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# Facilitators for, and barriers to, 12 New Zealand dentists' implementation of non-invasive and micro-invasive methods of managing non-cavitated proximal lesions in their clinical practice

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## Abstract

**Background and objectives:** This study aimed to identify the barriers to/facilitators for, the implementation of non-invasive (NI) and micro-invasive (MI) methods of managing non-cavitated proximal lesions (NCPLs).

**Methods:** In 2017, an international study focusing on the barriers to/facilitators for the implementation of NI/MI methods to manage NCPLs was undertaken with general dentists in NZ, Germany and the USA. This study reports the NZ findings. Telephone interviews were conducted with 12 NZ dentists, utilising an interview scheduled based on the Theoretical Domains Framework (TDF). Data were categorised in accordance with the TDF and a thematic analysis of the data was undertaken.

**Results:** Barriers to the non-restorative management of NCPLs included: unsupportive colleagues; anticipated regret about not restoring a NCPL before it became cavitated; less financial reimbursement for NI/MI methods than for restorations; and concern about a patient's oral health history and likely cooperation. The identified facilitators included: a belief that remineralisation can occur and caries can be arrested; the knowledge that restorations weaken the tooth structure and result in a cycle of replacement restorations; belonging to professional organisations; undertaking continuing professional development; supportive colleagues; capable auxiliaries; professional confidence; experience; possessing the 'necessary tools'; and professional satisfaction with doing what is in the "patient's best interests".

**Conclusion:** Numerous changes at the clinical, professional and structural levels are necessary to foster greater utilisation of NI/MI methods of managing NCPLs in dentists' clinical practice.

## Background

Traditionally, caries lesions have been treated by the surgical removal of all carious tissue and restoration with a suitable filling material. Nowadays, however, a more conservative approach to managing caries lesions (especially non-cavitated ones) is advocated, which has come about as a result of improved knowledge of caries pathogenesis and the wider availability of efficacious management options (Innes and Schwendicke 2017).

An increasing body of research has highlighted how non-cavitated lesions can be arrested and some remineralisation may occur through the use of non-invasive (NI) and micro-invasive (MI) methods (Fontana et al. 2014; Martignon et al. 2012; Mertz-Fairhurst et al. 1986; Meyer-Lueckel et al. 2012; Sharma et al. 2015). Consequently, such methods are currently recommended for managing non-cavitated lesions, because they foster "the natural repair process of teeth" (Paris et al. 2010, p. 823). By contrast, restorations lead to a loss of healthy tooth structure and may need to be replaced repeatedly over time (often with a loss of further healthy tissue) (Paris et al., 2010; Quist 2008). Consequently, restorative treatments are mainly recommended when caries lesions are cavitated, or to improve aesthetics and function in some situations (Innes and Schwendicke 2017).

Examples of NI methods include fluoride applications, dietary advice, and improving patients' oral hygiene practices (flossing and brushing techniques) (Selwitz et al. 2007), but their effectiveness depends on patients' adherence (Ashkenazi et al. 2012; Foster Page et al. 2017). Application of casein phosphopeptide-amorphous calcium phosphate (CPP-ACP) or Tooth Mousse® is a further NI method that serves to promote remineralisation in non-cavitated lesions (Gary et al. 2017; Rahiotis and Viougiouklakis, 2007). Tooth mousse contains calcium and phosphate ions that, when combined with fluoride and applied to the tooth surface, favour remineralisation; they also balance the acidity of the mouth after eating and drinking. Similarly, the direct application of high fluoride-releasing glass-ionomer cements (such as FUJI VII-EP, which also contains 3% CPP-ACP) can also guard against demineralisation. When applied, FUJI VII-EP protects the tooth from plaque build-up, and the subsequent release of fluoride, calcium, and phosphate ions can result in the halting of caries progression, and in some cases lead to remineralisation (Dashper et al. 2016; Mazzaoui et al 2003).

Other MI methods (such as sealants and resin infiltration) are also effective in arresting non-cavitated lesions or delaying their progression (Abuchaim et al. 2010; Ammari et al. 2014; Dorri et al. 2015; Foster Page et al. 2017; Martignon et al. 2006; Paris et al. 2010). When it comes to sealing proximal lesions, an orthodontic

separator is placed to open the contact, after which the non-cavitated lesion is acid-etched and sealed, to prevent the lesion from progressing (Abuchaim et al. 2010; Dorri et al. 2015). Resin infiltration is similar to sealing, but rather than staying on the proximal surface, the resin penetrates the porous tissue of the lesion (Meyer-Lueckel et al. 2012) and for infiltration, no tooth separation is needed.

A number of dentists continue to restore non-cavitated lesions, even when these are confined to the enamel (Baraba et al. 2010; Doméjean-Orliaguet et al. 2004; Meyer-Lueckel et al. 2012; Sharma et al. 2015; Traebert et al. 2005; Traebert et al. 2007; Tvelt et al. 1999). Qualitative studies that explore dentists' clinical decision-making in regard to the clinical implementation of NI/MI methods are needed (Schwendicke, et al., under submission). Moreover, a theoretical tool, exploring the factors that impact on dentists' clinical choices, is also necessary, so that interventions addressing these factors can be developed (Schwendicke, et al. 2018). In order to do this, the present study employed the Theoretical Domains Framework (TDF) to help identify those factors that shape dentists' attitudes towards NI/MI methods and the implementation of them in their clinical practice (Cane et al., 2012). The aim of this study was to explore the barriers to/facilitators for dentists' implementation of NI/MI methods to manage NCPLs. Qualitative interviews were conducted in New Zealand, the United States, and Germany (Schwendicke et al. 2018); however, this article reports the New Zealand findings.

## Methods

Some domains were considered less relevant to the topic under investigation than others, and so the research team developed an initial interview schedule based on ten of the 14 domains of the TDF (Cane et al. 2012). These ten included knowledge, skills, social/professional role and identity, beliefs about consequences, reinforcement, intentions, goals, environmental context and resources, social influences, and behaviour regulation. The interview schedule was trialled in a pilot interview with a dentist known to the research team in each of the three countries where the research was undertaken. The research team included a qualitative dental researcher (LS), a health psychologist (SB), and dental academics with considerable clinical expertise (FS, WMT, MF and LFP).

Ethics approval was obtained in late 2016 (University of Otago Ethics Committee reference 16/276). Names of potential participants were gathered from the New Zealand Dental Association's membership list. A large number of dentists (approximately 50) were approached via email and asked whether they were interested in participating in a telephone interview. After obtaining informed consent, LS conducted telephone interviews with 12 general dentists who responded to the initial email invitation. The interviews lasted 20–40 minutes; they were later transcribed by a transcription service, and checked for accuracy.

Electronic copies of transcripts were coded (by LS) in accordance with each domain of the TDF. Excerpts that corresponded with the definition of each domain

and related constructs were highlighted in different coloured fonts. Passages representing more than one domain or construct were coded under more than one domain. A sample of coded transcripts was sent to SB to check for consistency in coding; the transcripts were subsequently coded after that feedback. Ten separate documents were created, and excerpts that highlighted each domain and related constructs were pasted into the relevant document. Following this, a count of participants' mentions of domains was undertaken, to identify which domains and associated constructs were the most commonly mentioned. After the excerpts were grouped into domains, a thematic analysis of the data was undertaken with a specific focus on identifying the facilitators for, and barriers to, the implementation of NI/MI methods of managing NCPLs in the participants' practices. A qualitative descriptive approach is used to present findings as this approach presents participants' accounts in a straightforward manner without complex interpretations (Kim et al. 2017; Lambert and Lambert 2012).

## Results

The participants included five female and seven male general dentists, with an average of 26 years of clinical experience. Demographic information on the individual participants is reported in Table 1, with a researcher-chosen pseudonym used to protect participant anonymity.

Once the participants' comments were grouped into domains, a number of barriers to, and facilitators for, the implementation of NI/MI methods of managing NCPL were identified. Some domains had greater numbers of participants' responses grouped beneath them, as can be seen in Table 2. These are discussed under each domain heading.

In total there were 841 comments grouped into the ten domains, with knowledge having the most comments grouped beneath it, and behaviour regulation the least.

### Knowledge

An extensive knowledge of NI/MI methods, how to perform them and undertaking on-going professional development, were the most common facilitators for the implementation of NI/MI methods. As part of their continued professional development, all participants said that they had attended conferences or seminars where NI/MI methods were discussed. For instance:

*Kelli:* I think I did prior to [a dental academic] coming to [town] to talk to us and my reasoning for doing [restorations] it was in an adolescent that was having energy drinks ... and realistically wasn't going to stop it, that I felt that it was better to fill it, and ... she said "No", that isn't what you should do. You should still monitor it and do the preventive steps. And so since then I have been a lot more reluctant.

All participants also made comments showing that they had thorough knowledge on NCPLs, how to implement NI/MI methods in their practice, and the challenges involved in managing these lesions due to limited access.

**Table 1** Demographic information on the participants

Participant	Gender	Urban or rural practice	Sole or group practitioner	Years since graduation
John	Male	Rural	Sole	39
Steven	Male	Rural	Group	47
Mary	Female	Rural	Sole	22
Paul	Male	Urban	Sole	35
Kelli	Female	Urban	Group	19
Anne	Female	Urban	Group	9
Josie	Female	Urban	Group	6
Patrick	Male	Urban	Group	28
Liam	Male	Urban	Group	24
Oliver	Male	Urban	Group	26
Jack	Female	Urban	Group	16
Gary	Male	Urban	Group	41

**Table 2** Total number of participant responses grouped per domain

TDF Domains	Definition of domain	Total number of comments grouped per domain
Knowledge	An awareness of the existence of something	188
Beliefs about consequences	Acceptance of the truth, reality or validity about an ability, talent or facility that a person can put to constructive use	171
Social influences	Those interpersonal processes that can cause individuals to change their thoughts, feelings and behaviours)	108
Environmental context and resources	Any circumstance of a person's situation or environment that discourages or encourages the development of skills and abilities, independence, social competence, and adaptive behaviour)	92
Social and professional role and identity	A coherent set of behaviours and displayed personal qualities of an individual in a social or work setting)	70
Skills	An ability or proficiency acquired through practice	65
Reinforcement	Increasing the probability of a response by arranging a dependent relationship, or contingency, between the response and a given stimulus	59
Intentions	A conscious decision to perform a behaviour or a resolve to act in a particular way	39
Goals	Anything aimed at managing or changing objectively observed or measured actions	37
Behaviour regulation	Anything aimed at managing or changing objectively observed or measured actions	12

For instance:

**Steven:** Well, the thing is the proximal lesions are usually at the contact point ... where the two teeth touch and get the material into that lesion, you have to ... put the material between the teeth and then ... floss it into place and similarly with tooth mousse. It is not like it is a lesion on an open surface where you could easily, even put some on your fingers and put it in to the lesion, but you can't do that with proximal lesions because they are basically hidden and hard to access.

lesion progression, the potential for remineralisation and minimal loss of tooth structure) and the drawbacks of restorations (damage to healthy tooth structure and the need for replacement restorations) was also another common facilitator. For example:

**John:** Good hygiene can often heal [these lesions] on its own.

**Jack:** All these people started off with only small caries and they have got bigger over time, required ... drilling and filling and ... if there was sort of more minimally invasive treatment applied then maybe all of the subsequent issues down the track may not be necessary to the same degree.

### **Beliefs about consequences**

Being aware of the benefits of NI/MI methods (halting



At the same time, however, a small number reported that they were either sceptical about not restoring lesions at the dentine enamel junction (DEJ), or hesitant not to restore at the DEJ due to past experiences. These comments are typified by the following:

**Steven:** I have some real doubts about the effectiveness of arresting a lesion ... at the [DEJ] ... I have always been very disappointed that they come back in a year or so and you have ... do a slightly bigger filling than you otherwise would've done.

**Paul:** Potentially you may not see it for two years, and that beginning of that lesion could accelerate much more rapidly ... you can underestimate their size and their penetration of the tooth and they can progress rapidly in the wrong mouth. So you might see them come back and there's a thumping great hole where you saw the beginnings of one that you might have underestimated its progress.

### Social influences

All but one participant reported that a patient's oral health history and hygiene influenced their use of NI/MI methods. Patients with good oral hygiene and regular dental attendance were more likely to be considered for. Some participants said that, when a NCPL had reached the DEJ and they had to choose whether to conservatively manage or restore the NCPL, a patient's oral health history was vitally important.

**Mary:** At the [DEJ] ... I have to think more about ... what this patient is like ... how acidic is their mouth, how compliant are they going to be with the products ... and [if] they have terrible oral hygiene then ... I'd be more inclined to, if things start to head into the dentine to ... expect the cavities to flourish, to grow fast rapidly. So ... we would need to do other things ... it's just not going to work.

Social support provided by colleagues was a further facilitator for NI/MI method implementation. Belonging to the New Zealand Institute of Minimally Invasive Dentistry (NZIMID) and practising with dentists who had similar philosophies were commonly mentioned by the participants:

**Gary:** I think ... belonging to a group such as NZIMID has been probably the strongest thing 'cause you're mixing with a lot of like-minded colleagues and they most definitely do influence you and, and inspire you. And it becomes just a natural thing to move into that ... approach.

A small number stated that a barrier to the implementation of conservative approaches was having practice colleagues who were unsupportive of NI/MI methods. These comments are typified by the following response, after Josie was asked whether her colleagues supported NI/MI methods:

**Josie:** There would be some that would be pro and there would be some that would just be very ho hum about it ... like most of them don't even place fissure sealants in and that is really easy ... they are not into it.

### Environmental context and resources

The lower reimbursement rate for NI/MI methods than for restorations in both general practice and under the Adolescent Oral Health Scheme (AOHS) was a common barrier to their implementation. Some of these comments focused on the reduced revenue if a clinic focused solely on using NI/MI methods of management. Other comments centred on dental colleagues who might have undertaken unnecessary restorative work in return for greater monetary reward. For instance:

**Paul:** There's...a lot more advantages for the dentist to cut a filling 'cause...you get the fee for doing the filling and ... you ... get the fee for replacing that filling at some time in the future. And then maybe 20 years down the track you end up having to do a larger restoration or a crown when the cusp cracks. So you...reduce the ultimate workload of the practice by practising conservation.

**Steven:** One of the things that does come to mind is the way that the fee structure is set up for the adolescent children, the contract with the Health Board, I mean that is an external factor I suppose because if a person is looking ... just for income and they see a number of small spots on the enamel ... they may decide ... there's nothing for doing fluoride treatment but there is something for doing a filling.

Over half of the participants mentioned that loupes or digital x-rays made using NI/MI methods easier and allowed patients to be more informed about their treatment. Accordingly, the two pieces of equipment can be seen as facilitators for the implementation of NI/MI methods. For example:

**Paul:** Digital x-rays and being able to show people x-rays ... that makes it very real for people ... and also just the immediacy of a digital x-ray, which pops up on the screen and having good, clear x-ray[s] ... that patients can see clearly and you can demonstrate progress ... is the biggest educational tool 'cause we're living in a digital age where seeing is believing.

### Social and professional role and identity

Belonging to professional organisations such as the New Zealand Dental Association (NZDA) or the NZMID served to validate the conservative management of NCPL as a legitimate option for many participants. Belonging to these professional organisations also gave the participants confidence to implement NI/MI methods. For instance:

**Mary:** I noticed that after ... Professor Featherstone came out to New Zealand there was a really comprehensive article in the *NZDA Magazine* ... it was a big summary of ... his slides and ... so ... I thought well this ... [is] standard practice dentistry now so I'm not going to do this treatment thinking that I'm being out there and a fringe dentist.

Having patients who trusted the participants to have their 'best interests at heart' acted as a facilitator for incorporating NI/MI methods into their practice, as was

maintaining a systematic approach to the diagnosis and management of early lesions. Both of these facilitators are highlighted in the excerpts from Mary and Paul below. However, as evident in the excerpt from Paul, having capable dental auxiliaries who were also involved in NI/MI methods was important:

**Mary:** A lot of times I don't actually give people a lot of choice. I'll tell them what the best [treatment is] ... if it's really something they need to do, I'll do it ... I've got a ... pretty good bunch of patients there actually, who trust my opinions.

**Paul:** Well the routine care at the [DEJ] ... I always look back to previous x-rays to look at the rate of progress ... and that determines where I go from there. If there's been no change, I will have it on a monitoring basis ... which is usually, I'm alerted to by my practice nurse in the process of doing the check-up ... I will reiterate the importance of flossing ... sometimes I'll tell people if they're flossing ... infrequently that they can make that flossing more effective by usually putting a smear of toothpaste on their finger, smearing it along the teeth and flossing that between the teeth. To provide some sort of abrasive to help remove hardened plaque and to leave behind some fluoride that isn't already contained in the paste.

### Skills

Accumulating clinical experience was a facilitator for the implementation of NI and MI methods. The notion that clinical skills and competence increased with years of clinical experience meant that some participants felt more confident and capable of managing NCPLs. For instance:

**Patrick:** I mean you don't come out of Dental School having done lots ... of things. You have done a few of many things, and so ... the real learning starts, I mean certainly from personal experience in that first year out, where you become exposed to ... modern and preventive techniques that you might not have even heard of.

**Oliver:** Over time you ... gain a feeling for which lesions you think will ... respond to a non-invasive form of treatment and which ones you think are going to need more invasive treatment.

### Reinforcement

Almost all participants made comments highlighting how there were a number of incentives and rewards for implementing NI and MI methods in their practice. These included gaining professional satisfaction and excitement from seeing remineralisation in a NCPL or the arrest of its progression. The excerpts below typify these comments:

**John:** I do see lesions disappear on x-rays ... with improved hygiene and those strategies, you see those little grey flecks that sit halfway through the enamel ... a year or two later ... you see them disappear ... they don't always just get worse, they can get better.

**Kelli:** I've actually just [seen a patient] who just kept having ... decay ... and I've got her on a high fluoride toothpaste ... She said to me "I'll come more often" ...

So I see her ... every nine months now and it's quite exciting to think that it's all stabilised.

Paul also mentioned that his patient enrolments might increase if he implemented NI/MI methods:

**Paul:** Practising good dentistry as a health service, ultimately the people that really matter will begin to notice and you end up having a full book for that reason.

### Intentions, Goals, and Behaviour regulation,

As can be seen from Table 2, few comments were grouped under the remaining three domains, intentions goals, and behaviour regulation; however, one facilitator was identified per domain. The stability of their intentions to implement NI/MI methods in the future was identified in comments categorised under the intentions.

For example:

**Anne:** It does link with what I am doing now, so I do try to be as minimally invasive as possible. If we can ... improve the situation or stop progression of a lesion with good home care, regular visits to a dentist, I ... prefer not to drill.

A stated desire to implement NI and MI methods in clinical practice wherever possible was a facilitator identified under Goals. For example:

**Paul:** I really try ... to not intervene as often as possible.

**Anne:** I have had people though say just fill it and been really shocked and [I'm] saying ... I just can't do it.

Having a specific plan of action for the implementation of NI/MI methods to manage NCPLs in one's practice (e.g. "I would never drill them" (John), was a facilitator identified in comments grouped under behaviour regulation.

A number of facilitators for, and barriers to, the implementation of NI/MI in clinical practice were identified in the participants' responses. The most numerous domain in terms of the number of participants' comments grouped beneath it was knowledge. Having extensive knowledge of NI and MI methods and how to perform them in clinical practice was the most commonly identified facilitator for the non-restorative management of NCPLs. The least populous domain, in terms of participant comments grouped beneath it, was behaviour regulation; however, at least one facilitator for the implementation of NI/MI methods was identified in each of the ten domains utilised in the study.

### Discussion

In documenting the facilitators for, and barriers to, implementing NI/MI methods for managing NCPL, we found that there are numerous individual, clinical, professional and environmental factors affecting dentists' treatment decisions and actions for managing NCPLs. Numerous barriers to the implementation of NI/MI methods in clinical practice were identified. These included: less financial reimbursement for NI/MI methods than for restorations; anticipated regret about



not restoring a NCPL before it progressed to a cavitated lesion; an understanding that once a lesion reached the DEJ it needed to be restored; having unsupportive dental colleagues; and the understanding that high-carries-risk patients were too unreliable for NI/MI methods.

Approximately half of the participants mentioned that the lower reimbursement rates for NI/MI methods than for restorations (both in general practice and under the AOHS) comprised a disincentive to using them in their practice. Overseas studies have found that dentists may unnecessarily restore lesions because of the greater financial reimbursement than for more conservative treatments (Doméjean-Orliaguet et al. 2009). Moreover, some participants also said that, in the long-term, implementing NI/MI methods was not financially advantageous because of the loss of future revenue that would come with replacement restorations. Accordingly, the reimbursement rates for NI/MI methods need to be on par with restorations to encourage dentists to implement them in their practice.

Some participants were sceptical about whether a NCPL that had reached the DEJ could be conservatively managed. Studies have shown that some dentists still consider the penetration of the DEJ by the lesion to be the threshold for restorative treatment (Ricketts and Pitts 2009). However, many lesions extending into the dentine are not cavitated and can still be arrested using conservative management (ten Cate 2001; ten Cate 2008). This highlights a need for greater awareness of the appropriate management of caries lesions by dentists.

Patients considered to be of high caries risk were more likely to be targeted for restorations than those who were not. International studies focusing on dentists' decisions on restorative thresholds have also found that they are more likely to restore non-cavitated lesions (regardless of tooth surface) when patients are judged to be of high caries risk (Doméjean-Orliaguet et al. 2009; Gordon et al. 2009; Kakudate et al. 2012; Sbaraini et al. 2013). Moreover, some participants mentioned that their past attempts at managing NCPLs using NI/MI methods had been unsuccessful due to patients' lack of attendance at follow-up appointments. Consequently, anticipated regret about not restoring NCPLs in high-carries-risk patients who were non-regular dental attenders was a further barrier to using NI/MI methods.

Having colleagues who were reluctant to incorporate NI/MI methods into their clinical practice was a further barrier to their implementation. Those who mentioned having unsupportive colleagues said that those colleagues were generally older. There has been a shift towards more prevention-based dentistry over recent decades (Holmgren et al. 2014). It is likely that those older unsupportive colleagues had been trained in an era when restorations were the recommended treatment for all lesions. Practising with such knowledge would be likely to negatively impact on patients, and this further highlights the need for continuing professional development.

Numerous facilitators for the implementation of NI/MI methods were identified, including: participating in continuing professional development; belonging to professional bodies; knowledge of the advantages of NI/MI methods versus the drawbacks of restorations;

having supportive colleagues; capable auxiliary staff; using enabling technology; and the professional and personal rewards.

All participants mentioned that they were involved in continuing professional development (including attending conferences, workshops and presentations) on NI/MI and minimally invasive dentistry. Professional development has a proven positive impact on clinicians' knowledge acquisition, clinical practice, and standard of patient care (Belfield et al. 2001). A number of participants said that they had implemented the knowledge that they acquired through attending presentations in their practice. Undertaking professional development (and thereby improving clinical skills and knowledge) was the most strongly identified facilitator for the implementation of NI/MI methods in the participants' practice.

Moreover, one-third of the participants said they belonged to the NZIMID, while all reported belonging to the NZDA. The mission statement of the NZIMID includes "To lead the nation in promoting the science, technologies and philosophy surrounding minimal intervention dentistry, within a collegial and supportive environment, to the dental practitioners of New Zealand" (New Zealand Institute of Minimally Invasive Dentistry n.d.). As professional dental organisations often take a leadership role in encouraging good clinical practice (Douglas et al. 2016), they should encourage dentists to implement NI/MI methods of managing NCPLs (and other non-cavitated surface lesions), considering the benefits of these methods to patients.

All participants highlighted how they understood that restorations serve to weaken tooth structure and need to be continually replaced. They also stated that NI and MI methods can arrest a NCPL and, in some cases, lead to remineralisation. Thus, knowledge of the strengths and drawbacks of each method was a facilitator for the implementation of non-invasive management of NCPLs in the participants' practice (Fontana et al. 2014; Martignon et al. 2012; Mertz-Fairhurst et al. 1986; Meyer-Lueckel et al. 2012; Paris et al., 2010; Quist, 2008; Sharma et al. 2015).

The need to protect patient confidentiality means that dentists are often unable to discuss clinical matters with people outside their practice (Berthelsen et al. 2008). Some participants said that they practised and socialised with 'like minded' colleagues who also implemented NI/MI methods in their clinical practice. The practice and social support provided by fellow dentists was a further identified facilitator for the implementation of NI/MI methods in practice.

Modern dentistry is a team occupation where dentists work alongside dental hygienists, dental assistants and others (Newsome and Langley 2014). A number of participants said that they referred patients to the hygiene arm of their practice for NI methods such as fluoride applications. Some participants also reported that dental hygienists made notes on patients' files about the need to monitor some patients' non-cavitated lesions. Thus, employing capable dental auxiliaries was a further facilitator for the implementation of NI/MI methods.

Loupes increase magnification, which in turn may help in the identification of non-cavitated lesions and reduce

clinical errors (Thomas and Thomas 2007; van As 2001). According to Parsi (2013), digital radiographs produce clear images and there is no processing time for the radiographs. Some participants stated that loupes made identification of NCPLs easier, while digital radiographs provided clear images that were shown to patients in an attempt to foster their co-operation. In this instance, loupes and digital radiographs can be considered as aids in the implementation of NI/MI methods of managing NCPLs, as well as tools for enhancing patient cooperation.

The final identified facilitator for the implementation of NI/MI methods for managing NCPLs centred on reinforcement and rewards. A number of participants said that they gained a sense of professional satisfaction and excitement from seeing NCPLs arrest and in some cases, remineralise. The implementation of NI/MI methods for managing NCPLs was also deemed to enhance the dentist-patient relationship, because it promoted trust. Our findings support overseas work that has shown that dentists find it intrinsically rewarding and experience positive relationships with their patients, knowing that they are helping patients and engaging in good clinical practice (Berthelsen et al. 2010; Kaipa et al. 2015).

This study has a number of strengths and limitations. First, qualitative studies focusing on the implementation of NI/MI methods for managing NCPLs are non-existent. The research that is available has either been reviews of clinical studies or alternatively, has investigated whether sealing and other non-restorative methods have been effective in arresting lesions over a specific period (Abuchaim et al. 2010; Ammari et al., 2014; Kielbassa et al. 2009; Martignon et al. 2006; Martignon et al. 2012; Meyer-Lueckel et al. 2012; Paris, 2010). The current study adds a new dimension by exploring the implementation of NI/MI methods in practice. The qualitative interviews in combination with the TDF produced detailed findings on factors that affect dentists' clinical decision-making and actions in using NI/MI methods to manage NCPLs.

Half of the participants reported that they belonged to the NZIMID, and so it is likely that they had a professional interest in NI/MI and minimally invasive dentistry. Moreover, this interest in non-restorative management

of non-cavitated lesions may have impacted on their decision to volunteer for the study. Consequently, the findings may unduly favour NI/MI methods and the drawbacks of restorations. At the same time, however, belonging to the NZIMID may have meant that the participants' were 'information rich' so to speak, due to their professional interest in the topic under investigation.

Furthermore, NI methods such as fluoride application and dietary advice arguably do not require the same degree of skill as, for example, providing endodontic treatment. Consequently, few participant responses were grouped under the skills domain and its related constructs. There was also no clear domain under which statements on patient factors such as oral hygiene and perceived adherence to instructions could be grouped (with these grouped under social influences because of this). Moreover, the definitions of some domains (such as goals and intentions) were similar, while some constructs under domains were the same. This meant that it was difficult to distinguish among comments grouped into specific domains and constructs (Phillips et al., 2015). Consequently, the TDF had limitations when it came to exploring the implementation of NI/MI methods of managing NCPLs.

## Conclusion

This study provides insights into the barriers to, and facilitators for the implementation of NI/MI methods for managing NCPLs in the clinical practice of 12 New Zealand dentists. There were more identified facilitators than barriers, while restoration of these lesions was not considered to be appropriate. However, this study is small in scope and more studies are needed to provide greater insights into the implementation of NI/MI methods for managing NCPLs in practice. In the future, the findings of these studies can be utilised to foster interventions aimed at encouraging greater uptake of these methods of NCPL, which have more advantages for patients than restorations.

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