

A school intervention within an oral health promotion program in New Caledonia: Evaluation with a pragmatic approach

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Abstract

Background : The objective of this observational survey was to evaluate after one year, a dental sealants intervention conducted in New Caledonia, within an health promotion program. A greater or at least equivalent impact of the intervention was expected in socially deprived sectors with highest health needs.

Methods : The study population was the schoolchildren, aged 6 years in 2016, who benefited from the dental sealant program (n=2532). The study sample was randomly selected in 2017 from that population (n=550). The children's dental status was evaluated at school and compared with that recorded in 2016 during the sealant intervention allowing the calculation of the retention rates and one year carious increment (Δ DT 1rst molars). Socio-demographic variables (gender, region, public/private school) and conditions of sealants placement (school/dental office, presence of a dental assistant) were recorded. The carious increment was explained using a mixed multiple random-effects regression. A mediation analysis was conducted to assess the respective contributions of the retention rates and the region on caries increment.

Results : The participation rate was very high (89%) and 80% of the dental sealants were present after one year; 30% totally and 60% partially present. Caries increment varied depending on the sealant retention rate as well as on the region (North, South, Islands). The mediation analysis showed that living in a deprived area (The Islands) was a strong determinant for high caries increment particularly when the retention rates were low.

Conclusions : This survey showed a high participation rate and good effectiveness as measured with the one-year retention rates, for a sealant intervention integrated in a large health promotion program. Nevertheless, the program was not effective enough to balance the influence of other health determinants in socially deprived sectors characterized by high dental needs.

Background

Oral diseases remains a major health problem in both developing and developed countries [1]. Indeed, the prevalence of untreated oral conditions is high worldwide. Low-income, socially or medically disadvantaged populations experience higher rates of chronic diseases and this gradient is particularly apparent for oral diseases [2].

New Caledonia (NC) (pop. 245 580 persons) is a French Oceanian overseas territory, with extensive administrative autonomy. The population is a mix of 40% Kanak (indigenous population of New Caledonia), 30% White European (Caledonians and Metropolitans), 10% Polynesian (Wallisians) and South-East Asian or Vanuatu people. The population varies depending on the region, with more Kanak in the North and the Islands and more Polynesians, white Europeans and Asians in the South. Three quarters of the population live in the South, where economic activity is concentrated, and 39% of the population lives in Nouméa city. New Caledonia is one of the richest countries in the South Pacific area

but there are strong social and economic disparities between regions (North, Islands, South) [3]. As an example, the proportion of households with a computer at home varied in 2014 from 37% in the Islands, 53% in the North to 76% in the South.

A study conducted in 2011–2012 has evaluated the dental and weight status of 6, 9 and 12-yr-old children in NC. The prevalence of untreated dental caries was almost 60% among 6- and 9-yr-olds and about 50% among 12-yr-olds. Caries experience was unevenly distributed in the population, with one third of 12-yr-olds having more than five untreated carious teeth. The number of carious lesions was related to the unfavourable lifestyle, deprived social status and no preventive dental care [4]. Prevalence of overweight and obesity was high and greatly increasing from 6 years (respectively 10.8% and 7.8%) to 12 years (respectively 22.2% and 20.5 %) with one third of the 12-yr-olds having an excess of abdominal adiposity. Geographical location (region), ethnicity, tooth-brushing frequency and masticatory function were significant risk factors for oral diseases and overweight/obesity [5]. People with the lowest levels of resources also showed difficulties attending for dental care despite the public medical/dental coverage existing in NC.

The study highlighted the need for new strategies aimed at improving children's oral and general health and at reducing inequalities. An alternative approach to traditional health care was thus chosen in collaboration with NC local populations and government, based on the principles of health promotion (OHP) [6] with the development of - 1 - health education in schools in order to promote the adoption of health promoting behaviours [7], 2 - preventive interventions, such as implementation of toothbrushing at school, for the child population, 3 - a reorientation of school dental services towards more effective preventive interventions. The OHP program ("Mes dents, Ma santé") was developed in connection with other health programs related to the prevention of other chronic diseases such as rheumatic heart disease or obesity. The common risk factor approach was thus privileged in order to address risk factors common to those chronic conditions within the context of the local environment [8].

Within this framework, the dental sealant school program existing since 2009 was renewed in order to ensure that all schoolchildren, aged 6 years, can benefit from it. Indeed, dental sealants have been shown to be an effective preventive intervention when evaluated in real life school conditions [9, 10]. The program is now coordinated by the NC health agency in connection with regional educational and health authorities, health fund organisms and private dental practitioners. A standardized protocol was implemented in 2014 in order to ensure the quality and relevance of sealant applications by dentists.

The objective of this survey was to evaluate in 2016–2017, the dental sealants program, by measuring in 6-years-old children the participation and retention rates [11]. The aim was also to appreciate variations in the one-year caries increment depending on children's dental status, sealants' retention rates and social determinants such as the region of origin. Indeed, in order to tackle health inequalities, a greater or at least equivalent effectiveness one is expected in socially deprived sectors with highest health needs as compared to more favoured areas [12].

Methods

Population and study sample

The study population was the schoolchildren aged 6 years in 2016 who benefited from the dental sealant program; the program concerned 4329 children, was effectively offered to 3774 (87%) children and 2532 children participated (89%). The number of children to be selected in the 2017 study sample from that population was calculated to ensure enough precision of the the retention rates (estimated rate = 50%, precision 5%, $n = 385$). This number was increased to 550 considering a participation rate of 75%. Children were randomly selected using a computerised sampling method with a probability proportional to the region size.

Ethics approval and Consent to participate

Ethical approvals were obtained from the NC educational and health institutions. Schools were approached through local educational authorities. Data were recorded in a file registered within the ethical comity for data management (CNIL N° kpP1390145R). Explanatory letters and consent forms were sent to parents prior to the dental examinations and children whose parents returned written consent were examined. In order not to impact negatively the participation rate in the OHP program, it was decided not to collect individual social information nor behavioural ones at this stage.

Sealant program

The age of 6 years has been chosen because school is compulsory since age 6 and in order to allow sealant to be applied on first permanent molars as soon as their erupted. The recommendation for the dentists is to seal all the non-carious or with very early enamel lesions (ICDAS₁), erupted first permanent molars whatever caries risk [13]. Caries risk is very high in NC and it was considered not feasible nor pertinent to differentiate children according to caries risk. Photopolymerised resin sealants were applied with cotton rolls for saliva isolation [14, 15]. Sealants were applied either at school in a mobile dentist 'surgery or in public dental offices.

Study variables

The children's dental status was evaluated in 2017 at school. Radiographs were not used. Six general dental practitioners performed the children's examinations, after having been calibrated through a training course described in a previous study [4].

The presence of dental sealants was recorded. A sealant was considered as totally or partially present using standardised criteria [15]. The number of sealants applied in 2016 was compared with the number of sealants present during the 2017 examination. This allowed the calculation of the retention rates; total (totally or partially present), partial (partially present) and complete retention rate (totally present).

Dental caries were diagnosed at the dentinal threshold level (ICDAS₄₋₆) for deciduous and permanent teeth [16]. The dental status recorded in 2016 during the sealant intervention was compared with that of the 2017 dental examination. This allowed the calculation of the carious increment for first permanent molars: $\Delta DT_{\text{1rst molars}} = DT_{\text{first molars}} \text{ in 2017} - DT_{\text{first molars}} \text{ in 2016}$.

Socio-demographic variables (gender, region, public or private school) were recorded from the school register. The setting where dental sealants were applied in 2016 (school vs dental office) and the presence of a dental assistant during the sealing procedure were also retrieved.

Data analysis

Data entry was duplicated and errors were corrected before analysis. The statistical analyses were performed using the Statistical Package Stata software version 13.

Relationships between caries increment, retention rates, carious status, sealing process and socioeconomic variable (measured by an ecological variable, the region) were explored first using bivariate analysis. Chi-squared (with Rao-Scott correction), F Fisher-Snedecor, ANOVA or Student t-tests were used depending of the variables being considered.

Carious increment was explained using a mixed multiple random-effects regression. Mixed models were used including the examiner parameter as random effect [17–20]. Factors significantly associated with carious increment in bivariate analyses but also non-significant parameters considered as being relevant were integrated in the analyses. The Carious increment was not normally distributed (even with a normality transformation), thus 0-inflated Poisson model a used. The interactions between factors were tested.

We conducted a mediation analysis to assess the respective contributions of the retention rate and the region on caries increment. A mediation proportion was estimated, indicating how much of the whole increment value provided by an independent variable (the region) can be explained by the indirect path in which changes in this independent variable drives a change in the mediator (retention rate), and changes in the mediator then affect outcome [21, 22]. We performed multilevel mediation analysis with other explanatory variables and examiner effect being integrated. Three Models were conducted depending on the region being considered as the reference (A - South, B - Islands C—North). The complete and total

retention rates were considered separately. Results were summarized using a graph giving the proportion of mediation proportion and significance of the mediation analysis associations.

Results

Of the children selected, 81% participated and 459 children were examined. Among the participants, 52% were boys, 84% attended public schools, 9% lived in the Islands area, 29% in the Northern and 62% in the Southern region.

In 2016, caries prevalence was high with non-treated carious lesions in eight children out of ten in the Islands region (Table 1). In the sample, 31% benefited from the sealant program within schools and for 84.9% a dental assistant was present: the Southern region showed a very high rate of sealants set up at school with an assistant. The mean number of sealed teeth was 3.34 (1.01) with 39 children (8%) having had one tooth sealed and 295 (64%) four teeth sealed. Findings showed that 83.0% (95%CI: 79.9%–86.2%) of the dental sealants were present after one year. Among them, 31.1% (27.8%–34.5%) were present totally and 51.9% (48.6%–55.1%) were present partially (Table 1).

In the bivariate analysis, retention rates did not vary depending on the children sex, type of school (private vs public) nor the conditions of sealants placement (dental office vs school, presence of a dental assistant). Dental status in 2017 and 2016 as well as the number of sealants applied in 2016 did not influence retention rates. On the contrary, retention rates were slightly better in the Northern region (Table 1). Figure 1 shows retention rates and caries increment variations between regions.

In 2017, all children had their 4 first permanent molars erupted with no filling being recorded. It was observed that 63.6% of the children (58.6%–67.7%) had untreated carious lesions on permanent or temporary teeth. The 2017 caries prevalence varied depending on the region. At total, 168 first molars had carious lesions with a mean number of decayed teeth per child of 0.35 (0.84). The mean number of sealants on first permanent molars was 2.82 (1.26) with only 25 children having no sealants and 43% showing all their molars sealed. Carious increment $\Delta DT_{1rst\ molars}$ was 0.18 (0.76) and varied depending on the region with a much higher caries increment in The Islands (Table 1, Figure 1).

The multidimensional model showed that caries increment varied significantly depending on the complete sealant retention rate as well as on the region (Table 2). Children living in the South and North regions and children with a high retention rate experienced less new carious lesions. Child' gender, modalities of sealant application as well as initial dental status were not significant factors. There was a significant examiner effect that was managed by using a mixed multiple random-effects regression. Approximately, the same findings were obtained when considering the total retention rate (Regression Coefficient: -0.54 , 95% CI: -0.74 ; -0.34 , $p < 0,0001$)

A multilevel mediation analysis was performed to evaluate if the retention rate was a mediator of the effect of the region on caries increment. The direct association between the region and caries increment remained significant only in Model B. In models A and C, the retention rate was linked to the region. The

modalities of sealant application significantly influenced that relationship for the 3 models. For model B, the influence of the region increased when retention rate was considered as a mediator. This means that living in the Islands was a strong determinant for high caries increment particularly when the retention rate was low. For models A and C, the retention rate was not a mediator for the relationship between the region and caries increment. The mediator effect was lower for the total retention rate (35%) as compared to the complete retention rate (38%) (Figures 2, 3).

Discussion

The objective of this survey was to evaluate the dental sealants program by measuring the participation and retention rate. Findings showed that participation rate was very high and that after one year 80% of the dental sealants were present; 30% totally and 50% partially present. The aim was also to appreciate the impact of retention rates, social determinants and other explanatory factors on caries increment. Caries increment varied depending on the retention rates as well as on the region. The mediation analysis showed that living in a deprived area was a strong determinant for high caries increment particularly when the retention rates were low.

The notion of retention is capital because the main function of sealants is to form an efficient physical barrier between the enamel surface and oral environment. Thus, retention rates are used as clinical evaluation criteria to measure effectiveness. The total retention rate in this survey is comparable to rates found in other pragmatic studies that have evaluated school sealants program [23–25]. But the complete retention rate observed here (30%) was pretty low as compared to other studies where much higher rates (50–70%) have been found [11, 26–29]. The high proportion of partially present dental sealants could lower the effectiveness of the program in preventing dental caries development [30]. This low rate could be explained by the age of the children whose first molars were erupting at the time of sealant placement or to the fact that all teeth were sealed and not only teeth in high caries risk children.

The evidence of the effect of educational interventions or multi-component school- and community-based interventions is equivocal [12]. In our study, caries increment varied significantly depending on the sealant retention rates as well as on the region and retention rate was a mediator of the relationship between the region and caries increment. This evaluation of the program effect depending of social situation and oral health needs is very important as public health interventions may increase inequalities in the population. The 'inverse prevention law' is stating that those most in need of benefiting from preventive interventions are least likely to receive and benefit from them. Some interventions are successful at improving health across the population but they may increase health inequalities. This can happen when an intervention is of greater benefit to advantaged (lower-risk) groups than to disadvantaged (higher risk) groups [31, 32]. Conversely, some interventions may reduce inequalities, if they are of greater benefit to disadvantaged groups. In this survey, it was demonstrated that the participation rate was very high whatever the region but it was found in the South (the richer region) that sealants were applied mainly at school while they were applied in public dental offices in the poorer sectors. In the Islands, caries prevalence was high in 2016 and caries increment important between 2016

and 2017. The sealant program was not effective enough to help reducing the impact of other risk factors and social determinants. The mediation analysis showed that having a high retention rate was particularly important for the children with high dental needs. Hence, it was possible in our sample to show that a high total number of sealants made a decisive contribution to caries prevention, particularly in deprived areas. These findings were obtained within a short follow up period; the calculation of 2 years (or more) caries increment might have allowed higher impacts to be measured. Moreover, it was not possible to make a comparison with a control group as all 6 years old children are concerned by the program in NC.

Since the Ottawa declaration [6], there have been an expansion of health promotion programs but there is still a need for evidence-based data about their impact. Randomized Clinical Trials are needed but also other type of studies such as pragmatic surveys conducted in real life contexts. Evaluation studies have to be context sensitive to identify what works for whom and to take into account implementation processes, barriers and facilitators to health promotion programs [33]. Health promotion programs are frequently conducted in the school environment. Understanding schools as social complex systems may help adopt more well suited approaches for the diffusion and evaluation of programs in school systems [34]. In the present survey, sealant application procedures and evaluation process were adapted to the local situation. This has limited the theoretical quality of the program and evaluation protocol but, at the same time, this study provides invaluable context sensitive data that help understand what works and for whom within a pragmatic perspective.

The oral health promotion program (OHP) conducted in NC since 2014 has been developed after the identification of oral health needs, but also their recognition by the population and major local stakeholders [35]. The sealant application program that is part of the OHP program has been put in place within the context of routine practice. Existing intervention practices were identified and improvements were facilitated. The sealant intervention has been supported first because it is an evidence-based intervention with solid rationale. Moreover, a user-centred approach was privileged and an interdisciplinary team of researchers, political stakeholders together with health providers were involved in the program. The sealant program was thus integrated in the OHP program as the likelihood of adoption and implementation in daily practice was high. The sealant program was associated to other interventions aimed at modifying other health determinants such as the development of a health education program or the promotion of toothbrushing in schools. Those interventions will be evaluated progressively as soon as their implementation will be completed [36].

Conclusions

This survey showed that it was possible to obtain a high participation rate and good effectiveness as measured with the one-year retention rates, for a school sealant intervention integrated in a large oral health promotion program in NC. This pragmatic survey showed that, in socially deprived sectors, with highest health needs, the success of the intervention have greater impacts on caries increment scores. It was also demonstrated that the sealant program was not effective enough to balance the influence of

other health determinants in socially deprived sectors characterized by high dental needs. This study, even with its methodological limits, provides interesting context sensitive data that help understand what works and for who when implementing complex Health promotion interventions.

Abbreviations

NC: New Caledonia
OHP: Oral Health Promotion program
 $\Delta DT_{1rst\ molars}$: One year caries increment for first permanent molars
ICDAS : International Caries Detection and Assesement System
ICDAS₄₋₆: Untreated carious lesions recorded when dentine is involved
 $DT_{1rst\ molars}$: Number of untreated carious lesions on first permanent molars
CNIL: Comité national Informatique et Liberté (French ethical comity for data management)

Declarations

Ethics approval and consent to participate:

Ethical approvals were obtained from the NC educational and health institutions. Schools were approached through local educational authorities. Data were recorded in a file registered within the ethical comity for data management (CNIL N° kpP1390145R). Explanatory letters and consent forms were sent to parents prior to the dental examinations and children whose parents returned written consent were examined. In order not to impact negatively the participation rate in the OHP program, it was decided not to collect individual social information nor behavioural ones at this stage.

Availability of data and materials

The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

Competing interests

The authors declare that they have no competing interests

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Authors' contributions

HP participated in the conception and the design of the study, in the acquisition and interpretation of data, in drafting and revising the manuscript content and finally approved the version submitted.

BP participated in the analysis and interpretation of data, in drafting and revising the manuscript content and finally she approved the version submitted. EM participated in the design of the study, analysis and interpretation of data, in drafting and revising the manuscript content and finally she approved the version submitted. STJ participated in the conception of the study, the interpretation of the data, in drafting and revising the manuscript content and finally she approved the version submitted. All authors have read and approved the manuscript.

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Tables

Table 1: Description of the study variables, for the whole sample and per region

	Sample	North	Iles	South	p
	n=459	n=132	n=43	n=284	
% of private schools (n=550)	19.3%	32.3%	33.3%	12.9%	P<0001
Number of First molars present in 2016	3.63 (0.81)*	3.64 (0.76)	3.47 (0.88)	3.64 (0.82)	NS
% of children with caries in 2016	63.6%	69.7%	79.0%	58.5%	0.007
(permanent and temporary teeth)					
Number of carious first molars in 2016	0.19 (0.54)	0.20 (0.57)	0.14 (0.41)	0.19 (0.53)	NS
Number of sealants applied in 2016	3.34 (1.01)	3.41 (0.92)	3.21 (1.06)	3.32 (1.03)	NS
% of sealants placed at school	30.9%	44.7%	25.6%	87.0%	<0.001
Presence of a dental assistant (n=444)	84.9%	64.7%	73.2%	95.1%	<0.001
Number of carious first molars in 2017	0.35 (0.84)	0.32 (0.81)	0.65 (0.90)	0.37 (0.84)	0.06
Number of sealants remaining in 2017	2.82 (1.26)	3.08 (1.23)	2.74 (1.36)	2.72 (1.25)	0.03
Partial retention rate	0.52 (0.35)	0.59 (0.38)	0.45 (0.32)	0.50 (0.34)	0.004
Complete retention rate	0.31(0.36)	0.30 (0.36)	0.42 (0.37)	0.30 (0.36)	NS
Total retention rate	0.83 (0.35)	0.89 (0.31)	0.87 (0.45)	0.80 (0.34)	0.02
% of children with caries in 2017	63.6%	61.9%	88.4%	56.4%	<0.001
(permanent and temporary teeth)					
Caries Increment : $\Delta DT_{1rst\ molars}$	0.18 (0.76)	0.12 (0.59)	0.51 (0.83)	0.15 (0.81)	<0.001

n: number of subjects, * mean (standard deviation), p : p value

Table 2: Significant regression coefficients derived from the mixed multiple random-effects regression with one year carious increment ($\Delta DT_{1rst\ molars}$) as dependent variable

$\Delta DT_{1st\ molar}$			
	RC	95% CI	<i>p</i>
Region			
North	-0.30	(-0.61; -0.01)	0.05
South	-0.38	(-0.71; -0.05)	0.02
Islands = reference			
Complete retention	-0.28	(-0.48; -0.08)	0.005

RC : Regression coefficient, 95%CI : Confidence Interval, p : p value,

Explanatory variables integrated in the model : Child's gender. type of school (private vs public). region (islands. north. south). dental status in 2016 (number of first molars and % with carious lesions). conditions of sealant placement (school vs dental office. with or without dental assistant).

Examiner effect. p=0.002

Figures

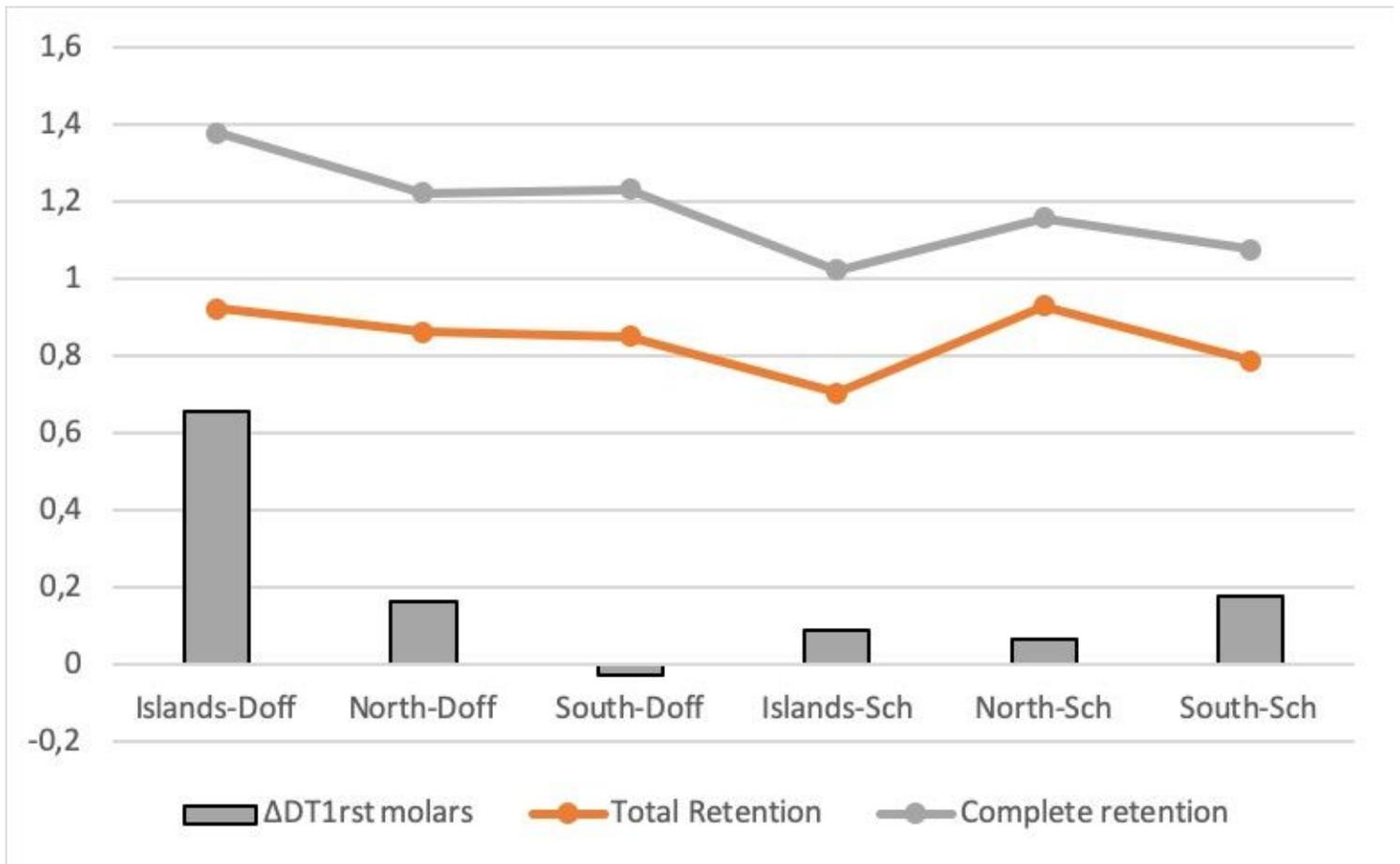


Figure 1

Complete and Total Retention rates and Caries increment depending on the region and setting of sealant placement SCH : school setting. Doff: Dental office setting

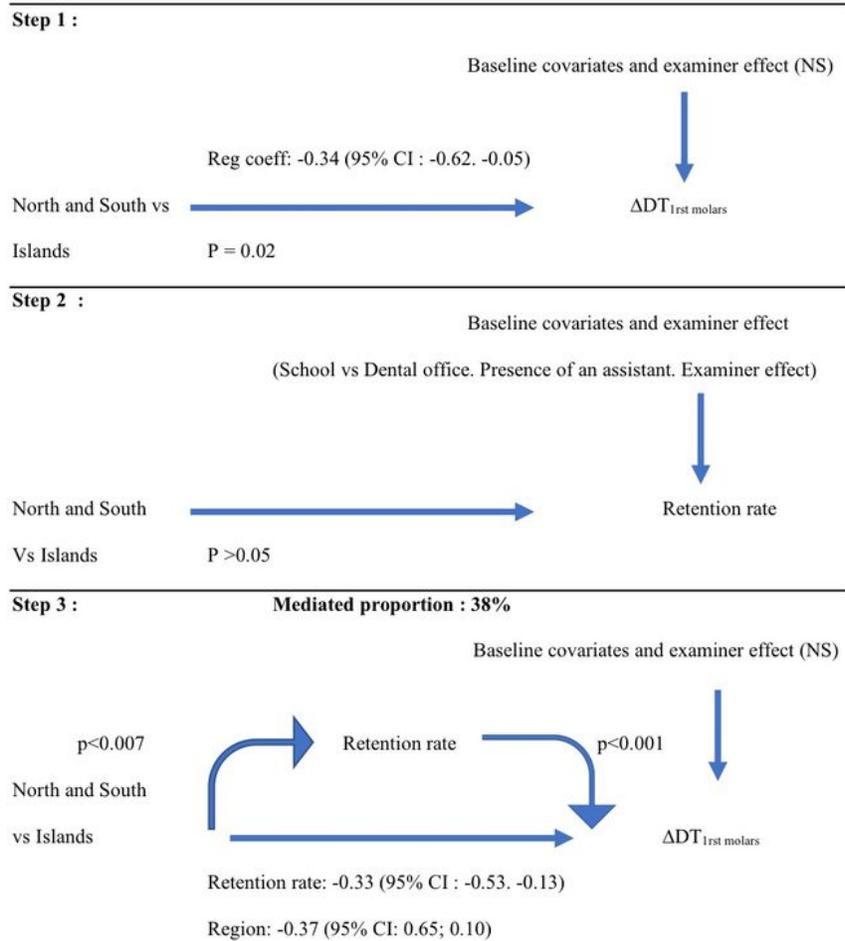


Figure 2

Mediation analysis of Caries increment (Model B) Tested mediator: complete retention rate Independent variable: Region (Model B: the Islands compared to North and South regions) Baseline risk covariates : gender, type of school (Private vs public), dental status in 2016 (number of first molars and % with carious lesions). conditions of sealant placement (school vs dental office. with or without dental assistant), examiner effect ((as random effect). Step 1: the first step in our mediational analysis was the

finding that belonging to the Islands region as compared to the North and South region. had a measurable impact on caries increment after accounting for baseline risk covariates. Step 2: second. we checked if the retention rate (mediator) was related with the region. after accounting for baseline risk covariates. Step 3: finally, a multilinear regression (mixed model) calculated the influence of the region on the tested mediator (retention rate). Subsequently. we jointly calculated the influence of the mediator and the direct effect of the independent variable on caries increment after accounting for baseline risk covariates. This last step shows that retention rate partially mediates [38%. P = for the average causal mediation effect (ACME)] the original effect of the region on caries increment and. consequently. remains directly associated with caries increment in an independent manner. The mediator (retention rate) and the main independent variable (Region) are assessed as binary variables.

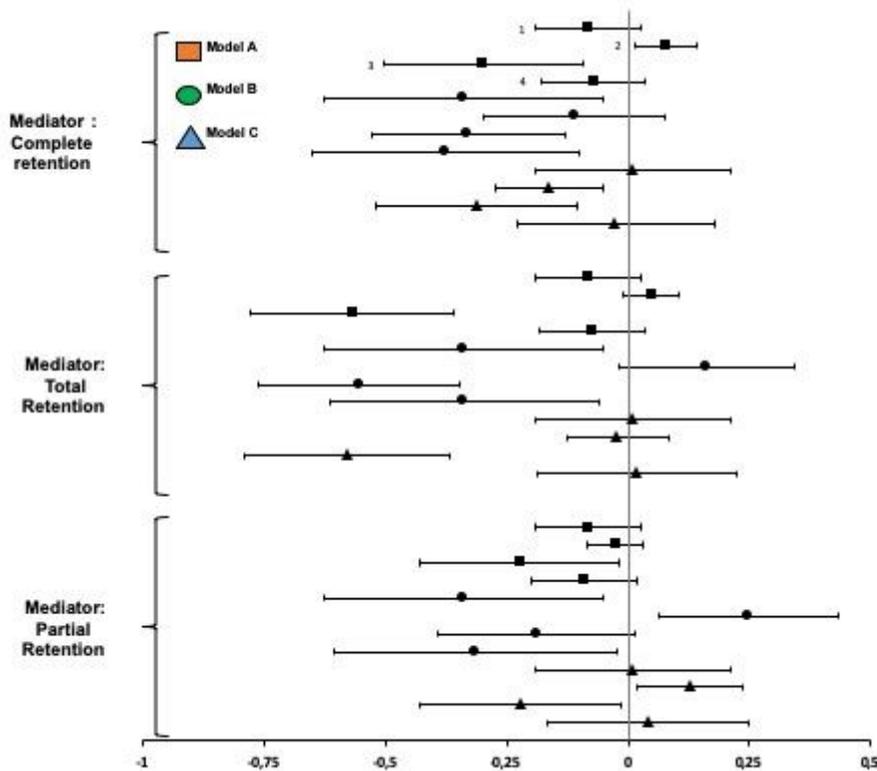


Figure 3

Forest Plot of Mediation analysis for Caries increment Tested mediator: complete, partial and total retention rate Independent variable: Region - Model A : the South compared to the Islands and North regions - Model B : the Islands compared to North and South regions - Model C : The North compared to the Islands and South regions Baseline risk covariates : gender, type of school (Private vs public), dental status in 2016 (number of first molars and % with carious lesions), conditions of sealant placement (school vs dental office. with or without dental assistant), examiner effect (as random effect) Multilinear : Multilinear regression (mixed model) estimated the influence of the mediator and the direct effect of the independent variable on caries increment after accounting for baseline risk covariates. For each Model and Each type of mediator (retention rates), the comparisons plots are ranked from the top to the bottom

as follow : 1 - Region on caries increment, 2 - Region on retention rate, 3 - Retention rate on caries increment, 4 - Multilinear regression