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Do socioeconomic determinants affect the quality of posterior dental restorations? A multilevel approach

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ABSTRACT

Objectives: This study aimed to evaluate posterior restorations placed in young adults, investigating the association between social determinants experienced during the life course and the quality of tooth fillings.
Methods: A representative sample ($n = 720$) of all 5914 individuals who were born in Pelotas in 1982 was prospectively investigated, and posterior restorations were assessed at 24 years of age. Exploratory variables included demographic and socioeconomic, oral health and dental service payment mode during the life course. Tooth-related variables (type of tooth, material and size of cavity) were also analysed.
Results: Multilevel logistic regression models showed that individuals who were always poor from birth to age 23 [odds ratio (OR) 2.35 (1.38–4.00)] and whose mothers had less years of education at their birth (OR 2.60 (1.44–4.68)) were with unsatisfactory restorations in posterior teeth more often. In addition, caries presence at age 15 (high decayed, missing, filled teeth (DMFT) tertile) (OR 1.95 (1.25–3.03)) and cavities with four or more surfaces (OR 18.67 (9.25–37.68)) were associated with the outcome.
Conclusions: These results show that socioeconomic characteristics of the individuals play an important role in restoration failures, reinforcing the need for preventive dental strategies and public policies to reduce inequalities as a major topic of oral health. In addition, the size of cavity appears as the most important determinant for restoration failure.
Clinical significance: Individual socioeconomic characteristics were associated with failure in posterior restorations in detriment of other clinical variables such as restorative material and type of tooth.

1. Introduction

Although a significant decrease in caries prevalence has been observed in some parts of the world, dental caries remains a public health problem.[1] Caries attack is more frequent in the posterior teeth and direct restorations have been largely employed to replace the lost dental structure because of their low cost, ability to remove less sound dental structures and good clinical performance.[2,3]

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Restoration replacement is one of the most common dental procedures in public and private dental offices, representing a high financial cost for the individual and for the health system. The yearly expenses for the National Health System- NHS (England) only with dental restoration replacement have been estimated to be £173 million.[4]

When evaluating failures in posterior direct restorations, studies have generally focussed on the clinical variables and characteristics related to materials and operators.[5,6] On the other hand, studies that investigate the influence of patient-related factors are very rare, and most of them were conducted in university clinical settings,[7] with a lack of population-based data. In addition, these studies consider tooth restorations as the unit of analysis, drawing erroneous inferences for individual determinants.

From a life-course perspective, health status at any given age is a result not only of current conditions but also of the embodiment of prior living conditions from conception onwards. Secondary caries is one of the most frequent reasons for restoration failure and considering that dental caries is strongly associated with social determinants experienced during the life-course,[1,8] it is plausible that these determinants could influence the longevity of restorations.

The aim of this study was to investigate the association between social determinants experienced during the life course and the quality of posterior restorations placed in young adults. In addition, the influence of clinical aspects was also investigated.

2. Methods

This study was carried out in Pelotas, a medium-sized city located in south Brazil. In 1982, all infants born in the city were identified. The 5914 live-born infants and their mothers were weighed and measured. The mothers were also interviewed. This population was followed up several times and further information is available elsewhere.[9] In 1997, a systematic sample of 27% of the city's census tracts was selected and every household was visited. We interviewed 1076 cohort members. Of these, 900 were randomly selected for the Oral Health Study (OHS-97). In 2006, the 888 adolescents (98.7%) who were evaluated in the OHS-97 were invited to be interviewed and examined for several oral health conditions.[10]

2.1. Tooth-level variables (level 1)

Restorations in posterior teeth were assessed according to: (1) tooth location – molars or premolars; (2) type of cavity – class and number of surfaces; (3) restorative material used – composite or amalgam; (4) estimated time in the mouth – indicated by the individual – up to 5 years or more than 5 years; (5) quality of restoration – satisfactory or unsatisfactory; and (6) reason for failure – secondary caries, fracture, etc. The quality of restorations was directly evaluated in accordance with the modified United States Public Health Services (USPHS) criteria.[11] Restorations were classified as satisfactory (0) when ranked with criterion A or B and unsatisfactory (1) when ranked with criterion C or D (except for secondary caries when B means unsatisfactory). To consider a restoration as unsatisfactory due to staining, this problem must have been associated with other restoration problems such as lack of marginal adaptation or proximal contour.

2.2. Personal-level variables (level 2)

The independent variables were obtained from the different assessments made in this cohort. For maternal schooling at childbirth, the mothers' years of education were considered and categorised into four groups: $\geq$12; 9–11; 5–8 and $\leq$4 years. Family income data were collected in 1982, using five categories of Brazilian minimum wage ($<$1, 1–3, 3.1–6, 6.1–10 and $>$10). Unfortunately, information on the continuous level of income was not available. To classify families into tertiles for the data analyses, it was necessary to regroup the five categories. A principal component analysis was carried out using four variables strongly related to wealth in our sample – delivery care payment mode, schooling, height and mother's skin colour. After this, second and third tertiles were grouped in one category ('not poor'), while the first tertile was referred to as the 'poor' category.[12]

Family income at age 15 and 23 were collected in continuous level and the subjects were divided into tertiles. The middle and higher tertiles were merged into a group that was deemed 'not-poor', while the lower tertile was designated as 'poor'. We performed group-based trajectory analysis to estimate the family income trajectory groups.[13] The combination of this classification resulted in four different family income trajectories from birth to 23 years of age: (1) those who were always poor; (2) those who were never poor; (3) those who were poor at birth and 'not-poor' later on (upwardly mobile) and (4) those who were 'not-poor' at birth and then became poor (downwardly mobile).

Dental service payment mode (out-of-pocket, public-free or private health insurance) was verified at 15 years of age. Dental caries at age 15 was determined by the decayed, missing, filled teeth (DMFT) index[14] but, as the outcome of the study was restoration failures (unsatisfactory restorations), only the component D (decayed), which was divided into tertiles, was taken into account.

The fieldwork team was comprised of six dentists and four advanced dental students from the Federal University of Pelotas (UFPel), who were trained and evaluated following previously described methodology.[15] Examiner reliabilities were calculated and the lowest kappa value for the quality of restorations was 0.70. For data quality control, 10% of the interviews were repeated by telephone with a short version of the questionnaire.

2.3. Data analysis

The software STATA version 11.0 was used for the analysis. Descriptive analyses were carried out to assess the distribution of posterior restorations by independent variables. Associations between variables were tested using the chi-squared test and chi-squared test for linear trends when appropriate. To determine the factors associated with unsatisfactory posterior restorations, a multilevel analysis model was used to adjust the results considering the effects of

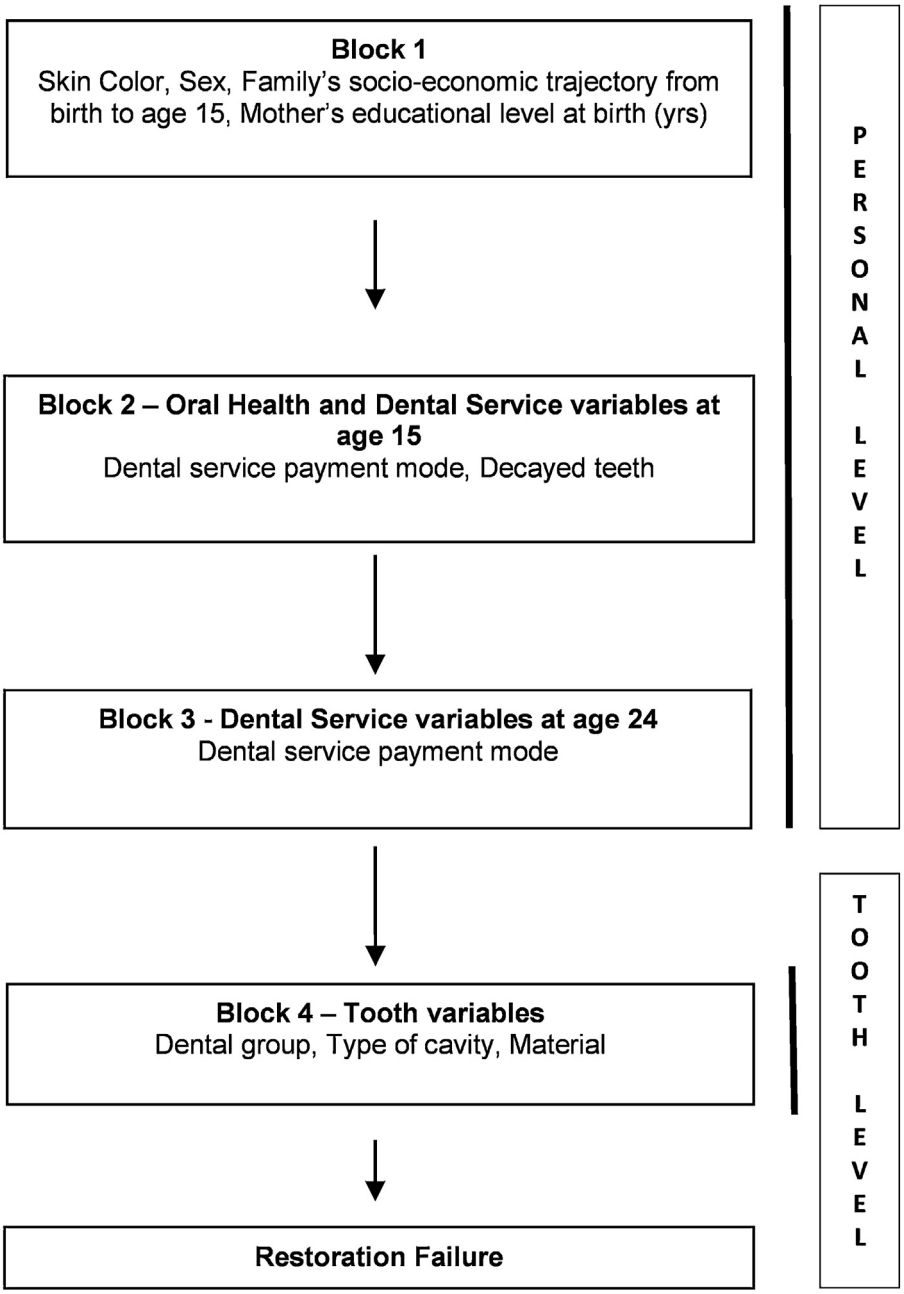

Fig. 1 – Theoretical model for analysis of failure in posterior restorations and independent variables from personal and tooth levels.

variables from both individual and tooth levels. Logistic multilevel regression was used in a way to take into account two levels of data organisation: the teeth (level 1) and the person (level 2). Variability at levels 1 and 2 was represented in the model as random coefficients. Model selection was carried out using deviance-based significance testing.

A theoretical model was adopted for multilevel analysis (Fig. 1), where independent variables were ordered by their levels in four blocks to determine their entrance into the multivariable model. Demographic and socioeconomic variables were placed in the most distal position in relation to the outcome, followed by variables related to oral health and dental service utilisation at age 15. Tooth-level variables were positioned in a different block as proximal determinants of restoration failures. All associations were adjusted for covariates positioned in the same and in the upper levels of the model. In addition, socioeconomic variables were also adjusted by tooth-level variables.

2.4. *Ethical issues*

This project was approved by the UFPel Ethics Committee. All the examinations and interviews were performed with individual authorisation after participants signed informed

consent forms. Individuals with treatment needs were referred to the Dental Clinic of the Graduate Program in Dentistry, Federal University of Pelotas.

3. Results

A total of 720 individuals were examined dentally (a response rate of 80% of OHS-97). Table 1 describes the sample population and the prevalence of restorations according to personal-level variables. Restorations were observed in 503 (69.9%) of the individuals at age 24, totalising 2135 restorations. Women presented a greater prevalence of restorations in posterior teeth. In addition, the prevalence of restorations decreased in individuals who were always poor from birth to age 23, whose mothers had less education and in people who had used public-free dental service in last 12 months at age 15.

Table 2 shows the results of bivariate analysis for the association between restoration failures and variables from individual and tooth levels. The number of unsatisfactory restorations was greater among individuals who were consistently poor from birth to age 23. Furthermore, children (1) from mothers with less years of education at childbirth; (2) who presented a great number of decayed teeth at age 15; and (3) accessed free public dental service in the last 12 months at age 15 also presented more unsatisfactory posterior restorations. Restoration or tooth fracture was the main reason for failures (54.9% (48.3, 61.4)), followed by dental caries (17.0 (12.4, 22.4)). From tooth-level variables, the number of unsatisfactory restorations increased with increasing the number of surfaces of restoration. In addition, composite restorations presented more failures than amalgam restorations.

The results of crude and adjusted logistic regression multilevel models are displayed in Table 3, which presents odds ratios (ORs) separately for each level of our conceptual model. After adjustment, the number of decayed teeth at age 15, the size of the cavity, mother's educational level at participants' birth and socioeconomic trajectory from birth to age 23 were associated with unsatisfactory restorations. Individuals who had more than five decayed teeth at age 15 presented odds of failure that were nearly twice as large as those who presented up to one decayed tooth. In addition, class II restorations with four or more surfaces presented an OR of 18.7 when compared with class I restorations with one surface. Even after adjustment for tooth-level variables, the odds of unsatisfactory restorations were 2.6 greater in individuals whose mothers has less years of education at their birth and 2.4 greater in individuals who were always poor in comparison with those who had never experienced poverty.

4. Discussion

In the present study, the socioeconomic trajectory from birth to age 23, the mother's educational level at birth, the presence of decayed teeth at age 15 and the size of the cavity remained

Table 1 – Presence of posterior restorations by socio-economic, oral health, and dental service utilisation variables in a sample of young adults of 24 years of age in Pelotas, RS, Brazil (n = 720 individuals).

Variable/category	Presence of restoration		Total sample	
	N (%)	95% CI	N (%)	95% CI
Total	503 (69.9)	66.4, 73.2	720	
Level 2 – personal				
Block 1				
Sex*				
Male	247 (65.9)	62.2, 69.3	375 (52.8)	49.0, 56.4
Female	251 (74.9)	71.5, 78.0	335 (47.2)	43.5, 50.9
Family's socio-economic trajectory from birth to age 23**				
Never poor	271 (81.6)	78.6, 84.4	332 (46.1)	42.4, 49.8
Downwardly mobile	96 (73.3)	69.9, 76.5	131 (18.2)	15.4, 21.2
Upwardly mobile	63 (67.0)	63.4, 70.4	94 (13.1)	10.7, 15.7
Always poor	73 (44.8)	41.2, 48.6	163 (22.6)	19.6, 25.9
Mother's educational level at birth (years)**				
≥12	73 (83.9)	81.0, 86.5	87 (12.3)	10.0, 15.0
9–11	60 (81.1)	78.1, 83.9	74 (10.5)	8.4, 13.0
5–8	228 (71.7)	68.2, 74.9	318 (44.9)	41.2, 48.6
0–4	135 (59.0)	55.3, 62.6	229 (32.3)	29.0, 35.9
Block 2				
Dental service payment mode at age 15*				
Out-of-pocket	161 (83.4)	80.4, 86.0	193 (29.8)	26.5, 33.3
Private health insurance	155 (86.6)	84.0, 89.1	179 (27.7)	24.4, 31.1
Public free	165 (60.0)	56.3, 63.6	275 (42.5)	38.9, 46.9
D (decayed) at age 15 (tertiles)				
0–1	205 (70.7)	67.2, 74.0	290 (40.9)	37.2, 44.5
2–4	180 (73.8)	70.4, 76.9	244 (34.4)	31.0, 38.0
≥5	113 (64.2)	60.5, 67.7	176 (24.8)	21.7, 28.2

* $P < 0.001$ for Chi-square test.
** $P < 0.001$ for Chi-square test for linear trend.

Table 2 – Association between unsatisfactory posterior restorations and socio-economic, dental service utilisation, oral health, and tooth variables in a sample of young adults of 24 years of age in Pelotas, RS, Brazil. Bivariate analysis (*n* = 503 individuals; 2135 restorations)).

Variable/category	Classification of restoration, *n* (%)		
	Satisfactory	Unsatisfactory	P value
Level 2 – personal			
Sex			0.453
Male	878 (89.87)	99 (10.13)	
Female	1029 (88.86)	129 (11.14)	
Family's socio-economic trajectory from birth to age 23			0.002
Never poor	1166 (90.32)	125 (9.68)	
Downwardly mobile	378 (90.87)	38 (9.13)	
Upwardly mobile	202 (87.07)	30 (12.93)	
Always poor	184 (83.26)	37 (16.74)	
Mother's educational level at birth (years)			≤0.001
≥12	376 (92.61)	30 (7.39)	
11-September	237 (88.43)	31 (11.57)	
8-May	879 (89.88)	99 (10.12)	
0–4	406 (85.84)	67 (14.16)	
Block 2			
Dental service payment mode at age 15			0.025
Out-of-pocket	723 (91.75)	65 (8.25)	
Private health insurance	646 (88.37)	85 (11.63)	
Public free	509 (87.61)	72 (12.39)	
D (decayed) at age 15 (tertiles)			0.001
0–1	848 (91.48)	80 (8.62)	
2–4	636 (89.45)	75 (10.55)	
≥5	423 (85.28)	73 (14.72)	
Level 1 – restoration			
Block 4			
Dental group			0.490
Pre-molars	346 (90.34)	37 (9.66)	
Molars	1584 (89.14)	193 (10.86)	
Type of cavity (class)			≤0.001
I (1 surface)	1510 (93.50)	105 (6.50)	
I (>1 surface)	121 (87.68)	17 (12.32)	
II (1 proximal surface)	227 (80.50)	55 (19.50)	
II (3 surfaces)	42 (60.87)	27 (39.13)	
II (≥4 surfaces)	29 (52.73)	26 (47.27)	
Material			0.034
Amalgam	1094 (90.64)	113 (9.36)	
Composite	828 (87.80)	115 (12.20)	
Estimated time in mouth			0.126
Up to 5 years	763 (88.11)	103 (11.89)	
More than 5 years	991 (90.26)	107 (9.74)	

associated with unsatisfactory restorations in posterior teeth in the final model. Variables that are highly valued in clinical research, such as restorative material, lost their significance after adjusted by personal-level variables. These results contradict a variety of studies in dental research, which focus on clinical variables and dental materials' properties, and do not take into consideration in the study design the analysis of important individual aspects. Reinforcing this finding, individual variables were responsible for almost 20% of the total variance in the final model.

The influence of socioeconomics in most health outcomes is well established in the literature.[16] However, this is the first longitudinal study that shows a relationship between socioeconomic characteristics and quality of posterior restorations. Individuals who were always poor from birth to age 23 and lower maternal schooling at childbirth were strongly associated with restoration failures. Until now, when patients were taken into consideration, generally only clinical variables, such as caries risk or presence of bruxism, were considered,[17] reinforcing the relevance and the novelty of the present findings.

The life course perspective appears as the more recently theoretical development to provide an explanation for social inequalities in oral health.[18] From this perspective, advantageous and disadvantageous situations have a cumulative effect during the life course, influencing the risk of developing chronic disease (i.e., dental caries). As secondary caries is one of the most common causes of failures in restorations,[17,19] the association between socioeconomic status and unsatisfactory restorations is not surprising. However, socioeconomic variables kept the association, even after the adjustment for dental caries. Considering that we have not followed up the restorations since they were placed, another explanation could be found in recent studies in Brazil, showing that people

Table 3 – Crude (c) and adjusted (a) odds ratios (OR) for independent variables from tooth and personal levels and unsatisfactory posterior restorations in a sample of young adults of 24 years of age in Pelotas, RS, Brazil. Multilevel analysis (*n* = 503 individuals; 2135 restorations).

Variable/category	OR[a]	95% CI	*P* value	OR[a]	95% CI	*P* value
Level 2 – individual						
Family's socio-economic trajectory from birth to age 23			0.015			0.011[a]
Never poor	1			1		
Downwardly mobile	0.91	0.57, 1.45		0.97	0.58, 1.60	
Upwardly mobile	1.39	0.82, 2.36		1.45	0.82, 2.56	
Always poor	2.01	1.22, 3.30		2.35	1.38, 4.00	
Mother's educational level at participants' birth (years)			0.021			0.004[a]
≥12	1			1		
9–11	1.6	0.84, 3.06		1.95	0.98, 3.89	
5–8	1.31	0.78, 2.19		1.33	0.77, 2.31	
0–4	2.09	1.21, 3.63		2.6	1.44, 4.68	
−2 log likelihood (block 1)					1410.2	
Dental service payment mode at age 15			0.023			–
Out-of-pocket	1			–		
Private health insurance	1.52	0.99, 2.33				
Public free	1.65	1.07, 2.56				
D (decayed) at age 15 (tertiles)			0.002			0.011
0–1	1			1		
2–4	1.34	0.89, 3.01		1.2	0.79, 1.83	
≥5	1.98	1.29, 3.04		1.95	1.25, 3.03	
−2 log likelihood (block 1 + block 2)					1363	
Level 1 – restoration						
Dental group			0.119			–
Pre-molars	1			–		
Molars	1.21	0.81, 1.82				
Type of cavity (class)			<0.001			<0.001
I (1 surface)	1			1		–
I (>1 surface)	2.12	1.16, 3.88		2.20	1.19, 4.09	
II (1 proximal surface)	4.19	2.77, 6.34		4.77	3.13, 7.28	
II (3 surfaces)	12.89	6.87, 24.19		13.97	7.26, 26.88	
II (≥4 surfaces)	17.64	8.76, 35.51		18.67	9.25, 37.68	
Material			0.053			–
Amalgam	1			–		
Composite	1.36	1.00, 1.86				
Estimated time in mouth			0.062			–
Up to 5 years	1			–		
More than 5 years	0.72	0.51, 1.02				
−2 log likelihood (restoration level + individual level)					1223	
rho					19.73%	

[a] Socioeconomic variables were also adjusted by restoration-level variables.

with lower socioeconomic conditions, in addition to having difficulties in the access,[20] do not use dental services regularly.[21] In other words, while restoration failures could probably be quickly repaired in patients among the privileged population, the poorest might not have the same opportunity.

A recent study showed that patients with caries risk presented a decrease in the longevity of tooth restorations,[22] corroborating our findings. Considering that caries levels for groups follow predictable trend lines, 'tracking', if environmental conditions are reasonably stable and where there was no effective intervention,[23] it is expected that individuals with a more significant presence of disease at age 15 have kept a 'sick' trajectory during their lives. As a result, they experience new carious lesions and restoration failures, which likely culminate in tooth loss.[24]

A strong relationship was observed between the size of the cavity and the outcome. Previous studies also reported that the larger the cavity size, the lower the longevity of restorations.[11,19] This factor appears to be one of the most relevant in terms of predicting the longevity of restorations, in detriment to other tooth-level variables. The main reason for failure classification in the present study was restoration or tooth fracture, followed by secondary caries. Restoration or tooth fracture is more prone to occur in teeth presenting larger restorations, since a higher amount of dental structure is removed and the overall resistance of the restored teeth is reduced.[25] Noteworthy, individuals from low socioeconomic or educational levels usually have more caries lesions and less access to oral health service and to preventive strategies.[1,21] As a consequence, when restorative treatment is required, it is expected that they will have cavity preparations with more surfaces involved in the caries process, resulting in larger restorations that tend to fail more.[19]

Early studies comparing amalgam and composite resin showed a higher longevity for amalgam restorations.[3,5] Nevertheless, the improvement in composite resin technology has enhanced the performance of this material in posterior teeth, producing a longevity comparable to amalgam.[26] Following this trend, recent data from this cohort and from other studies have shown in the last decade an increase of both use and teaching of composite in comparison with amalgam.[27–30] In the present study, the overall failure rates for composite and amalgam were 9.36 and 12.20, respectively, and these differences were significant only in the bivariate analysis, losing the significance when multilevel analysis was performed.

The fact that the evaluation of restorations was cross-sectional can be identified as a limitation of the study. Restorations were not followed up since their placement, and our data assume that fillings were all satisfactory in respect to their quality at this moment. Important variables such as type of composite and techniques used in the restorations were neither accessed nor controlled. Although these variables could differ from different social circumstances, most of the clinicians working at public services in Brazil also have a private practice and it is less probable that their professional conducts depend on where they are providing their services. This study is nested in a birth cohort monitored regularly since 1982,[9] providing reliable data about different moments of individuals' life course, and is the first in birth cohorts to assess restorations. However, the main strength of this study is the statistical approach. Multilevel analysis has been largely used to analyse the simultaneous effects of group- and individual-level variables on individual-level outcomes.[31] This approach has been introduced in dentistry more recently, to explore some site-specific natures of periodontal disease.[32] In restorative dentistry, the few articles that analysed individual characteristics and failure in posterior restorations[33] used a single-level analysis, which is based on the assumption that the computational units are independent, leading to incorrect and potentially misleading results, once a patient generally presents more than one restoration in the mouth. Thus, the use of a multilevel statistical approach appears as an important alternative to deal with hierarchical data structure presented when personal- and tooth-level conditions are considered simultaneously.

Data from the last decade reveal that the proportion of resources allocated for oral health varies from 3% to 12.5% of the health budget in several countries.[34] Restorative dental treatment represents a great challenge for public health systems, especially in underdeveloped countries, consuming a large amount of resources allocated to oral health care[35] and the costs tend to increase with the incorporation of more sophisticated technologies and materials. Since restoration replacement represents a significant expenditure for health systems, a minimal intervention policy[36] combined with population studies that collaborate to understand the true reasons for these failures may help to produce long-lasting restorative treatments and ultimately save public resources.[37]

5. Conclusions

Our findings reinforce the need for changing in dental research and dental practice, showing that caries preventive measurements and reduction of social inequities might be more important than the material properties for treatment longevity. Future research in dental restorative treatment should consider these variables when evaluating the longevity of dental treatments.

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