

# Comparative evaluation of shear bond strength to dentin with three different aesthetic chemically bonded restorative materials – an *In-vitro* study

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## ABSTRACT

### Introduction

The use of glass ionomer cements (GIC) as a restorative material was limited to areas of low masticatory forces due to their low mechanical properties which were also affected by the powder/liquid mixing ratio of this material. Bond strength is important for the clinical success of adhesive material. The shear bond strength (SBS) is the maximum force that an adhesive joint can tolerate before fracture which is tested by SBS tests. The high bond strength helps the adhesive to resist stresses caused by resin contraction and forces for a longer time and thus prevents the problems of bond failure such as recurrent caries, tooth sensitivity

and restoration failure. GIC as a restorative material has the capacity to release fluoride and shows good bonding ability. The use of GIC in anterior applications appears to be satisfactory, but they have limitations for use in permanent posterior teeth, particularly with regard to large restorations. Zirconia-reinforced GI (Zirconomer, Shofu Inc, Japan) is a new class of restorative material containing reinforced glass ionomer with special zirconia fillers that promises the strength and durability of amalgam with the protective benefits of glass ionomer while eliminating the hazards of mercury. Amalomer CR (Advanced Health Care, Tonbridge, Kent, UK), a novel ceramic-reinforced GIC, was introduced, which combines the benefits of GIC with the high strength of ceramics. In the present study, shear bond strength to the dentin with Zirconomer, Amalomer CR and Fuji type IX GIC (GC Tokyo) are compared.

### Aim

To evaluate the shear bond strength of three different aesthetic materials to dentin.

### Methodology

Thirty extracted human molar teeth were taken, cleaned, stored and the occlusal surfaces of the teeth were flattened with a straight fissured bur at a depth of three millimetres until dentin was exposed. Acrylic blocks were prepared by cold cure acrylic resin and the samples were embedded into the blocks and conditioning of dentin was done using dentin conditioner (GC Corporation Tokyo, Japan). Out of 30 dentin-exposed samples, 10 samples were restored with Zirconomer, the other 10 with Amalomer CR and the remaining 10 with GIC respectively. All the specimens were transferred to the universal testing machine individually and subjected to shear bond strength analysis.

### Result

Statistical analysis was done for all three groups by using descriptive statistics that include one-way ANOVA and Tukey's multiple post hoc procedures for intergroup comparison.

### Conclusion

Zirconomer showed better shear bond strength than Amalomer CR and GIC.

### Keywords

Zirconomer, Amalomer CR, glass ionomer cement, shear bond strength.

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## INTRODUCTION

The most common cause of tooth loss is dental caries which impairs the structure and function of the particular tooth.<sup>1</sup> This lost tooth structure is restored with restorative materials that regain aesthetic, functional and biological properties.<sup>2</sup> The need for restorative material with better adhesion and strength to withstand the stress of masticatory forces led to recent advances in restorative dentistry.<sup>3</sup>

Bond strength is one of the most important mechanical properties of a restorative material which restores the tooth structure in the posterior region.<sup>4</sup> Bond strength is defined as the amount of force required to break the connection between a bonded restoration and tooth surface with failure occurring in/near the adhesive interface.<sup>5</sup> Restorative material with poor mechanical properties will adversely affect the longevity of the tooth structure and the restoration, and a premature failure of restoration will. The base for aesthetics is laid by position, contour, texture and colour.<sup>7</sup> In the 1960s composites were used as an alternative to silicate cements and unreinforced methyl methacrylate direct filling resins for the restoration of anterior teeth (Bowen, 1962,1965a) and, in 1972, Wilson and Kent introduced an aesthetic restorative material – glass ionomer cement (GIC).<sup>8</sup> In 1962, Bowen developed the Bis-GMA monomer in an attempt to improve the physical properties of acrylic resins, as their monomers only allowed linear chain polymers to be formed. These early chemically cured composites required the base paste to be mixed with the catalyst, leading to problems with the proportions, mixing process and colour stability.<sup>9</sup> In 1970, composite materials polymerised by electromagnetic radiation appeared, doing away with mixing and its drawbacks.<sup>10</sup> GIC material bonds directly to teeth by chemical adhesion and also has a remineralising capacity because of fluoride content.<sup>11</sup> Since GIC has some disadvantages including lack of hardness and fracture resistance, low abrasion resistance and moisture sensitivity, many new aesthetic restorative materials were introduced with improved mechanical properties.<sup>12</sup>

Recently, a novel material called zirconia-reinforced glass ionomer cement was introduced which is also called “white amalgam” or “Zirconomer” and contains zirconium oxide, glass powder, tartaric acid (1-10%), polyacrylic acid (20-50%) and deionised water as its liquid.<sup>13</sup> In the early 1990s, zirconia was used in endodontic posts, implant abutments and hard framework cores for crowns and fixed partial dentures (FPDs).<sup>14</sup> Amalgomer CR, a novel ceramic-reinforced GIC, was introduced in the 2000s.<sup>15</sup> This tooth-coloured cement combines the benefits of glass ionomer cement with the high strength of ceramics.<sup>16</sup> The mechanism of bonding of Zirconomer and Amalgomer CR with the dentin is chemical in nature, thus lacking the reinforcement of bond with micromechanical interlocking.<sup>17</sup>

There are many in vitro studies and clinical trials conducted on the compressive and flexural strength of these materials but very few studies were done on shear bond strength. So, in the present study, the shear bond strength of dentin with Zirconomer (Shofu, Japan), Amalgomer CR and glass ionomer cements (GC Corp)

## MATERIALS AND METHODS

### Sample collection

#### Inclusion criteria

Thirty caries-free upper and lower permanent human molars that were extracted for periodontal reasons were collected, cleaned and then stored in distilled water until used for the study.

#### Exclusion criteria

Teeth with previous restorations, visible cracks, decay, fracture, abrasion or structural deformities.

#### Sample preparation

Teeth were mounted on self-cure acrylic blocks by using metal molds to embed the root portion and to expose the crown portion only. Then 3mm of the coronal tooth structure was removed using a diamond abrasive to expose the occlusal dentine. (Figure 1a). Teeth were randomly divided into three groups of 10 specimens each and restored as follows: Group 1: Zirconomer (Zirconomer improved-Zirconia reinforced glass ionomer cement, Shofu, Japan) (n=10), Group 2: Amalgomer CR (n=10) and Group 3: Glass Ionomer Cement (GC Corporation, Tokyo, Japan) (n=10). Conditioning of dentin was done to all the samples using a dentin conditioner (GC Corporation Tokyo, Japan) that contained 10% polyacrylic acid for 10 seconds. The surface was rinsed thoroughly with water and then blotted with a cotton pellet to remove excess water. Powder and liquid were hand mixed until putty-like consistency in a ratio of 1:1 according to the manufacturer's instructions (Figure 1b,c)<sup>18</sup> and cements were placed onto the occlusal surface using a straw as a template which was cut into dimensions (4mm x 4mm<sup>2</sup>) (Figure 1d).<sup>19</sup>

#### Experimental procedure

A universal testing machine was used to evaluate the shear bond strength, whereby the crosshead speed was 0.5mm/minute<sup>1</sup> and the load applied was 1kilonewton for all the samples. The shear bond strength of all samples was obtained and checked for statistical analysis (Figure 1e).

## RESULTS

Data were analysed using SPSS Version 20.0 with descriptive statistics that include one-way ANOVA and Tukey's multiple post hoc procedures for intergroup comparison. Statistical analysis was done for evaluating the bond strength. Table 1 shows the mean and standard deviation of shear bond strength values of different experimental groups. Group 1 showed the highest shear bond strength followed by Groups 2 and 3 (Graph 1). In Table 2, the shear bond strength of Zirconomer to dentin showed a statistically significant difference with Amalgomer CR and GIC ( $p < 0.001$ ).

Table 1: Descriptives: Mean and SD for all groups

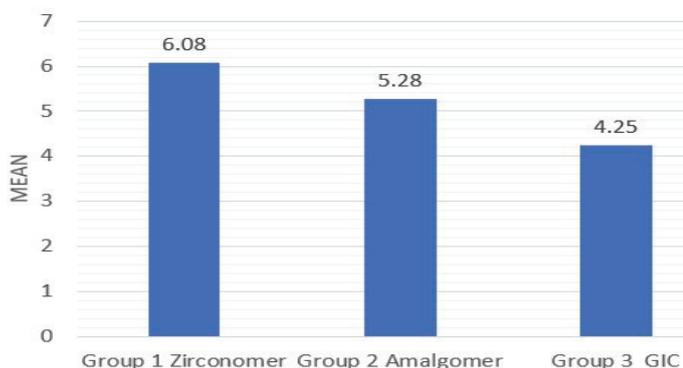
	Group 1	Group 2	Group 3
Group 1	-	0.003 (S)	0.000 (S)
Group 2	0.003 (S)	-	0.000 (S)

P-value is <0.001\*

## DISCUSSION

In the oral cavity, restorations undergo stress from masticatory forces producing different reactions that lead to deformation, which can ultimately compromise their

Table 2: P-value Tukey's post hoc test for pair-wise comparison



durability over time.<sup>20</sup> The selection of restorative material is mainly based on mechanical properties and manipulation.<sup>21</sup>

Among various mechanical properties, the bond strength of restorative materials is important because it usually replaces a large bulk of tooth structure and should give enough strength to resist the intraoral masticatory forces.<sup>22</sup>

The clinical success of restorative materials depends on good adhesion with tooth surfaces and resistance to various dislodging forces acting within the oral cavity.<sup>23</sup> The shear bond strength is described as the resistance to forces that slides restorative material past tooth structure.<sup>24</sup> It is assumed to have greater clinical importance because the most dislodging forces at the tooth restoration interface have a shearing effect.<sup>19</sup> Therefore, high shear bond strength shows better bonding of the restorative material to the tooth.<sup>25</sup> Many aesthetic materials like Zirconomer, Amalgomer CR and so on were introduced for better mechanical properties.<sup>26</sup>

In the present study, Zirconomer showed better SBS than Amalgomer CR and GIC. Zirconomer possibly exhibited superior

bond strength as the powder has various grain sizes and other ingredients such as yttrium oxide and alumina that are evenly dispersed throughout the substance. The material's porosity and translucency are influenced by the different grain sizes. This is in correspondence with the study done by Chalissery *et al.*<sup>14</sup> It showed improved resistance to erosion and abrasion, which is attributable to the cement's strength being derived from the ongoing development of aluminium salt bridges.<sup>27</sup> Zirconia is recognised as being a good material for strengthening and toughening in several contexts due to the special character of phase shift from tetragonal phase to monoclinic phase under stress.<sup>28</sup> This transformation produces a 4% change of volume which generates local compressive stress, which then offsets crack opening tension and so inhibits crack propagation and increases the incorporating material's fracture resistance.<sup>29</sup>

In the present study, Amalgomer CR showed better SBS than GIC but less SBS than Zirconomer. According to S Srinivasa Murthy *et al.*,<sup>30</sup> micronisation of the main glass components in the Amalgomer CR powder caused an increase in tensile strength, flexural strength and fracture toughness than those of conventional GICs and these properties could have made Amalgomer CR more resistant to shear stress.<sup>31</sup>

GIC showed less SBS than Zirconomer and Amalgomer CR because of its inferior mechanical properties such as low fracture toughness, tensile strength and brittleness when compared to other restorative materials and so it is better to avoid GIC in stress-bearing areas.<sup>23</sup> The bond strength tests for GICs cannot always express the interface bond strength as they report cohesive failures within the material, limiting the results to material strength.<sup>26</sup> The composition of GIC consists of powder: silica, alumina, aluminium fluoride, calcium fluoride, sodium fluoride and aluminium phosphate. Liquid: polyacrylic acid. The powder/liquid (P/L) ratio is one of the factors indicated in altering the mechanical properties of GICs; the higher amount of powder, the higher the mechanical properties.<sup>32</sup> The reason for less SBS than Zirconomer and Amalgomer CR is a modification of the powder composition

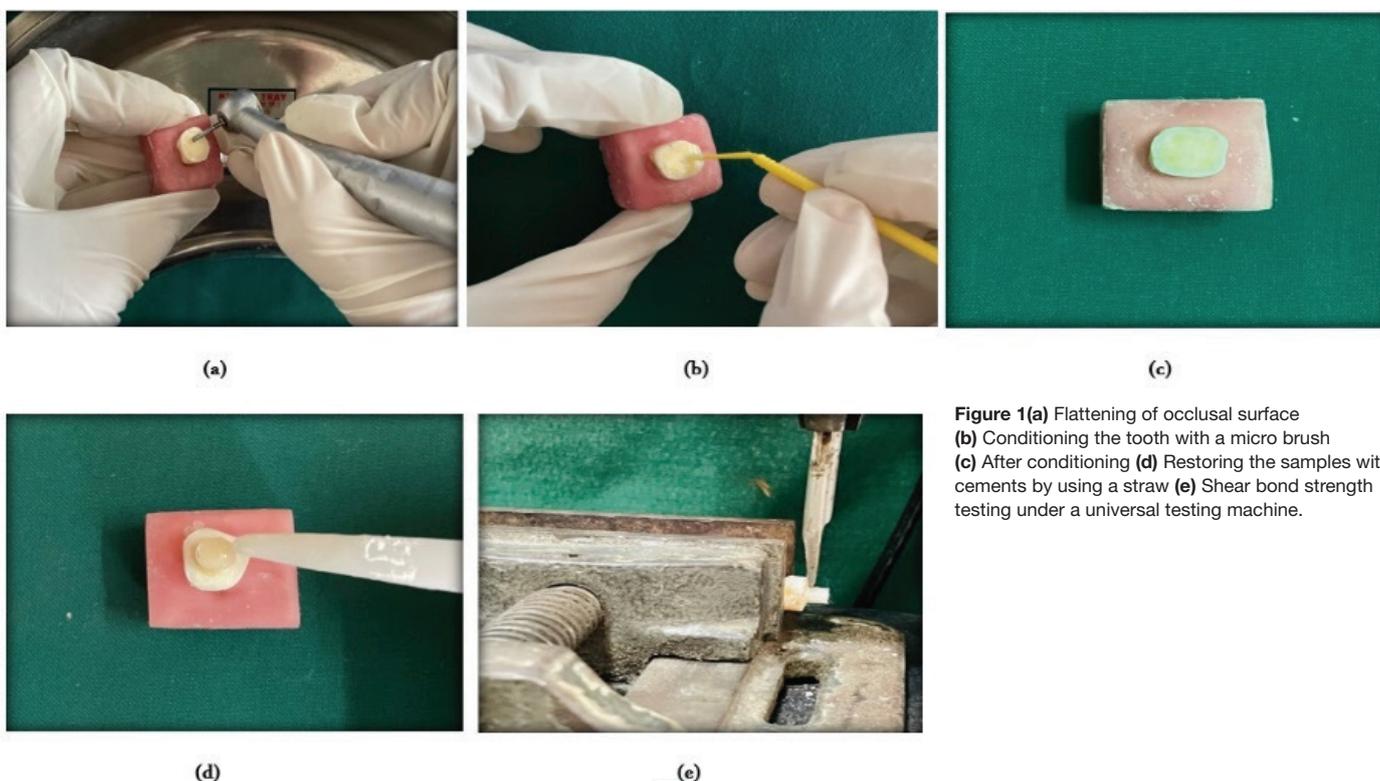


Figure 1 (a) Flattening of occlusal surface (b) Conditioning the tooth with a micro brush (c) After conditioning (d) Restoring the samples with cements by using a straw (e) Shear bond strength testing under a universal testing machine.

of GIC. The bonding strength of Zirconomer was increased by adding zirconia filler particles to the glass component of GIC.<sup>18</sup> Amalgomer CR powder includes a particulate ceramic component to increase its strength, supposedly without sacrificing the appearance or other general characteristics of GIC.<sup>33</sup> The manufacturer of Amalgomer CR claims the ceramic filler can partially react with the matrix to provide some bonding, increasing the overall strength of the restoration.<sup>34</sup>

## CONCLUSION

- Within the limitations of the in vitro study, all groups showed good shear bond strength with dentin.
- So, in comparison: Group 1 – Zirconomer showed the highest SBS followed by Group 2 – Amalgomer CR, and then with the least SBS is Group 3 – GIC.

## ACKNOWLEDGMENTS

### Conflict of interest

None

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## CPD questionnaire on page 56

The Continuing Professional Development (CPD) section provides for twenty general questions and five ethics questions. The section provides members with a valuable source of CPD points whilst also achieving the objective of CPD, to assure continuing education. The importance of continuing professional development should not be underestimated, it is a career-long obligation for practicing professionals.



# Oral health care service delivery in schools for special needs in eThekweni District, KwaZulu-Natal

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## ABSTRACT

### Introduction

Caries and gingival disease are prevalent oral health issues affecting more than 80% of school-going children including those with special needs attending special schools. Schools play a crucial role in promoting oral health, providing education and identifying issues early. These school-based health programmes are essential for addressing these issues and can reach more than 1 billion children worldwide, as well as school staff, families and the community.

### Aims and objectives

To determine the current delivery of oral health care programmes in the identified special schools by means of a semi-structured interview with school managers.

### Design

A descriptive qualitative study design.

### Methods

All school managers (principals) who were responsible for the facilitation of the implementation and delivery of oral health services in each of the 22 special schools were invited to participation in the study. Purposive sampling was used to select the managers at the various special schools. Data collection comprised face-to-face, semi-structured interviews to explore the specific provision of oral health-related interventions and programmes (1 interview was conducted per school, n=22).

## Results

Six emergent themes were present in the study: oral health activities, implementation and evaluation process, implementation challenges, policy content perceptions, dental examinations and oral health prevalence in special schools. Oral hygiene was identified as a priority, with educators and school nurses responsible for school oral health education, supervised teeth brushing programme, pain management, oral examinations in some cases and referral for dental treatments through engaging parents, learners and health workers in oral health promotion, which was supported by the school's health policy with the departmental heads responsible for programme evaluation. However, the implementation of the programmes was impacted by five factors: lack of parental support, lack of professional guidance, lack of resources, lack of support from the oral health department and the Covid-19 pandemic further exacerbated these challenges.

## Conclusion

The study reveals that special schools have preventative and promotive oral health programmes, but they need therapeutic or curative services to address unmet treatment needs. Factors affecting these programmes have led to gaps in implementation processes. Together, these findings point to an urgent need for a review of oral health care programmes in KwaZulu-Natal special schools to ensure proper support and collaboration between key stakeholders to reduce negative effects and improve overall oral health programmes.

## INTRODUCTION

Every day, learners with special needs deal with the negative effects of each of their unique disabilities, including the manner in which these effects impact their oral health.<sup>1</sup> The South African National Oral Health Policy, which presents measures to address learners' oral health needs in school settings, the Integrated School Health Policy document (2012) and the School Health Policy and Implementation Guidelines (2011) all suggest that learners' oral health needs are to be identified and addressed through targeted services offered to specific age groups.<sup>2-6</sup> These include oral health screening, fissure sealant placement on permanent molar teeth, fluoride varnish treatments and the administration of Atraumatic Restorative Technique (ART).<sup>7</sup>

Oral health-related problems, namely caries and gingival disease, are among the most widespread conditions in the human population, affecting more than 80% of school-going children. This has been noted in the special schools as well. A study conducted in Turkey reported 84% of decayed teeth among individuals with disabilities.<sup>8</sup> Furthermore, the oral hygiene status of participants was poor, with heavy plaque accumulation found in approximately one in three subjects.<sup>8</sup> The results reported that people with intellectual disabilities

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### Author's contribution

1. S Gumede – study conceptualisation, data analysis, manuscript preparation, writing and final editing (60%)
2. S Singh – data analysis, manuscript preparation and editing (20%)
3. M Radebe – data analysis, manuscript preparation and editing (20%)

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### Conflict of interest

The authors declare that there is no conflict of interest.

had poorer oral health. This included greater numbers of tooth extractions, more caries, fewer fillings, greater gingival inflammation, greater rates of edentulism, had less preventative dentistry and poorer access to services when compared to the general population.<sup>9,10</sup> According to a study conducted on children with special health care needs in Ile-Ife, Nigeria, the majority of the decayed teeth were left untreated and 49.0% had progressed to involve the pulp.<sup>11</sup> Contrary to these findings, a study conducted in Johannesburg, South Africa (SA) reported that children with special health care needs had lower caries prevalence compared with the general population. However, they also had higher unmet treatment needs regardless of their type of disability.<sup>12</sup>

Many oral health conditions are preventable and reversible in their early stages.<sup>13</sup> However, there is a lack of reported awareness among learners, parents, caregivers and educators on the causes and prevention of oral disease (particularly in people with special needs). The disability also makes most of these individuals dependent on parents, siblings and caregivers for general care as well as oral hygiene, especially among the young, severely impaired and institutionalised.<sup>14</sup> Most of these caregivers may not have the necessary knowledge to recognise the importance of oral hygiene and proper diet. This lack of knowledge may result in these individuals being pampered with unhealthy food or cariogenic snacks, eventually disregarding oral hygiene practices and failing to seek necessary oral care as recommended.<sup>15</sup> There are 1,179 schools in SA of which 464 (40%) are special needs schools and 14% (64) of those special schools are located in KwaZulu-Natal.<sup>16</sup> Schools are one of the important settings for oral health promotion, oral health education and early identification of oral health-related issues. Schools can reach more than 1 billion children worldwide – this could also involve the school staff, families as well as the community at large.<sup>9</sup> This is normally accomplished through school-based health programmes. SA has recognised the value of school-based interventions that include oral health initiatives.<sup>17</sup> However, the evidence is lesser in special schools.

This iterates the need for preventive measures and improved access and availability of oral health clinical care for children with special needs.<sup>18</sup> The school environment is capable of carrying out combined preventive and promotive oral health programmes provided these are adequately funded with sufficient resources.<sup>17</sup> Therefore, there should be an emphasis on appropriate oral health promotion activities for individuals with special needs. Such activities could include improving the health literacy and quality of care to caregivers, and providing the dental team with specialised training related to special needs dentistry.<sup>19</sup> The school environment as part of the health promotion settings approach, therefore, requires further interrogation to determine the viability of offering such services.

This study is part of a bigger study which aims to determine oral health needs for school-going children with disabilities in KwaZulu-Natal eThekweni district. This will be achieved through a systematic collection of commonly occurring oral health-related epidemiological data, as well as by implementing and evaluating an oral health promotion intervention in selected schools, so as to inform a framework

for oral health care for children with special needs. However, the objective of this paper was to determine the current delivery of oral health care programmes in the identified schools by means of a semi-structured interview with school managers. This was conducted to assess the extent to which oral health care programmes are implemented and evaluated within the special needs schools located in eThekweni district. The study concentrated on these four major categories: Oral health policy, oral health programmes, contextual variables influencing oral health promotion and prevalence of oral conditions.

## METHODS AND MATERIALS

### Study design

An exploratory study design was used for the qualitative data collection of this study.

### Setting

Participants in this study were school managers (principals) chosen from a community of special schools in the eThekweni district, KwaZulu-Natal (KZN), South Africa.

### Study participants

All school principals were invited to participate in the study. These managers were responsible for the facilitation of the implementation and delivery of oral health services in each of the 22 special schools that gave consent to participate in the study.

### Study size

Purposive sampling was used to select the managers at the various special schools. The inclusion criteria included all identified school principals who had been at least employed in the identified special school for a minimum period of one year in order for them to have a clear understanding of how the school runs (n=22).

### Ethical consideration

The study was approved by the University of KwaZulu-Natal's Biomedical Research Ethics Committee (BREC00003814/2022) and ethical procedures were followed to protect data confidentiality. The KZN Department of Education granted the gatekeeper permission to access the study participants.

### Data sources/measurement

Data collection comprised a face-to-face, semi-structured interview with 22 principals who volunteered to participate in the study; one interview was conducted per school. The purpose of the interview was to explore specific oral health priorities of the facilities' provision of health interventions, screening programmes for oral disease identification, policy statements on oral health care, integration of oral health into general healthcare within the primary healthcare (PHC) system and the dietary practice at school. The interview schedule included questions such as: Does the special school have a comprehensive oral health promotion programme? If yes, who is responsible for its implementation? How do budgets affect the implementation and sustainability of the programme? List all oral health services and oral health promotion provided by the facility. Which methods are used to evaluate your oral health promotion programmes? The questions also include further probes such as: What evidence is available in terms of statistical annual reports or

records to prove or support that oral health programmes are included and implemented in the school? and What are the barriers and challenges facing the staff in implementing oral health promotion? which were used to obtain responses in knowledge and comprehension.

For the data collection procedure, interviews were conducted with the identified school principals as per their choice and availability. Informed consent was obtained from all participants before the interview commenced. The audio recording was only done when permission was obtained from the interviewee and after all issues of confidentiality were explained. The researcher was engaging with participants by impartially presenting questions, while paying close attention to participants' responses, for approximately 30 minutes in duration, from August to September 2022. Field notes were made after the interviews.

### Data analysis

Thematic analysis was used to analyse the qualitative data, the analysis was inductive. Responses from interviews were transcribed verbatim and checked for quality. The initial set of codes representing the meaning and patterns were refined and coded. Links were formed between the codes and supporting data, codes were further grouped into themes and the themes were reviewed and revised. The conclusions drawn from the analysed data and the results were then presented as a narrative. The data analysis process was conducted in four stages – finding initial concepts, coding the data, sorting the data by theme and interpreting the data. Trustworthiness was created by ensuring that the questions asked of interviewees were closely related to the study's purpose. Data saturation

occurred during the first 11 interviews, despite the fact that the fundamental components of the meta themes were already present in the first five interviews. Confirmability was established by using actual quotes to convey the opinions of participants. Individual member checking was done through one-on-one conversation verbally throughout the interviews. Techniques such as paraphrasing and summarisation were used to clarify participants' answers. An email was then sent after the interviews were transcribed, asking for feedback on themes from the participants.

### RESULTS

Based on the three groups of interview questions, six themes were developed from the data. The first group focused on oral health programmes, which included three themes: (1) oral health priorities, (2) oral health activities, (3) implementation and evaluation process. These themes highlighted the current oral health programmes offered by special schools as part of oral health education and promotion, by describing the contributions and challenges encountered by schools when raising health awareness to prevent oral conditions and assisting learners in developing oral health care skills, as it involves parents, educators, health workers and the health department. The second group focused on oral health policy, with one theme – perceptions of policy content. This theme analysed policy contributions in oral health, based on the existing oral health policy, policy implementation and policy evaluation. The final group was the oral conditions, which included two themes – dental examinations and prevalence of oral conditions, which highlighted the current state of oral health conditions among learners with special needs attending special schools in KZN.

Groups	Themes	Codes	Illustrative quotes
Oral conditions	Dental examinations	Examination	<i>No, our nurse mostly addresses oral health complaints once there is pain and refers for additional testing and care, so we are reactive in a sense. However, without access to regular check-ups etc, it is difficult to know what interventions are needed (P3). Yes, since we have routine monthly check-ups to assess their general oral health and medication review (P1&amp;5).</i>
	Prevalence of oral conditions	Estimation of conditions	<i>There is generally a relatively moderate prevalence of caries, and low prevalence of periodontitis and gingivitis (P1&amp;5).</i>
		Evidence or oral conditions	<i>All this data is kept by the school sister (medical staff) in each student's health file (P1&amp;5).</i>
Oral health programmes	Oral health priorities	Oral health priorities	<i>Oral hygiene</i>
		Oral health promotion programmes	<i>Yes, tooth brushing programme, oral health education lessons including dietary advice and monthly mouth check-ups (P1). Yes, tooth brushing programme, oral health education lessons (P3).</i>
	Oral health activities	Staff responsible for implementation	<i>Educators, together with their assistants (P3). Medical staff (professional nurse, speech therapist (P1).</i>
		Evidence of oral promotion programmes	<i>Yes, teacher lesson plan (P3) and curriculum (P2). Professional nurse monthly record together with the health file of the learner (P1).</i>
		Evaluation of oral health programmes	<i>Quality management programmes, assessment worksheets (P1&amp;11). Departmental heads (P1).</i>
	Is the programme working?	<i>Yes – the oral health status of students has improved from the time they initially come to the school and we can identify caries early now (P1).</i>	