

Microbiology in Nursing Students Curricula: Significance, Education, Constraints and Perspectives

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Abstract:

Microbiology is an essential discipline for healthcare professionals. Indeed, they practice in environments at high risk of healthcare-associated infections, antimicrobial resistance and the emergence of new diseases. This discipline allows nurses to be well equipped for the practice of nursing care, to contextualize adequately their knowledge and competencies in multiple care situations. The purpose of this study is to highlight the importance of microbiology in nursing education and practice.

To carry out this review, we questioned: Pubmed, web of science, Scopus and Google scholar databases to select the articles. Only those available from 1990 to 2019 with full text and related study interest are studied. Thirteen relevant articles were selected. The themes emerged from this process review article are: the importance of microbiology study in current nursing practice and nursing student program, the constraints and recommendations education.

This review shows the undeniable role of microbiology in nursing practice, particularly infection control. It is suggested to promote the microbiology education based on significant clinical tasks nursing and adopt active learning methods. Further studies should be conducted to assess the level of microbiology application knowledge in clinical practice among nursing students.

Key words: Microbiology, curricula, nursing students, education, constraints, perspectives

Introduction:

The health care-associated infections is a public health problem for all health systems, including the most developed (Alp et al. 2011, Haque et al. 2018). In fact, it has a serious consequences: Functional disability, emotional stress, deterioration of quality of life, increased economic costs, length of stay and death (Who 2002). To prevent patient and health workers, the infection prevention and control (IPC) is the only scientific approach to deal with this problem (Who 2020). To succeed in this approach, health professionals have a key role because the IPC is an activity integrated into their daily practice. For this, they need

information and knowledge of disease transmission, infections, including hospital infections and prevention (Choe 2001) and have sufficient knowledge of the IPC in order to apply it appropriately (Cox et al. 2015). In fact, the IPC is an essential part of the initial and continuing education of health personnel (Rodríguez-Baño et al. 2015). The place of nurses in IPC is unavoidable; they are involved in the management of all aspects of ambulatory health and infection control in hospitals. (Who 2002).

In order to integrate and fully understand IPC knowledge of clinical patient care, epidemiology and microbiology are crucial (Emori and Gaynes 1993, Carrico et al. 2008). A strong background in microbiology is an important safeguard for both patients and practitioners in health care settings. For this, it constitutes an essential part of training for health care workers; it is linked to competencies that nurses need in their careers (Akpata 2012). In this sense, the microbiology course is required in curriculum of 96,2% of United States nursing schools (Goetz et al. 1992)

Microbiology is taught as a subject within the biosciences (Choi 2001) which are a scientific foundation of nursing practice (Taylor et al. 2015). They provide nursing students with a robust basis of knowledge required to practice and therefore ensure adequate preparation for the professional role (Birks et al. 2015).

This review search allows us to highlight the importance of microbiology study in current nursing practice and in nursing student program, particularly the link of microbiology and IPC competencies and the state of microbiology education: constraints and recommendations.

Materials and Methods

To carry out this review, we searched the following databases: Pubmed, Web of Science, Scopus and Google Scholar to select the articles. The key words used are: Nursing student, nursing education, nursing program, nursing curricula, which are connected with microbiology, microbiology education and microbiology courses.

Only articles available from 1990 to 2019 with full text are included. For the language of drafting of the articles, only those written in French or English were selected. We have also excluded studies related to the biosciences or to a specific subject of microbiology.

Results

First, we examined the titles and abstracts of the recovered articles that contain one or more study interests. Then, we analyzed the full text. Thirteen relevant articles were selected: Seven articles are from the United States and one each from Japan, India, Kuwait and three in Australia. The small number of relevant studies present a heterogeneity concerning the themes, objectives and study design (Table 1). The themes emerged from the process review article are the significance of microbiology study in current nursing practice and in nursing student program, the link of microbiology and infection especially understanding IPC competencies, the state of microbiology education: constraints and recommendations regarding curriculum, content and teaching / learning method.

Significance of Microbiology in nursing practice

The nurse is called to play several roles. These, include, establishing care plans which based on the results of microbiology and the immunological status of the patient, administering antibiotics according to the appropriate regimen (dose, route of administration, frequency), collection of specimens, care of patients with infectious or communicable diseases requiring isolation, education of patients and families, communication of results to the health care team, and establishment of a hospital vaccination schedule (Dhir 2019). To meet these requirements, a good understanding of basic microbiology is required to describe the different types of microorganisms, to recognize the diversity of pathogens, their role in diseases and transmission mode (Carrico et al. 2008). This course helps nurses to provide treatment with appropriate antibiotics, and to recognize appropriate techniques for collection, handling and transport of specimens to the laboratory to obtain accurate results (Wegner 2007).

Also understand immunity and pathogenicity as subjects areas of microbiology allows nurses, on one hand, to learn about the importance and efficacy of vaccines on immunization, and how to protect society through immunity and have knowledge of vaccination and cold chain. On the other hand, the subject of pathogenicity makes them able to explain to patients disease and care processes (Dhir 2019) and follow precautions not to transmit infection between patients, by adopting the correct sequence to follow when take care of infected patients (Gould and Drey 2013a).

Furthermore, the nurses are responsible for implementing appropriate measures to reduce hospital infections, especially those caused by multidrug-resistant bacteria. Which require that nurses had a firm understanding introduction to antimicrobial drug delivered by microbiology course (Norman-McKay 2018). It will provide an understanding of how organisms can rapidly acquire and share antimicrobial resistance through plasmids, and how the detection of these mechanisms can lead to a reduction in patient morbidity and mortality (Durrant et al. 2017).

The link of Microbiology and IPC

The IPC is a skill set such as standard and transmission based precautions, hand hygiene which is among the most effective healthcare infection control practices, aseptic technique, personal protective equipment (PPE), cleaning, disinfection and sterilization, waste management (Mehta et al. 2014, WHO 2019). The nurse is responsible to prevent and control spread infection while providing nursing care. Then, the knowledge of infection control and HCAI transmission help prepare nursing professionals to recognize infectious diseases and implement appropriate IPC measures and patient care interventions. These topics are considered as core competencies of microbiology (Durrant et al. 2017).

Moreover, the various and more complex IPC processes involve specialized education and competency (Rodríguez-Baño et al. 2015). For example, all transmission precaution IPC competencies, are an essential learning outcome in microbiology courses (Norman-McKay 2018). Thus, knowledge of the transmission mode of the infectious agent: contact, air, droplets, helps to understand how disease can spread and to determine the appropriate transmission-based precautions categories. As consequence, enhance awareness about the spread of infections through hands, surfaces and equipment, the importance to comply with handwashing, aseptic and sterilization techniques as the most important area of IPC competencies and an integral part of nurses' daily responsibilities (Liu et al. 2014). As a

result, the adoption of handwashing technique reduces the load of microorganisms on hands and reduces surgical infection and disease transmission in hospitals and limits the risk of HCAI. As well, aseptic techniques prevent the introduction of pathogenic organisms through equipment and surfaces.

In addition the knowledge of microbiology is also required to ensure proper waste medical management, allowing the acquisition of a proper segregation, handling and disposal procedure in order to reduce the spread of pathogens, prevent infection and avoid environmental pollution (McCall et al. 2019).

In sum, some authors demonstrated that sound knowledge of the mode of transmission of microorganisms leads to the implementation of appropriate IPC and to the reduction of these microorganisms. For example, the improvement of hand hygiene measures and disinfection of surgical instruments has led to a decrease the number of enterococci, which are frequently transmitted from person to person through the hands of hospital staff and medical devices. Similarly, protocols of linen management, disinfection of all surgical instruments have contributed to the reduction of environmental pathogens such as principally *Enterococcus* and *Acinetobacter* species (Jayasree and Afzal 2019)

Additionally, the Knowledge of microbiology is fundamental for nurses given the continued emergence of new pathogens and infectious diseases, and the increasing challenges associated with infectious disease control (Cox and Simpson 2018). In this regard, the use of personal protective equipment (PPE) (such as gloves, aprons and/or gowns, and eye protection) is an important aspect of IPC (Liu et al. 2014). To comply adequately to PPE requires effective evaluation, understanding of different types of PPE in various clinical scenarios especially for new and emerging infectious diseases for which an infection control protocol may not yet exist (Brown et al. 2019).

In short, microbiology provides the basis for the appropriate application of IPC competencies, which involves careful decision making (Cox and Simpson 2018).

Microbiology education: Constraints and recommendations

Constraints:

In order to make the nursing profession more effective, biological sciences should informed nursing education in a consistent manner (Choe 2001), particularly microbiology, which is a part of curriculum in nursing education. However Bioscience subjects have consistently been a source of anxiety for student nurses (McVicar et al. 2014). It has been evaluated by nursing students as ineffective and poorly taught. This is mainly due to the fact that students receive more theoretical knowledge than practical courses (Merkel 2012). In this sense, 22 microbiology topics were rated as having a moderate priority in teaching by academics who teach science to nurses (Birks et al. 2015).

As mentioned above, the student have approved difficulties in microbiology and are generally disinterested in course content (Frank Caccavo 2001). In this regard, Akpata noted that all study groups of nursing students had the lowest scores for pathogenicity and epidemiology which counts the subject of microbiology (Akpata 2012). The lack of knowledge of the transmission mode and contagioness of legionnaires' disease is noted by another author (Goetz et al. 1992).

Similarly, it's reported that nursing students had a low level of knowledge about antibiotics, particularly with respect to antibiotic resistance. The majority of them (>90%) stressed that the current curriculum of nursing should have more training on antibiotics and infection control, also 96,5% of student underlined the importance of strong knowledge of microbiology and infection control in their nursing career (Rábano-Blanco et al. 2019).

Regarding IPC competencies, several studies revealed: the low level healthcare workers of compliance with infection control measures (Mehta et al. 2014). Equally, a number of studies revealed that nursing students' knowledge of IPC was below the required level (Darawad and Al-Hussami 2013). They were failure to comply with hand hygiene protocols, isolation precautions, cleaning in the patient environment, personal protective clothing between patients, management of sharp instruments (Gould and Drey 2013b).

The development of students' IPC competencies is influenced, among other factors, by the curriculum structure (Cox et al. 2015). Therefore, some authors have suggested that a course on infection control precautions should include both theoretical and clinical training (Darawad and Al-Hussami 2013). Thus, The IPC constitutes a significant challenge for educational institutions (Sousa et al. 2017)

Recommendations:

In order to overcome the various constraints and limitations in the study of microbiology, different authors have mentioned the importance of microbiology in nursing education. In this line, Norman-McKay, presents a review of resources to support the inclusion of microbiology in nursing and allied health programs and recommends that microbiology be maintained as a full course (lecture and laboratory) in undergraduate nursing and allied health programs after presenting the factors that have changed the place of microbiology in United State nursing and allied health programs (Norman-McKay 2018). In the same vein, McCall et al, designed a curriculum of seven laboratories to give the nursing and allied health student a solid foundation to understand the importance of microbiology in healthcare settings and allow microbiology to remain in the nursing and allied health curriculum (McCall et al. 2019). In Australia, an author propose to review the curriculum: placement nature and timing of Microbiology education and infection control competency after exploring the importance of microbiology and infection control training in undergraduate nursing curricula (Cox and Simpson 2018).

In order to motivate students to attend the microbiology course, it is preferable to emphasis away from memorization and lecture (Merkel 2012). To this end, this author designed curriculum around learning goals and assessments to promote deep understanding of core concepts and empower instructors to adapt student-centered approaches. Another author recommend the adoption of active learning models such as problem-based learning that emphasize critical thinking skills and facilitate the continuous accumulation of new information (Ghosh 2019).

In this light, to increase the success of pre-nursing students in microbiology course, Hoffman, appreciate the need to integrate innovative teaching and learning methods. The results of adopting these methods have shown that student knowledge, course evaluations and student success rates have all improved (81% are successfully completed the courses). the students are

also satisfied in terms of learning that they rated some activities such as daily quizzes, class discussions, case studies, and extra credit projects helpful in achieving mastery of the material and assessed others activities as study groups, lab group projects, presentations, and individual papers as helpful for learning the material (Hoffman 2001).

In the same vein of ideas, to teach the microbiology course for nursing student, various educational interventions are used by Caccavo, such as: case study, prior reading, exam preview of each course session with potential exam questions, discussion and at the end of the session, writing point where the students express what they didn't understand. At the course end, students are required to synthesize the information they have learned and apply it to medical case studies. The author noted that these activities empower the students, increase their level of interest and participation, and improve student engagement and involvement. Finally, an increase of student learning. Furthermore, it allows teacher to assess teaching and the students' learning throughout the courses (Frank Caccavo 2001).

In addition, the scientific and laboratory skills are an indispensable element to develop a student's observational skills, reflective practice and promotes collaboration between individuals. Thus, to improve the laboratory course experience for pre-nursing, an inquiry-based cooperative learning approach was tested by one author, who conclude that approach can be effectively utilized in an introductory microbiology laboratory course to enhance student learning in a limited time and budget format. Furthermore, students commented that their investigative experience helped them to learn the real-world applications of microbiology, increased their thinking and analytical skills and heightened their awareness of the process of scientific discovery, also, student's curiosity, thinking ability, and enthusiasm were enhanced as a result of collaborative project (Ghosh 2019).

As regard the content of microbiology courses, it is important that should be related to nursing science based on interesting clinical tasks for the optimal preparation of students progressing to nursing practice (Wegner 2007). Based on the results survey, Durant et al intends to focus teaching on infection control, specimen collection, comparison of different types of infections and potential sources of health infections as content of microbiology relevant to nursing practice, also considers the importance of microbial genetics and thus addresses antimicrobial resistance (Durrant et al. 2017). Also, McCall et al, Propose to link the laboratory course that cover ,among others, aseptic technique, proper specimen collection, enumerating microorganisms, with a significant activity in the field of health care settings to allows the development of knowledge and competencies useful for practice (McCall et al. 2019).

In this sense, to assess changes in awareness of bacterial traits and ability to avoid spreading infections, a practical program about the effectiveness of hand hygiene by washing hand with or without disinfectants on eliminating hand bacteria, showed an increased awareness about microbiology in particular in terms of unseen bacteria inhabiting body surface, utensils and contact-based (Yano et al. 2019). This can lead the student to see the consequences of poor infection control practice for patients. In the fact, the contextualized learning can improve students' self-efficacy related to applying appropriate IPC in individual situations (Cox et al. 2015).

Finally, regarding educators role, it's required that they have their own speciality in biological sciences with nursing training and to develop their knowledge base theoretically as well as clinically (Choe 2001). In this sense, Caccavo, before starting his course in microbiology, he

consulted the Department of Nursing, to inquire about the background, abilities and needs of nursing students(Frank Caccavo 2001).

Conclusion:

This study showed the undeniable role of microbiology in nursing practice, particularly in infection control. It provides nursing students with the scientific tools to provide quality care, protect themselves and protect patients and their families. It is therefore important to give meaning to the study of microbiology in nursing care by referring to interesting clinical situations. The adoption of various active educational practices also allows the future nurse to develop critical skills and reflective practice.

Based on the results of this review, it is suggested that the teaching of microbiology should be promoted based on clinically important nursing tasks and by adopting active teaching methods for learning. Further studies need to be conducted to assess the level of knowledge of the application of microbiology in clinical practice, particularly adherence to IPC among nursing students. Continuing education of nurses in clinical settings is also necessary to develop their microbiology knowledge, improve their reflection on practice, and become role models for nursing students.

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Conflicts of interest:

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Table 1: Articles studied Authors, Titles, Countries, Objective /study design, Results

Authors	Titles	Countries	Objective /study design	Results
Yano et al 2019	A simple and short microbiology practical improves undergraduate nursing students' awareness of bacterial traits and ability to avoid spreading infections	Japan	to assess changes in awareness of unseen bacteria connecting bacterial traits and how to prevent infections / Educational intervention	the student's awareness of unseen bacteria was significantly increased as compared to those before practical in microbiology class
Cox et al 2015	Re-thinking microbiology/infection control education to enhance the practice-readiness of health professional students: More than just a curriculum issue	Australia	to enable accurate risk perception and maximise self-efficacy / synthesis of three key areas of influence for graduates' IPC knowledge, intentions and practice	Three key areas of influence for graduates' IPC knowledge, intentions and practice: perceptions of science, health behavior beliefs and applied knowledge microbiology/
Cox et al 2014	Putting it into practice: Infection control professionals' perspectives on early career nursing graduates' microbiology and infection control knowledge and practice	Australia	-To explore the importance of microbiology and infection control training in undergraduate nursing curricula and the perceived retention of that knowledge and its transferability to practice/ -Qualitative	-All participants indicated that many new graduates had deficits in their infection control and associated microbiology knowledge - Existence of a theory-practice gap around infection control prevalent in areas such as asepsis and aseptic techniques -Importance of role

			study/ Semi-structured interviews with eight infection control professionals from a range of hospital settings in Australia.	modelling: -Disjunction between university curricula and ‘the real world,’ and evident learning in context.
Cox 2018	Microbiology Education and Infection Control Competency: Offering a New Perspective	Australia	propose re-conceptualization of infection control (IC) competency/ Educational intervention	Review of curriculum: placement nature and timing of microbiology teaching: Concepts must be identified as relevant and necessary for future clinical practice. Use of active-learning models for teaching of microbiology and IC within the curriculum Modeling of IC best practices by clinical supervisors of students
McCall, 2019	A Simplified but Comprehensive Laboratory Curriculum for Microbiology in Nursing and Allied Health (MINAH) Courses	United states	Importance of Microbiology laboratory: development of knowledge and competencies useful for practice/ Educational intervention	Design of curriculum of seven laboratories : connect each lab with significance in healthcare/ Hospital Settings
Durrant et al ,2017	Microbiology Education in Nursing Practice	United states	To identify the relevance of current microbiology education to	-The most relevant topics of microbiology to current nursing practice are infection control, hospital-

			nursing practice/ Internet-based survey among 296 Registered Nurses	acquired infections, disease transmission, and collection and handling of patient specimens
Hoffman, 2001	Successful Application of Active Learning Techniques to Introductory Microbiology	United states	to allow students to address the material in a more active manner. / Educational intervention	-Student knowledge, course evaluations and student success rates have all improved (81% are successfully completed the courses). -Increase of satisfaction students in terms of learning
Caccavo 2001	Teaching Introductory Microbiology with Active Learning	United states	to diverge from didactic lecturing Development of the course using active learning / Educational intervention	-Increase their level of interest and participation, and improve student learning engagement and involvement -Allow teacher to assess teaching and the students' learning throughout the courses
Subir Ghosh, 2019	Learning Strategies to Initiate and Motivate Students of an Introductory Microbiology Laboratory Class to Perform Cooperatively an Inquiry-based project	United states	To Test of an inquiry-based cooperative learning approach in an introductory microbiology lab course/ Educational intervention	- helped student to learn the real-world applications of microbiology, increased their thinking and analytical skills and heightened their awareness of the process of scientific discovery -Student's curiosity, thinking ability, and enthusiasm were enhanced as a result of collaborative project

Norman-McKay 2018	Microbiology in Nursing and Allied Health (MINAH) Undergraduate Curriculum Guidelines: A Call to Retain Microbiology Lecture and Laboratory Courses in Nursing and Allied Health Programs	United states	to Retain Microbiology Lecture and Laboratory Courses in Nursing and Allied Health Program./ Review	-Resources to support the inclusion of microbiology in nursing and allied health programs -Recommends that microbiology be maintained as a full course (lecture and laboratory) in undergraduate nursing and allied health programs.
Goetz et al 1992	Microbiology, Infection Control, Immunizations, and Infectious Disease Exposure: Education and Practices in United States Nursing Schools	United States	Adressed curriculum requirement for microbiology courses / Survey among nursing schools (three types of nursing programs in the united states	96,2% of schools required a microbiology course A microbiology course was required before clinical experience by 49% of schools 98% of schools give instructions concerning universal precaution 94,6 % of schools give instructions other isolation practices 28,8% the expertise of an infection control
Anju Dhir,2019	Role of Microbiology in Nursing	India	Why microbiology is needed in nursing? / Synthesis of the role Microbiology in Nursing	The microbiology in nursing profession is an indicator of deep understanding of interaction of microbial world organisms Microbiology provides the basic foundation to the nursing profession

Akapata 2012	Assessing Student Nurses' Knowledge of Microbiology for Course Content Improvement	Kuwait	-To assess the knowledge of microbiology among nursing students in the ADN and BSN programs against a standard score by registered nurses who were clinical teachers in the College of Nursing./ -An anonymous questionnaire was administered to 330 nursing students and 14 faculty members.	-knowledge of microbiology was highest in immunity and infection control and least in pathogenicity and epidemiology. -Areas of pathogenicity and epidemiology require more emphasis in the nursing microbiology curriculum.
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