PR) and 95%CIs were estimated.

For each outcome variable, a null model was first performed to estimate the variability of the data before the insertion of contextual variables. In addition to the IDEB, the covariables that showed an association in the unadjusted analysis (multilevel bivariate Poisson regression) with a value of $p < 0.25$ were considered for the adjusted multilevel analysis. The statistical significance of each variable in the multilevel models was evaluated by the Wald test ($p < 0.05$).

The goodness-of-fit of the models was assessed, similarly to the models that use the Deviance Information Criterion, but using the parameter log pseudolikelihood - generated by Stata for multilevel Poisson regression analysis with robust variance adjustment. Thus, the analysis parameter (deviance) resulted from the calculation was: -2.log pseudolikelihood.

Results

Table 1 describes the outcome variables related to the OHPSE indicator. Three dimensions were generated using the CATPCA technique: OHPSE-D1, related to in-school aspects - sale of products with added sugar (soft drinks/beverages, candies, and sweets) and health promotion actions/programs (presence of a health group or committee, PSE and other actions in partnership with the PHU); OHPSE-D2, related to the area around the school – sale of products with added sugar at alternative places (soft drinks/beverages, candies, and sweets) and OHPSE-D3, related to schools' policies on alcohol and tobacco consumption. The percentage of data variance explained was acceptable (56.7%), and Cronbach's alpha coefficient was high (0.92), confirming the reliability of the analysis.

Table 2 shows the descriptive statistics of the variables considered in the multilevel analyses, both at the school level (OHPSE Total, D1, D2, and D3) and at the city level (IDEB, HDI, and "oral health care coverage"). Over 50.0% of the schools had low levels of the OHPSE indicators (total and dimensions).

The Poisson regression analysis of the associations between the outcomes and the independent variables are shown in Tables 3 and 4. No multicollinearity was identified between the independent variables: Spearman correlation coefficients were < 0.5, variance inflation factor was < 2, and tolerance statistic was > 0.7 (data not shown).

In the unadjusted analysis, the IDEB, the HDI, and "oral health care coverage" were associated with the outcomes Total OHPSE and OHPSE-D1 (Table 3). After adjustment, only "oral health care coverage" (PR: 1.01; 95%CI: 1.00–1.01; p = 0.002) remained associated with Total OHPSE, while the IDEB (PR: 1.38, 95%CI: 1.01–1.90; p = 0.045) and "oral health care coverage" (PR: 1.01; 95%CI: 1.00–1.02; p = 0.001) remained associated with the OHPSE-D1.

The OHPSE-D2 (Table 4) was associated with the IDEB, with the HDI, and with "oral health care coverage" only in the unadjusted analysis. None of the independent variables was associated with the outcome OHPSE-D3.

Discussion

This study investigated associations between the educational quality of public schools in the

Table 1. Summary data of the Oral Health Promoting School Environment (OHPSE) scores of public schools in the Brazilian state capitals, generated by the CATPCA analysis.

Dependent variables	Scores		
	Mean (SD)	Min–Max	Median (IQR)
OHPSE - Total[a]	0.01 (1.74)	-6.5–2.6	0.39 (2.1)
OHPSE - Dimension 1[b]	0.00 (1.0)	-3.7–1,34	0.27 (1.18)
OHPSE - Dimension 2[c]	-0.00 (1.01)	-3.43–2.21	0.21 (0.9)
OHPSE - Dimension 3[d]	0.00 (1.01)	-3.77–2.46	0.16 (1.01)

[a]Oral Health Promotion School Environment total score; [b]In-school aspects; [c]Aspects of the area around the school; [d]Prohibitive policies at school (alcohol and tobacco consumption); SD: Standard deviation. IQR: Interquartile range.

Table 2. Descriptive data of the variables related to schools and to Brazilian state capitals.

School level (n = 940)			
Dependent variables	Categories	n (%)	
OHPSE - Total[a]	Low (≤ median)	484 (51.5)	
	High (> median)	456 (48.5)	
OHPSE - Dimension 1[b]	Low (≤ median)	536 (57.0)	
	High (> median)	404 (43.0)	
OHPSE - Dimension 2[c]	Low (≤ median)	530 (56.4)	
	High (> median)	410 (43.6)	
OHPSE - Dimension 3[d]	Low (≤ median)	503 (53.5)	
	High (> median)	437 (46.5)	
Brazilian state capitals level (n = 27)			
Independent variables	Mean (SD)	Min–Max	Median (IQR)
IDEB[e]	4.03 (0.55)	3.0–4.9	4.1 (0.8)
HDI[f]	0.78 (0.03)	0.72–0.85	0.77 (0.05)
Oral health care coverage[g]	33.05 (23.34)	0.0–92.99	30.8 (26.71)

[a]Oral Health Promotion School Environment indicator; [b]In-school aspects; [c]Aspects of the area around the school; [d]Prohibitive policies at school (alcohol and tobacco consumption); [e]Basic Education Development Index, 2015; [f]Human Development Index, 2010; [g]Percentage of estimated population covered by oral health teams in the family health strategy, 2015; SD: Standard deviation. IQR: Interquartile range.

Table 3. Associations between the Basic Education Development Index (IDEB) and the Oral Health Promotion School Environment (OHPSE) Total[a] and Dimension 1[b] using multi-level Poisson regression.

Independent variables	Dependent variables - School level (n = 940)							
Brazilian state capitals level (n = 27)	OHPSE Total[a] (High)				OHPSE Dimension 1[b] (High)			
	Unadjusted		Adjusted		Unadjusted		Adjusted	
	PR (95%CI)	p-value[f]	PR (95%CI)	p-value[f]	PR (95%CI)	p-value[f]	PR (95%CI)	p-value[f]
IDEB[c]	**1.28 (1.01-1.61)**	**0.038**	1.13 (0.88-1.44)	0.339	**1.72 (1.22-2.43)**	**0.002**	**1.38 (1.01-1.90)**	**0.045**
HDI[d]	**60.04 (1.09-3,311.85)**	**0.045**	22.86 (0.27-1,903.76)	0.165	**3,245.36 (7.85-1,341,767)**	**0.009**	205.99 (0.60-70,734.71)	0.074
Oral health care coverage[e]	**1.01 (1.00-1.01)**	**0.005**	**1.01 (1.00-1.01)**	**0.002**	**1.01 (1.01-1.02)**	**0.001**	**1.01 (1.00-1.02)**	**0.001**
	Fixed effects:		Random effects:		Fixed effects:		Random effects:	
	Intercept (95%CI)	Deviance	Variance (95% CI)		Intercept (95% CI)	Deviance	Variance (95% CI)	
	(Constant)		(State Capitals level)		(Constant)		(State Capitals level)	
Null model	0.46 (0.40-0.54)	1,563.12	0.06 (0.02-0.18)		0.36 (0.27-0.48)	1,423.46	0.35 (0.19-0.65)	
Final Model	0.02 (0.00-0.40)	1,551.06	0.02 (0.00-0.28)		0.00 (0.00-0.05)	1,405.74	0.14 (0.06-0.32)	

[a]Oral Health Promotion School Environment indicator; [b]In-school aspects; [c]Basic Education Development Index, 2015; [d]Human Development Index, 2010; [e]Percentage of estimated population covered by oral health teams in the family health strategy, 2015; [f]Wald Test, statistical significance <0,05; PR: Prevalence ratio. CI: Confidence interval. Deviance = (-2. log pseudolikelihood).

Table 4. Associations between the Basic Education Development Index (IDEB) and the Oral Health Promotion School Environment (OHPSE) – Dimension 2 and Dimension 3[b] using multi-level Poisson regression.

Independent variables	Dependent variables - School level (n = 940)							
Brazilian state capitals level (n = 27)	OHPSE Dimension 2[a] (High)				OHPSE Dimension 3[b] (High)			
	Unadjusted		Adjusted		Unadjusted		Adjusted	
	PR (95%CI)	p-value[f]	PR (95%CI)	p-value[f]	PR (95%CI)	p-value[f]	PR (95%CI)	p-value[f]
IDEB[c]	**0.75 (0.58-0.96)**	**0.025**	0.78 (0.60-1.01)	0.061	1.20 (0.96-1.50)	0.113	1.11 (0.89-1.41)	0.407
HDI[d]	0.07 (0.00-34.30)	0.407			33.94 (0.41-2,782.01)	0.117	16.84 (0.12-2,291.45)	0.260
Oral health care coverage[e]	**0.99 (0.98-1.00)**	**0.043**	0.99 (0.99-1.00)	0.090	1.00 (1.00-1.01)	0.331		
	Fixed effects:		Random effects:		Fixed effects:		Random effects:	
	Intercept (95%CI)	Deviance	Variance (95%CI)		Intercept (95%CI)	Deviance	Variance (95%CI)	
	(Constant)		(State Capitals level)		(Constant)		(State Capitals level)	
Null model	0.41 (0.34-0.50)	1,478.86	0.14 (0.06-0.35)		0.44 (0.38-0.52)	1,532.12	0.08 (0.02-0.26)	
Final model	1.40 (0.51-3.85)	1,471.84	0.09 (0.03-0.23)		0.33 (0.00-1.08)	1,528.62	0.06 (0.02-0.21)	

[a]Aspects of the area around the school; [b]Prohibitive policies at school (alcohol and tobacco consumption); [c]Basic Education Development Index, 2015; [d]Human Development Index, 2010; [e]Percentage of estimated population covered by oral health teams in the family health strategy, 2015; [f]Wald Test, statistical significance <0.05; PR: Prevalence ratio. CI: Confidence interval. Deviance = (-2.log pseudolikelihood).

Brazilian state capitals (IDEB) and four outcomes related to the schools' potential for oral health promotion (OHPSE). We tested the hypothesis that cities with higher IDEB have more indicators of oral health promotion in schools. After adjustment for covariates, the hypothesis was confirmed for one of the four outcomes: the IDEB was associated with the OHPSE-D1, referring to in-school aspects (sale of products with added sugar, and health promotion actions/programs).

Thus, Brazilian state capitals with higher educational quality had more schools with a higher potential to promote oral health. This association might be due to a ripple effect of common broader determinants that affect both student achievement and the health-promoting environment of the school (such as adherence to health education school curriculum and/or social settings and processes as addressed in the Health Promoting Schools framework).[33]

This finding adds knowledge to the education-health binomial from an ecological perspective,[34] integrating information at multiple levels (city and school) with particular interest in oral health promotion. Notwithstanding, the positive influence of education at the individual level has been shown to positively affect the oral health of children and adolescents,[5,6,8-12] reinforcing the importance of contextual factors in changing oral health behaviours.[23]

Lee et al.[35] identified critical indicators of successful health-promoting school practice affecting the health profile of student in Hong Kong that, although more comprehensive than the present study, were based on a similar rationale: healthy school policies, the physical and social environment of the school, action skills for healthy lifestyle, community connections, and school-based health care and promotion. Interestingly, in a previous study based on data from the PeNSE 2015, public schools stood out as having a higher potential to promote oral health compared to private schools.[20]

In a previous ecological study of state primary schools in an inner-city of England, higher achievements in English, mathematics, and literacy were associated with the mean number of decayed, missing, or filled teeth (dmft) scores among 5-year-old children. Such analyses were possible due to the regular child dental health surveys, emphasizing the importance of ongoing surveillance programs.[21]

Another relevant finding refers to the associations between "oral health care coverage" and the Total OHPSE and its D1 dimension, even after adjustment for covariates. Despite the low magnitude of the associations, our findings suggest a positive influence of the partnership between public schools and local oral health teams in the FHS. However, studies on the effectiveness of the performance of oral health teams in the FHS,[36,37] and their relationship with local schools are still scarce and unclear.[38,39]

Given the ecological design of the study, the present findings must be interpreted with caution to avoid risk of ecological fallacy. Nor can it be said that there is a cause and effect relationship. One limitation refers to the low variability of the IDEB among the capital cities investigated. Further investigation should consider the IDEB of schools rather than the average per city and include inner cities to allow for greater variability of the IDEB as educational quality may vary across smaller populations. This was not possible in this study as these data were not available in the PeNSE 2015 national survey.

The use of national data related to health and education sectors and the multilevel approach are strengths of this study. In addition, our findings add new knowledge on oral health promotion in the school environment, exploring a contextual factor that was not previously examined: the IDEB. This indicator deserves attention in intersectoral public health promotion policies[32] aimed at improving both the educational quality of public schools and the health condition of students. Also, the evidence on the benefits of a health-promoting school environment for the students' oral health,[15-19] and academic achievement needs to be more widely disseminated.[4,33]

Conclusion

As measured by the national index IDEB, the mean educational quality of cities was associated with the potential support of schools for oral health promotion, in terms of sales of products with added sugar and actions/programs for health promotion in schools.

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