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Original Research Article

Developing safe porter protective syringe cap to prevent percutaneous injuries; a semi-experimental study

Zeynep Akidağı[1]*, Kadircan Kızıloğlu[1], Hatice Şener[1], Vesile Şenol[2]

[1]Department of Medical Laboratory Techniques, Cappadocia University, Vocational School, Nevşehir, Ürgüp, Turkey
[2]Department Nutrition and Dietetics, Cappadocia University, Nevşehir, Ürgüp, Turkey

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***Correspondence:**
Zeynep Akidağı,
E-mail: zeynep.akidagi@kapadokya.edu.tr

ABSTRACT

Background: Although healthcare professionals know how to avoid needle sticks, current safe syringes are not capable of preventing percutaneous injuries 100%. Therefore, infections caused by needle sticks could not be completely prevented.
Methods: First of all, a Likert type questionnaire were applied as a qualitative method in the study. Based on these survey data, 4 different types of safety syringe caps were developed and tested in a quasi-experimental method.
Results: The research was carried out with 344 health vocational school students. As a result of the research, the average level of knowledge of the students about percutaneous injuries was in female students (n=223, 64.8%) compared to male students (n=121, 35.2%) (females, mean: 78.8±10, males, mean: 76.5±10) (p=0.256) in the second grades compared to the first graders. It was found to be higher (1st class: 77.3, 2nd class: 81.0) (p=0.049). The mean level of knowledge showed a significant difference according to educational level (p=0.049), but did not show a significant difference according to programs (p=0.371) and gender (p=0.256). Among the safe injector caps of different diameters developed against percutaneous injuries, the largest diameter injector cap was defined as the most successful, safe syringe cap that prevents percutaneous injuries (p<0.001).
Conclusions: It was observed that education or experience was not significantly effective in preventing percutaneous injuries caused by needle sticks, and that percutaneous injuries and thus infections could be prevented by increasing syringe cap diameters.

Keywords: Needlestick injury, Syringe, Sharps injuries, Healthcare worker

INTRODUCTION

Hospitals are considered a mandatory need when it comes to health in the world. Health personnel working in these hospitals serve hundreds of patients every day. Health personnel serving patients have other responsibilities, such as protecting both their own health and the health of patients. But hospitals are big risk factors in this regard. Because both health workersand people who apply to the hospital carry the risk of contact with infectious diseases. The most-important factor that increases the risk of this contact is invasive interventions. Every day, healthcare professionals or healthy people encounter many harmful and even deadly pathogensthat are transmitted by blood due to needle stick and sharps injuries (NSIs). According to the Center for Disease Control and Prevention (CDC), healthcare professionals suffer percutaneousinjuries from 385,000 needles and other punctures each year. However, there is still the prevailing belief that these injuries are part of their occupation, not the use of protective equipment or safe products.[1]

Percutaneous injuries have been recognized as a source of exposure for healthcare workers to blood-borne pathogens such as Hepatitis B virus (HBV), Hepatitis C virus (HCV) and Human immunodeficiency virus (HIV) and are responsible for a significant proportion. Considering the causes of needle sticks that cause HBV, HCV and HIV infection; unsafe work practice- 47%, attempting to close the needle cap- 34%, removal of the phlebotomy tube holder- 13%, improper disposal of cutting tools- 35%, destruction system failure- 35%, high workload- 72%, and personal protective equipment deficiency is observed in-78%.[2] The syringe is a medical instrument used for invasive entry and is referred to as a Sharp- piercing medical tool (SPMT). SPMT is defined as medical equipment or tool (lancet, scalpel, intravenous entry apparatuses, and syringes) that can cause accidental percutaneous injuries to the skin.[3]

Syringes, which are SPMTs, are used for injection in medical applications, in units such as laboratories, services, emergency, operating rooms, and anesthesia. Failure to apply aseptic techniques or not pay attention to during the implementation of these procedures poses a serious risk in terms of transmission of blood-borne pathogens, especially viruses and bacterial infections. In this way, the risk of exposure to 20 different pathogens arises as a result of the penetration of the SPMT or syringe to the hand during the injection without paying attention to aseptic techniques.[4] According to the WHO, around 2 million of the 3 million pathogens that are at risk of contamination in injuries caused by syringes and similar SPMTs are transmitted percutaneously in more than 35 million healthcare workers worldwide. HBV (5.9%) is the first of the infections transmitted percutaneously, the second is HCV (2.6%), and the third is HIV (0.5%). Fifteen thousand of these injuries cause HCV, 7,000 cause HBV, and 500 cause HIV infection. As a result of these data, 37% of HBV infections worldwide. 6, 39% of HCV infections, 4% of HIV infections are transmitted to healthcare workers through occupational contamination.[5]

Needle stick injuries, which are at the top of the SPMTs injuries, are mostly experienced during the patient intervention, mostly during the opening of the needle tip, then separating the needle from the syringe and throwing it into the waste box.[6] In the early 2000s, subcutaneous needles are responsible at the rate of 32% for percutaneous injuries; suture needles are 19%, butterfly needles are 12%, scalpel needles are 7%, catheter needles are 6%, blood collection needles are 3%. 26% of these needle pricks are injuries caused during the manipulation of the patient's needle, 23% by throwing the needle, 10% of collision with a working person, 6% by IV insertion, and 6% during needle closing (ANA, 2007). Nowadays, according to the International security center (ISC) report, with the use of safe SPMT, the rate of trying to close the needle cap that causes percutaneous injuries has decreased to as low as 2.6% and preparation for use 9.9%.[7] According to the CDC, 44% of the population exposed to these injuries are primarily nurses, 28% are doctors, 15% are technicians, 4% are students, and 3% are caregivers.[1] Today, it has decreased to 36.5% of nurses, 14.7% of doctors and 5.5 of health technicians due to the use of safer medical tools.[8] Also, it has been reported that healthcare professionals are exposed to syringe needle injuries three to six times more than other colleagues abroad, and nurses and health care students are most frequently infected.[9] It was shown in a study conducted by Bozkurt et al, in a tertiary university hospital between 2010 and 2013 that the health care workers were injured at least once during their working life with SPMTs, and 90% of these cases occurred while closing the cap of the syringe needle.[10]

There is a risk of transmission of various bacterial infections as well, together with the HBV, HCV, and HIV infections caused by needles.[11] Such as malaria, tuberculosis, typhus, syphilis, toxoplasma, streptococcus pyogenes, diphtheria, ebola can be shown as examples among these bacterial infections.[12] Even though classical methods are still used to protect against the factors responsible for the transmission of all these diseases, it is not 100% possible to prevent these accidents due to the stressful and hectic working conditions of health personnel.[13] In a study by İlçe et al in which they investigated the effectiveness of protective activities applied to prevent needle sticks, it was shown that although all of the participants received training on prevention from NSIs and had 10 years of health experience, they could not be protected from NSIs, so education and experience were not important in these injuries.[14]

In other areas, especially in the health sector, new and improvable ideas are put forward in preventing infections caused by needles. Various 'safe' or 'protective' syringe needles or caps have been developed to prevent NSIs.[15] Syringe needles, which have been developed with safety in the foreground in recent years, have been made for two purposes- (a) syringe with protective apparatus- at the top of this type of needles, apparatuses that cap the needle and its tip are used after the injection process (Figure 1); and (b) non-reusable syringes- mechanisms that prevent the reuse of the needle after injection have been developed in these syringes (Figure 1).

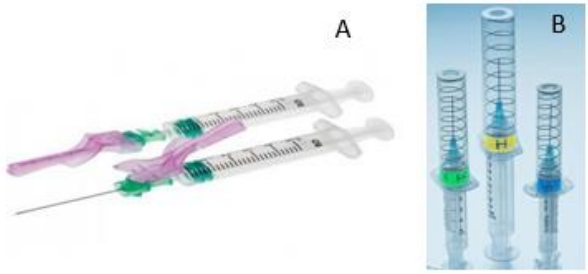

Figure 1: (A) Safe syringe with protective apparatus; and (B) non-reusable safe syringe.

It has been determined that all these physical measures mentioned above significantly reduce the injuries due to needle sticks. In a study conducted with a hundred

thousand people, it was found that percutaneous injuries, especially in emergency services, decreased from 18.5/100,000 to 0/100,000 as a result of safe tool use.[17] Although it has been determined that these developed protective tools or mechanisms prevent NSIs, they are still not widely used in the field. The only reason for this is their high cost. In line with this information in the literature, in this study, the health vocational school students, who have the ability to make invasive interventions as much as professional health personnel in a real hospital environment, took part in the study as representatives of health personnel. Therefore, the Health Vocational School students, who constitute the sample of the study, reflect the attitudes of the health personnel who make invasive interventions in hospitals in percutaneous injuries and their needs for safe medical tool use in cases of needle sticks that cause these injuries. In this study, it was aimed to determine the attitudes of health program students about percutaneous injuries and to prove the necessity of using safe syringe in order to increase safety and reduce the risk of injury in cases where professional health workers need to close the syringe cap.

METHODS

Study design

Two different methods, qualitative and semi-experimental, were used in this study.

Study population

In the study, 344 first and second year students of the Cappadocia University Health Vocational School in Nevşehir/Turkey who will work in health institutions as health personnel when they graduate and have the ability to perform invasive interventions in Kayseri city hospital, Kayseri state hospital, Nevşehir state hospital and Ürgüp state hospital were studied. Health college students who have the ability to perform invasive procedures in hospitals and school laboratories were included in the study. Students who are health college students and have not yet undergone invasive intervention were not included in the study. In the study, Dialysis (DY), Anesthesia (AN), Surgery tecnicians (ST), First and emergency aid (FE), Oral and dental health (OD), Medical laboratory techniques (ML) and Pathology laboratory techniques (PL) fields were accepted as universes among the health workers working in Nevşehir Health Institutions, were most exposed to needle injury.

Study duration

Four months (April 2019 to July 2019) was the study duration.

Sample size

According to the sample size calculation based on the 95% confidence interval and the alpha coefficient of 0.05, it was calculated that the participation of 278 people would be sufficient. 344 volunteers participated in the study.

Data collection methods

Students who wanted to participate in the study volunteers were asked to approve the voluntary consent form. An attitude scale towards the use of SPMTs was applied to the participants who approved the consent form, and prototype trials were recorded in writing.

Study tools

Uzunbayır's 'Attitude Scale of Health Care Professionals for the Safe Use of Sharps- Piercing Medical Tools' was used as an attitude scale in the study.[18] In the semi-experimental study method, safe syringe needle cap prototypes developed by the researchers were tested.

Ethical considerations

This study was conducted with the permission Scientific Research's Ethics Committee of the Cappadocia University in Turkey.

Application of the attitude scale towards the use of sharps-piercing medical tools. A representative sample of professional health workers was created from 344 associate degree students in the Health Vocational School who study in these fields and perform invasive practices in a real hospital environment. In this study, in which a semi-experimental method was used, first of all, The attitudes of the students towards the safe use of SPMTs were measured by using the 'Attitude scale for the safe use of SPMT' developed by Uzunbayır and whose reliability was approved (Cronbach alpha=0.80).[18] The lowest score on the scale used was 25, and the highest score was 125. According to this, it was accepted that the higher the score obtained by the student as a result of the questionnaire, the higher the level of knowledge.

Designing 'Porter protective syringe caps'

Based on the results of the attitude scale for the safe use of SPMTs applied to 7 different health associate degree, students, does increasing the diameter of the needle caps prevent needle sticking? The hypothesis were established. Based on this hypothesis, a kind of safe syringe, which we call the 'Porter protective syringe cap' (PPSC), was designed in 3 different prototypes and 4 different sizes. The characteristics of the designed PPSCs and standard needle caps and their definitions used in the study are presented in Table 1. The syringes we used in the study are standard syringes produced in accordance with the standards in the Turkish standards, European Standards and International Organization for Standardization (TS EN ISO 7864, TS EN ISO 7886-4 and TS EN ISO 7886-4) and any standard covering the design and production of the safe syringe caps we used in the trials not found.

Table 1: Syringe caps used in the study and their features.

Syringe cap types	Definition	Needle cap diameters (cm)
Standard cap	S0	0.5
Prototype 1	P1	2
Prototype 2	P2	4
Prototype 3	P3	1.5
Prototype 4	P4	3

Testing syringe caps

The developed PPSCs and the standard SC currently in use were tested by 344 volunteers using the semi-experimental method. Students were asked to open and close each needle cap 10 times in succession without giving, a time for each prototype designed in this method. An experimental material was developed by using a plastic apparatus at the tip of the needles used in these experiments (Figure 3). Thanks to the experimental material developed in this way, the penetration of the needle into the skin during the trials was prevented. Each student tried the Prototypes (PPSCs) and SC used in hospitals (Figure 2) 10 times. By observing the trials, the amount of needles contacting the skin during the trial, the numbers of protection of the caps from needle sticking, and the number of complete closure of the needle with the cap was recorded. The results were analyzed statistically.

Figure 2: (A, B, C, D) Prototype models; and (E) Standard syringe.

Figure 3: Experimental material.

Statistical analysis

The research findings were analyzed with IBM 25.0 and © 2020 Turcosa analytical statistics program and mean±standard deviation, Pearson χ^2 test, t test, Kruskall Wallis and Spearman correlation analysis were used in the analysis. A value of $p<0.05$ was considered statistically significant.

In addition, graphics were drawn using the excel program. Validity and reliability were confirmed, the effect value (Cronalpha 0.80), 95% confidence interval, type I error 0.05 and type II error 0.20, d=0.08, the attitude scale developed by Uzunbayır et al was reviewed by NCSS [Statistical and power analysis software (PASS)] package program.18 According to the sample size calculation based on the 95% confidence interval and the alpha coefficient of 0.05, it was calculated that the participation of 278 people would be sufficient with power analysis.

The attitude scores of the students were calculated according to the total score obtained from the Likert type scale used. The cap types were compared with each other statistically using analysis of variance, Kruskal Wallis, Shigel Castellan, Mann Whitney U, and t test.

RESULTS

In the study, the attitudes of 344 health profession associate degree students, 223 female and 121 male students, between the ages of 18-35 (mean: 22±10), 1st (n=278) and 2nd (n=66), who were voluntarily consented, were measured. The knowledge levels of the students were calculated according to the total score obtained from the Likert type scale used.

DY, FE, AN, ST, OD, PL and ML programs were found to be statistically significant among the programs in terms of knowledge levels, as a result of the attitude scale towards the safe use of SPMTs made with associate degree health programs students no difference was found (p=0.371). Dialysis technician program was found to be the program with the highest level of knowledge among health associate degree programs.

Following the dialysis technician program, the knowledge levels of the programs were determined as AN, FE, ST, OD, PL and ML programs from high to low (Figure 4).

When the knowledge levels of the programs were examined according to the classes, the knowledge levels of the 2nd year students on the safe use of SPMT were found to be significantly higher than the 1st year students (p=0.049) (Table 2).

Although it was not statistically significant, the knowledge level of female students studying in the programs included in the sample about the safe use of SPMT was higher than male students (p=0.256) (Table 2). As a result of the trials with the developed prototypes (Figure 2), the number of

trials of the students were compared according to the variables of the needle contact the skin, closing the cap completely and protecting the cap from needle sticking.

In how many students did the porter caps developed according to these variables protect the needle from skin contact? How many students were able to close the needle caps completely without the needle prickling, and how many students got a needle stuck in their hands while closing the caps?

The numerical data obtained in response to all these questions are shown in Figure 5.

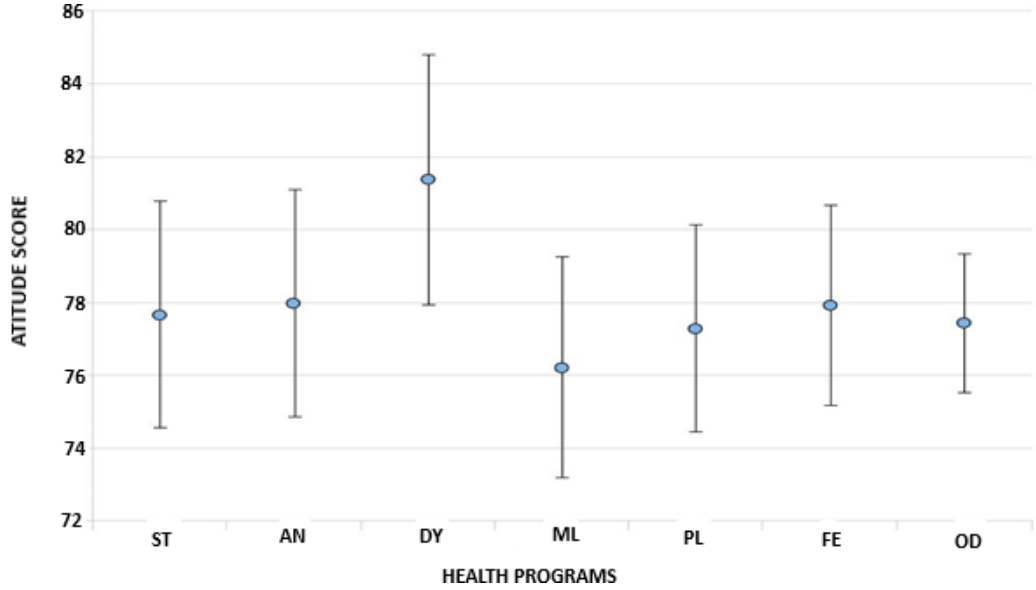

Figure 4: Knowledge levels on safe use of SPMT by health programs.

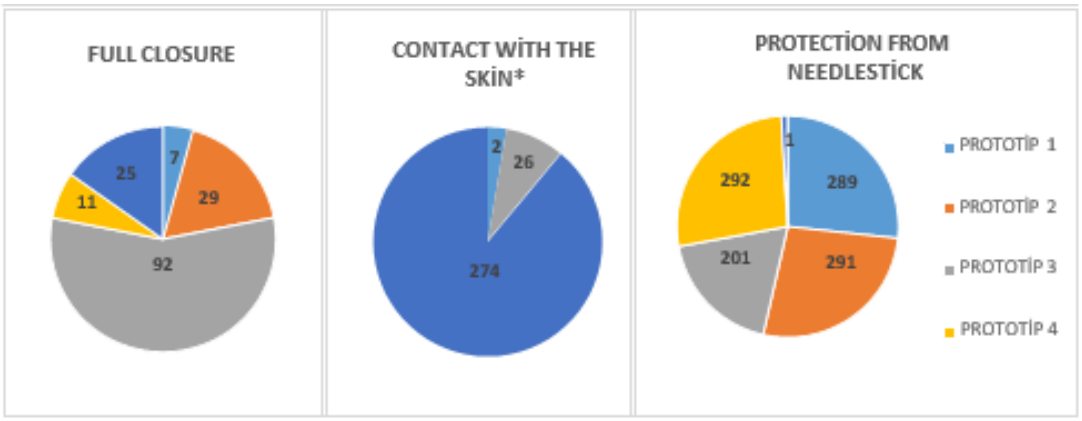

Figure 5: Representation of the number of people according to the variables of needle contact with the skin, full closure of the needle to the cap, and protection from needle sticking as a result of trials with the standard needle cap and prototypes.

Note:*-It is not shown in the graph since there was no skin contact in the trials with prototype 2 and prototype 4.

The differences between the prototypes and the SC according to the variables were evaluated by Kruskall-Wallis analysis of variance according to the groups and the results were presented at 95% confidence intervals (Table 3).

In this analysis, the critical threshold value of the difference between the means was taken as 99.2. The results were statistically compared using analysis of variance, Kruskal Wallis, Mann Whitney U and t tests.

Statistically significant differences were found between the cap types when the SC and PPSCs were compared in terms of protection from needle sticking, the number of needle contact with the skin, and the ability to fully close the needle and the cap without contact the skin ($p<0.001$) (Table 3).

The needle stick protection capacities of the cap types and the number of needle contact with the skin, according to the cap types are shown in Figure 5.

Table 2: Comparison of knowledge levels on the safe use of SPMTs according to somedemographic variables.

Demographic variables	Known levels				P value
Gen-der	N	Female Mean ±SS	N	Male Mean ±SS	0.256
	223	78.813±	121	76.592±	
Educa-tional level	N	1st class Mean ±SS	N	2nd class Mean ±SS	0.256
	278	77.30±	66	81.092±	

Table 3: Difference ratios between needle caps according to variables. The difference between the caps according to the variables is directly proportional to the numerical values.

Variables and difference ratios			
Syringe caps	**Skin contact**	**Full closure**	**Protection ratios**
S0-P1	690.9	25.4	608.3
S0-P2	695.1	159.8	764.0
S0-P3	639.5	451.6	316.3
S0-P4	695.1	247.9	936.1
P1-P2	4.2	185.3	155.6
P1-P3	51.4	477.1	447.7

It was seen that this difference was caused by the different cap diameters between the SC and PPSC. No significant difference was found when PPSC was compared among themselves.

It was seen that as the number value above the threshold value increases, the difference between the needle caps increases, according to the variables, and the difference between the caps decreases as it falls below the critical threshold value.

DISCUSSION

Health workers are seen as a risk group because they are exposed to certain blood-borne diseases due to the treatment and care interventions they apply.[3] Needle sticking, which is one of the leading causes of infectious diseases in healthcare workers, has not ceased to be a risk factor today. Moreover, although health personnel receive various trainings on NSIs, wig injuries caused by needle sticks cannot be prevented.[14]

In this study, the knowledge level of the Health vocational school students, who will be health personnel in the future, about the safe use of SPMTs before they start their profession was measured. The frequency of invasive interventions in 7 different health programs, the higher the level of knowledge of DY, FE, AN and STP, which have more contact with the patient and the needle, is an indication that these programs are more sensitive to the safe use of SPMT comes out. On the other hand, the low level of knowledge of the students of laboratory programs may be due to the fact that the students in these programs have less contact with needles and patients, and therefore do not make invasive interventions.

Although the fact that the second year students were statistically more conscious about this issue in the study makes us think that education and experience are important in the formation of awareness culture, İlçe et al showed in their study that education and experience are not effective in percutaneous injuries due to needle sticks.[14] Because it will not be possible to prevent such injuries as long as the heavy workloads and stressful working environments of healthcare workers who are trained in the prevention of needle sticks and even use the necessary safe equipment continue.[2] There is a great need to increase the safety of the syringes used for this purpose. The act of trying to close the needle cap has the largest share in the SPMT injuries while using a syringe.[18] This issue has not only been the subject of some studies in the literature, but it has been observed that the standard needle caps used are insufficient to prevent these accidents, and various syringe types with higher safety features have been developed continuously.[16] However, since these products are produced and marketed at higher costs compared to standard syringes, they have not yet found widespread use. In line with this requirement, with this study, 4 different sizes of syringe caps in 3 different prototypes with low cost but high protection were designed. These designed PPSCs, which were developed on the basis of preventing needle sticking and protecting against needles, were statistically compared according to their capacity to contact the needle, to close completely and to protect from needle sticking (Table 3).

As a result of the analyzes made, when the cap types were compared in terms of providing the desired features in terms of security, significant differences were found between them. The statistical significance stems from the differences between the SC type and the PPSCs in terms of providing protection from the needle, full closure and contact with the needle. According to the comparison results made in terms of the number of contacts, the source of the significant difference between the SC and the PPSCs was determined as the fact that large diameter caps reduce the number of needles to skin contact.

However, the absence of a significant difference when the larger diameter PPSCs were compared among themselves was attributed to the fact that the prototypes had the same effectiveness in reducing the number of skin contact (Table 3). Based on providing full closure, it was observed that the significant difference between the SC and PPSCs resulted from the increase in the capacitance of the cap as the diameter of the caps increased, thus increasing the closure capacity without contacting the skin (Table 3). When the needle stick protection features of the caps were compared, the ability of the SC and PPSCs to prevent pinprick was examined, and a statistically significant

difference was found between the SC and the PPSC no 4 (Figure 5). On the other hand, in the comparison between the PPSCs in terms of this feature, the lowest significant difference was observed between PPSCs 2 and 4 (Table 3).

These results prove that SC cause percutaneous injuries due to their current size. Therefore, it has been determined by the experimental differences made on the determined parameters that the standard needle cap, which is currently used, cannot prevent needle sticks and is insufficient to protect against needle sticks (Table 3) (Figure 6).

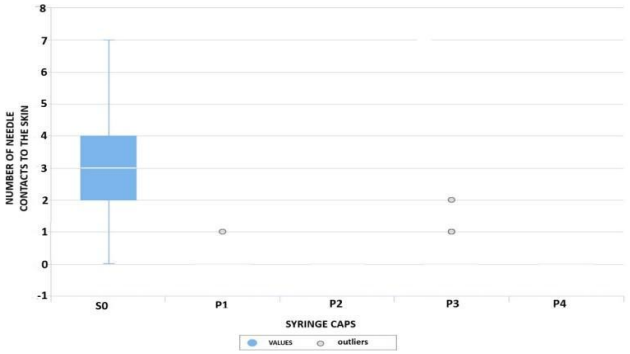

Figure 6: Number of needle contact with skin according to standard and prototype syringe cap types.

CONCLUSION

It is known that one of the causes of blood-borne diseases in health care workers are injuries caused by needle sticks. In this study, the Health Vocational School students who are educated in this field were studied a representation of health care professionals and it was investigated how effective their education was in preventing NSIs. As a result of the resulting knowledge levels and based on the studies in the literature, it has been understood that education and experience alone are not effective in preventing these injuries. As a result of our study, it was revealed that the SC used today only function as a sheath or a reservoir for the needle rather than protecting the user from the needle. Therefore, it has been determined that the existing diameters and shapes of standard needle caps are insufficient to prevent percutaneous injuries. By improving/developing the safe syringes used to prevent percutaneous injuries, by producing and using a larger diameter and conical needle cap, wig injuries due to needle sticks and subsequent infections can be prevented. In addition to being safe, products that provide automatic use or have a more aesthetic appearance and different shapes can be designed and developed.

Although safe syringe on the market are not preferred due to their costs, the same syringe can be developed using low-cost materials. In addition, during our study, a standard in the safety evaluation of SC was searched but could not be found. Therefore, existing standards [Turkish Standards, European Standards and International Standardization Organization (TS EN ISO 7864, TS EN ISO 7886-4 and TS EN ISO 7886-4)] can be improved in terms of occupational health and safety. Even new standards can be added. In addition, we worked with the Health Vocational School students as a sample. This study can be developed with different methods or experimental protocols by performing with experienced and trained healthcare professionals working in a real hospital environment, and different needs of healthcare professionals in this field can be revealed. The fact that the study was conducted with a certain number of health school students and the absence of a standard for the production and testing of protective syringe caps can be counted among the limiting factors in the study. If this study is carried out in a real hospital environment by developing a standard about protective syringe caps, more precise results can be obtained and different protective syringe caps can be developed.

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Ethical approval: The study was approved by the Institutional Ethics Committee

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