

Covid-19 outbreak and Oral Health Concerns – A Systematic Review

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Abstract

Background:

The aim of this systematic review is to shed light on practical implications of Covid-19 pandemic for the profession of dentistry. It examines the current literature and dental guidelines on Covid-19 in a systematic manner.

Methods:

A sequential systematic literature search was conducted on Pubmed, Medline, CINAHL, Scopus, Google scholar, Embase of Web of Science. The search results yielded the following results-Covid-19 ($n=5171$), Novel corona virus ($n=63$), Covid- 19 and dentistry ($n=46$), Covid-19 and oral health ($n=41$) Novel Corona virus and Dentistry ($n=0$), dental health and Novel Coronavirus ($n=26$), and dental practice and Novel Coronavirus ($n=6$)

Results:

The final review included 13 articles after elimination of other articles based on inclusion and exclusion criteria. Original articles and systematic reviews addressing 2019-nCoV and dentistry were entitled for inclusion, case reports, case series, correspondences, editorials were not included. Bias risk assessment was assessed using the Newcastle-Ottawa Scale (NOS)

Conclusion:

Covid-19 pandemic is an existential crisis for the profession of dentistry and requires a complete rethink about many aspects of the profession due to the nature of dental work. Evidence based research and multi-sectorial collaboration is required to make the profession safe again, both for the patient and dental team.

Background

Coronaviruses are a distinct group of viruses which can cause diseases of varying degree of severity. Corona viruses first became evident as Severe Acute Respiratory Syndrome in China followed by Middle East Respiratory Syndrome (MERS) in Saudi Arabia & Middle East ¹. SARS epidemic affected 26 countries with more than 8000 confirmed cases and 774 deaths before being contained in 2004 ². MERS affected 27 countries that was first reported in September 2012 with 2519 confirmed cases and 866 deaths by the end of January 2020, with a case fatality rate of 10% and 34% respectively ³. Evidence from previous research suggests that both SARS coronavirus (SARS-CoV) and MERS coronavirus (MERS-CoV) originated from bats and infected humans using intermediate host such as civets in case of SARS-CoV and camels in case of MERS-CoV. The chain of transmission for Human SARS-CoV was broken with isolation of probable cases and closing wet markets where it originated via direct contact with civets. However, in the case for MERS-CoV, such strategies were difficult to implement as camels are widely distributed throughout the Middle East and African countries and considered a viable source of milk, transport and meat for the local

population⁴. Until any effective strategies such as vaccine for camels against MERS-CoV is available, sporadic cases of human MERS-CoV will continue to appear⁴. In December 2019, pneumonia of unknown origin was reported in Wuhan, a town in Eastern China. The World Health Organization office in China provided the first reports of a new virus of unknown origin after a number of pneumonia cases and in conjunction with this the first cluster of cases were reported in people associated with the South China Seafood market in Wuhan. The surveillance system as it was established during the SARS-CoV outbreak was implemented and the patient's throat swabs were sent to the laboratories for etiological analysis⁵. The causative agent was identified by Chinese Centre of Disease Control and Prevention and the Wuhan seafood market was shut down immediately; but by then this virus had already begun to spread beyond the market itself⁶. Initially the virus was named as 2019 novel coronavirus; later it was named Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2) as suggested by Coronavirus Study Group (CSG) of the International Committee on Taxonomy of viruses⁷. On January 30, 2020, the World Health Organization (WHO) declared the rapid spread of SARS-CoV-2 and its associated Coronavirus Disease 2019 (Covid-19) as public health emergency of international concern with overall case-fatality rate of 3.4%^{8,9}. According to WHO situation report of April 16, 2020 there have been approximately 2 million reported cases and 130,000 deaths globally, and the number of reported cases continue to increase⁸.

SARS-CoV-2 is a β -coronavirus that is encapsulated with a non-segmented positive-sense RNA virus that can be transferred from person to person¹⁰. Based on the findings of virus genome sequencing and genetic research, bat was primarily suspected of being the host. In fact, similarity of protein sequences and phylogenetic analysis have shown that identical receptor residues have been found in several animals, offering new resources for potential intermediate hosts, such as turtles, pangolins and snakes^{9,10}. Here we performed dynamical simulations on a model that can closely capture the geometric features of the spike protein within the membrane wall of the virus and the presence of a micro domain within the membrane. The molecular docking studies were carried out using Schrödinger small-molecule drug discovery suite 2019-4. It was prepared for molecular docking studies using protein preparation wizard of Schrodinger 2019-4 using OPLS-3e force field at pH 7.40 ± 0.02 and the other default settings. The entry of SARS-CoV-2 inside humans is lungs whose pH is $7.38 - 7.42$. So, the protein was prepared at pH, 7.40 ± 0.02 . The SARS-CoV-2 spike protein binds with ACE-2 of lungs. In the crystal structure, 6LZG, chain A is hACE-2 protein and chain B is spike protein. The fragments were docked into protein and ligand sites using GLIDE module in Schrodinger and followed 'Standard precision' docking protocol with default settings. This model is a result of computational feasibility (**Fig 1**) mimicked by attractive interactions (ϵ_0) considering diffusivity, fluidity and rigidity as bilayers are obtained with widths of 5 nm. The electrostatic interaction between proteins and membrane polar head groups show no repulsive component. The notable feature is the subunit spike at the polybasic site at the junction of S1 and S2. There are proline turns flanking the cleavage site which is very unique to SARS-CoV-2. Given the known genetic variation and depth of the spike, there is enhancement of MERS-like coronaviruses infection transferring from bats to human cells¹¹. Studies are currently being conducted in our lab to assist scientists who have been doing research relevant to drug discovery and/or development; also to frame their research report in a way that appropriately places their findings within the drug discovery and development process.

Scientific studies have shown that there are two main routes of transmission of Covid-19 i.e. direct (person-to-person touch or inhalation of short-range respiratory droplets) and indirect (airborne and fomite-mediated) ^{12,14}. Individuals may acquire indirect infection by getting in touch with the contaminated surfaces and then contacting their oral, nasal or ocular mucosal surfaces ¹³. The infection is spread by large droplets formed by symptomatic patients while coughing and sneezing, which may also occur in infected asymptomatic individuals ^{14,15}. Some researchers from the United States and China have reported possible faecal-oral transmission of SARS-CoV-2, while vertical transmission from mother to infant is still being investigated. The most commonly cited clinical symptoms of Covid-19 are raised body temperature, dry cough, malaise, and dyspnoea ¹⁵. Computerized Tomography (CT) scan findings included pneumonia with anomalous findings in all cases. In the less common findings, cephalgia, diarrhoea, vomiting, sore throat, and production of sputum have been reported ^{10,16}. Although all demographics of global population are at-risk for Covid-19 infection, some groups including older adults (over 65 years of age) or people with co-morbidities (namely hypertension, diabetes, cardiovascular disease, lung cancer, people taking immunosuppressant drugs, and chronic obstructive pulmonary disease) can manifest severe forms of disease and associated complications, which may lead to death ¹⁷. Healthcare workers and patients hospitalized for other reasons are at higher risk for Covid-19 due to possibility of frequent close contact with symptomatic and/or asymptomatic individuals infected with Covid-19 ¹⁷.

The pandemic initially began in China which endured much of the infections of Covid-19. Over the passage of time cases in China have waned down, but the disease has continued to intensify in other parts of the world ¹⁷. Currently, USA with almost 1,645,353 cases and 97,655 deaths, Spain with 281,904 cases and 28,628 deaths, and Italy with 228,658 cases and 32,616 deaths are the epicentre for this epidemic ¹⁸. The current spread of coronavirus continues to grow, affecting almost all the countries with many fatalities. The World Health Organization declared SARS-CoV-2 outbreak a worldwide pandemic on March, 11th 2020. Not only has the pandemic impacted the physical well-being of the entire planet, but it has led to global economic decline which has influenced many industries in the first half of 2020 and dentistry is one of them ¹⁹. Similarly, the dental fraternity is experiencing a drastic transition and will continue to do so over the coming weeks and months as a consequence of the of the SARS-CoV-2 outbreak ²⁰. The consequences are far-reaching and unpredictable, particularly for the dental community and for patients seeking dental care. Results from a recent study showed that aerosols containing SARS-CoV-2 remain infectious for up to 3 hours in confined spaces, 4 hours on copper, 24 hours on cardboard, and up to 3 days on stainless steel and plastic (**Fig 2**). Since use of ultrasonic scaler, triple syringe, dental hand piece, and other high-speed driven instruments during dental treatment can generate tremendous amount of aerosols, putting dental practitioner's dental surgery assistants and their patients at high risk for contracting Covid-19 ²¹. There have been many recommendations in the United States and elsewhere to cease non-essential dental procedures and restrict treatment to emergency care ^{19,22}.

Dental practitioners are facing uncertainty and are being forced to rely on general information on Covid-19 transmission routes and other guidelines being followed by general frontline health staff to protect themselves and their patients ²². Dental practice serves as a contagion point and a vector for Covid-19

outbreaks in the population if appropriate protocols are not followed. With its outbreak, Covid-19 has raised the bar for delivering high-quality dental care around the globe. This scoping review is an effort to review all the relevant literature published so far on dental aspects of Covid-19 in order to serve as point of synthesis for future recommendations and guidelines for dental practices in these troubling times.

Methods

There were two independent reviewers (Drs. SM & ZA) who screened the titles and abstracts of all the identified studies to determine the relevance meeting the pre-determined inclusion criteria (**Table 1**). The authors screened PubMed, Scopus, Web of Science, Embase, CINAHL, Medline and Google scholar databases after December 2019 till April 2020 for appropriate articles addressing the question under review. The researchers reviewed all the articles after reading the abstracts of the relevant publications. Full text was screened if there were insufficient data to make clear decision based on abstracts. A structured and logical approach to literature search was used to identify the relevant papers that investigated Covid-19 and its dental implications. Reference lists of original studies were manually searched to identify any articles that could have been missed during the initial search, keeping the inclusion criteria in mind. Any disagreements regarding study selection were resolved via discussion. (**Table 1 of inclusion and exclusion criteria**).

Table 1: Inclusion and Exclusion Criteria

Inclusion Criteria	Exclusion Criteria
Articles published after the Covid-19 outbreak (Dec 2019 onwards)	Studies published prior to Covid-19
English language only	Articles not in English Language
Original articles, Reviews, Case reports, Case Series	Editorials, Opinions, Perspective, Correspondences
Only Articles Published in Peer-review and Indexed Journals	Non-peer reviewed/ Non-indexed journals
Data Bases examined (Pubmed, CINAHL, Scopus, Medline, Embase)	Little or no focus on dental aspects

Review Question

Based on the Preferred Reporting Items for Systematic Review and Meta-Analysis (PRISMA) guidelines, a specific question was constructed²³. The addressed focused question was “What is the future of Dentistry in the Covid-19 era?”

Data Sources & Study Selection:

A sequential systematic literature search was conducted on the above mentioned databases using the following key words; Covid-19 (*n*=5171), Novel corona virus (*n*=63), Covid-19 and dentistry (*n*=46), Covid-19 and oral health (*n*=41) Novel Corona virus and Dentistry (*n*=0), dental health and Novel Coronavirus (*n*=26), and dental practice

and Novel Coronavirus ($n=6$) (Table 2). A MeSH (Medical Subjects heading) search strategy didn't return any article, probably because the novelty and scarcity of articles for the topic under review. The following MeSH terms were used (Coronavirus and Dentistry, Corona virus and oral health, Covid-19 and dentistry, Covid-19 and oral health,) which gave zero results (PRISMA flow chart, Fig 3)²³. The search parameters used for inclusion criteria were: articles in English language, at least one keyword corresponding to the above entries in the title/abstract and study based on the evaluation of research articles (Table 3). Original articles and systematic reviews addressing 2019-nCoV and dentistry were entitled for inclusion, case reports, case series, correspondences, editorials were not included. All keyword searches, title and abstract screening, as well as selection of studies, were carried out independently by two investigators (Drs. SM/RA). Articles published before December 2019 were not included as Novel Coronavirus only emerged into the scientific conscience and mainstream after December 2019. Furthermore, online OPD reports/patient-physician testimonials and other online materials was skimmed for other relevant material (PRISMA flowchart, Fig 3)²³. Only articles published in peer reviewed journals were selected for the final review. As Novel coronavirus is a new disease, the data on dental aspects of the virus was extremely limited, but we were able to gather a sizeable number of studies that could serve as the initial groundwork for providing guidelines to the dental community in these uncertain times.

Table 2: Keywords & Search Strings

Covid-19	5171
Covid-19 and dentistry	46
Novel Corona virus	63
Covid-19 and Oral health	41
Dental practice and Novel Corona Virus	6
Dental health and Novel Corona Virus	26
Novel Corona virus and Dentistry	0

Exclusion Criteria:

Studies or other materials published before December 2019 were not included in our analysis. Therefore, the selected articles were published between January 2020 and April 2020. Papers not published in peer-reviewed journals were excluded, as well as studies not matching the inclusion criteria. Articles published in any language other than English were discarded as none of the author is fluent in other languages.

Risk of bias assessment

Assessment of the risk of bias of the reviewed studies is a fundamental aspect of conducting a systematic review. Bias risk assessment in the reviewed studies was examined using the Newcastle-Ottawa scale (NOS)²⁴. The Newcastle- Ottawa scale is a tool for quality assessment ranking studies by assigning them stars*. A modified version of the Newcastle-Ottawa scale was used in the study which used a 10-star rating instead of the usual nine. The stars are rank 3 key domains of the study being assessed i.e. (selection, comparability & outcome). The NOS can be interchanged with the commonly used AHRQ (Agency for healthcare research and quality standard assessment). The more stars, the lesser the risk of bias in the studies included. The study is rated as poor (0-4*), fair (5-6*) or good (7-9*). The results of the assessment are displayed in this article (Table 3).

Table 3: Newcastle-Ottawa scale Quality assessment form for Non-Randomized Studies included in the review

Study	<u>Selection</u>					<u>Comparability</u>		<u>Outcome</u>			<u>Overall</u>
	1	2	3	4	5	6	7	8	9	10	Score *
Kamate S.T et al 2020	*	*	*			*		*		*	6
Shacham m et al 2020	*	*		*		*		*	*	*	7
Ahmed M.A et al 2020	*	*		*	*	*	*			*	7
Khader Y et al 2020	*	*			*	*		*		*	6
Yang Y et al 2020	*	*	*			*	*	*	*	*	8

Statistical Analysis

For reliability evaluation, the inter-observer reproducibility and the intra-observer reproducibility were evaluated using weighted Kappa (κ_w) statistic.

Results

A summary of characteristics of the studies is presented in **Table 4**. The exhaustive process of literature searches and screening of articles (last electronic search done on 22nd April) is presented in the Prisma chart (**Prisma flow chart Fig 3**)²³. Data base and manual search yielded 5,353 articles in total. 4913 Articles remained after elimination of duplicate records. Furthermore 4786 articles were removed after examining abstracts, following which 127 remained for full text assessment. The final systematic review included 13 studies after excluding 114 articles due to lack of relevance in outcome to our stated research question, letter to editor and articles in languages other than English were also eliminated. 6 original articles and 7 review articles were selected for the final review. Four of the studies were cross sectional in nature^{28,33,36,37}. One study was a research article on practical recommendations for dentists during the Covid-19 pandemic³³. Furthermore, there was one article from China based on outpatient department (OPD) records of 48 tertiary care hospitals in China²⁹. Four of the studies were related to findings in China. One each was conducted in Austria³⁰, USA³¹, Jordan³³ and Italy³⁴. Infection control is a theme that was discussed extensively in the literature and remains the main theme of many of the Covid-19 articles on dentistry^{25,26,27,30,31,34}. Telephone triage using questionnaire to evaluate potential risk of SARS-Cov-2 and type of dental care was implement in the following studies^{25,27,31,32,34}. Three studies recommended that patients coming for elective treatments with temperature > 100.4 F or 38 C should be postponed, if possible or performed in an Airborne Infection Isolation Rooms (AIIRs) or negative pressure rooms^{27,31,32}. The guidelines to establish real need of emergency dental treatment was recommended in the following studies

28, 30, 33. Importance of hand hygiene, limiting number of patients in the waiting room/operator, removal of shared objects, proper ventilation and social distancing was highly recommended^{29, 31, 34}.

The weighed Kappa for intra-observer reproducibility exceeded the 0.70 cut off, with a mean of 0.86, indicating almost perfect reproducibility; while the mean weighted Kappa (κ_w) for inter-observer reproducibility was 0.80, showing substantial reproducibility. The other key recurrent themes discussed in the reviewed articles were pre-procedural mouth rinses with 1% hydrogen peroxide or 0.2 % povidone iodine to reduce viral load of aerosols^{25, 31, 34, 42} use of rubber dam and high-volume evacuation/suction (HVE) during aerosol generating restorative procedures was repeatedly advised to reduce airborne and surface contamination^{25, 27, 31, 32, 34}. The theme of protective masks was recurrent in the literature and differing views were observed, some authors suggested wearing FFP1/standard surgical mask for non-aerosol generating procedures and FFP2/N95 or higher for aerosol generating procedures^{25, 27} while several others suggested using FFP2/N95 for all procedures for both clinical and non-clinical staff^{31, 34, 35}. Waste management and psychological impact of Covid-19 on dental work force was another theme explored extensively in the literature^{25, 28, 33, 34, 35, 36}.

Table 4: The Characteristics of the Studies

First author, date, reference	Type of article	Sample size/ Setting/ Population	Article key points	Recommendations/outcomes	Limitations
Peng X et al. (March 3, 2020) [24]	Review Article	Setup: Routes of 2019-nCoV transmission and control in dental practice. Context: China	Dental care environments typically bear the possibility of contamination with 2019-nCoV owing to the complexity of its practice, which requires face-to-face contact with patients. Patients and dentist can be exposed via inhalation of suspended airborne particles, indirect contact from contaminated surfaces, and direct contact with bodily fluids of infected individuals.	<ol style="list-style-type: none"> 1. Patient evaluation should be performed in the clinic using non-contact thermometer for fever and questionnaire to identify suspected case of Covid-19, and treatment should be deferred for 14 days if established. 2. A two-before-and-three-after hand hygiene guideline should be adopted. Dental practitioners should wash hands before examination, before procedure, after touching patient, after touching surrounding, and after touching contaminated equipment. 3. Primary/standard protection for staff in clinical setting including gloves, surgical mask, cap, goggles, and white coat. Secondary/advanced protection for dental professionals including standard protection with extra layer of disposable surgical clothes and impermeable shoe cover. Tertiary protection with special protective outdoorwear for unlikely contact with 2019-nCoV infected patient. 4. A pre-procedural mouth rinse with 1% hydrogen peroxide or 0.2% povidone to reduce salivary load of 2019-nCoV 5. Rubber dam and extra high-volume suction in addition to regular suction to reduce spatter and aerosol. Use of hand scaler for 	Lack of evidence for effectiveness of chlorhexidine mouth rinse against 2019-nCoV

				<p>periodontal scaling and Carisolv for caries removal where rubber dam is unavailable. Dental handpieces with anti-retraction valve or anti-reflux design are highly suggested to prevent cross-infection.</p> <p>6. Standard disinfection of waiting area and operatory between patients. Gooseneck ligation is suggested for disposal of medical waste.</p>	
L Meng et al. (March 12, 2020) [25]	Review Article	Setup: Risk of Cross infection in dental settings. Context: China.	This report, based on expertise and related advice and study, offers critical information regarding COVID-19 and nosocomial infections in dental settings and presents appropriate management guidelines for dental practitioners and students in (potentially) infected areas.	<ol style="list-style-type: none"> 1. Dentists should take stringent personal safety precautions and prevent or reduce the development of droplets or aerosols. 2. Dental clinics are advised to create pre-check triages to test and report the temperature of each workers and patient as a standard practice. 3. In the epidemic time, online lectures should be used to prevent excessive chance of infection. 	None
Ge Z et al. (March 16, 2020) [26]	Review Article	Setup: Transmission and control of Covid-19 infection in dental setting via aerosol. Context: China	The article emphasizes on the importance of aerosol transmission of Covid-19 in dental settings and implementation of precautionary measures to limit its' spread.	<ol style="list-style-type: none"> 1. Multidisciplinary consultation for management of dental emergencies in suspected or confirmed cases of Covid-19. Negative pressure rooms (minimum of 12 air changes per hour or 160L/s/patient) along with highest personal protective equipment for urgent dental treatment of suspected/confirmed Covid-19 cases is suggested. Cough etiquette instructions in waiting area, use of mechanical ventilation in operatory and waiting area, 70-90% alcohol for hand hygiene using two- 	Distinguishing symptoms of fever and fatigue caused by dental infections from Covid-19 is merely dependent of practitioner's expertise. Effect of pre procedural mouth rinse against Sars-Cov-2 with oxidative agents and chlorhexidine is still unknown.

				<p>before-three-after technique, level 1 facemask for non-aerosol generating procedures, level 2 face mask for aerosol generating procedures, and level 3 face mask for confirmed/suspected case of Covid-19, rubber dam for aerosol generating procedures, and one minute surface disinfection of waiting and treatment areas has been recommended. Use of High Volume Evacuator (HVE) at a distance of 6 -15 mm from aerosol generating tip and High efficiency particulate arrestor (HEPA) can clean up to 90% and 99.99% of contaminated air, respectively.</p>	
Kamate SK et al. (March 31 st 2020) [27]	KAP Study	Setup: 860 dental practitioners from different continents. Context: Global	The present research was conducted with the intention of evaluating the awareness, behaviours and activities (KAP) of dental practitioners in the light of the COVID-2019 pandemic.	<ol style="list-style-type: none"> 1. Dentists were found to have good knowledge and practice scores, which are significant in the battle against COVID-19. 2. All dentists accepted that they should help spread knowledge of the disease, and that hand hygiene and PPE were successful in avoiding COVID-19. 	A bias in social desirability. Owing to the cross-sectional aspect of the sample and the sampling method used, the effect of self-selection to the part of the respondents may have arisen. Questionnaire bias.
Yang Y et al. (Apr 3 rd 2020) [28]	Original Article	Setup: 48 public tertiary dental hospitals. Context: China	The state of non-emergency dental care, emergency dental facilities, Online consultation and regional spread of hospitals were evaluated during Covid-19.	<ol style="list-style-type: none"> 1. All 48 public tertiary dental hospitals discontinued regular non-emergency dental care and were offering emergency dental facilities only. 2. The penetration rate of teleconsultation in the eastern area was considerably higher than in the central and western regions. 	Within the limitation of this report, we observed significant changes in the health service provision of Chinese public tertiary hospitals during the COVID-19 epidemic. Nonetheless, more research should

					concentrate on the possible long-term effects that the outbreak may contribute on dental treatment.
Zimmermann M et al. (Apr 4 th 2020) [29]	Review Article	Setup: Risk of Covid 19 risk in Oral & Maxillofacial surgery Department. Context: Vienna	The purpose of the study is therefore to compile and address facets of the treatment of patients in oral and maxillofacial surgery during the COVID-19 pandemic.	<ul style="list-style-type: none"> ▪ Correct usage of personal protection equipment should be made of. ▪ All patients should be considered to be contagious. ▪ Outpatient visits should be reduced to a minimum. ▪ All patients who are admitted to the inpatient unit should undergo a standard SARS-CoV-2 examination. 	Necessary investments should be made for future dreadful situation.
Ather A et al. (April 6 th , 2020) [30]	Review Article	Setup: Recommendations for clinical dental practice in Covid-19. Context: USA	The purpose of this article is to provide a brief summary of the epidemiology, symptoms and mechanisms of transmission of this novel infection. Implications for clinical dental practice in response to Covid-19 have been highlighted.	<ul style="list-style-type: none"> ▪ Every patient should be considered infectious with this virus, and all dental practices need to evaluate their infection management policies. Tele-screening and triaging for identification of suspected Covid-19 individuals. Elective dental care should be deferred for up to 2 weeks for patients with fever (>100.4 F = 38 C). All patients should sit 6 feet apart and wear surgical masks in the well-ventilated waiting area. Pharmacological management should be adopted for urgent care requiring pain management among suspected or confirmed Covid-19 cases. Center for Disease Control and Prevention (CDC) guidelines should be followed for reuse of N95 respirator to preserve scarce resources for personal protective equipment. 	Likelihood of treating an asymptomatic Covid-19 patient in a dental setting is high due to wide range of incubation period from 0 - 24 days and mild presentation of disease in some individuals.

				<p>In addition to standard infection control protocols, preoperative mouth rinse with 0.2% povidine-iodine or 0.5-1% hydrogen peroxide to reduce salivary viral load, use of disposable instruments and blood pressure cuff to prevent cross-contamination, extra oral radiograph preferred over intraoral if warranted then use of double barrier over sensor, rubber dam to prevent splatter, limiting use of ultrasonic/high-speed hand piece/3-way syringe, negative pressure treatment rooms/ air-borne infection isolation rooms (AIIRs) for suspected or confirmed cases, surface disinfection with approved chemicals, and dry environment has been suggested to curb spread of Covid-19 in dental practices.</p>	
Al Harbi A et al. (April 7 th , 2020) [31]	Original Article	Setup: Recommended provisions for dental care during Covid-19 pandemic. Context: Global	This research sought to establish recommendations for the treatment of dental patients before and after the COVID-19 pandemic.	<ul style="list-style-type: none"> ▪ The recommendations for the delivery of dental treatment during the COVID-19 pandemic were established after analysis of the severity of the COVID-19 pandemic and were focused on grouping patients according to symptoms and requirements and assessing treatments according to risk and benefit. In addition to standard infection control measures tele-screening, medical clearance for recovered cases, air borne infection isolation rooms (AIIRs) or negative pressure rooms, extra oral radiograph over 	The guidelines established in this research are general guidance and the final decision will always be made by the discretion of the practitioner.

				<p>intraoral to prevent gag reflex, preoperative use of 0.23% povidine-iodine for 15 seconds, disposable instruments and devices, rubber dam, minimal invasive procedures, and reducing aerosol generating procedures has been recommended. Use of ibuprofen for pain management should be avoided in suspected or confirmed cases of Covid-19.</p>	
<p>Khader Y et al. (April 9th, 2020) [32]</p>	<p>Cross sectional study</p>	<p>Setup: 368 Jordanian dentists from private clinics, hospitals, and health centers. Context: Jordan</p>	<p>The study assessed the degree of understanding, interpretation and attitude of coronavirus disease (COVID-19) and infection management among Jordanian dentists.</p>	<ul style="list-style-type: none"> ▪ However, most dentists were conscious of COVID-19 symptoms, transmission routes, and standard infection control protocols but had limited understanding of additional safety measures to prevent spread of Covid-19 infection between patients and staff. 	<p>Low response rate, Selection bias, and sampling error limits generalizability of the findings</p>
<p>Izzeti R et al. (April 17th, 2020) [33]</p>	<p>Review Article</p>	<p>Setup: Risk of transmission of Covid-19 in dental practice and preventive measures. Context: Italy</p>	<p>There is substantial risk of direct and indirect transmission of covid-19 among dental practitioners and between patients when performing dental procedures with hand piece under irrigation due to generation of aerosol and surface/environmental contamination.</p>	<ol style="list-style-type: none"> 1. Double-phase triage telephonic followed by in-clinic to identify high risk patients; pre and post-operative handwashing for 60 seconds followed by application for 60% hydro alcoholic solution; pre and post-operative mouth rinse for the patient with oxidative agents for 1 minute; level 2/3 facemask for non-clinical staff; level 2/3 facemask, long-sleeved water resistant gowns, surgical glasses, surgical cap, shoe cover for clinical staff; limiting use of ultrasonic/hand piece instrument and overall treatment time; use of rubber dam and 	<p>There is lack of systemic data on use of chlorhexidine against Sars-cov-2. Lack of evidence, data, and unpredictable nature of this disease is affecting adequate delivery of clinical dental care.</p>

				surgical aspiration; 5 minute ventilation of surgical and waiting room between patient; and surface disinfection with 0.1% sodium hypochlorite or 70% isopropyl alcohol has been suggested for the prevention of Covid-19 transmission in dental setting.	
Xu R et al. (April 17 th , 2020) [34]	Review Article	Setup: Role of Saliva in transmission and diagnostic tool for 2019-nCoV. Context: China	The article discusses saliva being a potential non-invasive diagnostic tool for 2019-nCoV detection and a potential transient medium for spread of infection via short distance droplets or sustained airborne aerosols.	1. Wearing masks, disinfecting indoor air, and maintaining social distance can prevent dissemination of infectious salivary droplets.	None
Ahmed M A et al. (Apr 19 th , 2020) [35]	Cross sectional Study	Setup: 669 dentists from 30 different countries. Context: Global	The present research measured distress and fear of infection among dentists operating during the current viral epidemic. In addition, the dentist's information on various practice modifications in the battle against a novel coronavirus disease (COVID-19) epidemic has been analyzed.	<ol style="list-style-type: none"> 1. More than two-thirds of general dental practitioners (78%) from 30 countries were nervous and frightened by the disastrous consequences of COVID-19. 2. A significant majority of dentists (90 per cent) were conscious of recent improvements to care protocols. 	Information gathered over a concise span of time, keeping in mind the sudden effect this epidemic had on the mind set and profession of dental health practitioner. Responses from all countries impacted by the outbreak were not received. Owing to the cross-sectional design of the research, we were unable to establish a cause-and-effect connection.
Shacham M et al. (Apr 22 nd , 2020) [36]	Cross sectional study	Setup: 338 Israeli dentists. Context: Israel.	The analysis examined the correlation of COVID-19 variables and psychological factors with psychological distress in dental workers during the outbreak of the COVID-19 pandemic.	<ol style="list-style-type: none"> 1. As far as self-efficacy is concerned, our findings indicate that dental workers with a higher score for self-efficacy have shown lower psychological suffering. 2. With respect to observational evidence, our studies 	Cross-section model, which precludes causal inferences. Low response rate. Selection bias and sampling error.

				have shown that dentists who have a history of disease have reported elevated clinical distress.	
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Discussion

The uncertainty and chaos caused by the covid-19 pandemic raises many concerns for dental profession regarding practice safety and evidence-based guidelines. A wide array of recommendations available through scientific publications related to covid-19 and dental practice management, makes the task of presenting the most relevant and up to date literature more important than ever. The aim of this scoping review was to capture, document, and demonstrate all the relevant literature published so far on dental aspects of Covid-19 in order to serve as point for future recommendations and evidence-based guidelines for dental practices in this challenging time.

Considering that dental professionals are at higher risk of exposure to Covid-19, infection control has been discussed intensively in the literature^{25, 26, 27, 30, 31, and 34}. Ge Z et al argued that aerosol-generating dental procedures for suspected/confirmed Covid-19 patients have a particularly higher risk of infection transmission²⁷. To achieve optimal infection control, a better understanding of the chain of infection is crucial for the control and prevention of any infectious disease³⁸. The chain of infection requires a pathogen (virus or bacteria), natural reservoir (human or animal) to reside and multiply, which then leaves host through portal of exit, and enters into a susceptible host through portal of entry using some mode of transmission³⁸. Interrupting chain of infection anywhere along the chain will stop the spread of infection³⁸. The standard infection control provisions in dentistry can potentially serve as first line of defence for many dental professionals. However, considering highly contagious nature of SARS-Cov-2, extra protective measures should be adopted to prevent the transmission of Covid-19 disease²⁵.

We have identified 4 crucial phases which can be adopted to break the chain of transmission: (i) protocols for patient triage before treatment, (ii) patient evaluation upon arrival, (iii) during treatment, and (iv) after treatment. With many countries and different states in the US limiting dental procedures to emergency care during Covid-19 pandemic, it is important to establish the real need of emergency treatment^{29, 31, 34}. We found six out of the thirteen articles across different geographic locations (including China, USA, Italy) and practice settings, which implemented telephone triage using questionnaire to evaluate potential risk of SARS-Cov-2 transmission and type of dental care needed^{25, 26, 27, 31, 32, 34}. Emergency dental care for patients reporting symptoms of Covid-19, contact with Covid-19 infected individuals, or travel to highly epidemic regions in the past 14 days should be postponed and pharmacologic management of pain or infection should be considered³¹. When the patient arrives at the clinic, the same questionnaire should be repeated and body temperature should be documented using non-contact thermometer^{25, 31, 34}. Patients with temperature > 100.4 F or 38°C should be postponed if possible or performed in an Airborne Infection Isolation Rooms (AIIRs) or negative pressure rooms^{27, 31, 32}. AIIRs are highly recommended for aerosol generating procedures. These are single patient isolated room with minimum 6 air changes per hour^{27, 39}.

Air from these rooms is exhausted outside, away from areas of human traffic or gatherings or filtered through high efficiency particulate air (HEPA) filter, with negative pressure monitoring system held in place^{27, 39}. AIIRs or negative pressure rooms have been recommended and utilized in the management of corpses with suspected/confirmed Covid-19 patient's⁴⁰. Waste management and psychological impact of Covid-19 on dental work force was another theme explored extensively in the literature.

Hand disinfection for patients, removal of shared objects (toys, drinks, magazines, etc.), 6 feet social distancing, limiting number of patients and use of mechanical or natural ventilation in the waiting area has been suggested to minimize risk of disease transmission to other patients and staff^{27, 31, 34}. If patient cannot go directly to the treatment area, then standard mask and a pair of gloves should be provided while waiting^{31, 41}. Ge Z et al suggested posting cough etiquette instructions at entrances and waiting area to promote respiratory hygiene²⁷. When preparing patient for the treatment, it has been suggested that pre-procedural mouth rinse with an oxidizing agent such as 1% hydrogen peroxide or 0.2% povidone iodine for 1 minute should reduce the viral load in aerosols^{25, 31, 34, 42}. Several studies reported that a common pre-procedural mouth rinse, chlorhexidine may not be effective against Sars-Cov-2, because there is lack of evidence or systemic data and virus is susceptible to oxidation^{25, 27, 34}. In addition, use of rubber dam and high-volume evacuation/suction (HVE) during aerosol generating restorative procedures can reduce airborne and surface contamination^{25, 31, 32, 34}. Use of less expensive high-volume evacuator (HVE) or expensive high efficiency particulate arrestor (HEPA) filters, if held within 6 -15 mm of aerosol generating tip can clean up to 90% and 99.99% contaminated air, respectively²⁷. A rubber dam should be used where possible, which can potentially eliminate all sources of aerosol contamination from blood or saliva by blocking the throat and soft tissue area, except the tooth/teeth undergoing treatment⁴³. An in-vitro trial conducted by Samaranayake et al found 70% reduction in aerosol with use of rubber dam during conservative pedodontic procedures⁴⁴. Peng et al recommends use of Carisolv, a minimally invasive chemo-mechanical removal of carious dentine and hand scaler for periodontal procedures where rubber dam is not feasible²⁵. Finally, the effectiveness of rubber dam as an isolation barrier is merely dependent on the placement skills of the provider and its' technique sensitivity⁴⁵. Peng et al emphasized use of dental hand piece with anti-retraction/anti-reflux valve to prevent aspiration of contaminated bodily fluids into the tubes of hand-piece or dental unit and subsequent cross-infection²⁵. Although there is limited evidence on effectiveness of anti-retraction valve for eliminating risk of cross-infection, its use has been suggested as an additional preventive measure to reduce cross-contamination⁴⁶.

There has been much debate about choice of filtering face-piece (FFP), level 1 vs level 2 vs level 3 for aerosol and non-aerosol generating dental procedures. Some authors suggest wearing FFP1/standard surgical mask for non-aerosol generating procedures and FFP2/N95 or higher for aerosol generating procedures^{25, 27} while others suggest FFP2/N95 for all procedures for both clinical and non-clinical staff^{31, 34, and 35}. A systematic review of clinical trials assessing effectiveness of N95 respirators in comparison to standard surgical mask found no additional protection in preventing influenza⁴⁵. The evidence from SARS-CoV research suggests that small infectious particles of up to 3 µm remain airborne indefinitely in an isolated room⁴⁸. Patients and dental professionals can be exposed via inhalation of sustained small

airborne infectious particles, upon entering the room used to perform airborne generating procedures when minimal protection of standard surgical mask is used^{25,35}. Therefore, considering highly infectious nature of Sars-Cov-2 compared to influenza, we recommend use of FFP2/N95 for both clinical and dental assistants and all dental procedures. Every patient should be considered potentially contagious. Hand hygiene has been extensively emphasized as key factor in preventing cross-contamination, a two-before-and-three-after hand hygiene guideline recommended by CDC and WHO has been suggested^{25,27,28,31, and 34}. Dental professionals should disinfect their hands with soap or 70 – 90 % alcohol before patient examination, before dental procedures, after touching the patient, after touching patient's contaminated surrounding or instruments, and after bodily fluid exposure^{25,27}. Eye protection with safety glasses and face shield has been suggested, which can be disinfected using 70% alcohol^{25,34}. Alharbi et al recommends use of extra-oral radiographs such as orthopantomogram, and cone beam computer tomography over intraoral to prevent gag and excessive salivation³². Overall, a layering approach including head covers, long-sleeved water-resistant gowns, shoe cover, level 2 FFP, and eye protection has been proposed for both clinical and dental assistant's staff to significantly break the chain of infection^{25,27,31, 34}.

After the procedure is complete, disinfection of the treatment room and waiting area including doorknobs, chairs, desks, restrooms, and elevators between patients has been suggested to break the chain of transmission^{27,31,34}. Hospital-grade disinfectants including quaternary ammonium-based, phenol-based, and alcohol-based products such as 0.1% sodium hypochlorite or 70% isopropyl alcohol has shown evidence to be effective against coronaviruses^{49,50}. Wei et al indicate that airborne aerosol particles of less than 50 µm can take up to 30 minutes to settle on the floor, while particles less than 3 µm may remain airborne indefinitely⁴⁸. It is also important to note that, research from Wuhan hospitals related to bio aerosol transmission of Covid-19 reveals high load of virus droplets on the floor and surfaces, indicating likelihood of fomite mediated, and that the dried large droplets may become airborne again^{53,54}. Thus, we recommend ventilating room for 30 minutes before disinfection or using high efficiency or HEPA filter air purifier, and possibly UVC light for small airborne particle^{51,52}. It is important to clean/mop floor between patients especially after aerosol generating procedures and wearing shoe covers, to effectively disinfect treatment and waiting area^{25,34,53,54}. Dental providers need to consider best practices approach to create clean and safe environment for their staff and patients and to minimize risk of disease transmission. Notable consideration should be given to staff training, education, revision & reinforcement of infection control protocols. We suggest creating separate clinical and non-clinical area.

Waste management and psychological impact of Covid-19 on dental work force was another theme explored extensively in the literature. Treatment and disposal of medical waste pose indirect health risk due to environmental contamination, therefore it should be disposed-off in accordance with the protocols provided by the local health authorities. A temporary storage area should be assigned in the clinic for storage of medical waste²⁵. Reusable instruments should be adequately pre-treated using oxidizing disinfectant, cleaned, sterilized, and stored in accordance with the local health authorities' protocol²⁵. Double-layered packing, appropriate labelling, and gooseneck ligation has been suggested for medical

waste generated from suspected/confirmed cases of Covid-19²⁵. The contaminated disposable PPE including gloves, gowns, head covers should be safely disposed-off in a bag, within clinical area before entering non-clinical area. FFP level 2/3 mask should be worn by all staff members at all times.

Dental healthcare professionals are at high risk for acquiring and transmitting infection to their peers, families, and other patients due to possibility of exposure to suspected/confirmed covid-19 patients³⁶. The risk is substantial due to aerosol generating procedures observed during routine dental care leading to subsequent development of fear, anxiety, mental/psychological challenges among dental professionals posed by Covid-19 crisis^{34,36}. This is especially important as emotional instability due to fear and anxiety can foster irrational behaviour and inadequate infection control practices³⁶. We identified four articles examining awareness, perception, attitudes, and behaviour among dental professionals regarding Covid-19 pandemic^{28,33,36,37}. Khader et al conducted a cross-sectional study among 368 Jordanian dentists from different clinical settings to assess awareness, perception, and attitude regarding covid-19 and infection control practices³³. Jordanian dentists were found to have limited knowledge about right incubation period, social distancing and mask for patients in the waiting area, hand hygiene practices, protective clothing for clinical and non-clinical staff, and over 80% reported to avoid treatment for suspected/confirmed covid-19 cases amid to fear of contracting disease³³. Another study conducted by Ahmed et al surveying 669 dentists from 30 different countries reported almost 80% feared contracting covid-19 and would avoid treating suspected cases³⁶. This is further backed by scientific evidence available from previous research showing unwillingness of dental providers to treat patients with infectious diseases such as SARS, HIV, tuberculosis, and MERS^{36,37}. Use of rubber dam and pre procedural mouth rinse with oxidizing agent were ignored by majority of dental providers³⁶. High level of anxiety was reported among dental professionals related to practice closure and subsequent economic implications³⁶. A study evaluating psychological stress experienced by Israeli dentists and dental hygienists during Covid-19 pandemic identified that elevated psychological distress was significantly associated with having an existing chronic medical condition, low self-efficacy score, and contracting Covid-19 from patients³⁷. The study further highlights that psychological distress among dental professionals may have long-term effects and recommends mental health education or workshops to enhance self-efficacy³⁷. The role of local authorities in providing procedural guidelines in the face of pandemic is vital to help healthcare providers in making informed decisions. Adequate knowledge of incubation period is essential to determine safe period in treating suspected Covid-19 patients³³. Use of rubber dam, protective clothing, and pre-procedural mouth rinse play a significant role to prevent cross-contamination³³.

Conclusion

The Covid-19 pandemic presents an existential crisis not just for the profession of dentistry but almost all other professions requiring human to human contact. With the first phase of the pandemic now receding, it is possible that we could see health care authorities permitting elective treatments, but with all the infection control protocols and preventive measures as well as risk assessment of patients. Performing social distancing in the dental practice is almost impossible, hence only strict adherence to laid down protocols

can protect the dental team and the patients from contracting Covid-19. The future trajectory of Covid-19, the strength of individual health care systems, availability of rapid testing kits, possible vaccines and successful therapeutic options for Covid-19 are factors that will influence the dental practice and the additional precautionary measures that the dental practitioners adapt in the coming weeks and month. These measures will have to be scaled up and scaled down depending on the factors mentioned above. The virus will stay for humanity for possibly years to come, hence the contingency plans and preventive measures will also stay with the dental profession for a long time to come⁵⁵. The biggest concern will remain the aerosol generating nature of dental work. More research is required on aerosol's specific risk assessment and measures that can protect the dental work force and patients from aerosol and droplet infection. The economic and psychological aspect of Covid-19 pandemic also need special attention as the pandemic is taking a toll on the mental health of large segments of the population in these unprecedented and stressful times. It is important to fill in the gaps in knowledge regarding the complex nature of Covid-19's impact on dentistry, there are still blind spots regarding transmission and possible precautions which need to be removed with more research and a concentrated and unified effort by Governments, regulating authorities and health care researchers. The goal is to make the practice of dentistry secure in the era of Covid-19.

Declarations

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Not Applicable

Consent for Publication:

Not applicable in this section.

Availability of Data & Materials:

Not Applicable

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The authors declare that they have no competing interests in this section

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Author contributions:

SM, RA, UD & ZA, conception and research design; SM, RA, UD, ZA, AP designed search strategies and laid down inclusion/exclusion criteria for review of literature on the topic; AP & SM prepared figures and charts; SM, ZA and RA drafted manuscript; MNB, SLL, UD & SM approved final version of manuscript; ZA, SM, RA analysed the results and wrote the discussion section; SLL, UD, MNB, SM, ZA edited and revised manuscript.

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Figures

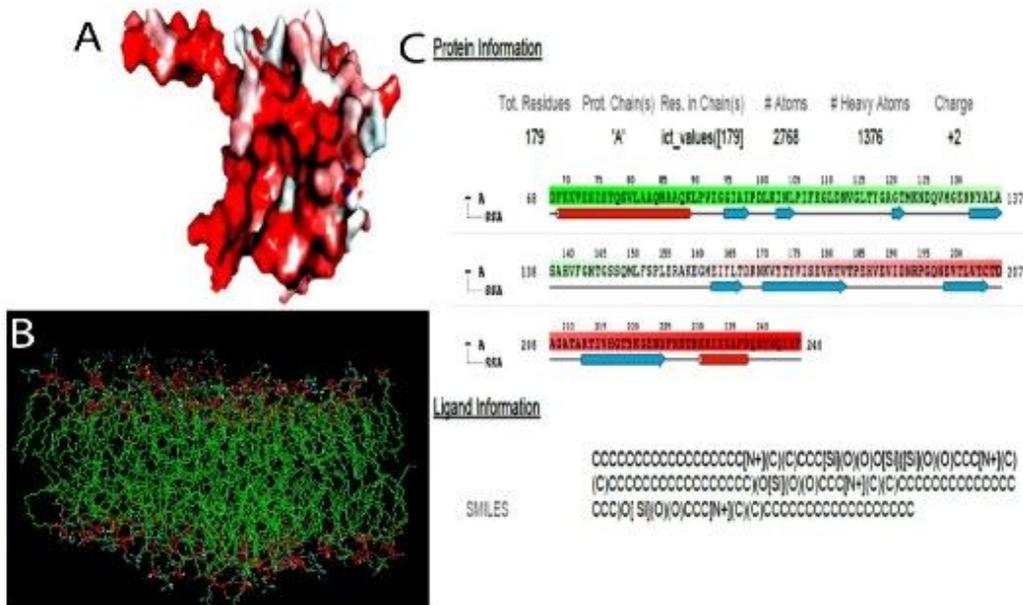


Figure 1

Dynamical simulations on a model capturing geometric features of the spike protein (A) within the membrane wall (B) of the virus. The fragments were docked into protein and ligand sites using GLIDE module in Schrodinger and followed 'Standard precision' docking protocol with default settings. The electrostatic interaction between proteins and membrane polar head groups show no repulsive component. The notable feature is the subunit spike at the polybasic site at the junction (A). There are proline turns flanking the cleavage site unique to SARS-CoV-2 (C).

SARS-CoV-2 Infections - Transmission Routes

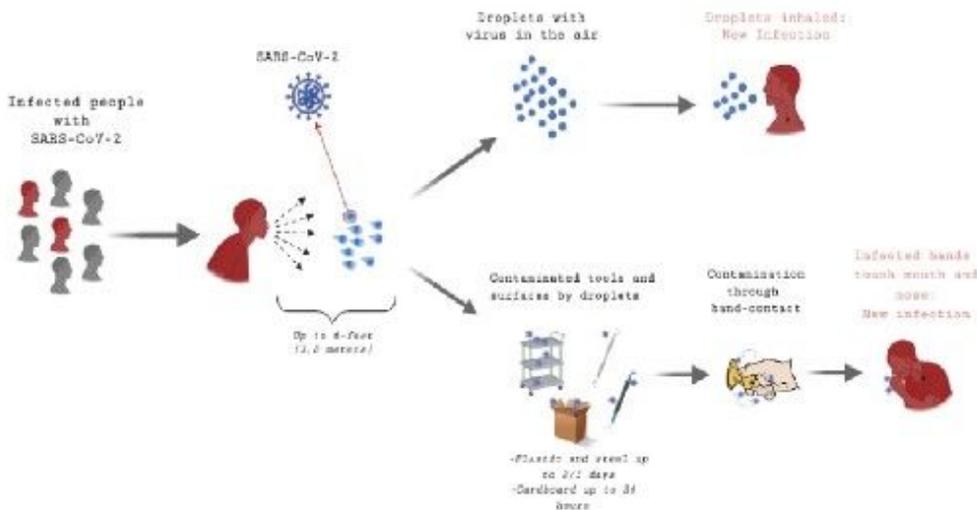


Figure 2

Figure 2 depicts the transmission routes of SARS COV-2 virus by direct, indirect or near close contact when the infected person coughs or sneezes. A person can also become infected by contamination through

shaking hands or touching the contaminated surface and eventually touching your nose, mouth leading to infection.

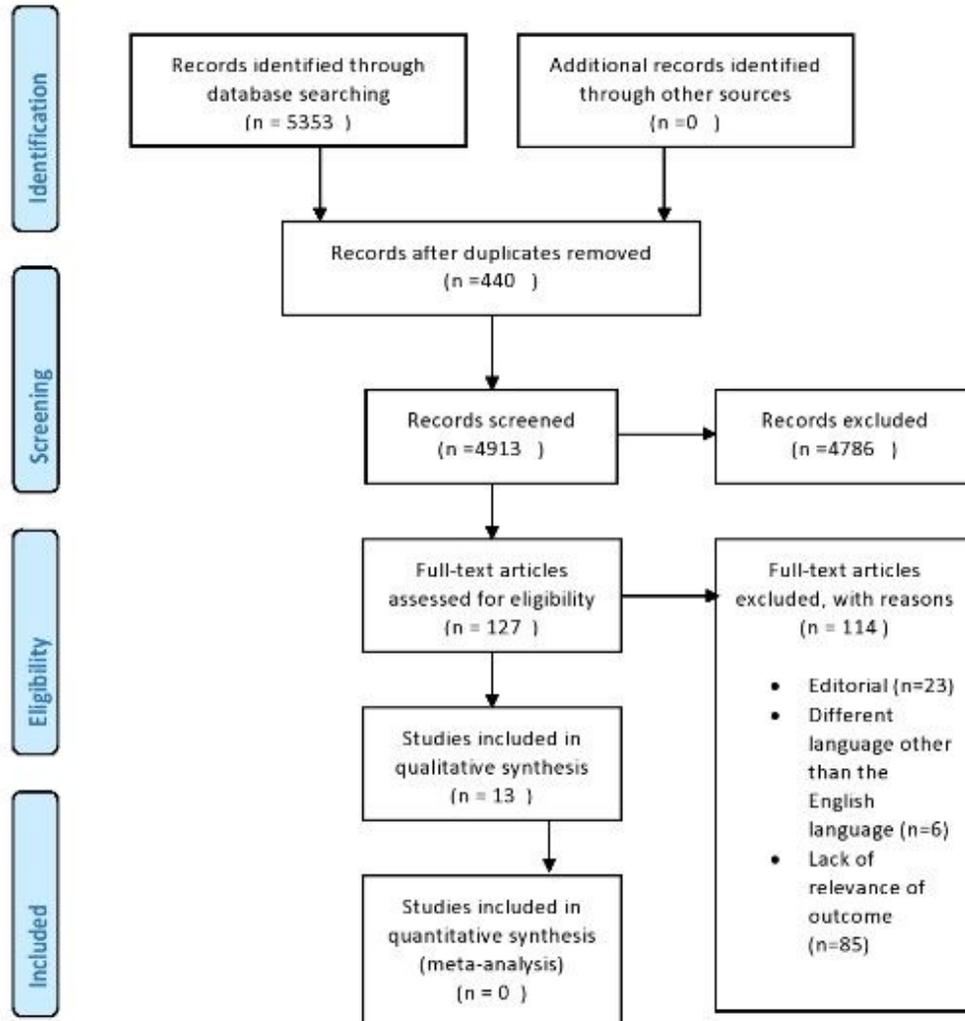


Figure 3

The PRISMA diagram details our search and selection process applied during the overview. Adapted from: Moher D, Shamseer L, Clarke M, Ghersi D, Liberati A, Petticrew M, et al. Preferred reporting items for systematic review and meta-analysis protocols (PRISMA-P) 2015 statement. 2015;4(1):1