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*Assessing the effectiveness of multimodal educational programs on the knowledge, attitudes, and practices of nurses in intensive care units regarding hand hygiene and healthcare-associated infections*

**SUMMARY OF THE DOCTORAL THESIS**

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# SYNTHESIS OF MAIN IDEAS

## I. The fundamental problem

Providing medical services in optimal conditions of quality and safety for patients is a professional and moral responsibility of professionals working in the medical field (physicians, nurses, physiotherapists, auxiliary staff, etc.). In this regard, professionals must have adequate skills to perform medical and care procedures that minimize any potential risk of medical error or adverse event associated with the medical act (AEAMA): healthcare-associated infections (HAI), pressure injuries, falls, surgical errors, medication errors, transfusion errors, etc. Regarding HAI, these are some of the most common AEAMAs that affect hospitalized patients globally, with a prevalence of 5% -10% of all hospitalized patients [1, 2]. In the case of Intensive Care Units (ICU), the level of prevalence of HAI is even higher, these complications being able to affect approx. 40-50% of patients cared for in these wards [3].

According to the World Health Organization (WHO), HAI consist of infections acquired by patients as a result of the provision of medical services in a medical institution, which were not present or incubated at the time of admission to the medical institution [2, 4]. Of these, urinary tract infection associated with urinary catheter, surgical site infection, vascular catheter-associated blood stream infection, and ventilator-associated pneumonia have been identified as the most common types of HAI in hospitalized patients [5]. The impact of these undesirable outcomes of healthcare delivery on the evolution of patients and healthcare facilities is particularly significant, with significant negative effects on increasing morbidity and mortality rates, hospitalization and additional costs associated with caring for patients with HAI [4].

Research to identify the causes of HAI has shown that the most common route of transmission of microorganisms responsible for producing HAI is through the contaminated hands of healthcare professionals (HCP) [6]. In this case, it is clear that non-compliance with hand hygiene or inadequate hand hygiene are the most important determinants of the occurrence and cross-transmission of HAI in medical institutions, and proper compliance with hand hygiene recommendations is the most effective method of prevention. and limitation of the HAI [6]. Unfortunately, studies conducted to assess the level of HCP compliance with hand hygiene have low compliance values (approx. 40%), which implies an increased risk of acquiring HAI by patients [6, 7].

In view of these issues, strategies have been developed and implemented to increase the safety of medical services provided to patients in medical institutions. Many of these strategies have proven effective in increasing hand hygiene compliance rates and lowering HAI rates: education and training, increasing accessibility and availability, use of alcohol-based products (ABP), reminder messages, promoting a safety culture, and more. However, in the end, it has been shown that the best results, in terms of sustained improvement in hand hygiene practices and reduction of HAI rates, have been achieved through the implementation of multimodal strategies, which include combinations of proven interventions and act simultaneously on several risk factors (observed or self-reported) and on several levels (individual, group, organization) [6].

In this regard, in order to be able to develop interventions aimed specifically at identified risk factors or barriers, research has been conducted to investigate the causes underlying non-compliant behaviors in HCP. Of all the causes identified, high workload, staff shortages, and overcrowding were significantly correlated with low levels of hand hygiene compliance and high HAI rates [8]. In this case, the role of organizational support becomes essential to ensure adequate conditions of patient care in medical institutions.

Another important cause of HCP non-compliance with hand hygiene protocols is the inadequate level of knowledge and attitudes regarding specific measures to prevent and limit HAI. Thus, it becomes essential that all HCP, including nurses, have appropriate knowledge, beliefs and attitudes in this area, which are subsequently transferred into daily patient care practice, through behaviors that comply with the recommendations of best practice based on evidence in the field of HAI prevention and control [9]. Ensuring an adequate level of knowledge and attitudes related to hand hygiene and preventing HAI can be achieved both through initial training programs for medical students and nursing, and through continuing professional education programs in which HCP participates throughout his professional career. Moreover, in the strategies to improve HCP compliance with HAI prevention and control recommendations, the literature mentions that educational interventions are central, as evidenced by a well-trained staff, with adequate knowledge and attitudes related to infection control, can significantly contribute to efforts to reduce the impact of HAI in medical institutions [6].

According to the WHO definition, HAI can affect both patients and staff working in medical institutions [2, 4]. In this case, the concerns of HCP and decision makers, related to the prevention and limitation of HAI and the impact of these complications on medical institutions,

are an issue that should be considered by both patient and professional safety. This is all the more evident and necessary in the current context, when the COVID-19 pandemic brought to the foreground the major importance of respecting hand hygiene and other measures to prevent the transmission of infections, both in the medical field and in the community.

The international literature presents numerous scientific researches on hand hygiene and HAI prevention in the medical field, both in terms of the level of knowledge, attitudes and compliance of HCP with hand hygiene, and the strategies applied to increase their compliance. Even so, as far as we know, there is no comprehensive research that addresses in a correlated way the evaluation of the knowledge, attitudes, self-reported practices of nurses in ICU, the measurement of their observed compliance with hand hygiene, the evaluation of the impact of an educational strategy on all these elements, as well as the role of the context and the organizational support in supporting the effects of the educational programs and of the individual approaches of the HCP destined to the improvement of the compliance with the hand hygiene. At the national level, however, very little research has aimed at investigating this important topic for the provision of quality medical and safety services for patients and professionals. Moreover, there is no published information regarding the level of knowledge, attitudes and practices of hand hygiene, both self-reported and observed, in the HCP of the ICU in Romania, much less for the nurses in the ICU. Also, there are no communicated results of the implementation of strategies to improve the knowledge, attitudes and practices of hand hygiene at HCP in the Romanian ICU.

Thus, in order to assess the level of knowledge, attitudes and practices related to hand hygiene and HAI in nurses working in ICU, we conducted a scientific research at four major hospitals in Bucharest, conducted in three distinct periods: before the implementation of a multimodal educational intervention, immediately after the application of the intervention and at 3 months after the application of the intervention.

This PhD thesis comprises a **General Part**, with *three chapters*, which addresses the topic of HAI, hand hygiene, as well as HCP knowledge, attitudes and practices related to hand hygiene and HAI. The **Special Part** of the PhDThesis comprises *seven chapters*, as follows: *a chapter* presenting the results of the pilot study for the development and validation of the questionnaire used in the main scientific research; *a chapter* in which the general methodological aspects of the main scientific research are presented; *two chapters* presenting the results of studies aimed at the initial assessment of nurses' knowledge, attitudes and practices, self-reported and observed, in

hand hygiene and HAI; *two chapters* presenting the results of studies aimed at determining the effectiveness of the multimodal educational program implemented on the knowledge, attitudes and practices, self-reported and observed, of nurses in terms of hand hygiene and HAI; *a chapter* with personal conclusions and contributions.

The results obtained from the scientific research confirmed the fulfillment of the research objectives and the working hypotheses established in the studies. In this regard, it has been shown that the initial level of knowledge, attitudes and practices of ICU nurses regarding hand hygiene and HAI are inadequate, and the multimodal educational program, applied in the main scientific research, has proved to be effective, by significantly improving the knowledge, attitudes and practices of nurses. Regarding the association between compliance with hand hygiene indications and the incidence of HAI, the heterogeneity of the reported data and the methodology of statistical data processing did not allow to demonstrate the existence of a direct relationship.

Given that hand hygiene and HAI prevention are areas applicable in any ward of a hospital and in any type of medical institution, these results become important and very useful, by providing an evaluation and implementation model that can be used in other clinical and scientific context, in order to improve the skills and professional activity of nurses. Future research directions may also cover all professional categories involved in the care of patients in ICU, but also in other departments of a hospital, in other hospitals and other medical institutions in Bucharest, as well as in other regions of our country.

## **II. Hypothesis, Objectives and Research Methodology**

Nurses are the largest HCP in the world and an essential part of the medical team in any medical field. Because HCP are present with patients most of the time, nurses perform a significant number of care procedures, and thus adherence to hand hygiene guidelines is a key element in daily care practice. In this case, it is mandatory for nurses to have adequate skills in the field of HAI prevention, in order to apply a safe and quality care process. Within these competencies, nurses' compliance with proper hand hygiene is central to the provision of clean and safe care for patients. In this regard, in order to ensure an optimal level of compliance, nurses need to have adequate knowledge and attitudes regarding hand hygiene and HAI prevention, and this goal can be achieved by regularly participating in forms of continuing medical education (CME) on specific

topics. These requirements are all the more important and necessary in the case of ICU, which are known for their increased risk of developing HAI.

In order to be able to obtain objective data on the knowledge and attitudes of HCP in relation to hand hygiene and HAI, as well as their possible educational needs, it is necessary to periodically evaluate these elements, by applying evaluation tools, standardized and validated. To date, a tool for assessing the knowledge, attitudes and practices of nurses in the field of hand hygiene and HAI has not been validated in our country. Also, there are no data on the level of knowledge, attitudes, beliefs and practices of hand hygiene and prevention of HAI among nurses in Romania, including ICU.

Considering the above, as well as the objectives of this thesis, which aims to assess the knowledge, attitudes and self-reported practices of nurses in ICU, I considered it appropriate to develop and validate a questionnaire to assess knowledge, attitudes and practices in the field of hand hygiene and HAI, in a **preliminary stage** of the scientific research of this doctoral thesis. To this end, I conducted a **pilot study**, and **Chapter 4** of the thesis presents the **process of elaboration and validation of this questionnaire**.

**Chapter 5** of the thesis describes the **general methodology of the main scientific research** of this doctoral thesis, the main research stage which consisted in carrying out **four main research studies**, presented in **chapters 6, 7, 8 and 9**. Thus, given that the four studies were conducted according to a different methodology from the pilot study (sample of subjects, research tools, data collection methods), the general methodology of the main scientific research, presented in this chapter, describes the common methodological framework for conducting the four main research studies.

**Chapter 6** presents study no. 1, which aimed at the *initial assessment* of the knowledge, attitudes and *self-reported* practices of nurses in adult ICU in four hospitals in Bucharest. The evaluation was performed by applying the validated *questionnaire before implementing a multimodal educational intervention*.

**Chapter 7** describes study no. 2, conducted to evaluate *the effectiveness of multimodal educational intervention* on the knowledge, attitudes and *self-reported* practices of nurses in adult ICU in four hospitals in Bucharest. The evaluation was performed by applying the validated *questionnaire* in two moments: *immediately after the implementation of the educational intervention*, as well as *3 months after the intervention*.



**Chapter 8** presents study no. 3, which aimed at the *initial assessment of observed compliance* with the indications of hand hygiene in nurses in adult ICU in four hospitals in Bucharest. The evaluation was performed by conducting *direct observation* sessions of hand hygiene practice, *before applying a multimodal educational intervention*.

**Chapter 9** presents the study no. 4, carried out to evaluate the *impact of the implemented multimodal educational intervention* on the *observed compliance* with ensuring adequate hand hygiene in nurses from adult ICU in four hospitals in Bucharest, and implicitly on the incidence of HAI in ICU. The evaluation was performed by conducting sessions of *direct observation* of the practice of hand hygiene of nurses, as well as by communicating with the Specialized Services/ Departments for the prevention of HAI in hospitals, *immediately after the application of the educational intervention*, and *3 months after the intervention*.

### ***A. Working assumptions and general objectives***

**The aim** of the main scientific research in this doctoral thesis was to study the effectiveness of *Multimodal Educational Programs* (MEP) on the knowledge, attitudes and practices, self-reported and observed, of nurses in adult ICU in Bucharest, in terms of hand hygiene and HAI.

**The research (working) hypotheses** that formed the basis of the main scientific research of the thesis resulted from the study of the current scientific literature in the field, as well as from the data obtained by conducting the pilot study, which showed that nurses in Romanian medical institutions, including those in the ICU, have an inadequate level of knowledge, attitudes and self-reported practices related to hand hygiene and HAI. These hypotheses are:

- The level of knowledge, attitudes and self-reported practices of ICU nurses regarding hand hygiene and HAI are inadequate.
- MEP can improve the level of knowledge, attitudes and self-reported practices of nurses in ICU regarding hand hygiene and HAI.
- The observed compliance rate with the indications of hand hygiene, in the nurses of the ICU, is low.
- Improving the knowledge, attitudes and self-reported practices of ICU nurses regarding hand hygiene and HAI may increase their observed compliance with hand hygiene indications and thus reduce the incidence of HAI in ICU.

Thus, as a result of the data provided by the scientific literature and the results of the pilot study, **two research questions** emerged:

1. Can the implementation of a MEP improve the knowledge, attitudes and self-reported practices of nurses in ICU regarding hand hygiene and HAI?
2. Can improving the knowledge, attitudes and self-reported practices of nurses in ICU in relation to hand hygiene and HAI improve their observed compliance with hand hygiene indications, and also reduce the incidence of HAI in ICU?

In order to be able to verify the established research hypotheses and answer the two research questions, the following **general research objectives** were established:

1. Assessing the effectiveness of the MEP on the knowledge, attitudes and self-reported practices of ICU nurses.
2. Assessing the impact of the MEP on observed compliance with the hand hygiene indications for nurses in the ICU and, also on the incidence of HAI in the ICU.

## ***B. General research methodology***

**The first part** of the main scientific research consisted of documenting and analyzing the scientific literature, a stage that ended with the *development of the scientific research framework* for assessing the knowledge, attitudes and practices, self-reported and observed, of ICU nurses, before and after implementation of a multimodal educational intervention. Thus, the framework for conducting the main scientific research comprised **four distinct stages**:

1. **Initial assessment stage**, before the educational intervention (*pre-intervention*)
2. **Educational Intervention** (*Multimodal Educational Program*)
3. **Evaluation stage immediately after the educational intervention** (*post-intervention immediately*)
4. **Evaluation stage 3 months after the educational intervention** (*post-intervention follow-up*)

**The educational intervention** implemented in this scientific research consisted of a **Multimodal Educational Program (MEP)**, which was developed based on the results obtained in the pilot study and which was revised based on the results obtained at the initial evaluation. The MEP comprised the following components:

- ✓ A 15-hour course on hand hygiene and HAI.
- ✓ Conducting *practical demonstrations* on hand hygiene; providing feedback.

- ✓ Watching videos on hand hygiene and HAI.
- ✓ Presentation and distribution of *informative materials* on hand hygiene and HAI.

Following the framework of the main scientific research, elaborated previously, **the second part** of the main scientific research, presented in **Chapters 6, 7, 8 and 9**, consisted in carrying out four longitudinal studies, descriptive, comparative, with pre-post intervention type measurement, by using the single-group model. Thus, **the four studies** that are part of the main research of this doctoral thesis are:

1. **Initial assessment of the knowledge, attitudes and self-reported practices of nurses in the ICU**, by applying the assessment questionnaire *before the intervention* (MEP).
2. **Evaluation of the effectiveness of the intervention (MEP)** on the knowledge, attitudes and self-reported practices of the nurses in the ICU, by applying the evaluation questionnaire *immediately after the intervention* and *3 months after the intervention*.
3. **Initial assessment of observed compliance with hand hygiene indications**, by conducting direct observation sessions for one month *before the intervention* (MEP).
4. **Assessment of the impact of the intervention (MEP) on observed compliance with the indications of hand hygiene**, by conducting direct observation sessions, for a period of one month *immediately after the intervention* and a period of one month *after 3 months after the intervention*.

### **The medical institutions where the main scientific research took place**

The main scientific research studies were carried out in ICU within four important public medical institutions in Bucharest: (1) Fundeni Clinical Institute Bucharest, (2) Elias University Emergency Hospital Bucharest, (3) Emergency Institute for Cardiovascular Diseases "Prof. Dr. C.C. Iliescu" Bucharest and (4) The Oncological Institute "Prof. Dr. Alexandru Trestioreanu" Bucharest. The scientific research was carried out with the approval of the institutional management and the study approval commissions from the four hospitals involved in the research. Also, the research was carried out in accordance with the request for the issuance of the opinion of the ethics commission of scientific research of the University of Medicine and Pharmacy "Carol Davila" in Bucharest. In addition, the voluntary consent of nurses for participation in the study and for the processing of personal data was obtained. All measures to ensure the confidentiality and security of the data provided by the research participants have also been taken. An additional measure to ensure the anonymity of the data collected from the four hospitals participating in the study and the results

obtained from the processing of these data was the random coding of the name of these hospitals, with hospital A, B, C and D, and the use of this coding. for the presentation of the results.

Given that the scientific research related to this thesis had **two main components**:

1. The study of **knowledge, attitudes and self-reported practices** on hand hygiene and HAI in ICU nurses, carried out in three moments: *before the intervention, immediately after the intervention and 3 months after the intervention*,
2. Study of **observed compliance with the hand hygiene indications** of the nurses in the ICU, carried out in three periods of one month each: *before the intervention, immediately after the intervention and 3 months after the intervention*,

*the sample of subjects, the research tool and the way data were collected* were different for each of the two components of the research.

### **The sample of nurses of the main scientific research**

*Study of the knowledge, attitudes and self-reported practices of nurses in ICU on hand hygiene and HAI.* In the pre-intervention and immediate post-intervention stages, the sample consisted of 184 nurses working in the ICU from the four hospitals involved in this scientific research. In the follow-up phase, the sample was reduced to 176 nurses, but the difference between the two samples was not significant, so it allowed the comparative analysis of the data.

*Study of observed compliance with hand hygiene indications in ICU nurses.* The sample of subjects observed in the pre-intervention phase consisted of 165 nurses in the ICU from the four hospitals included in this study. In the immediate post-intervention stage, a number of 176 nurses were observed, and in the follow-up stage 143 nurses.

### **The research tools used in the main scientific research**

*Study of the knowledge, attitudes and self-reported practices of nurses in ICU on hand hygiene and HAI.* The research tool I used to assess the knowledge, attitudes and self-reported practices of ICU nurses was an original *questionnaire* with 32 items, validated in the previous pilot study for use in main research of this thesis. The questionnaire included 8 items for recording demographic and occupational data, 10 items for assessing the level of knowledge, 5 items for assessing attitudes, 8 items for assessing self-reported practices and an item for recording the number of patients cared for during a shift.

*Study of observed compliance with hand hygiene indications in ICU nurses.* The research tool I used to assess observed compliance with hand hygiene in ICU nurses consisted of a *Hand Hygiene Direct Observation Sheet*, adapted from the model developed by WHO in 2009 [10].

## **Data collection in the main scientific research**

*Study of the knowledge, attitudes and self-reported practices of nurses in ICU on hand hygiene and HAI.* To assess knowledge, attitudes, and self-reported practices, I applied the survey method, using a 32-item *questionnaire*, which was completed by the ICU nurses participating in the study, under the supervision of the study's lead investigator, in all three evaluation stages: *before by participating in MEP* (184 nurses), *immediately after participating in MEP* (184 nurses) and *after 3 months from participating in MEP* (176 nurses).

*Study of observed compliance with hand hygiene indications in ICU nurses.* In order to assess observed compliance with the indications of hand hygiene, I applied the *method of direct observation*, considered the *gold standard* in this field [6, 11]. To collect compliance data, I conducted sessions of direct observation of ICU nurses' hand hygiene practice, where I used the *Hand Hygiene Direct Observation Sheet*, adapted from the Observation Form (WHO 2009) [10]. The observation sessions were conducted for one month, in all three stages of the evaluation: *before participating in the MEP* (165 nurses), *immediately after participating in the MEP* (176 nurses) and *after 3 months of participating in the MEP* (143 nurses).

*Study of the incidence of HAI in the ICU in the four hospitals included in the study.* To investigate the link between improved knowledge and compliance with hand hygiene indications due to the participation of nurses from ICU in MEP, and the decrease in the number of HAI, I collected data on the incidence of HAI per 100 outpatients in the ICU included in the research. The data collection was done by communicating with the representatives of the Specialized Prevention Services/Departments of the HAI from the four hospitals.

## **Statistical analysis of data in the main scientific research**

Databases and statistical processing were performed with IBM SPSS version 20. Both descriptive statistics (absolute and relative frequencies, averages, standard deviations) and inferential statistics were calculated using correlations (Chi-square test, ANOVA, linear correlations), to test the meanings of the differences between the values recorded for different descriptive parameters,

depending on the categories of interest for the research. The analysis criterion used was represented by the three moments of application of the questionnaire, respectively the three periods of conducting the observation sessions (pre-intervention, immediate post-intervention and post-intervention at 3 months). To determine the statistical significance of the differences between the data were the values of  $p$ , at a significance threshold  $p < 0.01$ , respectively  $p < 0.05$ .

### III. Synthesis of Chapters

#### Pilot study on the development and validation of a tool for assessing the knowledge, attitudes and self-reported practices of nurses

This chapter presents the results of the preliminary research phase of this thesis, namely information on the process of developing and validating a questionnaire to assess the knowledge, attitudes and self-reported practices of nurses in terms of hand hygiene and HAI. Following validation, this questionnaire will be used in the main scientific research of this doctoral thesis, in order to assess the knowledge, attitudes and self-reported practices of nurses working in ICU.

**Purpose:** To develop and validate a questionnaire to assess the knowledge, attitudes, and self-reported practices of nurses regarding hand hygiene and HAI.

**Specific objectives:** The objectives of this study were to develop and validate a questionnaire needed to assess the knowledge, attitudes and self-reported practices of nurses in ICU, in the main scientific research of this doctoral thesis. At the same time, I aimed to identify the deficient domains, as well as the educational needs of nurses in Romania, including in Anesthesia and Intensive Care (AIC) departments, necessary for the elaboration of the course curriculum of the multimodal educational program implemented within the main scientific research of the thesis.

**Material and method. In the first stage of this study,** I conducted a comprehensive and systematic scientific documentation to investigate the current state of knowledge in the field of hand hygiene and HAI prevention. The search for the relevant scientific literature in English and Romanian was performed in the online databases MEDLINE [PubMed], CINAHL, PsycINFO [Ovid], Scopus, Google Scholar, JBI Library, Cochrane Library, Web of Science and the following key words were used: hand hygiene, hand rubbing, hand washing, the 5 moments of hand hygiene, observed compliance, healthcare-associated infections, knowledge, attitudes, self-reported practices, nurses, questionnaire. After studying the relevant publications, I developed an original structured questionnaire with 32 items: "*Questionnaire for assessing the knowledge, attitudes and*

*practices of nurses, midwives and medical assistants regarding hand hygiene and healthcare-associated infections."*

**In the second stage of the study,** I conducted a prospective cross-sectional descriptive study, in order to test and validate the developed questionnaire, but also to identify the level of knowledge, attitudes and self-reported practices of nurses working in different types of departments and medical institutions, from all parts of the country. The study involved completing the questionnaire by the nurses participating in the National Conference of OAMGMAMR, which took place between September 13-14, 2018 in Bucharest. The questionnaire was provided to a number of 874 nurses, through the conference map, and was completed voluntarily by 576 participants at the beginning of the event (response rate 65.9%). Completing and returning the questionnaire was the agreement of the nurses to participate in the research study. In addition, the anonymity and confidentiality of the data provided by the participants were ensured. For statistical analysis, the data obtained by applying the questionnaire were entered into the IBM Statistical Package for the Social Sciences (IBM SPSS) version 20.

In the case of *demographic data*, descriptive statistics (frequencies and/or averages) were calculated. For the validation of knowledge items, *difficulty indices*, *discrimination indices* and *internal consistency analysis* (Cronbach's alpha coefficient) were calculated. In order to identify the level of knowledge, an *overall score* was calculated for each respondent, and by using the *cut points* option for 3 equal groups, three levels were determined: *high*, *medium* and *low*. The relationships between the level of *knowledge* and other variables were analyzed using correlations, ANOVA or the Chi Square coefficient, depending on the type of the variable correlated with knowledge. For items related to *attitudes and practices*, descriptive statistics (frequencies) were calculated. In the case of open-ended items, descriptive statistics were calculated after the different responses were analyzed by two researchers and aggregated into main categories.

**Results and discussions.** The results I obtained in this pilot study demonstrated the validity of the questionnaire developed following the scientific documentation, which can thus be used in the main scientific research of this doctoral thesis. Also, the application of this questionnaire in the pilot study allowed the identification of the level of knowledge, attitudes and self-reported practices of nurses in Romania, as well as the lack of specific knowledge and their educational needs. The identification of these aspects represented the basis on which I developed the conceptual framework of the *Multimodal Educational Program (MEP)*, this representing the

*educational intervention* intended to be implemented within the main scientific research of the thesis. Regarding the conclusions related to the results of the evaluation of the level of knowledge, attitudes and self-reported practices regarding hand hygiene and HAI in nurses in Romania, including from the ICU, these are the following:

- *Approximately 50% of nurses in Romania have average level of knowledge (scores between 5-7): 58% of the entire study group, respectively 49% of nurses in AIC departments.*
- *Nurses from AIC departments in Romania have significantly better knowledge ( $6.17 \pm 2.01$ ) than nurses from other departments/institutions (the whole group studied) -  $5.51 \pm 2.07$ .*
- *The deficient domains in terms of level of knowledge, similar for the whole study group and for the nurses in the AIC departments, are: (1) hygienic hand disinfection with ABP, (2) the 5 moments of hand hygiene, (3) the percent of preventable HAI, (4) the impact of HAI and (5) the wearing of gloves.*
- *There is a significant negative correlation between the level of knowledge of nurses in Romania and the number of patients cared for during a shift.*
- *An important percentage of nurses in Romania (79% of the whole group and 87% of those in the AIC departments) report high levels, of at least 70-80%, of compliance with hand hygiene.*
- *There is a significant association between self-reported compliance of nurses in Romania and access to hand hygiene resources, and recent participation in CME.*
- *Romanian nurses prefer washing with soap and water as a method of hand hygiene (85%); this preference is less prevalent among nurses in AIC departments (56%).*
- *There is a higher percent of nurses in Romania who state that they follow the indication after patient care as a priority (58%) compared to 42% who state that they follow the indication before patient care.*
- *The first 3 categories of causes of non-compliance with the indications of hand hygiene cited by nurses in Romania are: (1) causes related to the particularities of the activity, (2) causes related to the management of the unit and (3) causes related to level of training or knowledge; in the case of AIC departments, third place is given to causes related to nurses, cases which also include issues related to the level of training or knowledge.*
- *The 3 main categories of strategies useful for improving compliance with hand hygiene indications, mentioned by nurses in Romania, including those in AIC departments, are: (1)*



*solutions related to work organization, (2) solutions related to supply with hand hygiene solutions or materials and (3) education and training solutions.*

**Conclusions.** Issues of HAI prevention and limitation measures are more than relevant to the ICU, where concerns for HAI control, raising awareness of the importance of hand hygiene and raising awareness of the risk of HAI are particularly important and necessary for improving hand hygiene behaviors. It is therefore essential to have information on the level of knowledge, attitudes and practices of nurses working in ICU. In this sense, the next step will be to apply the questionnaire validated in this pilot study at the level of a representative group of ICU nurses from four major hospitals in Bucharest, who are in fact the sample of the main scientific research of this thesis.

Also, identifying the inadequate level of knowledge and deficient domains of hand hygiene and preventing HAI, achieved through this pilot study, argues the need for targeted educational intervention, tailored to the educational needs, in order to improve nurses' knowledge, attitudes and practices. In this sense, the deficit of knowledge and attitudes identified in this pilot study facilitates the development of a *Multimodal Educational Program*, which will represent the educational intervention to improve the knowledge, attitudes and practices of nurses in ICU in Bucharest, in the main scientific research of the thesis.

In addition, the usefulness of the questionnaire validated in this pilot study derives from the possibility of using this questionnaire in medical institutions across the country to assess knowledge, attitudes and self-reported practices related to hand hygiene and HAI prevention in all HCP involved in medical services. The results of these assessments will be able to underpin the implementation of targeted interventions to improve the safety and quality of care. Furthermore, this will facilitate the regular audit of HCP knowledge and attitudes, as well as the identification of knowledge gaps and inappropriate attitudes in key areas related to hand hygiene and HAI. Subsequently, these results obtained from the application of the questionnaire will allow the development of training curricula adapted to the identified educational deficits and the regular development of educational programs for the needs of HCP, and implicitly of nurses.

Also, given that the literature mentions the existence of important differences between self-reported and observed practices of HCP, an objective of the main scientific research will be to conduct an observational study to identify the level of compliance observed with hand hygiene in nurses in ICU in Bucharest.

## Study no. 1 - Assessment of the initial level of knowledge, attitudes and self-reported practices of nurses in the ICU (*pre-intervention*)

Following the pilot study, I identified the existence of an inadequate level of knowledge among nurses in various departments and medical institutions across the country. I also identified the existence of specific domains of hand hygiene and HAI, for which nurses have a significant knowledge deficit. Following these findings, as well as data from the literature showing that ICU are at high risk of developing HAI, I have determined that a study is needed to assess the initial level of knowledge, attitudes and self-reported practices of nurses in adult ICU from four major hospitals in Bucharest, by applying the *questionnaire* validated in the pilot study.

**Working hypothesis:** The level of knowledge, attitudes and self-reported practices of ICU nurses regarding hand hygiene and HAI are inadequate.

### Specific objectives:

1. Assessment the *level of knowledge* on hand hygiene and HAI in ICU nurses before applying the multimodal educational intervention (MEP).
2. Assessment of ICU nurses' *attitudes* towards hand hygiene and HAI before applying the multimodal educational intervention (MEP).
3. Assessment of *self-reported practices* of ICU nurses regarding hand hygiene and HAI before the application of multimodal educational intervention (MEP).
4. Identification of *initial deficient domains* of knowledge, the inadequate self-reported attitudes and practices of ICU nurses in order to provide an educational intervention tailored to their educational needs, as well as to review the MEP course support, which was developed on the basis of the lack of knowledge identified in the pilot study.
5. Identify the *self-reported causes of non-compliance* with hand hygiene indications in nurses in the ICU, as well as possible *useful strategies* to improve their compliance with hand hygiene indications, in pre-intervention.
6. Comparative assessment of the knowledge, attitudes and self-reported practices of ICU nurses *in the four hospitals* included in the research, in pre-intervention.
7. Comparison of the results obtained in this study, in terms of knowledge, attitudes and self-reported practices of nurses in the ICU in hospitals in Bucharest, with the results obtained in the pilot study, related to the knowledge, attitudes and self-reported practices of nurses in ICU in medical institutions in Romania.

**Material and method.** For the initial assessment of knowledge, attitudes, and self-reported practices regarding hand hygiene and HAI in nurses in adult ICU at the four hospitals in Bucharest, I used the 32-item evaluation *questionnaire*, validated in the pilot study. The questionnaire was completed by 184 nurses before participating in MEP.

In the case of the 10 *knowledge* assessment items, each correct answer was marked with 1 point and each wrong answer with 0 points, so the *maximum possible score* was 10 (*solid knowledge*) and the *minimum possible score* was 0 (*lack of knowledge*). I also created *three categories of knowledge levels*, depending on the score obtained in the assessment: (1) scores *between 8 and 10* - *high level of knowledge*; (2) scores *between 5 and 7* - *medium level of knowledge*; (3) scores *<5* - *low level of knowledge*. In the case of domains with deficient knowledge, I made the following classification: (1) domains with *major knowledge deficit* (> 40% wrong answers); (2) domains with *medium knowledge deficit* (20-40% wrong answers); (3) domains with *minor knowledge deficit* (<20% incorrect answers).

**Results and discussions.** The results obtained after carrying out this study, in the period of pre-educational intervention, proved the fulfillment of the research objectives and led to the issuance of the following findings:

- ICU nurses in Bucharest have *medium level knowledge, positive attitudes, and overestimated self-reported practices* in hand hygiene and HAI; the results confirm the working hypothesis.
- Domains with deficient specific knowledge are related to *the 5 moments of hand hygiene, hand disinfection with ABP, impact and prevention of HAI and wearing gloves*.
- Almost 80% of ICU nurses in Bucharest prefer *hand washing with soap and water* compared to *hand disinfection with ABP*.
- Almost 90% of ICU nurses in Bucharest say they have *sufficient resources* for hand hygiene at work, and 98% say that *managers promote the importance of hand hygiene*.
- Only half of ICU nurses in Bucharest have *participated in CME forms* on hand hygiene and HAI in the last year.
- Only half of the nurses in the ICU in Bucharest *know the percentage of HAI, respectively the rate of compliance with hand hygiene*, in the department where they work.
- There are significantly higher levels of *declared compliance* in the case of nurses who responded affirmatively to the item on *promoting the importance of hand hygiene by managers*, respectively to the item on *knowing the rate of compliance with hand hygiene*.

- Most ICU nurses in Bucharest have *positive beliefs* about *the role of jewelry and long nails in the etiology of HAI*, *the importance of hand hygiene for HAI prevention* or *the impact of HAI prevention on patient safety*.
- The main 3 *categories of causes of non-compliance* with hand hygiene indications, cited by nurses from the ICU in Bucharest, are: (1) *causes related to the particularities of the activity*, (2) *causes related to the management of the unit* and (3) *causes related to by nurses*.
- The main 3 categories of *factors facilitating compliance* with the indications of hand hygiene, mentioned by the nurses from ICU in Bucharest, are: (1) *solutions related to management/work organization*, (2) *solutions related to supply of materials* and (3) *solutions related to compliance with procedures and protocols*.
- There are significant differences between *the ICU nurses of the four hospitals in Bucharest* included in the study: average knowledge scores around 7 for two hospitals (A and C) and around 6 at the other two hospitals (B and D); significantly overestimated self-reported practices in nurses in hospital B compared to those in hospital A; a significantly more present practice of disinfection with alcoholic solutions in subjects from hospital A; significantly lower availability of resources for hospital C subjects; significantly higher participation in forms of CME in subjects in hospitals A and C; significantly lower knowledge of the HAI percentage in hospitals C and D; significantly lower knowledge of the rate of compliance with hand hygiene in subjects in hospital D; the nurses in hospital A show a much more critical attitude towards the causes of non-compliance, and those in hospital C mention more frequently the causes related to institutional management and the supply of materials.
- There are differences between *ICU nurses in Bucharest*, evaluated in this initial evaluation study, and *ICU nurses in Romania*, evaluated in the pilot study: higher average knowledge score of nurses in Bucharest compared to those in the country; only 55% of nurses in Bucharest participated in forms of CME compared to 81% of those nationwide; fewer nurses in Bucharest reported maximum levels of compliance and reported using alcohol solutions more frequently; several nurses in Bucharest said they had sufficient resources for hand hygiene; less than half of the nurses in Bucharest stated that they have knowledge about the percentage of HAI or the rate of compliance with hand hygiene in the department where they work, compared to approx. 70% of those across the country; higher percentages of *causes*

*related to the particularities of the activity and lower percentages for causes related to the management of the unit or causes related to nurses to nurses in Bucharest.*

**Conclusions.** Given the results of this initial assessment study, there is a need to implement an educational program tailored to the identified educational needs, by reviewing the curriculum I developed based on the knowledge gap identified in the pilot study. There is also a need to improve organizational support by ensuring sufficient and quality resources, conducting regular educational and training programs, monitoring hand hygiene practice, providing feedback on HAI rates and compliance with hand hygiene indications, and so on. In addition, taking into account the subjectivism involved in self-reporting of practices and attitudes, as well as the high tendency to overestimate, it is necessary to conduct an observational study (study no. 3), in order to objectively evaluate, by direct observation, hand hygiene practices of the nurses from the ICU in Bucharest.

### **Study no. 2 - Assessing the effectiveness of multimodal educational programs on the knowledge, attitudes and self-reported practices of ICU nurses (immediate post-intervention and 3-month post-intervention)**

The results of the study for the initial assessment of the knowledge, attitudes and self-reported practices of nurses in adult ICU in Bucharest showed that they have inadequate knowledge and overestimated practices regarding hand hygiene and HAI prevention. The initial assessment also showed that the assessed nurses had a significant lack of knowledge regarding some key issues specific to HAI prevention and limitation programs: *the impact and prevention of HAI, the 5 moments for hand hygiene, hygienic disinfection of hands with ABP and wearing gloves*. In view of these findings, I implemented a *Multimodal Educational Program* (MEP), which I developed following the results obtained in the pilot study and which I revised based on the results of the initial knowledge assessment of ICU nurses (Study No. 1). The aim of the MEP was to improve the level of knowledge, attitudes and self-reported practices of nurses in ICU. Subsequently, in order to be able to evaluate the effectiveness of the applied multimodal educational intervention (MEP), I applied again the *questionnaire* that I used in the initial evaluation, in two other moments: *immediately after the intervention and 3 months after the educational intervention*.

**Working hypothesis:** Multimodal Educational Programs (MEP) can improve the level of knowledge, attitudes and self-reported practices of nurses in ICU regarding hand hygiene and HAI.

**Specific objectives:**

1. Assessment of the *immediate effectiveness* of the MEP on the knowledge, attitudes and self-reported practices of ICU nurses (*immediate post-intervention*).
2. Assessment of the *over time effectiveness* of the MEP and the degree of retention of improved knowledge, attitudes and self-reported practices, as a result of the participation in the MEP of ICU nurses (*post-intervention follow-up at 3 months*).
3. Assessment of the impact of the MEP on the initial *deficient domains* of knowledge, as well as on the inadequate attitudes and self-reported practices of ICU nurses (*immediate post-intervention* and *post-intervention follow-up at 3 months*).
4. Assessment the impact of the MEP on *self-reported causes of non-compliance* with hand hygiene indications in nurses in the ICU, as well as on possible *useful strategies* to improve their compliance with hand hygiene indications (*immediate post-intervention* and *post-intervention follow-up at 3 months*).
5. Comparative assessment of the impact of the MEP on the knowledge, attitudes and self-reported practices of ICU nurses *in the four hospitals* included in the research (*immediate post-intervention* and *post-intervention follow-up at 3 months*).

**Material and method.** To assess the effectiveness of the MEP on the knowledge, attitudes and self-reported practices of nurses in adult ICU in four hospitals in Bucharest, I used the 32-item *evaluation questionnaire*, which was also used in the initial evaluation stage (in *pre-intervention*). The questionnaire was completed by 184 nurses *immediately after* participating in MEP, respectively by 176 nurses *at 3 months after* participating in MEP. In the case of the 10 *knowledge* assessment items, each correct answer was marked with 1 point and each wrong answer with 0 points, so the *maximum possible score* was 10 (*solid knowledge*) and the *minimum possible score* was 0 (*lack of knowledge*). Classification with three categories of knowledge levels was also used: (1) scores *between 8 and 10* - *high level of knowledge*; (2) scores *between 5 and 7* - *medium level of knowledge*; (3) scores *<5* - *low level of knowledge*.

**Results and discussions.** Following the implementation of MEP and the participation of ICU nurses from four hospitals in Bucharest in this program, I identified significant improvements in *knowledge*, evidenced by significant differences in *average knowledge scores*, in the three moments of evaluation:  $6.46 \pm 1.33$  before MEP,  $8.47 \pm 1.50$  immediately after MEP and  $8.07 \pm 1.62$  at 3 months after MEP. Also, the percent of nurses with a medium level of knowledge

decreased from 73% before MEP to 21% immediately after MEP, and to 28% at 3 months after MEP. In addition, significant differences were identified between the average knowledge scores of the subjects from *the four hospitals* included in the study, in all three evaluation moments: in the *pre-intervention*, the subjects from two hospitals (A and C) had an average score of approx. 7, and those in the other two hospitals (B and D) a score of approx. 6; *immediately after the intervention*, the impact of MEP increased by approx. two points of the average score for all four hospitals; *at 3 months after MEP*, for three of the four hospitals (A, C and D) the improved knowledge was maintained, but at the fourth hospital (B) the average score decreased by one point compared to the level identified immediately after MEP.

The analysis of the respondents' responses to the 10 items for knowledge assessment, provided in the three assessment moments, allowed to demonstrate the immediate and long-term effectiveness of the applied MEP, as well as the retention of improved knowledge as a result of participating in the MEP. There are, however, three items, regarding the *hygienic disinfection of the hands with ABP* and the *5 moments of hand hygiene*, for which, at the evaluation performed 3 months after the intervention, the percentage of correct answers, although maintained at high values compared to pre-intervention, is significantly lower compared to the percent of correct answers provided to the evaluation performed immediately after the intervention. I thus find a significant trend of returning improved knowledge to the initial level of pre-intervention. This is an important finding, as this knowledge, related to ABP and the 5 moments of hand hygiene, is one of the major domains of deficiency that were identified in the initial assessment phase. I note, therefore, a tendency to mitigate the effect of the intervention and to return to ABP responses based on traditionalist beliefs and misperceptions of nurses. In this case, it is necessary to periodically resume the educational programs, but also to permanently promote the benefits offered by the use of these products.

In terms of *self-reported practices*, compared to the *pre-intervention* assessment, where most nurses stated that they are at a level of compliance >70%, which reflects a high tendency to overestimate their own compliance, *immediately after participating in MEP*, the situation is changing significantly, with less than half of nurses falling within this compliance interval. *At 3 months after the MEP*, although the percentage of respondents with declared compliance >70% increases compared to the previous assessment time, it still remains significantly lower than before participating in the MEP. Thus, the participation of ICU nurses in MEP and the increase in average

knowledge scores have led to a more critical attitude towards their own compliance with hand hygiene, but which tends to fade over time.

In addition, as a result of the participation of ICU nurses in MEP, the analysis of the data showed significant correlations between the *declared compliance* and some characteristics:

- Significant negative correlation with *the level of knowledge* - with the increase of the level of knowledge, the level of declared compliance decreases, and the attitude of the nurses towards their own compliance with hand hygiene becomes more critical.
- Significant positive correlation with *age*, respectively *professional experience* - with the increase of age, respectively of professional experience, the declared compliance of nurses tends to increase.
- Significant negative correlation with the *average number of patients cared for* in a shift - with the increase in the number of patients, the declared compliance tends to decrease.
- Significant positive correlation with *recent participation (in the last year) in forms of EMC*.
- Significant positive correlation with the *knowledge of compliance rates with hand hygiene in the departments where they work*.

Significant differences were also identified between nurses in *the four hospitals*, immediately and 3 months after the intervention, in terms of the level of *declared compliance*, with higher percentages of nurses falling into the higher categories of compliance (>70%) in hospitals B and D. A possible explanation could be the existence of a negative correlation between the declared compliance and the level of knowledge, where the lower average scores of knowledge were associated with a high percentage of respondents who were in the upper intervals of compliance, and increased average knowledge scores were associated with a low percentage of respondents who were in the upper ranges of compliance.

In addition to improving knowledge and reducing overestimation of own compliance, the effectiveness of MEP was also demonstrated by the significant change in the *declared preference for hand disinfecting with alcoholic solutions*, immediately after MEP and 3 months after MEP, compared to the preference for washing with soap and water declared before the intervention. This change in self-reported practices could be explained by an increase in the level of knowledge of the nurses included in the study. In this respect, the increase in the percent of the declared preference for the use of alcoholic solutions could be associated with the significant differences identified at 3 months after MEP between the higher average scores of knowledge in nurses who



prefer alcoholic solutions and lower average scores in those who prefer washing with soap and water. Differences *between hospitals* were also identified, where nurses in hospital A demonstrated an increased level of preference for alcoholic disinfection at all three assessment times.

Regarding the *availability of hand hygiene resources*, although most respondents declared that they had sufficient resources, significant differences were identified between the nurses in the four hospitals at all three times of the assessment. In this regard, the nurses in hospital C answered in a significantly lower percentage to the question regarding the sufficiency of resources, compared to colleagues in the other hospitals.

Regarding the *knowledge of the HAI percentage*, as well as *the compliance with hand hygiene* in the department where they work, the percent of those who stated that they have knowledge about these issues was approx. 50% in all three evaluation moments. However, there are significant differences between hospitals, with a significantly lower percentage of nurses in hospitals C and D stating that they have information in this regard compared to those in hospitals A and B. This emphasizes the importance of feedback provided by wards/institution managers.

The analysis of the answers to the items aimed at evaluating the *attitudes* showed the existence of the effect of the implemented educational intervention, even if it is not significant. This aspect can be explained by the existence of positive attitudes, since the pre-intervention stage, in over 90% of the nurses included in the study.

Regarding the main *causes of non-compliance* with the indications of hand hygiene, these were (1) *causes related to the particularities of the activity*, (2) *causes related to the management of the unit* and (3) *causes related to nurses*. As a result of the impact of MEP, there has been an increase in the percent of causes related to nurses, most likely as a result of the growing awareness of the importance of hand hygiene and the essential role that nurses play in preventing and limiting HAI, but also of developing self-critical attitudes following participation in the MEP.

In the case of the *factors that could contribute to the increase of compliance* with the indications of hand hygiene, most of the answers were, in all three moments of evaluation, in the category of *solutions related to work management/organization*. Immediately after participating in the MEP, after the solutions related to organizational management, the next category of solutions cited by nurses were educational solutions, with a threefold percent compared to pre-intervention, and this percent is maintained at high values even at 3 months the MEP. The significant increase in responses to educational solutions also reflects the effectiveness of the implemented educational

intervention, by raising awareness among nurses of the particular importance of education as a strategy to improve compliance with hand hygiene. These findings regarding the identification of education by ICU nurses as a useful solution for improving hand hygiene practices should be an important milestone for the development of regular educational strategies at the level of medical institutions.

**Conclusions.** The results of this study showed a significant increase in the level of knowledge and improvement of self-reported attitudes and practices of hand hygiene of ICU nurses in four hospitals in Bucharest, both immediately after the intervention and at 3 months from educational intervention (MEP). These positive results proved the effectiveness of the MEP that I implemented in this study, the fulfillment of the research objectives and the confirmation of the working hypothesis. However, further research is needed to confirm the implementation of improved knowledge and self-reported positive attitudes by nurses in ICU. Thus, in order to be able to demonstrate the existence of the declared top-level practices of nurses, it is necessary to carry out observational studies (study no. 3 and 4), which provide objective data on the initial compliance observed with the indications of hand hygiene in ICU nurses from Bucharest. These studies will also provide information on the impact of the implemented MEP on observed compliance with hand hygiene indications at ICU nurses.

### **Study no. 3 - Assessment of the initial level of observed compliance with hand hygiene in nurses in the ICU (*pre-intervention*)**

The results I obtained after conducting studies no. 1 and 2 showed that nurses in adult ICU in Bucharest show an important tendency to overestimate the level of self-reported compliance. These results are consistent with the literature, which cites the existence of important differences between self-reported compliance, declared by HCP, and observed compliance, as measured by direct observation of hand hygiene practice of the HCP [12, 13]. It has also been shown that improving knowledge and attitudes positively influences the hand hygiene behavior of HCP [6, 14]. Thus, considering that study no. 2 demonstrated the effectiveness of MEP by increasing the level of knowledge of nurses in ICU in Bucharest, I further considered evaluating the effect of MEP and improving the level of knowledge on compliance with the indications of hand hygiene. In this regard, in order to quantify the impact of MEP on ICU nurses' compliance with hand hygiene indications, I conducted an initial assessment of observed compliance prior to MEP

implementation, using the direct observation method. Subsequently, these data, obtained in the initial assessment, will be compared with the measured values of compliance after the application of the MEP, in order to establish the impact of the MEP on observed compliance with the indications of hand hygiene in nurses in the ICU.

**Working hypothesis:** The rate of observed compliance with the indications of hand hygiene in nurses in the ICU is inadequate.

**Specific objectives:**

1. Assessment of the *initial rate of overall observed compliance* with the indications of hand hygiene in nurses in the ICU, before the application of the multimodal educational intervention (MEP).
2. Assessment of the *initial rate of specific observed compliance* with the indications of hand hygiene, depending on the type of maneuver to be performed/performed: *before patient care, before performing aseptic maneuver, after contact with biological fluids, after patient care, after contact with the surfaces around the patient*, before the application of MEP.
3. Assessment of the *initial rate of specific observed compliance* with the indications of hand hygiene, depending on the method used for hand hygiene: *disinfection with ABP or washing with soap and water*, before the application of MEP.
4. Assessment of the *initial rate of compliance* with hand hygiene in relation to the *wearing of gloves*, before the application of MEP.
5. Assessment of the *initial level of compliance* with the recommendations for wearing *jewelry on hands and long or lacquered nails* at work, before the application of MEP.
6. Comparing *self-reported practices* with *observed practices* in hand hygiene, before the application of MEP.
7. Comparative assessment of general and specific compliance of ICU nurses *in the four hospitals* included in the research, prior to the application of MEP.

**Material and method.** In order to initially assess the rate of observed compliance with hand hygiene in nurses in the ICU, I conducted a prospective observational study, for a period of one month, in adult ICU in the four hospitals in Bucharest included in the study, before implementing the MEP. The method used for data collection was the direct observation, and the tool used for data collection was the *Hand Hygiene Direct Observation Sheet*, adapted from the Observation Form (WHO 2009) [10]. In order to collect data on compliance with hand hygiene, I conducted

sessions of direct observation of hand hygiene practice, thus being observed 165 nurses. The observation sessions were held from Monday to Friday, in two time intervals: 07-12 and 16-21. The duration of each session was approx. 20-30 minutes, with a maximum of two nurses being observed simultaneously.

The statistical processing of the data aimed at calculating the *general compliance* rate with hand hygiene, as well as the calculation of the *specific compliance* rate, depending on the *method used by hand hygiene* and *the 5 moments of hand hygiene*. In the latter case, given that several indications can be identified in a hand hygiene opportunity, for which a single action is sufficient, I used the rule of equalizing the number of opportunities with the number of indications, by applying the following *prioritization rule*: *before performing a clean / aseptic procedure* > *after contact with biological fluids* > *after contact with the patient* > *before contact with the patient* > *after touching the surfaces around the patient* [11].

**Results and discussions.** Proper compliance of the HCP with the indications of hand hygiene is very important to ensure a safe and quality care process. By conducting this study, I obtained objective data on the initial level of compliance with the indications of hand hygiene in nurses in the ICU, and the results obtained confirmed the fulfillment of the research objectives. This information is useful for determining current compliance, as well as for setting a benchmark to be compared with compliance obtained after the implementation of the MEP, in order to assess its effectiveness. I thus established that the initial rate of general compliance with hand hygiene in ICU nurses in four hospitals in Bucharest is 40.5%, a suboptimal result that confirms the working hypothesis established at the beginning of the study. Other important findings also emerge from the data obtained from this study:

- There are important differences in the *initial observed compliance rate*, ranging from 16%-66%, to ICU nurses in the *four hospitals* in Bucharest.
- There are significant differences between the *self-reported level* of compliance and the *observed level* of compliance, which reflects the tendency for nurses in the ICU to overestimate their own compliance.
- The rate of compliance with hand hygiene is different, depending on the 5 indications of hand hygiene: lower rates for indications *before patient care*, *before performing aseptic maneuvers* and *after contact with biological fluids*, respectively higher rates for indications *after patient care* and *after contact with surfaces*. The results confirm the self-reported data

of nurses, who stated that they perform more frequently hand hygiene after patient care, as well as the increased tendency of self-protection of nurses. Also, the results are consistent with the high percentage of wrong answers provided by respondents to the item of knowledge on the 5 moments of hand hygiene. There are significant differences *between hospitals*, with nurses in hospital A proving significantly higher average compliance for all five types of indications compared to colleagues in the other three hospitals.

- Most hand hygiene actions performed by nurses in ICU are *disinfections with ABP*. The result does not confirm self-reported data, where only a quarter of respondents stated that they use alcoholic solutions more frequently. There are significant differences in the percent of disinfection actions with ABP between hospital A (high level) and hospital D (low level). This result confirms the self-reported data, where at A hospital a significantly higher percent of respondents was identified who stated that they use alcohol solutions more frequently.
- There are no significant differences in the compliance rate observed by *time interval*. However, there are significant differences *between hospitals*, with higher levels of compliance in the evening compared to morning care in hospital A.
- Nearly half of ICU nurses wear *jewelery* on their hands at work, with differences between hospitals: increased percent at hospital B and low percent at hospital A. Self-reported positive attitudes on this subject, where almost all respondents agreed with the role of jewelry in the emergence of HAI, are not confirmed.
- Many observed nurses in ICU were registered with *long or lacquered nails*, with a higher weight at hospital D and a lower weight at hospital A. Self-reported positive attitudes on this subject, where almost all respondents have agreed with the role of nails in the transmission of HAI, are not confirmed.
- The most frequent use of *gloves* was recorded for indication *before performing aseptic maneuvers*.
- Only 7% of *gloves* use was correct (with prior hand hygiene). The result does not confirm the results obtained in the assessment of knowledge, where most respondents answered correctly to the item on the need for hand hygiene before and after wearing gloves. There are significant differences between the correct use of gloves in hospital A (with a higher percentage of correct use) than in hospitals C and D.

**Conclusions.** Following the results of this study, I found that the observed compliance rate with the indications of hand hygiene in nurses in ICU in four hospitals in Bucharest is inadequate and may be a cause of HAI, in addition to other factors responsible for producing and transmitting HAI to patients cared for in the ICU. There is therefore a need to implement strategies to improve observed compliance with the indications of hand hygiene, in particular educational interventions, as well as the application of other types of interventions aimed at reducing HAI. Thus, in order to be able to demonstrate the impact of MEP implemented in the main scientific research of this thesis on the observed compliance with the indications of hand hygiene, I considered it necessary to conduct an observational study (study no. 4) to provide objective data on hand hygiene practice in ICU nurses in Bucharest, both immediately after the intervention and 3 months after the educational intervention.

#### **Study no. 4 - Assessment of the impact of the implementation of multimodal educational programs on the observed compliance with hand hygiene in ICU nurses (*immediate post-intervention and post-intervention at 3 months*)**

As a result of the implementation of the MEP, the percentage of nurses in adult ICU in Bucharest who demonstrated a *high level of knowledge* (scores 8-10) showed a major increase, from 20% before the MEP, to 79% immediately after the MEP, respectively at 68% 3 months after MEP. Thus, the special effectiveness of the implemented multimodal educational intervention was demonstrated. Also, the percentage of subjects with a *medium level of knowledge* showed a significant decrease, from 73% before MEP to 21% immediately after MEP, and to 28% after 3 months of MEP. However, there is a trend towards a reduction in the positive effects of MEP and a gradual return of knowledge to baseline values, which underscores the importance of regular access for nurses to CME.

Also, the results of study no. 3 showed that the average initial rate of general compliance with the indications of hand hygiene in nurses in adult ICU in Bucharest was 40.5%, a value which is in line with the data in the literature [7], but which does not confirm the high level of self-reported compliance (study no. 1), where 82% of subjects reported higher levels of compliance (>70%-80%). In addition, this suboptimal compliance may not be sufficient to ensure a safe and quality patient care process. This important aspect related to the care practice provided by ICU nurses emphasizes the need to improve their compliance with hand hygiene indications. To achieve this

goal, increasing the level of knowledge could be an important factor of influence. In this respect, the link between the improved level of knowledge as a result of participation in the MEP and the increase in the observed compliance rate with the indications of hand hygiene in nurses in the ICU is the aim of this study.

**Working hypothesis:** Improving the knowledge, attitudes and self-reported practices of nurses in ICU regarding hand hygiene and HAI can lead to improved compliance with hand hygiene indications and, thus, to a lower incidence of HAI in ICU.

**Specific objectives:**

1. Assessment of the *immediate effectiveness* of the MEP on the observed compliance (general and specific) with the indications of hand hygiene in nurses in the ICU (*immediate post-intervention*).
2. Assessment of the *over time effectiveness* of the MEP and the degree of maintenance of improved compliance with hand hygiene indications over time, as a result of ICU nurses' participation in MEP (*3-month post-intervention follow-up*).
3. Assessment of the impact of the implementation of the MEP and the improved compliance with the hand hygiene indications of the nurses on the incidence of HAI in the ICU (*immediate post-intervention and post-intervention follow-up at 3 months*).
4. Assessment of the impact of the MEP on compliance with hand hygiene in relation to the *wearing of gloves* in nurses in the ICU (*immediate post-intervention and post-intervention follow-up at 3 months*).
5. Assessment of the impact of the MEP on the level of compliance with the recommendations for *wearing jewelry on the hands and long or lacquered nails* at work, in nurses in the ICU (*immediate post-intervention and post-intervention follow-up at 3 months*).
6. Comparison of *self-reported practices* with *observed practices* in hand hygiene in nurses in the ICU (*immediate post-intervention and post-intervention follow-up at 3 months*).
7. Comparative assessment of the impact of the MEP on observed compliance in ICU nurses *in the four hospitals* included in the research (*immediate post-intervention and post-intervention follow-up at 3 months*).
8. Comparative assessment of the impact of the MEP on observed compliance in ICU nurses *participants in the MEP versus non-participants in the MEP* (*immediate post-intervention and post-intervention follow-up at 3 months*).

**Material and method.** In order to assess the impact of the implementation of the MEP on compliance with hand hygiene indications in nurses in the ICU, I conducted a prospective observational study, carried out over a period of one month immediately after the intervention (MEP), and for a period of one month after 3 months from application of MEP, in adult ICU from the four hospitals in Bucharest that were included in the study. *Immediately after the MEP*, 176 nurses were observed, and *after 3 months from the MEP*, 143 nurses. The methodology for collecting and processing data on observed compliance with hand hygiene was similar to that used in the initial assessment study (study no. 3). Regarding the incidence of HAI in the ICU, it was obtained by communicating with the representatives of the Specialized Prevention Services/ Departments of HAI from the four hospitals included in the main scientific research of this thesis.

**Results and discussions.** The results I obtained in this study, by significantly increasing, by over 35 percentage points, of the observed compliance rate with the indications of hand hygiene, as an immediate effect of the participation of nurses from ICU in MEP, confirms the established working hypothesis for this study. Also, by recording, at the evaluation carried out 3 months after the multimodal educational intervention, the persistence of the obtained improvements, the long-term effectiveness of the implemented MEP was demonstrated. However, the slight trend towards a decrease in the value of the 3-month compliance rate from the MEP underlines the importance of the regular development of the MEP for ICU nurses, in order to maintain an adequate level of knowledge and positive attitudes on a permanent basis. Also, in order to have a permanent overview of the level of compliance with hand hygiene, it is necessary to carry out regular audits of compliance with the indications of hand hygiene in nurses in the ICU.

As a result of the study, I identified differences in the observed compliance rates with the indications of hand hygiene in the groups of nurses in the *four hospitals*. I thus observed that the highest percentages of nurses who were within the maximum compliance interval (90%-100%), in all three observation periods, were identified at hospital A, at significant percentage distances from colleagues in the other three hospitals. The fact that this group has shown significantly greater compliance since before participating in the MEP shows that there is a strong culture of organizational safety at their institution: evidence-based practice, patient-centered care, open communication, feedback, positive role model and continuing education.

Further evidence of the effectiveness of the implemented MEP is provided by the identification, both immediately after the MEP and 3 months after the MEP, of significant differences in



compliance with the hand hygiene indications between the *MEP participants* and the *MEP non-participants*, under the conditions in which, before the MEP, these differences did not exist. In this respect, at the initial assessment, the results showed average compliance of approx. 40% for both categories of nurses. *Immediately after the MEP*, the situation changes significantly, with the MEP participants reaching a compliance rate of approx. 80%, and non-participants reaching a compliance of approx. 60%. Moreover, *at 3 months after the MEP*, the impact of the MEP is maintained for MEP participants, with compliance remaining around 80%, while for non-participants, compliance is close to baseline (40%). The fact that the compliance rate increased immediately after the MEP, even for non-participants, can be explained by the positive influence of specific information received indirectly from participating colleagues or promotional materials, but which could only ensure a sporadic effect on the behavior of nurses not participating in MEP. The implemented MEP had a positive influence, including on the option of nurses to achieve hand hygiene with one of *the two methods of hand hygiene*. Thus, if before participating in MEP, there was a percentage of 58% of nurses who used disinfection with ABP, immediately after participating in MEP, this percentage increased significantly and reached 82%, remaining almost 80% even and 3 months after MEP. The result is important because it reflects the increasing compliance of ICU nurses with evidence-based best practice recommendations and legal regulations, which state that hygienic disinfection by rubbing with ABP must be the main method of hand hygiene in clinical practice.

Regarding differences *between hospitals* in terms of compliance with the predominant use of one of the two methods of hand hygiene, as an effect of MEP, I found the reversal of the balance between *washing with soap and water* and *disinfection with ABP* in the case of hospital D and growth major preference for ABP disinfection in two other hospitals (B and C). In the case of hospital A, the predominant percent of ABP disinfection remains constant throughout all three stages of evaluation, reflecting the existence of a culture of routine use of this method of hand hygiene. Also, regarding the percent of the use of one of the two methods of hygiene according to *the indication of hand hygiene*, as a result of the development of MEP, it is found that *disinfection with ABP* becomes the predominant method for all 5 moments of hand hygiene immediately after MEP, and for 4 of the 5 moments 3 months after MEP. Moreover, there is a major increase (over 90%) in the use of ABP disinfection in the two moments that involve an increased risk of

developing HAI (*before patient care* and *before aseptic maneuvers*), both immediately after MEP and 3 months after MEP.

Another positive effect of the implemented MEP was the recording, immediately after the EMP, of significant increases in average compliance for each of *the 5 indications of hand hygiene*, with an emphasis on increasing compliance *before patient care* and *before aseptic maneuvers*, which remain improved even after 3 months from the MEP.

Comparative analyzes of observed compliance by *time interval* showed that, in general, higher levels of compliance were observed during evening/night shifts compared to morning shifts, one of the explanations may be the existence of a lower workload during the evening/night shifts.

Regarding the *wearing of jewelry*, I identified a percentage of approx. 50% of nurses in the ICU who wore jewelry on their hands at work in all three stages of the assessment. This absence of the MEP effect in this case may be justified by the resilience of nurses to change and the lack of administrative mechanisms necessary to comply with best practice recommendations and legal regulations in this field.

With regard to *long or lacquered nails*, a reduction of 29% to 17% in the percent of nurses wearing long or lacquered nails at work was obtained immediately after the MEP. However, in the evaluation carried out at 3 months after the MEP, the return of this percent to the initial value was recorded, thus emphasizing the importance of supporting educational interventions with effective organizational measures.

Respecting hand hygiene, including the *wearing of gloves*, is an essential aspect of the HAI's prevention and limitation programs. In this regard, in this study I found that before MEP, an extremely low percentage of glove use (7%) was correct use, with the prior achievement of hand hygiene before dressing. In this case, the impact of the MEP was significant, with the percentage of correct use of gloves increasing to 54% immediately after the MEP, and to 56% at 3 months after the MEP. In addition, as an effect of MEP, I noticed that the method mainly used for hand hygiene before wearing gloves was disinfection with ABP.

Regarding the degree of *correct wearing of gloves* for each of the two types of hand hygiene indications, the results of the study showed significant increases in the percentage of correct use immediately after MEP, both for the indication *before patient care* and for indication *before performing aseptic maneuvers*. Also, improved compliance with the correct wearing of gloves for the two types of indications was also identified in the assessment performed at 3 months after the

MEP. In the case of the indication *before performing aseptic maneuvers*, with a high risk of occurrence of HAI, the percentage of correct use of gloves that I identified both immediately after the MEP and 3 months after the MEP, represented 10 times the value of the percentage from pre-intervention for this indication. This result provides further evidence of the impact of the MEP on compliance with hand hygiene in ICU nurses.

**Conclusions.** The MEP I implemented in the main scientific research of this doctoral thesis proved its effectiveness, by significantly improving the immediate general and specific compliance with hand hygiene in nurses in adult ICU in four hospitals in Bucharest, as well as by maintaining the improvements obtained 3 months after the multimodal educational intervention. The results of the study thus confirm the working hypothesis regarding the impact of MEP on the observed compliance with the indications of hand hygiene. With regard to the objective of assessing the impact of the MEP and the improved compliance with hand hygiene indications on the incidence of HAI in adult ICU, it could not be met for the following reasons: (1) the data reported by each of the four hospitals are very different. and even contradictory; (2) the methodology of statistical data collection and processing used in this scientific research, with different databases, did not allow for direct links between nurses' level of knowledge, compliance with hand hygiene and HAI rates in ICU included in the study; (3) there are many etiological factors of HAI, not only the transmission of microorganisms through HCP; (4) there are several professional categories involved in the care of patients, not just nurses; (5) several methods of preventing HAI can be applied simultaneously, not just proper hand hygiene, making it very difficult to distinguish the impact of increased compliance with hand hygiene from the effects of other components of HAI prevention and limitation programs; (6) a longer monitoring and evaluation period is needed so that it can be seen that there is a direct link between increasing compliance with hand hygiene indications and decreasing the incidence of HAI in the ICU.

## **IV. Conclusions and Personal Contributions**

### **Personal Contributions**

The main scientific research I carried out in this doctoral thesis was carried out in adult ICU in four important hospitals in Bucharest: Fundeni Clinical Institute, Elias University Emergency Hospital, Emergency Institute for Cardiovascular Diseases "Prof. Dr. C.C. Iliescu" and the

Oncological Institute "Prof. Dr. Alexandru Trestioreanu". The research studies included ICU nurses from these four hospitals and aimed at the following research objectives:

- Assessment of the initial level of knowledge, attitudes and self-reported practices related to hand hygiene and HAI (*pre-intervention*).
- Assessing the effectiveness of MEP on knowledge, attitudes and self-reported practices related to hand hygiene and HAI (*immediate post-intervention* and *post-intervention at 3 months*).
- Assessment of the initial level of observed compliance with the indications of hand hygiene (*pre-intervention*).
- Evaluation of the impact of the implemented MEP on the observed compliance with the indications of hand hygiene and on the incidence of HAI (*immediate post-intervention* and *post-intervention at 3 months*).

The results I obtained as a result of the main studies confirm the fulfillment of the research objectives and provide important data on the current knowledge, attitudes and practices of the nurses in the ICU in Bucharest. I also achieved important results on the effectiveness of the MEP that I have implemented in order to improve the knowledge, attitudes and practices related to hand hygiene and the prevention of HAI in nurses in ICU. The only relationship that could not be demonstrated was the association between improved compliance with hand hygiene indications and the incidence of HAI in adult ICU.

The analysis of the data we collected in these main research studies provided the following results regarding the *pre-intervention period*:

- In the last year, **45% of nurses have not participated in forms of continuing medical education** on hand hygiene and HAI prevention.
- The majority of nurses (73%) have a **medium level of knowledge** (scores between 5-7) related to hand hygiene and HAI, a fact confirmed by the average knowledge score obtained at the group level:  $6.46 \pm 1.33$ . The result reflects the need for educational programs for nurses.
- The **main domains of deficient knowledge** regarding hand hygiene and HAI are: (1) *hygienic hand disinfection with ABP*, (2) *the 5 moments of hand hygiene*, (3) *impact and prevention of HAI*, (4) *wearing gloves*.

- The majority of nurses (94%-100%) **declare positive attitudes** regarding: wearing jewelry and long/lacquered nails; the role of hand hygiene in preventing and limiting HAI; the importance of HAI prevention to improve patient safety.
- About half of nurses (48%) **wear jewelry on their hands** at work and about 30% of nurses **have long or lacquered nails**. The results do not confirm the positive beliefs expressed by nurses in pre-intervention.
- The three main categories of **declared causes of non-compliance with the indications of hand hygiene** are: (1) *causes related to the particularities of the activity* (58%); (2) *causes related to the management of the medical unit* (21%) and (3) *causes related to nurses* (18%).
- The three main categories of **declared facilitators of compliance with hand hygiene indications** are: (1) *solutions related to work management/organization* (40%); (2) *solutions related to supply of materials* (23%) and (3) *solutions related to compliance with procedures and protocols* (17%).
- The majority of nurses (87%) state that they **have sufficient resources for hand hygiene** at work, and 98% state that managers of the workplace **promote the importance of hand hygiene**.
- About half of nurses (53% and 51%, respectively) **do not know the percentage of HAI**, respectively the **rate of compliance with hand hygiene**, in the department where work.
- Most nurses (**76%**) **say they use soap and water washing more often**, and only 24% say they use alcoholic disinfection more often.
- A percentage of **58% of the observed actions of hand hygiene is performed by disinfection with ABP**. Only 42% are soap and water washing actions. Data collected by direct observation do not confirm the information reported by the nurses.
- More nurses (56%) say that they **follow with priority the indication *after patient care*** compared to 44% who state that they follow with priority the indication *before patient care*.
- Most nurses (82%) have **overestimated self-reported practices** (report levels of hand hygiene >70%).
- Most nurses (77%) have an **initially suboptimal observed compliance** with hand hygiene (<60%). Only 23% of nurses have an observed compliance >70%, which infirm the overestimated compliance declared by the subjects. The average compliance rate observed

is 40.5%, a suboptimal value for the provision of clean and safe care. In the case of indications *before patient care* and *before aseptic maneuvers*, indications with a high risk of HAI, the compliance rate is very low (27.47% and 20.83%, respectively).

- Most (93%) **use of gloves is inappropriate** (without prior hand hygiene). 95% of the use of gloves for indication *before performing aseptic maneuvers* did not involve prior hand hygiene, which involves an increased risk of HAI.
- There are differences in the *initial level* of knowledge, attitudes and practices of ICU nurses in *the four hospitals* in Bucharest included in the study, which underline the *importance of CME* and the *availability of hand hygiene products*:
  - ✓ *Nurses from two hospitals (A and C)* - stated at the beginning of the research, a high level of participation in forms of CME on the subject of hand hygiene and HAI (approx. 80%-90%). These participations may have contributed to the achievement of significantly higher average knowledge scores (approx. 7) by these subjects. However, even if the initial level of specific knowledge was similar, the level of compliance observed differed significantly, with an initial compliance rate of approx. 65% in hospital A, and a much lower compliance rate of approx. 20% in hospital C. A possible explanation for this finding could be found in the different level of availability of hand hygiene resources that was stated by the subjects in the two hospitals: maximum availability (100%) at hospital A and approx. 40% at hospital C. These findings show that a good level of knowledge, accompanied by a good availability of resources, can help to achieve good compliance with hand hygiene. On the other hand, we understand that the presence of adequate knowledge is important, but it may not be enough to ensure optimal hand hygiene behaviors when hand hygiene products are missing or insufficient. Thus, the essential importance of organizational support for supporting educational strategies is highlighted.
  - ✓ *Nurses from two other hospitals (B and D)* - stated at the beginning of the research, a low level of participation in forms of CME on the subject of hand hygiene and HAI (<50%). This low level of participation may be the reason for low average knowledge scores (approx. 6). Regarding the declared availability of hand hygiene resources, this was around a percentage of approx. 90%. Under these conditions, the average initial observed compliance rate in these two hospitals was approx. 30%-40%. We note, in

this case, that the increased availability of resources, in the presence of an inadequate level of knowledge, could not be sufficient to ensure an adequate level of compliance with hand hygiene. This highlights the critical importance of CME and the permanent provision of an optimal level of knowledge regarding hand hygiene and HAI.

The analysis of the data collected in the four main research studies carried out also provided the following results for the **post-intervention period**:

- The MEP I implemented had a **significant impact on the knowledge** of nurses in ICU in Bucharest, so that the percentage of nurses with a high level of knowledge increased from 20% before MEP to 79% immediately after MEP and remained at 68% 3 months after MEP. Also, the percent of subjects with a medium level of knowledge decreased from 73% before MEP to 21% immediately after MEP, and to 28% at 3 months after MEP. In terms of average knowledge score, it improved significantly, from  $6.46 \pm 1.33$  before MEP to  $8.47 \pm 1.50$  immediately after MEP, and  $8.07 \pm 1.62$  at 3 months from MEP, thus reflecting the transition from a medium to a high level of knowledge of the ICU group of nurses. The effectiveness of the MEP was also demonstrated by the improvement in the percent of the correct answers in the case of items related to the domains that were identified in the pre-intervention as deficient.
- The MEP that I implemented had a **important impact on the attitudes** of nurses in ICU in Bucharest, especially in terms of beliefs about the role of jewelry and nails in the occurrence and transmission of HAI, but not significantly, in the conditions in which positive attitudes related to hand hygiene and HAI have been identified since the pre-intervention stage.
- The MEP I implemented had a **significant impact on the self-reported practices** of nurses in ICU in Bucharest, so that the percent of nurses who were in the upper compliance intervals (>70%) decreased from 82% before MEP to 39% immediately after MEP, and 62% at 3 months after MEP. Thus, we notice the reduction of the tendency to overestimate and the appearance of a self-critical attitude of one's own compliance, but which shows a tendency to return to the initial value. This attitude is also confirmed by the increase, after the MEP, in the percent of declared causes of non-compliance related to nurses, as well as in the increase in the percent of responses that mentioned educational solutions as possible factors for improving compliance. The effectiveness of MEP is also demonstrated by the

change in the stated preference for one of the two methods of hand hygiene, from washing with soap and water before MEP (76%) to disinfection with alcoholic solutions immediately after MEP (56%), preference that is maintained, and even increases, 3 months after MEP (59%). The effectiveness of MEP is also proven by the reversal of the percent of responses regarding the priority adherence to one of the two indications of hand hygiene, *before or after patient care*, in favor of the indication *before patient care* (54%), 3 months after MEP. An important effect of the MEP was also demonstrated by the significant improvement in the declared availability of hand hygiene resources (94%) at 3 months after the MEP. In addition, the percentage of those who say they have knowledge of the percentage of HAI and the rate of compliance with hand hygiene in their department is increasing.

- The MEP I implemented had a **significant impact on the observed compliance with the indications of hand hygiene** in nurses in ICU in Bucharest, effect demonstrated by the increase of the general compliance rate from 40.50% before MEP to 75.76% immediately after MEP and at 71.41% 3 months after MEP. The outstanding effectiveness of the MEP is also evidenced by the significant increase in the compliance rate, in the case of *MEP participants*, from approx. 40% before MEP at approx. 80% immediately after MEP, an increase that is maintained even 3 months after MEP. However, this effect did not manifest itself in the case of *non-participants in the MEP*. The positive influence of MEP was also observed in the case of compliance with one of *the two methods of hand hygiene*, so that immediately after MEP, the percentage of nurses who were observed using ABP reached 82%, compared to 58% before MEP, and remained at 80% 3 months after MEP. The impact of the MEP also stems from the major increase, immediately after the MEP and 3 months after the MEP, in compliance rates for indications of high risk of HAI production, for which the lowest compliance rates were observed in pre-intervention: *before patient care* - from 27.47% to 73%, respectively to 64.04%; *before aseptic maneuvers* - from 20.83% to 65.28% and 61.84%, respectively.
- The MEP I implemented had a **significant impact on the wear of gloves** by nurses in the ICU in Bucharest, so that the percentage of correct use (with prior hand hygiene) increased from only 7% before the MEP to 54% immediately after MEP and even at 56% 3 months after MEP. Moreover, there has been a significant increase in the percentage of correct use



of gloves *before aseptic maneuvers*, from only 5% before MEP to 50% immediately after MEP and to 51% at 3 months after MEP.

- The implemented MEP did not have a significant impact on the *wearing of jewelry* on the hands, in all three stages of evaluation being observed approx. 50% of nurses wore jewelry. A possible explanation may lie in the existence of a traditional culture of wearing jewelry, resistance to change or the absence of administrative measures necessary to comply with legal recommendations and regulations in this area.
- The implemented MEP had a significant but not significant impact on the *wearing of long or lacquered nails*. Immediately after MEP, the percentage of nurses with long or lacquered nails decreased from 29% to 17%, but increased to 28% at 3 months after MEP. This tendency to return to the initial situation highlights the need for organizational support, to support the benefits obtained from educational interventions.
- The MEP I implemented also had an impact on the *declared causes of non-compliance with hand hygiene indications*, where, immediately after the MEP and 3 months after the MEP, there is an increase in the share of responses focused on the *causes related to nurses* (24% immediately after MEP and 26% every 3 months after MEP), but also to the *causes attributed to the deficient management of medical units* (25% immediately after MEP and 20% at 3 months after MEP).
- Also, the implemented MEP had an impact on the *declared facilitators of compliance with the indications of hand hygiene*, where, both immediately after participating in the MEP and 3 months after the MEP, the percent of *educational solutions* increases significantly (from 10% in pre-intervention at 27% and 23%, respectively), thus exceeding the percent of *solutions related to supply of materials* (23% in pre-intervention, 22% immediately after MEP and 19% at 3 months after MEP).
- The MEP I implemented proved to be **effective both in the short term (immediately after the intervention) and in the long term (3 months after the intervention)**. In this sense, the comparison of the pre-intervention data with those collected immediately after the intervention, respectively at 3 months after the intervention, demonstrated: the improvement of the initial knowledge, attitudes and practices (self-reported and observed); retention of acquired knowledge; maintaining improved attitudes and practices. However, it should be noted that there is a tendency to return to the initial level of knowledge,

attitudes and practices, which highlights the need for regular resumption of MEP for nurses. Regarding the impact of the implemented MEP and the increase in observed compliance with the indications of hand hygiene on the incidence of HAI, the heterogeneity of the data reported on the incidence of HAI and the statistical data processing methodology did not allow the demonstration of existence a direct relationship.

- The results obtained in the *initial evaluation*, where I identified an inadequate level of knowledge, attitudes and practices, self-reported and observed, of nurses in ICU in Bucharest, as well as their educational needs, confirm the working hypotheses established in the initial assessment studies.
- The results obtained in the *post-intervention evaluation* demonstrate the significant impact of the implemented MEP, by significantly increasing the knowledge, attitudes and practices, both self-reported and observed, of nurses in ICU in Bucharest, and confirm the working hypotheses established in the post-intervention assessment studies, except for the association between the observed compliance with the indications of hand hygiene and the incidence of HAI in the ICU.

## **Conclusions**

The results of this scientific research have demonstrated the immediate and over time effectiveness of the MEP I have implemented, by significantly improving the knowledge, attitudes and self-reported and observed practices related to hand hygiene and HAI, at adult ICU nurses from four hospitals in Bucharest. Specifically, the average knowledge score of ICU nurses improved significantly (from 6.46 - medium level to 8.47 - high level), and the average observed compliance rate with the indications of hand hygiene increased significantly, from 40.5% to 75.7%. Thus, the transposition of improved knowledge and attitudes into clinical practice has been demonstrated by positively changing the professional behaviors of nurses and significantly increasing their compliance with hand hygiene indications, before and after any patient care maneuver, as a critical component in every patient care plan. However, in order to ensure the sustainability of improved outcomes, the fading tendency of the effect of educational intervention and the need for regular resumption of educational programs and clinical audit in terms of hand hygiene practices must be taken into account. Also, the differences related to the organizational context justify the need to improve the support from managers/leaders and the culture of safety in medical institutions.

Thus, the research I conducted in this doctoral thesis is of particular importance, from a scientific and practical point of view, for the health care activity provided by nurses. This importance derives from the provision of data and tools, of scientific and clinical utility, for the following purposes: (1) determining the current level of knowledge, attitudes and practices of hand hygiene and prevention of HAI; (2) identifying deficient domains and educational needs; (3) development and implementation of a MEP, adapted to the educational needs; (4) assessing the effectiveness and impact of a MEP on hand hygiene knowledge, attitudes and practices and the prevention of HAI in nurses. Among these information and tools, useful for improving the skills and professional activity of nurses, as well as for increasing the quality and safety of the patient care process in the ICU, I mention:

- A validated standardized structured questionnaire to assess nurses' knowledge, attitudes, and self-reported practices regarding hand hygiene and HAI.
- A methodological framework for assessing nurses' knowledge, attitudes, self-reported and observed practices regarding hand hygiene and HAI.
- A MEP model, including a model of plan and course curriculum, tailored to the educational needs of nurses.
- A model of methodological framework for assessing the effectiveness and impact of implementing a MEP designed to improve the knowledge, attitudes and practices of hand hygiene and the prevention of HAI in nurses.
- A database on the current level of knowledge, attitudes and self-reported and observed practices in nurses in ICU in Bucharest.
- A database on the level of effectiveness of the implemented MEP (immediate and over time impact) on the knowledge, attitudes and self-reported and observed practices in nurses in ICU in Bucharest.
- Useful educational materials for nurses and patients: a *Hand Hygiene Guide for the continuing professional education of nurses*, a *Booklet-Leaflet with information on hand hygiene for the continuing professional education of nurses*, and a *Booklet-Leaflet with information on hand hygiene for Patient Education*.

Also, improving the hand hygiene behavior and care practice of nurses in ICU, by increasing the level of knowledge and improving attitudes as a result of HCP participation in educational programs, can help reduce the risk of complications associated with patient care and reducing HAI

rates in the ICU. In addition, the target is to reduce the cost of care, increase the quality of medical services and improve patient satisfaction with the care provided in medical institutions. However, it should be considered that individual approaches and educational strategies to improve HCP knowledge, attitudes and practices must be supported by institutional management by: promoting the importance of hand hygiene, patient safety and increasing the quality of patient care; providing feedback and active leadership; ensuring an adequate level of human and material resources; conducting regular CME programs; development and implementation of specific procedures and protocols; ongoing monitoring of HAI prevention and limitation practices; regular audit of hand hygiene and HAI control practices. In the case of this research, the need to improve organizational support is suggested by the existence of a specific institutional culture and differences in the initial knowledge, attitudes and practices of nurses in the four hospitals, including access to CME and access to material resources, which argues the need to standardize the implementation of HAI prevention and limitation programs at the level of medical institutions.

Given that this scientific research aimed to assess the knowledge, attitudes and practices related to hand hygiene and HAI in nurses working in adult ICU in four major hospitals in Bucharest, *possible limitations* may be related to the conduct of studies at a limited number of hospitals, only in the adult ICU, for a single professional category and for a limited period of time. Another possible limitation of this research is also the intention to identify a causal link between the increased compliance of ICU nurses with the indications of hand hygiene and the decrease in the incidence of HAI in ICU. This second limitation of research can be justified by the existence of many determinants of HAI, but also by the multiple strategies applied to reduce the risk of occurrence of HAI, which can interfere with the applied educational intervention. In addition, it is necessary to monitor the variables of interest for a longer period of time, so that useful information can be extracted on the existence of a certain trend of evolution of compliance with the indications of hand hygiene and the incidence of HAI in the ICU. In view of these arguments, methods of assessing knowledge, attitudes and practices should be applied to all occupational categories involved in patient care. Also, the implementation of effective interventions, including MEP, in order to improve knowledge, attitudes and practices, should be addressed to all HCP working in ICU, so as to significantly increase the chances of preventing and limiting HAI acquired by patients cared for in these wards.

Furthermore, given the significant results of this scientific research, I consider the resulting information and tools to be a very good benchmark and starting point for *future directions* of scientific research and clinical audit, which could be aimed at assessing the level of knowledge, of attitudes and practices related to hand hygiene and HAI: in all types of ICU (adults, pediatrics, neonatology); for all occupational categories in the ICU (physicians, nurses, auxiliary staff, etc.); in the other types of wards of a hospital (Surgery, Internal Medicine, etc.); in other types of medical institutions (clinics, offices, etc.); in hospitals in other localities. Future research could also focus on conducting regular audits to identify: the educational needs of the HCP, the level of compliance with hand hygiene indications, the effectiveness of the implementation of educational strategies and the degree of maintenance over time of the improvements obtained. In addition, given that not only the quantitative dimension of compliance with hand hygiene indications is important, an interesting research perspective could be aimed at qualitative assessment of HCP compliance. In this case, this type of assessment should take into account the three essential criteria for performing a correct hand hygiene procedure (quantity, technique and time), but also the results obtained after applying a correct procedure (absence of microbial load on the hands of HCP). On the other hand, if we refer to the fact that the existence of a significant direct relationship between the increase of the observed compliance rate with the indications of hand hygiene and the reduction of the incidence of HAI in adult ICU in Bucharest could not be demonstrated in this scientific research, a future direction of research could aim at this goal, by continuing research in a postdoctoral scientific study, with a methodology adapted to this specific purpose.

### **Originality and innovation**

The research carried out in this doctoral thesis brings an important contribution of knowledge and novelty in the field of nurses' competencies related to hand hygiene and HAI, regarding the following original and innovative aspects related to the professional activity of nurses in Romania, respectively nurses from ICU in Bucharest:

- ✓ Current recommendations according to international guidelines and evidence-based best practices in the field of hand hygiene and HAI prevention (structured systematic analysis).
- ✓ Model methodology for *assessing the knowledge, attitudes and self-reported practices* of nurses, before and after the application of an educational intervention.

- ✓ *Original standardized structured questionnaire validated* to assess the knowledge, attitudes, and self-reported practices of nurses.
- ✓ Database on the *current level* of knowledge, attitudes and self-reported practices of nurses in Romania, including nurses in ICU at the national level.
- ✓ Information on *deficient domains* in terms of knowledge, attitudes and self-reported practices related to hand hygiene and HAI, as well as the *educational needs* of nurses in Romania.
- ✓ Information on *self-reported causes for non-compliance* with hand hygiene indications, as well as possible *useful strategies for improving compliance* with hand hygiene indications, declared by nurses in Romania.
- ✓ Model of *Multimodal Educational Program* (MEP) with proven effectiveness, both immediately and over time (educational plan, course curriculum, course support, educational materials): developed according to the recommendations of international guidelines and evidence-based best practices in the field of hand hygiene and HAI; correlated with the deficient domains and the educational needs of the nurses in Romania; revised in accordance with the deficient domains and educational needs of the nurses in ICU in Bucharest, identified in the initial assessment stage of their knowledge, attitudes and self-reported practices.
- ✓ Database on the *current level* of knowledge, attitudes and self-reported practices of nurses in ICU in Bucharest.
- ✓ Information on *deficient domains* in terms of knowledge, attitudes and self-reported practices related to hand hygiene and HAI, as well as the *educational needs* of ICU nurses in Bucharest.
- ✓ Information on *self-reported causes for non-compliance* with hand hygiene indications, as well as possible *useful strategies for improving compliance* with hand hygiene indications, stated by nurses from ICU in Bucharest.
- ✓ Information on the *current level* of knowledge, attitudes and self-reported practices of *nurses in ICU in Romania* compared to *nurses in ICU in Bucharest*.
- ✓ Database on the *impact of the implementation*, immediately and over time, of a *Multimodal Educational Program* on the *knowledge, attitudes and self-reported practices* of nurses in ICU in Bucharest.
- ✓ Model methodology for assessing *observed compliance* with hand hygiene indications, before and after applying an educational intervention.

- ✓ Database on the *current level of observed compliance* with the indications of hand hygiene (general and specific compliance) at the nurses of the ICU in Bucharest.
- ✓ Information on the current level of *use of gloves* and *wearing jewelry* on the hands, respectively of the *long/lacquered nails*, by the nurses from ICU in Bucharest.
- ✓ Database on the *impact of the implementation*, immediately and over time, of a *Multimodal Educational Program* on the *observed compliance* with the indications of hand hygiene (general and specific) in nurses from ICU in Bucharest, including the wearing of gloves, jewelry and long/lacquered nails.
- ✓ Information on the level of *declared compliance* compared to the level of *observed compliance* with the indications of hand hygiene at nurses in ICU in Bucharest.
- ✓ Information on the *comparative level* of knowledge, attitudes and practices of nurses in the *four hospitals* in Bucharest, including information on the *context and specific organizational culture* at the ICU level in the four hospitals.
- ✓ Models of *educational materials* for nurses and patients, developed on the basis of scientific documentation and research in this doctoral thesis, in accordance with current recommendations of international guidelines and evidence-based best practices in hand hygiene and HAI: *Hand Hygiene Guide for the continuing professional education of nurses; Booklet-Leaflet with information on hand hygiene for the continuing professional education of nurses; Booklet-Leaflet with information on hand hygiene for patient education.*

In view of the above, I consider that the results of this doctoral thesis are of significant importance both scientifically and practically.

In this respect, **the scientific relevance** of this scientific paper derives from the provision of the following results: (1) pre-post scientific research design model (initial evaluation and observation; application of the intervention; immediate and follow-up evaluation and observation); (2) validated standardized structured questionnaire to assess the knowledge, attitudes and self-reported practices of HCP regarding hand hygiene and HAI; (3) database on the knowledge, attitudes and practices of hand hygiene and HAI of nurses, which can be used as a benchmark for further studies in different parts of the country, in various types of hospitals and wards, to all professional categories.

Also, given that HAI represent complications with significant physical, psychological, social and economic implications on patients, HCP and healthcare systems, the **importance and practical applicability** of this thesis is extremely important and necessary, supported by the following results: (1) *validated standardized structured questionnaire* for the initial and periodic assessment of HCP knowledge, attitudes and self-reported practices regarding hand hygiene and HAI; (2) model of an effective *Multimodal Educational Program*, useful for the continuous professional education of HCP; (3) highlighting *the importance of education and an optimal level of knowledge* to ensure appropriate hand hygiene behaviors; (4) models of *educational materials* with information on hand hygiene for nurses and patients; (5) model of the *methodological framework* for the objective assessment, by *direct observation*, of the compliance of the HCP with the indications of hand hygiene; (6) identifying the *deficient domains and declared causes of non-compliance* with hand hygiene indications, as well as *possible useful strategies to increase compliance*, can contribute to the successful implementation of targeted interventions to improve HCP hand hygiene practices. In this regard, the significant potential benefit of the practical application of all these tools, models and strategies is the improvement of hand hygiene practices and the reduction of the incidence of HAI in medical units. In addition, the practical applicability of this research derives from the argumentation and highlighting of the role of institutional management in supporting the process of improving HAI control practices in medical institutions. In this regard, the results of this thesis can help to guide decision-making structures towards the development and implementation of effective and sustainable strategies and programs to increase patient safety and quality of care, based on procedure and standardization, regular education and resource provision, promotion and monitoring, auditing and feedback, leadership and organizational safety culture.

This comprehensive research thus makes a significant contribution to efforts to increase the safety and quality of health services, by contributing to the improvement of the specific skills and professional behaviors of nurses, aimed at providing clean and safe care, patient-centered and evidence-based, in order to improve patient outcomes, prevent HAI and save lives.



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## LIST OF PUBLISHED WORKS

### Published articles

1. **Nedelcu V**, Zazu M, Mazilu DC, Vernic C, Grințescu IM. Evaluation of the Nurses' Level of Knowledge Regarding Hand Hygiene and Healthcare-Associated Infections: A Survey. *Applied Medical Informatics* 2020; 42(2): 53-61.  
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### Articles submitted for publication\*

1. van der Kooi T, Sax H, Grundmann H, Pittet D, de Greeff S, van Dissel J, Clack L, Wu AW, Davitt J, Kostourou S, Maguinness A, Michalik A, **Nedelcu V**, Patyi M, Prosen M, Tellez D, Varga É, Veini F, Ziętkiewicz M, Zingg W, on behalf of the PROHIBIT consortium. Hand hygiene improvement of individual healthcare workers - Results of the multicentre PROHIBIT study. *BMJ Quality & Safety*. 2022. Factor de impact 7.035.  
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\* This article is currently in the form of a manuscript proposed for publication in a prestigious journal by a group of internationally renowned authors in the field of hand hygiene and HAI prevention. The article presents the results of the PROHIBIT study, an important international multicenter study, which was conducted in ICUs in 11 European countries and aimed to study the impact of some interventions on HAI. Partial results of this study have already been published: <http://dx.doi.org/10.1136/bmjqs-2017-007675>, <https://rdcu.be/cB6xs>. I was part of the study team as a study nurse, and this research experience was a defining milestone in my scientific and clinical concerns about hand hygiene and HAI prevention.

### Published abstracts

1. **Nedelcu V**, Zazu M, Mazilu C, Grințescu IM. *Studiu de evaluare a nivelului cunoștințelor asistenților medicali privind infecțiile asociate asistenței medicale și igiena mâinilor*. Volumul de Rezumate al celei de-a XV-a Ediții a Conferinței Naționale a OAMGMAMR, 13-14 sept. 2018. ISSN 2601-9221, ISSN-L 2601-9221, p. 34-36.  
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2. Zazu M, **Nedelcu V**, Mazilu C. *Metodologia de elaborare a procedurilor operaționale de practică medicală pentru asistenți medicali generaliști, moașe și asistenți medicali*. Volumul de Rezumate al celei de-a XV-a Ediții a Conferinței Naționale a OAMGMAMR, 13-14 sept. 2018, p. 266-268.
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