

# A literature review -nurses' interventions to prevent ESBL- producing bacterial infections

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### Abstract

ESBL-producing bacteria are the second most common antibiotic resistant bacterial group occurring in Sweden. Colonization caused by ESBL-producing bacteria pose a serious challenge for treatment of both common and life-threatening infections. Half of healthcare related infections could have been prevented with the implementation of good hygiene practices. **Aim:** to identify which evidence-based nursing interventions do nurses use for prevent healthcare related ESBL-producing bacterial infections. **Method:** a literature review study based on 11 original articles. **Results:** The evidence gathered suggest a list of risk factors. Furthermore, the following list of successful evidence-based nursing interventions was gathered: screening of patients on a regular basis, isolation or cohorting of carriers and infected patients, evidence-based education of the staff on a regular basis, monitored hygiene routines, policy implementation accompanied by educational programs. Finally, the gathered evidence pointed out the following list of known obstacles: insufficient knowledge of hygiene routines and antibiotic resistant bacteria in general, factors as lack of time or work environment stress, poor or incorrect usage of working materials, non-compliance with hygiene guidelines, and frequency of abroad travelling. **Conclusion:** This literature review has contributed with: 1. Knowledge about which barriers should be overcome in order to increase compliance. 2. Best practice guidelines can improve the work towards enhanced patient safety. ESBL-producing bacterial infections implies significant healthcare costs in terms of extended care time and more complicated care processes. 3. To ensure health care of the best possible quality, nurses should continuously evaluate the quality of their interventions. 4. Continued research is necessary to support up to date evidence-based interventions. 5. Finally, more nursing research is needed. As mentioned before, nursing research is the basis for evidence-based nursing intervention.

**Keywords:** infection prevention, infection control, nursing interventions, ESBL-producing bacteria, compliance, hygiene routines.

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# Introduction

Since the turn of the century, the World Health Organization (WHO) has raised concerns regarding the fast proliferation of resistant bacteria (WHO, 2001). Today it is a known fact, that antimicrobial resistance is a serious problem worldwide (WHO, 2015). Prevention against the proliferation of multiple drug resistant bacteria has taken place in Sweden since the 90's (Folkhälsomyndigheten, 2014).

In general, healthcare systems are dependent on antibiotics for prophylaxis and treatment of infections. However, with the lack of alternatives and the constant development of bacterial resistance the health care system as we know it faces difficulties keeping it self-sustainable (MSB, 2015). It is important to account that the most common type of health care injury are infections.

Much is known about MRSA, yet less information is known about Extended Spectrum Beta Lactamase (ESBL) producing bacteria. ESBL producing bacteria are one of the most common antibiotic resistant bacterial group occurring in Sweden at a national level (MSB, 2015). Furthermore, occurrence by patient group population can be alarming. While some groups are more vulnerable than others, individuals affected by ESBL-producing bacteria pose a potential risk for contagion.

ESBL-producing bacteria has become such a large problem in today's society, that its presence cannot be ignored by mass media. International and National press have addressed the issue raising questions regarding the different bacteria that pose a challenge to humankind (Hansson, 2017; Larsson, 2017a; Sällström, 2017; TGPA, 2017).

Furthermore, the particular importance of ESBL-producing bacteria was also addressed (Larsson, 2017b; Roos, 2017; TT, 2017). The issue revisited such an alarming character that even articles discussing the prevalence of ESBL-producing bacteria in Swedish children were written (Sundberg, 2017).

The present literature review intends to give an insight to the current knowledge regarding the nurses' interventions to prevent ESBL-producing bacterial related infections.

# Background

## Antibiotic and antimicrobial resistance

As stated by the World Health Organization antibiotic resistance occurs when bacteria change in response to overuse of antibiotics. As a consequence of such overuse, bacteria become antibiotic resistant. Antibiotic resistance falls under the umbrella term antimicrobial resistance; the last includes resistance to drugs that are used to treat infections caused by other microbes as well, such as parasites, viruses and fungi (WHO, 2015).

As it is mentioned previously, antibiotic resistant bacteria comprise a great risk to global health. The continuous use of certain antibiotics has led to the development of new genetic characteristics in the targeted bacteria. The issue does not only regard the “clinical” use of antibiotics, for instance the use of antimicrobials in food animals can create an important source of antimicrobial resistant bacteria that can spread to humans through the food supply (WHO, 2017).

The machinery by which bacteria obtains its antibiotic resistance is not completely known, and these mechanisms can vary within different bacterial cells. Nevertheless, one of the most common mechanisms that bacterial cells use against antibiotics is the development of enzymes that can damage the antibiotic molecular structure. Some antibiotics are more prone, for molecular structural damage by bacterial enzymes such as penicillin, cephalosporin and carbapenems. All the previous mentioned antibiotics have a molecular structure in common, called for a  $\beta$ -lactam-ring. Among the different bacteria that can hydrolyze penicillin, Methicillin-resistant Staphylococcus aureus (MRSA) and Streptococcus Aureus are the most known (Tortora, Case, & Funke, 2016).

However, MRSA is not the only growing antibiotic resistant bacteria. Gram-negative antibiotic resistant bacteria can become a larger problem than MRSA (Hallgren et al., 2007). Several gram-negative bacteria can produce extended spectrum  $\beta$ -lactamases enzymes, which can even degrade penicillins and new generations of cephalosporins. The bacterial family of enterobacteriaceae, which are gram-negative bacteria are the most related to ESBL production. E-coli and Klebsiella pneumoniae are some important examples of enterobacteriaceae, which are of high clinical relevance as they are responsible for regular infections such as pneumonia, urinary tract infection and bloodstream infections (Brolund, 2014).

## ESBL-producing bacteria

ESBL-producing bacteria can affect both humans and animals. Only between 2015 and 2016 there was an increase of 11 % of the human cases carrying ESBL-producing bacteria (Swedres-Svarm, 2016). Around 5 % of the Swedish population carries this type of bacteria and it is estimated that the number of carriers increases by a rate of 10 to 30 % annually (Socialstyrelsen, 2016).

It is important to note, as explained by Hijazi, Fawzi, Ali, & Abd El Gali (2016), that most data on prevalence of ESBL-producing bacteria comes from studies in adult patients in hospital and community settings. The available data concerning healthy populations is

limited. Resistance patterns are being followed and monitored based on samples mostly obtained in primary health care (Mölstad, Löfmark, Carlin, Erntell, Aspevall, Blad, Cars, 2017). According to Swedish nationwide studies done during 2016, (Mölstad et al., 2017) the prevalence of ESBL-producing *E. coli* in fecal carriage was 4,9%. However, as pointed out by the authors (Mölstad et al., 2017) comprehensive national as well as global data are still lacking.

Technically, when ESBL-producing bacteria colonize new tissues in the human body, they produce an infection. The latter explains why not all individuals carrying ESBL-producing bacteria are considered infected (MSB, 2015). The bottom line is that colorizations caused by ESBL-producing bacteria pose an immense challenge for treatment of both common infections and life-threatening infections.

One of the main reasons why antimicrobial resistance was of major interest for this literature review is because of the increasing amount of infections with antibiotic resistant bacteria in Sweden (Socialstyrelsen, 2016). Infections with ESBL-producing bacteria in particular, have been reported since 2007, these particular cases increased from 2099 to 8131 in less than five years, which is an increase of almost 387 % (Brolund, 2014).

According to Hallgren et al. (2007) ESBL- producing bacteria has become a large public health problem worldwide. Studies show that ESBL-producing bacteria is present in healthy individuals, which make it almost an unperceivable threat to society. Hallgren et al. (2007) mentions an ESBL outbreak in Uppsala University Hospital in 2005 -2006. The author reports that in 2007 the Swedish government in order to have a better regulation, classified ESBL-producing bacteria as a mandatory reportable infectious disease. Today according to Swedish law, it is the nurses' responsibility to report all healthcare related injuries or diseases, which can have arisen during clinical treatment (SFS 1982:763).

Common risk factors for ESBL-producing bacterial infections include high age, intensive care unit hospitalization, urine catheters, urinary infections, invasive clinical procedures and overseas visits (Hallgren et al., 2007). Several of the previous mentioned risk factors include interventions in which nurses play important roles, however as the author mentions, those risk factors are not exhaustive, and therefore the authors of this review wish to further explore this subject. The latter argument highlights and convey the importance of why nurses should have a higher knowledge regarding the nurses' responsibility in preventing antibiotic resistant bacterial infections such as the ESBL kind.

## **The relevance and obligations of preventing infections of ESBL-producing bacteria in the Swedish Healthcare**

Studies led by the Swedish National Board of Health and Welfare show that half of the so-called health care injuries could have been prevented, simply through the implementation of good hygiene practices (Socialstyrelsen, 2016). Indeed, this is why the role of nurses in preventing infections bear a high importance. It is well documented today, that healthcare related injuries are a frequent event and approximately 10% of the patients in contact with the Swedish healthcare system suffer healthcare related injuries. It is even more important to know, that almost one third of these injuries are healthcare related infections (SKL, 2017).

Swedish law states that healthcare should be of good quality with good hygiene standards (SFS 1982:763). The writers of this text believe that a central element in truly ensuring the “best possible care” is basic knowledge regarding the ways in which ESBL-producing bacterial infections occur. The Swedres-Svarm (2016) published by the Public Health Agency of Sweden (Folkhälsomyndigheten) and the Swedish National Veterinary Institute (Statens veterinärmedicinska Anstalt), accounted that in 2016, 10 659 cases of Extended spectrum  $\beta$ -lactamase producing Enterobacteriaceae (ESBL) infections were reported, which is an increase of eleven percent in comparison with the previous year. The previous stated report, also mentions that the infections were evenly distributed within the genders. It is also mentioned, by the report that the amount of cases of ESBL infections have increased since 2007. The national incidence was of 107 cases per 100 000 people, and an increased incidence occurred in 15 of 21 Swedish counties. The increase ESBL-infections is an important reason why the infection has to be taken seriously and it is something that must be studied.

Furthermore, the Swedish Law for Communicable Disease Control (SFS 2004: 168) describes that contingency measures should be based on evidence. Also, measures taken must respect the integrity of the individual and, as stated also in the Health and Medical Services Act (SFS 1982:763), work for the equal value of all people. Healthcare providers must also participate in preventive work through preventive measures, helping both infected and uninfected people. The Swedish Law for Communicable Disease Control also accounted that anyone suspected of carrying contagious disease should take steps to protect others in their environment.

Patient Safety Act (SFS 2010:659) states that healthcare related injuries are those that could have been prevented if adequate measures had taken place. Safety implies avoiding healthcare related injuries. The Swedish Patient Safety Act (SFS 2010:659) obliges healthcare providers to take the necessary measures to prevent occurrence of healthcare injuries. In order to comply with such high standard of patient safety, nurses should follow the so-called healthcare best practice guidelines (SOSFS 2015:10). Coincidentally, the Swedish National Board of Health and Welfare established the basic hygiene in care guidelines (SOSFS 2015:10). In the latter, the Board presented numerous of measures that nurses and healthcare providers should take in order to prevent healthcare infections. According to the board, following these guidelines and regardless of the type of infection, healthcare related injuries could be prevented. However, several studies have shown that healthcare related infections still arise. It seems necessary to analyze which nursing interventions are successful and what obstacles should be overcome.

As stated above, nurses in Sweden are obliged to follow the law, when it comes to following hygiene routines, nurses working outside hospital areas are also obliged to follow the law and those routines. Since January 1<sup>st</sup> 2016 according to SOSFS 2015:10 all home health aid workers including nurses, nursing assistants and workers within Service for Persons with Certain Functional Impairments (LSS) should all follow the same hygiene routines and procedures. It is important to highlight as well, that when it comes to people, with different types of disabilities the act concerning Support and Service for Persons with Certain Functional Impairments complies its workers in paragraph 9 a §, to aid those in need with their personal hygiene (SFS 1993:387).

The question is why a country like Sweden, which has laws, and hygiene routines to prevent infections still reports an increased number in ESBL related infections. This reinforces the

importance of this public health issue, concerning the relevance for nursing and the importance of nurses' actions for preventing further outbreaks.

## **Nurses' ethic and competences**

According to the international code of ethics for nurses, the International Council of Nurses (ICN) argues that it is within a nurse's responsibility to "promote health, to prevent illness, to restore health and to alleviate suffering" (ICN, 2012 p.1). The subject of prevention of antibiotic resistant bacteria should be taken seriously, as it not only concerns registered nurses, nursing assistants and doctors but also the healthcare system and everyone who receives its care. Therefore, the nurse's role in preventing infections is of high importance also for the general population, and it can thus be seen as a matter of public health. According to ICN (2012), it is also nurses' responsibility to provide health care to everyone equally regardless of gender, sexual orientation, physical disabilities, skin pigmentation, political beliefs or nationality. Moreover, it is therefore of high importance, that nurses bring the necessary care to those that require it. The latter can be motivated by e.g., keeping up with the necessary hygiene routines in Nursing Homes to stop a further spread to society. ICN (2012) also states that it is also a nurse's responsibility to educate and provide information concerning medical treatment, thus those infected by antibiotic resistant bacteria should also be given enough information about their infection and treatment. Between 2015 and 2016, an ESBL spread occurred in a thoracic clinic, and according to the Swedres-Svarm (2016) report, improvements in hygiene "routines have being undertaken since then at a national level". The previous statement remarks the nurse's responsibility in performing good hygiene routines and educating other health care personnel in order to enhance the infection control.

The Swedish National Board of Health and Welfare first established the necessary competencies for nurses in 2005. However, the responsibility for a competence description is no longer included in the mission of the Swedish National Board of Health. Today, the responsibility falls on the healthcare unit manager to ensure the right skills in their respective area.

The Swedish Society of Nursing (2017b) believes that a national competence description is necessary for the profession and the organization has taken responsibility for establishing a new description. The "traditional" competences (Socialstyrelsen, 2005) are complemented by the six "so-called" core competences, which include person centered care, evidence-based practice, quality improvement, safety, teamwork and collaboration, and informatics (Svensk Sjuksköterskeförening, 2017a, 2017c). In brief, the role of the nurse is to regard patients as equals and partners, by listening to their narratives and by making use of methods that can give the greatest benefit for them. Those methods have to be grounded in scientific knowledge, minimize the risk of harm to the patients and providers, aid in collaboration with other health professional groups, make use of structures, processes, outcomes and approaches that ensure an improve quality and safety (Svensk Sjuksköterskeförening, 2017c).

It is important to note, that as stated by the Swedish Society of Nursing (Svensk Sjuksköterskeförening, 2017c), patients should not suffer preventable harm due to care and treatment. Some of these adverse events could have been prevented by paying attention to good hygiene practices, in other words safety. Safety constitutes a central topic for healthcare and it permeates every aspect of the role of nurses. Safety should not only focus on past



incidents but should also be taken into consideration in future nursing intervention. “Safety first” is not just a saying, there are several laws in place, for instance the already mentioned Patient Safety Act.

## **Evidence-based nursing**

The law states what must be done, however it is the nurses’ responsibility to undertake the necessary measures, this implies action and reflection. The Swedish National board of Health and Welfare stated that an effective prevention of healthcare related infections should be evidence-based (Socialstyrelsen, 2006). As mentioned before the Swedish Society of Nursing (2017c) stated that nurses should base their work on evidence and hold their knowledge updated. In order to achieve an evidence-based work, nurses should reflect on the basis for their interventions. Healthcare providers in general and nurses in particular, have a major responsibility in the struggle against bacterial infections. It is indeed fundamental for the prevention of healthcare related infections, that nurses’ work in teams, with the rest of the staff to pursue high standards of evidence-based nursing.

Several authors have discussed the effectiveness of evidence based-practice as the answer to “lower cost, efficient science-based nursing care”. The strong belief in traditional care practices seems to be the case that creates barriers to the acceptance of evidence based-practice (Parse, 2014). In a recent Swedish study, the authors found that nurses and managers have different approaches towards the use of scientific knowledge. The study shows that both the managers and nurses support evidence-based practice. However, as the use of research is not controlled by the managers, several nurses do not pursue for scientific research to base their practices upon (Jansson & Forsberg, 2016).

As described by the Swedish Society of Nursing, it is the nurses’ responsibility to take clinical decisions that convey possibilities to better an individual’s health, health perspectives, disease or physical disabilities and to try to aid those in need to achieve the best possible wellbeing and quality of life during their whole life (Svensk Sjuksköterskeförening, 2017c). According to WHO’s 1948 constitution health is “a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity” (WHO, 2018). A bacterial infection such as an ESBL infection can be considered a factor that can decrease prosperity, because it endangers the human health, as it can worsen the state of physical, mental and social well-being in those that have been affected.

Non-evidence-based practice may lead to patient suffering. Suffering is a broad terminology that is highly subjective, it can be explained as an interconnection of physical, emotional and spiritual pain. Suffering can be described as the form by which an individual can withstand, carry and live with pain. The terminology of pain is closely related to wellbeing, sometimes these terms cannot be seen without each another. Pain can convey other feelings such as anxiety, unease and different types of pain as mentioned before. The suffering that is related to healthcare can normally be linked to bodily pain caused by disease, death or different feelings of hopelessness (Arman, 2017). It is a nurse’s responsibility to foment health and one way in doing so is by preventing disease, the latter in turn decreases suffering and promotes wellbeing.

There is enough consensus in nursing to affirm that the suffering experienced within healthcare can be divided into, disease caused suffering, existential suffering and health care

related pain or suffering (Wiklund, 2014). Diseases causing suffering is as its name denotes the pain that is caused by a disease and by its treatment and its outcome. This type of suffering is one that nurses encounters on a regular basis in any hospital unit. Existential suffering is related to a person's life experiences and their spiritual processes and understanding of living, it is again a very subjective matter. It is caused by strong experiences such as traumas or life decisive moments, which can force an individual to reflect about its life and existence. Healthcare related suffering can be explained as the suffering that arise when in contact with healthcare as Wiklund (2014) foretells, it is indeed something nurses can prevent and strive to eliminate.

Evidence-based nursing is defined as a process as well as an approach (Willman, Bahtsevani, Nillsson, & Sandström, 2016). As a process it implies the use of the results of nursing research as a complement to other types of knowledge; As an approach evidence-based nursing implies that nurses should integrate the best available external evidence in order to make decisions regarding their nursing interventions. It is important to mention that evidence-based nursing does not replace individual experience or their ability to empathize or to hold an ethical approach or even an ideology (William et al., 2016). Evidence-based nursing is a complement that do not compete with professionals', patients and their relatives' experiences.

An important difference should be named, evidence-based nursing it is not completely comparable with evidence-based medicine. The idea of the "golden standard" raised by the results of methodological randomized clinical trials do not always apply to nursing (William et al., 2016). In lack of nursing clinical trials, the best available evidence for evidence-based nursing can as well be systematic reviews of other types of scientific studies regardless their method as long as they present a clean methodology of high quality (William et al., 2016). Finally, given the unlikely scenario of a complete absence of scientific evidence nurses cannot refrain to intervene. As highlighted by William et al., (2016) it is only under such conditions that nurses should refer to collectively proven experience.

## **Problem Statement**

Nurses working in healthcare institutions have the unavoidable responsibility to limit infection risks and exposures in order to prevent further outbreaks. The law requires good hygienic standards, for all the Swedish healthcare providers. The ability to work under such standards is part of nurse's competences, which forms the basis for the professional practice of registered nurses.

Deeper knowledge about ESBL-producing bacterial infections and a deeper understanding of how these affect healthcare practitioners and their patients is indeed necessary. Furthermore, in order to truly improve the quality of healthcare by reducing unnecessary suffering and economical costs, it is important to have a minimum insight of the phenomena.

By understanding the scope in which ESBL-producing bacteria affects healthcare, there is a hope to contribute to a safer healthcare and to relieve patients from avoidable suffering. As presented above, time has proven that even with preventive measures in place, infection rates have actually increased since the first outbreaks.

## **Aim of the Study**

The aim of the study is to identify which evidence-based nursing interventions do nurses use for prevent healthcare related ESBL-producing bacterial infections.

# Method

## Design

A literature method was chosen for review the problem. The present work is a nursing review and it will therefore try to highlight the areas where nurses have or share responsibility, regarding, e.g. infection prevention, hygiene routines and staff education. Following Friberg (2012), the intention was to deepen the knowledge of the chosen topic by reading articles that have already been published and comparing their results with each other. In order to achieve good scientific standards reliability and validity are core methodological concepts (Ejvegård, 2009). The search method used for this review is reliable; it produces stable and consistent results. Thus, to maximize how well this assessment tool measures what it is purported to measure, a detailed description of the information search process was included in the following sections.

The present literature review follows the recommendations as outlined by Friberg (2012), SBU, (2013), Willman et.al (2016) and Östlundh (2012). A first orientation search was made following Friberg (2012) criteria for “helicopter perspective” and Östlundh (2012) “initial information search”. Only two databases were then used, PubMed and Cinahl. Two different search strings were used in Cinahl and PubMed. No restrictions were used for either search. These two initial searches intended to deepen the writers understanding of successful nursing practices and their obstacles.

## Information search

The information search process question was produced, by following the international method Population, Intervention, Comparison and Outcome (PICO) (SBU, 2013). Pico is a method that aids in simplifying and organizing a desired clinical research question. The PICO components are flexible and adapted to the research question (Fineout-Overholt & Johnston, 2005). Cinahl Headings was used to find the necessary operators and appropriate search words. In order to achieve a correct interpretation and a fluent discussion, Swedish MeSH was used to translate Swedish medical terms to English (KIU, 2018). During the search process, the search was focused on finding information with regard to infection, prevention, and nursing interventions (especially those focused on evidence-based hygiene routines). The used building block strategy was the following; the population (P) was patients within health care institutions; intervention (I) was defined as plausible nursing interventions, prevention and hygiene routines; comparison (C) was left out, as a general overview of the different interventions was desired; the outcome (O) was to minimize the incidence of infections. As it is described by SBU (2013) every building block was searched by itself and by combining them with the aid of Boolean search operators or strings, such as AND, OR and NOT. **In accordance to the aim** of this research, this literature review is about infections related to ESBL-producing bacteria, therefore search blocks that were not specific enough, such as antimicrobial resistance where excluded; hence, antimicrobial resistance can imply resistance to several substances as a broad spectrum of microorganisms.

## **Databases**

Following the recommendations given by William et al., (2016) the following databases were chosen for the information search process; Medline/Pubmed, Cochrane Library, Scopus & Cinahl. Pubmed's inclusion into to the search process was natural because of its wide database and its biomedical inclination. According to William et al. (2016) Medline's content is mostly within the field medicine and nursing. Cinahl (Cumulative Index to Nursing and Allied Health literature) as William et al. (2016) notes Cinahl's content is mainly of the field of nursing. The use of Cinahl was therefore also a conscious choice as this thesis is trying to answer its aim through a nursing perspective. Other databases that were used, in this literature review includes Scopus and the Cochrane Library. The use of Scopus intended cover the interdisciplinary aspects of nursing, this was performed following Friberg (2012). The Cochrane Library was used because it contains overview articles of six different databases and includes a wide range of information such as health care related subjects to economy (William et al., 2016).

## **Search strings**

The information search string was developed over two weeks, detailed information about this search can be found in the appendix (Appendix 1). With the knowledge granted by our first orientation search, the "actual information search" took place during the following week. As explained before, to broader our spectrum four databases where then used. The reported automated booleans/phrases and automated queries were saved and compiled in a search table for each search.

Two search strings were used in Cinahl, and four searches were then conducted in PubMed. Cinahl searches were limited to Peer Reviewed; Research Article while PubMed searches were limited to Case Reports, Classical Article, Clinical Study, Clinical Trial, Phase I, II, III, IV, Comparative Study, Controlled Clinical Trial, Guideline, Journal Article, Observational Study, Practice Guideline, and Randomized Controlled. Finally, two databases were used to complete the searches. Two of them were done with Scopus, no limitations were applied. The last two searches were made at The Cochrane Library, where no limitations were applied.

## **Inclusion and exclusion criteria**

The searches included all possible countries and regions, all possible patient groups and all possible healthcare contexts. Not all databases used shared or provided the same search possibilities. However, standardized criteria were applied, when selecting and controlling the quality of the articles.

Inclusion criteria: Peer reviewed published articles in scientific journal, articles in English, articles published during the last twenty years, articles that give insight to preventive interventions.

Exclusion criteria: studies related to specialist registered nursing interventions whose results were not generalizable outside the specialist field. Studies that discuss multi-resistant bacteria and exclude ESBL-producing bacteria.

Selection of articles followed Friberg (2012) principles. A total of 2631 articles titles were found in the performed searches; the following filtration was done based on the relation between the topics of the articles and the topic of the present study. Our selection criteria excluded those articles where evidence-based preventive practices or their barriers were not raised. Successful preventive interventions and obstacles can be found internationally, however, Swedish studies were included in order to compare to local laws and guidelines. In brief, around 600 titles were considered for the present review. Based on their titles, thirty-five articles were first found relevant. Their abstracts were read and 11 of them were selected for quality control (see appendix 1).

## **Selection of articles**

A quality examination of the chosen articles was done separately for qualitative and quantitative articles. Two forms were used: form for quality examination of studies with qualitative method (SBU, 2013), and a form for quality examination of studies with quantitative method (Willman et al., 2016) (see appendix 3 and 4). The form used to review the qualitative articles contained 21 questions. Yes and no were used as answer options, “yes” scored one point and “no” scored zero. The template used to review the quantitative studies contained only 11 questions. “Yes” and “no” were again used as possible answers. Total score was used to get the percentage quality.

The articles were divided into three quality levels depending on the score they received: high (90 %), medium (70-90 %) or low quality. Out of the 35 articles evaluated, 11 were selected to be included in the review. Seven of them fulfilled the criteria of high quality, three were medium and one was of low quality, it was included however the information given was important.

## **Data analysis**

In order to expose the articles to the same systematic analysis, three basic identification principles were applied: their core argument, their similarities and their differences with the rest of the analyzed articles (Friberg, 2012). The authors of the present literature review read all articles individually. Appendix 2 synthetizes the eleven articles’ overview. In order to get a deeper understanding and to avoid misinterpretation the articles were read and discussed several times. Beside the three basic identification principles, the articles were discussed to find common components that were then put together in a mind map. The mind map was then used to guide the writing of the result section.

Finally, the results were categorized to have a deeper understanding of evidence-based nursing interventions to prevent ESBL-related infections. From selected articles, four categories were chosen to answer the research question; successful evidence-based infection preventive interventions and their obstacles. The, following categories are discussed below; 1) Risk factors evaluation 2) Known ‘standard’ precautions, 3) Insufficient knowledge on ESBL-producing bacteria and 4) Environmental factors and Noncompliance.

## **Ethical considerations**

Ethics approval is used when research focuses on humans and its biological derivatives such as DNA (SFS 2003: 460). When dealing with people, research ethics aim at protecting the integrity of the participants while increasing their rights. The ultimate goal is to avoid them being harmed or injured during the research process (Kjellström, 2017). Scientific articles that can account for ethical approval indicate the willingness of the researchers for achieving high quality and in most cases high reliability (Wallengren & Henricsson, 2017). As explained by Wallengren and Henricson (2017) ethical approval by university committees and ethical considerations can improve the scientific quality of the articles. Nine of the articles included for the current literature have shown a clear understanding of ethical principles. For the two articles where ethical approval was not available, it will be further discussed in this review.

# Results

## General description of the chosen articles

The chosen articles were taken from different geographical areas but mainly from Europe and Sweden. The period for the chosen articles, ranged from 2007 to 2016. Most of the articles were of quantitative research in exception of two that were qualitative research articles. It could briefly be said that the methods used by the articles included: interviews, surveys, observational studies and lab analysis of microbiological samples.

All articles discussed the theme of antimicrobial resistance within healthcare environments. The following context were specifically addressed in the chosen articles: critical care units, primary healthcare and elderly homes. The sample groups described in the articles were: healthcare givers of several professions including doctors, nurses, nurse assistants and experts of the field of infection control, carriers of ESBL-producing bacteria, residents of elderly homes and critical care units' patients. The main topics of the chosen articles were: staff compliance regarding best practices guidelines, infections control measures, risk and transmission factors of contagion and prevalence ESBL-producing bacteria carriage. The following audiences were identified for the articles: policy makers, healthcare unit managers, team leaders and general staff.

The aim of the presentation is to highlight which interventions nurses perform. In doing so there is hope to gain a wider understanding of which interventions are proven successful and to have an outline of the risk factors that can affect the outcome of the executed interventions. Moreover, the four outlined categories will be presented without any priority order. The results are going to initially present nursing interventions that were addressed as successful, secondly it was aimed to describe which obstacles impede an application of evidence-based nursing.

### ***1- Risk factors for prevention of ESBL-related infections***

Particularly to studies (Cochard et al., 2015; Willemsen et al., 2015) raised the importance of risk factor evaluation. On one side Cochard et al., (2015) pointed out the following proven risk factors: patients in a poor health state, patients with malignant tumors, patients with urine or fecal incontinence, patients that were recently hospitalized and those under Carbapenem treatment. On the other, side Willemsen et al. (2015) shows proven risk factors: female patients, multiple room occupancy, multi-morbidity, patients with pressure ulcers, patients with fecal or urinary incontinence, presence of medical devices and patience under antimicrobial therapy. Other authors like Blom et al. (2016) have also named risk factors that are linked to ESBL-producing bacterial infections, those being immobilized patients. Furthermore, Sundvall et al, (2014) remarks that a long-time hospitalization comprises a risk factor for obtaining urinary pathogens. Finally, a Dutch study presented by Willemsen et al. (2015) demonstrated that no risk factors associated with carriage of ESBL-producing bacteria were found in nursing homes. However, with a multivariate analysis they Willemsen et al., (2015) concluded that a proven risk factors were higher age of residents and rooms with more than one bed.

The identification of risk factors can be considered as an intervention in itself (Cochard et al., 2015), as it is as also the ground for future interventions. As exemplified by several authors, many preventive interventions can be developed from a proper risk factor evaluation.



Sundvall et al, (2014) e.g. mentioned that trying to shorten the patients stay at hospitals can also be an important intervention, or Blom et al. (2016) who pointed out that mobilizing the affected patients is a good preventive mechanism that can be utilized by nurses

Evidence suggest the following summary of risk factors, taken out of the presented studies:

- Females patients*
- Multi-morbidity or patients with poor health condition.*
- Presence of malignant tumors.*
- Presence of urine or fecal incontinence.*
- Long or recently hospitalized patients.*
- Antimicrobial treatment.*
- Multiple room occupancy.*
- Immobilized patients.*
- Rooms with medical devices.*

## **2- Successful interventions for prevention of ESBL-related infections**

When identifying successful nursing interventions some 'standard' measures appeared recurrently. Authors like Cochard et al. (2015) accounts the importance of the 'standard' precautions. By standard, the authors understand the use of correct hygiene practices. Others, as Larson et al. (2007), showed broader understanding by mentioning the so-called 'known strategies' under the "search-and-destroy" paradigm. As known strategies the authors Larson et al. (2007) enumerated examples from Netherlands, Denmark and Germany where strategies to minimize the emergency of infections with antimicrobial resistance included admission screening, isolation of carriers, education of clinicians, implementations of guidelines and antibiotic restriction policies.

Moreover, screening as a standard intervention was mentioned in two studies. In one of the studies Willemsen et al. (2015) showed the effectiveness of screening of residents of elderly homes. On the other side Black et al. (2015) mentioned the efficacy of screening patients of nursing homes as well as those patients from acute care facilities.

Isolation of antibiotic resistant bacterial carriers was mentioned to be effective by two studies. On one side, Willemsen et al. (2015) pointed out effectiveness of using single rooms to avoid further spreading of ESBL-producing bacteria. While Black et al. (2015) mentioned the efficacy of cohorting patients with the same type of multi-resistant bacteria in the same room or wing of a floor.

Other successful interventions that fell into the category 'standard prevention' where evidence-based education concerning staff attitudes and responsibilities related to the work with patients at risk of multidrug resistant bacteria infections (Mamhidir et al., 2014; Willemsen et al., 2015). There was a broad consensus that teaching activities targeting better understanding of hand hygiene and cleaning performed on a regular basis are successful and needed interventions (Andersson et al., 2012; Cochard et al., 2015; Mamhidir et al., 2014; Willemsen et al., 2015; Wilson et al., 2011). Furthermore, the implementation of targeted outreach programs at regional and national level was also mentioned (Black et al., 2015). The importance of educational programs to promote good hygiene practices, waste management and cleaning procedures was raised in a French study (Cochard et al., 2015). It is important to note that similar conclusions were drawn in Swedish and Dutch studies (Mamhidir et al., 2014; Willemsen et al., 2015).

There seems to be a consensus concerning the hygiene routines and guidelines for infection prevention. Several authors agreed that same principles and practices apply for the prevention

of healthcare related infections as for the prevention of ESBL-producing bacterial infections (Black et al., 2015; Mamhidir et al., 2014; Wiklund et al., 2015). In the study by Larson et al. (2007) they showed the efficacy of monitored hand hygiene practices. Wilson et al. (2011) emphasize the importance of hygiene around the bed areas in Critical care Units. Andersson et al. (2012) also agrees with the importance of hand hygiene, alcohol-based hand disinfectants and using gloves in minimizing the risk of infections. Authors like Mamhidir et al. (2014) pointed out the importance of hand-wash knowledge assessment as a described effective method for preventing the spread of ESBL-producing bacteria. Finally, it is important to mention that it is strongly necessary to implement a wide system of nosocomial infection control and the use of high quality materials (Andersson et al., 2012; Larson et al., 2007). However, as stated by Larson et al. (2007), to make administrative changes and to provide materials needed to implement guidelines are not sufficient to effect any discernible practice change at the staff level. According to Wiklund et al. (2013) and Wilson et al. (2011) education of the healthcare personnel was the most important factor in preventing the transmission of multi-resistant bacteria.

The articles analyzed describes the following successful interventions to minimize ESBL-related infections:

- Screening of patients in a regular basis.*
- Isolation or cohort of carriers and infected patients.*
- Evidence-based education of the staff on a regular basis.*
- Monitored hygiene routines.*
- Policy implementation accompanied by educational programs.*

### ***3-Obstacles in knowledge among healthcare givers to prevent ESBL-related infections***

Knowledge is an important topic that have being mentioned through this review. Insufficient knowledge itself can be categorized as an obstacle for better infection control and prevention. As Wiklund et al. (2015) mentions it, Swedish regulations and hygiene routines are compulsory, yet compliance is not optimal, mainly because of lack of time and insufficient knowledge.

Knowledge seems to be such an important factor, that is not only mentioned by Swedish or European authors, the topic is even narrated by authors as Black et al., (2015) from the United States, who also mentions the lack of infection control and knowledge of personnel in skilled nursing facilities and acute care facilities. Black et al. (2015) addresses the level of relevance of knowledge and education in e.g. the skilled nursing homes as it was unclear for the staff due to insufficient knowledge if patients that were infected were to be isolated or not. The latter provides evidence of how important knowledge is about multi-resistant organisms so that personnel can take the right decision when it is needed. The previous mentioned statement also highlights the importance of a well-educated nursing team that can educate and establish a good leadership that can be follow by all health care staff. Wiklund et al. (2015) also remarks the effect that fear has regarding compliance due to the personnel avoidance of infected patients.

Likewise, Cochard et al. (2015) states that because of the insufficient knowledge regarding multi-resistant bacteria among others ESBL-producing bacteria, due to the infections infrequency, the nursing home's staff perform poor hygiene routines. The latter argument provides additional evidence, for the statement that insufficient knowledge regarding multi-resistant bacteria and the hygiene routines comprises a risk factor for the spread of e.g.

ESBL-bacterial infection and an obstacle for infection control.

Wiklund et al. (2015) noted that the lack of knowledge concerns not only hygiene routines, but also the meaning and possible consequences of antibiotic resistance. Coincidentally, in a Dutch study Willemsen et al. (2015) found that more attention should be placed on knowledge distribution. A USA based study by Black et al. (2015) found a clear need for public health interventions directed at healthcare facilities with fewer resources. Antibiotic overuse is also a main issue regarding the spread of multi-resistant bacteria (Blom et al., 2016; Sundvall et al., 2014). Research (Blom et al., 2016; Sundvall et al., 2014) showed that trimethoprim-sulfamethoxazole and ciprofloxacin are two commonly used antibiotics, which in over use during urinary tract infections can become an obstacle for infection control.

Moreover, it is a nurse's responsibility to see if prescribed ordinated medicaments have any adverse effects. Among other things if medicaments do not have any adverse effects, nurses should also be aware of infections, in order to inform a physician and maintain a good care. However, as Willemsen et al. (2015) acknowledges it, there is little or no knowledge of the pathogens and antibiotics involved in antibiotic resistance, within several members of the staff in the nursing homes. Moreover Willemsen et al. (2015) also argues that there are little microbiological tests performed in nursing homes, which also aid to the growth of the badly controlled antibiotic resistance. Knowledge insufficiency is so wide spread that for example Mamhidir et al. (2015) presented in their questionnaire, that 56 % of the asked participants had little knowledge regarding ESBL infections. The situation presented by Mamhidir et al. (2015) research seems alarming and provides evidence that there is a lack of knowledge regarding ESBL infections. According to the article only 7% of the staff received information about ESBL infections by their corresponding care unit. The latter highlights that care units in Sweden must provide further information and knowledge to their staff regarding antibiotic resistant organisms. Mamhidir et al. (2015) research could also be linked to the nurses' responsibility in informing a health care unit on antibiotic resistant organisms and how to prevent the spread of those.

#### ***4- Obstacles related to environmental factors and noncompliance***

The presence of ESBL-producing bacteria can be seen as an obstacle in itself. A French study Cochard et al. (2015) found high rates of prevalence of ESBL-producing bacteria carriage by nursing homes residents. The authors (Cochard et al., 2015) found frequent non-conformities by the staff by ignoring hygiene guidelines or by unnecessarily overusing their measures. Coincidentally, Wilson et al., (2011) mentions how microorganisms can be spread and they argued about how low hygiene measures can cause a poor prevention. The researchers (Wilson et al., 2011) data showed that enhanced cleaning was related with large reduction of MRSA, therefore similar measures could prevent the spreading of microorganisms such as ESBL-producing bacteria. That is why, it can be stated that poor hygiene routines of e.g. bed areas can comprise an obstacle for a good ESBL-producing bacterial infection prevention.

Noncompliance of hygiene routines can be caused by a stressful work situation, thus affecting the nurses' work and other health care personnel (Larson et al., 2007). The latter has negative implication on infection control for multi-resistant bacteria as ESBL-producing ones. Time pressure and work-related stress not only comprise an issue for performing good hygiene routines but also for the patients' treatment. Wiklund et al. (2013) accounts in an interview, that the staff did not listen enough to patients or answer their questions because of lack of time.

A topic of high relevance throughout this review consists of compliance of infection preventive routines, where hygiene routines are included. As it is mentioned by Willemssen et al. (2015), non-compliance with hygiene routines is a risk factor for ESBL-related infections. The article shows that bedsides, kitchens and toilet seats by them analyzed were heavily contaminated. Nevertheless, not all studies found correlations between hand hygiene and infection control as Larson et al. (2007) names it. Yet the latter suggests that this result might have been biased due to the acknowledgement that the staff had been observed, also the research time was only of two days. Education is not always a problem as Andersson et al. (2012) presents it, however the authors narrate that the issue is putting the knowledge into practice. It was mentioned in the research presented by Andersson et al. (2012), that some of the staff members could enter into new patient areas without changing dirty aprons and gloves and fail in disinfecting their hands before and after a dirty procedure.

It is also worth mentioning that another factor which can increase the prevalence of ESBL-producing bacteria is travelling abroad. For instance, Blom et al. (2016) highlights the latter by stating that six out of sixteen ESBL-carriers had travelled out of Sweden during the past six months.

In a Swedish research by Wiklund et al. (2015), the authors mentioned that although Swedish regulations are legally compulsory, compliance in following the best nursing practices is not optimal. In the same study (Wiklund et al., 2013) it was shown how noncompliance with specific hygiene routines can compromise the patients' health both physically and mentally. The authors (Wiklund et al., 2013) stated that patients could regard that health care professionals can either be very strict with hygiene routines or not follow them accordingly which might in turn become an obstacle for a good infection control. Likewise, noncompliance of hygiene routines is a topic that has been mentioned earlier in this review. Noncompliance can be caused by stressful work situations, thus affecting the nurses' work and other health care personnel (Larson et al., 2007). This has a negative implication on infection control for multi-resistant bacteria as ESBL-producing ones.

It was also shown that to work with short time frames or with poor quality materials such as low-quality gloves or aprons, can be factors that become obstacles for a decent infection control (Wiklund et al., 2015). Therefore, good hygiene routines must be followed and as according to Andersson et al. (2012) the most common path for bacterial infection is through contaminated hands, clothes or equipment. Andersson et al. (2012) also provided information on how staff from the five researched nursing homes did not always follow the preventive hygiene guidelines.

The information given from the above presented studies, gives evidence to summarize the following obstacles regarding ESBL-infection prevention:

- Insufficient knowledge of hygiene routines and antibiotic resistant bacteria in general.*
- Factors as lack of time or work environment stress.*
- Poor or incorrect usage of working materials.*
- Non-compliance with hygiene guidelines.*
- Frequency of abroad traveling.*

## Discussion

The aim of this literature review is to identify which evidence-based nursing interventions do nurses use for prevent healthcare related ESBL-producing bacterial infections. During the literature review, it was desired to broaden the knowledge of the methods and actions that nurses can improve in order to achieve a better infection control. This literature review also highlights the obstacles that can have a negative effect in preventing infections. In several studies, it was found that even though structured hygiene routines are available the compliance towards those are poor.

### Method discussion

According to Friberg (2012), it is important to analyze how the given information was obtained and how it is supposed to be qualified. Henricson (2017) says that the discussion of the method is the part of the thesis where the authors have to examine the strengths and weaknesses of the performed research.

Most of the chosen articles for the present review have a quantitative structure. Two of the eleven chosen articles, have a qualitative design and studied the nurses' perspective regarding hygiene routine compliance, while the other described the patients' feelings and experiences of being infected. Nonetheless, this review has an integrative approach (Friberg, 2012), quantitative and qualitative findings were used to sum up the results. It is clear that the articles dealt with different type of data due to their structure, however there were themes such as hygiene, which could be shaped with qualitative and quantitative information. The quantitative research articles discussed about the antibiotic overuse, the risk factors involved in the spread of the disease and the some of the preventive methods that can be undertaken. Therefore, all qualitative and quantitative articles showed results that the writers found they ought to be reviewed, analyzed, and eventually applied to improve nurses' interventions.

The initial inclusion criteria was to limit the articles to ten years but after acknowledging that the antibiotic resistance was already a problem seventeenth years ago as mentioned by WHO (2001), the search criteria was elongated to 20 years. Nevertheless, most of the chosen articles had no more than six years since publication in exception of Larson et al., (2007). The latter can be seen as a weakness and as a strength of the search method. The fact that a long period was chosen allowed the writers to find articles such as Larson et al., (2007), that had early information about antibiotic resistant organisms' outbreaks. However, it was a weakness of the review not to include more articles of earlier days, as those might have provided additional information to e.g. risk factors and other possible measures that might have been rectified today. The fact that many recent articles were chosen, can be seen as positive factor as it provides the latest information regarding preventive measure which can be applied within the field of nursing.

Several interesting articles were found during this search. However, the quantity chosen was decided after the writers felt that the given information was enough and of high relevance. The articles when evaluated fulfilled the criteria given by Karlsson (2017) for analysis, i.e. *does the chosen material answer to the given problem statement? Is more information needed? And is the obtained information credible?* It was the intention to have a broad example base of interventions in a minimum necessary of articles in order to fulfill information saturation. The addition or inclusion of more articles did not lead to newer

results, but it rather reinforced the existing categories that answer the aim of this review. The authors believe that for a more extensive work more articles could have been included. The risk of missing important or key articles have been reduced by the use of a systematic method.

After reviewing the articles by the qualitative and quantitative forms, it was found that the majority of the articles shared an estimated medium to high quality. However, one article resulted in low quality evaluation because of the lack of validity and reliability reflections. Black et al. (2015) had results about the need for identification of a clear need for public health interventions directed at healthcare facilities with fewer resources, hence its was considered relevant for this review as it could be related to ESBL-related infection. The article was included in our review because of the relevance of their core arguments. Considering these limitations, questions regarding their generalizability can be raised.

In the results, articles from four countries have been reviewed. Two of the selected articles are written outside Europe. All included articles are written in western countries. The vast majority of the chosen articles were written by Swedish authors, which can be seen as a strength of this literature overview as it refers to Swedish law and wants to provide an overview of how nursing infection control can be improved in Sweden. It is therefore strength that the information of this literature review can be transferable into a Swedish context (Henricson, 2017). Examining Swedish articles had also been of relevance having into consideration the current ESBL-producing bacteria situation in Sweden.

As stated by Ejvegård (2009), caution should be taken when generalizing the results of a research. Having articles written in different countries can be beneficial, as the results can show different plausible healthcare approaches. This in its turn enriches the described evidence-based interventions. A property of the selection of articles is e.g. the fact that no articles were chosen from non-western countries, this may implicate that the presented results are not globally generalizable. There is a limitation for the generalization of the obtained results. At international level only a superficial aspect of the ESBL phenomenon was reached (with only articles of five countries). At Swedish national level, even if a clear pattern was shown, an extensive review should be done to be able to transcend this limitation.

Results from only two qualitative articles were reviewed. The lack of extensive qualitative research may be a limitation in order to understand the obstacles that nurse's face when dealing with evidence-based interventions. Knowledge and attitudes are indeed key elements that affect how nurses understand their responsibilities. According to Rosén (2017), the selection between quantitative or qualitative perspective depends on the question that is ought to be answered. Indeed, this is of the highest relevance for nursing and it may be seen as a weakness for this review.

The theoretical reference framework chosen intended to highlight the most important aspect of the problem area. The authors of the present review therefore chose evidence-based practice as the theoretical frame of reference to increase understanding of nurses' responsibility. It is indeed nurses' responsibility not only to "have" knowledge but also to "reflect" over this knowledge in order to perform evidence-based interventions (William et al., 2016). Furthermore, the chosen articles were selected as they analyzed or described evidenced based nursing interventions. However, several of the chosen articles had numerous recommendations that were not necessarily evidence-based, and therefore those recommendations were not included in this review as successful practices.

## **Result discussion**

As mentioned in the method discussion, the theoretical reference framework chosen intended to highlight the most important aspect of the problem area. The result showed important evidence-based nursing interventions that were proved be successful in different contexts. In addition, the results also highlighted the obstacles that need be overcome in order to provide evidenced-based prevention interventions. It is important to mention that most of the articles, did not refer directly to patient suffering. Only a brief amount of the analyzed articles referred to such a qualitative concept. As stated by several authors (Arman, 2017; Parse, 2014; Wiklund, 2014), most studies focus on reducing unnecessary patient suffering and economical costs by the means of prevention. However, several interesting observations were derived from the present review.

### ***Observations on affected patient groups***

As explained before there are some limitations when interpreting statistics (Hijazi et al., 2016; Mölstad et al., 2017). Prevalence of ESBL-producing bacteria in Nordic countries is generally lower than in the rest of the world (Brolund, 2014). However, as illustrated in the present review, prevalence of ESBL-producing bacteria in Swedish nursing homes is similar to those of other western countries. The scope of this relation is difficult to analyze given the low number of international articles included in this review. For the cases of France and Netherlands (Cochard et al., 2014; Willensen et al., 2015) the results showed similar figures to those showed by Swedish research (Blom et al., 2016; Andersson et al., 2012). The total prevalence for carriage of ESBL-producing bacteria was over 10% for all the studies. These results are also alarming considering the national prevalence for the Swedish population which is of 5%. Prevalence of ESBL-producing bacteria in nursing homes is much higher than average national population. Incidence of ESBL-producing bacteria was not discussed in the studies. Nevertheless, it is worth mentioning that the Swedish national incidence was 107 cases per 100.000 inhabitants in 2016 showing a continuous increment from previous years (Swedres-Svarm, 2016). Based on the latter, a relevant observation for nursing is that the elderly populations are at high risk and will continue being at risk of contracting ESBL-producing bacterial infections.

Nonetheless an important observation should be done, Sundvall et al., (2014) shows that the average prevalence carriage of ESBL-producing bacteria in urine samples did not increase between 2003 and 2012. However, Sundvall et al., (2014) confirm that their result are inconclusive showing that the number of individual affected did not increase but that the number of antibiotic resistant bacteria found (ESBL included) did increase up to a 80% during these years. Sundvall et al., (2014) findings are comparable to those of Jonsson et al., (2011) whom has shown limited incidence of ESBL in urinary strains for a Swedish sample of residents in elderly homes.

### ***Observations on compliance***

The results have also shown that even given different set of guidelines and local regulations, nurses and the rest of the staff tend to non-compliance. For example, Andersson et al. (2012) states as mentioned previously, that non-compliance regarding hygiene routines occur for

many reasons such as, lack of time. An interesting finding according to Andersson et al. (2012) is that most staff members were aware of the hygiene routines, nevertheless these were not always followed. The latter may indicate that it might not always be a problem with the guidelines itself, but with other factors affecting the staff that might take away attention from the routines that they are obliged to follow.

Compliance with local regulations and guidelines are still of maximum importance. As described above, it is a nurse's responsibility to know and adhere to local hygiene guidelines. As team leaders, nurses also have the responsibility to share their knowledge, educate and verify that the rest of the team also work under the same standards. This is of fundamental relevance for nursing, because as mentioned earlier in this work, it is also part of a nurse's job to educate their peers and other healthcare personnel.

### ***Observations on knowledge and education***

Although given the low number of international articles included in this review, it is interesting to note what it seems to be an international pattern regarding knowledge of ESBL-producing bacteria. For the Swedish healthcare (Sundvall et al., 2014; Wiklund et al., 2015; Wiklund et al., 2013) as for USA, France, the UK and the Netherland contexts (Black et al., 2015, Cochard et al., 2015, Mamhidir et al., 2011; Willemsen et al., 2015) the results indicate that there is a lack of knowledge regarding several aspects of ESBL-producing bacteria. As mentioned in the background, nurses should keep themselves updated about the latest evidence-based interventions.

Efforts to improve national outreach programs were shown at international levels e.g. USA, Black et al., (2015) suggest that department of public health should offer education to nurses. In France, Cochard et al. (2015) suggest that first care personnel should be educated or informed on the importance of hygiene routines. Willemsen, et al. (2015) agrees as well, that many of the mistakes committed concerning poor hygiene are human caused and consequently also puts emphasis on education. Wiklund et al. (2013) for example mentions in their qualitative research how the sampled patients experienced or perceived the personnel to be ignorant and disrespectful regarding the hygiene routines and the treatment of those who were infected.

According to the results, there is a clear noncompliance in relation to the established hygiene routines, however there is little information described on what could be implemented to improve the current situation. The reviewed articles do not refer to evidence-based education programs established to improve the knowledge and adherence of hygiene routines. However, it is clear that nurses should be aware that a constant reflection and capacitation about evidence-based practice is part of their profession. It is therefore in the best interest of nursing and health care professionals in general to capacitate and educate all health care personnel. Knowledge should not be taken for granted, knowledge develops with research, and therefore it should always be regarded as a continuous learning experience. It is highly valuable to understand that the previous mentioned arguments bear a high relevance for the development of a better health care, patient treatment, nursing work and infection control.



## Conclusion

It is well known in healthcare that good hand hygiene is central to general infection control, but as it is shown in the results of this review, this knowledge by itself does not ontologically lead towards best practices.

This literature review has contributed with:

1. Knowledge about which barriers should be overcome in order to increase compliance.
2. Best practice guidelines can improve the work towards enhanced patient safety.
3. ESBL-producing bacterial infections implies significant healthcare costs in terms of extended care time and more complicated care processes.
4. To ensure health care of the best possible quality, nurses should continuously evaluate the quality of their interventions. Continued research is necessary to support up to date evidence-based interventions.
5. Finally, more nursing research is needed. As mentioned before, nursing research is the basis for evidence-based nursing intervention.

## Further research

Nursing practice as we know it would benefit from constant up to date high quality research. It is perhaps in the best interests of society and health care, if future research is aimed in a holistic matter both in the pharmaceutical field but also in the field of nursing, to have a better knowledge on which exact nursing intervention methods should be used and adhered to. Another suggestion that might be good to acknowledge, is the quality of the material that is used by personnel, this must be improved at least on a Swedish level, as it comprises an issue as Andersson et al. (2012) accounts it.

We believe that at any given moment there is sufficient research to opt for the best possible nursing interventions. However, nurses' responsibility implies constant reflection to evaluate present and future interventions.

## Clinical implications

It been highlighted that some caution has to be observed as to how the evidence behind the interventions presented appears. Overuse and overvalued interventions can cause more harm than positive outcomes. Increasing nursing compliance is a central responsibility of registered nurses. As it was shown, when compliance with best practice guidelines is under suboptimal levels, nursing interventions can lead to patient suffering.

There is a power aspect that was not fully considered, or at least covered by the articles included in this review. Compliance with best practice guidelines helps to avoid abusing the power the nurses possesses regarding access to patients' bodies and close surroundings. Furthermore, compliance with best practice guidelines can be linked to the care relationship as a whole. By actively working on several levels to overcome the obstacles to evidence-based infection prevention interventions, nurses can relieve suffering, prevent healthcare injuries and contribute to a health-promoting healthcare environment while ensuring patient does not suffer for unnecessary harm. In addition to such humanistic values highly regarded by national and international nursing ethics codes, there is potential for economic cost reduction. Nursing interventions that regard patient safety work to contribute to an appropriate management of healthcare resources.

Finally, some of the interventions found seem to belong to management level, still nurses should be aware of the scope of these interventions in order to be able to assess and request the necessary conditions at their work places. Knowing which managerial decisions are needed can help nurses to achieve a safer work environment for themselves and others.

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## Appendix 1

Database	Datum	Search word	Limits	Results	Relevant abstracts	Evaluated abstracts	Articles selected
Cinahl	25-02-2018	beta-lactam AND prevention	Limiters - Peer Reviewed; Research Article	4	1	1	1
Pubmed	26-02-2018	((ESBL) AND nursing) AND prevention	Case Reports, Clinical Study, Clinical Trial, Clinical Trial, Phase I, II, III, IV, Comparative Study, Controlled Clinical Trial, Guideline, Journal Article, Observational Study, Practice, Randomized Controlled Trial, Scientific Integrity Review, Systematic Reviews	24	0	0	0
Cinahl	06-03-2018	Extended spectrum $\beta$ -lactamase AND nursing	peer reviewed, research article	3	3	2	2
Cinahl	06-03-2018	Antibiotic resistance AND prevention AND Nursing	peer reviewed, research article	4	2	2	1
Pubmed	07-03-2018	Extended spectrum $\beta$ -lactamase AND nursing	Case Reports, Clinical Study, Clinical Trial, Clinical Trial, Phase I, II, III, IV, Comparative Study, Controlled Clinical Trial, Guideline, Journal Article, Observational Study, Practice, Randomized Controlled Trial.	174	7	5	2
Pubmed	07-03-2018	Antibiotic resistance AND prevention AND Nursing	Case Reports, Clinical Study, Clinical Trial, Clinical Trial, Phase I, II, III, IV, Comparative Study, Controlled Clinical Trial, Guideline, Journal Article, Observational Study, Practice, Randomized Controlled Trial.	657	10	5	3
Pubmed	08-03-2018	Extended spectrum $\beta$ -lactamase AND Infection control		1237	0	0	0
Pubmed	08-03-2018	Infection control AND Extended spectrum $\beta$ -lactamase AND nursing	Humans	60	5	5	0
Scopus	07-03-2018	antibiotic AND resistance AND prevention AND nursing	-	275	2	2	0
Scopus	07-03-2018	Extended spectrum $\beta$ -lactamase AND nursing	-	192	4	4	1
Cochrane Library	07-03-2018	antibiotic AND resistance AND prevention AND nursing	-	0	0	0	0
Cochrane Library	43166	Extended spectrum $\beta$ -lactamase AND nursing	-	1	1	1	1

## Appendix 2

Year	Country	Title	Authors	Aim	Method and Material	Result	Quality
2016	Sweden	The prevalence of ESBL-producing Enterobacteriaceae in a nursing home setting compared with elderly living at home: a cross-sectional comparison	Blom et al.	The aim of the study was to investigate the prevalence of faecal carriage of ESBL-producing bacteriaceae among residents living in nursing homes and to compare it with a corresponding group of elderly people living in their own homes.	Faecal samples, a standardized questionnaire regarding known risk factors for ESBL-carriage.	<b>Residents of nursing homes as well as elderly living in their own homes have high rates of faecal carriage of ESBL-producing bacteria. These findings may affect the choice of empirical antibiotic treatment of severe infections in older adults.</b>	HIGH
2015	Sweden	Staff experiences of caring for patients with extended-spectrum b-lactamase-producing bacteria: A qualitative study	Wiklund et al.	The purpose of this study was to increase the knowledge of what it means for staff in acute care settings and nursing homes to care for patients with extended-spectrum b-lactamase (ESBL)-producing Bacteria.	A qualitative research assistant nurses, registered nurses, and physicians from acute care settings and nursing homes were interviewed. A modified version of Grounded Theory was used for the analysis.	<b>Staff in acute care settings and nursing homes must have adequate knowledge and reasonable working conditions to be able to provide high-quality care for patients and residents who are ESBL carriers.</b>	HIGH
2015	Netherlands	Extensive dissemination of extended spectrum $\beta$ -lactamase-producing Enterobacteriaceae in a Dutch nursing home. infection control & hospital epidemiology	Willemsen, et al.	The aim of the study was the investigation of the risk factors for rectal carriage of ESBL-E and its transmission during an outbreak of extended-spectrum $\beta$ -lactamase-producing Enterobacteriaceae (ESBL-E).	The design: a cross-sectional survey by culture of perianal swabs or fecal samples. Nosocomial transmission was defined as the presence of genotypically related strains in $\geq 2$ residents within the NH. Patient characteristics and variables in infection control practices were registered to investigate risk factors for transmission.	<b>The study concluded that nursing homes constitute potential sources of multidrug-resistant bacteria, it is important to gain a better understanding of the risks factors and routes of transmission of ESBL-E.</b>	MEDIUM

2015	USA	Regional infection control assessment of antibiotic resistance knowledge and practice. infection control & hospital epidemiology	Black et al.	The aim of the study was to assess the facility-level of the perceived importance of and responses to various Multidrug-resistant organisms (MDROs)	A pilot survey that assessed the staffing, the knowledge, and the perceived importance of and response to various multidrug resistant organisms (MDROs).	<b>We identified stark differences in human resources, knowledge, policy, and practice between ACFs and SNFs.</b>	LOW
2014	Sweden	Antimicrobial resistance in urinary pathogens among Swedish nursing home residents remains low: a cross-sectional study comparing antimicrobial resistance from 2003 to 2012	Sundvall et al.	To estimate the native prevalence of antimicrobial resistance in uropathogens among Swedish nursing home residents is needed.	Urine specimens were collected for culture and antimicrobial susceptibility testing against mecillinam, ampicillin, cefadroxil, trimethoprim, nitrofurantoin and quinolones from the residents of 32 and 22 nursing homes, respectively.	<b>The average rates of antimicrobial resistance were low and did not increase between 2003 and 2012 in E. coli urinary isolates among Swedish nursing home residents. Antibiotic treatment during the previous month and hospitalization during the previous six months predicted higher resistance rates.</b>	HIGH
2014	France	Extended-Spectrum $\beta$ -Lactamase-Producing Enterobacteriaceae in French Nursing Homes: An Association between High Carriage Rate among Residents, Environmental Contamination, Poor Conformity with Good Hygiene Practice, and Putative Resident-to-Resident Transmission	Cochard et al.	Evaluation of the Spread of multiresistant drug Enterobacteriaceae in 38 nursing homes in central France	An amplified polymorphic DNA typing, was used to study the colonization isolates. Hygen and contamination of the environment were observed in NHs 8.	<b>In most of the participating Nursing Homes, improved application of standard precautions during incontinence care is needed, and greater efforts to clean the environment of residents are required</b>	HIGH
2013	Sweden	Living with extended-spectrum b-lactamase: A qualitative study of patient experiences	Wiklund et al.	The aim of this study was to increase our understanding of how infected individuals perceive their situation as “carriers” of multiresistant bacteria.	The article has a qualitative research model. A modified version of grounded theory was used to analyze 7 open interviews.	<b>To manage their life situation, it is important that persons diagnosed as carriers of ESBL-producing bacteria receive adequate information from the attending doctor.</b>	MEDIUM

2012	Sweden	<b>Prevalence</b> of antibiotic-resistant bacteria in residents of nursing homes in a Swedish municipality: Healthcare staff knowledge of and adherence to principles of basic infection prevention	Andersson et al.	The aims of this study were to investigate the prevalence of methicillin-resistant bacteria in residents living in Swedish nursing homes, and if carriage of resistant bacteria was related to antibiotic treatment, other risk factors, and/or staff's adherence to guidelines for infection control.	Microbiological cultures taken. Faecal samples were obtained from 495 residents (88.3%). ESBL-positive residents were followed for 2 y with repeated sampling. Two hundred and ninety-six staff members were interviewed and observed regarding familiarity with and adherence to infection control guidelines.	<b>Carriage of resistant bacteria was uncommon and only ESBL-producing Enterobacteriaceae were identified in Swedish nursing homes. Usage of antibiotics was higher on wards where ESBL-positive residents were detected and there was an indication of transmission of ESBL between residents.</b>	HIGH
2011	Sweden	Deficient knowledge of multidrug-resistant bacteria and preventive hygiene measures among primary healthcare personnel	Mamhidir, et al.	This paper is a report of a study conducted to describe primary healthcare personnel's knowledge of multidrug-resistant and preventive hygiene measures.	A descriptive and comparative questionnaire survey among primary healthcare personnel was performed in 2008. Convenient sampling was used and 10 physicians, 38 district nurses and 10 nursing assistants participated.	<b>Our findings suggest that evidence-based education of multidrug-resistant and hygiene preventive measures, in primary health with subsequent follow-ups should become a prioritized clinician and management concern.</b>	HIGH
2011	UK	The impact of enhanced cleaning within the intensive care unit on contamination of the near-patient environment with hospital pathogens: A randomized crossover study in critical care units in two hospitals*	Wilson et al.	To determine the effect of enhanced cleaning of the near-patient environment on the isolation of hospital pathogens from the bed area and staff hands.	Prospective randomized crossover study over the course of 1 yr. Setting: Intensive care units at two teaching hospitals. Interventions: In each of six 2-month periods, one unit was randomly selected for additional twice-daily enhanced cleaning of hand contact surfaces	<b>Enhanced cleaning reduced environmental contamination and hand carriage, but no significant effect was observed on patient acquisition of methicillin-resistant Staphylococcus aureus.</b>	MEDIUM

2007	USA	Relationship of antimicrobial control policies and hospital and infection control characteristics to antimicrobial resistance rates.	Larson, et al.	Aim was to examine which type of resistance is controlled by infection control programs and to associate resistance rates with characteristics of antimicrobial control policies, provider attitudes and practices, and systems-level indicators of implementation of the hand hygiene guideline of the Centers for Disease Control and Prevention.	The method used is an on-site survey of intensive care unit staff and infection control directors of 33 hospitals. The following data were collected: antimicrobial control policies; rates during the previous 12 months of methicillin-resistant <i>Staphylococcus aureus</i> , vancomycin-resistant enterococci, and ceftazidime-resistant <i>Klebsiella pneumoniae</i> ; an implementation score of systems-level efforts to implement the guideline; staff attitudes toward practice guidelines; and observations of staff hand hygiene.	<b>No statistically significant correlation was observed between staff attitudes toward practice guidelines, observed hand hygiene behavior, or having an antibiotic use policy and resistance rates. In logistic regression analysis, higher scores on measures of systems-level efforts to implement the guideline were associated with lower rates of resistant <i>S aureus</i> and enterococci.</b>	HIGH
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### Appendix 3

Form for the evaluation of studies with qualitative methods	Wiklund et al., 2015		Wiklund et al., 2013	
Is there a clear formulated problem? How is this problem, formulated and how is it delimited?		1		1
Is the sample selection relevant?		1		1
Is the sample selection well described?		1		1
Is it the context well described?		1		1
Have the researchers presented any ethical argumentation?		1		1
Is the relation researcher-sample well described?		1		1
Is the data collection well described?		1		1
Is the data collection relevant?		1		1
Does it fulfil data saturation?		1		0
Does the researchers reflect over their data collection method?		1		1
Is the analysis well described?		1		1
Is the analysis relevant in relation to data collection?		1		1
Does it fulfil analysis saturation?		1		1
Does the researchers reflect over their analysis?		1		1
Are the results logic?		1		1
Are the results understandable?		1		1
Are the results well described?		1		1
Is it possible to connect the theoretical outset with the results?		0		1
Does it generates hypothesis/theory/model?		1		1
Are the results transferable to a similar context?		1		0
Are the results transferable to a different context?		1		0
<b>Max points 21 (SBU, 2014)</b>	High	20	Medium	18

## Appendix 4

Form for the evaluation of studies with quantitative methods	Black et al., 2015	Willemsen et al., 2015	Cochard et al., 2014	Mamhidir et al., 2011	Larson et al., 2007	Wilson et al., 2011	Andersson et al. 2012	Blom et al., 2016	Sundvall et al., 2014	
Is there a defined aim of the study?	1	1	1	1	1	1	1	1	1	
Are ethics considered?	0	1	1	1	1	0	1	1	1	
Are there all relevant parts (background, aim, method, results, discussion)?	1	1	1	1	1	1	1	1	1	
Is the sample representative?	1	1	1	1	1	1	1	1	1	
Is the sample selection well described?	1	1	1	1	1	1	1	1	1	
Is the dropout analysis described?	0	1	1	1	1	1	1	1	1	
Is the dropout size described?	0	1	1	1	1	1	1	1	1	
Are the statistical methods adequate?	1		1	1	1	1	1	1	1	
Are the instruments valid?	0	1	1	0	1	1	1	1	1	
Are the instrument reliable?	0	0	0	1	1	1	0	1	1	
Are the results generalizable?	0	1	1	1	0	0	1	0	1	
<b>Max points 11 (Willman et al., 2016)</b>	Low	5	Medium	9	High	10	High	10	High	11