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Research Article

Occupational Exposure of Dental Nurses in a Tertiary Dental Hospital in Beijing

Yue Zhang[1], Yuge Zhang[2], Yang Liu[2], Lingxiao Wang[3*]

[1]Department of Periodontics, Beijing Stomatological Hospital, Capital Medical University, Beijing, China; [2]Department of Nursing, Beijing Stomatological Hospital, Capital Medical University, Beijing, China; [3]Department of Dental Implant Centre, Beijing Stomatological Hospital, Capital Medical University, Beijing, China

ABSTRACT

Background: Dental nurses are at high risk for occupational exposure, but how to reduce occupational exposure rates is still a challenge. This project aims to provide a theoretical basis for improving the safety awareness of dental nurses and reducing occupational exposure risks to a certain extent.

Methods: This study conducted a retrospective questionnaire survey to study the following aspects of the dental nursing population: (1) Exposure events, including the types and times of occupational exposure, as well as the devices that cause occupational exposure; and (2) Occupational expectations and attitudes toward patients with infectious diseases. Spearman correlation coefficient was calculated to analyze the relationship between vocational training courses and occupational exposure.

Results: The nurses (93.87%) had received vocational training. The vaccination rate of the hepatitis B vaccine is high (98.93%). The detection rate of HIV and human immunodeficiency virus was relatively low (10.93%). The majority (80.21%) had experienced occupational exposure. The nurses (98.93%) still stated that they would be willing to take care of patients with infectious diseases and would not change their profession (80.27%). No statistically significant association was found between vocational training and occupational exposure or sharp instrument injuries, while a certain relationship was found between vocational training and mucosal exposure ($p<0.05$).

Conclusion: The incidence of occupational exposure among dental specialty nurses in Beijing is relatively high, but the effectiveness of occupational exposure training programs is limited. In addition, they have a positive attitude and a sense of professional responsibility in caring for infectious disease patients.

Keywords: Dental nurses; Occupational exposure; Training course; Beijing; Sharp injuries

INTRODUCTION

Oral health is an important component of overall health. The World Health Organization has listed oral health as one of the top ten standards for human health [1]. Oral medicine is an important part of clinical medicine. In the field of oral medicine, most doctors complete treatment. However, in some clinical scenarios, stomatologists cannot complete diagnosis and treatment alone. The patients must have relevant auxiliary personnel cooperate and carry out four-handed operations to complete treatment smoothly and with high quality [2]. In China, this role is completed mainly by specialized dental nurses. In addition to collaborating with dental doctors to complete treatment, they also undertake tasks such as reception, triage services, health education, medical guidance and oral health care [3]. Unfortunately, the dental industry is centered around dentists and even though specialized dental nurses are extremely important personnel for dentists and are present in large numbers-there are more specialized dental nurses than dentists-records and documents related to specialized dental nurses are very scarce. There are many professionals in specialized oral care. According to community survey data from

Correspondence to: Lingxiao Wang, Department of Dental Implant Centre, Beijing Stomatological Hospital, Capital Medical University, Beijing, China; E-mail: lingxiaoccmu@163.com

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the United States from 2009 to 2013, the number of dental nurses matched to each dentist was 1.86. Scholars have estimated that the number of specialized oral nurses in Taiwan in 2020 will reach 28698. Currently, there are no statistical data on the number of specialized oral nurses in China. According to the 2020 China Health Statistics Yearbook, there were 195000 registered dental practitioners in China in 2019, based on which it is estimated that the number of specialized dental nurses in China was approximately 362700 [4].

Occupational exposure refers to the state in which workers contact blood or other potentially infectious substances containing blood-borne pathogens through the eyes, mouth, nose and other mucous membranes; damaged skin; or nongastrointestinal tract during occupational activities [5]. There is a risk of occupational exposure in medical activities. Occupational exposure can occur when medical personnel come into contact with toxic or harmful substances or infectious disease pathogens during diagnosis, treatment or nursing activities, resulting in adverse events that can negatively affect health or endanger life. Hepatitis B Virus (HBV), Hepatitis C Virus (HCV), Human Immunodeficiency Virus (HIV) and Thalassaemia Pallidum (TP) are the pathogens to which dental nurses are most susceptible during occupational exposure. This is mainly due to the widespread prevalence of blood-borne infectious diseases in the population [6]. Recent studies have shown that the probability of occupational exposure is 29.5% for nurses and 16.4% for clinicians, whereas previous studies have focused only on the occupational exposure of medical students and clinicians in dentistry. The occupational exposure rate of nurses is far greater than that of doctors. The main bloodborne infection that causes occupational contact among hospital staff is hepatitis B (30.8%), followed by HIV/AIDS (7.5%). In the other 36.3% of patients, the pathogen status of the source patient was uncertain [10]. Puncture injuries caused by sharp medical devices such as needles, scalers, pulp extractors, ultrasonic tips and periodontal probes are the main routes of occupational exposure for dental nurses, while other high-risk factors include aerosols from patients' saliva caused by pneumatic motors [7].

Beijing is the capital of China and one of the important international metropolises in the world, with a permanent population of 35 million. There are approximately 3000 specialized oral care practitioners who cooperate with doctors to complete nursing work for patients' oral health, facing the risk of occupational contact. However, most specialized oral care practitioners still lack attention on occupational contact and relevant systematic training and nursing experts often ignore the statistical data concerning the professional contact of specialized oral nursing practitioners. To further reduce the incidence of occupational exposure among dental nurses, improve healthcare safety awareness and enhance occupational exposure prevention, this study investigated the occupational exposure history of dental nursing staff, investigated the details of the exposure events and assessed their attitudes toward patients with infectious diseases and the impact of occupational exposures on their future career decisions.

MATERIALS AND METHODS

This was a retrospective study using routinely collected data and reported per the RECORD statement [8]. The Medical Ethics Committee of the Capital Medical University School of Stomatology exempted the present study from ethics approval because the data were deidentified, not easily reidentified and not part of a linkage study.

A pretest was also conducted to improve the suitability of the questionnaire for dental nurses. Based on the results of the questionnaire completed by the pilot study group (n=10), we improved the questions and reformulated the questionnaire to increase its relevance to the participants' comprehension and language skills (Supplementary Table S1). This survey was conducted from June 2022 to June 2023 and included 401 dental nurses from Capital Medical University School of Stomatology in Beijing. The inclusion criteria for patients were as follows: Must participate in clinical nursing work and nursing management and work for at least three years. The exclusion criteria for patients were as follows: Nonclinical nursing personnel in supply rooms, offices, etc., and nursing staff who were not on duty due to illness, maternity leave or other reasons during the investigation period. The interviewee was informed of the survey and agreed to voluntarily complete the questionnaire.

Filtering of invalid questionnaires:

- If there are too many missed answers in the questionnaire, it is generally based on two-thirds of the total number of missed answers;
- The questionnaire has designed reverse questions and if there is a contradiction between the positive and negative questions, it will be considered invalid;
- The options selected for the entire questionnaire were the same. For example, if you check "agree", the options selected for the entire questionnaire have regularity. For example, if you fill in options 1, 2, 3, 1, 2, 3, 1, 2, and 3, then the questionnaire is invalid;
- Patients not answered the questions indicated in the questionnaire.
- The question is a noncheck question, but there are two or more options available.
- If one person fills out two or more questionnaires repeatedly, all questionnaires completed after the second one will be deemed invalid.

Calculation of sample size

The incidence of occupational exposure among nurses was approximately 29.5%, with $n=u^2\alpha p\ (1-p)/\delta^2$. This study used p=0.29 as the basis for estimating the sample size; n=the required sample size when the population is greater than 10000; δ=the allowable error; δ=0.05; α=0.05; and u=standard normal deviation, usually set as 1.96, corresponding to a 95% confidence level. Finally, the sample size needed for this study was $n \approx 319$ and the effective responsivity was calculated to be 85%. Thus, the sample size needed for this study was 375.

Statistical analysis methods

The data were analyzed using SPSS version 20.0 (IBM, USA). The results are expressed as a percentage. The *chi-square* test was used to compare the data between groups and the significance level was set at $p<0.05$. A Spearman correlation coefficient was calculated to analyze the relationship between vocational training courses and occupational exposure.

RESULTS

In total, 375 nurses completed the questionnaire in this study (response rate: 93.52%) and 26 invalid forms were excluded from the analysis. The number of participants is presented in Table 1. The majority of the nurses (93.87%) had received vocational training, with a relatively low proportion receiving in-house training (5.60%) and hospital-level (10.93%) specialized vocational contact training. No one had received vocational training outside the hospital and the majority of nurses (93.33%) had received online vocational training. The vaccination rate of the hepatitis B vaccine is high (98.93%), but every year, it is administered blood-borne pathogens, including HBV, hepatitis B, TP and Treponema pallidum. The detection rate of HIV and human immunodeficiency virus was relatively low (10.93%).

Table 1: Basic characteristics of the study participants (n=375).

Features	N%
Have you taken the training course on occupational exposure?	
Yes	352/375 (93.87)
No	23/375 (6.13)
If you choose 'Yes', please select the type of training course. (multiple choice)	
Training within the department	21/375 (5.60)
Hospital level training	41/375 (10.93)
Off campus training	0/375 (0)
Network platform training	352/375 (93.33)
Other, _____	0/375 (0)
Have you received the HBV vaccine?	
Yes	371/375 (98.93)
No	4/375 (1.07)
Are you tested for HBV, TP and HIV every year?	
Yes	41/375 (10.93)
No	334/375 (89.07)

Note: HBV: Hepatitis B Virus; TP: Treponema Pallidum; HIV: Human Immunodeficiency Virus

Table 2 shows the occupational exposure rates of the dental nurses. Among the 375 dental nurses, the majority (80.21%) had experienced occupational exposure. Most dental nurses (73.42%) had experienced more than 3 occupational exposures, 17.61% had experienced 2 occupational exposures and only 8.97% had experienced 1 occupational exposure. Figure 1 shows the exposure of the display. Figure 1(a) mainly includes a suture needle (68.13%), an injection needle (50.18%), a dental pulp file (33.33%), a scalpel (4.03%), an ultrasonic probe (11.36%), a drilling needle (25.27%), a periodontal probe (28.21%), an archwire (4.76%) and a tray (32.60%). The time points at which mechanical injuries occurred are shown in Figure 1(b): During the preoperative preparation period (20.51%), delivery period (37.36%), nursing surgery period (65.20%) and postoperative treatment period (58.97%). Among them, 20.51% of people do not even know when they have suffered sharp injuries. Fifty-six nurses (14.93%) experienced mucosal exposure. Figure 2(a) shows that for the location of mucosal exposure, the eye mucosa accounted for 100.00% and the nasal mucosa accounted for 5.36%. Oral mucosal exposure was not reported. The main pollutants exposed to the mucosa in Figure 2(b) include blood (73.21%), treatment chair duct water (69.64%) and saliva (23.21%) and 1.25% of nurses are not sure what pollutants caused their own mucosal exposure. Figure 2(c) shows that at

the time points of mucosal exposure, most of the patients were cleaning instrument time points (58.93%) and operation time points (71.43%), as well as patient conversation time points (19.64%) and waste disposal time points (23.21%).

Table 2: Number (percentage) of participants who had experienced occupational exposure (n=375).

Features	N%
Have you ever experienced occupational exposure?	
Yes	301/375 (80.27)
No	74/375 (19.73)
If you choose 'Yes', please select the number of times	
Once	27/301 (8.97)
2 times	53/301 (17.61)
3 or more times	221/301 (73.42)
Have you ever had a sharp injury at work before?	
Yes	273/375 (72.80)
No	102/375 (27.20)
If you have suffered a sharp instrument injury, please choose the instrument. (Multiple choices)	
Suture needle	186/273 (68.13)
Syringe needle	137/273 (50.18)
Dental pulp file	91/273 (33.33)
Scalpel	11/273 (4.03)
Ultrasonic tip	31/273 (11.36)
Drilling needle	69/273 (25.27)
Periodontal probe	77/273 (28.21)
Arcuate wire	13/273 (4.76)
Tray	89/273 (32.60)
Other, _____	63/273 (23.08)
At what time did you get instrument injury? (Multiple choices)	
During preparation before operation	56/273 (20.51)
During the delivery of items	102/273 (37.36)
During nursing operations	178/273 (65.20)
During postprocessing	161/273 (58.97)
Not clear	56/273 (20.51)

Have you ever experienced mucosal exposure?	
Yes	56/375 (14.93)
No	319/375 (85.07)
Where does mucosal exposure occur? (Multiple choices)	
Eyes	56/56 (100.00)
Nasal cavity	3/56 (5.36)
Oral cavity	0/56(0.00)
What type of fluid causes mucosal exposure? (Multiple choices)	
blood	41/56 (73.21)
Treatment chair tubing water	39/56 (69.64)
Saliva	13/56 (23.21)
Not clear	7/56 (1.25)
At what time did you experience mucosal exposure? (Multiple choices)	
Cleaning instrument time point	33/56 (58.93)
Timing of patient conversations	11/56 (19.64)
Time points during operation	40/56 (71.43)
Time point for discarding waste	13/56 (23.21)

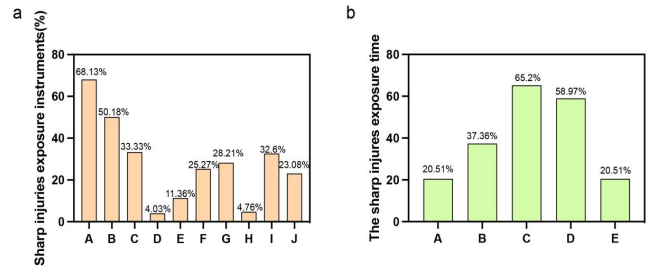

Figure 1: a) The sharp injury exposure instruments (%). A) Suture needle (68.13%); B) Injection needle (50.18%); C) Dental pulp file (33.33%); D) Scalpel (4.03%); E) Ultrasonic probe (11.36%); F) Drilling needle (25.27%); G) Periodontal probe (28.21%); H) Archwire (4.76%); I) Tray (32.60%); J) Other. b) The time points at which mechanical injuries occurred (%). A) Preoperative preparation period (20.51%); B) Delivery period (37.36%); C) Nursing surgery period (65.20%); D) Postoperative treatment period (58.97%); E) 20.51% of people do not even know when they have suffered sharp injuries.

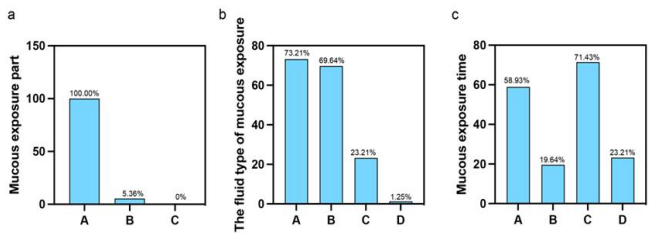

Figure 2: a) The location of mucosal exposure. A) Eye mucosa (100.00%); B) Nasal mucosa (5.36%); C) No one reported oral mucosal exposure. b) The main pollutants exposed to the mucosa. A) Blood (73.21%); B) Treatment chair duct water (69.64%); C) Saliva (23.21%); D) 1.25% of the nurses were not sure what pollutants caused their own mucosal exposure. c) The time points of mucosal exposure. A) Cleaning instrument time points (58.93%); B) Operation time points (71.43%); C) Patient conversation time points (19.64%); D) Waste disposal time points (23.21%).

According to the questionnaires we received, although 96.53% of the dental nurses in Beijing reported that they were afraid of the profession due to the presence of occupational exposures, the vast majority of them (98.93%) still stated that they would be willing to take care of patients with infectious diseases and

would not change their profession (80.27%) despite being aware of the risks of occupational exposures (Table 3).

Table 3: Occupational expectations (n=375).

Features	N%
Are you willing to take care of patients with blood-borne pathogens?	
Yes	371/375 (98.93)
No	4/375 (1.07)
Are you scared of this career because of the occupational exposure?	
Yes	362/375 (96.53)
No	13/375 (3.47)
Have you ever thought about giving up this career because of the occupational exposure?	
Yes	74/375 (19.73)
No	301/375 (80.27)

No statistically significant association was found between vocational training and occupational exposure or sharp instrument injuries (Table 4), while a certain relationship was found between vocational training and mucosal exposure ($p<0.05$).

Table 4: Correlations between nurses' characteristics and occupational exposures.

	Training course on occupational exposure
Occupational exposure	0.067
Sharp injuries exposure	0.052
Mucous membrane exposure	0.041*
Note: *$p<0.05$	

DISCUSSION

Currently, scholars are paying increasing attention to the issue of occupational exposure among nursing staff [9-12]. The main purpose of this study was to clarify the effectiveness of occupational exposure training courses for dental specialty nurses in tertiary hospitals in Beijing, the exposure rate of occupational blood-borne pathogens and the proactive care of infectious disease patients. In this study, more than 90% of the nurses had already participated in training courses related to occupational exposure before or during work, but the proportion of individuals receiving indoor training and hospital-level specialized occupational exposure training was extremely low. The majority of the nursing staff (93.33%) received online vocational training. As the capital of China, the health management department in Beijing has certain requirements for the participation of nursing staff in online vocational training. However, the effectiveness of online vocational training is limited, especially for equipment injuries. Online vocational training has not allowed dental specialty nurses to systematically learn and master relevant knowledge of occupational exposure and there is also a lack of awareness of the level of occupational exposure hazards. The relatively low proportion of departmental and hospital-level training indicates that the hospital departments of Beijing's tertiary and first-class dental specialty hospitals do not attach enough importance to the professional contact of dental specialty nurses. In particular, young nursing staff who have just joined the workforce lack certain work experience and are at high risk of occupational exposure. Occupational exposure training plays a very important role. Participating in training courses on occupational exposure and work experience accumulation can provide professional knowledge; help oral nurses master basic knowledge of oral hygiene, infection control and infectious disease prevention; strengthen patient safety and hygiene awareness; correctly disinfect and sterilize patients; perform personal protection and oral care operations; ensure that patients are not infected; and reduce the risk of cross-infection. Moreover, they can strengthen communication and collaboration skills, improve the quality and effectiveness of oral nurses' service in patient care and

update industry knowledge and technology in a timely manner, including but not limited to new treatment methods, protective methods and the use of new equipment, to keep nursing staff leading in the industry [13-16]. In addition, the proportion of dental nurses vaccinated for hepatitis B in Beijing was high (98.93%), while the proportion of dental nurses vaccinated for hepatitis B in Sichuan, China, was 90.3%. Scholars have assessed the occupational exposure of dental nurses in Nigeria to acupuncture and sharp injuries, as well as to the hepatitis B vaccine and found that 34 (41%) of 83 dental assistants had experienced acupuncture and sharp instrument injuries in the past 12 months, 43 people (51.8%) had been vaccinated with the hepatitis B vaccine and 62 (74.7%) of the respondents believed that it is easier to infect HIV through acupuncture than hepatitis B. The data of this survey emphasize that oral nursing staff urgently need educational intervention to encourage safe work practices and that hepatitis B vaccine vaccination, HIV-related knowledge and appropriate postexposure prevention are needed to prevent occupational transmission of bloodborne viruses. However, the proportion of blood-borne pathogens, including HBV, TP and HIV, detected annually in Beijing is relatively low (10.93%). The proportion of dental nurses in Sichuan, China, who receive blood-borne pathogens annually is 47.5%. Vaccination is a good method for preventing infectious diseases and the proportion of dental nurses in Beijing who undergo pathogen testing every year needs to be improved [17].

The occupational exposure types of dental practitioners are quite unique and include mainly biological exposure and chemical substance exposure. In addition, there is X-ray radiation exposure and physical exposure caused by prolonged head bending, bending, lifting and sitting for a long time [18]. Oral nurses are mainly involved in biological exposure to viruses, bacteria, fungi and other microorganisms. When needle pricks occur in patients with infectious diseases, oral nurses may be exposed to blood, saliva, secretions and other body fluids contaminated with pathogens, increasing the risk of infection. Out of the 375 valid questionnaires collected in this study, more than 80% of the dental nurses had experienced occupational exposure and 70% had experienced more than one occupational exposure. Suture needles (68.13%), injection needles (50.18%) and dental pulp files (33.33%) were the main chemical exposure devices. These devices are generally characterized by very sharp tips, which can lead to complications during the preoperative preparation and delivery of items. During nursing surgery and postoperative treatment, puncturing the skin can expose open wounds to the patient's body fluids. The body fluids of infectious disease patients can easily lead to the spread of the disease. The equipment most prone to chemical exposure among dental nurses in Beijing is suture needles, which is different from what is common among dental nurses in Sichuan, the state of Edo and Nigeria. In addition, scholars surveyed 154 oral care workers, 61.9% of whom stated that they had a history of occupational contact, with syringe needles being the most common tool of injury (45.8%) and the highest proportion of eye contact (90.9%). The most common period for chemical exposure was during nursing surgery (65.20%), possibly due to factors such as accidental injury by young doctors and patients. In addition, the postoperative treatment period (58.97%) is also a high incidence period when equipment is already contaminated, which increases the risk of transmission of infectious diseases. In this study, among the 14.93% of the dental nurses who had experienced mucosal exposure, the most common site of mucosal exposure was the eye. This may be because some of the young nurses did not wear protective goggles as per the established norms during the nursing process. The majority of mucosal exposure occurred at the time of instrument cleaning (58.93%) and during the operation (71.43%). Blood (73.21%) and treatment chair pipeline water (69.64%) were the two main pollutants related to mucosal exposure. Research shows that nurses caring for HIV-infected people are at high risk of contracting human immunodeficiency virus through acupuncture, cuts, eyes, mouths and skin when they are affected by bruises or dermatitis. It is suggested that decision makers in the health sector urgently need to formulate policies and guidelines and be programmed to rapidly expand postexposure prevention services in the health care environment to minimize preventable occupational HIV infection among nurses. Scholars have assessed the understanding of occupational exposure among oral nursing workers in Edo Prefecture and found that 6.6% of respondents reported biohazard infections, including HIV/AIDS (2.2%), hepatitis B (1.1%), tuberculosis (1.1%) and other infections (2.2%) and suggested that emergency measures and prevention education should be strengthened [19].

Dental nurses have a high occupational exposure rate and many job seekers are unwilling to bear the risk of a high occupational exposure rate, which makes the gap in dental care work in China very large. In Beijing, there are many dentists and the number of dental nurses cannot match the number of dentists, which is not conducive to the development of dental care work. According to the questionnaires we received, although 96.53% of the dental nurses in Beijing's tertiary and first-class hospitals reported that they were afraid of the profession due to the presence of occupational exposures, the vast majority of them (98.93%) still stated that they would be willing to take care of patients with infectious diseases and would not abandon their profession (80.27%) despite being aware of the risks of occupational exposures. The medical staff in Beijing have excellent professional responsibility and excellent medical technology. During the COVID-19 pandemic and the 2022 Winter Olympic Games in Beijing, patients undertook large amounts of medical treatment. In particular, during the 2022 Winter Olympic Games, the medical staff in Beijing treated 2897 athletes from 91 countries, 326 of whom were injured and 80 of whom were ill-equivalent to 11.3 injuries and 2.8 illnesses per 100 athletes-within 17 days. A total of 11% of athletes have suffered at least one injury and nearly 3% of athletes have suffered at least one illness. Beijing will take on increasingly important tasks in future international competitions or related activities and the demand for medical care will also increase. The task of dental care will also become more significant. Therefore, it is necessary to continue to enrich dental nurses' occupational exposure training courses and help nurses increase their awareness of reducing occupational exposure risks [20].

CONCLUSION

This study has innovative research subjects. Previously, the main research subjects related to medical occupational exposure were clinical doctors and medical students. This study targeted nursing professionals, especially dental nurses, who were relatively rare in previous studies and were at high risk of occupational exposure. In addition, this project is aimed at a group of dental specialty nurses. Based on the common scenarios of dental professional diagnosis and treatment, an innovative design of the dental specialty nurse occupational exposure questionnaire aims to comprehensively grasp the occupational exposure situation of dental specialty nurses through a series of questionnaire surveys, thereby improving the safety awareness of dental nurses and reducing occupational exposure risks.

LIMITATIONS

There are certain limitations in this study. This study has several limitations, as the study was conducted only within Beijing, selection bias and regional specificity could not be avoided. To verify the details of the occupational exposure of dental nurses, further multicenter surveys should be conducted.

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

The Ethics Committee of Capital Medical University School of Stomatology exempted this study from ethics approval because (i) It did not identify individuals, (ii) Data were not easily reidentifiable and (iii) Data were not part of a linkage study. The requirement for informed consent was waived by the Ethics Committee of Capital Medical University School of Stomatology because of the retrospective nature of the study. All methods were performed in accordance with the relevant guidelines and regulations as per the Beijing Municipal Health Commission recommendations on the use of deidentified data.

CONSENT FOR PUBLICATION

Not applicable.

AVAILABILITY OF DATA AND MATERIALS

The data sets used and/or analyzed during the current study are available from the corresponding author upon reasonable request.

CONFLICT OF INTEREST STATEMENT

None of the authors had any competing interests.

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AUTHORS' CONTRIBUTIONS

All authors contributed to the study conception and design. Material preparation, data collection and analysis were performed by ZY, ZYG. Material preparation was performed by LY. The first draft of the manuscript was written by WLX and all authors commented on previous versions of the manuscript. All the authors have read and approved the final manuscript.

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