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ORIGINAL ARTICLE

Using a Massive Open Online Course (MOOC) to promote infection prevention and control learning in healthcare education

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Abstract

***Background*:** The prevention of healthcare-associated infections (HAIs) is one of the most important subjects in healthcare education.
***Aim*:** The aim of this study was to describe Finnish, Spanish, Portuguese, and Polish healthcare students' perspectives on learning about HAIs using a Massive Open Online Course (MOOC). This study is part of the Erasmus+ project 'Educating students for innovative infection prevention and control (IPC) practices in healthcare settings' (InovSafeCare).
***Methods*:** The descriptive cross-sectional research design was used to describe healthcare students' perspectives on learning about HAIs using the InovSafeCare MOOC (ISC-MOOC). The participants (N = 135) were students recruited from partner institutions. The project group developed a semi-structured questionnaire that was used for data collection, containing questions of technical and pedagogical usability. The data were analyzed by statistical methods and content analysis.
***Results*:** The ISC-MOOC facilitated healthcare students' independent learning and promoted their knowledge of HAI prevention and control. Study materials were easy to use (84%), and the media of the study materials were of high standard (83%). Some technical problems (14%) were also identified with the use of the materials. The study materials were relevant (70%) for IPC learning but should also be provided in different languages.
***Conclusion*:** The MOOC will strengthen the role of the students as future healthcare professionals and will also be usable for those healthcare professionals who need to update their skills with today's HAI requirements. MOOC should also be translated into other languages other than English.

Keywords: *healthcare-associated infections; infection control; online learning; education; nursing students; public health nurses; medical laboratory personnel; Europe*

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Healthcare-associated infections (HAIs) are one of the most frequent adverse events in health care and lead to serious threats to patient safety and care efficiency (1). In the United States, almost 70,000 HAIs were contracted in acute care hospitals in 2015. About 72,000 hospital patients with HAIs died during hospitalization (2). In Europe, about 8.9 million patients acquire an HAI in hospitals and long-term care facilities each year. However, it is estimated that more than half of the HAIs could be prevented by following evidence-based HAI prevention protocols (3). Significant risk factors for infections include patients' high age, long duration of hospital stay, and invasive procedures. Microbial epidemics, which spread easily through contact or droplet infection, also increase the risk of disease (4).

Teaching HAI content is based on a constantly evolving knowledge base, updated international guidelines, and national legislation. Thus, HAI control and prevention is a rapidly evolving area of healthcare expertise. For example, the COVID-19 (Coronavirus disease 2019) pandemic has demonstrated the urgent need for information on such topics as how to quickly identify infected people, guide their treatment, and isolate the infected or exposed (5).

There is a need for more innovative learning methods, so that infection prevention and control (IPC) competence is sufficient to meet new challenges (6). The COVID-19 pandemic also caused urgent changes in education. In most countries, nursing schools and universities closed on March 2020, and more than 1.5 million students in 191 countries (7) shifted into distance learning. It was necessary to decide how to continue the education of future nurses as well as other healthcare employees, and multiple educational solutions were quickly deployed. In these new circumstances, it was found that teaching materials and methods did not cover the needs of distance learning

purposes and, thus, became a great concern for ensuring healthcare students reached academic requirements (8).

Guidelines alone are not enough to guarantee good practice. In addition to knowledge, attitudes affect the application of HAI control methods. Instead of just disseminating information, there is also a need for personal motivation and ability to apply the guidelines in practice as well as a need for information on the obstacles to complying with the guidelines (9, 10). There is plenty of guidance, among other things, about hand hygiene (HH); it is a key area of expertise in health care. Nevertheless, studies reveal shortcomings in the aseptic work of staff and students (11, 12). An observational study in the US found that only a few more than half of injections were performed according to recommendations (10). It seems that a fundamental change in attitude is needed to ensure HH meets the requirements of evidence-based information.

Structured and up-to-date education in HAI prevention and control is recognized as an important element of healthcare professionals' on-going competency development. Such educational initiatives should be included in the various healthcare courses in the nursing curriculum as well as in the education of other professionals. It is important to make HAI prevention and control a core component of professional education, certification, and continuous education to tackle the problem of an infection spreading globally (13).

The integration of international research and development into teaching promotes the introduction of new knowledge and increases the quality and effectiveness of teaching. A 2017 report by the European Centre for Disease Prevention and Control (ECDC) identified shortcomings in the fight against HAI and the need to develop the nursing curricula in all member states (1). The development of European infection control became particularly topical during the COVID-19 pandemic, as skilled and properly protected personnel are important to increase health performance.

Creation and development of an innovative pedagogical model to formally address HAI prevention and control could improve the quality of the current nursing curricula across the world in provision of safe and quality care. The Erasmus project, 'Educating students for innovative IPC practices in healthcare settings' (InovSafeCare), is helping nursing students to develop competence in HAI prevention and control by stimulating their critical thinking, decision-making, and providing them with the necessary skills to plan, implement, and evaluate nursing care. The main objective of the InovSafeCare project is to develop the InovSafeCare model for nursing education in HAI prevention and control. It will be a generic model containing the organizational, educational, and professional elements for the development of students' competence. In addition to the clinical recommendations of the best practices in this field, the model is composed of a pedagogical dimension to stimulate nursing students' development of their competence in HAI prevention and control. Therefore, the project created a didactically designed Massive Open Online Course (MOOC) to foster students' online independent learning. This article presents the development of the InovSafeCare MOOC (ISC-MOOC) for learning HAI prevention and control. The focus is on describing the piloting of the ISC-MOOC.

MOOCs have the potential to reach a large and internationally diverse group of students (14). MOOCs offer a flexible way for healthcare students to gain access to higher education without enrolment to a university, paying tuition, or commitment to a degree program (15). The concept of MOOC was first introduced in 2008 (16), but it has only recently been utilized in healthcare education. On the contrary, MOOCs are criticized for having high student drop-out rates, which may be due to MOOCs requiring students to be able to study independently and have good digital skills. However, even though there is no consensus on best practice, it appears that MOOCs are currently complementing the traditional healthcare education curricula rather than competing with them (14).

The ISC-MOOC was designed for healthcare students for the purpose of learning HAI prevention and control. The aim of the MOOC is to motivate students to study IPC independently and to concretize the learning content. The structure of the ISC-MOOC was based on the standard precautions of IPC (17, 18). The content was created and written collaboratively by the five project partner institutions. The reference materials consisted of international evidence-based recommendations and policies produced by the World Health Organization (WHO) and the ECDC (19, 20). In addition, scientific studies of HAI, audiovisual materials produced by partners, and videos by WHO were used as study material. The ISC-MOOC is organized into 11 modules (Fig. 1) that focus on the key areas and good practice guidelines of HAI prevention and control (19, 20).

The ISC-MOOC is published via the DigiCampus (21) platform. Students can sign in to DigiCampus with their Google accounts. The ISC-MOOC adapts to a variety of devices and screen sizes, such as computers, tablets, and smartphones, improving its availability and usability. In this study, technical usability describes ease of use of the learning materials, and pedagogical usability describes how meaningful it is to study them.

The ISC-MOOC includes interactive learning content such as quizzes, slide shows, and media elements (Fig. 2). Each module contains competency testing quizzes, in which the student needs to receive at least 50% of the

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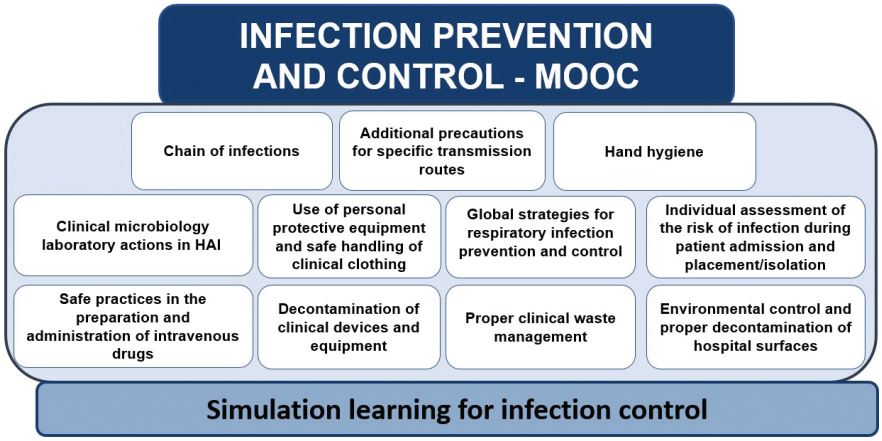

Fig. 1. Content of the infection prevention and control ISC-MOOC modules.

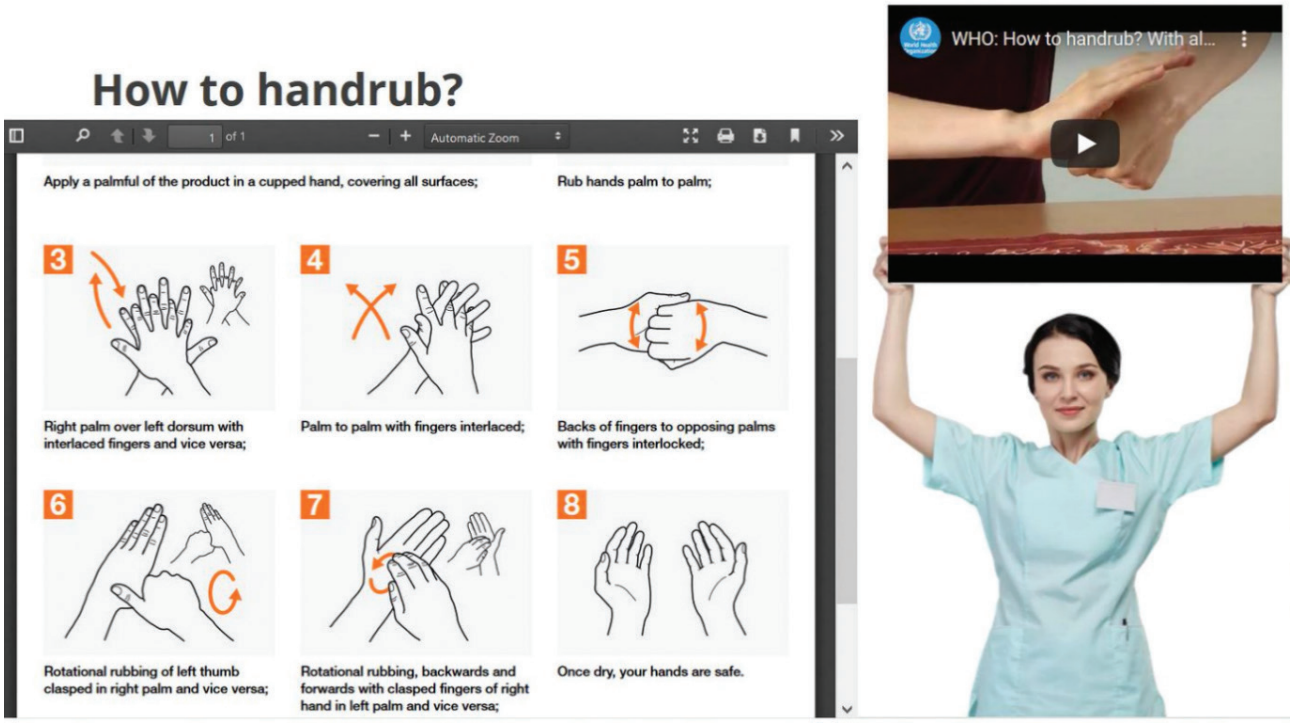

Fig. 2. ISC-MOOC illustration of the HH module with a poster and video clip.

mark to pass the module. Quizzes provide students feedback on their current level of competence. The ISC-MOOC is worth five credits, and it can be included as such in healthcare curricula. It includes a feedback system to assist students with the acquisition of competencies within HAI prevention and control.

The aim of this study was to describe Finnish, Spanish, Portuguese, and Polish healthcare students' perspectives on learning about HAIs by piloting the ISC-MOOC.

Methods

Study design

A descriptive cross-sectional research design was used.

Study settings

The project was carried out in a collaboration between the Portuguese Nursing School of Coimbra and the Health School of the Polytechnic Institute of Santarem, the

Polish Hipolit Cegielski State University of Applied Sciences in Gniezno, the Spanish University of Salamanca, and the Finnish Savonia University of Applied Sciences. The development of the ISC-MOOC started at the beginning of the year 2020. All partner institutions produced the content of the ISC-MOOC together, and the MOOC was published on the DigiCampus platform in January 2021. This study took place in February and March 2021.

The study questions were as follows:

1. How did the technical usability of the ISC-MOOC foster learning of HAI prevention and control?
2. How did the pedagogical usability of the ISC-MOOC foster learning of HAI prevention and control?
3. How should the ISC-MOOC be developed to maintain students' motivation to study HAI prevention and control?

Study population

The participants in each country were selected based on their curriculum. The students had to have completed the first year basic studies that provide a professional qualification. The participants (N = 135) were students of nursing (n = 87), public health nursing (n = 26), biomedical laboratory science (n = 7), midwifery (n = 2), and other healthcare students (n = 10).

Sampling techniques

Piloting the ISC-MOOC was part of each institution's compulsory or optional extracurricular studies. The modules selected for piloting were HH, use of personal protective equipment, and safe handling of clinical clothing.

Instrument for data collection

The semi-structured questionnaire that was used to collect data for this study was developed by the InovSafeCare project group. The questionnaire was pre-tested by 10 healthcare educators and modified based on their feedback. The questionnaire contained four parts. Part A collected information about technical usability and part B about pedagogical usability. In part C, the participants could provide feedback about improving the content of the study materials through an open-ended question. Part D collected information about sociodemographic variables. The questionnaire aimed to find out the deficiencies and inadequacies of the piloted version of the ISC-MOOC.

Data collection procedure

The self-administered questionnaire was used to collect data from the participants. The ISC-MOOC course was introduced to the students by their institutions' teachers. Teachers at each university explained the InovSafeCare project, the ISC-MOOC, and the two required piloting modules to students either via online connection or face to face in class**.** Students were also informed about the survey using the Webropol Survey Tool (Webropol 3.0, Webropol Oy, Helsinki, Finland), including the time needed to complete it, and how to fill in the questionnaire. Voluntary participation in the study was also explained. All the research information was delivered to the students in writing using the institutions' virtual platforms. All answers were collected anonymously. Students completed the two modules of the ISC-MOOC independently and were also able to pause their progress of completing the modules and continue later. The students filled in the questionnaire once they had finished both modules.

Statistical analysis

The collected data were analyzed by descriptive statistical methods such as frequency and percentage to present t he nursing students' perspectives on learning about HAIs. The analysis was performed using Webropol Professional Statistics (version 31.07.2020 MPO, Webropol Oy, Helsinki, Finland). The open-ended questions were analyzed using deductive content analysis (22). The main categories of the content analysis were technical usability, pedagogical usability, and students' motivation to study HAI prevention and control.

Results

Table 1 shows the sociodemographic characteristics of the students who participated in the study. Results of the study indicate that the greatest proportion of students was within the age group of 20–24 years from all partner universities. Students' current academic year of studies varied equally from the 2nd to 4th years of study.

Figure 3 shows the technical usability of the ISC-MOOC. Most students (93%) believed that the study materials were easy to use, and the instructions (86%) were clear. In addition, the essential information was easy to find in the study materials (85%), and navigation throughout the study materials was smooth (77%). Most of the students (83%) described that the media of the study materials (images, videos, graphics, and sounds) were of a high standard. Some technical problems (14%) were identified with the use of the materials.

Two subcategories were derived from the open-ended questions on technical usability: 1) visual layout of the modules and 2) technical aspects. The visual layout of the modules included the students' wish for the modules to be more uniform and the visual layout to be more versatile. They highlighted the importance of a bigger font size and better resolution of the text. Accordingly, the category of technical aspects indicated that some links, files, and web-tools were non-functional. The students also noted that there was a limitation in changing the size of the photos, and some of the photos were ambiguous. Furthermore, the navigation was challenging at the

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beginning of the course. Some students mentioned a problem with enrolment and using the study materials by phone.

'Modules could be uniform with each other'.
'Some of the photos could not be enlarged, which made the task difficult to complete.
'How to go from module to module was a bit confusing at the start'.
'On the phone did not work well'.

Table 1. Demographic characteristics of students

Variable (*N* = 135)	*n*	Percent
Gender		
Female	112	84
Male	20	15
Other/do not want to specify	1	1
Age		
17–19 years	7	5.2
20–24 years	97	72.4
25–29 years	18	13.4
30–34 years	7	5.2
35–39 years	1	0.8
40–44 years	2	1.5
45–49 years	2	1.5
50 years and more	0	0
Academic study year (AY)		
2nd AY student	39	28.9
3rd AY student	21	15.5
4th AY student	41	30.4
Other AY	34	25.2
Degree program		
Biomedical laboratory scientist	7	5.3
Registered nurse	87	65.9
Midwife	2	1.5
Public health nurse	26	19.7
Other	10	7.6

Figure 4 shows that the pedagogical usability of the ISC-MOOC was highly rated. The content of the learning materials was related to IPC. The study materials were suitable for (93%) and clarified the content of the IPC (87%), pointing out the learning objectives for each module (86%). Students stated that the study materials had added learning value compared to traditional learning methods, such as textual materials, instructional videos, and lectures (83%).

The content of the materials was suitable to the respondents' profession or field (92%), and the knowledge could be implemented into healthcare practice (89%) (Fig. 5). The ISC-MOOC provided useful feedback on their learning (79%), and these aspects increased the motivation to study IPC (72%).

The open-ended questions concerning the pedagogical usability of the ISC-MOOC were related to the quality and content of the learning materials as well as to the content and results of the quizzes. The quality of the materials was partially evaluated as poor because the given articles were stated to be too long and comprehensive. The content of the learning materials was relevant to the topic. The materials could include more interactive and fun content like pictures, videos, and games. The most challenging part for the students was the quizzes. They felt that the quizzes included unclear, partly irrelevant, and non-objective questions. The questions were not stated clearly, which interfered with answering. In addition, the quiz instructions changed between modules. The students felt there was a lack of feedback after the incorrect answers and after completing the quizzes. The estimated average time of completion of the ISC-MOOC was 2.3 h.

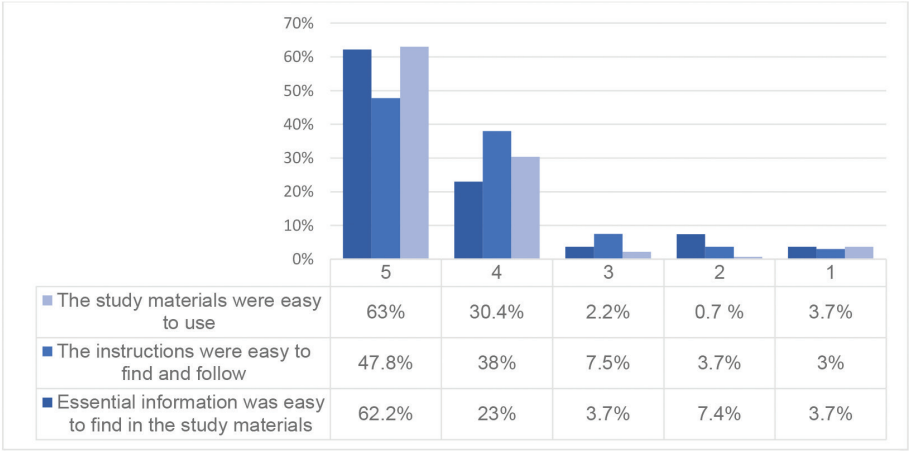
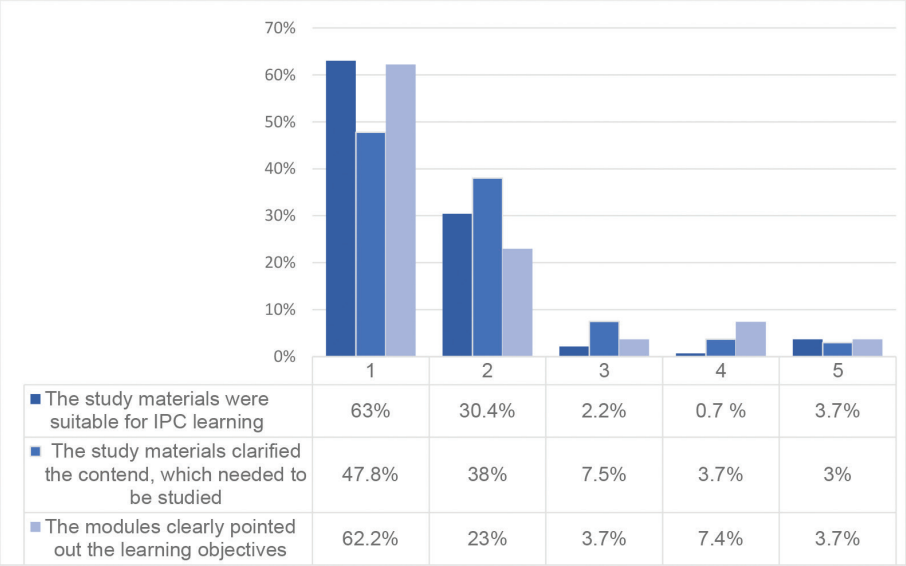
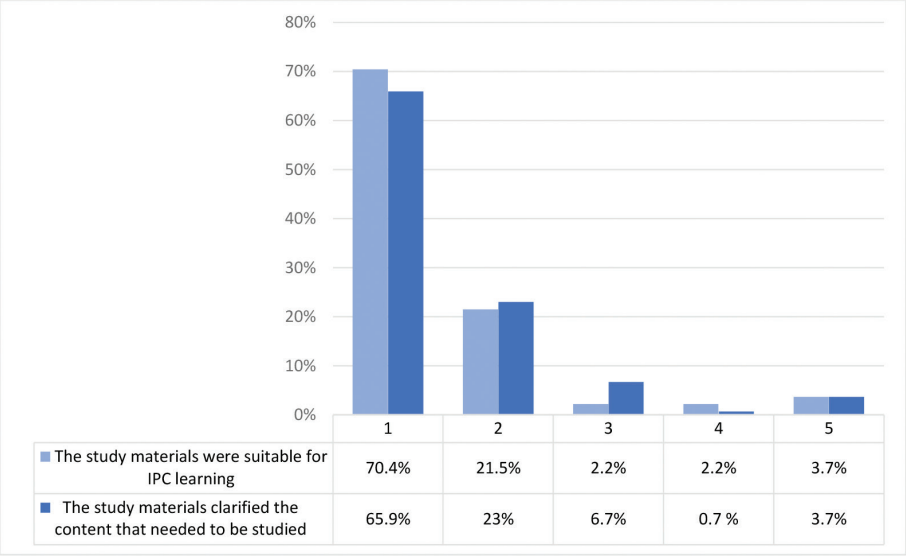


Fig. 3. Results of the technical usability of the ISC-MOOC study materials and instructions. 5 = completely agree, 4 = partially agree, 3 = do not agree or disagree, 2 = partially disagree, 1 = completely disagree.



	1	2	3	4	5
The study materials were suitable for IPC learning	63%	30.4%	2.2%	0.7 %	3.7%
The study materials clarified the contend, which needed to be studied	47.8%	38%	7.5%	3.7%	3%
The modules clearly pointed out the learning objectives	62.2%	23%	3.7%	7.4%	3.7%

Fig. 4. The results of the pedagogical usability of ISC-MOOC study materials and modules. 5 = completely agree, 4 = partially agree, 3 = do not agree or disagree, 2 = partially disagree, 1 = completely disagree.



	1	2	3	4	5
The study materials were suitable for IPC learning	70.4%	21.5%	2.2%	2.2%	3.7%
The study materials clarified the content that needed to be studied	65.9%	23%	6.7%	0.7 %	3.7%

Fig. 5. The results of the ISC-MOOC study material suitability for learning about infection prevention and control. 5 = completely agree, 4 = partially agree, 3 = do not agree or disagree, 2 = partially disagree, and 1 = completely disagree.

'The articles were a bit too long; it was hard to stay focused'.
'In my opinion the videos and posters are very concise and useful. With them it's easier to understand and study theory'.
'More clarity to the quizzes … there are some illogical and repeated questions'

The open-ended questions on student motivation comprised two subcategories: 1) enhancing motivation and 2) preventing aspects of motivation. The content and the relevance of the study materials enhanced the motivation to study the topic and complete the course materials. The students highlighted that there was a need for the ISC-MOOC. Some students believed that their proficiency in the English language was poor and would have preferred to have access to the study materials in their native language. Furthermore, the students reported that unclear study materials and limited digital skills decreased motivation to learn HAIs on ISC-MOOC.

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'It was more interesting than I expected'.
'There is a need for the course'.
'I do not understand English very well, so it was hard to understand difficult words'.
'More languages available (like Portuguese or Spanish)'.

Discussion

The ISC-MOOC facilitated healthcare students' independent learning about HAI prevention and control and promoted good practices. Students felt that the online activities motivated them to study infection control and most likely prepared students for the simulations and clinical practice where they can apply their theoretical knowledge (23). Learning about theoretical concepts from the ISC-MOOC also promoted understanding of the meaning of the importance of HAIs in health care. This type of pedagogical approach will supposedly strengthen the students' role as future healthcare professionals with high-quality clinical competence and enhance their entry into the labor market as transformational agents in clinical settings, positively contributing to the change of existing practices (24).

Students perceived the technical and pedagogical usability of the ISC-MOOC as good, while the materials were easy to use, information was easy to find, and the media were of high standard. On the contrary, negative features were also identified. For example, some links did not work properly, and there were problems with the navigation. The good usability of digital learning material is important to avoid having students lose their motivation to learn. Therefore, the technical usability of a learning unit aims to better the ease of its use, whereas the pedagogical usability aims to foster the meaningfulness of learning the content (25).

Students thought that the quality of the HAI prevention and control study material was reasonable. However, this MOOC contained too many reading activities, which was time-consuming. Moreover, study results indicate that there could have been more engaging elements such as simulations, social interactions, and a translation tool. Furthermore, in adapting teaching strategies to the model, either face to face or remote, it is essential to understand the challenges of incorporating more modern technologies into education. For example, using technologies like augmented and virtual reality requires adequate access to compatible devices and skills to use them.

MOOCs have been criticized earlier for having large student drop-out rates, which can be improved by increasing course interactivity, gamification, and other motivational contents (16). On the contrary, all healthcare and other disciplines' students as well are influenced by their lifelong learning, which is not only supported by the virtual learning environment but also based on intellectual and practical independence as well as students' ability to study independently and solve problems (26).

MOOCs are still a novel phenomenon in healthcare education, and there is a need for more scientific knowledge on the best practices for creating, implementing, and accrediting them (15). One of the necessary updates will be the production of different language versions. In this study, students gave feedback that they had some difficulties in understanding the articles because they were not used to reading English language texts. In earlier studies, it has been found that although studying in a foreign language promotes students' general expertise, studying new content in a foreign language may cause feelings of threat and discrimination (27). At the worst, linguistic challenges limit learning opportunities and professional growth and prevent the achievement of the learning objectives (28). To promote the use of the ISC-MOOC, it needs to be translated into the official language of each country.

According to the students, the MOOC added value to the HAI education compared to traditional learning methods. It has been recognized that online study platforms should be well-designed and organized, considering the variety of needs of the students, and to allow them to flexibly plan their studies (29). The study by Padilha et al. demonstrated that regardless of age, nurses found MOOCs useful in education and lifelong learning. This suggests that the ISC-MOOC will be suitable also for healthcare professionals who need to update their skills following today's HAI prevention and control requirements. Moreover, MOOCs open new opportunities for healthcare education and lifelong learning, enabling the improvement of patient safety (30).

The ISC-MOOC is suitable as such to be integrated into health curricula, which would, in all likelihood, reduce the number of student dropouts because the students would instead be motivated to complete the MOOC for credits. On the contrary, MOOCs should be of such high quality that students want to complete them (16). With the ISC-MOOC, healthcare teachers and educators gain an innovative pedagogical tool that can be integrated into healthcare education as an elective or a compulsory course. The ISC-MOOC could also greatly potentially benefit, for example, developing countries by offering access to up-to-date IPC learning materials.

Conclusion and recommendations

This novel ISC-MOOC was a feasible method of fostering IPC study motivation with healthcare students. Having identified the need for the language options, it is also necessary to alter the quality of the learning materials to meet the learning needs of the students. The ISC-MOOC will be available for free on the project website for all teachers and nursing students, nurses, and other

healthcare professionals. To obtain the MOOC, they will simply have to register (for free) as members of the InovSafeCare Community. Students with varying needs and backgrounds can benefit from using the ISC-MOOC, and thereafter, they transfer this benefit to their patients by being knowledgeable in IPC.

Acknowledgments

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Conflict of interest and funding

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Ethical considerations

Ethics Review Board (Ethics Committee Health Sciences Research Unit: Nursing (UICISA: E) of the Nursing School of Coimbra – reference 635/11-2019) approval was granted at each of the Healthcare Universities, and permission to collect data was approved in 2019. All participating students received a written information packet regarding the research topic of this study and gave verbal or written informed consent for their data to be used in this study.

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