ABSTRACT

Background: Infectious diseases are a major threat to healthcare workers and patients alike. Standard precautions (SPs) are a pivotal element in controlling their spread. However, worldwide reported compliance with SP guidelines is suboptimal among workers and students in the healthcare field.

Purpose: The objective of this study was to identify the knowledge, attitude, and practice among workers and students in the healthcare field.

Methods: This cross-sectional study employed a web-based structured questionnaire. Participants were students of nursing, emergency medicine for paramedics, physiotherapy, and medicine studying at a public university in Israel. The questionnaire assessed SP-related knowledge and behavioral intent, perceptions of personal responsibility, and the presence of mentors as role models. The k-means clustering method was used.

Results: The 259 students (33% response rate) who completed the questionnaire were enrolled as participants and divided into two knowledge and behavioral intent clusters. Cluster 1 (n = 156) had a higher proportion of nursing students and a lower proportion of medical students than Cluster 2 (n = 103). Emergency medicine for paramedics and physiotherapy students were more evenly distributed between the clusters. Participants who were classified in Cluster 1 reported higher intent with regard to proper hand hygiene, use of personal protective equipment, and decontamination practices. In multivariable analysis, only three variables predicted belonging to Cluster 1: nursing students, perception of their mentors as role models, and perception of having higher personal responsibility for microbiological safety.

Conclusions: We observed clear patterns of knowledge and behavior among the students in the healthcare field examined in this study. These patterns were influenced by profession, role mentoring, and sense of responsibility. This use of cluster analysis may contribute to the development of better SP educational endeavors. The patterns identified highlight the need for improved training and the importance of role modeling for healthcare students in all areas of specialization.

Key Words: standard precautions, healthcare profession students, knowledge, attitude, practice.

Introduction

Preventing healthcare-associated infections is a major issue worldwide that has gained extra pertinence in the current COVID-19 pandemic. Contamination and infection are central problems both within and outside healthcare systems (Carter et al., 2017; Sundal et al., 2017). Standard precautions (SPs) remain the first line of defense for healthcare workers and patients alike. Together with transmission-based isolation precautions, related guidelines offer an overall approach to protection from contagious diseases in healthcare settings (Siegel et al., 2007). Both the Centers for Disease Control and Prevention (Siegel et al., 2007) and the World Health Organization (2009) recommend adoption of SPs by all healthcare providers as a basic strategy to limit infection spread (Alshammari et al., 2018). SPs include practicing hand hygiene (HH) and glove use, using personal protective equipment, and following directives related to sharps and decontamination. Differences in knowledge and compliance among healthcare professionals are well documented (Asmr et al., 2019; Hamid et al., 2019; Nofal et al., 2017).

Although researchers of infection prevention generally agree on the importance of SPs in healthcare education in the global endeavor to prevent infections (Khubrani et al., 2018; Labrague et al., 2018), differences in knowledge and compliance exist both among healthcare professionals and healthcare students (Kingston et al., 2018; Labrague et al., 2018). One systematic review that included studies from several countries found that nursing students had higher scores for HH knowledge and practice than medical
students. Although differences were noted in the various study program curricula, all knowledge and compliance levels reported were low to moderate (Labrague et al., 2018).

Although some studies have reported nursing students’ SP knowledge and compliance to be higher than that of other healthcare students (Kingston et al., 2018; Labrague et al., 2018; Tavolacci et al., 2008), other conflicting results have also been found. A short intervention for healthcare students in an Indian hospital achieved positive results for knowledge of HH, SPs, and nosocomial infection, with medical students scoring higher than nursing students (Goyal & Chaudhry, 2019). A Saudi Arabian survey of knowledge about SPs and infection control among different healthcare students found no significant difference between the medical, nursing, dentistry, applied medical sciences, and pharmacy departments. All of the students knew less about the management of sharp objects (Khubrani et al., 2018).

Many factors other than the professional specialization being studied have been found to influence healthcare students’ compliance with SPs. In a self-report survey of several hundred Chinese nursing students, it was found that increased knowledge, better training, management support, and staff compliance in clinical rotations were associated with higher compliance (Cheung et al., 2015). Students in several healthcare professions cited lack of time as a reason for noncompliance (Baier et al., 2020). Cruz and Bashtawi (2016) found that older age, female gender, third year of study, recent infection-prevention training, and perceived hospital infection prevention climate all predicted better HH among Saudi Arabian nursing students. In another study, only clinical exposure was shown to be directly related to student SP compliance (Colet et al., 2017). Similarly, an infection control clinical course was found to be significantly correlated with SP compliance among Jordanian university nursing students (Tawalbeh et al., 2019). Furthermore, a recent study in the Netherlands found that medical students’ HH compliance was influenced by attitude and self-efficacy, but not by knowledge or perceived risk (Erasmus et al., 2020).

Number of years studied significantly relate to compliance and intent to comply in students. Thus, for nursing students, these rates are often higher in the middle years of study than during the last year (Alshammari et al., 2018; Cruz, 2019; Livshiz-Riven et al., 2014; Majidipour et al., 2019). In contrast, a Chinese study of nursing students found higher SP compliance in second- and fourth-year students than in third-year students and also revealed that compliance rates were significantly influenced by nursing staff compliance (Cheung et al., 2015). First-year medical students in South Asia earned moderate scores for knowledge of hygiene practices, and their scores improved progressively through their academic career (Jayarajah et al., 2019).

The aim of this study was to identify knowledge and behavioral intent patterns among students in the healthcare field and the relationship between these factors and the students’ study program, clinical exposure, and attitudes.

Methods

This cross-sectional study collected data using a web-based structured questionnaire and was conducted between December 2019 and March 2020. The participants were recruited from one public university located in the south of Israel with approximately 20,000 students. The study population included around 800 health science students studying in several areas of specialization, including nursing, emergency medicine for paramedics, physiotherapy, and medicine.

Data Collection

The research tool used in this study to assess compliance with SPs was a questionnaire adapted from Alshammari et al. (2018). The face validity of this questionnaire was reassessed by a content expert in nursing, infection control, epidemiology, and preventive medicine (Bolarinwa, 2015). The questionnaire was translated into Hebrew and then back-translated to ensure accuracy. The items were adapted to reflect Israeli healthcare policies. Three items were removed (showering after extensive splashing, removing waste to plastic bags, and alcohol rubbing as an alternative to handwashing), and two items were added (glove use as an alternative to HH as a reversed item and the use of soap and water when hands are visibly soiled). These items encompassed the use of personal protective equipment, HH and glove use, decontamination, and the handling of sharps. The 22 items in the final version of the questionnaire included 19 on behavioral intent and knowledge and three on attitudes, personal responsibility, and the perception of mentors’ behavior. Answers were scored using a 4-point Likert scale, with five items stated and scored in reverse. The demographic data collected included gender, age, field, and year of study. The questionnaire was designed to be completed within 10 minutes.

The questionnaire was constructed and distributed using Google Forms. It is customary for each study year in the Faculty of Health Science at the target university to choose representatives to represent them on various academic issues. These representatives, who regularly communicate with the student body via a shared WhatsApp group, were asked to distribute the explanation of the study and the questionnaire link on this group. This study was approved by the faculty ethics committee (31-2019) and by the heads of the participating programs. Student anonymity was guaranteed. The students received three reminders at several-week intervals.

Data Analysis

The minimum required sample size was calculated using a power of 80% and a significance level of 5%. To evaluate a medium effect (effect size \( \omega = 0.3 \)) of field specialization on patterns of SP knowledge and intent, 122 participants were required. Categorical variables were described using frequency and percentage. Age was evaluated for normal distribution and reported using median and interquartile range. The K-means clustering method was used to identify two patterns of SPs. K-means clustering is a method of vector
quantification that aims to group $n$ observations into $k$ clusters, in which each observation belongs to the cluster with the nearest mean (Steinley, 2006). The Mann–Whitney test and a chi-square test were applied to compare continuous, ordinal, and categorical variables between the two patterns. The variables significantly associated in univariate analysis were included in the multivariable analysis. Multivariable logistic regression was performed to identify independent predictors for patterns of SPs (Cluster 1 or 2).

Statistical analyses were performed using IBM SPSS Statistics Version 25.0 (IBM, Inc., Armonk, NY, USA) and R language (R Core Team, 2019; https://www.R-project.org/). All tests were two sided, and $p < .05$ was considered statistically significant. In addition, the STROBE checklist (checklist of items that should be included in reports of observational studies) was used to report the study (Wiehn et al., 2021).

## Results

Of the 783 students who received the link to the questionnaire, 259 (33%) completed the survey. Most ($n = 147$) of the respondents were students in the nursing field, followed by emergency medicine ($n = 30$), physiotherapy ($n = 22$), and medicine ($n = 60$). The response rate was highest among the emergency medicine students (30/55, 54%; Table 1).

The participants were classified into two clusters according to their answers to the knowledge and behavioral-intention questions. The score for each question was compared between the two clusters (Figure 1). The graphical representation of all observations into clusters (Figure 1A), personal protective equipment use (Figure 1B), and HH (Figure 1C). The participants who were classified in Cluster 1 reported higher intentions for proper sharps (Figure 1A), personal protective equipment use (Figure 1B), and HH (Figure 1C). The participants who were more likely to be in Cluster 1 were nursing students ($n = 103$ [66.0%] vs. $n = 44$ [42.7%], respectively). Conversely, Cluster 2 had a higher proportion of medical students than Cluster 1 ($n = 35$ [34.0%] vs. $n = 25$ [16.0%], respectively). Physiotherapy and emergency medicine students were more equally distributed among the two clusters.

Compared with Cluster 2, Cluster 1 had a higher percentage of participants who were female (82.1% vs. 68%, $p = .005$), in earlier clinical exposure (34.6% vs. 24.3%, $p = .007$), and younger (median = 25 vs. 26 years old, $p < .001$). In addition, Cluster 1 had better mean attitudes toward their personal responsibility (mean = 3.78 vs. 3.54, $p < .036$), better recognized the threat of infection (mean = 3.81 vs. 3.67, $p = .007$), and were more likely to perceive their mentors as being more SP compliant (mean = 3.41 vs. 2.97, $p < .001$).

The multivariable analysis identified only three variables as predictive of belonging to Cluster 1. As illustrated in Figure 2, those more likely to be in Cluster 1 were nursing students ($OR = 2.58$, $p = .015$), those who perceived their mentors as role models ($OR = 1.40$, $p = .042$), and those who self-perceived as having a high level of personal responsibility for microbiological safety ($OR = 1.80$, $p = .022$).

## Discussion

In this study, two distinct clusters of SP knowledge and behavioral intentions were identified, with nursing students being much more likely to be in Cluster 1 than Cluster 2. Cluster 1 included emergency medicine and physiotherapy students in similar proportions to those in Cluster 2. However, the proportion of medical students in Cluster 2 was twice that of Cluster 1. Participants in Cluster 1 were characterized as having a higher sense of responsibility for microbiological safety and a more positive perception of mentors as SP role models. In addition, Cluster 1 participants had higher levels of knowledge and behavioral intentions related to HH and glove use, the proper use of other personal protective equipment, and decontamination practices.

### Table 1

| Field of Specialization | Early Clinical Exposure | Late Clinical Exposure | Total Participants | Age in Years (n = 259) | Gender: Female (n = 259) |
|-------------------------|-------------------------|------------------------|--------------------|------------------------|-------------------------|
|                         | First Clinical Year     | Second Mid-Clinical Year | Third Last Clinical Year | Mean | SD | n | % |
| Nursing                 | 29/88                   | 56/124                 | 147/296           | 49.7% | 25 | 3 | 128 | 87.1 |
| Physiotherapy           | 14/29                   | 8/40                   | 22/69             | 31.9% | 26 | 2 | 16 | 72.7 |
| Emergency medicine      | 14/30                   | 16/25                  | 30/55             | 54.5% | 26 | 4 | 16 | 53.3 |
| Medicine                | 22/110                  | 24/128                 | 60/363            | 16.5% | 28 | 3 | 36 | 60.0 |
| Total                   | 79/257                  | 70/249                 | 259/783           | 33.1% | 26 | 4 | 214 | 82.6 |

*Years 2–4, b Years 3–4, c Years 2–3, d Years 4–6.*
Figure 1
Knowledge and Behavioral Intent by Cluster, Divided into Three Domains

A- Decontamination and Sharps

Scale of behavioral intent and knowledge

- Clean equipment after use
- Clean up spillage with disinfectants
- Disagree with "sharps container disposed only when full"
- Used sharp articles into sharps boxes
- Disagree with "Recap used needles after injection"

Cluster 1: 3.27, 3.54, 3.03, 3.91, 2.22
Cluster 2: 2.4, 2.26, 2.35, 3.9, 2.25

B- Personal Protective Equipment

Scale of behavioral intent and knowledge

- Mouth and nose covered w. mask
- Reuse PPE
- Remove PPE in designated area
- Use PPE if splash
- Wear gown when exposed body fluids

Cluster 1: 3.89, 1.65, 3.65, 3.43, 3.45
Cluster 2: 3.62, 1.33, 2.74, 2.38, 1.86

C- Hand Hygiene

Scale of behavioral intent and knowledge

- Change gloves between patient
- Cover wound dressing
- Clean hands between patient
- Clean hands after glove removal
- Gloves don’t replace HH
- Only water for hand washing
- Handwash when visibly soiled
- Gloves to clean equipment
- Gloves exposed to body fluids

Cluster 1: 3.92, 3.37, 3.79, 3.58, 2.4, 2.04, 3.34, 3.63, 3.71, 3.89
Cluster 2: 3.85, 2.04, 3.61, 2.96, 1.92, 2.96, 3.09, 3.18, 3.7
Regarding gender and demographic factors, most respondents in Cluster 1 were female. This may be explained by the predominance in this cluster of nursing students, who in Israel are predominantly female (Ashkenazi et al., 2017). Other demographic findings revealed that Cluster 2 participants were older, which may be explained by the relatively older average age of Israeli medical students (Terebessy et al., 2016), possibly because of mandatory army service and the 6-year medical program requirement. Gender and age were not found in the multivariable analysis to be related to clusters of knowledge and behavioral intentions. However, other studies have reported that women have higher levels of knowledge and compliance (Haile et al., 2017; Sharma et al., 2020) and that age is negatively related to perceptions regarding the infection control climate (Cruz, 2019) and positively related to SP compliance (Fashafsheh et al., 2016; Osborne, 2003). It is noteworthy that knowledge and behavioral clusters were the dependent variables in our study rather than the general levels of SP knowledge and intentions. These clusters identified clear patterns of behavioral intentions. Cluster analysis in nursing research may lead to new insights that are important for clinical practice (Dunn et al., 2018).

Several previous studies identified differences between groups of students in different years of study. In some of these studies, and compliance (Haile et al., 2017; Sharma et al., 2020) and that age is negatively related to perceptions regarding the infection control climate (Cruz, 2019) and positively related to SP compliance (Fashafsheh et al., 2016; Osborne, 2003). It is noteworthy that knowledge and behavioral clusters were the dependent variables in our study rather than the general levels of SP knowledge and intentions. These clusters identified clear patterns of behavioral intentions. Cluster analysis in nursing research may lead to new insights that are important for clinical practice (Dunn et al., 2018).

Several previous studies identified differences between groups of students in different years of study. In some of these studies,
student SP compliance was found to be higher in the middle years of study (Alshammari et al., 2018; Cruz, 2019), whereas in others, compliance and knowledge were found to be higher in later years of study (Cheung et al., 2015; Jayarajah et al., 2019). The findings of this study classified more students in their earlier years of clinical exposure to Cluster 1 than Cluster 2, with a reverse trend in later years. However, the significance of this difference did not hold in the multivariable analysis.

Regarding different healthcare field specializations, Khubrani et al. (2018) found no differences in SP knowledge among students in different healthcare disciplines, whereas other studies (both interventional and cross-sectional) that compared nurses, doctors, and students, and knowledge or practice found that doctors had slightly higher SP knowledge (Arinze-Onyia et al., 2018; Asmr et al., 2019; Goyal & Chaudhry, 2019). Nevertheless, some prior studies have reported better results for SP knowledge and compliance in nursing students and nurses than in other healthcare professionals (Ehimen et al., 2020; Haile et al., 2017; Kingston et al., 2018; Labrague et al., 2018; Tavolacci et al., 2008).

The findings of this study support much of the evidence previously reported in the literature. This may reflect the generally central importance of infection control and SPs in nursing education and the nursing profession (Hessels & Wührmer, 2020; Thomas & Rosser, 2017). Florence Nightingale’s (1863) work continues to be a major influence on the continued major contributions of nursing to epidemiology and infection control (Martischang et al., 2020) and the importance of hygiene and cleanliness in nursing (Brown et al., 2008).

Two factors in addition to being a nursing student were identified in this study as predictive of belonging to Cluster 1. These were having a mentor as a role model for SPs and having a strong sense of personal responsibility. These findings are consistent with previous work in this area. A systematic review of factors associated with HH knowledge and compliance reported that having a positive HH mentor partially explains better compliance (Labrague et al., 2018). Other research identified mentors as a factor that positively influences infection control knowledge and practice (Hinkin & Cutter, 2014) as well as university education being the major influence on undergraduate nursing students in the United Kingdom.

Positive attitudes (including sense of responsibility) toward SP relate directly to knowledge and compliance (Erasmus et al., 2011, 2020; Nofal et al., 2017; Sharma et al., 2020). A sense of responsibility and belief in the value of professional guidelines enhance the motivation of healthcare workers to follow SP protocols (Houghton et al., 2020).

The last factor, SP training, has been linked to higher compliance rates in other studies (Haile et al., 2017; Tawalbeh et al., 2019). However, in this study, recollection of participation in an SP educational session was not related to membership in either cluster. The questionnaire used in this study asked respondents whether they recalled participating in any SP-related educational activity, with no specifications given. Different educational scopes and methods may have been used among the different departments. For example, a previous investigation into the effect of HH interventions on medical students found variance in compliance, moderate effectiveness for individual training, and a higher effect for role modeling (Qasmi et al., 2018).

Limitations
Although this study was designed to investigate all relevant study programs in our university, the numbers of participants from the emergency medicine and physiotherapy programs were relatively small, and the compliance rate for medical students was very low. Moreover, this study was conducted in one university only. These factors may limit the generalizability of the findings to other academic settings. Training in infection control is essential in all healthcare education programs. However, the study scope did not include a description of educational endeavors. In response to these issues, further studies may be designed to assess the relationship between teaching strategies and SP knowledge and intentions.

Conclusions
To the best of the knowledge of the authors, this was the first study to use cluster analysis to investigate SP knowledge and intentions. The results of this analysis identified clear behavioral patterns that cross healthcare specializations. However, being a nursing student was predictive of being in Cluster 1, which exhibited better knowledge and intentions. In addition, having a mentor as a role model and a sense of personal responsibility were significant in the total study population. Cluster analysis may be an effective method to further advance SP educational endeavors through a focus on improving mentor role modeling and study programs for relevant professions. Furthermore, the findings pinpoint important problematic issues such as gloves not being a replacement for good HH and the importance of not recapping needles. Together, these strategies can help improve student guideline compliance and infection control.

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Author Contributions
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