The novel coronavirus, or COVID-19, emerged from Wuhan, Hubei Province, China, and has recently spread all over the world. During the COVID-19 pandemic, healthcare workers struggle against this microscopic enemy due to their job responsibilities, thus leading to be infected in some of them, even some of them are died in line of duty. As of 2 February 2021, 37 million cases of COVID-19 among health workers from 183 countries and regions were reported to the World Health Organization (WHO), a figure that represents 36% of the total cases globally. The median age of these cases was 42 years and 68% were women. On May 24, 2021, the World Health Organization (WHO) stated that at least 115,000 healthcare workers have died due to COVID-19.
worldwide since the pandemic began last year. It is important to pay attention to the situation related to COVID-19 infection for medical staff and their preventive measures. This paper reviews the literature on all available information about the situation and preventive measures (The primary prevention of COVID-19 is to break the chain of transmission from infected to healthy people, secondary preventive measures comprise the use of health screening and recognition activities to ascertain those infected with COVID-19 and tertiary prevention consists of treatment and proper rehabilitation) related to COVID-19 infection for medical staff.

Keywords: COVID-19; SARS-CoV-2; medical staff; healthcare workers; preventive measures.

1. INTRODUCTION

1.1 Background

In late December 2019, a cluster of cases with 2019 novel coronavirus pneumonia (SARS-CoV-2) in Wuhan, Hubei Province, China, aroused worldwide concern [1]. The illness then promptly spread worldwide before the eve of the 2020 Spring Festival in China, [2] and was subsequently named COVID-19 by the World Health Organization (WHO). At the time of reviewing the data globally; (July 16, 2021, 07:21 PM), it was found that 188,655,968 cases of COVID-19 were confirmed, including 4,067,517 deaths reported to the World Health Organization (WHO); with respect to countries, the highest number of cases in the world have been observed in the United States of America (33,643,529 cases), India (31,026,829 cases) and Brazil (19,209,729 cases). As of 15 July 2021, 3,402,275,866 vaccine doses have been administrated [3]. The COVID-19 pandemic has become a clinical threat to the general population worldwide and healthcare workers (HCWs) on the front lines are at high risk of contracting the virus due to their close contact with the source of infection [4-7]. Coronavirus was primarily termed the 2019 novel coronavirus (2019-nCoV) on January 12, 2020, by the World Health Organization (WHO). The Coronavirus Study Group (CSG) of the International Committee suggested that the new coronavirus be named SARS-CoV-2 on February 11, 2020 [8]. According to the World Health Organization (WHO) surveillance database, healthcare workers (HCWs) are defined as employees accountable for direct treatment or service of patients, mainly includes doctors, nurses, related medical staffs (x-ray, laboratory staff, physiotherapists), and administrative and support staff, such as cleaning and laundry staffs, admission/reception clerks, patient transporters and cooking staff [9]. HCWs need to be in close contact with these virus-infected patients and their contaminated environments at work, so they are at great risk of job exposure [10]. In this review, we aim to explain the situation and preventive measures related to COVID-19 infection for healthcare workers and provide a reference for the prevention of SARS-CoV-2 infection, based on the knowledge from researches on SARS-CoV and recent research progress of COVID-19.

1.1.1 How many healthcare workers have been infected by COVID-19?

The exact number of HCWs who have tested positive is still unknown and is probably higher than the reported number. As of April 8, 2020, the World Health Organization (WHO) stated in its daily situation report (Situation Report-82) that there are 22,073 positive cases of COVID-19 among HCWs in 52 countries [11]. The International Council of Nurses (ICN) suggests that on December 31, 2020, more than 1.6 million healthcare workers have been infected in the COVID-19 pandemic, which is nearly 10% of all confirmed COVID-19 infections worldwide; this figure is based on limited data and excluded countries who haven’t stated their data [12]. As of 2 February 2021, 37 million cases of COVID-19 among health workers from 183 countries and regions were reported to the World Health Organization (WHO), a figure that represents 36% of the total cases globally. The median age of these cases was 42 years and 68% were women [13]. On May 24, 2021, the World Health Organization (WHO) stated that at least 115,000 healthcare workers have died due to COVID-19 worldwide since the pandemic began last year [14]. Here, we summarize the situation of HCWs infected with SARS-CoV-2 from China, the USA, India and Brazil. (Fig. 1).

1.1.1.1 HCWs infected with COVID-19 in China

A report from China-WHO coronavirus team, that 3387 healthcare workers of 476 medical institutions in China were infected with COVID-19 (2055 confirmed cases, 1070 clinically
diagnosed cases and 157 suspected cases), and more than 90% of them (3062 cases) came from Hubei Province [15]. As of April 3, According to the Chinese Red Cross Foundation, the National Health Commission of the People's Republic of China, and public media, at least 23 had died [16]. Another report from National Health Commission of the People's Republic of China records that cases of HCWs infected with SARS-CoV-2 account 4.4% of all cases of infection in China [17].

1.1.1.2 HCWs infected with COVID-19 in the Americas

From the time when the first confirmed cases of COVID-19 were notified and until 17 June 2021, there were 1,980,343 COVID-19 cases among health care workers, including 9,819 deaths, in 35 countries and regions in the Americas [18]. The total represents 13% of the estimated 15 million health workers in the Americas [19].

1.1.1.2.1 HCWs infected with COVID-19 in the United States of America (USA)

In the United States on June 17, 2021, the Pan American Health Organization (PAHO)/World Health Organization (WHO) Epidemiological Update on COVID-19 reported a total of 482,432 cumulative confirmed cases of COVID-19, including 1,579 deaths among health care workers [18].

1.1.1.2.2 HCWs infected with COVID-19 in Brazil

As of June 17, 2021, the Pan American Health Organization (PAHO)/World Health Organization (WHO) Epidemiological Update on COVID-19 reported that 753,089 healthcare workers infected with coronavirus and 656 deaths from Covid-19 in Brazil [18].

1.1.1.3 HCWs infected with COVID-19 in India

In India, As of September 03, 2020, the Ministry of Health reported that over 87,000 health workers have been infected with Covid-19 [20]. As of April 17, 2021, According to the national registry of Indian Medical Association (IMA) shows that 747 healthcare worker have died from Covid-19. The highest number of such deaths were from Tamil Nadu (89) and West Bengal (80) [21]. On May 20, 2021, the Indian Medical Association (IMA) has said during the first wave in 2020, India had lost 748 doctors. With the updated toll shared by the IMA on May 20, 2021, India has now lost over 1,000 doctors due to Covid-19 [22].

1.1.2 Reasons for such a high number of infected HCWs

HCWs are at high risk while battling against COVID-19 on the front lines. Therefore, the director of the National Hospital Infection Management and Quality Control Centre provided a list of explanations for such a high number of infections among HCWs [23]:

1) A lack of sufficient knowledge about the pathogen is the first reason for infection among HCWs, particularly at the beginning of the epidemic.
2) A lack or shortage of personal protective equipment (PPE) is also a serious problem. HCWs must use common plastic products (photographic film, plastic wrap, file bag, and so forth) to make simple PPE. [23].
3) Many infected patients presented with atypical symptoms, such as gastrointestinal symptoms and fatigue, or were asymptomatic. Furthermore, HCWs were not well prepared for the sudden outbreak of coronavirus, particularly in other departments [24].
4) Healthcare worker shortages and Long-term contact with abundant numbers of infected patients without adequate rest periods are significant causes leading to fatigue, and insufficient adherence to infection prevention practices which is directly increased the risk of infection among HCWs. Additionally, the pressure of treatment, work intensity, and a lack of rest indirectly increased the likelihood of infection for HCWs. [23,25,26].
5) Anxiety and mental stress due to several causes, such as losing colleagues and patients, may have contributed to an increased risk of infection among HCWs. [23].
6) HCWs may have had inadequate systematic training for personal protection awareness. Frontline HCWs (except infectious disease physicians) received insufficient training for infection prevention and control (IPC), leaving them with a lack of knowledge of IPC for respiratory-borne infectious diseases.[23].
7) Some COVID-19 patients were admitted to other departments due to their epidemiological history, which led to unnecessary exposure of HCWs. [24].
8) The positive rate of the COVID-19 nucleic acid test kit remains relatively low even at present, and many patients are diagnosed after more than four tests. These factors led to a diagnostic delay and opportunities for exposure among HCsWs.[24]

9) Professional supervision and guidance, as well as monitoring mechanisms, were lacking. This has increased the risk of infection for medical staff. [23]

1.2 Virology

Genomic and phylogenetic analysis showed that the CoV causing COVID-19 is a β-CoV in the same subgenus as the SARS virus but in a different clade [27]. On January 7, 2020, the virus was recognized as a CoV that had >95% homology with the bat CoV and >70% similarity with the SARS CoV [28]. The composition of the receptor-binding gene region is very similar to that of SARS-CoV, and the virus has been demonstrated to utilize the same receptor, angiotensin-converting enzyme 2 (ACE2), for entrance into respiratory cells [29].

1.3 Method of Literature Search

Considering the lack of direct evidence for this newly identified 2019-nCoV infection, we searched and referred to papers related to SARS and MERS. Articles providing data on COVID-19 were found by searching PubMed, Google Scholar, ScienceDirect.com and the Cochrane Library. Given the paucity of available updated material, research was extended to current guidelines and reports available on the following websites: the WHO (https://www.who.int/), the CDC (Centers for Disease Control and Prevention, https://www.cdc.gov/), https://www.uptodate.com and https://www.reuters.com/article/us-health-coronavirus-nurses/over-90000-health-workers-infected-with-covid-19-worldwide-nurses-groupidUSKBN22I1XH. The following MESH terms were used: COVID-19, SARS-CoV-2, medical staff, healthcare workers, and preventive measures. We included all relevant scientific publications written in English in the review. Publications cited in articles selected by the researchers were retrieved and reviewed.

2. EPIDEMIOLOGY

2.1 Host and Reservoir

Wild animals and bats are considered natural reservoir hosts and play a core role in the spread of several coronaviruses and other viruses [30, 31]. A recent study found that the virus is 96% identical at the whole-genome level to a bat coronavirus. This indicates that bats are the most likely host of SARS-CoV-2 [32,33]. Additionally, Ji and colleagues revealed snakes as possible virus reservoirs for human infection [34]. Zhu et al. indicated that bats and minks may be the two potential hosts of the novel coronavirus, while minks may be the intermediate hosts of this virus. Other studies have shown that pangolins are potential intermediate hosts. Overall, there may be several intermediate hosts. [35].

2.2 Risk and Route of Transmission

Respiratory droplets and contact transmission are considered to be the main transmission paths. [36]. Recent reports indicate that SARS-CoV-2 can be discovered in the urine and stool of laboratory-confirmed patients, indicating a risk of fecal-oral transmission [37]. Contact finding studies confirm that extended close contact is the key risk factor for transmission and that the risk of infection is much higher in household contacts compared to non-household contacts [38,39]. Transmission may also occur indirectly through infected surfaces or fomites [40]. In utero transmission is possible, as proven by a case from France [41]. As per current information, trans-placental transmission is possible, seems however extremely rare [41–44]. Breastfeeding: World Health Organization (WHO) and other organizations like Royal College of Obstetricians and Gynaecologists (RCOG) and American College of Obstetricians and Gynecologists (ACOG) support the practice of breastfeeding even in the context of active SARS-CoV-2 disease, provided hygienic measures are applied [41,45].

2.3 Incubation Period and Period of Infectivity

The incubation period of SARS-CoV-2 infection is assumed to be 14 days after exposure, with most patients experiencing symptoms in approximately 4 to 5 days [46]. The interval during which an individual with COVID-19 is infectious is unclear. Viral burden in the upper respiratory tract is highest around the day of symptom start, followed by a steady decline over time [47,48]. A recent meta-analysis have found that detection of RNA from upper respiratory tract samples was higher at symptom onset [49].
3. PATHOGENESIS

3.1 Virus Entry and Spread

Initial viral replication supposedly occurs in the mucosal epithelium of the upper respiratory tract (nasal cavity and pharynx), with additional multiplication in the lower respiratory tract and gastrointestinal mucosa, [50], giving rise to mild viremia. Few infections are controlled at this point and remain asymptomatic. Some patients have also revealed non-respiratory symptoms such as acute hepatic and heart injury, renal failure, and diarrhea, [51,52–54] indicating multiple organ involvement. ACE2 is generally expressed in the nasal mucosa, bronchi, lungs, heart, esophagus, kidneys, stomach, bladder, and ileum, and these human organs are all exposed to SARS-CoV-2.[55] Recently, the potential pathogenicity of COVID-19 to testicular tissues has also been proposed by clinicians, indicating fertility concerns in young patients [56].

4. PATHOLOGICAL AND CLINICAL FINDINGS

The important pathological findings of severe COVID-19 showed pulmonary bilateral diffuse alveolar damage with cellular fibromyxoid exudates [57]. Interstitial mononuclear inflammatory infiltrates, dominated by lymphocytes, could be detected in both lungs. Multinucleated syncytial cells with atypical enlarged pneumocytes characterized by large nuclei, amphophilic granular cytoplasm, and prominent nucleoli were recognized in the intra-alveolar spaces, indicating viral cytopathic-like modifications [58,59]. Moderate microvascular steatosis and mild lobular and portal activity were detected in hepatic biopsy specimens, which might be caused by either SARS-CoV-2 infection or drug use. In addition, only a few interstitial mononuclear inflammatory infiltrates were found in the heart tissue, which means that COVID-19 might not directly impair the heart [60]. Most patients had mild illness (81%), had symptoms that were usually self-limiting and recovered within two weeks [61]. A meta-analysis including 79 studies determined that 20% of people [17-25%] continue asymptomatic throughout the course of infection [62]. The most frequent symptoms are headache,[63] loss of smell[64] and taste,[65] nasal congestion and runny nose, cough, muscle pain, sore throat, fever,[66] diarrhea, and breathing difficulties [67]. In individuals without preceding ear, nose, and throat complaints, loss of taste combined with loss of smell is linked with COVID-19 [68]. Fever, dyspnea and gastrointestinal symptoms were more common in severely ill patients than in mildly ill patients [69]. Severe patients quickly developed acute respiratory distress syndrome (ARDS) and septic shock, eventually ending in multiple organ failure [70].

5. PREVENTIVE MEASURES

5.1 Primary Preventive Measures

The evidence comes from studies of SARS-CoV, suggests that the primary preventive measures are directed toward stopping the occurrence of the disease before it occurs [71]. In the absence of a vaccine, the most effective approach to control a new viral disease, such as COVID-19, is to break the chain of transmission from infected individuals to healthy people [72]. For prevention of SARS-CoV-2 infections among healthcare workers, the following five activities can break the chain of virus transmission to their family, colleagues and other patients [73].

1. Triage, early recognition, and isolating suspected and confirmed COVID-19 cases.
2. Apply standard precautions for all patients, with distinctive attention to hand hygiene, environmental cleaning, personal protective equipment (PPE).
3. Apply additional precautions measures
   • Contact and droplet precautions measures
   • Airborne precautions for aerosol-generating procedures
4. Implement administrative measures
5. Using environmental measures

The following negotiations comprise the above approaches in different sections.

1. Triaged, early recognition, and isolating suspected and confirmed COVID-19 cases

Triage is a system for evaluating all patients at admission, permitting for early recognition of possible COVID-19 cases and prompt isolation of suspected cases in a separate place from other patients [74].Screening everyone entering the healthcare facility for sign-symptoms of COVID-19 and triage, them according to the following effective source control measures [75]. A well-equipped triage station should be established at entrance with visual information to patients. For all patients attending healthcare facilities should be provided screening questionnaires, and
medical staffs should be fully equipped with personal protective equipment (PPE). Screening personnel should maintain at least 1-meter distance from patients, created by a physical barriers with glass or plastic windows in screening and triage area, registration desk at emergency department or pharmacy counter to decrease risk of virus spread to HCWs. If it is impossible, mask and eye protection should be worn. Patients with features of COVID-19 should be kept in a well-ventilated waiting room before admission. Adequate Ventilation is considered airflow of 60L/sec per patient in a naturally ventilated room. A separate area should be designated in the outpatient department for patients with respiratory symptoms. There should be at least 1-meter distance between benches, chairs in the waiting room. The isolation area should have dedicated toilets, hand hygiene stations, and dustbins for disposal of paper tissues used for respiratory hygiene or after hand washing [76]. All HCWs, patients, visitors, service providers and others must wear masks while entering the healthcare facility (‘Universal masking’), and cover their nose and mouth with bent elbow or tissue while coughing or sneezing. Tissues must be disposed immediately to dustbins, followed by performing hand hygiene [77,78]. Limit the number of visitors in health care facilities and provide telehealth services. Telemedicine will reduce the risk of disease transmission while providing adequate patient care. (reviewed in [75]).

2. Applying standard precautions for all patients

Standard precautions are basic level of preventive measures, which have to be followed by all medical staffs in the care of Covid-19 patients to protect the patients from healthcare associated infections and protect themselves from getting infections from the patients. Standard precautions measures include hand hygiene, respiratory hygiene, use of personal protective equipment (PPE) according to risk assessment, prevention of sharp injury, cleaning and disinfection of equipment, cleaning of environment and appropriate placement of patient. [74,75,76].

2.1 Hand hygiene

Hand hygiene is the most effective preventive measures to avoid the spread of COVID-19 and other pathogen. For best hand hygiene performance, the WHO’s My 5 Moments should be practiced by all health workers in the following five situations: before contact with patients, before any clean or aseptic procedure is performed, after contact with body fluid, after touching a patient, and after contact with each patient and/or/his/her surroundings. Hand should be sanitized by using alcohol-based hand rub (ABHR) with 70% alcohol for at least 20 seconds, or with soap, water for at least of 40 seconds and disposable towels; if hands are not visibly dirty (ABHR) are preferred [74,76,79]. Medical staffs should not shake hands and hug while meeting colleagues, and should not touch their facial parts (eyes, nose, and mouth) without cleaning hands [80]. HCWs should be encouraging to wash their hand before donning PPE, after doffing PPE, when changing gloves, before and after touching other people, before, after preparing food, before, after eating, after coughing or sneezing and before, after using the toilet. Besides to WHO’s ‘5-moments of hand hygiene’ Functional facilities should be settled in strategic places (e.g., healthcare facility, donning and doffing area, waiting room, and where health care wastes are handled) to practice hand hygiene for all HCWs, patients and their visitors.[74,75,79]

2.2 Social distancing

As diseases transmitted by respiratory droplets, require a certain vicinity of people [81], keeping a distance of at least 1m while talking to colleagues in duty rooms, working place, eating food with colleagues, with family members, with co-workers at the hospital, or with others in public places (e.g. shopping, social gatherings) means that droplets from a normally breathing person will not touch you [82,80] and a meta-analysis has been shown that the social distancing of persons will decrease viral transmission [83].

2.3 Respiratory hygiene and cough etiquette

Providing graphical information on respiratory etiquette in visible places to cover nose and mouth with a tissue or bent elbow when coughing or sneezing; wash hand after contact with respiratory secretions or potentially contaminated objects with respiratory secretions and suspected COVID-19 patients while they are in waiting/public areas should wear medical mask.[74,76].

2.4 Personal protective equipment (PPE)

COVID-19 is primarily transmitted from infected person to healthy people by contact and
respiratory droplet routes, either directly (inhalation) or indirectly (deposited droplets on mucosal surfaces). [74] These respiratory droplets (larger particles) including aerosols (smaller particles) are generated from the nose and mouth of infected person by actions of breathing, coughing, sneezing and talking or laughing. Covid-19 has been obtained, mainly from respiratory, blood and faecal specimens of infected patient. However, until date there is no evidence of spread of this contagious virus across skin, either intact or non-intact, and through contact with blood of infected persons [84,85]. To avoid spread of SARS-Cov-2 through aerosol, droplet and fomites, various components of PPE offer various level of protection [85]. HCWs should wear gowns, gloves, medical mask and eye protection (goggles or face shield) when participated in the direct care of Covid-19 patients [86] to avoid contamination of their hands, skin and clothes, which might cause transfer of virus to the nose, mouth, and eyes [85]. HCWs should wear respirators, eye protection, gloves and gowns and aprons should be used if gowns are not waterproof for aerosol-producing procedures. Individuals has a respiratory symptom or those servicing for COVID-19 patients at home should wear medical masks. [86] PPE has various components like various type of masks, clean, nonsterile long-sleeved gown, gloves, disposable plastic aprons, waterproof apron/coverall, boots, goggles or face shield/ visor or goggles / safety spectacles and theatre caps/hoods and shoe covers. [85,86] PPE should be used based on the risk of exposure (e.g., type of activity) and the route of virus transmission (e.g., contact droplet or aerosol) (Table 1). [86] The correct use of PPE not only protect HCWs, but also protect the non-infected patients from contacting infection. The effectiveness of any type PPE strongly depends on staff training about donning and doffing of PPE, quick access to sufficient supplies, appropriate hand hygiene, health worker compliance and regular monitoring and feedback by IPC personnel. [76] All HCWs must be trained about the appropriate PPE and demonstrate an understanding of the following: [78,87] When to put on, remove PPE to prevent self-contamination. How to properly disinfect and clean PPE and the limitations of PPE. All HCWs must wear surgical mask all the time while inside the health care facilities; it is called ‘targeted continuous medical mask use, and everyone (staff, patients, visitors, service providers and others) to wear a mask at all times except when eating or drinking; it is called ‘Universal masking in health facilities’ [77] HCWs should change the masks and put on new surgical masks before going home. Cloth masks are not recommended for use in healthcare settings. [86].

<table>
<thead>
<tr>
<th>Target personnel or patients</th>
<th>Activity</th>
<th>Type of PPE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Medical staffs</td>
<td>Screening without direct contact*</td>
<td>Keep social distance of at least 1m No needed for PPE</td>
</tr>
<tr>
<td></td>
<td>Physical examination of patient with respiratory Symptoms</td>
<td>Surgical mask</td>
</tr>
<tr>
<td></td>
<td>Physical examination of patients without respiratory Symptoms</td>
<td>Gown</td>
</tr>
<tr>
<td></td>
<td>Direct care of suspected/confirmed COVID-19 patients</td>
<td>Gloves</td>
</tr>
<tr>
<td></td>
<td>Direct care of suspected/confirmed COVID-19 patients including Aerosol-generating procedures</td>
<td>Eye protection</td>
</tr>
<tr>
<td></td>
<td>Direct care of COVID-19 patient at home</td>
<td>Respirator N95 or FFP2</td>
</tr>
<tr>
<td></td>
<td>Carrying suspected COVID-19 patients to</td>
<td>Standard or equivalent</td>
</tr>
</tbody>
</table>

Table 1. Type of PPE for HCWs [86]
<table>
<thead>
<tr>
<th>Target personnel or patients</th>
<th>Activity</th>
<th>Type of PPE*</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>the referral healthcare facility</td>
<td>Gowns, Gloves, Eye protection</td>
</tr>
<tr>
<td>Medical technician</td>
<td>Collecting, handling and processing of specimens from suspected COVID-19 patients, including respiratory samples</td>
<td>Respirator N95 or FFP2, Surgical mask, Gown, Gloves, Eye protection (if risk of Splash)</td>
</tr>
<tr>
<td>Cleaners</td>
<td>Entering the room of COVID-19 patients</td>
<td>Surgical mask, Gown, Heavy duty gloves, Eye protection (if risk of splash from organic material or chemicals), Boots or closed work shoes</td>
</tr>
<tr>
<td></td>
<td>After and between consultations with patients with respiratory symptoms</td>
<td>Surgical mask, Gown, Heavy duty gloves, Eye protection (if risk of splash from organic material or chemicals), Boots or closed work shoes</td>
</tr>
<tr>
<td>Cleaning the area where Passengers with fever are being screened</td>
<td>Surgical mask, Gown, Heavy duty gloves, Eye protection (if risk of splash from organic material or chemicals), Boots or closed work shoes</td>
<td></td>
</tr>
<tr>
<td>Cleaning isolation area</td>
<td>Surgical mask, Gown, Heavy duty gloves, Eye protection (if risk of splash from organic material or chemicals), Boots or closed work shoes</td>
<td></td>
</tr>
<tr>
<td>Cleaning after and between carrying of suspected COVID-19 patients to the referral healthcare facility</td>
<td>Surgical mask, Gown, Heavy duty gloves, Eye protection (if risk of splash from organic material or chemicals), Boots or closed work shoes</td>
<td></td>
</tr>
<tr>
<td>Ambulances Driver</td>
<td>Carrying Suspected/confirmed COVID-19 patient, with separation between driver’s and patient’s compartments</td>
<td>Maintain spatial distance of at least 1m, No PPE required</td>
</tr>
<tr>
<td></td>
<td>Helping with loading or unloading patient with suspected COVID-19 patient</td>
<td>Surgical mask, Gowns, Gloves, Eye protection, Surgical mask</td>
</tr>
<tr>
<td></td>
<td>Without direct contact with suspected COVID-19 patient, but no separation between driver’s and patient’s compartments.</td>
<td></td>
</tr>
</tbody>
</table>

*Hand and respiratory hygiene should be followed always;” They should use no-touch thermometers, thermal imaging cameras and restricted observation and questioning

2.5 Environmental Cleaning

As the SARS-CoV-2 is an enveloped virus with a fragile outer lipid membrane, so it makes less stable in environment and more liable to disinfectants like chlorine [88]. Several studies have assessed the survival of the SARS-CoV-2 virus on various surfaces. It was found that the SARS-CoV-2 virus stayed viable up to 1 day on cloth and wood, up to 2 days on glass, 4 days on...
stainless steel and plastic, and up to 7 days on the outer layer of a surgical mask [89]. Another author have revealed that the SARS-CoV-2 virus stay alive 4 hours on copper, 24 hours on cardboard and up to 72 hours on plastic and stainless steel [90]. Cleaning with water and soap or neutral detergent along with some mechanical action like brushing or scrubbing help to eliminates virus and considerably decreased their load on contaminated surfaces. As the effectiveness of all disinfectants is affected by organic material (such as blood, sputum, secretions), all surfaces first should be cleaned with detergent / soap and water. [88] After cleaning a chemical disinfectant, like chlorine or alcohol, should be used to kill any remaining pathogen. All surfaces of rooms, beds, tables and other tools of suspected/confirmed COVID patients should be cleaned and disinfected at least once in a day, and after patients are discharged, transferred, or died. High touch surfaces like switches, bed-railings, side of curtains, door knobs should be cleaned twice daily [88]. Cleaners working for suspected/confirmed COVID-19 patients should be trained about the performing of cleaning and waste disposal procedures. [85] They should wear well-fitting PPE (Table 1), and should follow hand hygiene practice. Cleaners should know how to correctly and safely prepare chemical disinfectant solutions. Disinfectants should be prepared in a well-ventilated room. [88] Room surfaces and other objects of COVID-19 patients first should cleaned with a neutral detergent, and then disinfected with 0.05-0.1% sodium hypochlorite (i.e. dilution 1:100 to 1:50 if household bleach at an initial concentration of 5% is used). [85] Environmental services personnel using sodium hypochlorite (0.1% for large surfaces and 0.5% for spilled blood or body fluids) must be careful while cleaning as it is highly corrosive. Small surface areas and medical equipment should be disinfected with 70% ethyl alcohol. Contact time of minimum 1 min is recommended while disinfecting with ethanol, chlorine-based products and >0.5% hydrogen peroxide. Medical devices (e.g. stethoscope, hammer) of the isolation/COVID ward is potentially contaminated. Therefore, these should be kept inside that ward/room, and should not be used for non-COVID patients. Personnel dealing with waste management should wear appropriate PPE (boots, long-sleeved gown, heavy-duty gloves, mask, and goggles or a face shield) and should follow hand hygiene after removing the PPE. [85,88]

3. Additional precautions

As Covid-19 is mainly transmitted from infected person to others via close contact through respiratory droplets, aerosol, contaminated surfaces and objects, therefore all HCWs should be applied droplet, airborne and contact precautions measures before entering the suspected/confirmed COVID-19 patients room [91]. The principles skills of these preventive measures are mentioned in Table 2. Contact and droplet preventive measures are for medical staffs when providing care for suspected/confirmed COVID-19 patients; and furthermore, air-borne preventive measures required for HCWs who carry out aerosol generating procedures (AGPs) or who labor in places where frequently AGPs occur. The following aerosol generating procedures have been associated with increased risk of virus transmission: endotracheal intubation, bronchoscopy, open suctioning, manual ventilation before intubation, non-invasive ventilation, tracheostomy, cardiopulmonary resuscitation and high-frequency oscillatory ventilation. AGPs should be performed in a negative pressure isolation room. During performing procedures, the number of people should be limited in the room. All HCWs should wear the appropriate PPE (Table 2). [85] All cases should be placed in well-ventilated single rooms (considered to be 60 L/s per patient). If a single rooms is not possible, suspected, probable or confirmed COVID-19 cases should be separately grouped together with beds placed at least 1m apart (e.g. suspected with suspected). Use a disposable equipment (e.g. stethoscopes, blood pressure cuffs, pulse oximeters and thermometers). If needs to be shared equipment among patients, clean and sterilize between each patient (e.g. by using ethyl alcohol 70%). HCWs should avoid from touching their eyes, nose or mouth with possibly contaminated gloved or hands. Limit the number of HCWs, family members, and visitors who are in contact with suspected/confirmed COVID-19 cases. Regularly clean and disinfect surfaces with which the patient is in contact. [74,76].
Table 2. Additional precautions measures

<table>
<thead>
<tr>
<th>Route</th>
<th>Explanation</th>
<th>Preventive measures</th>
</tr>
</thead>
<tbody>
<tr>
<td>Droplet</td>
<td>• Droplets are contagious particles &gt;5μm in size</td>
<td>• Surgical mask</td>
</tr>
<tr>
<td></td>
<td>• Produced when patient coughs, sneezes or talks, and during certain procedures</td>
<td>• Eye protection (googles or face shield)</td>
</tr>
<tr>
<td></td>
<td>• Usually travels short distance (1 meter)</td>
<td>• Hand hygiene</td>
</tr>
<tr>
<td></td>
<td>• Spread indirectly to mucosal surfaces (mouth and nose) or conjunctiva (eyes) (e.g. via hands)</td>
<td>• Gloves</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Clean non-sterile, long-sleeved gown</td>
</tr>
<tr>
<td>Air borne</td>
<td>• Small-particle (&lt;5μm) aerosols</td>
<td>• Fitted filtering face piece respirator (FFP2 or equivalent, N95)</td>
</tr>
<tr>
<td></td>
<td>• Produced during breathing, talking, coughing or sneezing</td>
<td>• Eye protection (goggles or face shield)</td>
</tr>
<tr>
<td></td>
<td>• Aerosols can be spread over long distances (&gt;1 meter)</td>
<td>• Long-sleeved gown and gloves.</td>
</tr>
<tr>
<td>Contact</td>
<td>Contact Direct: i) Direct skin to skin contact (hands), ii) Ingestion, iii) Injection</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Indirect: Through a contaminated intermediate object or person (e.g. stethoscope or thermometer)</td>
<td></td>
</tr>
</tbody>
</table>

4. Administrative measures related to healthcare workers

To improve knowledge and awareness about infection prevention and control measures regarding to Covid-19, regular training should be provided to all HCWs particularly in areas of hand hygiene and PPE, providing of adequate resources for IPC measures, optimization of the duty schedule, establishment of clear IPC policies, patient to staff ratio should be sufficient. Early recognition of Covid-19, infections among HCWs can be attained through active syndromic surveillance of HCWs before they enter the healthcare facilities. [74,76,86] The design and ventilation of duty rooms and cafeteria should be improved during the pandemic, and large crowds should be avoided in the wards. In addition, medical staffs should be encouraged to exercise and adequate psychological support should be provided to them regularly. [80].

5. Possible transmission from animals

The implementation and maintenance of appropriate control measures during close contact, such as the handling, slaughtering and trading of wild animals offered for human consumption in food markets, is critical in the primary prevention of SARS-CoV2. [92].

6. Vaccine

As of May 7, 2021, the World Health Organization (WHO) reported that, 183 vaccines are in pre-clinical development and 97 vaccines are currently in clinical development. For use and development of Covid-19, vaccines apply different vaccine technology platforms. The core types include nucleic acid vaccines (DNA and RNA), viral-vector vaccines (replicating and non-replicating), virus vaccines (attenuated or inactivated) and protein-based vaccines (virus-like particles, protein subunits). [62] Advice from World Health Organization (WHO) and the United Nations Children’s Fund (UNICEF) is that the initial high-priority targets for vaccination should be HCWs, older people and those with underlying health problems. Therefore, all medical staffs should be vaccinated against COVID-19, influenza, and Streptococcus pneumoniae, according to local policies. [77].

7. Chemoprophylaxis

Front Line COVID-19 Critical Care Alliance (FLCCC), has published two protocols for prevention of COVID-19. The first one I-MASS Prevention protocol includes (Ivermectin 18mg on day 1, and then repeat weekly, Vitamin D 32000IU (50mcg) daily, multivitamin 1 tablet daily and digital thermometer (for checking body temperature) [93]. The second one is MASK+Prevention Protocol, which includes (high-risk individuals: Ivermectin 0.2 mg/kg (take before or after meals) one dose on first day, and then repeat after 48 hours, then weekly. For Post COVID-19 exposure: 0.2 mg/kg (take before or after meals) one dose on day 1, and then repeat after 48 hours, then weekly. For Post COVID-19 exposure: 0.2 mg/kg (take before or after meals) one dose on day 1, and then repeat after 48 hours, Vitamin D3 1,000–3,000 IU/day, Vitamin C 500–1,000 mg twice a day, Quercetin 250 mg/day, Zinc 30–40 mg/day and Melatonin 6 mg before bedtime (causes drowsiness) [94].
recent review and meta-analyses concluded that there was no evidence to recommend vitamin D supplements in primary prevention. However, any deficiency should be avoided, and therefore existing guidelines (update January 2021) for supplements in e.g. elderly people (800 IU vit D/d – 10 mg Zn/d) should be followed. [62] Available evidence shows that the use of hydroxychloroquine (HCQ) as prophylaxis in individuals after a high-risk exposure of COVID-19 did not find any advantage for HCQ but did find increased side effects. [62]

5.2 Secondary preventive measures

Secondary preventive measures comprise the use of health screening and recognition activities to ascertain those infected with SARS-CoV2. The purpose of secondary prevention is to block the progression of the virus and its complications and sequelae, as well as to shorten the period of disability. Infrared equipment (Thermofocus) was preferred to measure the surface temperature of the forehead without making physical contact with individuals [95].

5.2.1 Diagnostic approach

The clinical diagnosis of COVID-19 is mainly based on the following:

5.2.1.1 Epidemiological history and clinical manifestation

5.2.1.2 Some auxiliary examinations

Include nucleic acid detection (including reverse-transcription polymerase chain reaction (RT-PCR), real-time RT-PCR (rRT-PCR), and reverse transcription loop-mediated isothermal amplification (RT-LAMP)) [96]. RT-LAMP has similar sensitivity to rRT-PCR, is highly specific and is used to detect MERS-CoV. [97]. According to current diagnostic criteria founded by the China National Health Commission, laboratory examinations, including nasopharyngeal and oropharyngeal swab tests, have become a standard assessment for the diagnosis of COVID-19 infection. CT scan, immune identification technology (point-of-care testing (POCT) of IgM/IgG, enzyme-linked immunosorbent assay (ELISA)) and blood culture are also used for assessment. However, the clinical symptoms and signs of patients infected with COVID-19 are highly atypical. Hence, auxiliary examinations are essential for the diagnosis of COVID-19, similar to the epidemiological history [27].

5.3 Tertiary Preventive Measures

The purpose of tertiary prevention is to halt the progression of disease in persons who are already infected. Tertiary prevention consists of limiting the occurrence of disability by providing prompt diagnosis, treatment, and proper rehabilitation to slow the progress of disease or prevent its recurrence. [98].

5.3.1 Treatment Approach

5.3.1.1 Supportive care

Supportive care is the mainstay of treatment. This comprises bed rest and palliative therapy. Adequate calories should be supplied, and the replacement of fluids should occur to compensate for deficits caused by diarrhea or fever. Water-electrolyte balance and homeostasis should be sustained. Vital signs and oxygen saturation should be assessed. The opening of the airways should be maintained, adequate supplemental oxygen should be administered to correct hypoxemia, and antipyretics and analgesics should be administered to control fever and pain [99].

5.3.1.2 Antimicrobial therapy

The latest guidelines issued by the National Health Commission of China for the diagnosis and treatment of COVID-19 infection (version 7) advised against the inappropriate and unnecessary use of antimicrobial therapy. [100] particularly a combination of broad-spectrum antibiotics. If the sputum or blood specimens revealed clear evidence of etiology or if the procalcitonin levels increased, the administration of antimicrobial agents should be considered.

The anti-parasitic medication Ivermectin was demonstrated to inhibit the replication of SARS-CoV-2 in vitro. Ivermectin was previously found to have broad-spectrum antiviral activity in vitro. It was capable of reducing ~5000-fold viral ribonucleic acid replication at 48 hours [101].

5.3.1.3 Antiviral therapy

At present, there is no evidence from RCTs to support specific drug treatment against the new coronavirus in suspected or confirmed cases. Antiviral drugs, e.g., ribavirin and lopinavir-ritonavir, have been tried based on anecdotal knowledge with HIV, SARS and MERS infection therapies. [102].
5.3.1.4 Chloroquine / hydroxychloroquine

Both chloroquine and hydroxychloroquine hamper COVID-19 replication in vitro. However, hydroxychloroquine seems to have a more powerful antiviral effect. [103].

5.3.1.5 Corticosteroids

According to the latest guidelines issued by the National Health Commission of China (version 7) [98] and the interim guidance of the World Health Organization (WHO), [93] when COVID-19 infection is suspected, corticosteroids should be recommended for use with caution. Only patients presenting ongoing deterioration in the oxygenation index, rapid progression of radiological findings, or excessive activation of immune responses will be considered for the use of short-term corticosteroid therapy within 10 days of the onset of illness.

5.3.1.6 Antibody and plasma therapy

It has also been reported that there are many convalescent patients donating plasma against COVID-19, similar to SARS and MERS trials [104]. SARS coronavirus-specific human monoclonal antibodies can bind strongly with the receptor-binding domain (RBD) of COVID-19 and have the potential to be developed as candidate therapeutics for COVID-19 infections [105].

5.3.1.7 Psychological support and counseling

Medical staff report higher levels of burnout, psychological distress associated with quarantine, fear of contagion, concern for family and perceived stigma, as well as posttraumatic stress. Psychological and moral support for medical staff should be established in the acute phase and, ideally, in the pre-pandemic period to provide adequate preparation for future outbreaks. [106].

Here, we summarize the Preventive measures against COVID-19 infection for medical staff. (Fig. 2).

6. CONCLUSION

Since there are no approved effective antiviral therapies at this time, prevention is crucial. The greatest risk in COVID-19 is transmission to medical staff, and it is important to protect medical staff to ensure continuity of care and to prevent transmission of the infection to other patients. The most effective way to control COVID-19 is to break the chain of transmission from infected to healthy persons through strategies such as case detection, isolation of suspected or confirmed cases, contact tracing and the incorporation of primary, secondary, and tertiary preventive measures. Medical staff with confirmed or suspected COVID-19 infection are recommended to undergo appropriate symptomatic therapy, obtain supportive care and receive suggested psychological interventions.

Fig. 1. The situation of HCWs infected with SARS-COV2
Preventive measures against COVID-19 infection for medical staff

1. **Primary preventive measures:** Primary prevention of SARS-CoV-2 is directed toward stopping the occurrence of the disease before it onset.

2. **Secondary preventive measures:** The purpose of secondary prevention is to block the progression of the virus, its complications and sequelae, and shortened the period of disability.

3. **Tertiary preventive measures:** The purpose of tertiary prevention is to halt the progression of disease in persons who are already infected.

**Diagnostic approaches:**
- Epidemiological history
- Clinical manifestations
- Molecular and serological detection
- CT scan
- Immune identification technology
- ELISA
- Blood culture

**CONSENT**
It is not applicable.

**ETHICAL APPROVAL**
It is not applicable.

**COMPETING INTERESTS**
Authors have declared that no competing interests exist.

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