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INFLUENCE OF THE COVID-19 PANDEMIC ON DENTAL PRACTICE: WHY MEASURES SHOULD BE TAKEN - THE EXPERIENCE OF AN EUROPEAN UNIVERSITY HOSPITAL (PART 1)

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ABSTRACT

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Introduction The COVID-pandemic does not leave the dental practice unattended. The objective is to analyze why the COVID-19 pandemic urges changes in daily dental practice in the Belgian context.
Methodology The Leuven University Hospital's view is based on Belgian and Leuven University data and existing guidelines concerning hygiene measures in dental practices. The approach chosen is a narrative qualitative approach.
Results Although no transmission of COVID-19 has been reported in Belgian dental practices, the number of health care workers infected and deceased urges for safety measures.
Conclusions In the absence of a vaccine and of reliable data about the infectivity of droplet and droplet cores, dental procedures causing aerosol should be considered as possible sources of viral spread when treating contagious patients, symptomatic or asymptomatic.

KEYWORDS

COVID-19; Aerosol; SARS-2-COV; Personal Protective Equipment; Respirator.

1. INTRODUCTION

After the outbreak of COVID-19 in Wuhan, China, the virus spread to the rest of the world and on March 11th, 2020, the COVID-19 pandemic was formalized by the World Health Organization. On March 18th 2020, the lock-down was decreed in Belgium and many dental practices decided to carry out only urgent treatments. A gradual reopening from 18.5.2020 was again possible thanks to guidelines from Sciensano concerning the organization of the dental practice. The government provided with an additional 20 € per treated patient up to maximal 200 patients per month as from March 1st – December 31st 2020. This manuscript (in two parts) is intended to provide an answer to the question why measures should be taken by the dental community (part 1 of the manuscript) and which measures should be taken in the general dental practice based on the experience and the guidelines issued at Leuven University Hospitals (part 2 of the manuscript).

2. METHODOLOGY

In contrast to the flu, the COVID-pandemic has caused massive overload of the hospital system in different European countries (Italy, Spain). The disruptive nature of the pandemic urges an analysis of the chain of transmission and its translation into daily dental practice. There is a substantial differ-

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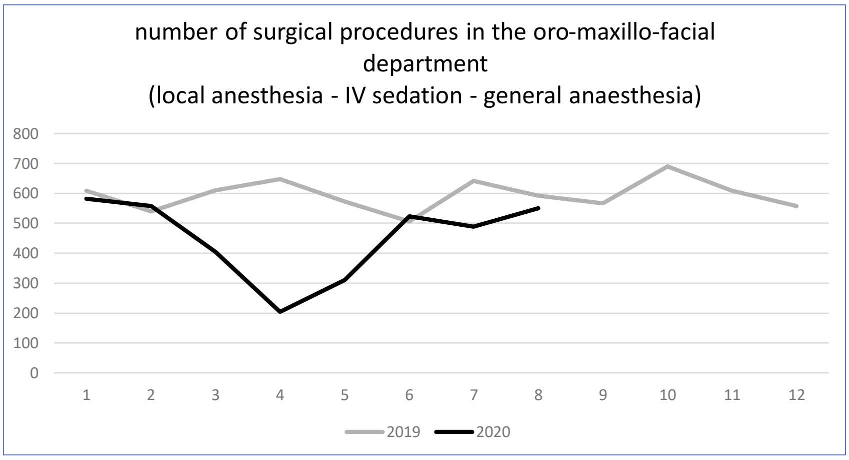

Figure 1. The guidelines issued at Leuven University Hospitals caused a significant impact on the number of executed oral and maxillofacial surgical procedures, during and after the lockdown.

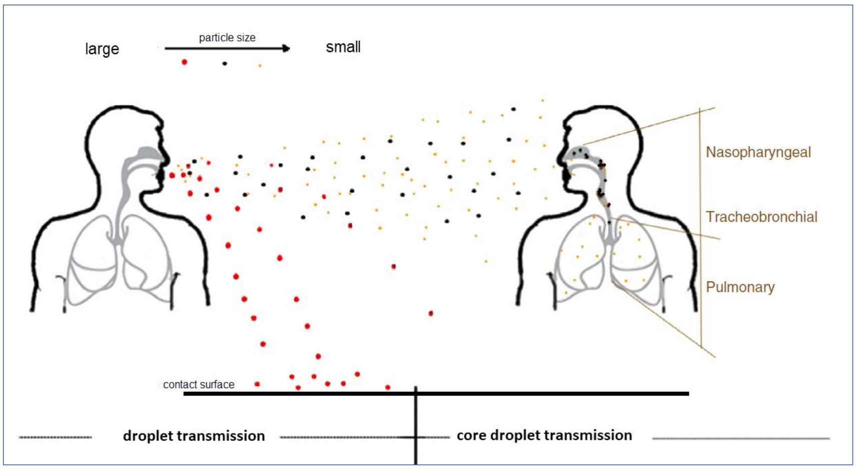

Figure 2. The infectious chain in its simplest form in the COVID-19 virus: the source (the patient in the infectious phase) - the susceptible person (healthcare providers) - the transmission route (aerosol, direct and indirect contact).

ence between hospitals and private dental practices both in guidelines and in exposure to infective micro-organisms. The chain of hygiene in hospitals offers an excellent framework of existing measures which might fit dental practices in an adapted form. The Belgian COVID-19 policy is based on a factsheet which is written by scientists from the Epidemiology of Infectious Diseases Unit of Sciensano, a Scientific Public Health Institute. This factsheet is regularly updated and integrates knowledge of over 4000 articles published on COVID-19 [1]. The existing guidelines for infection control in dental practice in Belgium date back to May 4th, 2011 and have not been revised since [2]. In Leuven University Hospitals the policy followed was to allow only treatments which could not be postponed during the lockdown period. Ever since the lockdown on Marcht 18th, every patient in need of an aerosol producing intervention or treatment was subjected to a COVID-19 RT-PCR test. If the test turned out negative, the planned procedure was carried out. In case of a positive RT-PCR test the procedure is postponed for 14 days without renewed taking of the RT-PCR test. In case of a positive RT-PCR test and medical need for immediate or prompt treatment, this was carried out in an isolated facility with operating rooms having negative pressure and with maximal personal protective equipment including PAPR (Powered Air-Purifying Respirators). At all times measures of physical distancing, sanitizing and wearing of masks were made obligatory in the hospital setting and remained up to date.

3. RESULTS

As a result of these measures none of the health care providers in the oro-maxillo-facial nor dental department got infected with COVID-19. If a health care provider for one reason of another tested positive, contact-tracing was able to determine the source of the infection, never being a treated patient. These measures inflicted reduced revenue (Fig.1), while at the same time incurring new costs (FFP2 masks, RT-PCR testing, sanitizing measures. The dental community and the dental alumni of the Catholic University of Leuven requested scientific substantiation of these measures (PART 1 of the manuscript) and their translation into daily dental practice (PART 2 of the manuscript).

3.1. The disruptive nature of this pandemic

There are 4 reasons why the COVID-19 pandemic has a disruptive effect on dental practice: the raising of public awareness through government measures on public health hygiene, the characterization of dental practice as an increased risk of transmission, the likelihood that the dentist himself may be infected, the likelihood of stigmatization in the event of a practice-related epidemic. If a country decides to take little or

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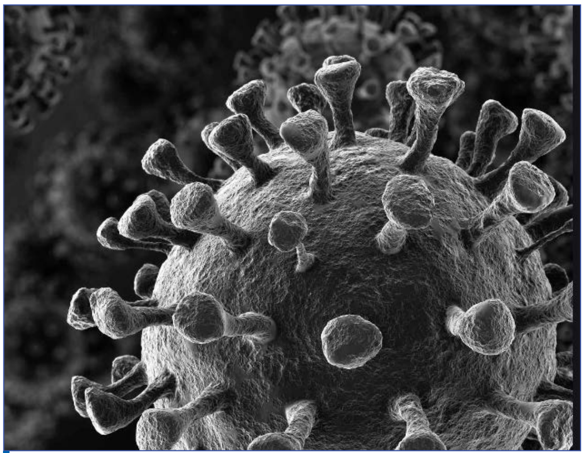

Figure 3. The COVID-19 virus has a two-layer phospholipid membrane containing glycoprotein antennae that allow the virus to vaccinate on the ACE-2 receptors of human cells (the ACE-2 receptor is expressed in lung tissue, the cardiovascular system, the renal and urogenital systems, the gastrointestinal system, the endocrine system, the nervous system).

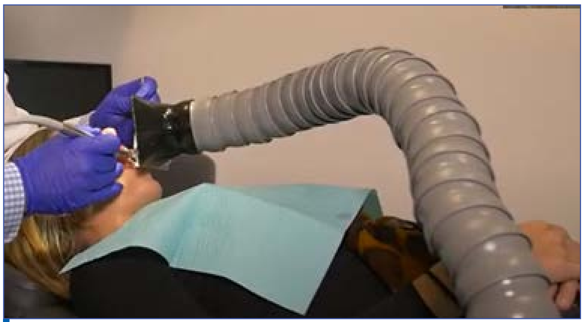

Figure 4. An extra-oral fog extraction system.

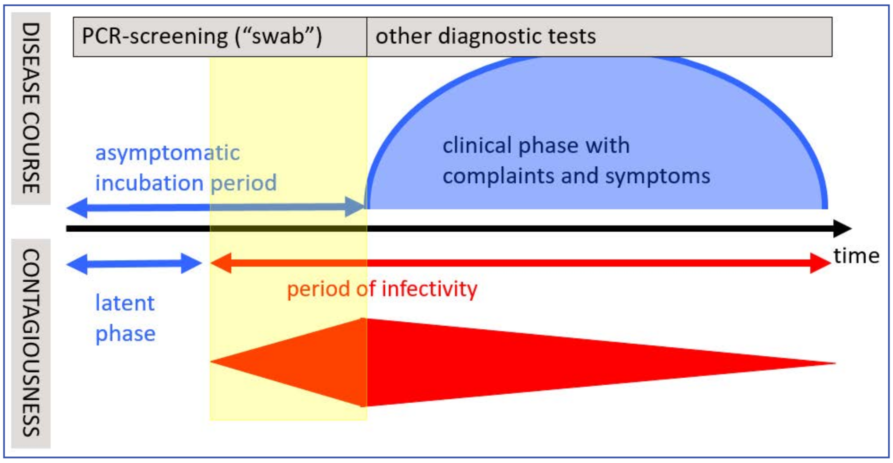

Figure 5. COVID-19 infection and disease course: asymptomatic people can also be highly contagious during the incubation period of the virus.

no action against a growing epidemic in the hope of obtaining herd immunity, dentists are also not expected to change their daily practice routine. However, when a country quarantines itself, including the outpatient health sector, to prevent the spread of the epidemic, the dental practice is paralyzed, except for urgent treatment. Once all health concerns have been re-established, public opinion will be made aware of this infectious agent. For example, there has been no national or international public campaign on the flu virus and dental practice has not changed under the influence of the flu epidemics. If someone catches the flu in the waiting room of a dental or medical practice, it will not cause stigma to the practice. However, if several patients in the same practice are infected with HIV or hepatitis virus or MRSA or Legionella bacteria, this is very stigmatizing when this is publicly known. It is therefore not surprising that over the past few decades, possible contaminations through water, blood and surfaces have been brought under control through numerous hygiene, disinfection, sterilization and organizational measures. And certainly, when the dentist and the practice staff can themselves become victims of contamination. In the circles of ophthalmologists, ENT doctors, dentists and CMF doctors - disciplines that are in immediate proximity to the patient for more than a few minutes - it caused a sensation when ophthalmologist Li Wenliang from Wuhan alerted the Chinese authorities to the consequences of this "new" coronavirus, only to die of it himself on 7 February 2020 [3].

The COVID-19 virus will also have an impact on practice that goes beyond protection against the virus itself, but rather on its route of transmission, just as HIV, hepatitis and legionella have done previously with transmission via blood, surfaces and water. History shows that many of the measures that will affect outpatient medical or dental practice were implemented much earlier in the hospital sector [4].

This will not be different now. As the existing measures will not disappear, infection control in the dental practice will be extended again. Only this time, a pair of sterile gloves or a water filter will not suffice, even though – at present- no dental health professional working in a private practice in Belgium is known to have died in the line of duty from Covid-19.

3.2. The chain of infection

A three-pronged approach is necessary because three elements are inseparable: the chain of infec-

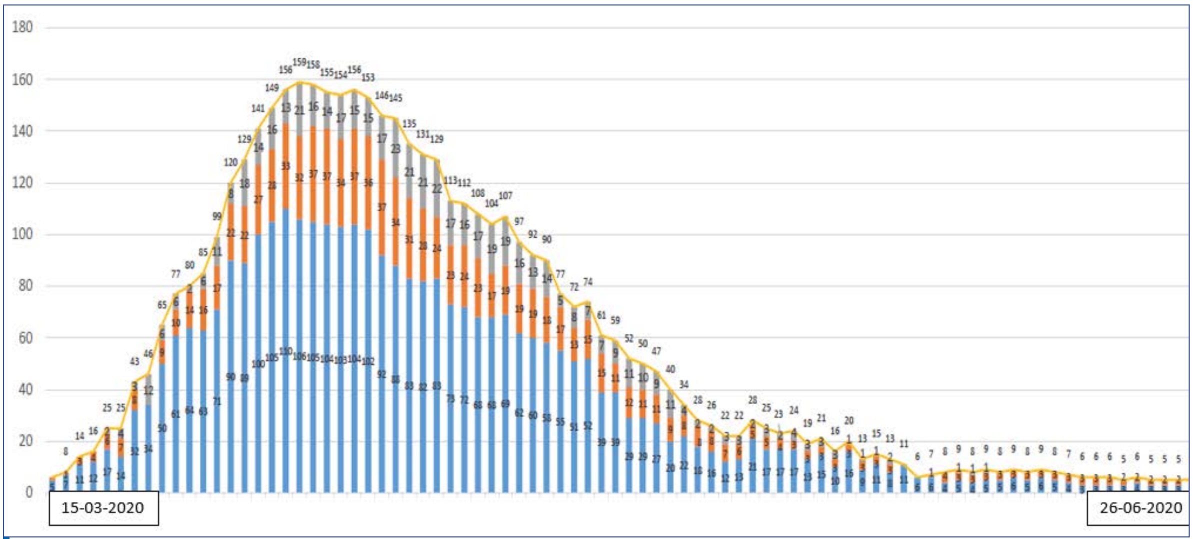

Figure 6a. Evolution of the situation in UZ Leuven between 14.03.2020 and 26.06.2020. The orange (ventilated) and grey (unventilated) bars show patients admitted to the intensive care unit; the blue bars show patients admitted to hospital wards. During this period COVID-19-positive patients are separated from COVID-19-negative patients for surgical interventions. Only urgent procedures can be performed on COVID-19-positive patients. For this purpose, all patients who qualify for surgery will be examined using PCR.

tion, measures to contain the risk of infection and the time factor throughout the epidemiological phases.
In its simplest form, the chain of infection is characterized by three basic elements: the source - the route of transmission - the susceptible individual [5]. (Fig. 2)
Measures to contain the risk of infection are classified according to a certain hierarchy, ranging from elimination of the source of infection to technical measures, from organizational measures to personal protection measures.
The epidemic has a bell-shaped progression with an accumulation phase until a peak and then a decline that never reaches zero and - in the absence of a vaccination programme - can lead to new local or generalized outbreaks [6]. Depending on the phase of the epidemic, the impact on dental practices varies. The health policy choices that the country makes throughout these phases also have a major influence on the overall picture.

3.3. The virus

There are 7 coronaviruses that can infect humans, with SARS-CoV-1, SARS-CoV-2 and MERS-CoV spreading worldwide. SARS-CoV-2 (severe acute respiratory syndrome coronavirus 2) is a respiratory single stranded RNA-virus and is responsible for the COVID-19 pandemic. Scientists in Hong Kong had already warned in 2007 about this "time bomb", which was triggered in 2020 [7,8].
The virus is relatively small, about 125 nm (0.125 µm) in diameter [9]. It is spherical and its mantle consists of a two-layered lipid membrane in which antennae of glycoproteins (so-called 'spike proteins') are anchored that protrude (Fig. 3) and allow them to connect to ACE-2 receptors in the respiratory epithelium (and other cells with ACE-2 receptors). Inside the casing is the viral RNA genome. The entry points are the respiratory epithelium and the oral epithelium, but the oral epithelium has a greater washing effect, so the viral load mainly affects the respiratory epithelium [10]. The ocular epithelium can also become infected with the virus. The virus is excreted through the faeces and faecal-oral transmission is theoretically possible, but infection through the digestive system has not been proven [11,12].
Blood-borne transmission has also not been proven [13]. The virus cannot do anything on its own and is inactive outside a host. The virus is carried by a drop and it is this drop that can be stopped by mouth masks. The virus therefore likes humidity and is believed to persist longer in humid conditions [14].
The virus is lipophilic and can be relatively easily deactivated with 75% ether and many disinfectants: alcohols (ethanol 70% or isopropanol 70-80%), iodine 0.5%-1% (iodized alcohol, iodophors such as povidone-iodine), chlorinated compounds such as sodium hypochlorite 0.1% (bleaching javelin), peroxyacetic acid, hydrogen peroxide (hydrogen peroxide from 1%) and also quaternary ammonium compounds such as ammonium chloride (deterioration of the lipid membrane) [1,15].
Chlorhexidine digluconate is not suitable for the inactivation of the COVID-19 virus [16]. Chloroxylenol 0.12%-0.24% is only suitable for surfaces but not for the inactivation of viruses on the skin (Dettol wax gel) [17]. Benzalkonium chloride is not sufficiently effective against the corona virus [16].
Physical disinfectants are also suitable: a temperature of 56°C for 30 minutes, UV-C rays are all suitable for inactivation. Thorough hand washing with ordinary soap also dissolves the lipid mantle, which inactivates the virus, as the soap molecules trap the virus particles and form micelles [18].
The virus can only survive for a very limited time outside a host. It needs a host to survive, multiply and spread. The ideal host for an epidemic is a host that remains asymptomatic or does not become (too) sick, that does not develop antibodies and in which

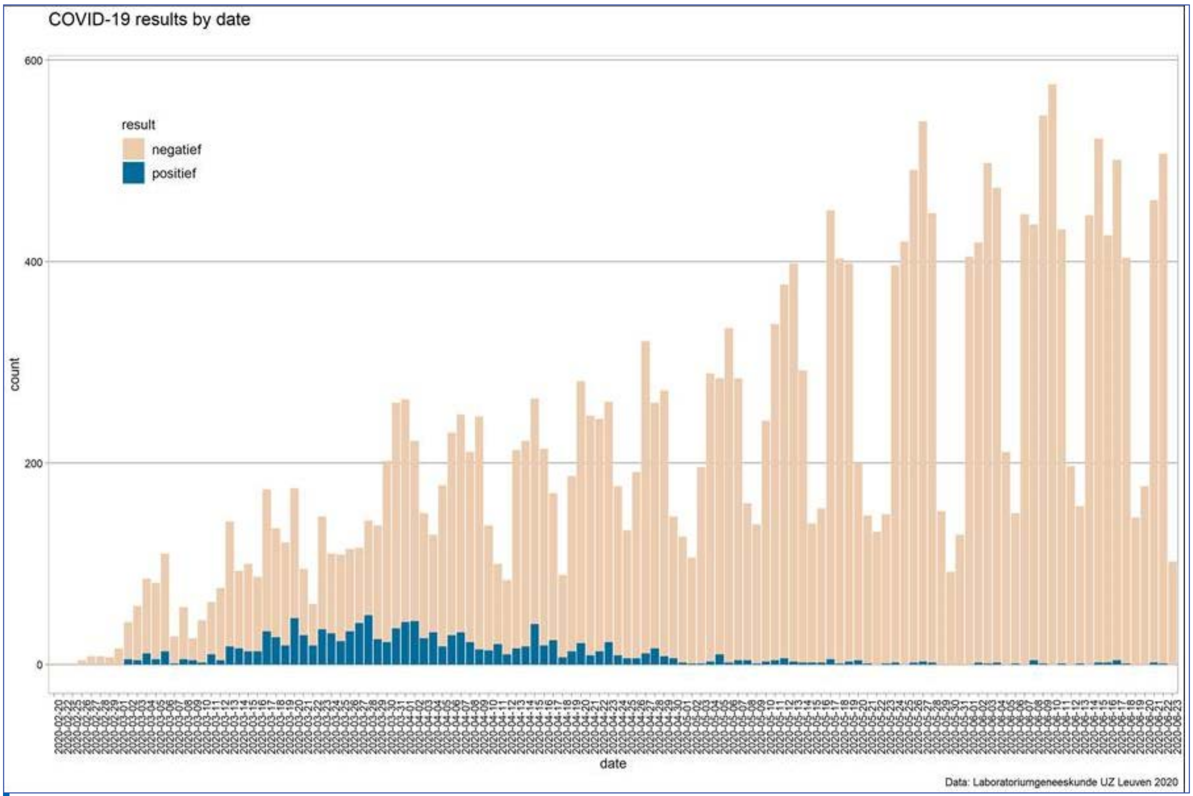

Figure 6b. Daily overview of the number of positive and negative COVID-19 tests performed at UZ Leuven. In mid-June 2020, the number of positive PCR tests in asymptomatic patients fell to 1 positive in 1368 patients (0.07%), at a cost of 46.80 euros per PCR test.

the virus can survive and multiply, after which the host continues to spread the virus; in short, a host that is a good carrier and super spreader.

3.4. Route of transmission

For dental practice, 3 situations are important in the transmission of the COVID-19 virus [19].

3.4.1. Transmission from the patient to the dentist and auxiliary personnel.

An infected person can infect the dentist and auxiliary personnel through direct contact (hands) or indirect contact (surfaces), through drip contamination (moisture particles) or through contaminated air (drip cores) when coughing, sneezing, talking. Contamination by droplets and droplet nuclei is also called aerosol contamination. The aerosol also contains contaminated water, blood, saliva and solid particles (pieces of scale). There is no transmission through blood splashes, needlestick injuries or tap water.

3.4.2. Patient transmission to the following patients

Transmission between patients occurs through indirect contact with contaminated surfaces, materials and instruments and by holding contaminated aerosols in treatment rooms or through the dentist.

3.4.3. Transmission from dentist to patient

Transmission by an asymptomatic carrier dentist is possible by aerosol transfer, by direct or indirect contact, but it is more likely to be a dentist who still carries the viral load of a previous patient and transmits it by direct or indirect contact, not by aerosol transfer.

3.5. Aerosol

Aerosol is a fine suspension of liquid and solid particles. This suspension is responsible for the transfer of micro-organisms into the air. These particles consist of droplets or droplet cores. The droplets are by definition > 5 µm ("Flügge" droplets) and are carried up to 1.5 m away when sneezing and coughing, but do not remain suspended in the air due to the heavy weight [20]. Droplet cores, on the other hand, are between 1 and 5 µm in size, remain in the air for a long time and are transported over long distances. Coughing and sneezing can transport particles up to 9 meters. Droplets and droplet nuclei are both part of the aerosol and can contaminate surfaces [21]. In addition, an aerosol also contains contaminated water, blood, saliva and solid particles. Breathing also ensures air circulation when transporting the aerosol. An adult breathes 5 to 8 liters of air per minute. This can go up to 70-100 liters per minute with very great effort. The particle size determines the depth of the inhalation route through the nose or mouth. Large particles are captured by the mucous membranes of the nose, mouth and oropharynx. Particles < 10 µm are inhalable and can reach the lungs. Finer particles < 2.5 µm can penetrate the halves of the lungs (22). Ultrafine particles < 0.1 µm (100 nm) can be absorbed directly into the blood stream. COVID-19 viruses penetrate deep into the respiratory epithelium via the aerosol but cannot enter the bloodstream. Although no clinical studies are available, it is assumed that an aerosol containing the COVID-19 virus remains contagious for about 3 hours. Modifying fac-

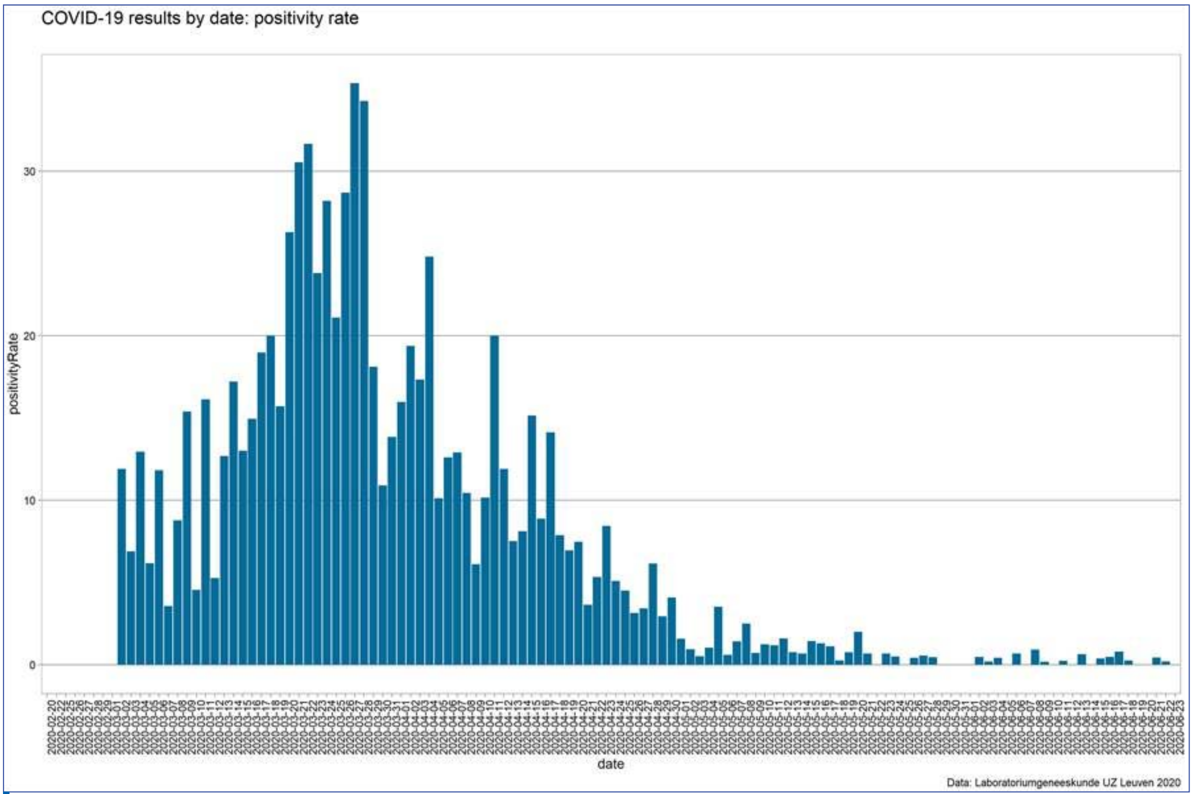

Figure 6c. Number of COVID-19: percentage of positive tests of all tests performed at UZ Leuven.

tors are the degree of aspiration of the aerosol, the number of air changes in the room, humidity, airflow characteristics and room temperature. As a high viral load in infected patients is more often associated with a more severe course of the disease, it is recommended to keep the aerosol viral load as low as possible. Super spreaders are asymptomatic patients with a high viral load during aerosol production. The fact that this issue is taken seriously in the medical world is demonstrated by modified resuscitation protocols where mouth-to-mouth resuscitation in adults is no longer allowed because the risk of infection is estimated to be almost 100%. There is good experimental evidence that the COVID-19 virus survives in aerosol form for 3 hours on plastic and stainless steel for 72 hours, but less than 4 hours on copper surfaces [23]. This is little compared to the Coxsackie virus which survives more than 2 weeks on surfaces and the Hepatitis B virus which can survive more than 14 days in a splash of dried blood on a surface. There is no clinical evidence or in vivo measurements of the COVID-19 virus in aerosols. There are no known numbers of COVID-19 viruses in aerosols, let alone whether they are "infectious". On the other hand, however, there is overwhelming clinical evidence of doctors, dentists, nurses who have treated COVID-19 patients without protection (and sometimes even protected) and have fallen ill to a much greater extent than the average population. For other viruses as well, serological monitoring shows that they have more antibodies against the cytomegal virus (CMV), the Epstein-Barr virus (EBV), but also against the Legionella bacteria than the general population. In short, aerosols cannot be considered a "fictitious" risk in the absence of hard evidence-based data on aerosols produced in dental practices. Aerosol-generating procedures include those in oro-maxillo-facial surgery and dental care : tracheotomy and tracheostomy care; airway suctioning; drainage of abscesses, wound irrigation; use of ultrasound scalers; use of piezotomy; use of turbines and high-speed hand and angle pieces; use of airway syringe ; use of electrocoagulation; inspection of the throat or base of the tongue using a tongue depressor; anterior rhinoscopy; endoscopic examinations of the naso- or oropharynx; all intubations of the nose or mouth; tooth extractions; all surgical procedures in the mouth, jaws or face [24, 25]. The possibilities of preventing contamination by aerosol production in the oro-maxillo-facial surgery practice are limited: prior rinsing of the patient with iodophoric water or hydrogen peroxide; use of osteotomes for extraction; use of self-tapping screws. In addition, air and smoke control systems must be used as usual; in hospital operating theatres: negative pressure in the operating theatre; ± 60 air changes per hour in an operating theatre, smoke extraction systems, HEPA filtration and complete cleaning of the operating theatre between two patients. HEPA filtration stands for High Efficiency Particle Air Filter and is a filter that physically removes harmful microorganisms but does not inactivate them [26,27]. In dental practice, the use of the rubber dam simultaneously with the surgical aspiration allows a reduction of ± 70% of aerosols [28,29]. Here too, it is advisable to rinse the patient beforehand with isobetadine or hydrogen peroxide. The use of osteotomes for dental extractions is a sensible measure. The use of a handpieces fitted with anti-retraction valves is recommended [30]. Ultrasound, piezoelectric and angle handpieces should be avoided if a good alternative is available. Here again, air treatment systems will be used in addition to extra-oral fog extraction systems for aerosols, although the latter penetrate the working field (Fig. 4). The systems that have been known for a long time in the hospital sector will be used as a basis for achieving germ reduction. It is not known how many COVID-19 viruses are contained in one ml of aerosol, but it is known that 1 ml of saliva contains about 10 million bacteria and also that 15 minutes of unprotected operation corresponds to the inhalation of 0.014-0.12 µl of saliva per aerosol. The use of atropine for dry mouth has been observed in patients who drool but not in healthy patients. Hypothetically, dry mouth should lead to a reduction in aerosols, but this is not supported anywhere.

3.6. The patient as the source of COVID-19 virus

As soon as the virus enters the patient and is anchoring its antenna-like glycoproteins on the ACE-2 receptor of the epithelial cells, the latent phase begins in which the virus must develop a whole production chain in order to replicate and release the newly formed viruses. The latent phase ranges from infection to the release of new infectious virus particles and the latent phase is immediately followed by the period of transmissibility or infectivity [31,32]. This phase is also known as the infectious phase. The exact duration of the latency phase of the COVID-19 virus cannot be determined precisely but varies between 1 and 4 days. The duration of the transmissibility period (contagious phase) is also not known with certainty, but as a guide, a 14-day contagious phase is maintained, with patients who present symptoms for the duration of clinical symptoms being considered contagious. The fact is that symptomatic patients are more contagious than asymptomatic. In some studies, PCR positivity has been established up to 37 days [33]. The patient's clinic does not strictly follow the path of virus replication and therefore does not follow the line between the latent and contagious phases. The patient clinically follows an incubation period (first asymptomatic phase) followed by either an asymptomatic or symptomatic evolution, identifying a diverse spectrum of diseases ranging from mild, moderate, severe, critical to fatal. The incubation period does not run parallel to the latent phase (Fig. 4). The patient starts to be contagious during the incubation period when he or she is not yet aware of a disease, in the asymptomatic phase. This means that simple questioning and examination of the patient's symptoms is not sufficient to detect infected patients [34,35,36]. The most important contagiousness is at the beginning of the disease course, during the period when symptoms are minimal to mild. During the incubation period, therefore, screening tests are used [37]. The incubation period of the COVID-19 virus is estimated at 5-6 days, with a range of 1-14 days [38]. This is very different from the SARS-1 virus, which has an incubation period of 2-7 days, but where the person carrying the virus is infectious only after showing symptoms. In MERS, infectivity is present during the incubation period of 2-14 days, but human-to-human infection is relatively limited. SARS and MERS infection is mainly associated with nosocomial spread, while COVID-19 virus is transmitted by aerosol, contact and possibly fecal-oral transmission in the community (RNA for the virus has been found in the faeces of patients, but actual fecal-oral transmission has not been demonstrated yet). For all three coronaviruses (SARS, MERS, COVID-19), transmission on emergency health personnel has been detected [39, 40]. It is completely unknown how many viral particles a person has to inhale in order to become infected. For the Ebola virus, one article on the virus is sufficient. For the noro-virus, 10 to 100 virus particles are sufficient. For the coronavirus, it is assumed that 100 to 1000 virus particles are required for an infection. A number of host-related factors also play a role (diffusion of receptors in the respiratory tract, advanced age of the patient, ...).

3.7. Evolution of COVID-19 disease

In general, it can be said that a large number of infected patients remain asymptomatical. Depending on the infected groups (cruise ships, aircraft carriers), it is known that between 20 and 60% of patients with a positive PCR test result were asymptomatic. For those with a symptomatic course, about 80% will mainly have a flu-like viral syndrome characterized by fever, dry cough, sore throat and some general symptoms. Prodromal symptoms are possible and consist mainly of a sudden loss of smell and taste [41]. The remaining fraction of patients with symptoms require hospitalization, with a significant fraction ending up in intensive care with a risk of death from pulmonary, cardiovascular, thromboembolic, renal complications and/or multi-organ failure. These complications are not so much considered as an effect of the virus, but rather as a host effect on the virus (excessive immune response with cytokine storm) [42]. Not everyone has the same risk of developing a serious illness. Advanced age, male sex, obesity, high blood pressure, cardiovascular disease, diabetes mellitus, smoking, chronic obstructive pulmonary disease, malignancies, chronic kidney disease, immune incompetence are considered to be patients at risk for serious disease progression. In some reports, health professionals are also referred to as "at-risk patients" because of the high incidence of infection with serious diseases and even death [43]. For the dental practice, the course of the disease is important in order to establish good questionnaires to detect potentially infected patients in time and to measure body temperature on arrival at the practice.

3.8. RT-PCR screening

As the patient may already be contagious during the

asymptomatic incubation period, it is necessary, in addition to the questionnaire, to develop a screening test that can detect the presence of viral particles. In Belgium, a reverse transcriptase polymerase chain reaction test (RT-PCR screening test) has been chosen. A throat or nasopharyngeal swab is taken and the test can detect very small amounts of viral genetic material. The detection of viral material is not synonymous with infectivity. This test is not immediately readable, but requires a procedure in a clinical biology laboratory [44,45]. Under ideal circumstances, the sensitivity of this test is particularly high (over 95%). However, in real life, it is assumed that false negative results of up to 30% are detected when testing upper respiratory tract wipers, for several reasons. Incorrect sampling is by far the main cause of a false negative result, followed by the quality of the wipers, transport problems, the margin of error of the test itself, and the presence of too few viruses [46,47]. It is assumed that these false negative (i.e. truly positive) patients have a low level of infectivity. A PCR test is a snapshot in which it is often assumed that the result is valid for about 48 hours. The guideline at Leuven University Hospitals states that a person with a positive PCR test is considered COVID-19 positive, a person with a negative PCR test is considered COVID-19 negative, and a person who had a positive PCR test 14 days ago and has been quarantined since then, and who has not had a fever for at least three days, may continue to be considered negative after those 14 days without a new PCR test. The reason why no new PCR test is recommended is that RNA can remain present for a very long time, allowing the PCR test to remain positive for a long time without proving infectivity [48]. In immunocompromised patients, and after a stay in intensive care with artificial respiration, it is necessary to wait 28 days after a positive PCR test and a new PCR test is subsequently recommended. PCR tests are logistically cumbersome for clinical biology laboratories, are expensive (€ 46.80 in Belgium and € 60 in Germany since the end of May 2020) and the testing capacity is limited per country and per hospital. PCR testing is particularly useful in communities where COVID-positive patients or healthcare providers are located (ships, camps, residential care centers, hospitals). Furthermore, the social cost is only justified in the phase of the epidemic when PCR testing actually influences local policy (Fig. 6 a, b, c). However, once the epidemic has passed its peak and a large number of tests are needed to find a positive test in an asymptomatic patient, the cost-benefit ratio becomes very unfavorable and, in addition to screening, general hygiene and prevention measures as well as contact tracing will be used. This has repercussions on dental practice. During a phase of national closure, it is justified to state that anyone requiring an aerosol production procedure must undergo a PCR test. In the event of a negative result, treatment can continue with the usual personal protection measures. If positive, treatment is carried out in health care facilities or care centers equipped to treat patients who are positive for COVID-19 or treatment is deferred for 14 days and the patient may undergo the aerosol production procedure if they are clinically completely cured. This policy can only be justified when the number of dental and oro-maxillo-facial surgery procedures is limited to emergencies. Once the lock is lifted and citizens are allowed to return to the dentist for dental care, the PCR test is no longer a tool that can be used in the event of a very low number of positive results. Figures from the health insurance funds show that about 40-50% of members go to the dentist every year and that more than half of the patients go to the dentist for curative care, mainly for the treatment of caries. However, there is also aerosol production during extractions, periodontal treatment and preventive dental care. In total, more than 2 million treatments can be carried out. Add to this more than 300,000 oro-maxillo-facial surgery operations per year and it soon becomes clear that a pre-operative test at 46.80 euros is not realistic, even if there were sufficient test capacity for it. At the Leuven University Hospital, as of March 11th 2020, every patient in need of an aerosol producing procedure, receives an RT-PCR testing the day before the intervention. This policy has been continued and probably will be continued until cheaper reliable chair-side testing becomes available or an approved vaccine becomes available. Without a laboratory test, all that remains is a patient questionnaire. Interrogation does not conclusively detect an asymptomatic contagious patient, but may be indicative of recent contact with a person with a COVID-19 diagnosis. There are also a number of drawbacks to interrogation that allow both false positive and false negative conclusions to be drawn. In practice, the dentist will be faced with a situation in which he cannot be sure whether a patient is contagious or not with COVID-19. Unlike the influenza virus, which repeats itself every year, the dentist is forced to take the necessary measures against the transmission of a possible COVID-19 virus in the dental practice.
At least until a sufficient part of the population has been vaccinated against the COVID-19 virus.

3.9. Chains of hygiene

Just as there is a chain of infection, there is also a chain of hygiene to reduce the risk of exposure to germs. Here we identify a series of measures and a ranking of these measures. This set of measures is usually grouped by sector in guidelines or recommendations.

3.9.1. Dentistry sector

In 1997, a Belgian guideline for dentistry was developed under the title "Hygiene in Dental Practice" by the Ministry of Social Affairs, Public Health and the Environment [49]. It stated that "the spread of the Human Immunodeficiency Virus (HIV), the prevention of infections with the hepatitis viruses (HBV and HCV) and the increase in cases of Therapy Resistant Tuberculosis (TB) are at the root of the greatly in-

creased concern for the prevention of transmission of infections in medical procedures in hospitals. To date, there are no binding guidelines for measures to be applied in the dentist's office. In the absence of any form of external control, it is the duty of every dentist to assume his or her responsibility in this respect".
This publication was followed by the "Infection Control Recommendations during dental care" of 4 May 2011 issued by the High Council of Health (publication no. 8363) [2]. The prevention of airborne transmission of germs is explicitly mentioned, with attention being paid to the use of rubber dam, a nebuliser, a nasal mask and a face shield, as well as to rinsing the patient's mouth before any procedure. These recommendations are not legally binding.
In the Netherlands, the "Guideline on Infection Control in Oral Care Practices" is regularly updated [50]. This is also based on the same concerns as above. In the 2016 edition of the Dutch Aerosol Directive it is also stated: "The amount of pathogenic micro-organisms in an aerosol is strongly diluted by water. Therefore, for most interventions, the risk of infection due to aerosol contamination is negligible". Perhaps this wording will be changed in a future edition. In the United States, the Center for Disease Control and Prevention has also updated the 2016 guidelines for infection control and prevention in dental offices, but states that "dental facilities are generally not designed to apply all transmission-based precautions (for example, airborne infection precautions for patients suspected of having tuberculosis, measles, or chickenpox) that are recommended for hospitals and other ambulatory care facilities." This is clearly a guideline that predates COVID-19 [5].
3.9.2. Hospital sector
As far as hospitals are concerned, there is no "no commitment" choice. Infection prevention and control manuals in hospitals are more than 1000 pages long and there are binding regulations and accreditation standards that are verified through internal and external audits of hospitals [51]. The well-known JCI audits and JCI hospital accreditations are an expression of this. Infection control is a set of procedures and policies to prevent or stop the spread of infections [52]. There are two types of measures: standard measures and transmission control measures.
3.9.2.1. Standard measures have been steadily expanded over the past several decades. They relate to hand hygiene, personal protective measures for the health care provider, respiratory hygiene, allocation of separate rooms for patients, prevention of the spread of infections inside and outside the health care facility ("environmental control"), safe injection techniques, prevention of needlestick injuries, cleaning and disinfection of instruments and surfaces. The standard measures apply to all patients, whether symptomatic or asymptomatic. Environmental control can be divided into several categories: waste control, animals in care facilities, washing and bedding, samples for control and monitoring, disinfection of premises, water and air quality control [4].
3.9.2.2. These standardization measures have long since been supplemented by measures to prevent transmission by direct or indirect contact, droplet and droplet core transmission (aerosol transmission). They applied only to patients with or suspected of having an infection.
These additional measures aim to prevent transmission and consist of isolating patients, defining and limiting patient pathways by providing separate routes for staff and visitors, limiting the number of contacts with the infected person, the use of disposable products and the application of personal protection measures also for the person suspected of infection, as well as strengthening cleaning and disinfection procedures for the environment and equipment (both frequency and products as indicated). It seems obvious that a number of measures which were generally designed for hospital use and related to the transmission of aerosols will have to be progressively translated into dental practice. It may be possible to progressively review each chapter of infection control, but it seems more appropriate to take an approach closer to the chain of infection described above.

4. LIMITATIONS AND FUTURE AIMS

The limitation of this paper is that it does not compare two patientgroups and health care providers, one following the guidelines and the other not following the guidelines. Future research should determine the number of COVID-19 virus particles in dental aerosols and in the air of the dental practice in order to quantify the risk of contracting COVID-19 through droplets and droplet cores.

5. CONCLUSION

The COVID-19 pandemic highlighted aerosol transmission in the chain of infection bringing both health professional and patients at risk. Implementation of adequate measures in the general dental practice can be achieved by returning to solutions that have already existed for some time in the hospital environment and, where possible and feasible, integrating them into daily practice.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

AUTHOR CONTRIBUTIONS

All authors contributed to this paper. CP: contributed to concept and writing. AS and MVP: contributed to protocol. KL: contributed to data gathering and analysis. JK: contributed to critically revising the manuscript.

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Questions

1. The COVID-19 virus is a(n):

❑a. Enveloped virus;
❑b. Non-eveloped virus;
❑c. DNA-virus;
❑d. Double-stranded RNA virus.

2. The least probable route of transmission is:

❑a. Contaminated aerosol;
❑b. Contaminated respiratory droplets;
❑c. Contaminated fomites;
❑d. Blood of COVID-19 patients.

3. PC-R testing for COVID-19:

❑a. Allows results to be read in 30 minutes;
❑b. Has less false positive than false negative results;
❑c. Has hardly ever false negative results;
❑d. Is only positive in COVID-19 symptomatic patients.

4. The following is not suitable for the inactivation of the COVID-19 virus:

❑a. Ethanol 70%;
❑b. Sodium hypochlorite 0.1%;
❑c. Hydrogen peroxide from 1%;
❑d. Chlorhexidine biguanide.