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Experience of comprehensive interventions in reducing occupational exposure to COVID-19

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ABSTRACT

Importance: The infection of medical personnel with COVID-19 was a disaster for both patients and doctors. However, some effective measures can prevent medical staff from becoming infected. This article introduces those measures and thus provides a reference for other hospitals.

Objective: In order to reduce the risk of occupational exposure and of the infection of medical staff, this article analyzed the factors, causes and experience of medical personnel on their occupational exposure to COVID-19. Some effective and targeted intervention measures can be implemented in order to avoid the occupational exposure of medical staff to COVID-19.

Evidence review: In this single-center case series involving 196 medical personnel, occupational exposure to COVID-19 was present. Nursing staff accounted for 67.35% of those cases. The relationships with an exposure source were found to be as follows: doctors and patients (87.24%), colleagues (10.20%), and roommates (2.55%). Occupational exposure was found to be present in the clinical department, radiology department, central sterile supply department, as well as in the outpatient clinics and operating rooms. The non-surgical departments accounted for 72.96% and direct contact accounted for 84.69% while failure to wear surgical masks (84.18%) and operating on the patient without wearing goggles/face shield (8.16%) were the main causes of occupational exposure. The occurrence of occupational exposure to COVID-19 declined to 0.19% after an extensive and comprehensive intervention program.

Conclusions and relevance: Some effective measures such as hand hygiene, wearing surgical masks in and around the hospital, reasonable use of goggles/face screens, raising awareness of protective measures, minimizing the number of elective operations, strengthening training as well as many other control measures were instrumental in reducing occupational exposure. For any medical institution there is room for improvement in terms of personal protection to reduce occupational exposure.

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Introduction

Since December 2019, a significant number of Coronavirus infections (COVID-19) [1] have been discovered in Wuhan City, Hubei Province, with the virus rapidly spreading into other countries as well [2]. By 19:00 h Beijing time on March 2, 2020, more than 9000 confirmed cases of COVID-19 have been reported in 65 countries and regions outside China. By 24:00 h on March 2, 2020, 30,004 confirmed cases, 587 suspected cases, 2943 deaths and

47,204 cured cases were reported in China. Hubei province remains the worst-hit region by the epidemic. Research indicates that by February 11, a total of 3019 medical personnel had been infected with COVID-19, including confirmed cases, suspected cases, clinically diagnosed cases, and asymptomatic infections, of which 1716 were confirmed cases. Serious cases of infection among medical staff were also reported in some regions within the provinces of Wuhan and Hubei. So far, the specific causes for infection among medical staff and protection failures are yet to be investigated in depth [3]. By May 7, 2020, a total of 45,924 medical personnel in Spain were had been infected with COVID-19, accounting for about 20% of the total number of infected people [4]. For medical staff, the occurrence of nosocomial infections of COVID-19 will cause great harm and seriously threaten the quality and safety of medical treatment. The occurrence of COVID-19 infections among medi-

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cal staff has sounded the alarm for us. Medical institutions should strengthen their preventive methods and tighten their control on hospital infections in order to reduce the occurrence of COVID-19 infections among their medical staff. An investigation into occupational exposure is essential to curb the spread of the epidemic. Some preventive and control measures that were adopted by a tertiary general hospital are shared below in order to provide a reference for other medical institutions and thus effectively reduce the risk of occupational exposure and infection among medical staff.

Objects and methods

Survey objects

The hospital in this study is a tertiary general hospital with three branches. The actual number of beds is 3,080, the number of registered physicians in the hospital is 996, the number of registered nurses is 1718, and the number of staff in other categories is 406. The total number of health care workers is 3120.

During the epidemic period, 24 specialized fever wards were renovated, with a total of 664 open beds. 1450 suspected or confirmed patients were treated (of which 307 were confirmed patients with COVID-19 and 1143 were suspected patients), 516 doctors and 755 nurses worked in the fever clinics/wards, the doctor to patient ratio was 2.81, and the nurse to patient ratio was 1.92. The subjects with occupational exposure to COVID-19 from January 1 to February 18, 2020 were taken as the research objects.

Survey method and content

When medical staff encounters an occupational exposure to COVID-19, the victim needs to report to the Hospital Infection Control Office, recall the specific actions undertaken prior to the incident and fill in a self-designed summary table of the occupational exposure personnel for COVID-19. This summary table includes crucial information such as the department, occupation, name, gender, age, information about the source of exposure, relationship with the source of exposure, earliest exposure time, last exposure time, name of operation performed and protective measures taken during the operation, among other vital details. The Hospital Infection Control Office will then evaluate whether, according to the filled-in summary, it constitutes close contact and whether it needs to take corresponding management measures. Then appropriate preventive and control measures (isolation, etc.), regular follow up and review are taken in order to know the final outcome of the victim.

Statistical method: SPSS20.0 statistical software was used for the statistical analysis. Classified data is expressed in “cases” and “percentages”. The count data was tested by the **Mc Nemar** test with $P < 0.05$ considered as statistically significant.

Criteria for occupational exposure

Occupational exposure refers to people who live, study, work or have close contact with the individual exposed to COVID-19. In this case, those that are subject to occupational exposure [5] are the medical staff, family members or other people who have a similar close contact with the individual in question, but have not taken effective precautions when diagnosing, treating, nursing or visiting them as well as when interacting with other patients and caregivers in the same ward.

Comprehensive intervention measures

Improve layout process and management structure

1. Essential measures were taken to improve the building structure of the fever clinic ward, so that the two channels (patient channel and medical staff channel) and the three areas (clean area, potential contaminated area and polluted area) met the requirements.
2. At the hospital, a leading group for COVID-19 prevention and control was established, with the hospital director as the team leader and the vice president as the deputy team leader. The leading group has a COVID-19 prevention and control office which incorporates the Medical Department, Nursing Department, Hospital Infection Control Office, Public Health Department, Laboratory Department, Pharmacy Department, Equipment Department, General Affairs Department and other crucial departments. Members of each department performed their duties and cooperated with each other to jointly deploy and supervise the implementation of various measures for the prevention and control of COVID-19 in the hospital.
3. The workers in the Hospital Infection Control Office supervised the use of protective equipment for medical staff every morning. Upon the observation that some individuals among the medical staff were not using protective equipment in accordance with the specifications, they urged the medical staff to rectify their mistake.
4. Each department established a prevention and control team for COVID-19 with the department director as the primary responsible party. The deputy director and the head nurse were the deputy team leaders, while all the medical, technical and nursing personnel were valuable members of the team. The team should establish a relationship that promotes a collaborative effort towards the undertaking of tasks. The head nurse distributed protective equipment for the staff in the department on a daily basis. The director and deputy director checked the implementation of the correct usage. The use of protective equipment in the department should be established by a ledger. The group leaders kept track of health statuses for all members in the department through daily monitoring of their temperature and symptoms. The group leaders should master and register the history of areas in affected regions for all members.

Improve the regulations and strengthen training and learning in order to ensure that personnel have them mastered.

1. In accordance with our hospital's situation, we formulated a series of rules in order to regulate the behavior of medical staff. These regulations included “nosocomial infection prevention and control system of COVID-19 (interim)”, “cleaning and disinfection procedures”, “some cleaning and disinfection matters of 120 transport vehicles”, “the making method of chlorine-containing disinfectant”, “the standardized training courseware for the prevention and control strategy of COVID-19”, and “video for the guidelines of protective equipment instruction” [6].

2. In order to avoid cross-infection, live training for the “Ding Talk App” as well as small-scale departmental training on nosocomial infection-related knowledge was carried out to strengthen training and learning. After the training, examinations were used to evaluate the mastery of the theory.

3. In order to ensure the effective implementation of cleaning and disinfection work in the fever ward, each ward is equipped with two nurses who are specially responsible for the cleaning and disinfection of equipment and environmental objects in the section. Based on the actual situation of our hospital, we formulated the standards for the COVID-19 occupational protective equipment in all departments. Each department was reasonably equipped according to the standards. It is essential that the hospital maintains a sufficient supply of protective equipment.

Provision and proper use of personal protective equipment (PPE)

Requirements of person management

1. Health education is vital for medical personnel, patients and their family members. A poster containing notable tips on the use of protective equipment was made and displayed on the hospital walls, thereby constantly reminding medical staff to use protective equipment correctly. All patients and their family members were required to wear masks when they entered the hospital. In the event that a person came down with a fever, cough, and/or other symptoms but an accurate diagnosis could not be made, the individual was advised to make a decision based on the WeDoctor's Digital general hospital online consultation. Currently, hospitals in some cities gather a large number of patients with respiratory diseases together. This not only increases the likelihood that individuals will not be able to effectively obtain useful information but also means that they are prone to cross-infection when visiting the hospital.

2. The behavioral management of medical personnel was essential in reducing cross-infection. Hand hygiene is crucial for the minimizing of infections, hence the need for medical personnel to raise awareness on effective protection [7]. Masks were worn for the entire period that medical personnel were in the medical area, medical personnel were not allowed to work when feeling ill and the number of people gathering in and around the hospital was reduced. Everyone was requested to eat at different times and maintain social distancing [8]. Individuals were also requested not to wear gloves when pressing the elevator button, answering the phone or during contact with public amenities. Wearing protective clothing, gloves and other protective equipment against infection was prohibited in the cleaning area. After removing the polluted protective supplies, medical personnel should ensure that they maintain a high level of personal hygiene by taking a shower.

Results

196/3120 health care workers were occupationally exposed to COVID-19 over the study period but before the implementation of comprehensive interventions. The basic characteristics of these persons were as follows:

Occupational distribution: nurses accounted for 67.35%, doctors accounted for 26.53%, cleaning workers accounted for 2.04%, surgical operations assistant nurses accounted for 1.53%, anesthesiologists accounted for 1.02%, professional engineers accounted for 1.02% while their assistants accounted for 0.51%.

The source of the exposures was 26 confirmed patients, and 170 suspected patients (accounted for 86.73%).

The relationship cases with an exposure source were: doctors and patients (87.24%), colleagues (10.20%), and roommates (2.55%).

Acts performed when the occupational exposure occurred were accounted for by 61.22% in nursing patients, 15.82% in the diagnosis and treatment of patients, 8.16% in operations on patients and 5.10% by individuals eating together.

The number of cases with occupational exposure in the distribution department were 27.04% in the surgical department and 72.96% in the non-surgical department. 84.69% were due to direct contact and 15.31% were due to indirect contact. Furthermore, 84.18% were attributed to the failure to wear surgical masks (only wearing a simple mask instead) and 8.16% of occupational exposure was attributed to operations performed on patients without goggles/face shields. The details are all shown in [Table 1](#).

After the extensive promotion of comprehensive interventions, the occurrence of COVID-19 occupational exposure declined to 0.19%. [Table 2](#) shows the details of the impact that the comprehensive interventions had. After the comprehensive implementation of the intervention measures, the occurrence of the occupational exposure of medical personnel decreased, hence proving that the intervention measures have achieved notable results.

After the quarantine measures and observation period had been completed, the final outcome from the follow-up investigations on the victims of occupational exposure was tested through: CT, blood tests, and nucleic acid tests. No abnormalities were found and thus no medical staff who had suffered occupational exposure in our hospital was infected with COVID-19.

Discussion

Nursing staff accounted for 67.35% of the individuals who had suffered from occupational exposure, something which was related to the fact that nursing staff needed to perform a significant number of operations such as sputum suction and oral care, monitoring vital signs and injecting and changing medicines during their daily routines. Doctors, surgical operations assistant nurses and anesthesiologists also suffered from occupational exposure. The prevalence of occupational exposure forced the hospital to minimize the number of patients it admitted, as well as the number of patients allowed in the operating room in order to reduce the risk of occupational exposure during the epidemic. This is consistent with the results of Antonia E's research that elective surgery should be postponed, while emergency surgery should be performed without delay by using PPE. This is due to the risk of catching the virus through airborne pathogens and going on the presumption that the patient has tested positive for COVID-19 [9].

Occupational exposure occurred in a significant number of departments, including the clinical departments, the radiology department, outpatient clinics, operating rooms, the central sterile supply department as well as other crucial departments. The prevalent nature of occupational exposure reminded the management to strengthen supervision and provide guidance on the use of protective equipment in the corresponding departments. A bulk of the occupational exposure occurred in non-surgical departments, which may be because elective surgery was postponed, however, most non-surgical patients with an emergency or a severe disease also have to be hospitalized, so the number of non-surgical patients was also relatively large. Furthermore, some non-surgeons were transferred to support fever wards thereby reducing the number of non-surgeons which then resulted in an increase in the burden ratio of doctors treating patients and thus increased the chance of occupational exposure.

The primary reason for occupational exposure was the fact that medical staff did not wear surgical masks and only wore simple masks. Simple masks are only for single use, they are never washed or reused and provide no protection against microbes during operations [10]. This behavior is inconsistent with the requirements in the "Specifications for the Prevention and Control of Infections by Hospital for Airborne Diseases" which was implemented in June 2017 and states that medical staff's protective requirements in general outpatient and general wards are surgical masks, hand hygiene, and work clothes. In 2009, the State Food and Drug Administration issued a document titled "Notice on Further Regulating the Registration of Simple Masks" [11], which defined the use scope of simple masks. The protective effect simple masks have on pathogenic microorganisms is not exact, but they can be used for disposable sanitary care in ordinary environments, or to block or protect particles other than pathogenic microorganisms such as pollen. Such masks generally lack the filtration efficiency requirements for particles and bacteria, or their filtration efficiency is at least significantly lower than those for surgical masks and medical protective masks. Therefore, simple masks are not recommended for clinical use. Prior to February 6, excluding fever clinics and fever wards, most general clinical departments were not equipped with surgical masks. Surgical masks should be worn throughout the entire hospital consultation region. It is necessary to remind med-

Table 1
Basic information of health care workers when occupational exposure occurred.

Category	Classification	Cases	Percentages (%)
Acts performed when the occupational exposure occurred	Nursing patients	120	61.22
	Diagnosis and treatment of patients	31	15.82
	Operations on patients	16	8.16
	Individuals eating together	10	5.1
	Talk up close	8	4.08
	Sleeping in the same room	5	2.55
	The patient was given CT	3	1.53
	Ward cleaning and disinfection	3	1.53
	Neurology department	36	18.37
	Oncology department	34	17.35
	Cardiology department	26	13.27
	Neurosurgery department	22	11.22
	General surgery department	18	9.18
	Radiology department	13	6.63
Department of occupational exposure	Department of traditional Chinese medicine	11	5.61
	Surgical and anesthesiology department	10	5.1
	Rehabilitation department	7	3.57
	Respiratory department	6	3.06
	Fever ward	4	2.04
	Gynecology department	3	1.53
	Cardiology clinic	2	1.02
	Digestive department	2	1.02
	Central sterile supply department	2	1.02
	Non-surgical department	143	72.96
Surgical department	Surgical department	53	27.04
	Direct contact	166	84.69
Contact method	Indirect contact	30	15.31
	Without wearing surgical mask	165	84.18
Causes of occupational exposure	Without wearing goggles/protective mask	16	8.16
	Without wearing a mask	15	7.65

Table 2
Comparison of the occurrence of COVID-19 occupational exposure in our hospital before and after comprehensive promotion of comprehensive intervention.

Before the comprehensive implementation of the intervention measures	After the comprehensive implementation of the intervention measures		Total
	+	–	
+	1	189	190
–	5	2925	2930
Total	6	3114	3120

Mc Nemar Test: $P = 0.000 < 0.05$.

ical staff to standardize the wearing of surgical masks, N95, FFP2, and FFP3 during both clinical diagnosis and treatment [12,13]. Each country has its own certification standard for each mask type, e.g. USA [NIOSH 42CFR Part 84], Europe [149:2001, and China [GB2626]. The European Union classifies respirator masks into FFP1, FFP2 and FFP3 where FFP stands for Filtering Face Piece. The term filtering face piece for FFP2, FFP3 and N95 is used in reference to high performance filtering masks. N95 is roughly equivalent to FFP2 and N99 is roughly equivalent to FFP3 masks [10]. Different countries in the world have different guidelines on situation-specific use of masks, and their usefulness and efficacy in such situations. These guidelines need to be consistent at both national and global levels. For regional use, medical staff needs to wear masks properly, and change them when they become contaminated or wet.

The second reason that occupational exposure was so prevalent was that during operations in the operating room or when aerosol-prone operations such as sputum suction were performed, goggles or protective masks were not worn, and therefore the protection was deficient. Goggles and face shields are the primary protective equipment used to prevent the eyes and face from being sprayed. It is indispensable for medical personnel to wear goggles and face shields when they are engaged in possible diagnostic operations such as sputum suction, swab collection, tracheal intubation or tracheotomy for suspected or confirmed patients [14]. It is necessary

to remind medical staff to increase standard prevention awareness and pay attention to the reasonable use of goggles/face screens, especially during aerosol-prone operations. Antonia E's research also pointed out that protective measures will vary depending on the urgent or emergent character of the case. For example, any surgical procedure where mastoid cells are exposed is high risk and therefore the use of a N95 surgical respirator and goggles that achieve a proper facial seal is necessary [9]. The study from Zhifeng Huang et al. showed that epidemic prevention and control measures for COVID-19 have achieved significant results. As of April 8, 2020, 22,073 COVID-19 infection cases among healthcare workers from 52 countries had been reported to the WHO. COVID-19 has strong infectivity, high transmission speeds, and causes serious infection among healthcare worker. The implementation of effective, appropriate-grade protection and the formulation of practical treatment protocols can increase the protection of healthcare workers and reduce the risk of COVID-19 infection [15].

The main cause of occupational exposure between colleagues was that when a member of the medical staff felt discomfort, others who had rested in the same dormitory or had eaten with him/her before they were diagnosed as a suspected case, then became exposed to the infection. Medical staff who had directly treated or nursed patients were advised to be mutually preventive in their daily routines, including staying and resting in single rooms. If they

did not have the conditions necessary to live in single rooms, they would usually need to wear medical surgical masks in the place where they would be staying, and maintain a distance of one meter when communicating with others [16]. The study from Hao-Yuan Cheng, et al. showed that the high transmissibility of COVID-19 before and immediately after the onset of symptoms suggests that finding and isolating symptomatic patients alone may not suffice in containing the epidemic and thus more generalized measures may be required, such as social distancing [17]. During the epidemic, everyone should try to reduce the number of gatherings and eat at individual times.

Conclusion

Some effective measures such as hand hygiene, wearing surgical masks in and around the hospital, reasonable use of goggles/face screens, raising awareness of protective measures, minimizing the number of elective operations, strengthening training as well as many other control measures were instrumental in reducing occupational exposure. For any medical institution there is room for improvement in terms of personal protection to reduce occupational exposure.

Existing deficiencies

The investigation should be based on the history of activities described by the patient during the case investigation. Due to patient recall, there may be the presence of bias. Single-center research may have errors, we look forward to multi-center research analysis.

Authors' contributions

Huan Liu were responsible for the conception, design, data collection, data analysis interpretation, and write-up and in the preparation of the draft manuscript. Jia-li Chen and Hua Liu were involved in the design, data analysis, interpretation, write-up and revision of the paper. They should be regarded as Correspondence Authors. Ya Wang, Hong-yan He, Liang-bao Liu, Qing Zhang were involved in the design, data collection. All authors read the final manuscript.

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Competing interests

None declared.

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