

# Insulin-Injection-related Needle-stick Injuries Among Clinical Nurses at a Tertiary-Care Hospital in China

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**Abstract:** Needle-stick injuries (NSIs) are the main type of occupational injury experienced by health-care workers worldwide. They are widely reported in the literatures, but there have been few studies of insulin-injection-related NSIs. This study aimed to determine the prevalence of and risk factors for insulin-injection-related NSIs among clinical nurses working at a Chinese tertiary-care hospital. **Methods:** We used a questionnaire to investigate the incidence of and risk factors for insulin injection-related NSIs in a tertiary-care hospital in Guangzhou, China. The study involved 576 nurses from various departments, including endocrinology, internal medicine other than endocrinology, surgery, and obstetrics and gynecology. **Results:** Approximately half (54%) of the participants reported having >5-years of experience in clinical nursing, and 66.3% reported that they had received training on injection safety at work. While 16.0% of the nurses had experienced an insulin-injection-related NSI before, 58.7% of them did not report it to the relevant hospital department. When NSIs occurred, 69.6% of nurses were not wearing gloves, and 75% of the needles had been contaminated by patients. The largest proportion (34.8%) of the NSIs occurred when the needle cap was being re-attached after an injection. Multivariate logistic analysis showed that participation in training (odds ratio [OR]=0.605) and being a diabetes specialist nurse (OR=1.814) were independent factors related to the incidence of insulin-injection-related NSI. **Conclusion:** Insulin-injection-related NSIs are common among clinical nurses. Hospital management departments need to improve their training of nurses in preventing and handling NSIs, provide appropriate safety equipment, and implement simpler procedures for reporting NSIs.

**Keywords:** Clinical Nurse, Insulin-injection-related Needle Stick Injuries, Risk Factors, China

## 1. Introduction

The global prevalence of diabetes is increasing, with the number of diabetes patients worldwide reaching 463 million in 2019, and this is predicted to increase to 700 million in 2045. China has the largest number of diabetics in the world, with 116.4 million adult diabetic patients [1]; their prevalence increased from 0.67% in 1980 to 10.9% in 2013 [2-5]. Diabetes mellitus covers a group of metabolic diseases characterized by hyperglycemia that result from deficient of insulin secretion, insulin effects, or both mechanisms [6]. Many patients with diabetes require insulin therapy, and so the rapid increase in the prevalence of diabetes in China has

resulted in the rate of insulin use also increasing.

The incidence of needle-stick injury (NSI) is at least as high among nursing staff performing insulin injections as it is in other medical departments and wards. A NSI refers to a skin injury caused by a sharp instrument such as a scalp needle, syringe needle, intravenous catheter, blood sampling needle, or hypodermic needle [7]. A survey involving 14 European nations found that nearly one-third of nurses giving injections to diabetics in hospitals have experienced NSIs [9]. A very large survey of insulin-injection-related NSIs among hospital nurses in China found that 39.1% of nurses had experienced at least one NSI related to insulin injection [8].

A NSI caused by an insulin pen may transmit at least 30 types of life-threatening blood-borne pathogens, including

hepatitis B virus (HBV), hepatitis C virus (HCV), and human immunodeficiency virus (HIV) [9]. NSIs caused by insulin injections reportedly accounted for 3.2% and 0.9% of cases of nurses being infected with HBV and HCV, respectively [8]. Insulin-injection-related NSIs will not only cause physical injury and have an emotional impact on the medical staff, but they are also associated with significant direct, indirect, and intangible cost [10], that further results in economic losses at the society and country levels [11, 12].

Currently there are about 86 million people infected with HBV in China, which accounts for the largest proportion (30%) of the infected people worldwide [13]. In addition, in recent years an average of 1 million new cases of hepatitis B have occurred in China [14] and the incidence of HIVs is also on the rise [15]. Therefore, NSIs caused by insulin injections represent a serious occupational hazard for Chinese nurses. Despite this situation, there have been few investigations of the status of and risk factors for insulin-injection-related NSIs in Chinese nurses.

The purpose of this study was to understand the problems experienced by clinical nurses when they are performing insulin injections, including the incidence of insulin injection-related NSIs, and to identify the risk factors for these injuries.

## 2. Material and Methods

### 2.1. Setting and Subjects

This study was performed in a Chinese tertiary-care hospital in Guangdong, Province, China during July 2020, with convenience sampling method used to select 576 nurses as the research objects. The inclusion criteria were (1) registered nurses engaged in clinical nursing work and (2) providing informed consent and participating voluntarily. Nursing interns and nurses in administrative roles who were not involved in the direct care of patients were excluded.

### 2.2. Measurements

A questionnaire was prepared that included general demographic characteristics and insulin-injection-related NSI, and it was approved by the Diabetes Committee of the Chinese Nursing Association.

### 2.3. Data Collection

Data collection began in July 2020, with the investigators using an online survey via a unified training platform (<https://www.wenjuan.com/>). Subjects meeting the eligibility criteria were sent an electronic questionnaire survey, the respondents anonymously completed the questionnaires online, and the online survey platform automatically collected data while, following the principle of informed consent. The questionnaire data collection process was completed within 1 week. All of the 576 recovered questionnaires were valid, giving an effective recovery rate of 100%.

The first part of the questionnaire collected demographic data. The second part collected information on whether the

participants had experienced insulin injection-related NSIs and the characteristics of the NSIs, including the device and activity that caused the NSI, the degree of contamination of the sharp instrument, the protective measures taken, and the degree of injury.

### 2.4. Statistical Analysis

After preprocessing the original data, SPSS (version25.0, IBM, NY, USA) was used to establish a database for statistical analysis. Descriptive statistical analysis was used to summarize the study variables, and the chi-square test was used to assess the associations between insulin-injection-related NSI and selected demographic factors. In addition, variables that were statistically significant in the chi-square test were screened into a logistic regression model for further analysis while controlling for confounding factors. The dependent variable in the logistic regression analysis was insulin-injection-related NSI (yes/no), while the independent variables were being a diabetes specialist nurse (yes/no), receiving training (yes/no), type of working department, and number of department beds. The criterion for statistical significance was set as  $p < 0.05$ .

## 3. Results

### 3.1. Demographic Characteristics of Participants

The 576 nurses who participated in the survey all answered the survey questions completely. Demographic factors, job characteristics, and previous participation in training courses were all included in the further analysis to identify the factors that affect the occurrence of NSIs. General information and the results obtained in the single-factor analysis are presented in Table 1. The respondents were from department of endocrinology (2.4%), internal medicine other than endocrinology (29.2%), surgery (27.3%), obstetrics and gynecology (13.2%), and other departments (28.0%). Approximately half (54%) of the nurses reported to having >5-years of nursing experience, 57.6% had a job title of senior nurse, and 66.3% reported that they had received training on injection safety at work.

### 3.2. General Condition of Needle-stick Injury

The respondents included 92 (16%) who had experienced an insulin-injection-related NSI. The rate of NSIs was significantly higher in certified diabetes specialist nurses (23.8%) than among other nurses (14.7%), and significantly lower in nurses who had participated in training for preventing NSIs (13.6%) than in those who had not received such training (20.6%), the differences were statistically significant ( $p < 0.05$ ).

The incidence of NSIs also varied between departments, being significantly higher in departments with 31-50 beds ( $p < 0.05$ ); and in endocrinology departments than in departments of internal medicine (other than endocrinology), surgery, and obstetrics and gynecology ( $p < 0.05$ ).

**Table 1.** Comparison of insulin-injection-related NSIs according to selected demographics factors.

Category	Data	Person with injury n (%)	X <sup>2</sup>	p value
Total	576	92 (16%)		
Work experience				
in 2 years	86 (14.9%)	7 (8.1%)	4.869	0.182
3-5 years	179 (31.1%)	31 (17.3%)		
6-10 years	159 (27.6%)	27 (17.0%)		
>10 years	152 (26.4%)	27 (17.8%)		
Diabetes specialist nurse				
No	496 (86.1%)	73 (14.7%)	4.187	0.041
Yes	80 (13.9%)	19 (23.8%)		
Bed's number				
1-30	110 (19.1%)	8 (7.3%)	14.206	0.003
31-50	190 (33.0%)	44 (23.2%)		
51-70	162 (28.1%)	22 (13.6%)		
>70	114 (19.8%)	18 (15.8%)		
Job title				
Nurse	194 (33.7%)	25 (12.9%)	3.425	0.331
Senior nurse	332 (57.6%)	58 (17.5%)		
Nurse-in-charge	45 (7.8%)	9 (20.0%)		
Deputy chief nurses	5 (0.9%)	0 (0.0%)		
Prior NSIs prevention training education				
No	194 (33.7%)	40 (20.6%)	4.705	0.030
Yes	382 (66.3%)	52 (13.6%)		
Work department				
Endocrinology	14 (2.4%)	5 (35.7%)	9.705	0.046
Internal medicine (Other than endocrinology)	168 (29.2%)	29 (17.3%)		
Surgery	157 (27.3%)	31 (19.7%)		
Obstetrics/gynecology	76 (13.2%)	8 (10.5%)		
Others department	161 (28.0%)	19 (11.8%)		

Multiple insulin-injection-related NSIs had been experienced by 42.2% of the clinical nurses. Among those who had experienced any NSIs, 60.9% had skin punctures and

bleeding, 69.6% were not wearing gloves at the time of their NSIs, and 75% of the needles had been contaminated by patients (Table 2).

**Table 2.** Specific situations of insulin-injection-related NSI (n=92).

Item	Number	Composition (%)
Times of insulin-injection-related NSIs		
1 Times	52	57.8
2 Times	29	31.5
3 Times	6	6.5
≥4 Times	5	5.4
Severity of injuries		
Superficial (no or almost no bleeding)	36	39.1
Moderate (skin puncture, a certain amount of bleeding)	55	59.8
Severe (deep penetration/cutting, or significant bleeding)	1	1.1
If the hand gets injured, whether the needle penetrates the hand		
A pair of gloves	23	25.0
Two pairs of gloves	5	5.4
No gloves	64	69.6
Contamination degree of sharp objects		
Contaminated (known to be exposed to patients)	69	75.0
Uncontaminated	21	22.8
Unknown	2	2.2

### 3.3. Risk Factors for NSI

Multivariate logistic regression analysis was applied to the factors that were statistically significant in the single-factor analysis (Table 1), with the likelihood-ratio forward method used to screen the factors at a threshold of  $\alpha = 0.05$ . The results are listed in Table 3. Participation in needle-stick knowledge

training and being a diabetes specialist nurse were independent factors influencing insulin-injection-related NSIs.

The risk of insulin-injection-related NSIs was lower in nurses who had not received hospital needlestick training (odds ratio [OR]=0.605, 95% confidence interval [CI]=0.383,0.954), and higher in diabetes specialist nurses than in non-diabetes specialist nurses (OR=1.814, 95%CI=1.021,3.223).

**Table 3.** Results from a logistics regression model of insulin-injection-related NSIs.

Variances	OR (95%CI)	P value
Prior NSIs prevention training education	0.605 (0.383,0.954)	0.031
No		
Yes		
Diabetes specialist nurse	1.814 (0.383,0.954)	0.042
No		
Yes		

CI, confidence intervals.

### 3.4. Devices Involved and Times of Occurrence of NSIs

Table 4 lists the types of devices that caused insulin-injection-related NSIs and the times when they occurred. Most NSIs had occurred when using traditional insulin pens without safety equipment, and the largest proportion (34.8%) of the NSIs occurred when the needle cap was reattached after an injection.

**Table 4.** Devices involved and times of occurrence of NSIs.

Item	Num	Composition (%)
Types of equipment with NSIs		
Traditional syringe needle (no safety device)	20	21.7
Traditional insulin pen needle (without safety device)	70	76.1
Insulin pump needle	2	2.2
Times of occurrence of NSIs		
Before using the needle	9	9.8
Using the needle	3	3.3
Transfer instrument	1	1.1
When putting on the needle cap again	32	34.8
When putting items in the sharps box	13	14.1
After disposal	8	8.7
Patient holding contaminated needle	6	6.5

### 3.5. Management After Occurrence of NSIs

Most (58.7%) of nurses with insulin-injection-related NSIs did not report the injury to the relevant hospital departments. The main reasons for not reporting the injury were “I think the incident has no health risk” (58.7%) and “I was very busy at the time” (28.2%) (Table 5).

**Table 5.** Reports of insulin-injection-related NSIs (n=92).

Item	Classification	Num	Composition (%)
Report after NSIs	Yes	38	41.3
	No	54	58.7
Reasons for not reporting	“I don’t think the incident has health risks”	54	58.7
	“I was very busy”	26	28.2
	“I was so embarrassed”	5	5.4
	“I think reporting may have a negative impact on my work/career”	6	6.5
	“I don’t want to know the result”	1	1.1

## 4. Discussion

### 4.1. Analysis of the Occurrence of and Risk Factors for Insulin-injection-related NSIs

Previous researches on NSIs have mostly focused on the overall NSI status of medical staff, and few studies have investigated the incidence of insulin-injection-related NSI and their influencing factors. In the present survey, 16.0% of nurses reported experiencing at least one insulin-injection-related NSI, which is lower than the rates found by Zhao *et al.* [16] (39.1%), Dong *et al.* [8] (19.33%), and Costigliola *et al.* [9] (32%). Two large-scale surveys in China found that the overall incidence rates of NSIs among nurses were 7.8% [17] and 10.3% [17, 18], which are lower than the rate found in this study. These discrepancies in the incidence of NSIs among different studies may be related to factors such as the included hospitals and countries [19]; however, overall the results of the various studies show that there is a relatively high incidence of NSIs caused by insulin injection among clinical nurses [20]. Meanwhile, NSI is a transmission route for HIV, HBV, and HCV, and it is reported that the prevalence of AIDS, hepatitis B, and hepatitis C in diabetic patients is at least as high as those in healthy people and patients with other diseases [20-23]. Therefore, the risk of

blood-borne infections may be higher in nurses who experience an insulin-injection-related NSI, which need to be addressed by both hospital managements and the actual nursing staff.

This study also found that the risk of insulin injection-related NSIs is affected by factors such as receiving training on preventing NSI, being a diabetes specialist nurse, departments type, and number of beds. However, the multivariate logistic regression analysis showed that receiving training and being a diabetes specialist nurse are independent factors influencing the occurrence of insulin-injection-related NSIs.

The risk of NSI was found to be lower in nurses who had received training, which is consistent with previous reports of training significantly reducing the incidence of NSIs among medical staff [20, 24-26]. Moreover, organizing training is cheaper and more feasible than providing safety devices and other NSI prevention measures, which makes it worth promoting [24, 27]. The present study found that, diabetes specialist nurses had a 1.8-fold higher risk of insulin-injection-related NSIs compared with non-specialist nurses. The core role of the diabetes specialist nurse is as a clinical caregiver [28, 29], and so ward nurses may need to perform more injection operations when they are looking after diabetic patients. At the same time, unlike foreign specialist

nurses who need to complete regular assessments after obtaining certification, most domestic specialist nurses only need to pass a single assessment in China [30]. The insufficient follow-up management and guidance of specialist nurses may mean that the abilities of diabetes specialist nurses need to be further improved.

#### **4.2. What Happens When a NSI Occurs**

Medical staff should regard the blood and body fluids of patients as sources of infections of blood-borne infectious diseases such as HIV, HBV, and HCV. Moreover, the transmission risk of blood-borne pathogens is three times higher for deep damage than for surface damage [20]. Therefore, medical staff should wear gloves whenever they are performing procedures in which they may come into contact with the blood and body fluids of patients in order to prevent occupational exposure. In this study, 69.6% of nurses were not wearing gloves when they experienced a NSI, which is a higher proportion than in previous studies [31]. Moreover, nearly half of the nurses had experienced multiple stabbing wounds. Most nurses experience NSIs in which the skin is punctured and bleeding, and nurses are at a greater risk of blood-borne infections. Previous studies have shown that medical staff who wear gloves either only occasionally or never have a higher risk of NSIs than do those who wear gloves regularly [26]. Mischke et al. [32] demonstrated that the use of double-layer gloves can reduce the occurrence of NSIs without affecting their dexterity.

In the present study, 75% of the devices had been contaminated when an insulin-injection-related NSI occurred, which is similar to the findings of previous NSI surveys conducted in Korea [33] (60.6%) and China [18] (77.5%). More than two-thirds of insulin-injection-related NSIs experienced by clinical nurses involved contaminated sharps. There are more than 80 million patients with hepatitis B in China [34], and the incidence of hepatitis C is 16 cases per 100,000 people, and the number of people infected with HIV exceeds 570,000 [35]. These three diseases are how major epidemics in China, and so Chinese nurses must be aware of their high risk of being infected by blood or body fluid pathogens on contaminated devices.

#### **4.3. Types of Syringes That Cause Insulin-injection-related NSIs and the Times When They Occur**

Most of the NSIs in this study occurred when using traditional insulin pens without safety equipment. Many previous studies [20, 24, 36, 37] have demonstrated how important safety equipment is to preventing NSIs. EU legislation enacted in 2013 stipulated that medical workers must use safety equipment when performing dangerous injections, including for diabetic patients [20]. The largest proportion (34.8%) of the NSIs in the present study occurred when the needle cap was being re-attached after an injection. Other studies have shown that recapping needle is an important risk factor for NSIs [38, 39]. The safe injection guidelines of the World Health Organization [40] forbid the

disassembly or retraction of the needle after an injection, and state that the needle and syringe should be integrated immediately and placed in a sharps box.

It had been reported [20] that the provision of adequate safety equipment can effectively reduce the occurrence of NSIs caused by trocars and other devices, while cost-benefit analysis showed that the cost savings of using safety equipment to reduce injuries from sharp objects can offset the increased hospital costs associated with using such equipment [16]. Therefore, hospital managers should provide nurses with safety equipment for use with insulin injection tools.

#### **4.4. Reporting After a NSI**

In this study, after a NSI occurred, most of the nurses failed to report the injury to the relevant department of the hospital. The main reason for not reporting the injury was “I think the incident has no health risk” (58.7%), followed by “I was very busy at the time” (28.2%), which is similar to the results of Dong et al. [8], Joukar et al. [41], and Sabermoghaddam et al. [42]. Nurses may think that an insulin injection device will not be contaminated by blood, which will reduce their vigilance. However, it has been shown previously that blood attached to a used injection device is sometimes not visible. Only small amounts of infected blood are needed to transmit highly contagious viruses such as HBV, which can be present even when a device is not used specifically for drawing blood or obtaining vascular access [20].

Previous research results demonstrate that training can improve the above-mentioned problems such as not reporting NSIs, not wearing protective gloves, and retracting used needles [27]. Hospital managers need to provide appropriate training programs, regularly update staff with knowledge about NSIs, improve the general safety awareness of medical staff, and establish a rapid and effective reporting system. After a NSI occurs, managers need to strengthen the guidance and support to nurses, and arrange for special personnel to help with this.

## **5. Conclusions**

Clinical nurses experience a high incidence of insulin-injection-related NSIs, and most of them fail to report such events. Such injuries should not be ignored. The occurrence rate of NSIs is significantly affected by factors such as training, department type, number of beds, and being a diabetes specialist nurse, with participation in NSI knowledge training and being a diabetes specialist nurse being the most important independent factors. Hospital managers need to strengthen training on NSI prevention and provide safety equipment, provide standardized insulin injection training for nurses based on the latest guidelines, and comprehensively improve the awareness that clinical nurses have of injection guidelines and the adverse effects of NSIs.

The main limitations of this study were that the survey subjects only included clinical nurses in a single tertiary-care hospital in Guangdong Province, and so the scope of the survey needs to be expanded in the future. Moreover, the survey subjects used self-evaluations to complete the

questionnaire, and so future studies should attempt to obtain more objective research results.

## Author Contributions

Zhiqi Luo and Na Li are co-first authors.

## Conflict of Interest

All the authors do not have any possible conflicts of interest.

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