

SYSTEMATIC REVIEW

Infectious Diseases

A pre-systematic review on the use of masks as a protection material for SARS-COV-2 during the COVID-19 pandemic

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Abstract

Background: Coronavirus disease 2019 (COVID-19) was first reported in Wuhan, China on 31 December 2019. Aims: to review, analyse and discuss all works about the wearing and development of facemasks as potential protection against SARS-COV-2 during the COVID-19 pandemic.

Methods: *PubMed*, *SciELO*, *Google Scholar* and *DOAJ* were browsed. Keywords: "mask and (SARS or Cov)" (1 August 2019 to 12 April 2020). Inclusion criteria: original research. PRISMA criteria were followed.

Results: Twenty-one works were selected. Identified topics: effectiveness of protective equipment/devices (PE) (n = 3), universal wearing of facemasks plus other protective measures in the community (n = 3), impact of infection control measures on hospitals and epidemiological tracing (n = 3), development of new PE (n = 2), sanitisation of facemasks (n = 4), clinical guidance (n = 4) and questionnaires (n = 2).

Discussion: It seems that the effectiveness of PE, namely facemasks, is not fully known. Universal wearing of facemasks may be simultaneously recommended with other protective measures. Nosocomial and community infections seem to be preventable. New PE, methods of facemask sanitisation and clinical guidance are emerging, but caution is recommended regarding their adoption, revision and monitoring by international boards and institutions. Questionnaires are useful tools for collecting citizens' opinions on implementing public health measures, and thus contribute to mitigating the COVID-19 pandemic.

Conclusions: Universal wearing of facemasks in the community is likely to be recommended during the COVID-19 pandemic. Since SARS-COV-2 is highly contagious, a set of measures should be considered. Facemask sanitisation is possible, but standardised procedures are lacking. New PE is emerging and requires detailed regulatory approval. It is advisable to monitor public opinion.

Review criteria

- Four databases, namely *PubMed*, *SciELO*, *Google Scholar* and *DOAJ* were browsed, with the following keywords: "mask and (SARS or Cov)" (1 August 2019 to 12 April 2020).
- Inclusion criteria: original research related to wear or development of facemasks as a protection against SARS-COV-2.
- Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) criteria were followed.

Message for the clinic

- Universal wearing of facemasks seems to be recommended. Governments taking prevention measures are more prepared to face COVID-19, gaining more time to prepare/organise health care systems.
- Sanitisation of facemasks is possible, but standardised procedures are lacking.
- New protective equipment is appearing, which requires regulatory approval.
- New clinical orientations are emerging; consequently, international peer-review by institutions is recommended.
- Popular opinions/perceptions are relevant to adopting tailored public health measures.

1 | INTRODUCTION

Coronavirus disease 2019 (COVID-19) was reported for the first time in Wuhan (31 December 2019), then rapidly spread worldwide. SARS-CoV-2 (severe acute respiratory syndrome coronavirus 2) is the aetiologic agent of COVID-19.¹ Symptoms of COVID-19 may include fever, fatigue, cough, sore throat, difficulty breathing and other severe respiratory affections in some persons.² The declaration of a pandemic by the World Health Organisation (WHO) occurred on March 11, 2020.³ According to WHO, infection with SARS-CoV-2 may affect people of all ages. However, certain groups may be at a higher risk of getting severe COVID-19. These groups include older people (over 60 years old) and people with underlying medical conditions (such as cardiovascular disease, diabetes or chronic respiratory diseases).⁴

The spread of COVID-19 occurs by contact (eg, direct or through objects/fomites), droplets (eg, coughing or sneezing) or airborne (eg, intubation).¹⁻⁴ There is no evidence that SARS-CoV-2 can be transmitted through the faecal-oral route, although it is possible to find viral RNA in faeces.¹⁻⁵ In this sense, WHO recommends that all persons avoid groups and crowded spaces, maintain physical distance, perform frequent hand hygiene, cover the nose and mouth when coughing or sneezing (eg, bent elbow or paper, which should be immediately disposed of after being used, while performing hand hygiene) and avoid touching the mouth, nose or eyes. Additionally, symptomatic persons should wear a medical mask, self-isolate and seek medical advice.² Besides the severe stress to health systems because of the COVID-19 crisis, personal protective equipment, including facemasks, are facing shortages and contributing to the pollution of the planet. Thus, diverse studies are presenting new techniques on decontamination procedures for protective equipment with the aim of reusing this equipment without damage (eg, decontamination of facemasks with ultraviolet germicidal irradiation, autoclave treatment, ethylene oxide gasing, ionised hydrogen peroxide fogging or vapourised hydrogen peroxide, cobalt-60 gamma irradiation).⁶⁻⁹ Overall, any possible type of decontamination of protective materials, such as facemasks, must ensure the effective killing of pathogens and the non-degradation of these materials.⁹

Two main types of facemasks are available surgical masks and N95 (or FFP) masks. The first offers protection against fluids,

providing a barrier to droplets (eg, protecting the nose, mouth and respiratory tract). The second prevents the user from inhaling airborne particles (eg, during aerosol-generating procedures).¹ Both masks should be used with eye protection, and their use should never constitute an isolated prophylactic measure.²

The use of facemasks in the community remains polemic, with the WHO recommending that “medical masks should be reserved for health care workers,” namely “when entering a room where patients with suspected or confirmed COVID-19 are admitted,” while persons presenting symptoms (eg, coughing or sneezing), caregivers of COVID-19 patients or persons in other situations that require special care also should wear facemasks. WHO reiterates that “the use of medical masks in the community may create a false sense of security, with neglect of other essential measures, such as hand hygiene practices and physical distancing, which may lead to touching the face under the masks and under the eyes, result in unnecessary costs and take masks away from those in health care who need them most, especially when masks are in short supply”.^{2,3} In opposition to WHO orientations, some health experts support the use of facemasks to reduce COVID-19 spread, including homemade cloth facemasks. Importantly, the lack of clinical trials on this topic should not be used as a valid or ethical argument to avoid their use.^{3,10,11}

Particularly, health professionals should wear special facemasks, such as a US National Institute for Occupational Safety and Health certified N95 or a European Union standard FFP2 (or and equivalent), gloves, gown, filtering mask and full-face visor or goggles (protective equipment), if undertaking aerosol-generating procedures (eg, intubation, non-invasive ventilation, tracheotomy, etc); uncertainty remains in relation to some items, namely hoods and visors.^{2,12,13} For instance, N95 facemasks present some constraints, such as an ineffective seal during talking or after prolonged use, may not be adequately fitted to face shape and may be in short supply.¹³

Interestingly, there are diverse studies comparing the use standard facemasks with respirator masks in the influenza setting, but the number of studies reporting the use of facemasks to prevent SARS-CoV-2 infections is still limited. For instance, N95 or FFP facemasks may not be effective in preventing laboratory-confirmed influenza, respiratory viral infections, respiratory infection and influenza-like illness, although they appeared to protect against

bacterial colonisation (review of data from six clinical trials; a total of 9,171 participants with influenza-like illnesses).^{14,15}

2 | AIMS

To review, analyse and discuss all works about the wearing and development of facemasks as potential protection against SARS-COV-2 in *PubMed*, *SciELO*, *Google Scholar* and *DOAJ*.

3 | METHODS

3.1 | Screened databases and keywords

On 12 April 2020, four databases were screened: *PubMed*, (Scientific Electronic Library Online) *SciELO*, *Google Scholar* and *Directory of Open Access Journals* (DOAJ),¹⁶⁻¹⁹ with the following keywords: ("mask and SARS" and "mask and Cov"). These keywords were conveniently selected to cover a likely high number of papers.

PubMed is managed by the National Center for Biotechnology Information (NCBI), at the US National Library of Medicine (NLM), covering 30 million citations from diverse sources, such as MEDLINE, life science journals or online books.¹⁶ *SciELO* is an electronic library comprising Brazilian scientific journals (around 400 listed).¹⁷ *Google Scholar* aims to organise the global academic information, such articles, theses or books, comprising around 389 million records.¹⁸ *DOAJ* is a directory offering open access to peer-reviewed journals (14,447 journals and 4 788 192 articles).¹⁹

3.2 | Covered period

The covered period was between 1 August 2019 and 12 April 2020. The months of August to October 2019 were considered to ensure the inclusion of all potentially relevant papers.

3.3 | Inclusion and exclusion criteria

Inclusion criteria: any original research related to the wearing or development of facemasks as protection against SARS-COV-2, including preprints and reports, although non-peer-reviewed sources should not be used to guide clinical practice. Exclusion criteria: papers out of the covered period, papers written in languages other than Portuguese, Spanish, English, French or Italian because of time and economic constraints such as translations costs, and all published documents not comprising original experimental research, ie, all descriptive/informative studies were excluded (eg, reports, opinion papers, commentaries, reviews, letters to editor or editorials not comprising data from original research or case reports or other original data).

3.4 | PRISMA checklist and flow diagram

The Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) criteria (checklist and flow diagram) were followed. Because of time constraints the review protocol was not registered.²⁰

4 | RESULTS

4.1 | PRISMA 2009 flow diagram

The PRISMA 2009 flow diagram, including the number of selected studies on mask development and use as protection against SARS-COV-2, is presented in Figures 1 and 2.

Twenty-one works were selected in this brief review. For the keywords "SARS and mask," 18 studies were selected (Figure 1), as follows: nine full-text articles in *PubMed*; nine works in *Google Scholar* (two full-text articles, five preprint full-text articles,^{7-9,11,21} one letter³ and one report⁶); 0 full-text articles (or other documents) were found in *DOAJ* and *SciELO*. For the keywords "COV and mask," three studies were selected (Figure 2), as follows: 0 full-text articles (or other documents) in *PubMed* and *SciELO*, two full-text articles in *Google Scholar*, both preprints^{22,23} and one full-text article in *DOAJ*.

Overall, two works out of 102 were excluded because they were written in German and Chinese. The remaining papers were excluded because they did not contain information about original research on the use or development of masks as potential protection against SARS-COV-2 (n = 74), or they were repeated studies (n = 26).

4.2 | Main findings

The main findings on the selected studies for each searched resource are presented in Table 1 (sample size, methods, results and conclusions and identified limitations).

5 | DISCUSSION

Overall, the number of selected studies and involved participants was limited, and clinical trials or controlled studies were not identified. Additionally, only a limited number of studies have been carried out in the SARS-CoV-2 setting involving authors from different research centres (ie, multicentric studies). As expected, the countries with more selected publications were the United States followed by Hong Kong and the United Kingdom, Korea and China with the same number. This was expected since the United States is the most affected country, and China was the first known affected region; moreover, these countries belong to a group of countries with considerable research and development (R&D) capacity.³² Selected works are grouped by topics and the main findings and study limitations are discussed, as follows:

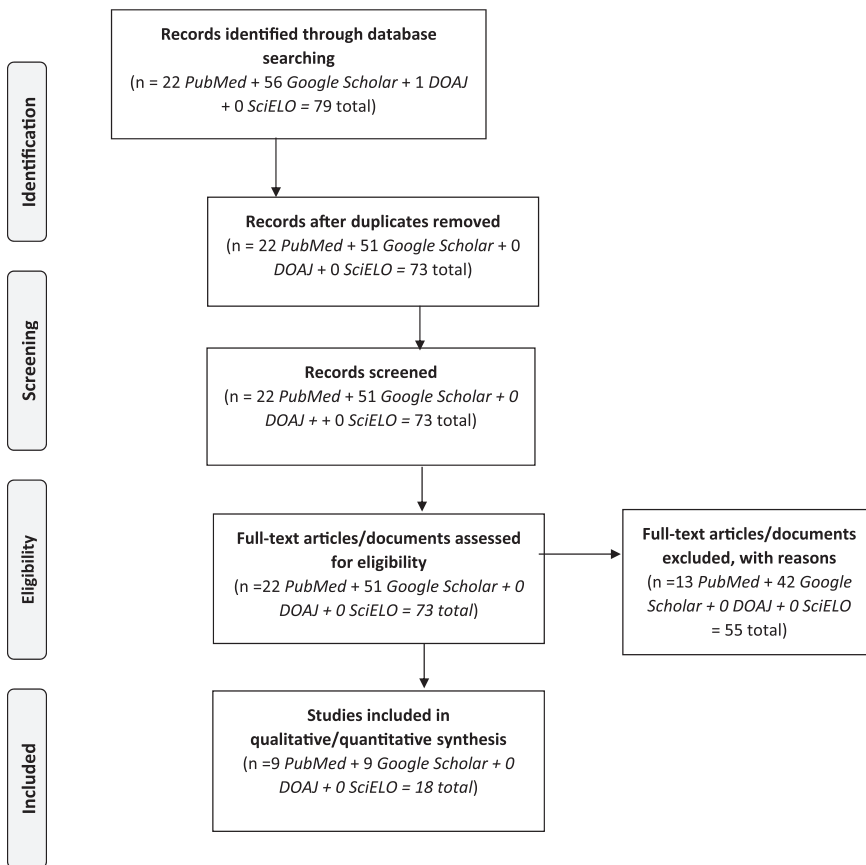


FIGURE 1 PRISMA 2009 Flow Diagram²⁰: selected studies on mask use as a protection for SARS-CoV-2 for keywords “SARS and Mask”

5.1 | Effectiveness of protective equipment: studies not quantifying viral load (eg, physical evaluations, such as aerosol dispersion)

Additional neck, face and hair protection, namely a full-face visor and a high-necked hooded coverall suit are recommended as additional extra protective equipment in the health setting to prevent SARS-CoV-2 infection.¹²

5.2 | Effectiveness of protective equipment: studies quantifying viral load with another virus as a mock-up (eg, avian influenza)

N95, medical masks or homemade masks could, respectively, block 99.98%, 97.14% and 95.15% of the avian influenza virus in aerosols (ie, they are not 100% efficient), which reinforces the need for additional measures, such as hand hygiene to slow virus spreading.²⁴ Importantly, these experiments were carried out with a virus similar to SARS-CoV-2, but the real efficiency of mask-wearing plus hand hygiene may be more modest in a real pandemic setting, as SARS-CoV-2 is a highly contagious virus (the basic reproductive number (R0) was estimated to be 2.2; meaning that 1 patient has been spreading infection to 2.2 other people).³³

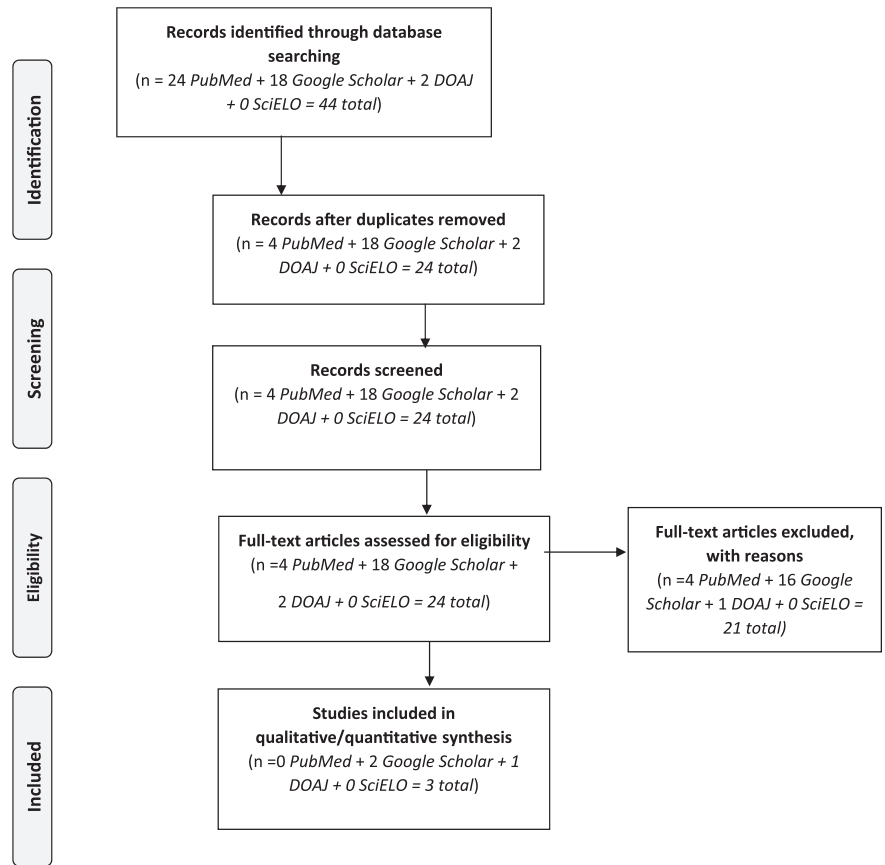
5.3 | Effectiveness of protective equipment: studies quantifying viral load of SARS-CoV-2

Worryingly, during coughing, both surgical and cotton masks may not effectively filter SARS-CoV-2 from the environment and external mask surface, which is also reinforced by the facts that particles 0.04 to 0.2 μm can penetrate surgical masks and that surgical masks and unvented KN95 respirators only reduce the outward particle emission rates by 90% and 74% (average values), respectively, when speaking and coughing in comparison to wearing no mask.^{25,34,35} SARS-CoV-2 has a diameter of about 100 nm (0.001 μm) and cough droplets are usually $>5 \mu\text{m}$ in diameter (droplets that fall rapidly to the ground under gravity; eg, distances $\leq 1 \text{ m}$; in contrast, droplets $<5 \mu\text{m}$ in diameter may remain suspended in the air, eg, at distances $>1 \text{ m}$).^{36,37} Thus, it seems essential that patients with COVID-19 remain isolated, since this disease may spread even using a mask, especially during coughing.

5.4 | Universal wearing of facemasks plus other protective measures in the community

There is a clear variation in the number of citizens using facemasks between different regions in the community, for instance in airports.³ This may indicate a lack of international regulations about

FIGURE 2 PRISMA 2009 Flow Diagram²⁰: selected studies on mask use as a protection for SARS-COV-2 for keywords “COV and Mask”



the use of facemasks in the community, namely, in the transport sector. This situation is supported by the WHO, which recommends that “medical masks should be reserved for health care workers” and in the case of non-health workers, their use is directed towards persons with symptoms or those who are required to take care of infected patients.² However, the position of the WHO about the use of masks is not followed by all countries, such as Hong Kong or Japan.¹¹ In contrast to the position of the WHO, some studies already show evidence on the universal wearing of facemasks (without compromising health care use) as a way of effectively reducing the transmission and acquisition of respiratory viral infections because of SARS-CoV-2.^{11,22} Of course, the universal wearing of mask must be accompanied by other prevention measures, such as hand-washing or social distancing, which constitute effective approaches to mitigating and delaying the epidemic (by at most 7 months for a 3-month intervention).^{2,11,22}

5.5 | Impact of infection control measures in hospitals and epidemiological tracing

The prevention of the nosocomial transmission of SARS-CoV-2 through the application of appropriate hospital infection control measures seems to be possible (eg, provision of surgical masks to all health workers, patients and visitors, enhanced laboratory surveillance, rapid diagnostics, epidemiological tracing, etc),²⁶ although

these findings may not be conclusive, since not all medical staff and patients were tested in relation to SARS-CoV-2 in the present study. It seems very important to implement a set of measures at the hospital level to prevent infection with SARS-CoV-2.

However, the number of investigated patients was very limited in epidemiological tracing studies (one patient in both cases),^{1,15} so it seems that, either in the nosocomial or community setting, the cumulative application of the infection control measures, ie, wearing a facemask (eg, surgical mask), hand washing, social distancing and environmental hygiene (eg, cleaning and disinfection of environmental surfaces, such as in hospitals) are likely to prevent the transmission of SARS-CoV-2. For instance, not all individuals that come into contact with a contaminated subject are infected.

5.6 | Development of new personal protective equipment

Facemasks present some constraints, such as single use during a restricted number of hours (ie, regular changing is required), complex sanitisation methods, costs and/or shortages. Thus, new personal protective equipment has been developed during the COVID pandemic, such as PerSo or 3D printed reusable N95 comparable respirators.^{13,21} PerSo ensures the delivery of air (HEPA filtered) using a battery through a lightweight hood/face mask¹³ and the 3D printed reusable N95 comparable respirator can be used with multiple

TABLE 1 Selected studies by screened database: main findings

Resource	Study aim, country, reference and topic	Sample size	Methods	Results	Conclusions and identified limitations
PubMed ¹⁶	To evaluate the effectiveness of protective equipment (UK) ¹² Effectiveness of protective equipment	1 volunteer (healthy)	Three tests: Hat, goggles, mask and gown (Test 1); Hat, goggles, mask, necked full-body suit and full-face visor (Test 2); A colloidal solution (brown cornstarch-based) was sprayed at arms-length.	It was observed droplet contamination of exposed skin. Droplet spray forehead, bridge of nose, cheeks and neck (Test 1). It was possible to observe exhalation (Test 2). Elimination of droplet skin contamination (Test 3).	Extra protective equipment is recommended, such as additional neck, face and hair protection, namely a full-face visor and a high neck hooded overall suit. Limitations: Only one volunteer.
	To evaluate the efficacy of three types of masks (N95 masks, medical masks) and homemade masks) and instant hand wiping using the avian influenza virus to mock (China) ²⁴ Effectiveness of protective equipment	Not applicable	Virus quantification (avian influenza): real-time reverse transcription-polymerase chain reaction.	Instant hand wiping respectively using a wet towel 1.00% soap powder, 0.05% active chlorine or 0.25% active chlorine (from sodium hypochlorite) removed the virus from hands: 98.36%, 96.62% and 99.98%. N95 masks, medical masks and homemade masks (four-layer kitchen paper and one-layer cloth) could block 99.98%, 97.14% and 95.15% of the virus in aerosols.	It was proposed mask-wearing and hand hygiene to slow the exponential spread of the virus. Limitations: Experiments were not performed with SARS-CoV-2, thus the calculated mask efficiency may not be the same (eg, different viruses present different morphologic characteristics).
	To evaluate the effectiveness of surgical and cotton masks in filtering SARS-CoV-2 (South Korea) ²⁵ Effectiveness of protective equipment	4 patients (SARS-CoV-2 positive)	Comparison: disposable surgical masks vs 100% cotton masks. Using the following sequence of masks: no mask, surgical mask, cotton mask and no mask. Patients were required to cough five times into a petri dish with viral transport media.	Median viral loads of nasopharyngeal and saliva samples (4 participants): 5.66 log copies/mL and 4.00 log copies/mL, respectively. Median viral loads after coughs were, as follows: 2.56 log copies/mL (without a mask), 2.42 log copies/mL (with a surgical mask) and 1.85 log copies/mL (1.85 log copies/mL).	During coughing, both surgical and cotton masks not effectively filtered SARS-CoV-2 to the environment and external mask surface. Limitations: The number of participants is limited.
	To describe the infection control measures undertaken for coronavirus disease in the first 42 d after the announcement of a cluster of pneumonia in China, on December 31, 2019 (day 1) (Hong Kong) ²⁶ Impact of infection control measures in hospitals and epidemiological tracing	43 public hospitals: 1275 patients; 42 cases of COVID-19	Hospitals: active and enhanced laboratory surveillance, early airborne infection isolation, rapid molecular diagnostic testing and tracing of healthcare workers with unprotected exposure. For confirmed cases: epidemiological characteristics, environmental and air samples were collected and analysed.	42 (3.3%) were confirmed cases of COVID-19; zero nosocomial transmission of SARS-CoV-2 after the importation of the first confirmed case on day 22 in Hong Kong. Examples of specific measures: provision of surgical masks to all health workers, patients and visitors in clinical areas (day 5) and use of personal protective equipment amongst health workers performing aerosol-generating procedures, even if caring for patients without clinical features/epidemiological exposure risk in general wards.	It was possible to prevent nosocomial transmission of SARS-CoV-2 through the application of appropriate hospital infection control measures. Limitations: Not all medical staff and patients were tested in relation to SARS-CoV-2.

(Continues)

TABLE 1 (Continued)

Resource	Study aim, country, reference and topic	Sample size	Methods	Results	Conclusions and identified limitations
	To present an investigation about a patient (COVID-19 positive) who has received nursing assistance in an open cubicle of a general ward before diagnosis (Hong Kong) ¹ <i>Impact of infection control measures in hospitals and epidemiological tracing</i>	1 patient (SARS-CoV-2 positive)	All contacts were identified and categorised into two groups: 'close' or 'casual'. Quarantine and/or medical surveillance was adopted. Collection of respiratory specimens (test for SARS-CoV-2); contacts with fever and/or respiratory symptoms.	Number of contacts (total): 71 staff and 49 patients; close contacts: 7 staff and 10 patients. Surveillance 28 d; 76 tests in 52 contacts were carried out (all were negative).	It seems nosocomial transmission of SARS-CoV-2 is prevented through usual infection control measures, such as wearing surgical masks, hand and environmental hygiene. Limitations: The number of participants is limited.
	To define recommendations for obstetric care (Italy) ²⁷ <i>Clinical guidance</i>	42 labours (SARS-CoV-2 positive)	An obstetrics task force was constituted. Overall, interstitial pneumonia in 20 women, with seven requiring respiratory support; two premature labours. All cases did well in comparison with the usual 10-15 d, which are necessary to overcome the critical phase of SARS-CoV-2 pneumonia.	Breastfeeding: <ul style="list-style-type: none"> - All women breastfeed while wearing a surgical mask. - COVID-19-positive mothers with mild or no symptoms can breastfeed. - COVID-19-positive and symptomatic mothers are separated from their newborns, and women can use pumps to express breast milk. Defined recommendations in labour: <ul style="list-style-type: none"> - During labour the midwife and labouring woman wear surgical masks. - During the second stage of labour the midwife wears appropriate personal protective equipment. - A woman's partner is permitted to attend during labour and delivery but is not permitted on the postpartum ward. 	A set of rules of protection for healthcare providers were extended to all labouring women, including breastfeeding. Limitations: laboratorial findings were not divulged.
	To report the 1st case of a woman (SARS-CoV-2 positive) delivering a baby through cesarean section at 37 + 6 wk of pregnancy (Republic of Korea) ²⁸ <i>Clinical guidance</i>	1 (SARS-CoV-2 positive)	1 case report Woman with mild symptoms; conservative treatment without medication.	Labour was anticipated due to obstructed labour with incomplete rotation of the foetal head. The mother was discharged. Baby (3.13 kg) was born with Apgar scores at 1 and 5 min of 9 and 10, respectively. The SARS-CoV-2 PCR results (placenta, amniotic fluid and cord blood) were negative. Nasopharyngeal swab of the baby was negative on two consecutive SARS-CoV-2 RT-PCR tests.	Suggested conditions for a safe delivery: negative pressure operating room, skillful medical team and enhanced personal protective equipment including N95 masks, surgical cap, double gown, double gloves, shoe covers and powered air-purifying respirator. Medical staff was reported negative. Limitations: The number of participants is limited.

(Continues)

TABLE 1 (Continued)

Resource	Study aim, country, reference and topic	Sample size	Methods	Results	Conclusions and identified limitations
	To apply online surveying to determine knowledge and perceptions of COVID-19 amongst the general public (United States and the United Kingdom) ²⁹ <i>Questionnaires</i>	3000 adults (United States) and 3000 adults (United Kingdom)	Online survey (February 23 and March 2, 2020) Questionnaire completion: 2986 (United States); 64.4% tertiary education) and 2988 (United Kingdom); 51.5% tertiary education)	General good knowledge: disease transmission and common symptoms. Misconceptions: prevention of infection and care-seeking behaviour. For instance, almost half of UK and US participants thought that using a surgical mask was "highly effective" in protecting them from acquiring COVID-19.	Online questionnaires seem to be useful tools to inform public health authorities, as well as, to take public health and political measures during infectious disease outbreaks. Limitations: Middle- and low-income countries were not involved.
	To evaluate how nursing students will face patients with severe acute respiratory syndrome (Hong Kong) ³⁰ <i>Questionnaires</i>	102 nursing students	Questionnaire survey.	96.1% of students disagree to be involved in the intubation of severe acute respiratory syndrome patients if N95 mask and gown were not available, 37.3% agree with a distribution of N95 masks should be by casting lot (if there are insufficient N95 masks) and 94.1% agree with an intensive care unit specifically for severe acute respiratory syndrome patients.	Training on infection control practice and isolation facilities during outbreaks of infectious diseases should be considered in nursing education programmes. Limitations: Other health professions, such as physicians and graduated health professionals were not enrolled.
Google Scholar ¹⁷	To divulge data on facemask use prevalence in international airports in Asia, Europe and the Americas, March 2020 (USA) ³ <i>Universal use of face masks plus other protective measures in community</i>	1797 (health state unknown)	Photo Frames	Presence of facemask (number of Faces identified): Airport of Bangkok, Thailand (n = 279; 46%; March 6, 2020); Airport of Paris, France (n = 356; 4%; March 7, 2020); Airport of Boston, USA (n = 371; 3%; March 7, 2020); Airport of Atlanta, USA (n = 554; 2%; March 7, 2020) and Airport Lima, Peru (n = 237; 27%; March 12, 2020).	Clear variations in facemask use rates between regions were detected, which support the need for additional research on the possibility of facemask use, as well, as to provide uniform recommendations to all persons. Limitations: The type of mask or the number of infected individuals were not quantified.
	To assess the association between COVID-19 diagnoses per inhabitant and the national promotion of face masks in Public (Belgium) ¹¹ <i>Universal use of face masks plus other protective measures in community</i>	Not applicable	Linear regression: 8 of the 49 countries with available data and supporting the wearing face masks in public. China, Czechia, Hong Kong, Japan, Singapore, South Korea, Thailand and Malaysia.	Face mask wear was negatively associated with the number of COVID-19 cases/inhabitant (coef. -326, 95% CI -601 to -51, P = .021).	Face mask usage may reduce the transmission and acquisition of respiratory viral infections because of SARS-CoV-2. Limitations: Residual confounding should be evaluated

(Continues)

TABLE 1 (Continued)

Resource	Study aim, country, reference and topic	Sample size	Methods	Results	Conclusions and identified limitations
	To evaluate the impact of self-imposed prevention measures (handwashing, mask-wearing and social distancing) on the spread of COVID-19 (Netherlands) ²² <i>Universal use of face masks plus other protective measures in community</i>	Not applicable	A transmission model was developed (a deterministic compartmental model).	Handwashing, mask-wearing and social distancing can be effective strategies to mitigate and delay the epidemic.	The peak can only be delayed (by at most 7 mo for a 3-mo intervention) by early implementation of short-term government interventions. This delay seems to be precious for healthcare systems to prepare for facing an increasing COVID-19 burden.
	To report a typical case of cluster outbreak caused by public transportation exposure (China) ¹⁵ <i>Impact of infection control measures in hospitals and epidemiological tracing</i>	1 patient (SARS-CoV-2 positive)	Epidemiological survey. First bus: 39 other passengers (2 h and 10 min). Second bus (minibus): 14 other passengers (50 min).	This patient has transmitted the infection to five people in the first vehicle (he does not wear a face mask), but no one was infected later in the second vehicle (he wears a face mask)	Trips should be avoided by infected persons (or if there is a suspicious of infection). The use of a face mask may have contributed to prevent transmission of infection. The authors suggest further research "should focus on assessing the efficacy of face masks against COVID-19, investigating reuse of face masks and assessing compliance". Limitations: only one case. The real dimensions of the buses were not described (eg, average space per passenger).
	To develop a "Personal Respirator – Southampton" (PeRSo); PeRSo delivers air (HEPA filtered) using a battery through a lightweight hood/face mask (United Kingdom) ¹³ <i>Development of new personal protective equipment</i>	Healthcare Worker Feedback (the number was not detailed)	Fit and Air-Tightness Tests: 3 M FT-30 & FT-32 solution and spray apparatus. Biological filtration efficacy: settle plates according to ISO14698.	PeRSo can be worn for several hours. Usability tests with doctors and nurses: PeRSo prototype was preferred to standard N95/FFP3 masks. Preliminary tests indicate that the device removes microbes and passes the "fit tests" widely used to evaluate face masks.	PeRSo may constitute an alternative to traditional face masks. Possible advantage of PeRSo: it may not need to be changed as often. Limitations: Safety and efficacy of PeRSo for the prevention of SARS-CoV-2 infections are not established, for instance, tests with SARS-CoV-2 were not carried out. In addition, information on how to sanitise PeRSo was not presented.

(Continues)

TABLE 1 (Continued)

Resource	Study aim, country, reference and topic	Sample size	Methods	Results	Conclusions and identified limitations
	To develop a 3D printed reusable N95 comparable respirator that can be used with multiple filtration units (US) ²¹ <i>Development of new personal protective equipment</i>	Prototype respirator model	Candidate mask: a respirator (found on an open-source maker website) and developed with PLA (printer filament), a removable cap, a removable filtration unit (two layers of MERV 16 sandwiched between MERV 13) and removable elastics.	Candidate mask: passed a suction test protocol to evaluate leakage and passed a qualitative Bitrix N95 fit test. Seal against face, comfort and sizing are still being developed.	A prototype respirator model was developed: 3D printed N95 reusable respirators could provide a viable alternative to N95 masks. 3D printing procedures should ensure that this type of candidate masks fit the individual, since all air needs to pass through the filter to reach the wearer's face with no leaks. Limitations: It seems the safety and efficacy of this prototype were not evaluated in SARS-CoV-2 settings.
	Process for Decontamination and Reuse of N95 Filtering Facemask Respirator Ultraviolet Germicidal Irradiation (UVGI) (US) ⁶ <i>Sanitisation of facemask</i>	Not applicable	Decontamination procedure involving the delivery of UVGI to used N95 (exposure of 60 mJ/cm ²); RNA virus may be inactivated by UVGI exposure of 2-5 mJ/cm ² in general. The number of times a mask has gone through decontamination is controlled through the application of a mark.	After the decontamination procedure masks are redistributed. It was planned to decontaminate and reuse N95 FFRs multiple times until respirator fit is impacted	It seems decontamination and Reuse of N95 Filtering Facemask Respirator is possible. Limitations: It seems that control quality measures have not been implemented, ie, it is necessary to prove the microbiologic decontamination, as well as, the integrity of facemask after the decontamination procedures.
	To test four different decontamination methods to decontaminate four different N95 masks of experimental contamination with SARS-CoV-2 or vesicular stomatitis virus as a surrogate, as well as, to evaluate functional integrity (Canada) ⁷ <i>Sanitisation of facemask</i>	4 types of N95 masks	Decontamination methods: autoclave treatment, ethylene oxide gassing, ionised hydrogen peroxide fogging and vapourized hydrogen peroxide exposure. Tested masks (4 types): 3 M's 1860, 1870 and VFlex 1804 respirator models (3 M Company, St. Paul, Minnesota) as well as AO Safety 1054S (Pleats Plus) Respirator (Aearo Company, Indianapolis). Effectiveness of decontamination (potential virus was eluted from mask after decontamination and transferring each into 1 mL of virus culture medium) and impact of decontamination on structural and functional integrity was evaluated (TSI PortaCount 8038+ to assess functional integrity).	4 tested methods: one cycle of treatment was effective in decontamination without structural/functional deterioration; vapourized hydrogen peroxide treatment was tolerated to at least five cycles by masks; standard autoclave treatment was associated with no loss of structural or functional integrity to a minimum of 10 cycles for the three pleated mask models.	It seems decontamination and Reuse of N95 Filtering Facemask Respirator is possible. Limitations: Only four types of N95 were evaluated; thus, standardisation procedures, for instance at the hospital level, may require tight quality control, including evaluation of effectiveness of decontamination and the impact of decontamination on structural and functional integrity. Additionally, the present test not considered the rough handling of these masks by health care workers.

(Continues)

TABLE 1 (Continued)

Resource	Study aim, country, reference and topic	Sample size	Methods	Results	Conclusions and identified limitations
	To test Hydrogen Peroxide Vapour sterilisation of N95 respirators for reuse (US) ⁸ <i>Sanitisation of facemask</i>	1 type of mask	Hydrogen Peroxide vapour decontamination of respirators using a Clarus C system (Bioquell, Horsham, PA) which normally is used to fumigate hospital rooms. Inoculation of 3 M 1870 N95 respirators (3 M, St. Paul, MN) with three aerosolised bacteriophages (classified as proxies for SARS-CoV-2). Virucidal activity was measured by a standard plaqueing assay prior to and after sterilisation.	A single Hydrogen Peroxide vapour cycle: complete eradication of phage from masks (limit of detection 10 PFU). After five cycles, the respirators appeared like new (no deformity).	It seems decontamination and Reuse of N95 Filtering Facemask Respirator may be possible, namely through using a Bioquell machine. This machine can be scaled to allow simultaneous sterilisation of many used but otherwise intact respirators. Limitations: Previous contamination of mask specifically with SARS-CoV-2 was not performed. It seems impact of decontamination on structural and functional integrity was not evaluated through the application of specific tests.
	To evaluate Cobalt-60 (60Co) gamma irradiation as a possible method of sterilisation of masks (US) ⁹ <i>Sanitisation of facemask</i>	3 M 8210 and 9105 masks (3 masks of each type)	Masks were irradiated to doses of 0 kiloGray (kGy), 10 kGy and 50 kGy of approximately 1.3 MeV gamma radiation from cobalt sources (dose rate of 2.2 kGy per hour).	However, tested masks passed OSHA Gerson Qualitative Fit Test QLFT 50 (saccharin apparatus), masks' filtration of 0.3 µm particles was significantly degraded.	Findings suggest against gamma and possibly all ionising radiation, as a method of disposable N95 sterilisation, as well as, the qualitative fit test alone to assess mask integrity cannot be used. Limitations: It seems gamma irradiation and possibly all ionising radiation are not proper methods to decontaminate and reuse N95 Filtering Facemasks, since filtration of particles was significantly degraded.
	To evaluate aerosol-spread in cardiopulmonary resuscitation (CPR) using different methods of airway management (Germany) ²³ <i>Clinical guidance</i>	Not applicable	Resuscitation dummy: ultraviolet sensitive detergents were nebulised into the artificial airway of a resuscitation dummy. Cadaver model: nebulised detergents into human cadavers by an endotracheal tube (a laryngeal tube with and without a connected airway filter was used). After, CPR was performed and a camera was used to register the spread of the visualised aerosol.	The insertion of a laryngeal tube connected to an airway filter leads to a remarkable reduction of aerosol-spread, which mostly occurred during CPR compression. The use of a surgical mask deflected the spread.	The early insertion of a laryngeal tube connected to an airway filter before CPC is advisable to treat hypoxemia, as well as, to protect health professionals during CPR. Limitations: It seems more studies are required to prove that the use of surgical masks in CPR plus the application of a laryngeal tube connected to an airway filter is enough to prevent a potential infection by SARS-CoV-2.

(Continues)

TABLE 1 (Continued)

Resource	Study aim, country, reference and topic	Sample size	Methods	Results	Conclusions and identified limitations
DOAJ ¹⁸	To provide guidance for surgery during the COVID-19 crisis (USA, Germany, Italy, Philippines, Spain, Guatemala, Portugal, Poland, Israel, Turkey, Brazil, Iran, Ecuador, Australia, Austria) ³¹ Clinical guidance	Not applicable	Various scientists and clinicians from diverse specialties were involved. Surgery includes surgical procedures by distinct surgical disciplines such as cancer surgery, cardiothoracic surgery, emergency, general surgery, gynaecology, neurosurgery, orthopaedics, paediatric surgery, reconstructive and plastic surgery, surgical critical care, trauma surgery, etc	Amongst others, recommendations on personal protective equipment are here highlighted. Personal Protective Equipment for Low-risk patients (LRP = Double gloves, booties, surgical gown, FFP3 (N99) or P3 (N100) face mask, Face shield (± googles), head cover. Personal Protective Equipment for High-risk patients: As in LRP plus overalls under surgical gown, gowns (plastic ponchos) and train dressing/undressing and supervision.	The guidance is relevant for surgical procedures in different surgical settings.
SciELO ¹⁹					

filtration units.²¹ Amongst the limitations of the new equipment are that details about their sanitisation or safety and efficacy specifically in SARS-CoV-2 infections has not been detailed and discussed.

5.7 | Sanitisation of facemasks

Overall, four studies on the sanitisation of facemasks were identified, which may represent an effort to overcome the global shortage of protective equipment. Three studies support that the decontamination and reuse of N95 filtering facemask respirators may be possible (suggested methods: ultraviolet germicidal irradiation, autoclave treatment, ethylene oxide gassing, ionised hydrogen peroxide fogging and vapourised hydrogen peroxide exposure).⁶⁻⁸ Also, ionising radiation is suitable for killing pathogens in facemasks, but this methodology seems to damage facemask integrity (eg, N95 filtering facemasks). One study concluded that gamma irradiation and possibly all ionising radiation (cobalt-60 gamma irradiation) seems to not be suitable for the reuse of N95 filtering facemasks, since the filtration of particles was significantly degraded (eg, damage to the fibre material caused the cross-linking of polymers, triggering cracking and degradation during fitting and/or deployment).⁹

It seems that standardised procedures and quality control for sanitising facemasks are internationally lacking, for instance, because the properties, structure and composition of facemasks is not universal and the number of sanitisation cycles is a function of the type, conditions and duration of usage. Quality control is required to ensure that protective equipment, including facemasks, is decontaminated without damage, which necessarily requires a microbiologic and physical evaluation.³⁴ In this sense, not all hospitals may be prepared to institute such procedures. Moreover, a proper cost analysis is advisable, since decontaminating facemasks may be more expensive than buying new ones.

5.8 | Recommendations: pregnancy and breastfeeding and other clinical guidance

Only one study presented recommendations on breastfeeding for COVID-19 mothers: all breastfeeding COVID-19-positive mothers should use a surgical mask, "COVID-19-positive mothers with mild or no symptoms can breastfeed" and "COVID-19-positive and symptomatic mothers are separated from their newborns and women can use pumps to express breast milk".²⁷

In pregnant women with COVID-19, the symptoms tend to be mild or moderate, which may be explained because of combined effects of gender, young age and the immune status of pregnancy.²⁷ Regarding recommendations during labour for SARS-CoV-2 positive women, one study recommends: "a negative pressure operating room, skilful medical team and enhanced personal protective equipment including N95 masks, surgical cap, double gown, double gloves, shoe covers and powered air-purifying respirator," to avoid medical staff being infected.²⁸ Another study on the same topic allowed the presence of

the partner during labour, but not on the postpartum ward,²⁷ which seems logical especially if labour occurs in a negative pressure room and partners have access to the same type of protection as medical staff. This study also recommends that, during labour, the midwife and labouring woman are required to wear surgical masks and other personal protective equipment. Therefore, the development of an international consensus on breastfeeding, pregnancy and labour in women positive for SARS-CoV-2 is recommended.

Another study contributed to increasing the knowledge about aerosol spread during CPR, finding that the insertion of a laryngeal tube connected to an airway filter led to a remarkable reduction of aerosol spread, which may have contributed to preventing potential infection with SARS-CoV-2.²³ In addition, an international collaboration has provided guidance for surgery during the COVID-19 crisis.³¹ This clinical guidance seems to be fundamental to facing the COVID-19 pandemic, assuring that all countries are efficiently and properly prepared.

5.9 | Questionnaires to collect subjects' opinions

Subjects' misconceptions were detected at the populational level (US and UK), for instance that surgical masks may be "highly effective" for the protection against COVID-19 infections.²⁹ This study confirms that, even in developed countries, the population remains insufficiently informed. In this sense, large online questionnaires may be useful tools to collect data about population knowledge, to inform public health authorities and to implement measures such as specific informative campaigns.²⁹ These questionnaires are especially recommended, since they are quickly, economically and easily implemented. Similar studies in middle- and low-income countries are also recommended.

Additionally, the administration of questionnaires was reported in a group of nursing students to evaluate how they will face patients with severe acute respiratory syndrome. As expected, 96.1% of students refused to be involved in the intubation of severe acute respiratory syndrome patients if an N95 mask and gown were not available.³⁰ Besides raising ethical and deontological concerns about how to manage intubation procedures in the case of severe acute respiratory syndrome without protective material (eg, N95 masks) available, this study supports the need for health professional curricula to include training on infection control practices and/or isolation facilities during outbreaks of infectious disease. Thus, the performance of future studies enrolling undergraduates from other health courses, such as medicine, is suggested.

6 | CONCLUSIONS

Homemade masks may offer some protection against virus dissemination; thus, populations may benefit from their universal usage. It seems that governments that implement prevention measures, such as handwashing, mask-wearing and social distancing are more

prepared to face COVID-19, gaining more time to prepare, equip and organise their health care systems.

Since COVID-19 is highly contagious, a set of measures should be considered at the community and nosocomial levels to prevent or follow infections. For instance, the provision of surgical masks to all health workers, patients and visitors, epidemiologically tracing infections, social distancing and regular hand washing (ie, mitigation measures). Importantly, there is some evidence that the prevention of nosocomial transmission of SARS-CoV-2 through the application of mitigation measures is possible in hospitals and/or other health care settings.

The reuse of protective material, such as facemasks, or the development of new protective equipment is an emergent topic due to the shortage of these materials. Methods such as ultraviolet germicidal irradiation, autoclave treatment, ethylene oxide gassing, ionised hydrogen peroxide fogging and vapourised hydrogen peroxide exposure may be applied to decontaminate and reuse of N95 filtering facemask respirators, with the establishment of quality procedures to control microbiological decontamination, as well as the physical integrity and functionality of facemasks. Simultaneously, new protective equipment to substitute facemasks is being developed due to the global shortage and because facemasks present some disadvantages, such as unique use (eg, surgical masks) for a limited number of hours as well as costs.

Populations may remain uninformed in relation to basic topics, such as the protective efficiency of masks, since they may give a false sense of security (eg, masks alone, including N95 are not effective in filtering SARS-CoV-2 from the environment, especially when coughing). In this sense, it is fundamental to repetitively reinforce the relevance of social distancing and hand washing, plus face masking, at the community level.

Clinical guidance and diverse types of clinical guidelines are emerging in the literature, such as those on surgical procedures and COVID-19 patients who are in labour or breastfeeding, which seems to be useful for all countries that are facing the COVID-19 pandemic.

7 | PRACTICAL IMPLICATIONS AND FUTURE RESEARCH

Sanitisation and reuse of protective equipment is a hot topic, but international recommendations must be developed to ensure standardised efficient and safety procedures. Also, the development of international guidelines for women who are in labour or breastfeeding, as well as the early insertion of a laryngeal tube connected to an airway filter before CPC plus mask use is recommended. Undergraduates in the health professions should be trained in the management of infectious diseases during a pandemic.

Clinical guidelines may benefit from the peer-review of clinical boards and international organisations, such as the WHO. Also, the development of regulations on the approval of new protective equipment for COVID-19 and guidance on epidemiological tracing methodologies at the community and nosocomial levels is suggested.

Classic public health measures, such as massive information campaigns directed at the population, should be encouraged in the actual pandemic scenario, for instance, based on large online national questionnaires to characterise population knowledge, eg, alerting people that facemasks may not be highly effective, especially when coughing and that other measures, such as hand hygiene or social distancing are simultaneously recommended.

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