Potential Use of Chemo-Mechanical Caries Removal as an Innovation for Caries Treatment in Remote Areas: Literature Review

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Abstract. Caries prevalence in Indonesia reached 88.8% and predominantly occurred in a remote areas. Dental caries is a chronic infection of hard tooth tissue that demineralized due to organic acids produced by bacteria. Caries in the dentin layer will cause collagen and other matrices form two zones, infected-dentin and affected-dentin. Infected dentin is essentially removed in the restoration procedure due to its bacterial infiltration mechanically using a bur with a handpiece. Chemo-mechanical Caries Removal (CMCR) itself or incorporated with rotary instruments is an alternative therapy to remove carious tissue and is consistent with the principle of minimal invasion dentistry. This literature aimed to find the potential use of CMCR as an innovative caries treatment in remote areas. The results of this literature are through a scientific literature review from 2011–2021. Based on the previous literature, we can conclude the effectiveness of CMCR in removing carious tissue to prevent the progression of caries severity. CMCR can be brought to bear in adult and pediatric carious tissue removal procedures. CMCR reduces pain and anxiety in children, so it certainly increases the prevalence of children taking caries treatment at the dentist. The utilization of CMCR is potential caries treatment in the region with low socioeconomic levels because of its relatively cheap. CMCR has the potential to succeed in the 2030 Caries Free Indonesia program because of the effectiveness of CMCR in caries tissue removal and the treatment of childhood caries. This literature concludes that CMCR has a lot of applicable potentials to solve caries cases in remote areas and potentially support the success of the 2030 Caries Free Indonesia government program.

Keywords: Caries · Carisolv · Papacarie · Chemomechanical Caries Removal

1 Introduction

Dental caries is a chronic infection when the acid products of bacteria dissolve the hard tissue [1]. Based on WHO data in 2017, caries was the highest case of oral health disease. The highest prevalence occurs in developing countries with low-medium per-capita income. Caries prevalence in Indonesia is 90.5% higher than in other developing countries [2]. According to Riskesdas (Baseline health research) data in 2018, caries prevalence in Indonesia is 88.8%. FDI World Dental Federation explained that some

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causes of caries prevalence are excessive sugar consumption, lack of dental health care, and difficulty accessing standard dental health care facilities. Healthcare facilities carry out promotive, preventive, curative, and rehabilitative treatment held by the local government. Remote areas are hard to reach due to geographical conditions (islands, mountains, land, forests, and swamps), transportation, and social and economic conditions [3].

Based on Iin Nurlinawati (2020), *tooth extraction* is a treatment often chosen in an area with minimal access to healthcare facilities, increasing the number of tooth loss suffered. The principle of caries treatment is to remove carious tissue and fill the cavity with restorative materials to restore the function and aesthetics of the teeth [4]. Chemo-mechanical Caries Removal (CMCR) is a caries removal method by applying a material to the tooth surface, resulting in a chemical reaction that can dissolved infected dentin and retain affected dentin. Furthermore, the infected dentin carious that dissolved is removed mechanically by hand instrument. CMCR is potentially used in areas with minimal healthcare facilities because the procedure does not use electric tools and is plausibly cheap.

1.1 Caries

The etiologies of caries are microbiota, include acid products by cariogenic bacteria on the tooth surface, and host factors include the condition of teeth and saliva and dietary factors [5]. These three factors must influence each other to be able to cause caries. The main bacteria are *Streptococcus mutans, Lactobacillus*, and *Actinomycetes* which have acidogenic and aciduric properties. *Acidogenic* is a bacteria that can produce acid, while *aciduric* is a bacteria that can survive in acidic environment [6]. Saliva acts as a natural antibacterial by maintaining the pH of the oral cavity. The reduced amount of saliva causes an acidic atmosphere which potentially increase caries occurence. Consuming carbohydrate can increase the occurrence of caries because the fermentation products of carbohydrates will be converted by bacteria into organic acids, thereby increasing the attachment of caries bacteria colonization [2].

Enamel is the outermost layer of the tooth, composed of 92–95% inorganic material in the form of *hydroxyapatite crystals.* Beneath the layer of the enamel is dentin. Dentin has a lower inorganic matrix than enamel, which is 70% *hydroxyapatite.* The highest number of organic substances in dentin is type 1 collagen. The pulp chamber under the dentin is a space with blood vessels and nerves extending to the root canal. The root canal is surrounded by dentin and cementum with 50% *hydroxyapatite* and a collagen matrix. Teeth will undergo a continuous process of remineralization and demineralization. The atmosphere in oral affect the process of demineralization and remineralization processes [5].

Caries progression undergoes two stages, there are reversible caries and irreversible caries. Reversible occurs when the remineralization process is higher than demineralization. Irreversible occurs when demineralization is higher than remineralization and cavities are found in the teeth. Early caries phase occurs when the acid product of the bacteria dissolves the mineral substance in the enamel. The initial demineralization of the enamel layer forms an opaque surface known as a ‘white spot.‘ In this phase, the enamel layer can remineralize because *hydroxyapatite crystals* are not completely demineralized. When *hydroxyapatite crystals* demineralize completely, remineralization will

not occur. When caries reach the dentin, the dentinal tubules will provide access for acid attachment, causing demineralization of the dentin [5]. The organic matrix in the dentin will be demineralized, collagen and other matrices will degrade enzymes so it forms two zones on the dentin, namely the infected-dentin and affected-dentin areas. Histologically, dentinal caries divides into some layers, including normal, subtransparent, turbid and infected. The base layer is healthy dentin. The layer above the base layer is subtransparent or transparent. In this layer, there is minimal demineralization where there is still collagen and no bacterial penetration. This layer is also known as affected-dentin caries. The turbid and infected-dentin layers are characterized by damage to the dentinal tubules, collagen decomposition, and bacterial infiltration. Layers with bacterial infiltration of the dentin are called infected-dentin caries [7].

Treatment for caries can be preventive and restorative. In the early stage of caries, preventive procedures are conceivably considered when cavity has not formed yet. The preventive procedure by giving certain materials to increase the remineralization of dental hard tissue, reduce the growth of bacteria, increase plaque pH and instruct patients to improve habits in maintaining dental and oral hygiene [8]. The treatment option for a cavity is a restorative procedure when hard tissue can not be remineralized. The treatment is accomplished after removing demineralized caries and following minimally invasive dental treatment, which focuses on removing infected dentin and preserving as much of the affected dentin as possible. Conventional method accomplished by filling the cavity with restorative materials after removing caries using highspeed bur [9].

1.2 Chemomechanical Caries Removal

Chemomechanical caries removal (CMCR) is a treatment by dissolving carious tissue using chemical agents and removing mechanically. Minimal invasive dentistry in the CMCR method achieved when the materials can selectively dissolve infected dentin without affecting affected dentin [7, 9]. CMCR is divided into two types, that are sodium hypochlorite (NaOCl)-based and enzyme-based. Sodium hypochlorite–based are GK-101, Caridex, and Carisolv. The enzyme-based CMCR agents are Papacarie and Biosolv [10]. GK 101, discovered by Goldman and Kron in 1976 composed of 0.05% N-monochloroglycine (NMG) and NaOCl. Several literature evaluated GK-101 and concluded that GK-101 was inefficient in removing caries, so the formula developed from GK-101 to GK-101E (Caridex). GK-101E consists of an ethyl derivative, N-monochrome-DL2 amino butyrate (NMAB). However, some literature states that removing carious tissue with GK-101E is too time-consuming compared to conventional methods. After being evaluated, GK-101 and GK101E were found to have no significant effect on caries removal compared to conventional methods. In 1998, Carisolv was the newest version of the NaOCl-based CMCR agent, which is currently one of the most widely marketed CMCR agents. The enzyme-based CMCR agent is Papacarie. The main components of Papacarie are papain, chloramine, and toluidine blue. Biosolv is one of the enzyme-based CMCR agents and is still in the testing phase and has not been marketed in general yet. Based on product information, this ingredient contains the enzyme pepsin in phosphoric acid/sodium biphosphate buffer. Previous research stated that the CMCR materials that are often used are Carisolv and Papacarie [7, 11]. CMCR was applied to the cavity using an applicator and stand for 40 s, and a blunt excavator

was used to remove and clean the dissolved dentin. The remaining gel is cleaned with a cotton pellet. When the gel's color remains consistent, it implies that the cavity is caries-free [12].

1.2.1 Carisolv

Carisolv consists of a set of instruments and materials. The instrument is a non-cutting tip to increase efficiency in removing infected dentin and retaining affected dentin. The instrument has right angles to make removing caries easier than conventional excavators. The movement when applying this instrument is a scooping motion [13]. Carisolv materials consist of gel and liquid. Before being put in, the gel and liquid were manipulated until homogeneous. Subsequently, the material is placed on the hand instrument and applied to dental caries, waiting for 30 s and then gently remove the carious tissue. Carisolv needed several times repetitions until there was no caries-infected dentin tissue on the teeth. The total time needed is generally 5–15 min. Carisolv's mechanism in dissolving carious undergoes several stages of destroying fiber tissue in collagen-infected dentin. Carisolv has three amino acids with different charges that allow electrostatic bonding to the carious dentinal protein. All peptide bonds in protein, collagen are formed by hydrophilic (has positive/negative charges) and hydrophobic (does not have electric charges). Each amino acid in Carisolv will bind electrostatically to the protein and produces a chemical process without affecting affected-dentin [14].

1.2.2 Papacarie

Papacarie is patented, registered, and approved by ANVISA *(Brazilian Health Regulatory Agency)* Brazil and available in gel. Papacarie's main composition consists of papain, chloramine, and toluidine blue [9]. *Papain* is an enzyme extracted from the leaves and fruits of ripe green papaya and papaya Carica. Papain is a bactericidal, bacteriostatic, and anti-inflammatory and will not affect healthy tissue. In caries, papain works by cleaving collagen molecules damaged by caries and can eliminate caries-coated fibrin. Chloramine is a compound of chlorine and ammonia, which has bactericidal and disinfectant properties. This material is commonly used as an irrigation solution in root canals and can dissolve dentinal caries. Toluidine blue was originally a coloring agent but proved effective as an antibacterial against *Streptococcus mutans.* The mechanism of Papacarie occurs 30–60 s after being applied. In the necrotic zone of carious tissue, the proteolytic agent papain gel will degrade and eliminate the caries-coated fibrin. Furthermore, papain agents will digest necrotic cells. The degraded collagen will be chlorinated by chloramine, and O_2 will be released and cause a bubbling effect. Hydrogen bonds will be disrupted and affect the secondary and quaternary structures. Afterward the caries will be chemically dissolved and removed with an excavator on the opposite side [9].

2 Method

2.1 Inclusion

2.1.1 Articles published in the range of 2011–2022
2.1.2 Articles using english
2.1.3 Articles that obtained using keywords carisolv, papacarie and chemomechanical caries removal.

2.2 Exclusion

2.2.1 Articles published before 2011
2.2.2 Articles in abstract form or not accessible

2.3 Result of the Literature Review

This article uses a literature review to summarize previous literature correlated with a particular topic from secondary data. The data was obtained through the search for scientific articles in 2011–2021 through Researchgate, Pubmed, NCBI, IJCPD, MPDI, Australian Dental Journal, IOSR-JDMS, BMC Health, JPDA, and European Journal Dentistry. The keywords used are carisolv, papacarie, and chemomechanical caries removal. The articles used in this study are from 24 international journals relevant to the topic.

3 Result and Discussion

Caries is the highest case of oral disease in Indonesia, with a higher incidence in areas with limited healthcare facilities and accessibility. The prevalence of crown caries is higher than root caries. CMCR material selectively removes carious-infected dentin tissue both on the crown and roots. The prevalence of caries in children and adults reaches more than 75%, with the prevalence of going to the dentist higher in adults than in children. CMCR material is effectively used in the treatment of childhood caries, so it can potentially increase the number of children going to the dentist. This literature was obtained from research that conducted by previous researchers regarding CMCR in the range of 2011–2021 as seen in Table 1.

The prevalence of caries in Indonesia is 88.8%, with the incidence of crown caries is higher than root caries. Crown caries occur in the enamel or dentin layer, while root caries are in the cementum or dentin layer [13]. CMCR method has proven effetive removing both crown or root infected caries than the conventional method. Literature by Vartikha et al. state that Carisolv removes carious tissue in roots effectively [15]. Research conducted by Hamdi H. Hamama stated that the removal of caries tissue was more effective in Papacarie than in Carisolv, referring to the remaining bacteria in the crown dentinal tubules after Papacarie was applied less than Carisolv. Literature by Dr. Sivakumar Pydi compared the efficacy of carious tissue removal with Carisolv and the conventional method based on the time of work and the size of the carious tissue removed. Carisolv proved effective in removing carious tissue compared to the

Table 1. Potential use of CMCR in previous literature

No	Title	Author	Year	Publisher	Language	Method	Aim
1.	Evaluation of the Efficiency and Effectiveness of Three Minimally Invasive Methods of Caries Removal	(Boob, Manjula, Reddy, Srilaxmi, & Rani)	2014	IJCPD	English	An in vitro Study	To compare the efficiency (time taken for caries removal) and effectiveness (Knoop hardness number of the remaining dentin) of caries removal by three minimally invasive methods, i.e. Hand excavation and chemomechanical caries removal using Carisolv and Papacarie.
2.	Atraumatic Restorative Treatment and Interim Therapeutic Restoration	(Saber, El-Housseiny, & Alamoud)	2019	MPDI	English	Literature review	This review discusses the techniques and uses of atraumatic restorative treatment (ART) and interim therapeutic restoration (ITR) and states the differences between these two approaches.
3.	Evaluation of the Efficacy of Caries Removal Using Polymer Bur, Stainless Steel Bur, Carisolv, Papacarie	(Divya et al.,)	2015	Journal of Clinical and Diagnostic Research	English	An Invitro Comparative	To evaluate the efficacy and efficiency of Caries removal Using Polymer Bur, Stainless Steel Bur, Carisolv and Papacarie.
4.	A short review: Effectiveness combination with glass ionomer cements and chemo-mechanical caries removal	(Yamada)	2018	J Clin Dentistry Oral Health	English	Literature review	To understand caries treatment effectivity by combining chemomechanical caries removal and glass ionomer cement
5.	Current update of chemomechanical caries removal methods	(H. Hamama, Yiu, & Burrow)	2014	Australian dental journal	English	Literature review	To understand the development of chemomechanical caries removal materials

(*continued*)

Table 1. (*continued*)

No	Title	Author	Year	Publisher	Language	Method	Aim
6.	Effect of chemomechanical caries removal on bonding of resin-modified glass ionomer cement adhesives to caries-affected dentine	(H. H. H. Hamama, Yiu, & Burrow)	2015	Australian dental journal	English		
	Case study and field research	This study evaluated the effect of: chemomechanical caries removal (CMCR); dentine surface treatments and dentine substrates on adhesion of resin-modified glass ionomer cement (RMGIC) adhesives.					
7.	Does chemomechanical caries removal affect restoration survival?	(Stolic)	2015	Malmö University Faculty of Odontology	English		
	Systematic review	This systematic review aimed to summarize randomized controlled trials (rcts) that evaluate the survival rates of restorations, comparing the Carisolv system to hand excavation and/or the conventional drilling method. The aim was also to collect all data in one place to be used for further research					
8.	Caries Removal by Chemomechanical (carisolvtm) and Conventional (Airotor) Methods	(Pydi & RaoV)					

(*continued*)

Table 1. (*continued*)

No	Title	Author	Year	Publisher	Language	Method	Aim
	2015	Journal of Dental and Medical Sciences (IOSR-JDMS)	English	Comparative In-Vitro Study	To compare the caries removal efficacy between chemomechanical method (carisolvtm) and conventional method (airotor) in freshly extracted molars.		
9.	Comparative Evaluation of Microleakage in Restored Primary Molars using Conventional and Chemomechanical Removal of Carious Tissue	(Avula Samatha et al.,)	2016	Journal of Contemporary Dentistry	English	An in vitro Study	To compare the microleakage of primary molars restored with conventional glassionomer cement (GIC) and Giomer after caries removal using conventional cavity preparation (CCP) and chemo-mechanical caries removal (CMCR) techniques.
10.	The impact of minimally invasive restorative techniques on perception of dental pain among pregnant women	(Adham, El Kashlan, Abdelaziz, & Rashad)	2021	BMC oral health	English	A randomized controlled clinical trial	To compare the efectiveness of chemo-mechanical caries removal using
11.	The Assessment of a Minimally Invasive Procedure in the Treatment of Deep Carious Lesions	(Ali, Thani, Foschi, Banerjee, & Mannocci)	2020	King College London Journal	English	In Vivo and In Vitro Studies	To determine the effectiveness of a minimally invasive indirect clinical pulp protection technique in preserving pulp vitality in symptomatic teeth in vivo

(*continued*)

Table 1. (*continued*)

No	Title	Author	Year	Publisher	Language	Method	Aim
12.	Microtensile bond strength of gic and rmgic restored to carious teeth treated with carisolv and papacarie	(Varun, Chamarthi, & Annamalai)	2018	J. Evolution Med. Dent. Sci.	English	An in vitro study	To evaluate the influence of Carisolv and Papacarie on the microtensile bond strength (μtbs) of conventional glass ionomer cement (GIC) and resin modified glass ionomer cement (RMGIC) restored to caries-affected dentin.
13.	Shear bond strength of conventional glass ionomer cement to mechanically treated versus chemomechanically treated dentin	(Shamim, Ullah, & Ali)	2011	JPDA	English	A randomized controlled clinical trial in vivo	To determine the effect of a chemo mechanical caries removal (CMCR) gel Carisolv™ on shear bond strength (SBS) of conventional glass ionomer cement bonded to human permanent dentin
14.	Comparative Evaluation of Mechanical and Chemo-mechanical Methods of Caries Excavation:	(Hegde & Chaudhari)	2016	Journal of International Oral Health	English	An In Vivo Study	To compare the efficacy of caries removal, time taken, pain threshold experienced by the patient and anxiety experienced during various caries removal methods.
15.	Chemomechanical Caries Removal: A Conservative and Pain-Free Approach	(Mithra Hedge et al.,)	2018	JP publisher	English	Literature reviewe	To compare papacarie affectiveness as chemomechanical caries removal than with atraumatic restorative removal
16.	Randomized controlled clinical trial of longterm chemo-mechanical caries removal using papacarietm gel	(Motta et al.,)	2014	J Appl Oral Sci.	English	Randomized controlled clinical trial	Compare the effectiveness of papacarietm gel for the chemo-mechanical removal of carious lesions on primary teeth to conventional caries removal with a low-speed bur with regard to execution time, clinical aspects and radiographic finding

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Table 1. (*continued*)

No	Title	Author	Year	Publisher	Language	Method	Aim
‘**17.**	No Drill Dentistry: A Review of Advances in Non-Rotary Methods of Caries Removal	(Pradnya Bansode)	2018	Journal of medical science and clinical research	English	Literature review	To reviews the newest developments in non-rotary caries excavation techniques and their mechanism of action
18.	Chemomechanical caries removal method versus mechanical caries removal methods in clinical and community-based setting	(Kumar et al.)	2020	European journal dentistry	English	A comparative in vivo study	To compare the effectiveness of various caries removal techniques in mandibular primary molars using Smart Burs, atraumatic restorative technique (ART) (mechanical caries removal) and Carie-care (chemomechanical caries removal [CMCR]) among primary school children in clinical and community-based settings.
19.	Chemomechanical caries removal	(Krishnan, Ganapathy, & Ranjan)	2020	Drug invention today journal	English	Literature review	To understand cmcr development depends on eficacy, time, materials and instruments
20.	Costs and benefts of Papacarie in pediatric dentistry	(Bottega et al.,)	2018	Nature of scientific report journal	English	A randomized clinical trial	To analyzed the cost, per procedure, of Papacarie gel compared to the traditional method (drilling), and performed a comparison between these methods of carious tissue removal
21.	Evaluation of Marginal Leakage and Shear Bond Strength of Bonded Restorations in Primary Teeth after Caries Removal by Conventional and Chemomechanical Techniques	(Viral Maru, Shakuntala, & Nagarathna)	2016	International Scholarly Research Notices	English	In vivo study	To evaluate and compare the marginal leakage and shear bond strength between conventional and Papacarie techniques of caries removal in primary molars

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Table 1. (*continued*)

No	Title	Author	Year	Publisher	Language	Method	Aim
22.	Endodontic implications and innovative preventive strategies during novel COVID-19 pandemic requiring emergency endodontic treatment	(Navin et al.,)	2020	Journal of dental problems and solutions	English	Literature review	To understand endodontic inovation treatment in Covid era
23.	Chemomechanical caries removal (CMCR) agents: Review and clinical application in primary teeth	(Ganesh & Parikh)	2011	J. Dent. Oral Hyg.	English	Literature review	To understand effectiveness of carisolv and papacarie in decreasing pain during treatment
24.	Carisolv- An Innovative Method of Caries Removal	(Kathuria, Ankola, Hebbal, & Mocherla)	2013	Journal of critical and diganostic research	English	Literature review	To understand effectiveness CMCR as an alternative procedure in removing caries treatment

conventional method because in conventional method healthy tissue was removed. In line with that, the literature by Ahmed H. Ali states that Carisolv removal maintains more health .tissue than caries removal using a bur, so there is enough affected-dentin left to maximize the function of dentin as pulp protection. Removing carious tissue with the help of Carisolv and Papacarie can minimize the damage of dentinal tubules compared to Stainless Steel bur so that more healthy tooth tissue remains higher [18]. The mechanism of CMCR that selectively dissolves infected tissue is a line with the minimally invasive principle because healthy tissue is preserved to the greatest extent [9, 12].

In the restoration procedure, after the carious tissue is removed, the next step is to prepare the cavity and filled with an adhesive material to restore its function, shape, and aesthetics and to maintain the remaining healthy tissue. Treatment with extraction is more common in remote areas than with restoration. The percentage of tooth extraction is 29.6%, and the restoration treatment reached 2.6% [4]. In children aged 5–9 years, tooth extraction treatment reached 33.2%, and restoration treatment 3%. In adults aged 55–64, tooth extraction treatment reached 29%, and restoration treatment only 5% [3]. ART is a caries treatment procedure used in areas with limited facilities and accessibility. The most effective restorative material in ART procedures is high-viscosity glass ionomer cement. Some advantages of GIC are fluoride release that will increase the potential of remineralization, bind well to enamel and dentin, does not irritate the pulp, and easy to manipulate [34]. The use of CMCR did not affect the bonding of the GIC to the affected dentin. The literature by Yoshihide Yamada states that CMCR with GIC is effective in areas with limited instruments and materials because there is no need to use a bur.

CMCR procedure filled with GIC shows a slighter incidence of microleakage rather than the conventional method. Literature by Ravi Prasaanthini Varun, comparing the strenght bond of CMCR and GIC, found that GIC binds better to Carisolv than to Papacarie. The specifics instrument used in the Carisolv and Carisolv's ability to dissolve the carious tissue can minimize trauma to the dentin and make the remaining tissue surface suitable for the restorative materials attachment.. The research of Ali Shamim Atta Ullah was alined, where the results of the GIC bond were better when caries tissue was removed with Carisolv compared to without using Carisolv.

Literature by Santoso in 2020 stated that treatment to the dentist is higher in adults than children [35]. Riskesdas data state that more than 95% of children aged 3–14 years do not go to dental treatment. Pediatric dental care causes pain and anxiety in children during the procedure. During conventional methods, removal using a bur is often painful in children. The sound produced by the device and the vibrations generated will trigger anxiety and affect the level of cooperativeness of pediatric patients [36] Literature by Rahul J Hegde states that CMCR can reduce pain and anxiety during treatment for children because it does not cause thermal or vibration effects compared with bur. The specific hand instrument used in the Carisolv design is without a sharp surface, so the caries tissue removal procedure does not cause pain. Based on some literature, anxiety in children is lower in the CMCR treatment than in the bur treatment. Another study also stated that carious tissue removal with CMCR can reduce apprehension and fear in children compared to hand instruments without CMCR. Literature by Mithra N Hegde and Abhishek MA stated that pain perceptions during treatment in children and medically compromised patients could be suppressed using CMCR due to not using bur in the procedure, which possibly increasing pain perception. Carie-care with an enzyme-based mechanism is proven more effective in children than Papacarie and Carisolv [26]. Conventional caries removal using a bur has the potential to widen and affect the healthy dentin even to a deeper layer so that the dentinal tubules will be more exposed, which will cause pain and pressure, so local anesthetic injection is often required. Injection of local anesthetic in pediatric patients often causes fear and discomfited and is not easy to do because of the low level of cooperation in children [36]. Referring to the basic principles of pediatric dentistry, which is painless treatment and minimal intervention, CMCR with papacarie method have lower perceptions of pain and anxiety than conventional methods [37]. That is in line with research conducted by Motta LJ that caries tissue removal with CMCR causes a lower degree of pain than conventional methods and does not require local anesthesia. Taking carious tissue with CMCR material preserved more healthy tissue to be maintained. The literature by Cardoso et al. conducted a study based on previous research and found that from 6 studies, the final cavity produced by conventional methods was relatively more comprehensive than the Carisolv, and Papacarie. This resulted in a relatively more minor caries-free cavity. Carisolv was statistically more efficient than an excavator, ten previous studies stated that patients who were approached with CMCR materials for carious lesions had a significantly better treatment experience.

Based on Riskesdas data in 2018, the prevalence of caries incidence in rural areas is higher than in urban areas, with visits to the dentist higher in cities than in rural areas. In 2018, 96% of Indonesians did not visit the dentist. In addition to the lack of availability of

health facilities, according to Cornelia et al., low economic status affects an individual's ability to visit the dentist. Based on the literature by Santosh Kumar et al., the ART method with the addition of CMCR is effective in areas with low incomes because of its lower price and minimal use of instruments compared to other atraumatic restorative methods such as atraumatic resin restoration, air abrasion, and laser. In line with this, literature by Preethi Krishnan states that apart from being effective in removing carious tissue, the addition of CMCR material to ART procedures has other advantages, such as this method proven to be easy, more convenient, and cheaper. Research conducted in Mecca, an area with limited facilities and resources, Papacarie is more effective than Carisolv because it is cheaper and takes less time to remove caries tissue [12]. This follows Preethi Krishnan's research which states that Papacarie is cheaper than Caridex and Carisolv. Papacarie also proved to be 42% cheaper than the conventional method with a bur. In conventional treatments that require anesthesia, the use of Papacarie is 58% cheaper because the procedure does not require anesthesia. In line with this, the literature by Viral P Maru in 2013 states, caries removal with Carisolv takes longer than conventional methods, the advantages of Carisolv are it does not cause pain and does not require anesthesia.

The 2030 Caries-Free Indonesia Program targets children aged 12 years to be caries-free by 2030, with the DMFT index reaching 1. One of the efforts made is to provide preventive and curative caries care. The ART method is one of the caries treatment launched by the government in the 2030 Caries Free Indonesia program [38]. CMCR has the potential to succeed in the 2030 Caries Free Indonesia program based on the effectiveness of CMCR as a caries removal method with ART principles and the effectiveness of CMCR in the treatment of childhood caries.

In cases with deep or proximal caries, it is necessary to open the cavity using a bur. CMCR can be combined with a bur in caries removal procedures. Recent research has developed a tool in the form of Cera-bur and Polybur on Carisolv with a low-speed handpiece to reduce the work time of caries re [7]. Another advantage of CMCR is that it can be used as a treatment option during a pandemic because the procedure uses a hand instrument to reduce the potential for aerosols, and Carisolv has a high pH, and after being applied to dental hard tissue, Carisolv can remineralize after two weeks [38]. Some of the disadvantages of CMCR are that the Carisolv excavation time is longer than conventional, because the procedure requires to be applied several times. CMCR cannot be used on enamel caries because the ability to remove caries tissue is selectively only in dentinal caries [9].

4 Conclusion

CMCR is potentially helpful in solving caries cases in remote areas because the procedure does not require electricity. CMCR has proven to be more effective in removing caries than conventional methods. Adhesive materials bind well with the CMCR method, especially GIC. CMCR can potentially increase dental treatment in children due to its ability to reduce pain and anxiety perception. CMCR can support the success of the Indonesian government's Caries Free 2030 program.

References

1. Yadav K, Prakash S. Dental Caries: A Review. 2016; (August). https://doi.org/10.15272/ajbps.v6i53.773
2. Sibarani MR. Karies: Etiologi, Karakteristik Klinis dan Tatalaksana. *Maj Kedokt Univ Kristen Indones*. 2014;XXX(1):14–22
3. Jawab P, Kurniawan R, Widiantini W, Mulya D, Kesehatan S, Kesehatan D. Faktor Risiko Kesehatan Gigi dan Mulut. 2019:2016–2021
4. Dewanto I, Koontongkaew S, Widyanti N. Characteristics of Dental Services in Rural, Suburban, and Urban Areas Upon the Implementation of Indonesia National Health Insurance. *Front Public Heal*. 2020;8(May):1-8. https://doi.org/10.3389/fpubh.2020.00138
5. Lamont RJ, Egland PG. *Dental Caries*. Elsevier Ltd; 2014. doi:https://doi.org/10.1016/B978-0-12-397169-2.00052-4
6. P SM, Mallya S. Microbiology and Clinical Implications of Dental Caries – A Review. *J Evol Med Dent Sci*. 2020;9(48):3670–3675. https://doi.org/10.14260/jemds/2020/805
7. Hamama HHH, Yiu CKY, Burrow MF. Effect of chemomechanical caries removal on bonding of resin-modified glass ionomer cement adhesives to caries-affected dentine. *Aust Dent J*. 2015;60(2):190-199. https://doi.org/10.1111/adj.12318
8. Slayton RL, Fontana M, Young D, et al. Dental Caries Management in Children and Adults. *NAM Perspect*. 2016;6(9). https://doi.org/10.31478/201609d
9. Ganesh M, Parikh D. Chemomechanical caries removal (CMCR) agents : Review and clinical application in primary teeth. *J Dent Oral Hyg*. 2011;3(March):34-45.
10. MA A. Chemomechanical Caries Removal: A Conservative and Pain-Free Approach. *Adv Res Gastroenterol Hepatol*. 2017;5(4):69–71. https://doi.org/10.19080/argh.2017.05.555666
11. Chatterjee AN, Das L, Khushboo, Biswas R, Saha S, Sarkar S. Chemomechanical Caries Removal with Respect to COVID-19 in Dentistry. *Int J Res Rev*. 2020;7(11):517–523
12. Adham MM, El Kashlan MK, Abdelaziz WE, Rashad AS. The impact of minimally invasive restorative techniques on perception of dental pain among pregnant women: a randomized controlled clinical trial. *BMC Oral Health*. 2021;21(1):1–9. https://doi.org/10.1186/s12903-021-01432-3
13. Hamama H, Yiu C, Burrow M. Current update of chemomechanical caries removal methods. *Aust Dent J*. 2014;59(4):446–456. https://doi.org/10.1111/adj.12214
14. Mds R, Education H, Education H, Mds R. MINIMAL-INVASIVE METHODS OF. 2020;07(03):2068-2078.
15. Kathuria V, Ankola A V., Hebbal M, Mocherla M. Carisolv- An innovative method of caries removal. *J Clin Diagnostic Res*. 2013;7(12):3111–3115. https://doi.org/10.7860/JCDR/2013/6676.3873
16. Boob AR, Manjula M, Reddy ER, Srilaxmi N, Rani T. Evaluation of the Efficiency and Effectiveness of Three Minimally Invasive Methods of Caries Removal: An in vitro Study. *Int J Clin Pediatr Dent*. 2014;7(1):11–18. https://doi.org/10.5005/jp-journals-10005-1226
17. Saber AM, El-Housseiny AA, Alamoudi NM. Atraumatic restorative treatment and interim therapeutic restoration: A review of the literature. *Dent J*. 2019;7(1):1–10. https://doi.org/10.3390/dj7010028
18. Divya G, Prasad MG, Vasa AAK, Vasanthi D, Ramanarayanar B, Mynampati P. Evaluation of the efficacy of caries removal using Polymer Bur, Stainless Steel Bur, Carisolv, Papacarie – An invitro comparative study. *J Clin Diagnostic Res*. 2015;9(7):ZC42-ZC46. https://doi.org/10.7860/JCDR/2015/12705.6202
19. Yamada Y. A short review: Effectiveness combination with glass ionomer cements and chemo-mechanical caries removal. *J Clin Dent Oral Heal*. 2018;02(01):9–12. https://doi.org/10.35841/oral-health.2.1.9-12

20. Stolic N. Does chemomechanical caries removal affect restoration survival ? A systematic review. 2015
21. Pydi S, RaoV N. Caries Removal by Chemomechanical (Carisolv TM) and Conventional (Airotor) Methods – Comparative In-Vitro Study. *IOSR J Dent Med Sci Ver I*. 2015;14(7):2279-–861. https://doi.org/10.9790/0853-14716366
22. Samatha Y, Birra C, Bandi S, Chinta M, Enuganti S, Mukthineni S. Comparative Evaluation of Microleakage in Restored Primary Molars using Conventional and Chemomechanical Removal of Carious Tissue: An in vitro Study. *J Contemp Dent*. 2016;6(2):108–113. https://doi.org/10.5005/jp-journals-10031-1153
23. Ali AH, Thani F Ben, Foschi F, Banerjee A, Mannocci F. Self-limiting versus rotary subjective carious tissue removal: A randomized controlled clinical trial—2-year results. *J Clin Med*. 2020;9(9):1–10. https://doi.org/10.3390/jcm9092738
24. Varun RP, Chamarthi VR, Annamalai S. Microtensile Bond Strength of Gic and Rmgic Restored To Carious Teeth Treated With Carisolv and Papacarie- an in Vitro Study. *J Evol Med Dent Sci*. 2018;7(12):1488-1492. https://doi.org/10.14260/jemds/2018/337
25. Shamim A, Ullah A, Ali B. CEMENT TO MECHANICALLY TREATED VERSUS CHEMO-. 2010;19(3):139-143.
26. Hegde RJ, Chaudhari S. Comparative Evaluation of Mechanical and Chemo-mechanical Methods of Caries Excavation: An In Vivo Study. *J Int Oral Heal*. 2016;8(3):357-361. https://doi.org/10.2047/jioh-08-03-11
27. Motta LJ, Bussadori SK, Campanelli AP, et al. Randomized controlled clinical trial of long-term chemo-mechanical caries removal using papacarie^{TM} gel. *J Appl Oral Sci*. 2014;22(4):307-313. doi:https://doi.org/10.1590/1678-775720130488
28. Bansode DP V. No Drill Dentistry: A Review of Advances in Non-Rotary Methods of Caries Removal. *J Med Sci Clin Res*. 2018;6(6):327–333. https://doi.org/10.18535/jmscr/v6i6.55
29. Kumar S, Dentistry P. Irrigation in pediatric dentistry : A review. *Eur J Mol Clin Med*. 2020;07(11):7610–7616.
30. Krishnan P, Ganapathy D, Ranjan M. Chemomechanical caries removal – A review. *Drug Invent Today*. 2020;14(3):304–309.
31. Bottega F, Bussadori SK, Battisti IDE, Vieira EP, Pompeo TS, Winkelmann ER. Costs and benefits of Papacarie in pediatric dentistry: a randomized clinical trial. *Sci Rep*. 2018;8(1):1–7. https://doi.org/10.1038/s41598-018-36092-x
32. Maru VP, Shakuntala BS, Nagarathna C. Caries Removal by Chemomechanical (Carisolv^{TM}) vs. Rotary Drill: A Systematic Review. *Open Dent J*. 2016;9(1):462–472. https://doi.org/10.2174/1874210601509010462
33. Navin M, Isha N, Ragini M, et al. Endodontic implications and innovative preventive strategies during novel COVID-19 pandemic requiring emergency endodontic treatment. *J Dent Probl Solut*. 2020;2020(April):059-062. https://doi.org/10.17352/2394-8418.000086
34. Frencken JE, Leal SC, Navarro MF. Twenty-five-year atraumatic restorative treatment (ART) approach: A comprehensive overview. *Clin Oral Investig*. 2012;16(5):1337-1346. https://doi.org/10.1007/s00784-012-0783-4
35. Santoso CMA, Bramantoro T, Nguyen MC, Bagoly Z, Nagy A. Factors affecting dental service utilisation in indonesia: A population-based multilevel analysis. *Int J Environ Res Public Health*. 2020;17(15):1–11. https://doi.org/10.3390/ijerph17155282
36. Anwar AI. Persepsi anak terhadap dokter gigi pada Rumah Sakit Gigi Mulut Halimah Dg. Sikati di Makassar(Children's perception of their dentist at Halimah Dg.Sikati Dental Hospital in Makassar). *J Dentomaxillofacial Sci*. 2014;13(2):91. https://doi.org/10.15562/jdmfs.v13i2.395
37. Banerjee A, Frencken JE, Schwendicke F, Innes NPT. Contemporary operative caries management: Consensus recommendations on minimally invasive caries removal. *Br Dent J*. 2017;223(3):215–222. https://doi.org/10.1038/sj.bdj.2017.672

38. Direktorat Bina Upaya Kesehatan Dasar, Ditjen Bina Upaya Kesehatan KK. Indikator Penilaian Keberhasilan Pelaksanaan Pelayanan Kesehatan Gigi dan Mulut. 2015;5