Assessing the Impact of Educational Strategies on Reducing Needle Stick Injuries for Nurses in Jordanian Hospitals

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KEYWORDS

Needle sticks injury; Education strategies; Private hospitals; Nurses; Jordan

ABSTRACT

Background: Needle stick injuries (NSIs) are frequent occupational health hazards among nurses with several consequences including blood-borne infections. Literature indicates inadequate knowledge among nurses as an important associated risk factor. Notwithstanding, little attention has been given to the intervention programs to reduce the occurrences of NSIs in Jordan.

The main objective of this research was to implement and assessing the impact of educational modules and strategies to minimize NSIs for nurses in Jordanian hospitals. Methods: a randomized control trial design with four arms including three intervention groups and one control group was applied. A total of 400 nurses were selected based on stratified random sampling from the four randomly sampled private hospitals. The educational intervention was then provided through three different strategies (Social Media (SM), Audio-Visual (AV), and combined method). Data were collected in three phases, at baseline, after three months, and after six months of the intervention. Results: There were statistically significant differences in the number of NSIs between the control and combined strategy groups (P= 0.002). After 6 months, significant differences were found between control and SM groups (P=0.032), control and AV groups (P= 0.007), and control and combined groups (P<0.001). The leading risk factors of NSIs included fatigue (P<0.001), lack of assistance (P= 0.001), emotional distress (P= .021), being rushed (P= .002), and Lack of skills (P= .001). The hierarchical regression for the prediction of changes in NSIs occurrence produced a model with four predictors after three months (P< .001), and six predictors after six months (P< .001). Conclusion: The educational intervention significantly decreased the occurrences of NSIs. Hospital administrators must consider significant risk factors for NSIs.

1. Introduction

Needle stick injuries (NSIs) refer to “any percutaneous injuries, penetration of skin resulting from a needle or other sharp object, which has been in contact with blood, tissue, or other body fluids prior to the exposure” [1]. They are one of the most frequently reported occupational health hazards among healthcare workers (HCW) [2, 3]. Exposure to NSIs may lead to serious complications such as blood-borne diseases for example, HIV and Hepatitis [4], which may adversely affect the overall well-being of the affected people [5]. Available estimates from the Center for Disease Control and Prevention (CDC) indicate that there are 385,000 hospital workers who reported sharp injuries in the US annually [6]. At a global level, the World Health Organization (WHO) reported that a million HCW are exposed annually to percutaneous fluid contaminated with hepatitis B (about 2,000,000 exposures), HIV (approximately 170,000 exposures), and hepatitis C (about 900,000 exposures) which are attributed to NSI [7].

A large number of international previous researchers noted that nurses are the leading HCW with the

highest risk of NSIs [8]. They are almost always in direct contact with patients. They have the role of administering most of the injections and are responsible for the provisions of intravenous fluid using needles. Hence, nurses are at high risk of exposure to NSIs. A cross-sectional online survey in Saudi Arabia indicated that a one-year incidence of at least one event of NSIs among HCWs (n=361) is estimated at 22.2% where the incidence of NSIs was highest among physicians (36%) and was followed by nurses (34.8%) [9]. In another cross-sectional descriptive study in Central Greece, results indicated that 74.1% of the participants had at least one event of NSIs, with the highest number of them occurring in nursing staff at 65.1% [10]. Moreover, in a recent systematic review and meta-analysis study, it has been shown that the pooled prevalence of NSIs among nurses was 42.8% [3]. The occurrences of the NSIs have been linked to various risk factors including environmental factors and HCW characteristics such as gender, age, and experience [9-17].

Moreover, studies have noted that difficult working conditions, lack of training, lack of re-enforcement, unsafe procedures, unsafe devices, and fatigue were significant risks for NSIs among nurses [16, 18, 19]. The comparatively higher cases among nurses than the other healthcare providers have been linked to fatigue [3], huge workload, job stress, burnout, and long working hours [20-22], or not attending training courses [16].

Notably, NSIs are more common among nurses who work in the private hospitals than those in the public hospitals [23]. For instance, Abozead et al. [23] noted that 90% of nurses who work in private hospitals have reported suffering at least one NSI during their work, which is much higher than 70% of nurses in the public hospitals. According to Kebede et al. [12], the difference could arise from the hug workload among nurses in the private hospitals – nurses working in private hospitals are highly and significantly exposed to the hazards of NSIs.

Many NSIs can be prevented using proper strategies, but the risk related to non-compliance to these strategies poses persistent challenges. Accordingly, the Jordanian healthcare system has put in place several measures and protocols to reduce chances of injuries arising from the needle stick and sharps. For instance, the healthcare systems have put in place measures like elimination of hazards, the use of personal protective equipment, administrative controls, engineering controls, and work practice controls [24-26]. At the same time, improving nurses' knowledge using the educational strategies is significant in reducing cases of NSIs among the healthcare workers. Providing education for nurses about NSIs' prevention, along with effective communication and proper placement of sharp containers, was shown to decrease NSIs by 60% among healthcare workers and nurses [26, 27] and improved nurses' knowledge about NSIs [28]. There are gaps in knowledge and practice among nurses that need to be focused on, and some steps are necessary to control these gaps like providing education to the nurses regarding universal precautions as successful methods of preventing NSIs such as discouraging recapping and adopting proper disposal of needle behaviors [21].

In a previous research investigation, Yao et al. aimed to confirm the effect of occupational safety training and education programs (OSTEP) on NSIs among nursing students in China [29]. These researchers reported that NSI was high before the intervention with average of 4.65 events/nurse. However, the educational intervention reduced it rapidly to 0.16 events/nurse ($P< 0.005$). The knowledge and the behavior of occupational safety in these nurse students by handling NSIs had an improvement after the OSTEP than before ($P< 0.005$). Several other previous researchers have also confirmed the significant impact of educational intervention on NSIs [26, 30, 31]. Markovic-Denic et al. [32] also noted a significant reduction in NSIs months of implementing the intervention the NSIs rate declined from 13% to 11.2% ($P=0.3$).

This research was thus designed, trailing the previous empirical evidence on the significance of educational intervention to change nurses' behaviors and practices towards reduction of NSIs. Accordingly, the education intervention was hypothesized to affect the positive change for better health outcomes according to the Health Belief Model (HBM) for behavior change [33]. The study tested the following null hypotheses:

H1: There are significant differences in NSIs occurrence between the intervention groups and the control group after the interventions.

H2: There are significant differences in the knowledge, attitudes, and practices of nurses between the intervention groups and control group after the interventions.

H3: There are significant differences in nurses' beliefs between the three intervention groups and the control group after the interventions.

H4: There is a significant association between risk factors and the number of NSIs among nurses in Jordanian private hospitals.

2. Methodology

A randomized control trail was performed among four private hospitals in Jordan that have bed counts of between 200 and 300. An experimental study based on Randomized Control Trial (RCT) design with four arms was used. Three hospitals were selected for the randomized educational intervention while one hospital was used as a control. By using the sample size determination of [34], a sample size of 400 nurses was determined suitable for the study with 100 participants in each arm. The study thus believes that, unlike in the non-clustered participants, the individuals within any cluster are likely to respond in a similar manner and hence the expected significant differences among the groups [35]. The identified number of research participants were selected based on a simple two-stage sampling was applied. The hospitals were selected first randomly in stage one, then the units (nurses) were sampled in stage two using stratified random sampling inside each hospital. These research participants were selected by considering four inclusion criteria, including staff nurses, practical nurses, nurses working in medical wards, surgical wards, ICU, emergency department, or pediatric wards, and nurses providing a direct care to patients.

Three different educational intervention strategies were administered in three selected hospitals as hospital remained as the control group without any intervention. The educational strategies aimed to provide information to cover the gaps in practice causing NSIs, information about blood-borne infections, its risk, work practices to prevent NSIs throughout devices handling and use, problem-specific strategies for sharps injury prevention, importance of reporting, and standards precautions to prevent occupational blood exposures. The educational strategies included:

The SM strategy involved the provision of educational information through SM sites, including Facebook. The researcher created a closed Facebook group providing informational material about NSIs. AV strategy involved showing a short video to the nurses before the start of their shift using computers and CDs. Each participating ward or unit received a CD containing a copy of the video. The nurses could watch the video on the unit/ ward's computer. Finally, the combined strategy involved the provision of both SM intervention and the AV intervention combined together for the nurses inside the selected hospital. These interventions were randomly allocated to the hospitals. Accordingly, Istiklal hospital was allocated for SM strategy, Istishari hospital was allocated for AV, Jordan hospital was allocated for combined strategy, and Essra hospital was left as a control.

Module Construction

The educational module was constructed based on the guidelines published by the Centers for Disease Control and Prevention (CDC) in the years 2004 and 2007 that illustrates the designing, implementation, and evaluation of a sharp injury prevention program. The module was developed and validated among a group of experts in the relevant field.

Table 1. Sections of the Educational Module

No.	Section	Aim
1	Blood-Borne Infections	a) To increase nurses' knowledge about NSIs.

		b) To increase the perception of threats for the nurses by targeting both the perceived susceptibility to the diseases and the perceived severity of any possible threat that can be transmitted by NSIs.
2	Work Practices to Prevent NSIs	To enhance the practices and attitudes of the nurses by teaching the recommended and wrong practices associated with NSIs.
3	Strategies for NSI Prevention	To increase nurses' knowledge about proper solutions to prevent NSIs.
4	Standard Precautions	To motivate the nurses to take positive actions by targeting the perceived benefits and perceived barriers of the nurses towards NSIs.
5	Actions When NSIs Occur	To enhance the knowledge, attitudes, practices, and cues to actions of the nurses when dealing with NSIs.

Data were collected using a newly developed and piloted survey questionnaire. The questionnaire was developed by following three significant stages – theoretical existence and construct importance, representativeness, appropriateness of data collection, in addition to statistical analysis and statistical evidence of the construct.

The questionnaire had 52 items that gathered data. Practices were measured using a 5point Likert scale (Never/ Seldom/ Occasionally/ Frequently/ Always), and a 5-point Likert scale was applied to measure attitudes, practices regarding NSIs, perceived susceptibility to NSIs, perceived severity to NSI, perceived benefits of NSI prevention, perceived barriers of NSI prevention and actions to prevent NSI (Cues to action).

The questionnaire was translated to Arabic and back according to the suggestion of Brislin [36]. The self-report questionnaire was used to collect data from the selected participants in three separate phases. Baseline data was collected in February 2015 Interventions implementation was done in March 2015. Measurement after 3 months was done in June 2015 and the last measurement was done in September 2015.

Data Analysis

Data analysis was performed using IBM SPSS version 21. The alpha for statistical significance was specified as $\leq .05$ for all analyses. Each NSI was coded by the type of needle that caused the last injury (syringe needles, suture needles, and intravenous catheter), a procedure that caused the last injury (recapping, intravenous line administration, blood collection, giving the injection, suturing, and disposal of needles), the time of last NSI (morning shift, evening shift, and night shift), and which ward/unit of the last NSI (medical ward, surgical ward, pediatric ward, ICU, and ER).

Shapiro-Wilk test was used to test the normality of the data before applying the nonparametric tests. Mann-Whitney U test was used to test hypothesis one. The Generalized Estimating Equations (GEE) method was used to compute the main and interaction effects of the study group and the repeated NSI count measure. The second and third hypotheses were tested in two steps; initially by applying the Kruskal-Wallis nonparametric analog to 1-way ANOVA to ascertain whether significant overall differences existed between the study groups at baseline, this step is important in order to control for the pre-intervention differences in the measurement of the post-intervention differences.

The Spearman Rho coefficient was used to estimate the correlations of the NSI counts at each of the three observation occasions with the risk factor assessments relevant to the test of Null hypothesis 4, which proposed that there is no significant relationship between risk factors and the numbers of NSIs

among nurses in Jordanian private hospitals. Also, the hierarchical multiple regression to predict each baseline-post-intervention change in NSI count. Exploratory factor analysis was used to check the factorability of the items of the questionnaire variables. Across the variables, measure of sampling adequacy (KMO) was noted to be more than .60. The Bartletts' tests of Sphericity was also reported to be significant (P <0.001).

3. Result and Discussion

At baseline, a total of 400 questionnaires were distributed to all the groups with 100 questionnaires for each group. However, only 364 and 348 and 335 questionnaires were returned and considered for analysis in the second and third round, respectively. Therefore, the questionnaires received a response rate of 82%. The characteristics of the participants as measured on categorically-scaled variables are presented in Table 2.

Table 2. Participant Characteristics on Continuously-Scaled Variables by Group and Overall (N=335)

Variable	SM	AV	Combined	Control
	N (%)	N (%)	N (%)	N (%)
Gender				
Male	36 (45)	33 (40)	41 (47)	35 (44)
Female	44 (55)	50 (60)	46 (53)	45 (56)
Marital status				
Single	40 (48)	32 (39)	42 (48)	37 (46)
Married	42 (50)	49 (61)	43 (49)	42 (53)
Divorced	2 (2)	0	2 (3)	0 (0)
Education				
Diploma	8 (10)	10 (12)	18 (21)	13 (15.6)
Bachelor	67 (77)	65 (81)	64 (74)	60 (76)
Master	12(13)	5 (6)	5 (5)	7 (8)
Place of work				
ICU	15 (17)	14 (17)	16 (18)	13 (16)
ER	14 (17)	15 (19)	17 (18)	11 (14)
Pediatric ward	12 (15)	14 (17)	13 (16)	11 (14)
Medical ward	16 (19)	12 (15)	15 (17)	13 (16)
Surgical ward	14 (16)	14 (17)	15 (18)	16 (20)
OR	14 (16)	13 (15)	12 (13)	12 (14)
Occupation				
Staff nurse	76 (90)	73 (89%)	72 (82%)	66 (83)
Practical nurse	10 (10)	9 (11)	16 (18)	14 (17)

At baseline, the SM group 55% of the nurses suffered at least one NSI in the past three months of the study, this percentage was 57%, 65% for the combined intervention group, and 41 % for the control group (Table 3, Table 3 and Table 5).

The percentage of nurses who suffered at least one NSI in the past 3 months changed in all intervention groups after implementing the intervention, in the SM group the percentage with a decrease from 55% (baseline) to 40% (2nd measurement) and to 32% (3rd measurement). While in the AV group the percentage decreased from 57% (baseline) to 43% (2nd measurement) and 35% (3rd measurement).

There was also a decrease in the percentage of nurses who encountered a NSI in the combined strategy group from 65% (baseline) to 38% (2nd measurement) and 29% (3rd measurement). Comparatively, there was an unpredictable change in the control group from 41% (baseline) to 31% (2nd measurement) 29% (3rd measurement).

Some findings did not change across the measurements. For example, at baseline only 16% of the nurse did not complete at least two doses of HBV vaccine in the SM group, this percentage was 20% in the AV group, 18% at the combined intervention group, and 22% in the control group, it was found that at the second measurement and the third measurement there was increase in the numbers of nurses who completed the immunization.

Table 3. Distribution of respondents by NSI and work environment at baseline (N=335)

Variable	SM	AV	Combined	Control
	N (%)	N (%)	N (%)	N (%)
NSI				
No	38 (45)	33 (40)	32 (35)	45 (59)
Yes (one time)	27 (32)	35 (43)	34 (38)	18 (24)
Yes (more than once)	20 (23)	14 (17)	24 (27)	13 (17)
Immunization				
Yes	71 (84)	65 (80)	73 (82)	61 (78)
No	14 (16)	16 (20)	16 (18)	17 (22)
Needle type				
Syringe needle	33 (65)	24 (49)	32 (54)	17 (53)
Suture needle	6 (12)	12 (24)	15 (25)	6 (21)
Cannula	10 (20)	10 (20)	9 (15)	8 (24)
Other	2 (4)	3 (6)	3 (6)	1(2)
Procedure				
Recapping	19 (37)	20 (40)	21 (36)	14 (41)
Cannulation	7 (13)	4 (8)	6 (10)	4 (12)
Blood collection	15 (29)	5 (10)	7 (12)	6 (18)
Giving injection	3 (6)	3 (6)	5 (8)	2 (6)
Suturing	4 (8)	9 (18)	8 (14)	3 (9)
Needle disposal	5 (12)	7 (14)	11 (20)	5 (14)
Time of NSI				
Morning shift	35 (70)	31 (76)	38 (64)	15 (50)
Evening shift	11 (22)	10 (20)	18 (31)	10 (33)
Night shift	4 (8)	5 (10)	3 (5)	5 (17)

Table 4. Distribution of respondents by NSI and work environment at 2nd measurement (N=335)

Variable	SM	AV	Combined	Control
	N (%)	N (%)	N (%)	N (%)
NSI				
No	48 (36)	39 (48)	53 (59)	44 (57)
Yes (one time)	24 (28)	36 (44)	33 (36)	18 (24)
Yes (more than once)	14 (18)	7 (8)	5 (5)	15 (19)
Immunization				

Yes	72 (84)	66 (81)	80 (90)	58 (76)
No	14 (16)	15 (19)	9 (10)	18 (24)
Needle type				
Syringe needle	22(57)	23 (55)	19 (50)	17 (54)
Suture needle	10 (26)	9 (22)	10 (27)	6 (19)
Cannula	5 (13)	8 (19)	7(18)	8 (25)
Other	2 (4)	2 (4)	2 (5)	1 (2)
Procedure				
Recapping	16 (40)	17 (42)	15 (39)	11 (36)
Cannulation	5 (11)	3 (6)	3 (6)	4 (12)
Blood collection	6 (17)	7 (16)	5 (14)	4 (15)
Giving injection	2 (6)	5 (12)	4 (10)	3 (8)
Suturing	7 (16)	4 (10)	6 (14)	4 (11)
Needle disposal	3 (10)	6 (14)	7 (17)	7 (18)
Time of NSI				
Morning shift	26 (65)	28 (70)	25 (67)	23 (68)
Evening shift	9 (23)	10(25)	11 (28)	6 (21)
Night shift	5 (12)	2(5)	2 (5)	4 (11)

Syringe needles were the type of needle responsible for the majority of NSIs in all 4 groups and at all three measurements. Recapping needles after use, recapping contributed more than any other procedure in all four groups. It was also noted that majority of the reported injuries have taken place during morning shift, while the less number of injuries occurred during the night shift across the three measurements.

Table 5. Distribution of respondents by NSI and work environment at 3rd measurement (N=335)

	SM	AV	Combined	Control
Variable	N (%)	N (%)	N (%)	N (%)
NSI				
No	52 (62)	49 (60)	61 (68)	44 (56)
Yes (one time)	24 (29)	28 (34)	24 (27)	23 (30)
Yes (more than once)	8 (9)	5 (6)	5 (6)	11 (14)
Immunization				
Yes	70 (82)	70 (85)	80 (90)	59 (77)
No	15 (18)	12 (15)	8 (10)	18 (23)
Needle type				
Syringe needle	20 (65)	20 (65)	14 (48)	15 (47)
Suture needle	4 (13)	7 (23%)	9 (31)	8 (25)
Cannula	6 (19)	3 (10)	6 (20)	8 (25)
Other	1 (3)	1 (3)	1 (3)	1 (3)
Procedure				
Recapping	10 (32)	11 (35)	11 (37)	9 (29)
Cannulation	3 (10)	2 (6)	3 (10)	4 (13)
Blood collection	7 (23)	6 (19)	3 (10)	6 (19)
Giving injection	2 (6)	4 (13)	2 (6)	3 (9)
Suturing	4 (13)	5 (16)	4 (13)	3 (9)
Needle disposal	5 (16)	4 (13)	5 (17)	7 (21)
Time of NSI				

Morning shift	18 (58)	18 (58)	20 (68)	17(53)
Evening shift	9 (29)	10 (32)	5 (17)	10 (3)
Night shift	4 (13)	3 (10)	4 (13)	5 (16)

Intervention's Effect on NSI

The outcomes showed a difference from the control group's marginal 2nd measurement mean. NSI count was significant for the combined intervention group (Table 6). Consequently, the null hypothesis is rejected for the baseline 2nd measurement differences between the intervention and control groups. The Combined group's baseline adjusted mean 2nd measurement NSI count was significantly lower than that of the control group. Further, the results indicate that the difference from the control group's marginal 3rd measurement mean NSI count was significant for all three intervention groups (Table 7).

Table 6. Pairwise Comparison of Differences in Mean Baseline-Adjusted baseline–2nd measurement in NSI Counts between Intervention Groups and Control Group (N=335)

Group	Int. Group	Control	Difference	Std. Error	df	*p*
SM	.55	.80	-.25	.115	1	.193
AV	.63	.80	-.17	.113	1	.751
Combined	.40	.80	-.40	.112	1	.001

Table 7. Pairwise Comparison of Differences in Mean Baseline-Adjusted baseline–3rd measurement Differences in NSI Counts between Intervention Groups and Control Group

Group	Int. Group	Control	Difference	Error	df	*p*
SM	.45	.76	.-31	.109	1	.031
AV	.47	.76	-.29	.105	1	.006
Combined	.25	.76	-.51	.108	1	<.001

Intervention's Effect on KAP

The results of the comparisons for the six variables for which a significant interaction effect was found (Table 8). Further significant interaction effects for the baseline–3rd measurement pre-post analyses reported (Table 9).

Table 8. Post Hoc Pairwise Comparisons of Estimated Marginal 2nd Measurement Means of Intervention Groups to the Control Group for Variables with Significant Group Baseline–2nd Measurement Interactions

	Intervention (2nd measurement)		Control (2nd measurement)		
KPA	Name	Mean	Mean	SE Diff	**Sidak p**
Disposing	SM	1.68	1.86	.11	**.38**
Knowledge	AV	1.65	1.86	.107	**.242**
	Combined	1.53	1.86	.108	**.014***
HCV	SM	1.64	1.78	.115	**.774**
transmission	AV	1.63	1.78	.118	**.734**
Knowledge	Combined	1.46	1.78	.120	**.053**
Reporting	SM	3.16	3.35	.233	**.956**
department	AV	3.36	3.35	.230	**1.00**
Attitude	Combined	3.60	3.35	.242	**.889**

Hand-pass	SM	2.77	3.21	.242	**.338**
needle practice	AV	2.89	3.21	.243	**.707**
	Combined	2.28	3.21	.220	**<.001*** **
Gloves-needles	SM	2.79	2.46	.242	**.674**
Practice	AV	2.86	2.46	.202	**.252**
	Combined	3.31	2.46	.205	**<.001*** **
Recap practice	SM	2.57	3.07	.167	**.016***
	AV	2.75	3.07	.183	**.380**
	Combined	**2.37**	**3.07**	**.179**	**.001*** **

Table 9. Post Hoc Pairwise Comparisons of Estimated Marginal 3rd Measurement Means of Intervention Groups to the Control Group for Variables with Significant Group Baseline– 3rd Measurement Interactions

	Intervention (3rd measurement)		**Control (3rd measurement)**		
	Name	Mean	Mean	SE Diff	**Sidak p**
HBV	SM	1.45	1.74	.106	**.038***
transmission	AV	1.57	1.74	.104	**.537**
Knowledge	Combined	1.26	1.74	.109	**<.001*** **
HCV	SM	1.48	1.86	.095	**<.001*** **
transmission	AV	1.67	1.86	.121	**.383**
Knowledge	Combined	1.25	1.86	.101	**<.001*** **
Goggles		1.75	2.05	.101	**.019***
Knowledge	AV	1.88	2.05	.095	**.273**
	Combined	1.78	2.05	.097	**.030***
Reporting	SM	3.15	3.05	.235	**.999**
department	AV	3.52	3.05	.224	**.163**
Attitude	Combined	3.72	3.05	.232	**.016***
Reporting		3.67	3.07	.241	**.073**
Supervisor	AV	3.49	3.07	.201	**.187**
Attitude	Combined	3.70	3.07	.246	**.046***
Taking action		3.57	3.08	.252	**.264**
Attitude	AV	3.52	3.08	.197	**.180**
	Combined	3.76	3.08	.211	**.008** **
Hand-pass		2.62	3.26	.227	**.018***
needle practice	AV	2.61	3.26	.228	**.025***
	Combined	2.27	3.26	.205	**<.001*** **
Gloves-	SM	2.94	2.72	.242	**.931**
Needles	AV	2.95	2.72	.242	**.926**
Practice	Combined	3.77	2.72	.208	**<.001*** **
Goggles-	SM	2.37	2.07	.242	**.81**
Needles	AV	2.7	2.07	.216	**.083**
Practice	Combined	2.15	2.07	.188	**.998**
Recap practice	SM	2.33	3.25	.205	**<.001*** **
	AV	2.43	3.25	.223	**.001*** **
	Combined	**2.19**	**3.25**	**.213**	**<.001*** **

Intervention's Effect on Nurses' Beliefs

A significant interaction effect was found between the intervention and nurses' beliefs. A total of 11 comparisons of intervention groups to the control groups were significant. This substantially exceeds the chance expected result of 4 significant comparisons given a family-wise error rate of .05. Therefore, the null hypothesis is rejected for the effect of the interventions on the HBM variables measured at the 2nd measurement (Table 10).

Table 10. Post Hoc Pairwise Comparisons of Estimated Marginal 2nd Measurement Means of Intervention Groups to the Control Group for HBM Variables with Significant Group Baseline–2nd Measurement Interactions

		Intervention Group	**Control Group**		
HBM **Variable**	Name	2nd Measurement Mean	2nd Measurement Mean	SE Diff	**Sidak p**
Recap likelihood	SM	3.18	3.16	.147	**1.000**
NSI	AV	3.21	3.16	.137	**1.000**
	Combined	3.62	3.16	.163	**.033***
Likelihood of	SM	3.37	2.82	.198	**.034***
disease	AV	3.17	2.82	.214	**.405**
	Combined	3.51	2.82	.206	**.005****
Recapping severity	SM	3.53	3.21	.118	**.043***
	AV	3.59	3.21	.125	**.023***
	Combined	3.54	3.21	.128	**.077**
Being scared	SM	2.96	2.65	.217	**.686**
Severity	AV	3.01	2.65	.215	**.488**
	Combined	**3.33**	**2.65**	**.22**4	**.017***

The identified significant interactions indicate that a total of 11 comparisons of intervention groups to the control groups were significant. This substantially exceeds the chance expected result of 4 significant comparisons given a familywise error rate of .05. It can be concluded, therefore, that the null hypothesis is rejected for the effect of the interventions on the HBM variables measured at the 2nd measurement (Table 11).

Further, a total of 22 comparisons of intervention groups to the control groups were significant. Therefore, the null hypothesis is rejected for the effect of the interventions on the HBM variables measured at the 3rd measurement (Table 12).

Table 11. Post Hoc Pairwise Comparisons of Estimated Marginal 2nd Measurement Means of Intervention Groups to the Control Group for HBM Variables with Significant Group Baseline–2nd Measurement Interactions

		Intervention Group	**Control Group**		
HBM Variable	Name	2nd Measurement Mean	2nd Measurement Mean	SE Diff	**Sidak p**

Recap likelihood	SM	3.18	3.16	.147	**1.000**
NSI	AV	3.21	3.16	.139	**1.000**
	Combined	3.62	3.16	.163	**.033***
Likelihood of	SM	3.35	2.82	.198	**.034***
Disease	AV	3.17	2.82	.212	**.405**
	Combined	3.51	2.82	.206	**.005****
Recapping severity	SM	3.53	3.21	.116	**.043***
	AV	3.58	3.21	.125	**.023***
	Combined	3.52	3.21	.128	**.077**
Being scared	SM	2.95	2.67	.217	**.686**
Severity	AV	3.02	2.67	.213	**.488**
	Combined	**3.32**	**2.67**	**.224**	**.017***

Table 12. Post Hoc Pairwise Comparisons of Estimated Marginal 3rd Measurement Means of Intervention Groups to the Control Group for HBM Variables with Significant Group Baseline–3rd Measurement Interactions (N=335)

	Intervention Group		**Control Group**		
HBM	3rd measurement		3rd measurement		
Variable	Name	Mean	Mean	SE Diff	**Sidak p**
Blood likelihood NSI	SM	2.5	2.91	.182	**.120**
	AV	3.08	2.91	.179	**.941**
	Combined	3.02	2.91	.178	**.995**
Recap likelihood NSI	SM	3.42	3.37	.177	**1.00**
	AV	3.52	3.35	.173	**.943**
	Combined	3.92	3.35	.188	**.019***
Recapping severity	SM	3.7	3.14	.134	**<.001*****
	AV	3.78	3.14	.147	**<.001*****
	Combined	3.74	3.14	.143	**<.001*****
Being scared severity	SM	3.14	2.75	.221	**.436**
	AV	3.21	2.75	.212	**.194**
	Combined	3.50	2.75	.215	**.004****
Problems last long	SM	3.22	2.68	.176	**.016***
Time	AV	3.05	2.68	.163	**.150**
	Combined	3.01	2.68	.188	**.412**
Endangered career	SM	2.45	2.37	.176	**.999**

severity	AV 3.16	2.37	.198	**.001*** **
	Combined 2.71	2.37	.178	**.330**
Wearing glove benefit	SM 3.10	2.95	.214	**.986**
	AV 3.51	2.95	.186	**.019***
	Combined 3.63	2.95	.185	**.002****
Standard prec benefit	SM 2.87	3.37	.192	**.058**
	AV 3.73	3.37	.174	**.181**
	Combined 3.77	3.37	.16	**.092**
Training & education	SM 3.69	3.36	.156	**.221**
benefit	AV 4.13	3.36	.18	**<.001*** **
	Combined 3.95	3.35	.164	**.002****
Reporting benefit	SM 3.27	2.94	.202	**.512**
	AV 3.43	2.94	.178	**.042***
	Combined 3.75	2.94	.185	**<.001*** **
NSI not preventable	SM 2.20	2.65	.185	**.076**
	AV 2.06	2.65	.185	**.008****
	Combined 2.17	2.65	.178	**.034***
Injection likelihood	SM 2.42	2.75	.223	**.560**
NSI	AV 2.57	2.75	.215	**.933**
	Combined 3.26	2.75	.204	**.091**
No knowledge barrier	SM 1.81	2.27	.135	**.006****
	AV 1.90	2.27	.133	**.047***
	Combined1.65	**2.27**	**.152**	**<.001*** **

NSI associations with risk factors

Regarding the demographic features, the results show that there is a significant relationship between NSIs and age (p= 0.048) and experience (p= 0.021) (Table 13).

Table 13. Relationships between NSIs and Nursing Characteristics at Baseline

Variable					**NSIs**	**χ^2**	**df**	**p**
	No	(%)	Yes	(%)	Total			
Age **<25**	15	(30)	33	(70)	48			
25-29	66	(40)	97	(60)	163			
30-34	30	(42)	42	(58)	72	3.439	4	**.048***
35-39	28	(66)	16	(36)	44			
≤40	7	(64)	4	(36)	11			

Total	146	(44)	189	(56)	335			
Gender **Male**	66	(46)	79	(54)	145			
Female	80	(42)	110	(58)	190	.161	1	**.386**
Total	146	(44)	189	(56)	335			
Experience **1-5 years**	68	(45)	82	(55)	150			
6-10 years	37	(36)	66	(64)	103	3.053	2	**.021 ***
> **10 years**	40	(48)	41	(52)	81			
Total	145	(43)	189	(57)	334			
Marital status **Single**	63	(41)	91	(59)	154			
Married	81	(45)	96	(55)	177	3.889	2	**.143**
Divorced	0	(20)	4	(80)	5			
Total	145	(43)	191	(57)	336			
Education **Diploma**	22	(46)	26	(54)	48			
Bachelor	113	(44)	146	(56)	259	.846	2	**.655**
Master	10	(37)	17	(63)	27			
Total	145	(43)	189	(57)	334			
Occupation **Staff nurse**	126	(44)	164	(56)	290			
Practical nurse	20	(44)	25	(56)	45	.201	1	**.385**
Total	146	(44)	189	(56)	335			
Immunization **Immunized**	118	(44)	152	(56)	270			
Not immunized	28	(44)	35	(56)	63	.151	1	**.401**
Total	**146**	**(44)**	**187**	**(56)**	**333**			

Hierarchical Multiple Regressions

All predictor coefficients were significant, indicating the significant impact of the intervention on the NSI counts (Table 14). Hence, the null hypothesis is rejected with respect to the modeling of baseline–2nd measurement changes in NSIs.

Table 14. Regression Coefficients of the Variables in Model Predicting Baseline–3rd Measurement Changes in NSI Counts (N=335)

	Unstandardized Coefficients			
Predictor	β	Std. Error	*T*	***p***
(Constant)	.192	.080	2.400	**.017**
Combined intervention	-.543	.112	-5.035	**<.001**
AV intervention	-.365	.108	-3.379	**.001**

SM intervention Hand-passing practices, baseline-3rd measurement	-.299	.108	-2.776	**.00**6
Change	-.064	.021	-2.975	**.003**
Disposing practices, baseline-3rd measurement change Following needle safety policies, baseline-3rd	.083	.034	2.485	**.014**
measurement change	**-.041**	**.020**	**-2.018**	**.045**

Discussion

NSIs still count significantly in private hospitals in Jordan. At baseline, the most frequent needle type causing NSIs was the (syringe needle), which caused 68% of the total injuries in the SM group, 48% in the AV group, 53% in the combined group, and 55% in the control group. A few studies have reported the same finding [37, 38]. Notably, recapping was found to be the procedure with most NSIs at baseline, responsible for 35% of the injuries in the SM group, 44% of the injuries in the AV group, 37% of the injuries in the combined group, and 42% of the injuries in the control group. Similar outcomes were noted [21, 39, 40].
Although few studies reported (giving injections) as the procedure responsible for most of the NSIs, they still reported recapping as the second procedure [9, 41, 42]. This finding was reported as a practice gap among Jordanian nurses [43].

At baseline, the vast majority of NSIs occurred during morning shifts when compared to evening and night shifts. These findings can be connected to the risk factors of NSIs; the findings of this study (which will be discussed in the following sections) revealed that the most frequent risk factors are fatigue and lack of assistance, which are associated with morning shift duty that is busier and has more tasks to be performed.

Interventions' Effect on NSIs

This study noted significant differences between baseline and 2nd measurement (after 3 months) only between the Combined Intervention group and the control group (P=0.002). However, the SM and AV groups did not show significant differences from the control group at this point. After six months, all the NSIs were lower in the intervention groups, and three intervention groups showed significant differences from the control group, indicating the positive effect of the three interventions (SM group P= 0.032; AV group P= 0.007; combined group P<0.001).

The Combined intervention gave faster results than the SM and the AV interventions after 3 months of the intervention, which can be explained by the higher intensity of the intervention. Nurses received more comprehensive education utilizing two strategies rather than one strategy, which intensified the knowledge impact. This finding is consistent with the outcome noted by Yao et al. [29] who examined the effect of occupational safety training and education programs (OSTEP) on NSIs among nursing students in China. These studies focused on increasing nurses' knowledge to decrease NSIs but none of them modified the nurses' behaviors, beliefs, or perceptions.

Other researchers, including Srikrajang et al. [44] reported the significance of intervention programs in decreasing the chances of NSIs among nurses in Thailand. Similarly, the three-armed randomized control trial by Molen et al. [18] also revealed a significant impact of increasing nurses' knowledge on reducing the cases of NSIs. These interventions significantly reduced NSIs among nurses, although combining the two interventions provided better results (P = 0.046), which is consistent with the findings of this study. Consistently, the significance of the intervention programs is apparent across the literature. Elsewhere, Markovic-Denic et al. [32] noted that educational programs presented using the traditional methods reduced the cases of NSIs from 13% to 11.2% (P=0.3), which is consistent with the findings of this study.

Interventions' Effect on KAP

This study noted significant differences between the intervention and control groups at the second measurement (three months). The significant difference is attributed to the educational intervention program, which brought significant differences in six different activities, including disposing knowledge (P= 0.028), HCV transmission knowledge (P= 0.016), reporting department attitude (P=. 0024), hand-pass needle practice (P < 0.001), gloves-needles practice (P= 0.003), and recap practice (P= 0.007).

However, after six months, the number of differences increased in the activities related to NSI. These activities include HCV transmission knowledge. (P= 0.001), HBV transmission knowledge (P < 0.001), goggles knowledge (P= 0.017), reporting department attitude (P= 0.002), reporting supervisor attitude (P= 0.039), taking action attitude (P= 0.043), hand-pass needle practice (P < 0.001), gloves-needles practice (P < 0.001), goggles-needles practice (P= 0.005) and recap practices (P= 0.001). Comparatively, a study conducted in the Netherlands was not able to change the level of knowledge (P= 0.225) or attitudes (P= 0.229) [18]. However, Molen et al. [18] used a different intervention, which only included a one-hour lecture to increase the participants' knowledge and change their attitudes.

Interventions' Effect on Nurses' Beliefs

This study noted no significant differences in the constructs of the HBM between any groups at baseline, which indicate the similarities between the nurses' perceptions and beliefs towards NSIs at baseline in all groups. After three months, a total of 11 HBM constructs' variables showed significant differences with the baseline measurement. These significant differences are attributed to the educational intervention strategies, and this matches the reduction at the same time in NSI counts. After 6 months, the number of significant differences between HBM constructs' variables increased from 11 to 22. This increase in the significant relationships is attributed to the effectiveness of intervention strategies to alter the nurses' beliefs and their ability to sustain effect over time. Comparatively, no previous interventional studies examined nurses' beliefs to decrease NSIs.

According to the HBM, changing the beliefs and perceptions of a person towards a certain issue can change his/her behaviors, which will result in changes in the outcome of that person's action. In this study, the researcher provided the subjects with the necessary information and guidance to change their beliefs, perceptions, knowledge, attitudes, and practices through new strategies utilizing simple technology such as the SM and AV material.

Factors Contributing to NSIs

This research noted that the risk factors that can lead to NSIs include age, experience, negligence, lack of required skills, heavy workload, fatigue, lack of assistance, emotional distress, and being rushed while handling needles.

The number of NSIs decreased among nurses with higher age (P= 0.048) and more experience (P= 0.021). This finding can be referred to as the ability of experienced nurses to cope with work stress and fatigue more efficiently than less experienced nurses. More experienced nurses have developed their practice skills to handle needles more conveniently than less experienced nurses, who might need more assistance. A study in Malaysia [45] has reported the same finding, the study reported age as a predictor of NSIs (P= 0.001). However, the same study did not report a significant relationship between experience and NSIs (P= 0.69); this result can be attributed to categorizing experience into two categories only; less than 10 years and more than 10 years, which is different than this study. Another study in Thailand [46] also reported that experience is a predictor of NSIs. In addition, age and experience were emphasized by a recent literature review of 43 articles [16] where the analysis showed that younger-aged nurses with less work experience were of greater risk for NSI.

Moreover, 5 out of 7 risk factors were found associated with NSIs on at least on one occasion; including lack of assistance, emotional distress, being rushed, and lack of skills. Fatigue and lack of assistance

were found associated with NSIs in all three measurements whereas emotional distress, being rushed, and lack of skills were found to be significant with NSIs only at one measurement. A study conducted in Italy found that a proactive, integrated, and comprehensive management of emotional stress program were effective in reducing NSIs among nurses at their workplace (OR 0.60; 95% CI 0.43-0.83), which means that emotional stress is a risk factor for NSIs [47].

These findings are consistent with data available from two studies, in Iran [48] and in Ethiopia [49] fatigue was reported as a risk factor for NSIs. Fatigue can decrease concentration and attention during work. A study also referred to emotional distress to be another risk factor for NSIs [50]. Although Kasatpibal et al. [46] observed that being rushed is a risk factor for NSIs, this was not confirmed by this study. The inconsistency in this conclusion can be attributed to measuring NSIs for a sample with a majority of inexperienced subjects in this study. Whereas, the majority of nurses sampled by Kasatpibal et al. [46] had a low experience which can explain acquiring NSIs when work demands flow faster

4. Conclusion and future scope

The NSI is a critical health issue. It is obvious that the NSI incidence will not decline without proper intervention. Accordingly, an educational intervention was provided and tested on reducing the number of NSIs in the selected private hospitals in Jordan. The results showed a significant decrease in the number of NSIs after three months of the educational programs, and further reductions after six months. These changes in the number of NSIs are attributed to the implemented intervention strategies, changes in knowledge, attitudes, practices, and changes in the beliefs according to the HBM constructs. These outcomes have a theoretical and practical implications that could be used to improve nurses' practices and knowledge, and to design research that is capable to effectively reduce NSIs. Notably, this study provides practical solutions to NSIs rather than only describing the problem. Further, this study can provide guidance and help to policy makers and education program developers in hospitals through providing a reliable framework to reduce NSIs.

The study limitations

The outcomes of this study can only be generalized to staff nurses working in private hospitals since the study was limited to staff and practical nurses, and did not include any other health occupational group (physicians, pharmacists, technicians, etc.). Another limitation is that the strategy of intervention and implementation, which hindered blinding for the nurses working in the participating wards and for the researcher. Nevertheless, the different interventions were applied in different hospitals to avoid any chances of possible contamination.

6. Patents

Funding: Please add: This research received no external funding.

Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.
Data Availability Statement: Data will be available upon request from the corresponding author.

Acknowledgments: The researchers acknowledge all nurses participated in the study and completed the given questionnaire.

Conflicts of Interest: The authors declare no conflict of interest

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