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An investigation into Dental Practice Ventilation and Air Purification in Waikato and Bay of Plenty, New Zealand

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Abstract

The SARS-Cov-2 virus is more likely to be spread when people are indoors and in close contact. In response to the COVID-19 pandemic, workplace governing authorities and dental workforce regulators in many jurisdictions have updated their air quality guidelines. Good indoor ventilation provides for a healthier environment and may reduce the risk of airborne pathogen transmission.

Representatives of 104 dental practices in the Waikato and Bay of Plenty regions in New Zealand were contacted to seek information about their ventilation systems and any plans for improvement. Responses were obtained from 70.2% (N= 73) of these practices, representing the workplaces of 233 oral health practitioners. The majority of the responding practices (68.5%, N=50) were unventilated. For those that had ventilation systems, only a few knew how many air changes per hour their system was providing. Air purification units are uncommon and any opening windows are usually kept closed. Most of the dental practices surveyed did not have adequate ventilation and if a ventilation system was installed there was often limited knowledge about its performance. This study highlights the need for more attention to be given to air quality in New Zealand dental practices.

Introduction

In late 2019 in Wuhan, China, a cluster of atypical viral pneumonia cases of unknown cause was detected. Days later, the virus was found to be SARS-CoV-2 and it subsequently spread rapidly across the globe. By March 2020, the World Health Organization (WHO) had characterised COVID-19 as a pandemic (WHO, 2021). Transmission of the virus mostly occurs between people at close range through inhalation. The risk of transmission is much greater indoors (Tang, 2021; Rowe et al, 2021). In an attempt to reduce transmission, the WHO and workplace governing authorities in jurisdictions like New Zealand have updated their guidance on air quality, often with a focus on providing good ventilation (WHO;, Manatū Hauora-New Zealand Ministry of Health, 2022; Safe Work Australia,2021; United Kingdom Health Security Agency, 2022).

To our knowledge, no study has been previously undertaken to investigate ventilation and air purification in New Zealand dental practices. We also wanted to know whether practitioners intended to install or upgrade systems to improve air quality. An enquiry was also made into the factors that might affect the ability to improve the air quality in each practice.

Ventilation and air quality of indoor spaces affects the health and wellbeing of the occupants, and so the study findings will be of interest to all involved in dental care provision. Practitioners and practice owners will want to know they have a comfortable and safe working environment. The study will also be of interest to the dental servicing industry, who will be asked to respond to the guidelines and knowledge we now have following the COVID-19 pandemic. The findings of this study will be important for authorities and regulators concerned with public safety and workplace standards.

Aim

The purpose of the study was to gain an overview of the ventilation and air purification systems in dental practices located in the Waikato-Bay of Plenty regions of New Zealand. Additionally we wanted to understand the factors that might affect the provision of future installations or upgrades of air quality systems.

Methods

We undertook an internet search and used the New Zealand Dental Association membership book to locate dental practices in the Bay of Plenty and Waikato regions of New Zealand. Each practice was contacted by telephone. Following an introduction, the enquiry commenced by determining who would be the best person to answer questions on ventilation and air quality for the dental practice. We designated this person as the practice representative. Most often, this person was one of the practice dentists but sometimes it was the practice manager. For some of the larger dental practice groups, it was a practice owner who did not work on site in the practice.

Most (93.1% N= 68) of the information on each practice was gathered by a telephone call or an in-person meeting. The remaining five practice representatives replied by way of a completed email questionnaire. Because most of the practice representatives were dentists, the interviews needed to be undertaken when the practitioner was free from patient contact, usually at a pre-arranged time. The most common reason why responses could not be gained (from 29.8% of the practices approached) was that the practice representative was too busy, or they were away.

Each practice representative was asked how many oral health practitioners worked in the practice and how many dental surgery rooms (surgeries) the practice had. We asked whether the surgeries had opening windows and, if so, whether they were usually kept open or closed. We asked about what (if any) mechanical ventilation systems were installed, and whether air purification was also being used. The type of building that the practice occupied was categorised as either a converted residence or a commercial building. In order to understand the factors relating to an upgrade or installation of a mechanical ventilation system, we noted whether the building was single or multilevel, and whether there was access to the roof space or crawl spaces access to the surgeries. To gain insight into who might approve and pay for an upgrade or installation, we asked whether one of the practitioners owned the building and whether any costs incurred would be paid for by the tenant or landlord.

Results

We approached 104 dental practices seeking a representative who would be agreeable to participate in this study. In response 73 (70.2%) practice representatives agreed to be interviewed. Of the represented practices, 48 (65.7%) were in the Bay of Plenty region and 25 (34.2%) were in the Waikato region. The results represent the workplaces of 233 oral health practitioners.

Of the 73 practices, 17 (23.3%) were in converted residential buildings, and of those in commercial buildings 36 (49.3%) were in single-level buildings, and 20 (27.4%) were in multi-level commercial buildings. The majority of the practices (90.4% N=66) had access to either underfloor and/or ceiling space, six did not and one was unsure.

The majority (68.5%, N=50) of dental practices had no ventilation systems. Most (83.6% N=61) of the practices had air conditioning units to control their air temperature. Mechanical ventilation systems were installed in 23 (31.5%). For those with mechanical ventilation, 7(30.4%) knew their air change rate which varied between 10 and 12 air changes per hour (ACH). The majority of practices had opening windows (75.3% N=55) in the surgeries and of these only 9 (16.4%) usually practiced with the windows open. Only 10 (13.7%) of practices used an air purifier, and of these, 7 contained a ultraviolet (UV) light.

The landlord practised in 30 (41.1%) of the practices. In most (73.9%, N=54) practices it was expected that the cost of installing a ventilation system would be borne by the tenant. Less than half (42.5% N=31) of the practices were looking towards improving their ventilation systems

A case-study of the installation of a ventilation system into a dental practice

During the practice visits and interviews, a detailed case study of the installation of a ventilation system was further documented. This is a four-surgery dental practice operating out of a 1935 residential bungalow house. Prior to the COVID-19 pandemic, the building had no ventilation system and each surgery had an air conditioning unit for temperature control. The surgeries all have opening windows that are usually kept closed. A mechanical ventilation system was installed in 2021 which resulted in each surgery having negative air pressure with 12 ACH.

Figure 1 illustrates the newly installed ventilation system. The ventilation ducting was placed through the loft.

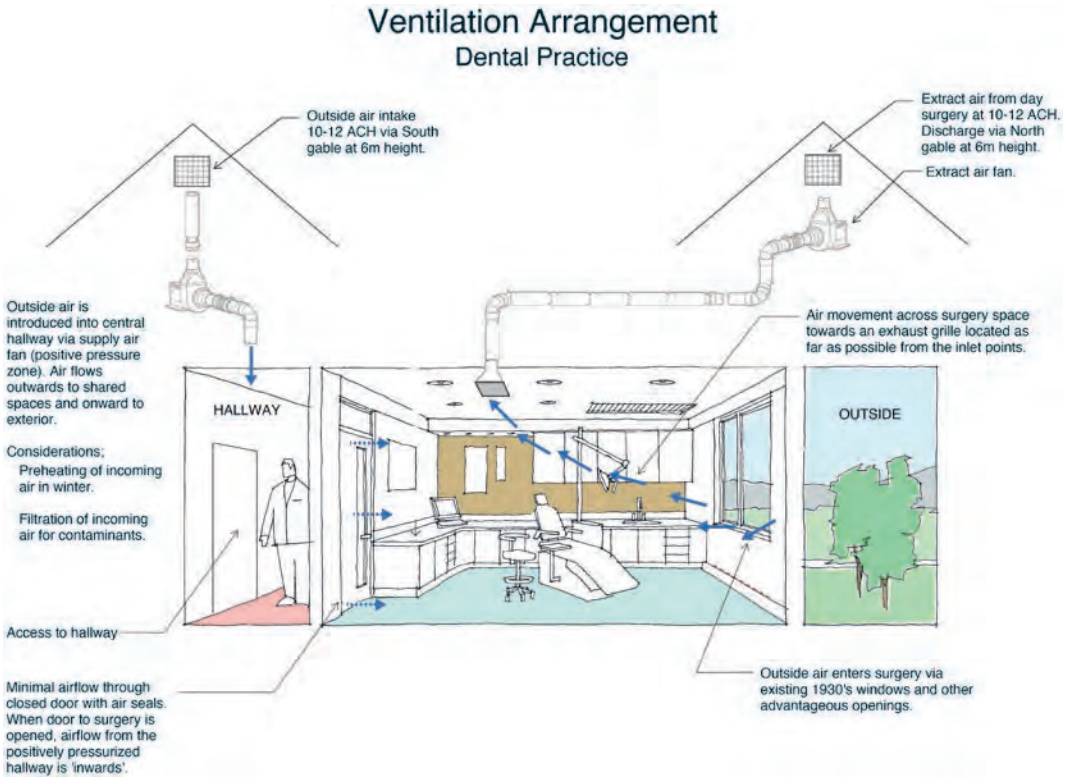

Figure 1. Diagram of a surgery in a converted residential building with a recently installed mechanical ventilation system.

Outside air is now brought into the clinic on one side of the building and expelled on the other. The high gables allow for intake and expulsion 6 meters above ground level. Although the windows are usually closed, the original wooden casement frames are not airtight and allow the ingress of outside air. Air is extracted from each dental room above and past the seated clinicians at a set rate of 12 ACH. Outside air is also delivered into the hallway, creating a positive pressure airflow from the hallway. When dentistry is being undertaken, the surgery door is closed against air seals to minimise aerosol migrating into the rest of the building. Air from the positively pressured hallway flows out through the windows and doors of the shared spaces. After treatment, when the surgery doors are opened, the positively pressured hallway forms a pressure barrier to reduce surgery air migrating to the shared spaces. A tempering thermostat means that the air coming into the hallway is at least 20 degrees. The clinicians continue to use the air conditioning units for temperature control and these also provide air stirring within the space to minimise stagnant areas. Presently, additional air purification systems are not used in this practice. The cost of this installation was $NZ 22,000.

Discussion

Knowledge of the transmission of SARS-Cov-2 virus and the best strategies of prevention evolved through the COVID-19 pandemic. Early in the pandemic many prevention guidelines were based upon the mode of transmission being by droplets with such measures as handwashing and surface cleaning emphasised. Increasingly it has become recognised as having an airborne route of transmission which has focused attention on indoor air quality (Greenhalgh 2022; Dancer 2022).

Dental workforce regulators sought to reduce SARS-Cov-2 transmission by updating guidelines on ventilation. In December 2021, the DCNZ published ventilation guidelines for oral health practice for the first time. The guidelines recommend practitioners review their practice air quality and consider upgrades and installations if required. For patients with a high risk of transmission, a negative air pressure room, also termed an airborne infection isolation room, is preferred and if not available the patient should be treated in a single, well ventilated room that is not positively pressured (DCNZ, 2021). The Australian management principles published in October 2021 are similar. Australian practitioners are recommended to optimise their facility ventilation and to manage the airflow for high risk patients(ADA, 2021). Similar standards are also found in the United Kingdom and there is a specific recommendation for a minimum of 10 ACH for a dental surgery (NHS, 2020).

The COVID -19 pandemic has brought the issue workplace air quality to the forefront. Good ventilation can reduce acute and chronic health outcomes by the dilution of indoor air pollutants and pathogens (Wolkoff 2021; Peters 2022).Ventilation is the exchange of air within a space. Natural ventilation is the passive movement of air through apertures such as windows and doors. Mechanical ventilation controls air pressures to move air through a room or building and is measured in ACH (Ren et al., 2021). The aim of ventilation is to reduce the concentration of aerosols which, in turn, reduces the risk of airborne microbial and pollutant threats. The time taken following aerosol production for the aerosol particles to settle or be safely cleared is known as the stand-down or fallow time. Aerosol removal time is lower with greater ventilation. Many dental practices in New Zealand are fitted out into existing residential and commercial buildings. Although there are ventilation standards for new builds, they are all unlikely to be adequate for dental practice (Ministry of Business, Innovation & Employment, 2019).

Our study revealed that two thirds of oral health practitioners in the sampled area are working in unventilated spaces, commonly with air conditioning units providing temperature control. Whilst air conditioning units control air temperature and humidity and circulate air within a space, they do not filter or supply fresh air. The use of filters and air purification units was uncommon, and it was apparent that there is little knowledge about these. Since the pandemic, most practice representatives have become aware of their ventilation systems and many are considering making improvements. Generally, practitioners felt they needed a better understanding of the subject. Most surgeries have opening windows but there is a culture of working with closed windows. This may be related to our climate, because as our findings contrast with those of a study in Colombia, an equatorial nation, where it is more common to operate with an open window (Plaza-Ruiz et al., 2021). Opening an outside window can greatly improve aerosol clearance but this varies with factors such as the width of the opening and wind and temperature differentials (Linden, 1999).

The COVID19 pandemic has brought attention to the risks associated with air mixing from one room to another within a building. Potentially, airborne pathogens and pollutants generated in a clinical space could contaminate other shared areas of the facility. In some commercial buildings, there may be a remixing of air across an entire floor or building (Chow et al., 2006). Hospital operating theatres and other places designed to prevent patient infections (such as bone marrow transplant units) traditionally had positive air pressure systems. For example, incoming filtered air is delivered through a HEPA filter above the operating table during an orthopaedic joint replacement. The air then migrates out under the doors of the operating theatre into adjacent spaces which are maintained at air pressures lower in that of the theatre (a negative pressure gradient). In this way, bacterial contamination from other areas in the theatre complex are prevented from getting into the joint. Our study found that most oral health practitioners do not work within negative pressure rooms.

Aerosol can be removed by filters within in-built ventilation systems or by portable air purifiers. Filters remove particles, but they are less efficacious for smaller particles, and UV lights placed after the filter will kill smaller microorganisms. Good air purification systems correctly positioned can provide an additional layer of protection against aerosol borne infection risks (Chen et al., 2009; Zhao et al., 2020).

The COVID-19 pandemic will eventually pass but it is still worthwhile to have good ventilation to promote a healthy environment in which to work (Wargocki, 2013; Tang 2022).

Conclusions

The COVID-19 pandemic has highlighted the importance of disease prevention and control through adequate ventilation and air quality. The majority of practices in this study did not have good ventilation, and open windows or air-purification units were uncommon. Practitioners do not usually know the rate of ACH they have, even if they have an installed ventilation system. Oral Health practitioners need more information on ventilation and air purification, and there is a clear need for practices to improve their clinic air quality with good ventilation and air purification.

Good ventilation provides a healthier work environment and will likely reduce the transmission of airborne pathogens.

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Conflicts of interest

Kevin O'Conner works for a company providing ventilation systems.

References

ADA. Risk management principles for dentistry–During the COVID-19 pandemic 2021. https://www.ada.org.au/getdoc/d3eecaba-d0aa-4803-a7ea-89facae6f274/Risk-Management-Principles-for-Dentistry-(1).aspx

Chen C, Zhao B, Cui W, Dong L, An A, Ouyang X. The effectiveness of an air cleaner in controlling droplet/aerosol particle dispersion emitted from a patient's mouth in the indoor environment of dental clinics. *J R Soc Interface* 2010; 1105-1118.

Chow T, Kwan A, Lin Z, Bai W. Conversion of operating theatre from positive to negative pressure environment. *J Hosp Infect* 2006; 371-378

Dancer SJ. Airborne SARS-CoV-2. Time for an indoor air revolution. *BMJ 2022*;377:o1408 http://dx.doi.org/10.1136/bmj.o1408

Dental Council of New Zealand. Supplementary standard to the Infection Prevention and Control Practice Standard. Risk management principles for oral health during the COVID-19 pandemic; 2021. https://www.dcnz.org.nz/assets/Uploads/COVID/COVID-19-section-2Dec21.pdf

Greenhalgh T, Ozbilgin M, Tomlinson D. How covid-19 spreads: narratives, counter narratives, and social dramas. *BMJ 2022*;378:e069940 http://dx.doi.org/10.1136/bmj-2022-069940

Manatū Hauora-New Zealand Ministry of Health. COVID-19; Ventilation. 2022. https://www.health.govt.nz/covid-19-novel-coronavirus/covid-19-health-advice-public/covid-19-ventilation

Ministry of Business, Innovation & Employment, Acceptable Solutions and Verification Methods for New Zealand. Building Code Clause G4 Ventilation. 2019. https://www.building.govt.nz/building-code-compliance/g-services-and-facilities/g4-ventilation/

NHS Scotland. SBAR Ventilation, water and environmental cleaning in dental surgeries relating to COVID-19 2020. https://www.scottishdental.org/wp-content/uploads/2020/08/Ventillation-Final-Copy-1.pdf

Peters SE, Dennerlein JT, Wagner GR, Sorenson G. Work and Health in the post-pandemic world; a public health perspective. *Lancet Public Health 2022*;7 e188-94.

Plaza-Ruiz SP, Barbosa-Liz DM, Agudelo-Suárez AA. Ventilation and air-conditioning systems in dental clinics and COVID-19: How much do we know? *J Clin Exp Dent* 2021; 692.

Ren YF, Huang Q, Marzouk T, Richard R, Pembroke K, Martone P, Venner T, Malmstrom H, Eliav E. Effects of mechanical ventilation and portable air cleaner on aerosol removal from dental treatment rooms. *J Dent* 105 2021; 103576.

Rowe BR, Canosa A, Drouffe JM, Mitchell JBA. Simple quantitative assessment of the outdoor versus indoor airborne transmission of viruses and COVID-19. *Environ Res* 2021;*198*, 111189.

Safe Work Australia. Improving ventilation in indoor workplaces:COVID-19. 2021. https://covid19.swa.gov.au/doc/improving-ventilation-indoor-workplaces-covid-19

Tang JW, Marr LC, Yuguo Li, Dancer SJ. Covid-19 has redefined airborne transmission. Improving indoor ventilation and air quality will help us all to stay safe. *BMJ 2021*;373:n913 http://dx.doi.org/10.1136/bmj.n913

United Kingdom Health Security Agency. Ventilation to reduce the spread of respiratory infections, including COVI-19. 2022. https://www.gov.uk/guidance/ventilation-to-reduce-the-spread-of-respiratory-infections-including-covid-19

Wargocki, P. The effects of ventilation in homes on health. *Int. J. Vent 2013;* 101-118.

WHO. Listings of WHO's response to COVID-19 2021. https://www.who.int/news/item/29-06-2020-covidtimeline

WHO. Roadmap to improve and ensure good ventilation in the context of COVID-19. https://www.who.int/publications/i/item/9789240021280

Zhao B, An N, Chen C. Using an air purifier as a supplementary protective measure in dental clinics during the coronavirus disease 2019 (COVID-19) pandemic. *Infect Control Hosp Epidemiol* 2020;11 1-2.

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