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New Approaches to Prevention of Hospital Acquired Infections in ICU, Surgery and Other High Risk Facilities

MASTER THESIS

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SUMMARY

Master thesis by Daniil Farber

Title – New approaches to prevention of hospital acquired infections in ICU, surgery and other high-risk facilities.

Introduction – Hospital-acquired infections (HAI) are nosocomial acquired infections that are typically not present or might be incubating when patients are admitted to a medical facility. These infections are usually acquired after hospitalization and start manifesting after approximately 48 into hospitalization. Due to the high death rate and risk aiming from those infections, they are monitored by agencies such as the National Healthcare Safety Network (NHSN) of the Center for Disease Control and Prevention (CDC). Their significant cost in financial aspects, as well as general health and human lives, require constant adaptation and development of new interventions.

The aim of the theses- Review the new approaches to preventing hospital-acquired infections in ICU, surgery and other high-risk facilities.

Objectives of the study-

1.To review the recent hospital-acquired infection types, including target population and facilities.

2.To review and analyze recent evidence and recommendations to prevention and control of hospital-acquired infections.

3.To review novel approaches to prevention and control of hospital-acquired infections.

Methodology - systematic review that analyzes different research publications and works in the last 10 years in the English language using PubMed Medline research engine.

Results and conclusions- HAI distribution differ worldwide and in different departments, depending on the population and procedures performed. Basic infection control techniques must be used for HAI prevention. New approaches in addition to the basic measures are used in order to improve HAI prevention and control.

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CONFLICT OF INTEREST

The author reports no conflicts of interest.

CLEARANCE ISSUED BY THE ETHICS COMMITTEE

No clearance issued by the Ethics Committee required in this study.

ABBREVIATIONS

HAI - healthcare-associated infections

NHSN- National Healthcare Safety Network

CDC- Center for Disease Control and Prevention

CLABSI - central line-associated bloodstream infections

SSI - surgical site infections

HAP- Hospital-acquired Pneumonia

VAP - Ventilator-associated Pneumonia

CDI- Clostridium difficile infections

ICU- intensive care unit

H1N1- influenza virus A

MRSA - methicillin-resistant Staphylococcus aureus

HCOs -Health Care Organizations

CRBSIs -Catheter-related bloodstream infections

HAI-CoSIP - HAI Core Set criteria & Indicators Prevention

AID - antimicrobial, infection prevention and diagnostic

ASP- Antimicrobial Stewardship Program

DSP- Diagnostic Stewardship Program

ISP- Infection Prevention Stewardship Program.

PLGA–BCP3- Poly(lactic-co-glycolic acid) –styrylbenzene-based antimicrobial

INTRODUCTION

Hospital-acquired infections, also known as healthcare-associated infections (HAI), are nosocomially acquired infections that are typically not present or might be incubating at the time of a patient's admission to a medical facility. These infections are usually obtained after hospitalization and start manifesting after approximately 48 into hospitalization. Due to the high death rate and risk of those infections, they are monitored by agencies such as the National Healthcare Safety Network (NHSN) of the Center for Disease Control and Prevention (CDC). (1) This surveillance is done to prevent the spread and reduce HAI prevalence and improve patient safety. HAI infections can stem from many sources. Such as catheter-associated urinary tract infections (CAUTI), central line-associated bloodstream infections (CLABSI), Hospital-acquired Pneumonia (HAP), surgical site infections (SSI), Ventilator-associated Pneumonia (VAP), and Clostridium difficile infections (CDI) (1).

Due to the severity of these conditions, the need to put a great effort to avoid them is clear (2). Many actions were taken to reduce the amount of HAI. Several hospitals have made infection tracking and surveillance systems in place and robust prevention strategies to reduce the HAI rate. The impact of HAI is seen at an individual patient level and the community/ systematic level because they have been linked to creating multidrug-resistant infections. Identifying patients with risk factors for HAI and multidrug-resistant infections is critical in preventing and minimizing these and other types of infections (3).

AIM AND OBJECTIVES OF THE THESIS

Aim: Review the new approaches to prevention of hospital acquired infections in intensive care unit (ICU), surgery and other high-risk facilities.

Objectives:

1.To review the recent hospital-acquired infections types, including target population and facilities.

2.To review and analyze recent evidence and recommendations to prevention and control of hospital-acquired infections.

3.To review novel approaches to prevention and control of hospital-acquired infections.

RESEARCH METHODOLOGY AND METHODS

Data collection and search strategy

This systematic review PRISMA 2009 statement and checklist were used as the main resource for research methodology. The main search engine was MEDLINE PubMed, which yielded about hospital-acquired infection research works published from 2011 to the present day. Some articles published later than 2010 were included to review previously known data. Included randomized clinical trials, retrospective studies, systematic and literature reviews.

Inclusion criteria:

- Randomized clinical trials, retrospective studies, systematic and literature reviews regarding.
- Papers themed hospital-acquired infections and\ intensive care unit acquired infections
- Published in English.
- Published from 2011 to this day.

Exclusion criteria:

- Works written not in English.
- Not relevant title or abstract
- Published in 2010 or earlier.

Terms used:

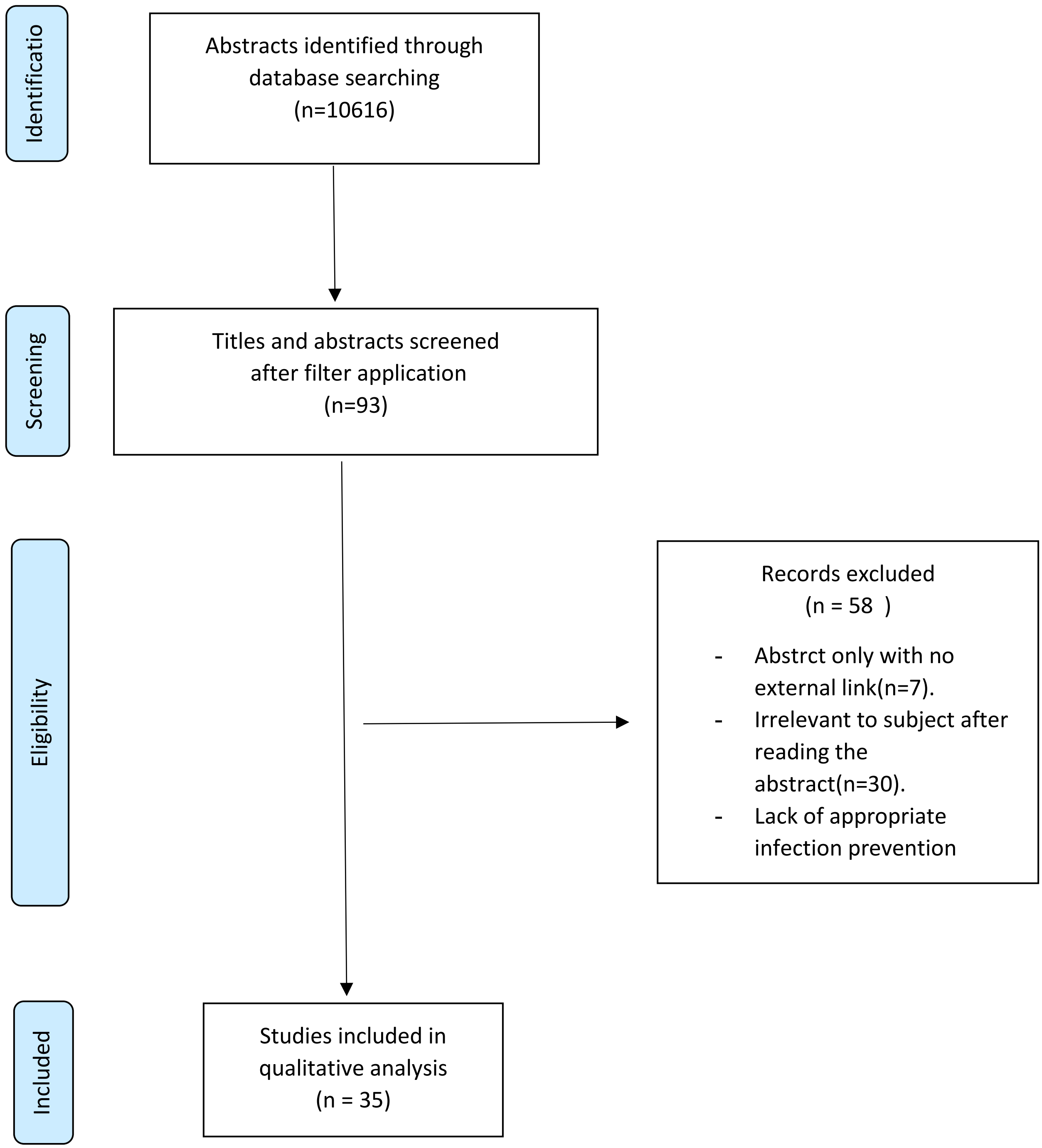
- Hospital acquired infection, Intensive care unit acquired infections, pathogens, epidemiology, prevalence.

Sentences used:

- Hospital acquired infection prevalence.
- Hospital acquired infection prevention.
- Hospital acquired infection pathogens.
- Hospital acquired infection epidemiology.
- Prevention of Hospital acquired infection.

Information source:

MEDLINE PubMed online research engine



RESULTS AND DISCUSSION

Common hospital-acquired infections

Common organisms for CLABSI are Candida spp /yeast, Enterobacteriaceae, Enterococcus spp, and Staphylococcus aureus (4). Common pathogens are known to cause CAUTI are Escherichia coli, Candida spp, Enterococcus spp, Pseudomonas aeruginosa, Klebsiella spp. (5). The common causative organisms for SSI include (in descending order) Staphylococcus aureus, coagulase-negative staphylococcus, Enterococcus, E Coli, P. aeruginosa, Enterobacter, Klebsiella pneumonia (6). The most common pathogens for VAP and HAP are S. aureus and P. aeruginosa, while E. Coli and Klebsiella pneumonia can be seen in higher proportions in pediatric departments. Acinetobacter baumannii was predominant in surgical ICU (7).

Hospital-acquired influenza is one of the main HAI worldwide, and it may be associated with a poor prognosis. In Germany, a case fatality rate of 9% was mainly associated with influenza virus A (H1N1) (8), and in Sweden, hospital-acquired influenza A with a case fatality rate of 9.6% has been reported (9). Moreover, hospital-acquired influenza A has been reported to be an independent factor associated with mortality among patients admitted to an intensive care unit (ICU) (10).

Regarding ICU infections, a recent study from Brazil, which included 303 patients of these, 155 (51.2%) were infected, and 123 (79.4%) had at least one ICU-acquired infection. The most common ICU-acquired infections were pneumonia (53.0%) and bloodstream infection (27.6%). One hundred and nineteen bacterial isolates were cultured; the most common were S. aureus (39.0%), Acinetobacter baumannii and P. aeruginosa, with a prevalence of (27.1%). In pneumonia, the most common pathogen was P. aeruginosa (30.4%), in bloodstream infections, coagulase-negative staphylococci (23.4%) and Enterobacteriaceae (23.4%), and in urinary tract infections Enterobacteriaceae (47.6%) (11).

Epidemiology

The true meaning and significance of HAI are best understood when determining its prevalence around the world. Their epidemiology can be determined by prevalence surveys, although only providing a snapshot of the frequency of HAIs, represent a cost-effective alternative to prospective incidence studies, notably at the facility level (12).

Isolated reports of infection prevention campaigns resulting in zero hospital-acquired infections exist. In the most recent hospital survey by the Leapfrog Group, 12.7% of the almost 2000 participating acute care hospitals reported zero CLABSIs, 11.3% zero CAUTIs, 14.6% zero methicillin-resistant Staphylococcus aureus (MRSA) HAIs, 2.8% zero hospital-onset C. difficile, and 19.2% zero colon surgery SSIs. The group notes that the number of hospitals reporting zero infections is falling since 2015, even though hospitals are improving their rates overall. It suggests that increased awareness and reporting of HAIs may be responsible for the drop in the number of hospitals claiming zero HAIs over the past year. In the published scientific literature, outcomes of zero events are of a limited time frame and in selected patient populations (13)(14).

HAIs are thought to affect hundreds of millions of patients worldwide annually, in both developing and developed countries (15). In some Australian public hospitals, HAIs affect 1 in every 74 hospitalizations (16). In Europe, the annual total number of patients with HAIs in 2011–2012 was around 3.2 million. In acute care hospitals, the number of patients with at least one HAI was 6.0% (country range 2.3%–10.8%) (17). Moreover, throughout Europe, HAIs accounted for total costs estimated at approximately €7 billion. Each year in the USA, about 2 million patients developed HAIs, and nearly a hundred thousand of these patients were estimated to die. It ranked HAIs as the fifth major cause of death in acute care hospitals. In certain developed countries, the risk of acquiring infection is 2–20 times higher (18).

The impact of HAI is well demonstrated in a study conducted in Australia, and it is estimated that 150 000 HAI occur annually; numerous of them are preventable. HAI, including Clostridium difficile infection (CDI) and catheter-associated urinary tract infections (CAUTI), affect 6–10% of hospitalized patients and result in 7000 deaths in Australian hospitals per year. Two million hospital bed days are lost to HAI annually, at an estimated cost of over $1 billion. In addition, there are significant unmeasured physical, psychological, and financial costs to patients and communities (19)(20).

The severity of the topic is demonstrated best when shown in the American health care system. Central line-associated bloodstream infection (CLABSI) and catheter-associated urinary tract infection (CAUTI) are among the most common device-associated infections, whereas Clostridium difficile and methicillin-resistant Staphylococcus aureus (MRSA) are among the most prevalent pathogens causing HAI. In 2011, there were an estimated 721 800 HAIs in U.S in acute care hospitals, with C. difficile, S. aureus, Enterococcus species, and gram-negative bacilli being the most common pathogens (21). To deal with these infections, evidence-based infection prevention strategies, including "bundles" or combinations of interventions, have been designed and successfully applied in many hospitals to prevent HAIs (22).

In a 15- year survey conducted in France, 20,401 patients were included. 6.07 % of the patients affected by 1389 HAIs. The prevalence of patients presenting with at least one infection acquired in the University Hospital of prevalence surveys in eight university hospitals, each consisting of 60–700 beds. The study was conducted during all four seasons of 2008–2009. All of the patients admitted for ≥2 days were studied. A total of 3450 patients were prospectively collected and analyzed. The overall prevalence of HAI was 9.4%. The most common HAIs were bloodstream infections (2.5%), unlike what was seen in the French study, surgical site infections (2.4%), urinary tract infections (1.4%), and pneumonia (1.3%) (23).

Risk factors of hospital-acquired infections development.

The risk of HAI is different from facility to facility. It is affected by the infection managment practices at the facility, the patient's immune status, and the prevalence of the different pathogens within the community and center of the question. There are risk factors related to the patients, such as immunosuppression, older age, length of stay in the facility, comorbidities, amount and frequency of visits to healthcare facilities, need of mechanical ventilatory support, recent invasive procedures, inserted medical devices, and stay in an intensive care unit (ICU) which is considered especially dangerous in developing such infections (24). In recent years, reports found that intravenous antibiotics within the last 90 days are one of the significant risk factors for developing antimicrobial resistance to multiple drugs, which could lead to HAI. The source of HAI pathogens can be anyone related to the health care system, starting patients, hospital staff, or the hospital facility (25).

Lymphocytopenia, hypoalbuminemia, and pleural effusion can be linked with hospital-acquired influenza A. Hypoalbuminemia is often observed in hospitalized patients. Hence early detection of vulnerable individuals is essential for the implementation of infection control. Albumin supplementation in case of hypoalbuminemia is not recommended, but preventive droplet transmission measures such as single room isolation might be done for the prevention of influenza A (26).

Basic procedures regarding hospital-acquired infections management

When discussing the prevention of HAI, we must remember first the general guidelines of work in those cases (27):

1. Evaluation of the necessity for isolation has to be performed. Watch all ICU patients for the following: Neutropenia and immunological disorder, diarrhea, dermatological rashes, known communicable disease, known carriers of epidemic bacterial strains.
2. Identify the type of isolation needed.
    - Protective isolation- for neutropenic/immunocompromised patients to minimize the chances of getting infected by opportunistic infections
    - Source isolation- of colonized or infected patients to reduce potential vertical transmission.

Isolation rooms should have tight-fitting doors, transparent partitions for observation, negative-pressure (for source isolation), and positive-pressure (for protective isolation) ventilations.

Hand hygiene

Especially at this period of time, when COVID-19 is one of the main hospitalization reasons globally, patients at risk of nosocomial infections should be treated with the highest level of care. Risk factors for HAI development: 70 years and older, Shock, Major trauma, Acute kidney injury, Coma, Prior antibiotics use, Mechanical ventilation, Immunosuppressive drugs (steroids, chemotherapy), Indwelling catheters, and Prolonged ICU stay (more than three days).

One of the basic tools we have in HAI prevention is hand hygiene. It is one of the first discovered HAI prevention principles and still is one of the most important there are. The most common source for transmission are hands, and "hand hygiene" is the single most efficacious tool for preventing the horizontal transmission of infections amongst patients and healthcare workers (28)(29).

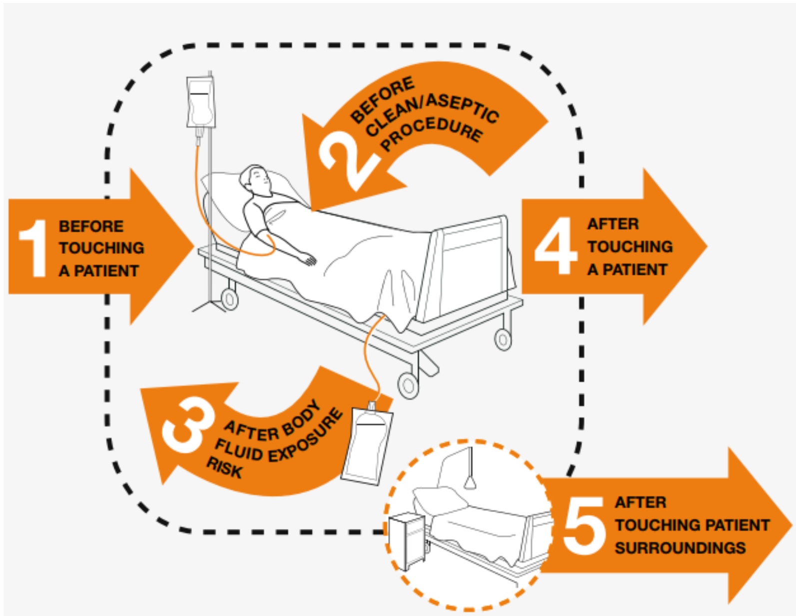


Fig 1- When and why – follow World Health Organizations (WHO's) five moments for hand hygiene

There are five moments when a caretaker should sterilize their hands before\ after contact with a patient. The guide assessment is based on the quality of evidence from high (A) to very low (C) and sets the strength of recommendations.

1. After body fluid exposure/risk (A)- health worker and environmental protection
2. Before aseptic procedures (B) –patient protection against harmful germs, as well the patient's germs
3. Before touching a patient (B) – patient protection against harmful germs on health worker hands
4. After touching the patient (B) – health worker and environmental protection
5. After touching the patient's surrounding (B) – health worker and environmental protection

Soiled or visibly dirty washed with soap and water for a minimum of 15 seconds. Hands and fingers, all surfaces are covered. Then drying thoroughly using a disposable towel (B) or an alcohol-based hand rub (A), e.g., 0.5% chlorhexidine with 70% w/v ethanol, if hands are not visibly contaminated. Combining chlorhexidine and alcohol is excellent as they cover Gram-positive and Gram-negative germs, viruses, mycobacteria, and fungi. During surgical hand preparation, all hand jewelry must be removed (A). Fingernails should be trimmed to less than 0.5 cm (A) with no residual of nail polish or artificial nails (A).

Gloves

Sterile gloves should be used after hand hygiene procedures while touching mucous membrane and non-intact skin and performing sterile procedures (A). In case of a need for contact with blood, other body fluids, and any other potentially contagious substances-clean, non-sterile gloves are used.

Gloves should be changed between procedures and tasks and in the same patient, particularly when moving between a contaminated body area to a clean body area (A). Hand hygiene should be applied each time gloves are removed.

Gown

The gown is used for protection of contamination of clothing and skin during procedures that are likely to generate spatter of blood, body fluids, secretions or excretions (B). For aseptic procedures, a sterile gown is used, and for the rest, a clean, non-sterile gown is enough (A).

Mask, eye protection/face shield

Mask and proper eye protection such as a face shield are used to protect mucous membranes of the eyes, nose, and mouth during procedures and patient care activities that are likely to generate spatters of blood and body fluids (B).

New techniques in HAI prevention

Recent approaches go "back to basic" when emphasizing the basic elements mentioned in the previous chapter. However, their main contribution is by producing educational and customized elements. The programs involve self-study material as well as monthly group learning.

Behavior technique

The TAP strategy developed by the CDC can be utilized to identify facilities and units with a high burden of HAIs and highlight gaps in infection prevention. In this way, finite infection prevention resources can be directed to areas of greatest opportunity. The TAP strategy incorporates the TAP reports generated in the CDC's NHSN, along with standardized assessment tools and implementation strategies for CLABSI, CAUTI, and CDI (22).

The foundational domain emphasized core infection control practices known to have variable compliance but are critical for any HAI prevention success. Many are considered “horizontal” infection control strategies in that they affect not one but many pathogens and HAIs. Eight elements for the foundational domain identified in an American study: 1) competency-based training, inspection, and feedback; 2) hand hygiene; 3) personal protective equipment; 4) environmental cleaning; 5) antimicrobial stewardship; 6) making an effective infection prevention business case; 7) patient and family engagement, and 8) socioadaptive strategies for preventing infection. The HAI-specific domains concentrated on best practices for preventing CDI, CLABSI, CAUTI, and hospital-onset MRSA bloodstream infection. In total, subject-matter experts created 51 short (10 to 20 minutes), Web-based, on-demand educational modules covering key topics in the two domains (22).

HAI-CoSIP- Healthcare-associated infections-Core Set criteria & Indicators Prevention

Several strategies have been developed and checked to improve HAI management. The availability of a set of performance indicators represents a major element to guide HCOs towards identifying main gaps, implementing necessary and practical actions, and continuous improvements. The development of an exhaustive and informative core set of indicators and standards by regulatory authorities and its implementation within institutional accreditation may supervise the accomplishment of goal performance standards and promote quality improvements within national HCOs. A new review conducted by “Italian Study Group of Hospital Hygiene of the Italian Society of Hygiene, Preventive Medicine and Public Health” identified a set core of 96 indicators and requirements for HAI prevention and control (HAI-CoSIP - HAI Core Set criteria & Indicators Prevention) in the hospital setting. (30) The method was based on well-known evidence and is purposed to bring them into the present time (31).

The unique approach of this method allows to address every area prone to HAI and make a specific protocol considering its most vulnerable spots.

The HAI-CoSIP included 20 key areas for HAI control and prevention evaluated via a core set of 96 criteria and requirements as reported in Table 1:

HAI-CoSIP - HAI Core Set criteria & Indicators Prevention

Table 1 - HAI-CoSIP Key Areas

Area	Description
A	Presence of a policy/program and of an organization for the HAIs prevention and control in the hospital
B	Appointment of a manager/multi-disciplinary committee for the control and surveillance of HAIs in the hospital
C	Performing HAIs[1] surveillance within the hospital
D	Presence of a staff training program on HAIs prevention and control
E	Presence of protocols to communicate HAIs surveillance results and incidents involving the risk of infection transmission
F	Defined protocols for proper cleaning of the environment
G	Detection and measurement of air and water quality
H	Presence of protocols for proper hand hygiene
I	Presence of procedures for the sterilization of medical devices and electro-medical equipment
J	Presence of guidelines for reusing medical devices
K	Defined proper management of laundry and linen
L	Presence of provisions for proper waste disposal
M	Defined strategies for the prevention and control of surgical site infections
N	Presence of specific protocols to prevent CVC-related infections
O	Presence of protocols to prevent and control multi-drug resistant bacteria (especially methicillin resistant *Staphylococcus aureus* [MRSA])
P	Presence of protocols for the proper use of antibiotics and for the correct identification of processes that require antibiotic prophylaxis
Q	Presence of systems to ensure the isolation of patients with infectious diseases
R	Communication with patients and caregivers
S	Existence of a vaccination program for staff
T	Defined indicators

[1] HAI: Healthcare-Associated Infections; [2] CVC: Central Venous Catheter

Table 1 - Tardivo, S., Moretti, F., Agodi, A., Appignanesi, R., Baldovin, T., Barchitta, M., ... & Auxilia, F. (2018). Essential strategies in HAI prevention and control: performance assessment through the implementation of the HAI-CoSIP tool of the GISIO-SItI group: A pilot study in a sample of Italian Organizations.

It is focused on outcome indicators such as the Surgical Site Infection (SSI) rates after joint replacement surgery, the Catheter-related bloodstream infections (CRBSIs) rates, and HAIs point prevalence estimation.

Standards fulfillment was evaluated in the initiation of the method as follows according to a 4 point Likert Scale:

- Score 0: “no, the Organization fails to meet the requirement under evaluation”;
- Score 1: “Organization partially satisfies the requirement under evaluation, e.g., either the process to fulfill the requirement has just started, or the level of fulfillment is limited to just some of the organizations work units”;
- Score 2: “Organization mostly satisfy the requirement under evaluation, e.g., either the process to fulfill the requirement is almost concluded, or the level of fulfillment is already extended to the majority of the organizational work units”;
- Score 3: “yes, the Organization totally satisfies the requirement under evaluation”.
- The fifth possible answer is referred to the feasibility of the requirements within the HCO under evaluation (Requirement “Not Applicable”: the services provided by the organization do not include the requirement under evaluation”).

The technique was translated into a more measurable scale:

- Class A: it included organizations that showed the highest performance index (e.g., score above the 80 percentile of the score distribution of the whole sample). They showed an implementation of continuous sustainable improvements to monitor and control HAIs.
- Class B: it referred to 60-80 percentile distributions and included organizations that require improvements in a few areas to obtain excellent performances.
- Class C: refers to 40-60 percentile distribution and included organizations requiring improvements in limited areas.
- Class D: refers to 20-40 percentile distribution and included organizations that require improvements in several areas.
- Class E: includes organizations with the lowest performance index (below the 20 percentile) and required substantial corrective actions in multiple areas.

It is potential implementations as a uniform criterion that may lead to HAIs management and control strategies and overcome regional differences (30).

An integrated stewardship model: antimicrobial, infection prevention and diagnostic (AID)

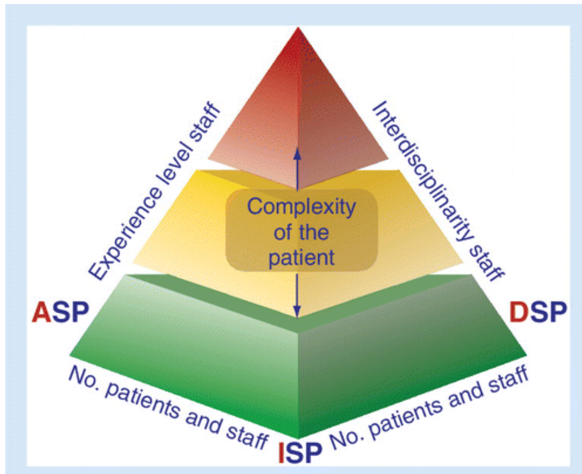


Fig 2 - Multistakeholder platform of the antimicrobial, infection prevention and diagnostic stewardship model. Dik JW, et al. An integrated stewardship model: antimicrobial, infection prevention and diagnostic (AID) (green - low complex, orange - intermediate complex and red for high complex)

This Pyramid platform is showing the interdisciplinary stakeholder connections between the ASP(Antimicrobial Stewardship Program), ISP(Infection Prevention Stewardship Program), and DSP(Diagnostic Stewardship Program) within the antimicrobial, infection prevention, and diagnostic stewardship model. This model demonstrates the complexity of the patients that correspond with the number of patients and treating staff and the experience level of the treating staff. The more complex a patient, the more the requirement of experienced specialists from multiple disciplines supplemented with proper, in-time performed diagnostics and eHealth tools. This, together, is necessary to adequately cope with the specific infectious-related problems, whereby the complexity of the patient is a continuously changing state which varies over time.

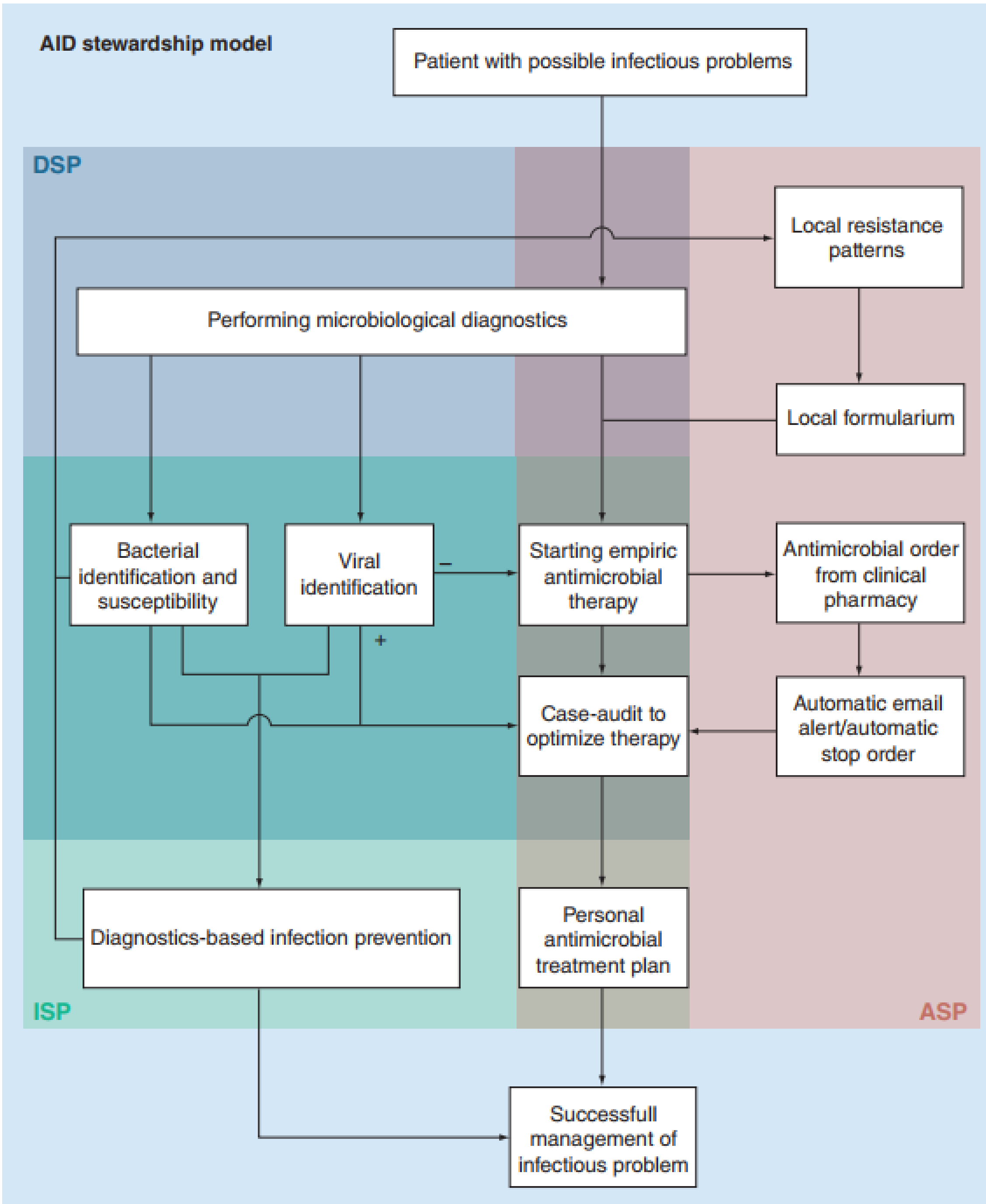


Fig 3 - Master scheme antimicrobial, infection prevention and diagnostic stewardship model.

Dik JW, et al. An integrated stewardship model: antimicrobial, infection prevention and diagnostic (AID)

The Flow chart above depicts the path of care of a patient from top to bottom, surrounded by the building blocks of the three different but supplemental stewardship programs and how they are intertwined.

AID: Antimicrobial, infection prevention and diagnostic; ASP: Antimicrobial Stewardship Program; DSP: Diagnostic Stewardship Program; ISP: Infection Prevention Stewardship Program.

In the view of this approach, infection control can not be adequately achieved by a single doctor/one medical specialty/single hospital, nor by one country. Management of infections in healthcare networks is based on an interdisciplinary and inter-regional approach. The movement of patients between and within healthcare institutions entails the movement of microorganisms within and other institutes. For this reason, they have developed an integrated AID stewardship model in close cooperation with healthcare institutions and diagnostic laboratories within the region. Besides, eHealth technology is crucial to support multidisciplinary, cross-border infection management (32).

1. **Antimicrobial stewardship**- Key components of this part are appropriate, timely microbiological diagnostics, calculated empirical therapy, close cooperation with the pharmacy department and continuous clinical and financial outcome evaluations focusing on a day-2 bundle of audit/feedback. Pharmacokinetic and pharmacodynamic data are used to improve further and personalize antimicrobial treatment.

   The area of optimization and personalization of therapy must be taken very carefully in this section. This should consider basic patient factors such as preliminary diagnosis, compartment of the infection, bodyweight, pharmacokinetic aspects (including organ dysfunction and the current volume of distribution, among others), pharmacodynamic characteristics of the drugs (e.g., killing activity, among others) and characteristics of the microorganisms (most relevantly the MIC). Pharmacokinetic and pharmacodynamic (PK/PD) models and data may be used to integrate these factors. This approach can optimize empiric therapy (based on population data for both patients and microorganisms) and personalize treatment to particular patients over time. Especially for the latter aspect, appropriate therapeutic drug monitoring (TDM) needs to be implemented. When integrating all available data, the result is optimizing the effect of antimicrobial therapy and limitation of the collateral damage (toxicity and emergence of resistance).
2. **Infection prevention stewardship**- Infection Prevention Stewardship Program entails early detection and close surveillance of multidrug-resistant organisms, as well as an adequate rapid reaction to every possible transmission. Continuous communication within the healthcare region and unification of guidelines is important. Infection control and prevention measures must be integrated

into this unified program to improve overall infection management. Other strategies would not have the desired impact unless infection prevention measures are not taken. Infection prevention stewardship involves early detection and close surveillance of them and an adequate rapid reaction to every possible transmission. This task depends on easy access to rapid microbiological diagnostics for direct patient care and surveillance purposes. Therefore, infection control and prevention and medical microbiology units must be organized within one department for maximal collaboration and cooperation and work together closely with the internal medicine department and the hospital pharmacy. It is also important to take into consideration ISP, the use of eHealth technology, developed in a multidisciplinary environment by medical experts and eHealth experts, has considerable potential to facilitate these work processes.

3. **Diagnostic stewardship-** For personalized treatment and infection control and prevention purposes, state-of-the-art diagnostics should be performed timely before initiating antimicrobial therapy. Diagnostics must be appropriate and detect colonization and/or infection within 24–48 h of admission. In order to achieve optimal therapy for individual patients and for infection control and prevention purposes, state-of-the-art diagnostics must be performed timely before initiating antimicrobial therapy. Diagnostics must be customized for the individual patient, target all pathogens causing acute infections, and detect colonization and/or infection. Diagnostic stewardship's major goal is to assist individual physicians in selecting and interpreting diagnostic tests on suitable clinical specimens. To be most effective, these diagnostic tests should provide relevant clinical data as soon as possible, but for sure, within the first hours of admission (viral) or the first 24–48 h of admission (bacterial and fungal). Molecular diagnostics can largely meet these requirements. With new point-of-care (or point-of-impact) assays (e.g., testing different biomarkers) becoming available, the turnaround time for an increasing number of viral and bacterial/fungal pathogens can be reduced to less than 2 h, supporting clinical decision-making. Furthermore, an important issue is supporting a noninfectious differential diagnosis for certain conditions if appropriate diagnostics rapidly yield negative results. Like the theragnostic approach in oncology, this should ultimately lead to a more personalized infection management plan for the patient, whereby diagnostics, therapy and infection prevention are integrated (32).

Antimicrobial device coatings

A variety of coatings techniques and products have been developed to achieve long-term antimicrobial activity to lower the risk of infection. The coatings can be divided into two categories: those that rely on the material's intrinsic properties to kill or repel bacteria that meet the surface and those that use antibiotics in conjunction with a polymer coating.

Many coatings rely on the encapsulation of various antibiotics or antifungal drugs to prevent device infection by locally delivering the drug. Affinity-based drug-eluting device coatings have been used in a wide variety of applications. It has been incorporated into hernia mesh coatings, orthopedic coatings, catheter coatings, and vascular graft coatings. The coating is providing therapeutic doses of the drug over extended periods of time. This is an advancement over conventional delivery systems, which rely solely on diffusion to extract the drug from the polymer and lack additional affinity interactions between the polymer and the drug.. When diffusion is the primary mechanism of drug release, it can often result in most of the loaded drug being released over a brief period of time which is not desirable for many antibacterial applications (33).

An example of such use can be seen in medical tubes:

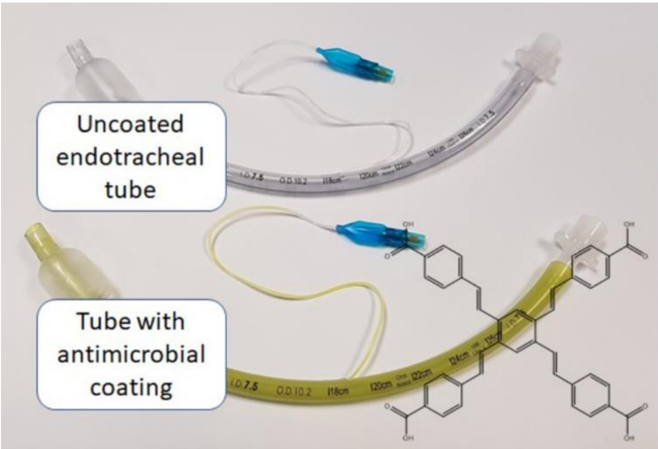


Fig 4 - Taken from the article "Evaluation of the Novel Antimicrobial BCP3 in a Coating for Endotracheal Tubes"

It has been found that a simple and reliable coating method combining the highly biocompatible polymer and the novel antimicrobial compounds. The poly(lactic-co-glycolic acid) –styrylbenzene-based antimicrobial (PLGA–BCP3) coatings can be applied using a facile dip-coating process that allows the controlled loading of BCP3. A vitro study has shown a concentration-dependent release of BCP3 for at least

31 days with a tunable release profile. The PLGA–BCP3 coatings were able to release BCP3 to significantly inhibit the growth of major VAP pathogens, methicillin-resistant and methicillin-sensitive S. aureus, and to a smaller extent, the Gram-negative P. aeruginosa. While inhibiting bacterial growth, using the facile coating method, the entire tube coated quickly and easily, making the PLGA–BCP3 coatings highly favorable for large-scale manufacturing (34).

Adhesives

Skin glues are particularly useful in percutaneous wounds or basic pediatric cases because they are relatively painless and simple to apply. Deeper sutures may also benefit from adhesive tapes and skin glues. They cause less wound inflammation than sutures, have a lower infection risk, and are simple to remove. The following steps should be kept in mind regardless of which wound closure technique is applied: Line up the skin edges precisely to ensure minimal scarring. Do not pull too hard to reduce tension with sutures, as that can lead to further wound breakdown. Use skin adhesives and/or glue in conjunction or an adjunct to sutures or staples to strengthen wound closure. Those steps help to achieve a thoroughly healed incision with minimum scarring. The goals of wound management are to avoid infection, tamponade the bleeding, and provide a better cosmetic outcome (35).

Conclusion

This research aimed to review new approaches to preventing hospital-acquired infections in ICU, surgery, and other high-risk facilities. Works from the last 10 years were included to provide the most updated information on the subject. Several conclusions should be made from it:

1. HAI is a serious problem globally, despite the technological and scientific medical progress in the last decades.
2. HAI causes excessive resource use, additional hospitalization periods, and increased death rates.
3. The HAI types differ from areas around the world and different departments in the hospital, depending on the population and procedures performed.
4. In order to prevent HAI spread, basic infection control techniques must be used. Identification and isolation on the infection carrier must be made as soon as possible. Besides, in all cases, hand hygiene protocols must be kept, and the proper use of gloves, gowns, masks and eye\ face protection shield.
5. New approaches were suggested in addition to the basic measures in order to improve HAI prevention.
   - Behavior technique- used to identify facilities and units with a high burden of HAIs and highlight gaps in infection prevention. In this way, finite infection prevention resources can be directed to areas of greatest opportunity.
   - HAI-CoSIP – a set of tests that allow to address every area prone to HAI and to make a specific protocol considering its most vulnerable spots.
   - An integrated stewardship model: (AID)- Infection management in healthcare networks is based on an interdisciplinary and inter-regional approach. For this reason, there was an integrated AID stewardship model made in close cooperation with healthcare institutions and diagnostic laboratories within the region. In addition, eHealth technology is crucial to support multidisciplinary, cross-border infection management.
   3. A variety of promising techniques such as PLGA–BCP3 coatings of medical devices, tapes, and glue for wound management have been implemented in modern medicine. They allow better healing and decrease the risk of HAI.

In summary, this is an integrated approach that sees HAI prevention not only as a battle against infection spread but as an approach to better medicine. It includes antimicrobial aspects as well as infection prevention and correct diagnosis. For the prevention of HAI, all of the components must be taken into consideration.

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