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Economical Implications of the Institution-Level Implementation of Evidence-Based Infection Control

Doctoral Thesis

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LIST OF ABBREVIATIONS

AMR	Antimicrobial resistance
CDC	Centers for Disease Control
CD(I)	Clostridium difficile (infection)
CPAP	Continuous Positive Airway Pressure
CVC	Central venous catheter
DALY	Disability Adjusted Life Year
EARSS	European Antimicrobial Resistance Surveillance System
ECDC	European Centre for Disease Prevention and Control
EEA	European Economic Area
HAI	Healthcare associated infections
ESAC	European Surveillance of Antimicrobial Consumption
ESGCD	European Study Group for Clostridium difficile
EU	European Union
HELICS	Hospitals in Europe Link for Infection Control through Surveillance
ICU	Intensive Care Unit
ISCP	Infection Surveillance and Control program
MH EK	Military Hospital – State Health Centre
MRSA	Multiresistant Staphylococcus aureus (infection)
NEAK	National Health Insurance Fund of Hungary
NNIS	National Nosocomial Infections Surveillance System
NNSS	National Nosocomial Surveillance System
OSZIR	Hungarian National Professional Information System
PIC	Perinatal Intensive Care Centre
PPS	Point Prevalence Survey
PVC	Peripheral venous catheter
RFID	Radio Frequency Identification Card
SENIC	Study on the Efficacy of Nosocomial Infection Control
TESSY	The European Surveillance System
WHO	World Health Organization

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I. INTRODUCTION

Decades ago, countries with developed healthcare systems recognised an alarming tendency in the onset of nosocomial infections and bacterial resistance (the ability of infectious bacteria to withstand pharmacological therapy), therefore their prevention and treatment became a matter of increasing focus. However, the past two decades saw this becoming an urgent necessity all over the world due to the accelerated spreading of multidrug-resistant bacteria (i.e., bacteria resistant to antimicrobial agents which are traditionally effective) and the dramatic loss of antibiotic efficacy[1].

Infection control is the set of prevention practices based on the scientific grounds of hospital epidemiology. The objective of infection control is to prevent the occurrence of healthcare associated infections and the spreading of multidrug-resistant microorganisms.

Current infection control focused approach and terminology became widely used in hospital epidemiological practice after publishing the results of "The SENIC PROJECT Study on the Efficacy of Nosocomial Infection Control" [2, 3]. Results of a study performed by the US Centers for Disease Control (CDC) in three phases between 1976 and 1979 demonstrated that complete infection surveillance and control programs (ISCP) are efficacious and cost-effective measures for the prevention of nosocomial (hospital) infections. The SENIC project set the following four goals:

1) To address the efficacy and cost-efficiency questions related to the completion of nosocomial surveillance programs.

2) To describe the infection control program, the rate of nosocomial infections and to define the specific risk factors.

3) To identify and present those items of the ISCP programs which can be recommended for widespread use due to their importance.

4) To highlight those areas which should be further investigated with fundamental and applied research.

Multidrug-resistant pathogens and their healthcare associated infections, as well as the related Clostridium difficile infection (CDI) represent one of the greatest challenges healthcare providers have to face nowadays. Based on the results of the European surveillance network of clinically and epidemiologically significant pathogens obtained from invasive samples, the Hungarian microbial resistance situation is not favourable in a European perspective, as we are among those European countries where the rate of antibiotic resistance is higher than the average (EARS-Net, 2018) [4]. Data from domestic surveillance systems and situation analysis both confirm that antimicrobial resistance (AMR) is one of the most significant public health risks.

According to the World Health Organization (WHO) 2016 guidelines on infection prevention and control, the average rate of patients acquiring a nosocomial infection in developed countries is 7%. In Europe, this translates to 16 million extra days of hospital stay, 37,000 deaths directly and another 110,000 deaths indirectly attributed to infection, as well as EUR 7 billion extra costs, assuming the direct costs only [5]. Depending on the patient population, mortality rate attributable to nosocomial infections varies between 12% and 80% [5].

The following recommendation is made in Section 13 of the Council Recommendation of 9 June 2009 on patient safety, including the prevention and control of healthcare associated infections [6]:

"It is essential that the necessary resources for implementing the components of the national strategy are allocated as part of the core funding for healthcare delivery."

As a practising senior consultant in hospital hygiene, I have been involved in infection control for more than 15 years. Acting as Head of the Military Hospital – State Health Centre (MHEK) Department of Hospital Hygiene, I took an active part in implementing an evidence-based institutional ICP as director and responsible person of the project. In my work I had an opportunity to familiarise myself with the international IC guidelines and practices, and I took part in creating the national IC. Working in the MH EK as a unit head allowed me to obtain a broad perspective on the challenges associated with creating the institutional professional minimum criteria of IC, as well as with implementing them in practice. Furthermore, it has become evident to me that in addition to clinical particulars (efficiency,

implementation, acceptance), appropriate funding conditions are necessary in order to successfully establish IC. No successful IC can be created and maintained without the support of analyses based on high-quality clinical and healthcare economy evidence. Although several scientific questions remain open in the international literature, there are especially scarce local, institution-level data and information available on the IC practice, its efficiency, costs and healthcare economy aspects. I was looking for answers to these questions in my research described in the Thesis.

II. LITERATURE REVIEW

II.1. Basic concepts of institutional infection control

In order to discuss institutional infection control, some basic concepts must be defined and explained. These are as follows:

a) **healthcare associated infection**: an infection which occurred during healthcare in the patient, a healthcare worker or any other person who came in contact with healthcare (like a volunteer assistant or a visitor);
b) **infection control**: interventional activity aiming to prevent infections based on the understanding and analysis of factors involved in the onset of healthcare-related infectious diseases;
c) **surveillance**: continuously operational information system which allows data collection, analysis, interpretation, feedback and intervention using criteria validated by standardised definitions and methodology;
d) **targeted surveillance**: activity aiming to monitor a certain infection, risk factor, pathogen, antibiotic sensitivity/resistance, prophylactic or therapeutic drug use;
e) **nosocomial (hospital) infection**: healthcare-associated infection acquired by the patient, a healthcare worker or any other person who came in contact with healthcare during the inpatient specialist care, which was not present upon admission even in an underlying form;
f) **nosocomial surveillance**: surveillance aiming the onset, prevalence and detailed investigation of nosocomial infections, as well as the risk factors of developing infections;
g) **microbiological surveillance**: tracing the occurrence and resistance of pathogens, targeted surveillance aiming to identify the occurrence of pathogens;
h) **antibiotic resistance surveillance**: targeted surveillance aimed at the changes of antibiotic sensitivity/resistance of pathogens;
i) **surveillance of the use and utilisation of antimicrobial agents**: targeted surveillance aimed at the consumption and appropriate use of the antimicrobial agents used by the healthcare institution;

j) **antibiotic stewardship**: planning, analysis and revision of the reasonable and cost-effective use of antibiotics administered for the prevention and curing of infections, as well as a set of methods used against the development and spread of resistance to antibiotics;

k) **infection control interventions** include interventions administered to prevent the spreading of healthcare associated infections and multidrug-resistant pathogens, as well as to eliminate their accumulation.

l) **isolation**: a set of procedures and rules to inhibit the spreading of infections and pathogens;

m) **disinfection (decontamination):** a procedure used to prevent the spreading of an infection by applying distinct (physical, chemical) methods to reduce the number (sanation) of infectious pathogens in the environment (on surfaces, tools, objects, hand, skin etc.);

n) **environmental infection control**: the prevention of healthcare associated infections by mitigating the risk factors originating from the microenvironment (air, water, surfaces) of the healthcare institution;

o) **critical surface**: surfaces involved in the indirect transmission of pathogens, referred to as "frequently touched surfaces".

p) **patient zone**: an area of healthcare, consisting of the patient and their lifeless surroundings which the patient may touch or come in direct physical contact with;

q) **point of care**: a site within the patient zone where the patient, the healthcare worker, as well as care giving, patient care and curative actions are present together, at the same time.

r) **epidemiological measures**: mandatory actions implemented in order to prevent the transmission and accumulated occurrence of healthcare associated infections, as well as to stop any epidemic which has developed;

s) **Committee of Infection Control and Antibiotics**: a multidisciplinary committee to steer and to supervise infection control activities, including the use of antibiotics.

II.2. Incidence of infections caused by nosocomial and multidrug-resistant pathogens

Clostridium difficile (CD) is the most prevalent pathogen associated with the use of antibiotics. This pathogen can be held responsible for approximately 25% of all cases of diarrhoea developing in conjunction with the use of antibiotics, and its incidence has increased significantly from the second half of the 90s until now. According to the European Study Group for Clostridium difficile (ESGCD) surveillance study involving 38 hospitals from 14 European countries, incidence was 2.45 ± 1.8 cases /10,000 patient days [7].

Results from a hospital study performed in 2008 involving 34 countries showed that among the nosocomial CD infection cases in Europe PCR ribotypes 014/020 (16%), 001 (9%) and 078 (8%) are the most common, while the hypervirulent ribotype 027 has a prevalence of 5%. Weighed mean incidence was 4.1 CDI cases/10,000 care day/hospital (value range: 0.0–36.3) [8].

As reported by Zilberberg et al., the United States witnessed a significant increase in CDI related hospitalisations between 2000 (5.5 hospitalisations due to CDI/10,000 inhabitants) and 2005 (11.2 hospitalisations due to CDI/10,000 inhabitants) [9].

Information on the incidence of healthcare associated infections and multidrug-resistant pathogens (MRP) can be obtained from the data published by the community network (The European Surveillance System, TESSY) and the National Nosocomial Surveillance System (NNSS) [10]. The amended Commission Decision 2002/253/EC laying down case definitions for reporting communicable diseases to the Community network under Decision No 2119/98/EC of the European Parliament and of the Council entered into force in 2012 and was published in Hungarian as well. The updated NNSS, launched in 2014 with an IT background provided by the Hungarian National Professional Information System (OSZIR), uses the European case definitions.

Operational since 2005, the national surveillance system is an integrated part of the community network, except for the traditional "nosocomial epidemic reporting module". NNSS results are published annually.

Regarding the time period between 1 January and 31 December 2018, 94 inpatient care institutions reported infections caused by C. difficile. This amounts to 70% of the inpatient care institutions (134 hospitals) included in the 2018 "Report on Hospital Bed Numbers and Patient Turnover" by the National Health Insurance Fund of Hungary (NEAK). In 2018, a total of 6412 cases of C. difficile infection affecting 6153 patients were reported and analysed according to the data submitted by the 94 inpatient care institutions. The tendency of healthcare associated domestic CDI cases is presented in Table 1.

Table 1. Annual data on healthcare associated infections caused by *Clostridioides* (historically: Clostridium) difficile between 2013 and 2018.

Year	Number of reporting institutions	Number of releases	Number of days of care	Number of cases	Incidence per 10,000 released patients	Incidence per 100,000 days of care
2013	85	1,943,941	16,859,789	6182	31.8	36.7
2014	90	2,051,141	17,476,277	6551	31.9	37.5
2015	101	2,061,443	17,564,516	5754	27.9	32.8
2016	95	2,010,385	17,293,212	4966	24.7	28.7
2017	92	1,972,926	17,045,170	5404	27.4	31.7
2018	94	1,977,696	16,935,562	5549	28.1	32.8

Source: National Nosocomial Surveillance System [11]

The NNSS module on healthcare associated infections caused by MRPs contains data of infections caused by pathogens specified in the relevant legislation and methodological letter (Table 2).

Table 2. Antibiotic resistance and brief name of multidrug-resistant pathogens

Name of the pathogen		Antibiotic resistance
Staphylococcus aureus	MRSA	methicillin/oxacillin
Staphylococcus aureus	VISA	Vancomycin-intermediate S. aureus
Enterococcus spp.	VRE	vancomycin
Enterobacter spp.	MENB	ESBL-producing
Escherichia coli	MECO	3rd generation cephalosporins and/or ESBL-producing
Klebsiella spp.	MKLE	3rd generation cephalosporins and/or ESBL-producing
Klebsiella pneumoniae	CRKL	Not sensitive to imipenem/meropenem and/or carbapenemase-producing
Other Enterobacteriaceae	CRE	Not sensitive to imipenem/meropenem and/or carbapenemase-producing
Acinetobacter baumannii	MACI	imipenem and/or meropenem
Pseudomonas aeruginosa	MPAE	Sensitive only to up to 2 of the listed agents with antipseudomonal efficacy (piperacillin/tazobactam, ceftazidine, cefepime, imipenem, meropenem, ciprofloxacin, gentamicin, tobramycin, amikacin, aztreonam)
Stenotrophomonas maltophilia	MSTM	Co-trimoxazol (sumetrolim)

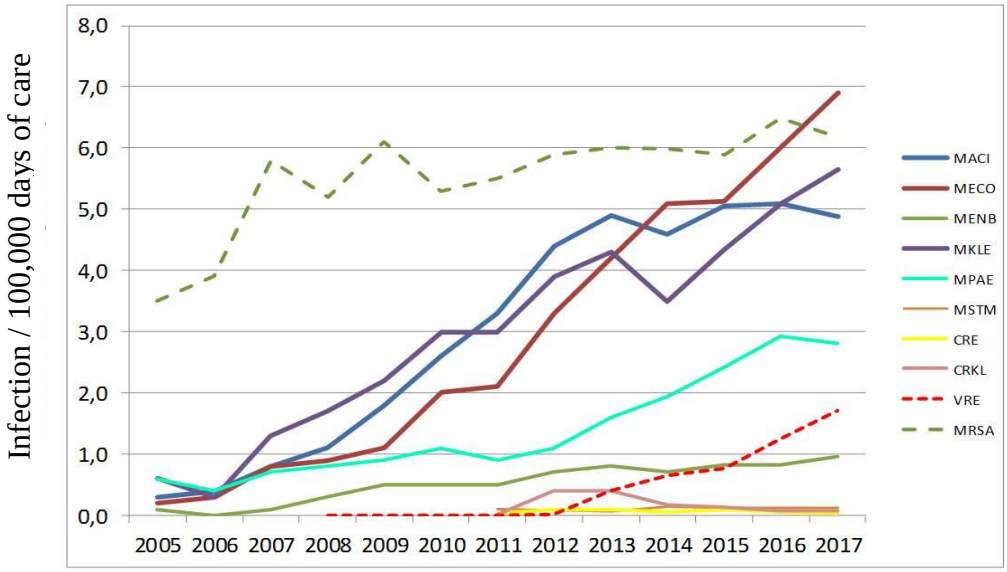
Tendencies in the number of domestic nosocomial infections can be concluded from the number of infections registered at the Hungarian institutions.

Number of reporting institutions in 2018: out of 134 hospitals reimbursed by the National Health Insurance Fund of Hungary (NEAK), 87 were reporters (65%). (Range of capacity: 10 to 3472 hospital beds.) The report covers 96% of patients released from hospitals with active and/or chronic bed capacities, 91% of care days and 92% of reimbursed hospital bed capacities.

The Military Hospital – State Health Centre (MHEK) is an institute created by merging 5 institutions in Budapest. Nosocomial infections based on microbiological culture methods were regulated under a surveillance institutional procedure, epidemiology specialist nurses followed up 2932 patients (6.18% of those who received care) in 2011, after investigation, 660 nosocomial infections were registered in 575 patients (1,21% of those who received care). Proportionate with the gradual increase in the number of active beds, the coverage area and the severity of cases

under care, 3675 patients (6.27% of patients under care) were followed in 2018 and after investigation, 1120 nosocomial infections were registered in 894 patients (amounting to 1.53% of all patients under care).

Figure 1. Incidence density of healthcare associated infections caused by multidrug-resistant pathogens (number of infections per 100,000 days of care), Hungary, 2005–2017.



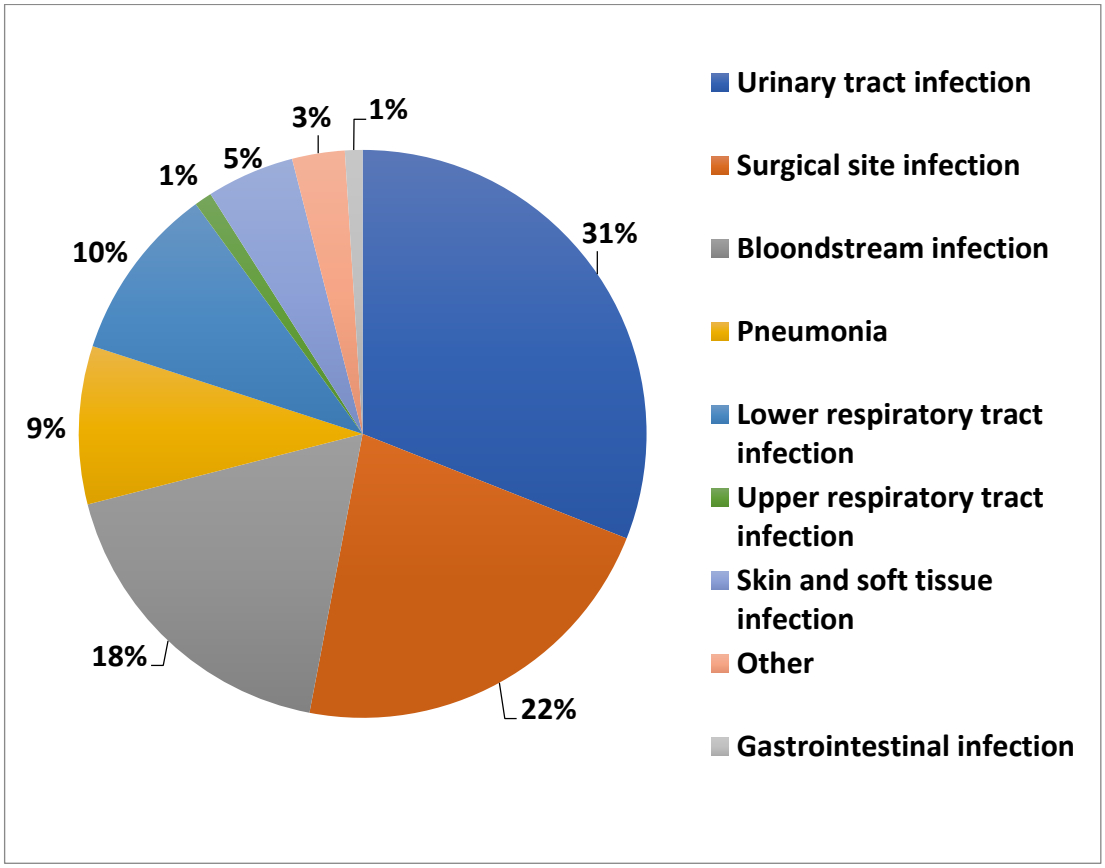
Source: National Nosocomial Surveillance System [11]

Table 3. Infection rate of nosocomial infections caused by multidrug-resistant pathogens between 2013 and 2018

Year	Number of reporting institutions	Number of releases	Number of days of care	Number of cases	Incidence per 10,000 released patients	Incidence density per 100,000 days of care
2013	85	2,146,170	19,152,889	3837	19.3	22.7
2014	93	2,062,773	17,517,968	3998	19.4	22.8
2015	93	2,032,955	16,888,007	4187	20.6	24.8
2016	92	2,051,564	16,950,222	4830	23.4	28.4
2017	89	1,966,229	16,812,675	4935	25.1	29.4
2018	87	1,937,986	16,419,281	5153	28.1	33.1

Source: National Public Health Center [10]

Figure 2. Occurrence of healthcare associated infections caused by multidrug-resistant pathogens by the clinical type of disease manifestation in 2018 (N=5442)

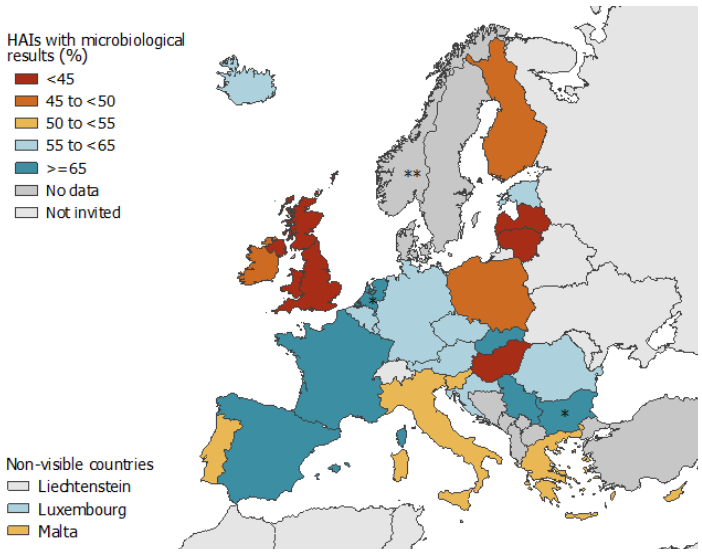


Source: National Public Health Center [10]

The cross-sectional study coordinated by the European Centre for Disease Prevention and Control (ECDC) is the largest European survey on healthcare associated infections (HAIs) and the use of antimicrobial agents. It is carried out every 5 years, involving those institutions which offer active inpatient care. The first point prevalence survey (PPS) was carried out in 2011-2012, and the second one was carried out in 2016-2017 [12]. According to the relevant Hungarian decree, the latter one involved every hospitals.

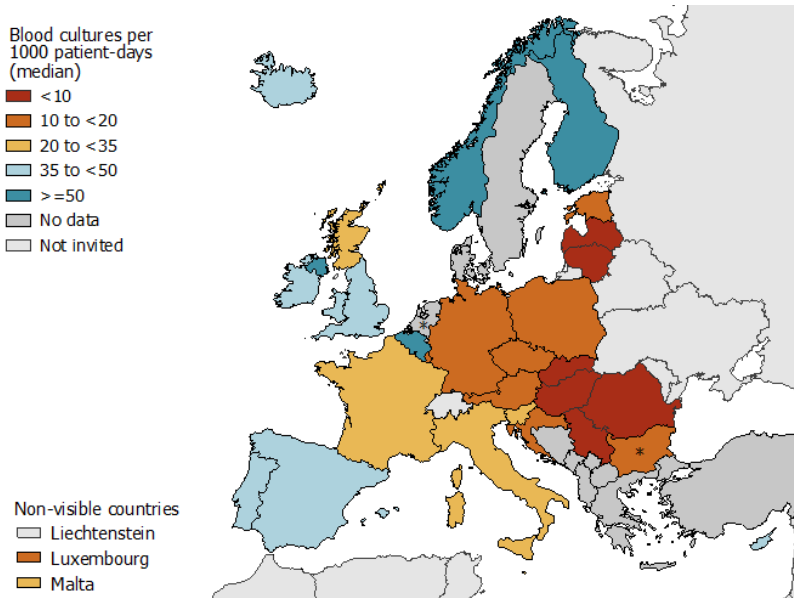
Published data from the study carried out in Hungary in 2017 are presented below.

Figure 3. Rate of infections confirmed by microbiological testing (ECDC, PPS 2016-2017)



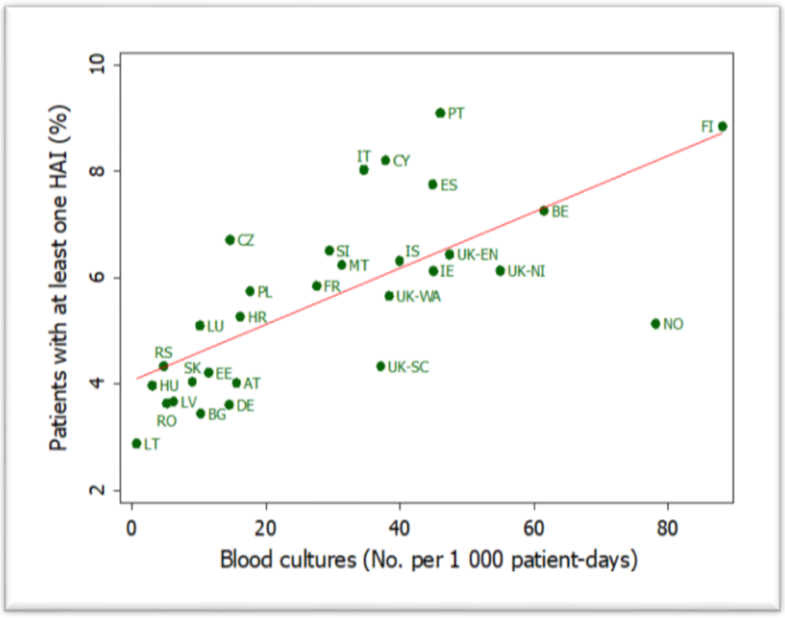
Source: ECDC, 2017 [12]

Figure 4. Number of blood culture tests per 1000 care days (ECDC, PPS 2016-2017)



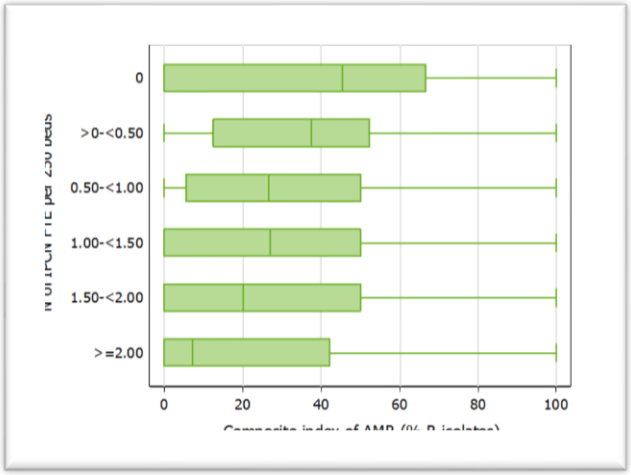
Source: ECDC, 2017 [12]

Figure 5. Positive correlation between healthcare associated infections and frequency of sampling for blood culture (ECDC, PPV 2016-2017)



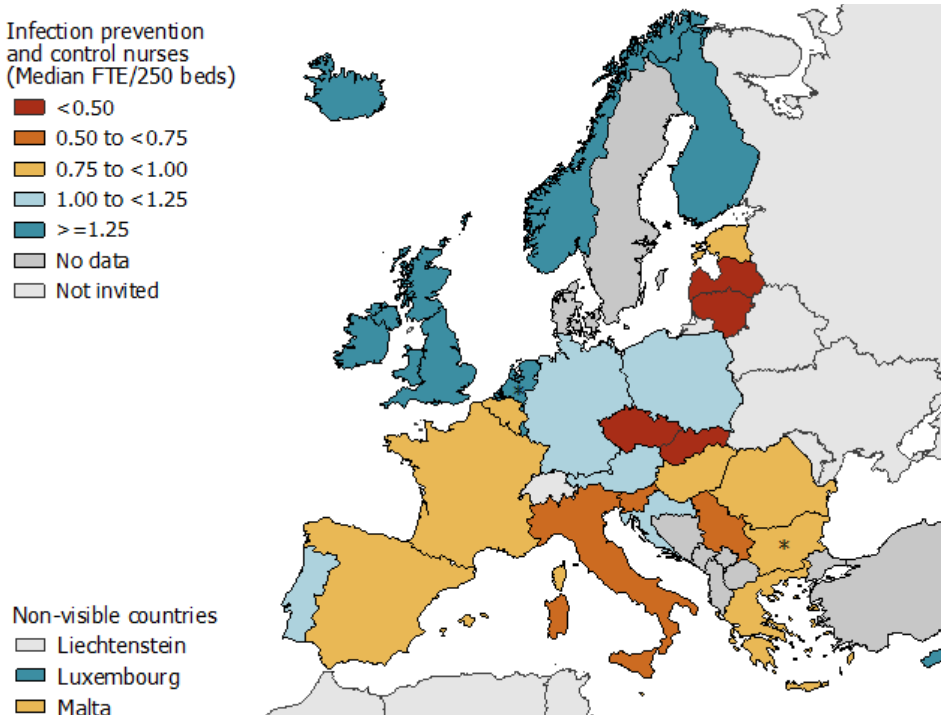
Spearman rho 0.75, p<0.001 R2=0.487
Source: ECDC, 2017 [12]

Figure 6. Relationship between the number of infection control nurses (FTE/250 beds) and the proportion of antibiotic-resistant isolates (ECDC, PPS 2016-2017)



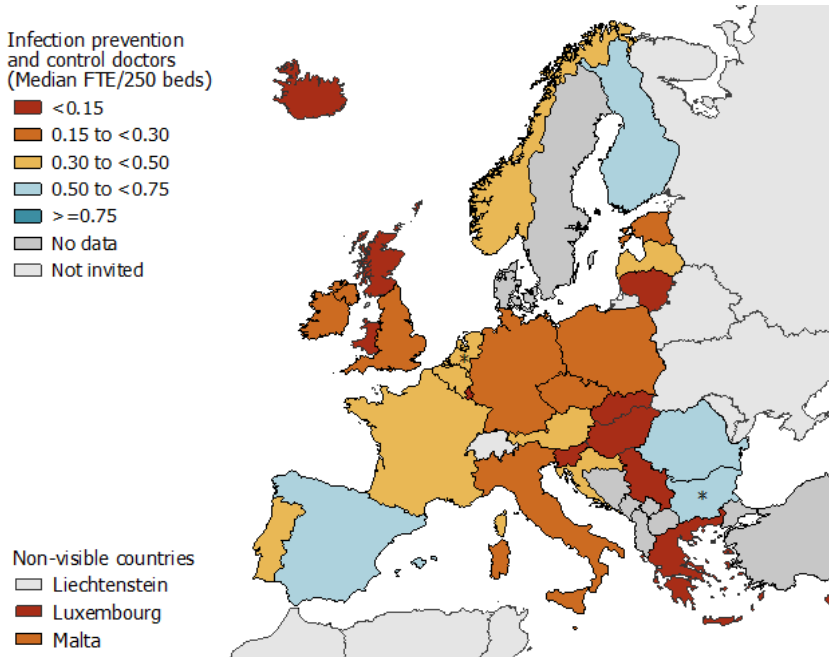
p<0.001
Source: ECDC, 2017 [12]

Figure 7. Number of infection control nurses: median full-time equivalents (FTE)/250 hospital beds (ECDC, PPS 2016-2017)



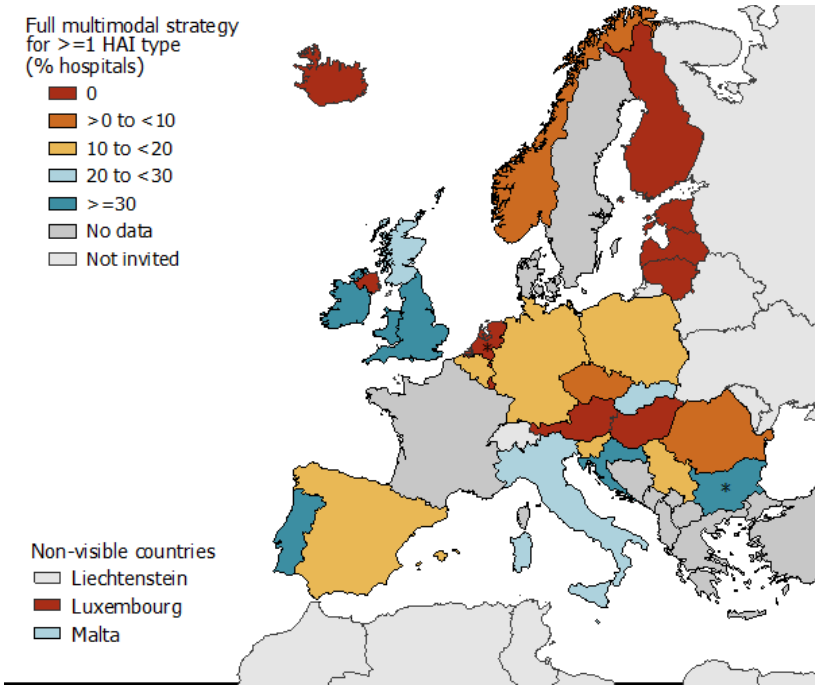
Source: ECDC, 2017 [12]

Figure 8. Number of infection control doctors: median full-time equivalents (FTE)/250 hospital beds (ECDC, PPS 2016-2017)



Source: ECDC, 2017 [12]

Figure 9. Rate of multimodal strategy application (WHO, 2016) in at least one HAI institutional infection control program of the investigated hospitals (ECDC, PPS 2016-2017)



Source: ECDC, 2017 [12]

The cross-sectional study surveyed the frequency of healthcare associated infections (HAIs) and antimicrobial use in institutions providing active inpatient care at a specific time. The study also assessed hospital structural and procedural indicators supported by scientific evidence. The purpose of the introduced community-level cross-sectional study is to provide a uniform tool (method) for European hospitals to allow defining their quality development goals.

The prevalence of HAI, weighed by country, was 5.5% (95% cCI: 4.5–6.7%) before validation correction carried out in acute care hospitals, similar to the prevalence of 5.7% (95% cCI: 4.5–7.4%) measured during the 2011-2012 ECDC PPS [13].

Estimated incidence rates from the data obtained are presented in Table 4.

Table 4. Estimated incidence of nosocomial infections, 2016-2017

Description	Hungary	EU/EEA
Patient case number (patients)	20,588	310,755
Prevalence (as per PPS methodology)	818 (4%)	18,287 (5.5%)
Estimated incidence	3.5% (2.1–5.4%)	3.7% (2.4–5.3%)

Source: Suetens, 2018 [13]

II.3. Infection control: A historical overview

The greatest challenge of the 21st century healthcare is halting the spread of multidrug-resistant bacteria [14]. The European Union Council recommendation issued in 2002 "on the prudent use of antimicrobial agents in human medicine" highlights the importance of developing strategies for the prevention of infections and containment of resistant pathogens [15]. 2010 saw the establishment of The European Surveillance System (TESSY) program. In 2009, the Council of the European Union issued its recommendation (2009/C 151/01) on patient safety, including the prevention and control of healthcare associated infections, which specifically highlights the importance of establishing infection control structures to be operated at a healthcare institution level, as well as the importance of establishing local infection control programs [6]. The Hungarian legislation has also been created considering the similar recommendations and the domestic particularities.

Hungary has a history of over 40 years of hospital hygiene. The first legal act on this area of expertise was "Instruction 15/1967 (Eü. K. 11.) of the Minister of Health concerning the operation of public health-epidemiology physicians and committees at inpatient and outpatient care units" which entered into force in 1967. This decree was considered up-to-date at its time. It was followed up by the "Professional guidelines for the work of hospital hygienist physicians" (a publication) in 1970. In order to combat infections, both the legal act and the professional guidelines emphasised adherence to the existing hygienic rules. The same attitude is reflected in Instruction 32/1980.(Eü. K. 24.) of the Minister of Health on the prevention of iatrogenic infections. Reporting iatrogenic, or in modern terms, nosocomial infections was mandatory even in those earlier times, although their scouting was

"passive". Furthermore, data collection was operated without using standards, therefore the reports yielded a database which was unfit for scientific analysis.

Since the early 90s, a kind of a paradigm shift may be observed in terms of the hospital hygiene practice of healthcare institutions, which is possibly related to the initiation of healthcare reforms, i.e. the implementation of performance-based funding. Hospital managements needed to understand the actual situation of healthcare associated sporadic infections. This new perspective served as a starting point for creating and implementing cost-effective prevention strategies. Hungarian journals started to publish more and more papers on the United States CDC National Nosocomial Infections Surveillance System (NNIS) and the European HELICS programs, as well as on their possible domestic application. (The American NNIS is operational since the 1970s, currently as part of the National Healthcare Safety Network.)

The principle of general precautions and regulations was created in 1985. This was triggered by the spreading of AIDS. It is intended to prevent transmission of infections by blood and bodily discharges between the patients and the care giving personnel. This was the first instance when precautions were aimed at everyone, irrespective of their assumed infection status.

Starting from the 1990s, supplementary regulations based on the known ways of pathogen spread (contact, droplets, respiratory) were developed and implemented; this is the spreading-based approach for prevention.

In Europe, the need for a unified infection control strategy was declared when the European Union Committee (hereinafter: Committee) issued "A strategy against the microbial threat" in 1999. The resolution highlights that antimicrobial resistance increases morbidity and mortality secondary to communicable diseases, leading to an impaired quality of life and an increase of additional healthcare costs. Community-level action was substantiated by the Council Recommendation 2002/77/EC on the prudent use of antimicrobial agents in human medicine. This document declared that in order to develop strategies for the prevention of infections and containment of resistant pathogens, accurate surveillance systems generating valid, reliable and comparable data on the incidence, prevalence and modes of spread of resistant microorganisms as well as on the prescription and use of antimicrobial agents must

be established throughout the Community. Subsequently, several community-established standardized and harmonised surveillance programs were created one after the another which allowed generating comparable data: HELICS (Hospital in Europe Link for Infection Control through Surveillance), EARSS (European Antimicrobial Resistance Surveillance System), ESAC (European Surveillance of Antibiotic Consumption). By now, all three systems have been merged within the unified European surveillance system (The European Surveillance System, TESSY).

In Hungary, the NNSS operated by the National Public Health Center (NPHC) and its predecessors has been gathering relevant data on infection control since 2005. On its website, the organisation publishes annual nationwide surveillance data according to the European standardized methodology and case definitions, along with their analysis.

General assemblies of the WHO have addressed the issue of AMR since 1986. The first global action plan was developed in 2001 (WHO, 2001).

The next milestone in Europe was the Council Recommendation (2009/C 151/01) on patient safety, including the prevention and control of healthcare associated infections, which made it clear that healthcare associated infections are the largest set of patient safety hazards, therefore their prevention is a priority in terms of patient safety. The Hungarian decree regulating the national infection control was issued as a document harmonising this Council Recommendation. In Hungary, national level infection control activities have been regulated in terms of operational authorisation of healthcare services in Decree 60/2003. (X. 20.) ESZCSM of the Minister of Healthcare, Social and Family Affairs on professional minimum requirements for the provision of healthcare, Decree 20/2009. (VI. 18.) EüM of the Minister of Health on the prevention of *healthcare associated infections and the professional minimum requirements and supervision* of such activities, as well as among epidemiology measures in Decree 18/1998. (VI. 3.) NM of the Minister of Public Welfare on *epidemiology measures required for the prevention of communicable diseases and epidemics*. National, regional and institutional structures (Committees, surveillance, reporting and supervisory systems) and tasks, contents of the required infection control at an institutional level (corresponding to the level of progressivity and care) according to the type of hospital, as well as the personnel (staff number per areas of expertise) and material requirements for these tasks are defined by the relevant law.

In order to provide global support for preventive activities and activities to combat antimicrobial resistance, the WHO issued their updated infection control guidelines in November 2016, which offers evidence-based and expert consent-based recommendations regarding the key elements of healthcare provider infection control programs, for the effective prevention of HAIs and the reduction of AMR.

The guidelines provide support for healthcare providers and care managers so that they can create their own infection control programs and action plans. The measures intended to correct and to improve the activities of the Hungarian healthcare system are created and implemented in line with the recommendations set forth in this guideline.

II.4. Professional guidelines for infection control

International professional guidelines of infection control are summarized in Table 5.

Table 5. International professional guidelines of infection control

International professional guidelines
CDC Guideline for Isolation Precautions: Preventing Transmission of Infectious Agents in Healthcare Settings Source: https://www.cdc.gov/infectioncontrol/pdf/guidelines/isolation- guidelines.pdf
WHO Guidelines on Hand Hygiene in Health Care: a Summary. Source: http://apps.who.int/iris/bitstream/10665/70126/1/WHO_IER_PSP_2009.07_eng.pdf ?ua=1
Guidelines on core components of infection prevention and control programmes at the national and acute health care facility level. Geneva: World Health Organization; 2016, Source: http://www.who.int/gpsc/ipc-components-guidelines/en/

National professional guidelines for infection control utilize the procedures summarized in Table 6.

Table 6. Professional guidelines for infection control in Hungary

Hungarian professional guidelines
Information by „Johan Béla" National Center for Epidemiology, title of publication: "A nosocomiális surveillance során alkalmazható módszerekről I. és II." (Applicable Methods During Nosocomial Surveillance, Part I. and II.) Source: http://oek.hu/oek.web?nid=1070&pid=1
Letter on Methodology by the National Center for Epidemiology, title: "A multirezisztens kórokozók által okozott fertőzések megelőzéséről" (Prevention of Multidrug-resistant Pathogens). Source: http://www.oek.hu/oek.web?to=16&nid=444&pid=1
Letter on Methodology by the National Center for Epidemiology, title: "A Clostridium difficile fertőzések diagnosztikájáról, terápiájáról és megelőzéséről (2017)" (Diagnostics, Treatment and Prevention of Clostridium difficile Infections). Source: http://www.oek.hu/oek.web?to=16&nid=444&pid=1
Letter on Methodology of the Chief Medical Officer of Hungary on the prevention of wound infections during surgery (NNK 2019) Source:https://www.antsz.hu/data/cms92859/Modszertani_level_a_muteti_sebfertozes_megelozesere.pdf
Letter on Methodology of the Chief Medical Officer of Hungary on the prevention of pneumonia related to mechanical ventilation (NNK 2019) Source: https://www.antsz.hu/data/cms90553/A_gepi_lelegeztetessel_osszefuggo_pneumonia_megelozesere.pdf
Letter on Methodology of the Chief Medical Officer of Hungary on the prevention of urinary tract infections associated with urinary catheters (NNK 2019) Source: https://www.antsz.hu/data/cms89838/Modszertani_level_a_holyagkateterrel_osszefuggo_hugyuti_fertozes_megelozesere.pdf
Letter of Methodology of the Chief Medical Officer of Hungary on the prevention of blood stream infections associated with angiocatheters (NNK 2019) Source: https://www.antsz.hu/data/cms89792/Modszertani_level_az_erkateterrel_osszefuggo_veraramfertozesek_megelozesere.pdf
Letter of Methodology to enhance the prevention and surveillance of healthcare associated infections via institutional and individual risk assessment Source: https://www.antsz.hu/felso_menu/temaink/jarvany/modszertani_levelek/KJ_modszertani_levelek.html
Epinfo 2008; Volume 15, Issue 1: GUIDELINE FOR ISOLATION PRECAUTIONS: PREVENTING TRANSMISSION OF INFECTIOUS AGENTS IN HEALTHCARE SETTINGS – CDC GUIDELINE, USA, 2007. Source: http://oek.hu/oek.web?nid=1070&pid=1
Letter of Methodology by the National Public Health Center on evaluating the risk of Legionella infection in environments and institutions where such risk exists, as well as on interventions to mitigate this risk (NNK 2021) Source: https://www.nnk.gov.hu/attachments/article/950/Modszertani%20level_Legionella_2021.pdf
Letter of Methodology by the National Center for Epidemiology on hand hygiene practice in healthcare and nursing social services (OEK 2010) Source: www.oek.hu
Letter of Methodology by the National Public Health Center on evaluating the risk of Legionella infection in environments and institutions where such risk exists, as well as on interventions to mitigate this risk (NNK 2021) Source: https://www.nnk.gov.hu/attachments/article/950/Modszertani%20level_Legionella_2021.pdf
Tájékoztató a fertőtlenítésről. A járványügyi gyakorlatban és az egészségügyi szolgáltatásban alkalmazható fertőtlenítő eljárások kézikönyve (Information on disinfection. A Handbook of Disinfection Protocols Applicable in Epidemiology Practice and Healthcare) (OEK 2012) ISBN 978-963-89500-0-0

II.5. Legal background of infection control

Hungarian regulations on infection control are summarized in Table 7. .

Table 7. Hungarian legal background of infection control

Council Recommendation 2009/C 151/01 of 9 June 2009 on patient safety, including the prevention and control of healthcare associated infections http://ec.europa.eu/health/patient_safety/docs/council_2009_hu.pdf
Decree 20/2009. (VI. 18.) EüM of the Minister of Health on the prevention of healthcare associated infections and the professional minimum requirements and supervision of such activities http://net.jogtar.hu/jr/gen/hjegy_doc.cgi?docid=A0900020.EUM.
Decree 60/2003. (X. 20.) ESzCsM of the Minister of Health, Social and Family Affairs on the minimum professional requirements necessary for the provision of healthcare services
Decree 1/2014. (I. 16.) EMMI of the Minster of Human Resources on the procedure of reporting communicable diseases
Decree 18/1998. (VI. 3.) NM of the Minister of Public Welfare on epidemiology measures required for the prevention of communicable diseases and epidemics

II.6. Management and economical aspects of infection control

Based on data from a point prevalence study carried out in several European countries, Table 7 summarizes the economical and social burdens of healthcare associated infections per 450 million inhabitants.

Table 8. Economical and social burdens of healthcare associated infections

Healthcare associated infections • 4.5 million infections per year • 37,000 deaths per year
Infections caused by MRPs • 400,000 infections per year • 25,000 deaths per year
Healthcare associated infections • Approx. 16 million extra days of care per year • Approx. EUR 7 billion extra hospital costs per year
Infections caused by MRPs • Approx. 2.5 million extra days of care per year • Approx. EUR 1 billion extra hospital costs per year • Absence from work approx. EUR 600 million per year

Source: ECDC, 2008 [16]

II.7. Evidence supporting the efficacy of infection control

Project SENIC was a milestone study confirming the efficacy of up-to-date infection control measures. This study evaluated the adherence to the US Center for Disease Control (CDC) recommendations and the results of these measures all over the United States. The study was based on the analysis of 500 medical charts selected randomly in 1970 and in 1975-1976. The key message of the study was that complete adherence to the measures recommended by CDC could have possibly prevented 32% of hospital infections, however the infection control programs established in 1976 were only able to prevent 6% of infections. The program helped identify those measures which were critical in terms of effective infection control. Surveillance-based or control-based strategies turned out to be effective in different types of infections. One important finding of SENIC was that in hospitals where no infection control program had been implemented, the prevalence of hospital infections increased by 3% annually between 1976 and 1979 [3].

II.8. Study results confirming the cost-effectiveness of infection control

International papers published during the past two decades also demonstrate that CDI is associated with an extremely significant disease burden. Ghantoji et al. carried out a systematic literature search, identifying 13 relevant publications from different countries. According to their results, non-US-based studies showed an estimated incremental cost of $5243 to $8570 per case for primary CDI. It should be noted that neither of the papers discussed indirect costs [17].

According to McGlone et al., the median cost of a case ranged from $9179 to $11,456 from the hospital perspective, $8932 to $11,679 from the third-party payer perspective, and $13,310 to $16,464 from the societal perspective. Most of the costs incurred were due to primary CD infection [18]. According to the systematic literature review by Wiegand et al., incremental cost of CDI ranged between £4577 (in Ireland) and £8843 (in Germany), after standardization to 2010 prices. An additional significant finding of the authors is a high 30-day CDI-related mortality (ranging from 2.8% to 29.8%) in different countries. According to Craig et al., no publications are available on the cost-efficiency of therapies against CD [19].

According to our systematic literature search covering the period until April 2012, a high methodological quality Canadian study investigated the cost-efficiency of vancomycin treatment versus metronidazole in serious CD infection, but no other health economy analyses are available [20].

Results of project SENIC suggest that the cost-efficiency of infection control measures should be one of the drivers for spreading the use of effective infection control practices. Calculating with the 1985 price level, the annual cost of the CDC recommendations is 60,000 USD per 250 beds, which amounts to a total of 243 million USD for all hospital beds in the USA. For the same period, the estimated cost of hospital infections was 4 billion USD (at the 1985 price level). Accordingly, the costs of implementing an infection control program are covered by a 6% reduction in the incidence of hospital infections, while an effectiveness over 6% yields net savings. In the homogeneous patient group based reimbursement system of the USA, every hospital infection means net losses. Infection control is the only effective measure to reduce these infections [21, 22].

Table 9. Costs incurred by multidrug-resistant A. baumannii infection, USA

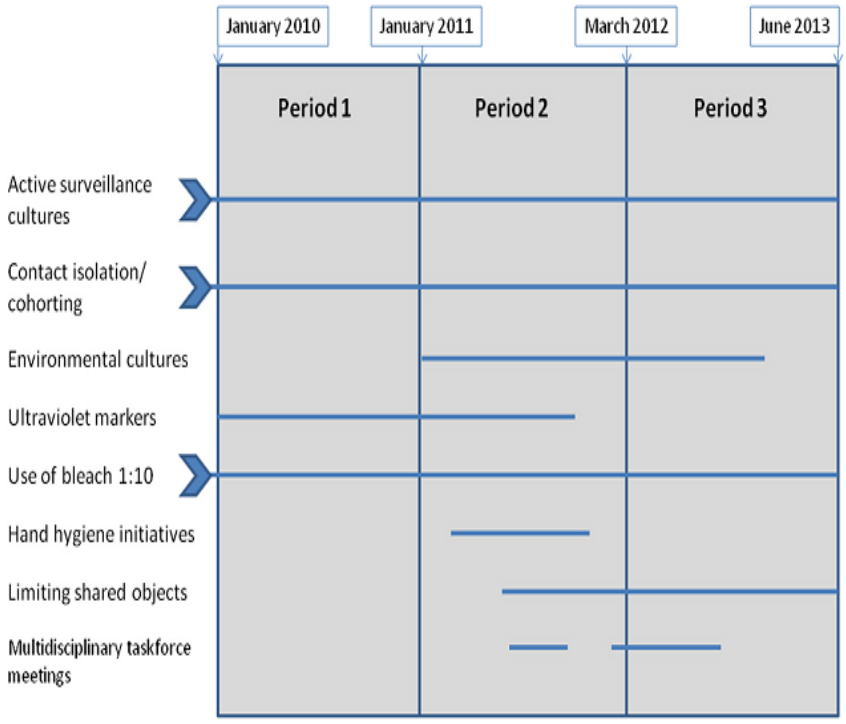
	Study design	**Study population**	**Average cost (USD)**
Lautenbach et al. (2009)	Multicentre, retrospective cohort (2001-2006)	386 patients with infection or colonization	334.00
Lee et al. (2007)	Single centre, retrospective case-control (1996-2001)	92 nosocomial blood stream infections	9,349.00

Recommendations on the prevention of multidrug-resistant Acinetobacter baumannii infections, which imposes the greatest patient safety hazard in intensive care, were devised by Munoz-Price et al. published in 2010. (Guide to the Elimination of Multidrug-resistant *Acinetobacter baumannii* Transmission in Healthcare Settings (Association for Professionals in Infection Control and Epidemiology, APIC 2010))

The professional guideline recommended the application of the following rules: active surveillance, contact isolation/cohort, environmental microbiology testing, use of fluorescent staining, disinfection of surfaces, improved hand hygiene, reducing common tools to a minimum, multidisciplinary consultations.

Figure 10 presents the measures implemented in a tertiary hospital intensive care unit in three phases, between 2010 and 2013 [23].

Figure 10. Measures implemented in a tertiary hospital intensive care unit in three phases, between 2010 and 2013



Source: Munoz-Price, 2014 [23]

Table 10 presents the results of the implemented measures.

Table 10. Success rate of infection control measures, USA

	Total in-hospital		CAICU		Trauma-ICU	
	cases	/10,000 care days	cases	/10,000 care days	cases	/10,000 care days
Phase I	198	5.13	46	67.15	54	55.9
Phase II	168	4.25	10	9.5	81	89.65
Phase III	72	1.93	18	17.4	14	14.71

The statistical difference between phases I and III is significant ($p<0.001$)
Source: Munoz-Price, 2014 [23]

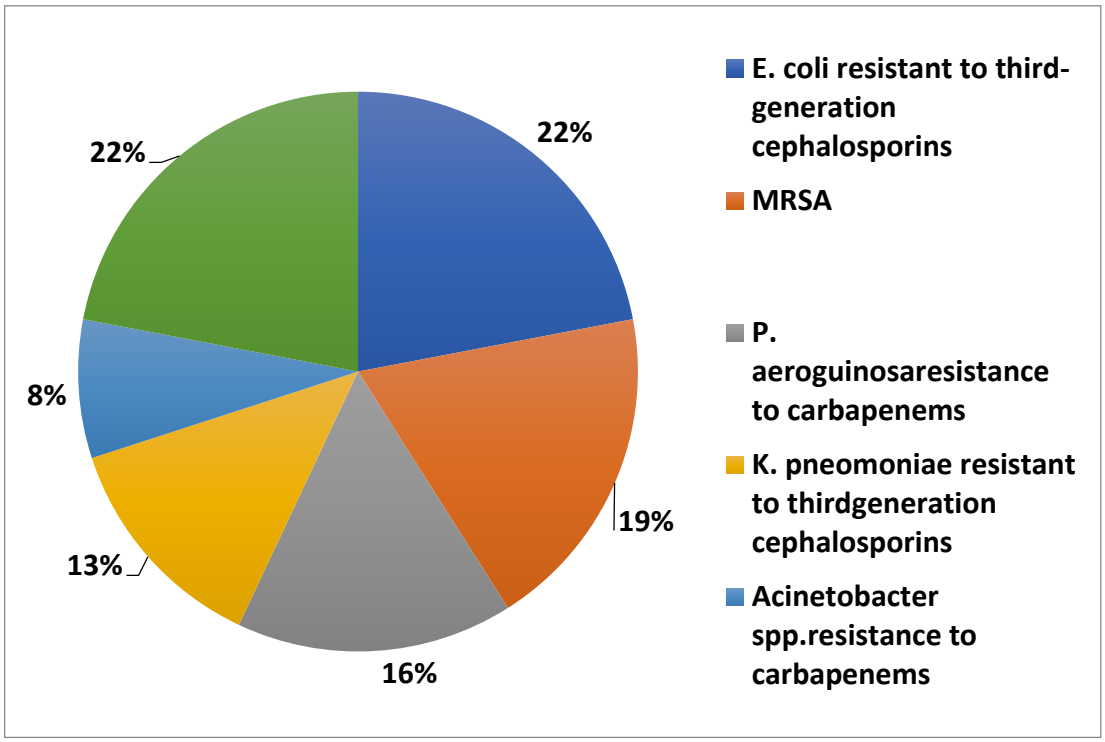
Cassini et al. estimated the burden of five types of infections caused by antibiotic-resistant bacteria of high public health concern (8 bacterial species, 16 antibiotic resistance–bacterium combinations) in countries of the EU and European Economic Area (EEA) in 2015, measured in number of cases, attributable mortality, and disability-adjusted life-years (DALYs). One DALY may be considered as the loss of one "healthy" year of life [24].

The paper estimated the burden of five types of infections caused by antibiotic-resistant bacteria of high public health concern (8 bacterial species, 16 antibiotic resistance–bacterium combinations) in countries of the EU and European Economic Area (EEA) in 2015, measured in number of cases, attributable mortality, and disability-adjusted life-years (DALYs). The proportion of disease burden due to each multidrug-resistant pathogen is shown on Figure 11 in the form of DALY per 100,000 population.

Among the European population, the disease burden caused by antibiotic-resistant bacteria matches that of influenza, tuberculosis and HIV/AIDS combined. The disease burden caused by all of the 16 investigated antibiotic-resistant bacteria increased between 2007 and 2015.

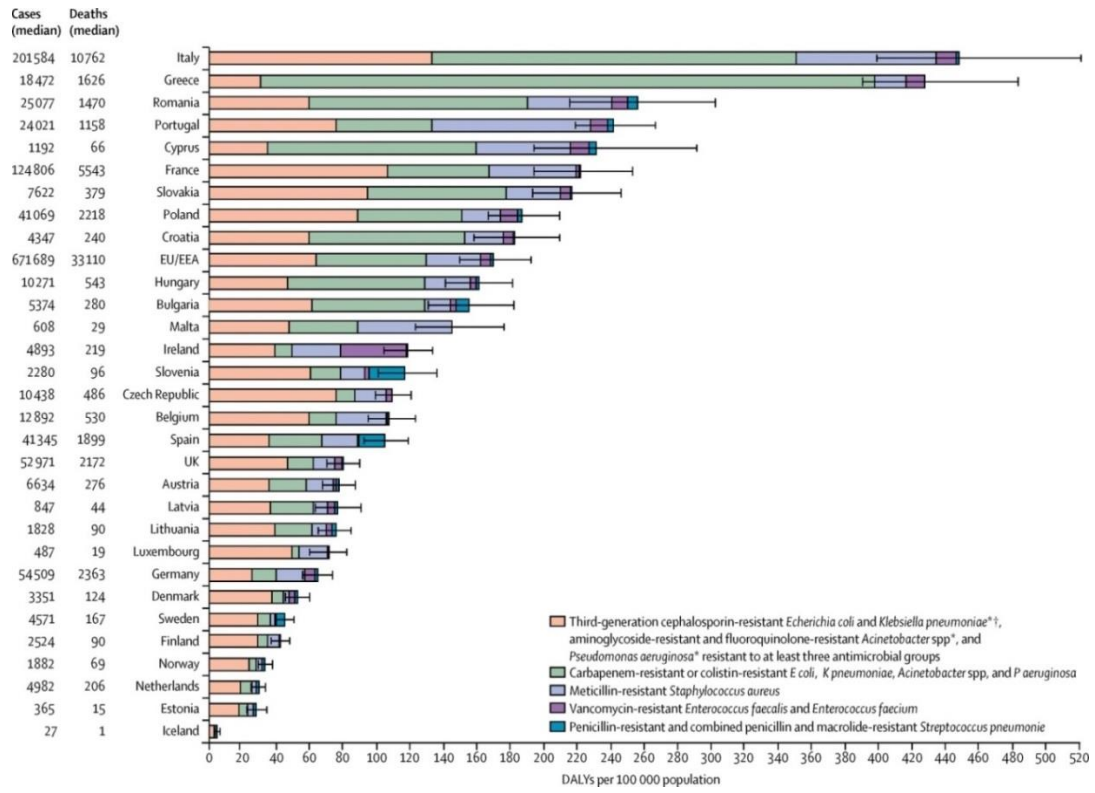
Healthcare associated infections amount to 75% of the European disease burden caused by antibiotic-resistant bacteria. This is a significant problem, which can be reduced in healthcare institutions by appropriate infection control measures and by applying a prudent antibiotic prescription practice.

Figure 11. Proportion of disease burden due to alarming multidrug-resistant pathogens expressed as DALY / 100,000 population



Source: Cassini, 2019 [24]

Figure 12. Estimated public health significance of certain antibiotic-resistant bacterial strains in the EU and in the member states of the European Economic Area (2015, DALY/100,000 population)



Source: Cassini, 2019 [24]

According to the opinion of the WHO Guideline Development Group, in summary, the positive impact and even the cost-effectiveness of infection control interventions can be assumed confidently, while the cost of interventions might still be high. The statement on cost-effectiveness is supported by the 2016 paper by Arefian et al. [25].

Literature search resulted in a Hungarian cost-effectiveness study: According to the cost-effectiveness study by Knausz et al. carried out at Petz Aladár County Training Hospital, Győr, and published in 2010, prevention of multidrug-resistant Staphylococcus aureus (MRSA) infections is cost-effective: at the intensive care unit (ICU), an extra cost of HUF 17.3 million occurred versus prevention (screening) costs amounting to HUF 144,000, while the same figures at the internal medicine department are HUF 933,000 of cost increase versus HUF 60,000 [26-28].

II.9. Hungarian practices and improvement goals of infection control

According to certain international analyses, comprehensive infection control programs allow prevention of 30% to 50% of healthcare associated infections. (1)

Healthcare associated infections are the most common adverse events occurring during patient care, which impose a serious hazard on patient safety. (2)

During patient care, several risk factors should be considered which might contribute to the onset and the high rate of adverse events, and to the increase of avoidable costs, thus significantly impairing the effectiveness and efficacy of care.

In the current situation, the following challenges were identified beyond the factors considered for analysis during the creation of the new reimbursement model:

the performance-based reimbursement system was introduced in 1993 and a general revision of fees has been overdue since 2000; current reimbursement parameters do not reflect the costs of infection control activities that meet the required standards;

since 2000, the proportion of multidrug-resistant pathogens has increased significantly, therefore healthcare associated infections are an ever-increasing problem and burden both in terms of the patients' life expectancy, as well as for service providers and the society. This is an especially prominent issue all over the world, which is associated with a continuous increase in care demands and costs;

in 2009, personnel and material minimum requirements of infection control underwent a significant change: according to instruction 32/1980 EüM of the Minister of Health, which used to be in force before 2009, hospital hygiene departments operated with a staff of 2 to 3 employees, their activity was centred around the quarterly hygienic revision, there was no active surveillance at the institutions, and according to data from the NCE, in 2004, 24% of hospitals did not undertake any infection control activities as we define it now (5); implementing an appropriate level of infection control requires the necessary number of trained experts, who are not available yet at all levels of care;

There are no nation-wide data on the magnitude of applying isolation protective regulations (it is not identical with the number of reported infections, it is highly

impacted by the willingness to take samples and the existence of an appropriate laboratory background, local surveillance activities etc.); national recommendations which serve as the basis for reimbursement calculations are issued in the spring of 2019, their use in healthcare practice is not generally adopted yet [29].

III. MY OWN RESEARCH IN THE FIELD OF INFECTION CONTROL

Hereinafter I report five significant research projects carried out in the field of IC:

1. Implementation and efficiency of IC in a Perinatal Intensive Care Center
2. Learning model of acquiring appropriate hand hygiene techniques
3. Disease burden and costs of Clostridium difficile infections
4. Meeting the professional minimum requirements of IC in domestic healthcare institutions
5. Institutional costs associated with the IC of multidrug-resistant pathogens

These research projects evaluate the clinical evidence of the efficacy of IC (1) and challenges of implementing IC (2) in practice, while funding requirements of implementing IC at an institutional level and the related costs are also assessed (3, 4, 5).

In addition to scientific results, each of these projects intended to promote the implementation of IC programs in Hungary. IC is one of the major areas of healthcare institution quality management. Its successful implementation and operation requires a complex management attitude [30-32]. The WHO has issued a guidance document for the implementation of international IC programs, summarizing the most important practical actions to be taken. Table 11 presents the association between the research carried out and the major steps of institutional IPC development. The essence of the WHO multimodal IC strategy is that the development of key IPC elements (professional contents), like personnel training, back testing of results, communicating goals and feedback etc., should be harmonised and carried out concomitantly, in a parallel manner. One of its central elements is emphasizing the effectiveness and cost-efficiency of IC [33]. Accordingly, the individual projects show several overlaps with the main steps of IPC institutional implementation.

Since the studies were carried out in different fields with different methodology, each topic is presented in a separate subsection for ease of understanding. These subsections detail Background, Objectives, Methods, Results, Discussion and Conclusions.

After presenting the studies (subsection Discussion and conclusions), I summarize the main results of the five research projects and discuss their practical importance and relevance in public policies.

Table 11. Relationship between the research projects and the steps of implementing institutional infection control programs in practice

		Research 1	**Research 2**	**Research 3**	**Research 4**	**Research 5**
		Implementation and efficiency of IC in a perinatal intensive care centre	Learning model of acquiring appropriate hand hygiene techniques	Disease burden and costs of Clostridium difficile infections in Hungary	Meeting the minimum requirements of IC in domestic healthcare institutions	Institutional costs of standard and spreading-based protective regulations against multidrug-resistant pathogens, according to international recommendations
WHO practical guidance on the implementation of institutional IC programs	1. IC program, provision of personnel requirements for ICP			+	+	
	2. Setting up IC professional guidelines	+		+	+	+
	3. Personnel education and training	+	+			+
	4. HAI surveillance program	+		+	+	+
	5. Multimodal strategies: change management and culture change	+	+	+	+	+
	6. Monitoring, IC audit and feedback	+	+		+	+
	7. Human resource requirements, providing personnel requirements			+		
	8. Providing site and material requirements			+		+

III.1. Implementing and measuring the effectiveness of surveillance protocol NEO-KISS at the Military Hospital – State Health Centre, Department of Obstetrics and Gynaecology, Perinatal Intensive Care Center

The next section is based on the following original publication: *Kopcsóné Németh Irén, Bodrogi Eszter, Fekete Mónika, Nádor Csaba: Az infekciókontroll eredményességének mérése: Újszerű surveillance a PIC-ben. Gyermekgyógyászat 2014; 65(4):283-289. [34]*

III.1.1. Background

In 2009, a complex project was launched to reorganize the operation of the MH EK Department of Obstetrics and Gynaecology, Perinatal Intensive Care Centre (PIC), aiming to transform care in a family-friendly manner, as well as to reduce nosocomial infections [35]. Requirements on hand hygiene, device use and surface disinfection were determined by infection control measures at the department, concentrating on points which are critical in terms of the transmission of infections (the WHO's 5 moments with an additional preventive item 0) before entering the patient zone, then 1) before touching a patient, 2) before aseptic treatment, 3) after body fluid exposure/risk, 4) after touching a patient, 5) after touching patient surroundings). An up-to-date protocol on the use of antibiotics has been implemented, furthermore internal auditors were trained to educate personnel on infection control requirements, to measure compliance with the regulations and to develop them further [36-40]. The MH EK meets all professional minimum requirements of IC, an appropriate number of experienced epidemiology specialist nurses is available in terms of bed number, and an in-house microbiology laboratory is operated. Local protocols on surveillance-based interventions and isolation regulations were introduced in 2011.

III.1.2. Objectives

The research aimed at measuring the effectiveness of the IC program implemented at the MH EK PIC centre, using active surveillance.

III.1.3. Methods

In Hungary, standardized methodology of infection control event follow-up is set forth by the NNSS launched by the National Centre of Epidemiology in 2004. The NNSS defines the frameworks of a standardized national database, which allows comparison between data from the participating hospitals, thus allowing their use as reference in following up nosocomial infections.

At the time of the research, the NNSS PIC surveillance case definitions and composition of the collected data were hard to apply for PIC. Domestic reference data on PIC centres in terms of care quality indicators are incomplete. Therefore, our research utilized the NEO-KISS surveillance protocol, developed in Germany specifically for PIC departments [41]. NEO-KISS is methodologically different from the NNSS PIC module: it is patient-based, monitoring pre-term infants born with less than 1500 grams in 3 groups (<499 grams, 500–999 grams, 1000–1499 grams), follow-up only lasts until reaching 1800 grams in case of hospital stay, which is defined as a minimum of 72 hours (shorter periods are not registered by the surveillance), the applied case definitions and the collected device uses are specific to pre-term infants [42]. Depending on weight category, 150 to 250 PIC department provide data for the NEO-KISS about 1,300 to 21,000 cases, therefore 5-year cumulative reference data, which are updated annually, are sufficiently valid and reliable [41]. A detailed description of the NEO-KISS protocol is provided in Appendix VIII.1.

Patient data were collected at the MH EK Department of Obstetrics and Gynaecology, PIC ward. Every year, 230 to 280 pre-term infants or ill newborns are treated at this 12-bed PIC ward. Almost 30% of the treated patients (80 cases annually) are pre-term infants with less than 1500 grams birth weight belonging to the group at high risk of nosocomial infections, most of whom are born in the institute. Data collection was performed over 6 months between October 2012 and March 2013.

III.1.4. Results

In the three weight groups, the individual infection categories and interventions were compared with the NEO-KISS data recorded in 2008-2012. The NEO-KISS data

present the incidence of cases in proportion to the total case number, while also providing the frequencies corresponding to the 25th/50th/75th percentile of the incidences measured at each centre.

Table 12. Surveillance data from the Military Hospital – State Health Centre PIC ward in comparison with the NEO-KISS database

A. Birth weight: <499 g Reporting PIC: 157 (MH EK) Total patient number: 1313 (1) Total days of care: 70,410 (101) Average days of care: 53.63

	Number of infections	**25%**	**Median**	**75%**	**MH EK**
Total number of severe infections	682	2.33	7.97	14.29	9.9
Pneumonia	102	0.00	0.00	2.15	0.0
Blood stream infection	580	0.00	6.07	12.30	9.9
Necrotising enterocolitis	83	0.00	0.00	1.72	0.0
	Days of device use	**25%**	**Median**	**75%**	**MH EK**
Central venous cannula	28658	30.84	40.79	53.01	3.96
Peripheral venous cannula	13526	9.43	16.57	29.46	15.84
Intubation	24350	25.00	36.88	52.55	2.97
Ventilation (CPAP)	29953	22.47	36.61	49.10	51.48
Antibiotics	30762	33.94	44.21	57.63	11.88

B. Birth weight: 500–999 g Reporting PIC: 221 (MH EK) Total patient number: 13,220 (19) Total days of care: 644,982 (546) Average days of care: 48.79

	Number of infections	**25%**	**Median**	**75%**	**MH EK**
Total number of severe infections	4112	2.29	4.86	7.52	5.49
Pneumonia	495	0.00	0.25	0.89	0.0
Blood stream infection	3617	1.60	4.25	6.75	5.49
Necrotising enterocolitis	640	0.00	0.70	1.34	0.00
	Days of device use	**25%**	**Median**	**75%**	**MH EK**
Central venous cannula	204134	19.08	29.94	39.12	10.26
Peripheral venous cannula	131731	12.23	18.93	27.05	28.94
Intubation	130771	11.63	18.94	24.77	9.16
Ventilation (CPAP)	278005	25.92	37.62	48.55	52.02
Antibiotics	209811	24.19	31.07	38.92	19.60

C. Birth weight: 1000–1499 g Reporting PIC: 234 (MH EK) Total patient number: 20,716 (20) Total days of care: 565,980 (481) Average days of care: 27.32

	Number of infections	**25%**	**Median**	**75%**	**MH EK**
Total number of severe infections	1891	1.50	2.57	4.41	2.07
Pneumonia	100	0.00	0.00	0.00	0.0
Blood stream infection	1791	1.33	2.52	4.18	2.07
Necrotising enterocolitis	259	0.00	0.06	0.68	0.0
	Days of device use	**25%**	**Median**	**75%**	**MH EK**
Central venous cannula	103972	7.90	17.29	25.90	0.00
Peripheral venous cannula	160022	21.20	29.40	36.22	23.70
Intubation	33151	3.36	4.75	7.43	0.42
Ventilation (CPAP)	132130	3.36	4.75	7.43	39.29
Antibiotics	124534	15.68	21.20	28.30	10.19

III.1.5. Discussion and conclusions

The 6-month pilot use of the NEO-KISS system revealed that the protocol is well usable in the Hungarian care system, data can be collected and recorded in a simple and easy-to-process manner. In the two evaluable groups, our infection rates were between the 25% and 75% quartiles, which indicates that the frequency of serious nosocomial infections at the PIC is similar to the German figures, which are not exceeded. Differences observed in terms of device use (much less central venous catheters (CVC), peripheral venous catheters (PVC), intubations and antibiotics, but significantly more non-invasive respiratory pressure therapy (Continuous Positive Airway Pressure, CPAP)) are well indicative of our care giving characteristics, and, in an indirect manner, indicate that our strategy modified meticulously as mentioned in the introduction allows us to achieve infection rates similar to the German figures.

Our research demonstrated that instead of the missing national reference data, published NEO-KISS reference data enable the quantification of the care and infection control practice of each PICs with a high probability, which might contribute to the improvement of care by its objective markers.

III.2. Learning model of acquiring appropriate hand hygiene techniques

The following section is based on the following oral presentation: *Irén A. Kopcsóné Németh, I. and T. Szabó, Optimization of hand rub volume assisted by automated visual feedback – coverage versus volume, in Second CEE Conference on Hospital Hygiene and Patient Safety. 2017, Semmelweis Foundation: Budapest.[43]*

III.2.1. Background

MH EK PIC infection control surveillance program included a regular training of the department staff on the appropriate hand hygiene technique. Despite appropriate hand hygiene is one of the most prominent methods of preventing hospital infections, an observation of PIC personnel showed that they seldom followed the 6-step hand disinfection protocol by the patient's bed as recommended by the WHO, therefore certain parts of the hand, which impose a significant risk in terms of transmitting infections by touch, were not disinfected in a proper manner [44]. Previous research demonstrated that appropriate hand hygiene practice becomes a habit by regular

training, the correct technique should be repeated even up to 5 to 32 times. PIC personnel, resident doctors and consultants underwent regular training on hand hygiene, organised 2 or 3 times per week, with each session lasting for 45 minutes within the MH EK. Hand hygiene trainings required a significant portion of the PIC employees' time on duty, therefore one might wonder which methods could be used to speed up the learning curve of the appropriate hand hygiene habits. Semmelweis Scanner (HandInScan Zrt.), a device providing visual feedback on the appropriate use of hand disinfectant (and thus on the condition of the hands in terms of hygiene) was installed at the department, which allowed for an objective method of confirming the effectiveness of the hand disinfection practice employed by the workers [45]. In addition to answering scientific questions, the research helped the department personnel to practice and learn the appropriate hand disinfection technique.

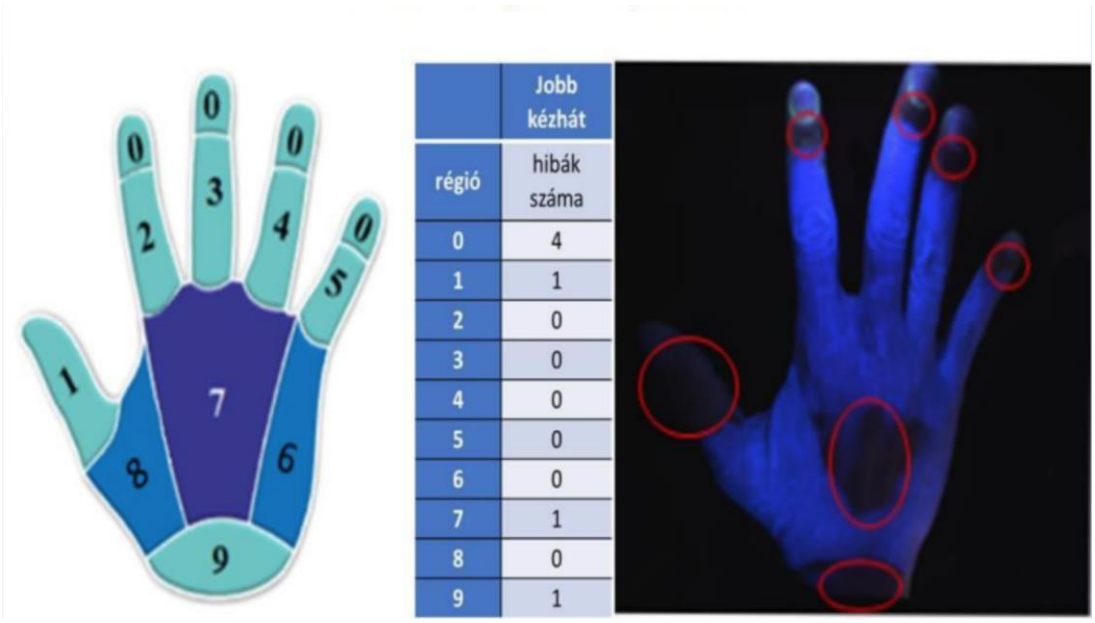
III.2.2. Objectives

Investigating the speed of learning the hand disinfection movements which lead to a perfect result after applying 1.5 mL or 3 mL disinfectant (used at the MH EK PIC department on each occasion on average).

III.2.3. Methods

In 2016, 39 employees of the MHEK PIC department took part in this 8-week research. Each employee received a radio frequency identification (RFID) chip, which allowed their identification while maintaining their anonymity. After an introductory training, hand hygiene technique of the employees was reviewed before the end of each shift, following an RFID identification. Research participants washed their hands according to the WHO 6-step protocol, using ultraviolet (UV) labelled antibacterial hand disinfectant dispensed in 1.5 mL doses. Afterwards, the device made an image of both sides of the hands (Figure 13.), providing immediate visual feedback on the distribution of the hand disinfectant. The device stored this image in its memory, along with the unique identifier. During the first three weeks, 1.5 mL disinfectant was allowed to be used on each occasion, which was afterwards increased to 3 mL [46]. The amount of disinfectant used for hand disinfection was also recorded along with the images.

Figure 13. UV image taken on the result of hand disinfection and touch zones identified on the hand surface



régió	Jobb kézhát hibák száma
0	4
1	1
2	0
3	0
4	0
5	0
6	0
7	1
8	0
9	1

Effectiveness of hand disinfection was assessed using a Markov learning model. According to the learning model, two statuses may occur after hand disinfection: appropriate or inappropriate. Appropriate condition is defined as a 95% coverage of the hands with disinfectant. The system allows four transitions between the two statuses (e.g. from inappropriate to appropriate etc.), and according to the model, system status (the learning process) is characterised only by its current condition and transition, previous conditions do not affect its behaviour. Successful learning outcome was defined as two subsequent occasions of appropriate hand disinfection. Statistical calculations were made using R version 3.11 (The R Foundation for Statistical Computing, Vienna, Austria) and MATLAB version 2015a (The MathWorks Inc., Natick, MA USA), as well as Stata version 14.2 (StataCorp. 2015. *Stata Statistical Software: Release 14*. College Station, TX: StataCorp LP.). Significance level was $p<0.05$, confidence intervals were calculated using the Wilson's method.

III.2.4. Results

Demography characteristics of the employees enrolled in the research are summarized in Table 13.

Table 13. Demography characteristics of the participants of the hand hygiene training experiment

Classification		Physician	Other healthcare worker
Gender	Male	3	0
	Female	7	29
Dominant hand	Left	1	3
	Right	9	26
Age	<25 years	0	2
	26-35 years	4	0
	36-45 years	4	12
	46-55 years	2	14
	>56 years	0	1
Total		**10**	**29**

The rate of achieving a successful learning outcome among workers over the subsequent measurements is presented in Figure 14. . When 3 mL of disinfectant was used, practically all participants managed to learn the appropriate hand disinfection technique. The incidence of disinfection errors on the touch zones of the hand are illustrated by Figure 15. . Neither the age of the participants (p=0.25) nor the hand size (p=0.90) had an impact on training success. During the course of the study, the consumption of hand disinfectant per patient day increased by 157%. Although no correlation could be demonstrated between the incidence of hospital infections and consumption of hand disinfectant per patient day, the number of events per care giving day showed a significant decrease during the study and the preceding year (2015/2016), as well as during the subsequent years (2017/2018) (Table 14.).

Figure 14. Rate of successful learning outcomes during subsequent measurements when 1.5 mL and 3 mL of disinfectant was used

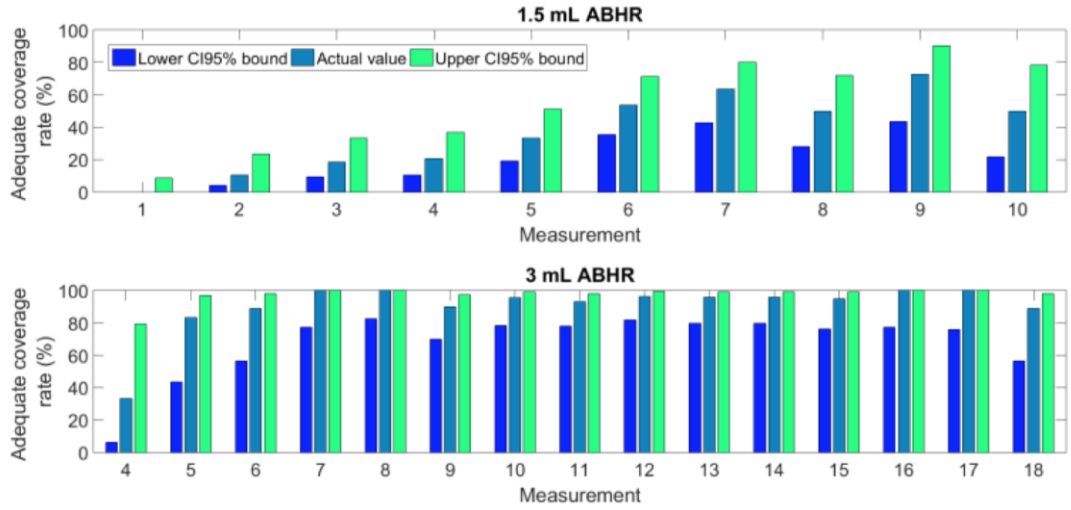


Figure 15. Disinfection errors affecting specific touch zones of the hand when 1.5 mL and 3 mL of disinfectant was used

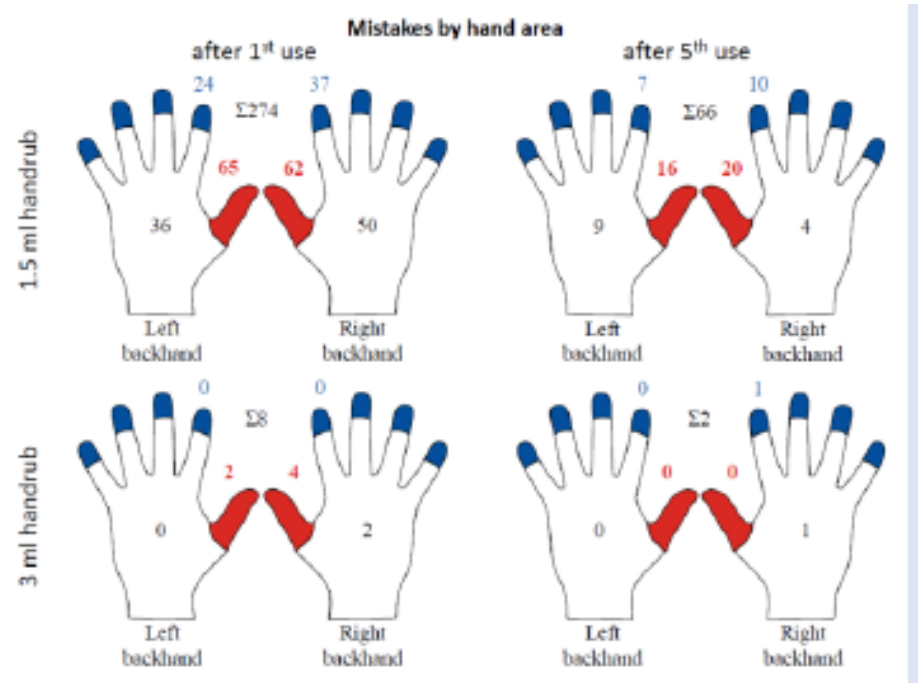


Table 14. Hand disinfectant consumption and the occurrence of infection control events in proportion to patient days

			Patient number (cases/patient day)				
Year	hand disinfectant consumption (L)	patient days	hand disinfectant consumption / 1000 patient days	microbiological surveillance	hospital infection	reported hospital infection	bloodstream infection bound to hospital infection
2015	591	3853.3	153.4	69	9	12	8
2016	530	2203.5	240.5	43	11	19	13
2017	620	4764.0	130.1	32	15	12	5
2018	698	6524.5	106.1	59	5	5	1
2015-16	1121	6056.8	185.1	112	20	31	21
2017-18	1318	11,288.5	116.8	91	20	17	6
Incidence rate ratio				0.36	0.54	0.29	0.15
One-sided binomial exact *p*				<0.001	0.026	<0.001	<0.001

III.2.5. Discussion and conclusions

Previous research confirmed that applying 1–3 mL of disinfectant is insufficient to provide appropriate hand hygiene. For individuals with large hands, some studies demonstrated an appropriate microbiological result when 6 mL of disinfectant was used [47].

The study results showed that with sufficient repetitions, 3 mL disinfectant is enough to achieve appropriate hand hygiene, regardless of hand size [48]. During the study year, average daily disinfectant consumption increased by 57% versus the previous year. When the study started, 1 L of hand disinfectant cost approx. HUF 807, accordingly the estimated annual cost increase is HUF 304,800 when projected to the average 4336 patient days during the four years investigated. Assuming that hand hygiene training also had a significant part in reducing the incidence rate of hospital infections in the period after the study, the above cost increase seems to be negligible when compared to the hazard reduction achievable with appropriate infection control training. A limitation of the study is the absence of control group measurements, therefore the effect of other factors which might have had an impact on study results could not be investigated. Further limitation is that the cost efficiency of infection control training could not be exactly calculated due to missing data.

In summary, our research confirmed that while the use of 1.5 mL disinfectant allowed about half of the participants to learn the technique of perfect hand disinfection, the use of 3 mL made it available for practically all of the healthcare workers [48-50]. The visual feedback accelerated the learning process, and the costs related to the increased disinfectant consumption seem to be negligible when compared to the expected reduction in hospital infections secondary to the appropriate hand hygiene practice.

III.3. Disease burden and costs of Clostridium difficile infections in Hungary

The following section is based on the following publication: *Kopcsóné Németh Irén, Kertész Adrienne, Strbák Bálint, Gulácsi László: A Clostridium difficile fertőzések költsége magyarországi kórházakban. Egészségügyi Gazdasági Szemle 2013; 51(2):9-16. [27]*

III.3.1. Background

CDI is an infection occurring as a complication of antibiotic use (and, as such, hospital antibiotic treatment) with symptoms ranging from mild diarrhoea to serious conditions associated with a significant risk of mortality. According to data from 2011, its incidence is 8.81/10,000 patients released from hospital and 12.1/100,000 days of care [51]. Considering international data, the real number of cases might be significantly higher than the 1803 cases reported in 2011, possibly amounting up to 7000 cases per year [9, 52]. International studies report that CDI is associated with a high cost burden and disease burden, however, there were no Hungarian data available on the incremental costs of institutional CDI.

III.3.2. Objectives

The study aimed to analyse the incremental hospital cost burdens of CDI, with specific regard to severe cases recurring several times.

III.3.3. Methods

A retrospective study was performed for 2011, involving two hospitals in Budapest. The study reviewed hospital files of adult (aged 18+ years) CDI patients who were

admitted because of CDI or had their CDI confirmed during their hospital stay. Retrospectively, 151 patients were enrolled from study initiation.

Incremental costs were estimated as follows: costs related to patient isolation were calculated as per the institutional quality system procedures, separately for the ICU and for the internal medicine departments. Costs for both the standard and the CDI-related special isolation protocol were calculated based on the current costs of the required interventions and the materials used, from the institution's perspective. In case of missing data, the extent of interventions and their demand of materials were assessed by an expert's review (e.g., hand disinfection; protective equipment: use of gloves, gowns, masks; environmental measures: disinfection of critical surfaces, daily cleaning for disinfection, disinfection when care has ended; other activities: diaper requirement, bed disinfection, washing the patient). In addition to isolation costs, the costs of the applied medicines and the investigations performed were also calculated according to the current social security reimbursement rules. Incremental costs were calculated by the difference in the daily costs of mean time in isolation, standard isolation and CDI-warranted contact isolation. Patient demographics, the conditions when they contracted the disease, as well as their hospital treatment outcomes were also recorded during the study.

III.3.4. Results

Records from 151 CDI patients were investigated in total. 58.3% of patients were women, the average age was 71.4 (SD=15.20) years and the average body weight was 68.9 (SD=16.23) kg. On average, patients were admitted because of CDI on 1.4 occasions (SD=0.70). 105 patients (69.54%) were admitted once, 36 patients (23.84%) were admitted twice, while 7 patients (4.64%), 2 patients (1.32%) and 1 patients (0.66%) were admitted three, four and five times, respectively. Upon 1st admission, 62 patients (41%), 62 patients (41%), 18 patients (12%) and 9 patients (6%) were admitted in mild, moderate, severe and life-threatening condition, respectively, out of the 151 patients. Severity distribution was similar in patients who underwent repeated admissions. Among those who were first admitted in mild condition (62 patients), 5 patients (8.1%) died, while the same was 13 patients (21%), 3 patients (16.7%) and 8 patients (88.9%) among those admitted in moderate (62 patients), severe (18 patients) and life-threatening condition (9 patients),

respectively. From the 151 patients with CD infection, 92 patients (60.93%) were discharged as cured and 30 patients (19.87%) with remaining symptoms, while 29 patients (19.20%) died. 14 deaths (48.30%) could be related with CD infection.

Based on the questionnaire, the total number of days spent in isolation was 17.56 days (SD=13.36 days) for 2011. An average episode was 12.57 days long (SD=8.31), one CDI patient was admitted to hospital 1.4 times on average. However, 10 out of the 151 patients underwent hospital admission three or more times. The 151 investigated patients had 211 admissions in 2011, meaning 221 isolations because certain patients were isolated at several departments during one admission. Table 15.
,

Table 16. and Table 17. present the hospital treatment costs of a single hospital episode of a generic CDI patient, hospital treatment of a generic patient calculated with multiple admissions and the hospital treatment of a recurrent patient with three or more repeated admissions at internal medicine, intensive care and surgery departments.

Table 15. Average (incremental) costs of an average hospital episode of a CD-infected patient for 2011

Source of costs	**CDI incremental costs at a department with internal medicine profile (gross HUF)**	**CDI incremental costs at an intensive care unit (gross HUF)**	**CDI incremental costs at a department of surgery (gross HUF)**
Nurse time[a]	5943	11,886	8915
Hygiene costs[a]	66,478	89,098	77,788
Cost of medicines	42,464	42,464	42,464
Laboratory costs	12,673	12,673	12,673
Total	**127,558**	**156,121**	**141,840**

[a]Difference between standard and CDI contact isolation

Table 16. Average (incremental) costs of the hospital stay of a CD-infected patient with several admissions for 2011

Source of costs	CDI incremental costs at a department with internal medicine profile (gross HUF)	CDI incremental costs at an intensive care unit (gross HUF)	CDI incremental costs at a department of surgery (gross HUF)
Nurse time*	8304	16,607	12,455
Hygiene costs*	92,901	124,509	108,705
Cost of medicines	59,449	59,449	59,449
Laboratory costs	17,750	17,750	17,750
Total	**178,404**	**218,315**	**198,360**

* Difference between standard and CDI contact isolation

Table 17. Average (incremental) costs of the hospital stay of a CD-infected patient admitted three or more times, for 2011

Source of costs	CDI incremental costs at a department with internal medicine profile (gross HUF)	CDI incremental costs at an intensive care unit, gross HUF	CDI incremental costs at a surgery ward, gross HUF
Nurse time*	21,560	43,119	32,340
Hygiene costs*	241,668	347,723	294,696
Cost of medicines	88,076	88,076	88,076
Laboratory costs	28,128	28,128	28,128
Total	**379,432**	**507,046**	**443,240**

* Difference between standard and CDI contact isolation

III.3.5. Discussion and conclusions

In 2011, one CDI case increased the cost of care by HUF 100,000 to 200,000 on average. CDI incremental costs per institution may be estimated as HUF 130,000 to 150,000 / CDI-related hospital admission. In case of third-time or any subsequent CD infections, costs are HUF 400,000 to 500,000 /patient/year. Costs are strongly dependent on the time required for care and the number minutes required by care of patients with CD infection. Care of CD-infected patients require significant nurse time capacities, which is a significant factor since hospitals already face labour shortage.

The most important limitations of our study is that the survey was made with a small case number, involving two hospitals in total. Data were collected retrospectively, the number of interventions and the time required were based on experts' estimates. Only the nurse time costs were estimated during cost calculation, while the physician's time cost had not been quantified. We did not measure the costs of

leaving empty beds besides the patients due to CDI isolation, which is likely to be a significant factor of cost. Our research did not cover the patients' quality of life burden either, therefore the available information are insufficient to carry out CDI-related cost-effectiveness analyses.

III.4. Investigation on meeting the minimum requirements of infection control in domestic healthcare institutions

III.4.1. Background

Personnel and material minimum requirements of infection control in Hungary are regulated by Decree 20/2009. (VI. 18.) EüM of the Minister of Health on the prevention of healthcare associated infections and the professional minimum requirements and supervision of such activities. In addition to outlining the structures to be deployed at the national level, the decree defines the expected professional minimum requirements at the institutional level based on the size of healthcare providers and the type of departments operated by the providers. In terms of personnel requirements the decree defines the minimum warranted number and qualification of managers responsible for infection control management, epidemiology and infectology associates, public health/epidemiology supervisors and epidemiology specialist nurses, as well as the minimum material requirements of infection control, depending on the size of the specific healthcare providers and the profile of the departments operated. For more than 15 years the National Public Health Center and its predecessor institutions have been collecting annual data on the compliance of Hungarian in-patient care institutions with personnel and material minimum requirements, along with data (microbiology testing carried out, hospital infections) on the hospital epidemiology activities of the institutions.

III.4.2. Objectives

To investigate the relationship between meeting the infection control minimum requirements and the size of the institution, as well as with the incidence of hospital infections.

Hypothesis 1 (H_1)

We hypothesise that the incidence of hospital infections is lower in institutions where the minimum requirements of infection control are met. In institutions where there is a change in terms of compliance with the minimum requirements of infection control, the incidence of hospital infections changes the opposite way (i.e., where minimum requirements are met, the number of hospital infections is reduced).

Hypothesis (H2)

Since meeting the minimum requirements of infection control are costly, we hypothesise that the savings obtained by a reduced case number will balance out the costs of meeting the minimum criteria in institutions with a higher patient turnover. Therefore, we hypothesise that institutions with a higher patient turnover are more likely to meet the minimum requirements.

III.4.3. Methods

Data collection

In the course of our research we have analysed the Year 2017 and Year 2018 hospital-epidemiology reports of 103 Hungarian institutions submitted in compliance with Decree 20/2009. (VI. 18.) EüM. Personnel requirements of hospitals with over 400 beds are shown in Table 18, while the minimum requirements for high-progressivity institutions with over 400 beds and special hospital departments (perinatal intensive care centre progressivity level II or III, intensive care unit progressivity level II or III, department of surgery progressivity level III) are presented in Table 19.

Table 18. Personnel minimum requirements of infection control at inpatient institutions with over 400 beds

Minimum requirements for the healthcare provider	Job	Qualification or specialist training required for the job
Personnel requirements: Manager:	1 hospital epidemiologist in full-time	specialist in public health/epidemiology, specialist in preventive medicine and public health, other specialist who has earned professional advanced training in hospital hygiene and infection control
Associate	1 hospital epidemiologist (full-time if bed number exceeds 800)	specialist in public health/epidemiology; specialist in preventive medicine and public health; professional expertise in infection control obtained in specialist inpatient care of at least 5 years: expert with university degree in medicine or other health sciences, - public health/epidemiological inspector, - public health/epidemiology supervisor, - public health inspector, - public health expert with degree earned in public health supervisor studies, - public health expert with degree earned in epidemiology studies
	1 infectologist	infectology specialist; specialist in infectious diseases
	1 public health/epidemiological inspector or public health/epidemiology supervisor	public health/epidemiological inspector; public health/epidemiology supervisor, - public health inspector, public health expert with degree earned in public health supervisor studies, public health expert with degree earned in epidemiology studies,
	at least 2 specialist nurses in epidemiology, with 1 more after every 300 additional beds	specialist nurse in clinical epidemiology, specialist nurse in epidemiology, qualified nurse

Source: Decree 20/2009. (VI. 18.) EüM

Table 19. Personnel minimum requirements for infection control in high-progressivity inpatient institutions with over 400 beds and specialist departments

Minimum requirements for the healthcare provider	Job	Qualification or specialist training required for the job
Personnel requirements: Manager:	1 hospital epidemiologist in full-time	specialist in public health/epidemiology, specialist in preventive medicine and public health. other specialist who has earned professional advanced training in hospital hygiene and infection control
Associate	1 hospital epidemiologist (full-time if bed number exceeds 800)	specialist in public health/epidemiology, specialist in preventive medicine and public health. other specialist who has earned professional advanced training in hospital hygiene and infection control
	1 infectologist	infectology specialist specialist in infectious diseases,
	1 public health/epidemiological inspector or public health/epidemiology supervisor (2 in case of universities)	public health/epidemiological inspector public health/epidemiology supervisor, public health inspector, public health expert with degree earned in public health supervisor studies, public health expert with degree earned in epidemiology studies,
	at least 2 specialist nurses in epidemiology, with 1 more after every 300 additional beds	specialist nurse in clinical epidemiology, specialist nurse in epidemiology, qualified nurse

Source: Decree 20/2009. (VI. 18.) EüM

Data

Data show the specific year, institution ID, as well as the category, patient turnover, infection control events and compliance with the personnel minimum requirements of the institution. Contents of each variable are detailed in Table 20.

Table 20. Compliance with the minimum criteria in domestic inpatient institutions: Data structure

Variable	Category
Year	2017 2018
Hospital	Hospital ID 1-103
Hospital category	1 Rural active hospital, <400 beds 2 Rural active hospital, >400 beds 3 Municipal chronic hospital 4 County hospital 5 County-level hospital in Budapest 6 Regional rural hospital 7 Regional hospital in Budapest 8 University clinic 9 Regional rural chronic hospital 10 Regional chronic hospital in Budapest 11 National institute (paediatric) 12 National institute (adults)
Average bed number	In 2017–2018
Number of patients	Annual patient turnover
Number of days of care	Annual patient turnover
Microbiology tests	Total / year
Blood cultures	Total / year
Clostridium difficile (CD) infection	Total cases / year
Multiresistant staphylococcus aureus (MRSA) infection	Colonised cases / year Symptomatic cases / year
Vancomycin-resistant enterococcus (VRE) infection	Colonised cases / year Symptomatic cases / year
Gram+ infection	Colonised cases / year Symptomatic cases / year
Multidrug-resistant pathogen (MRP) infection	Total symptomatic cases / year
Number of beds	1<400 beds 2>400 beds 3 Highlighted institutions
Epidemiologist physicians	Full-time personnel Part-time personnel
Supervisors	Full-time personnel Part-time personnel
Specialist nurse in epidemiology	Full-time personnel Part-time personnel
Infectologist	Full-time personnel Part-time personnel
Meets minimum criteria	1 Meets all criteria 2 Meets the number of physicians 3 Meets the number of supervisors 4 Meets the number of epidemiologists 5 Meets the number of infectologists

Patient turnover data, infection control events and their rate of occurrence, as well as compliance with the institutional minimum criteria are analysed using descriptive methods.

Statistical analysis

The effect of meeting the minimum requirements for infection control on the frequency of hospital infections is investigated using panel data regression method (Poisson random effects model), while analysing the correlations of meeting the infection control minimum requirements and the incidence density of events (first hypothesis, H_1). The dependent variable is the annual incidence density of hospital infections (case number / 10,000 days of care), the predictor variable is the change in the infection control minimum requirements (epidemiologist physicians, supervisors, specialist nurses, infectologists, all conditions, number of minimum criteria met), the parameter investigated in the hypothesis is the predictor variable coefficient (ΔMinimum requirement, β). The hypothesis is that $\beta_{\Delta\text{Minimum requirement}} < 0$, i.e., the frequency of infection control events is reduced once the minimum conditions are met.

Correlations between compliance with the minimum criteria and the institution category (second hypothesis, H_2) are also investigated using panel regression (logistic regression, random effects model, or random effect ordered logit model). The hypothesis is that larger institutions are more likely to comply with minimum requirements. The dependent variable is the binary variable indicating whether the minimum requirements are met (minimum requirement met/not met). The hypothesis is tested based on the coefficient representing the size of the institution (annual number of days of care, β). Hypothesis: $\beta_{\text{number of days of care}} > 0$.

III.4.4. Results

The annual number of days of care was 178,474 in the 103 institutions, with a standard deviation of 167,710. (Median 118,371, interquartile range: 72,455 – 213,413). Compliance with minimum requirements is presented in Figure 16. A slight increase was observed in terms of all personnel requirements between 2017 and 2018. However, the change was not unequivocally positive in all institutions. While some institutions demonstrated an improvement in compliance with the requirements (14 out of 103; 13.6%), others presented a decline (10 out of 103; 9.7%). One institution presented change in both ways, and there was no change in most of the institutions (78 out of 103; 75.7%) (Table 21).

Figure 16. Compliance with infection control minimum requirements in Hungarian inpatient institutions (2017/2018)

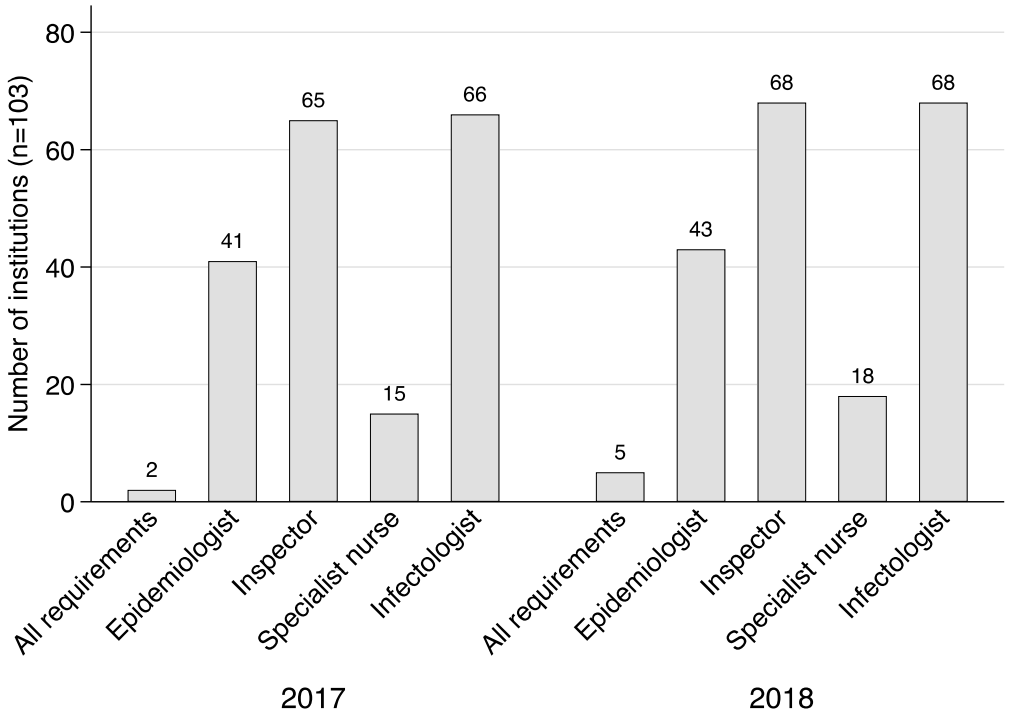


Table 21. Changes in compliance with minimum requirements, 2017 / 2018

Number of institutions	Epidemiologist	Epidemiological inspector	Specialist nurse	Infectologist
1 / 103	-	-		
1 / 103			-	-
2 / 103	-			
3 / 103		-		
2 / 103			-	
1 / 103				-
78 / 103				
1 / 103	+		-	
2 / 103				+
5 / 103			+	
2 / 103		+		
1 / 103		+	+	
2 / 103	+	+		
1 / 103	+	+		+
1 / 103	+	+	+	+

- Decline: the minimum requirement is no longer met in 2018 while it was met in 2017
+ Improvement: the minimum requirement is met in 2018 while it was not met in 2017
Empty cells: no change between 2017 and 2018.

Table 22 shows the number of institutions by the number of minimum requirements met. Out of the 103 institutions, none of the minimum requirements were met in 10 (9.7%) institutions in 2017 and in 9 institutions (8.7%) in 2018. All requirements were met in 2 institutions (1.9%) in 2017 and in 5 institutions (4.9%) in 2018.

Table 22. Number of institutions according to the number of minimum requirements met (2017/2018)

Number of minimum requirements met	Number of institutions 2017 (n=103)	Number of institutions 2018 (n=103)
0	10	9
1	30	30
2	34	30
3	27	29
4	2	5

Figure 17 shows the incidence density distribution of hospital infections at the 103 institutions per pathogen for the basis year 2017. All pathogens were characterised by a significantly right-tilted data distribution, and some institutions presented excessively high values. Regression study results are presented in tables (Table 23. Table 24. Table 25.). Coefficients describe relative frequencies for years 2018 and 2017.

Figure 17. Distribution in the incidence density of hospital infections in 103 domestic institutions (2017)

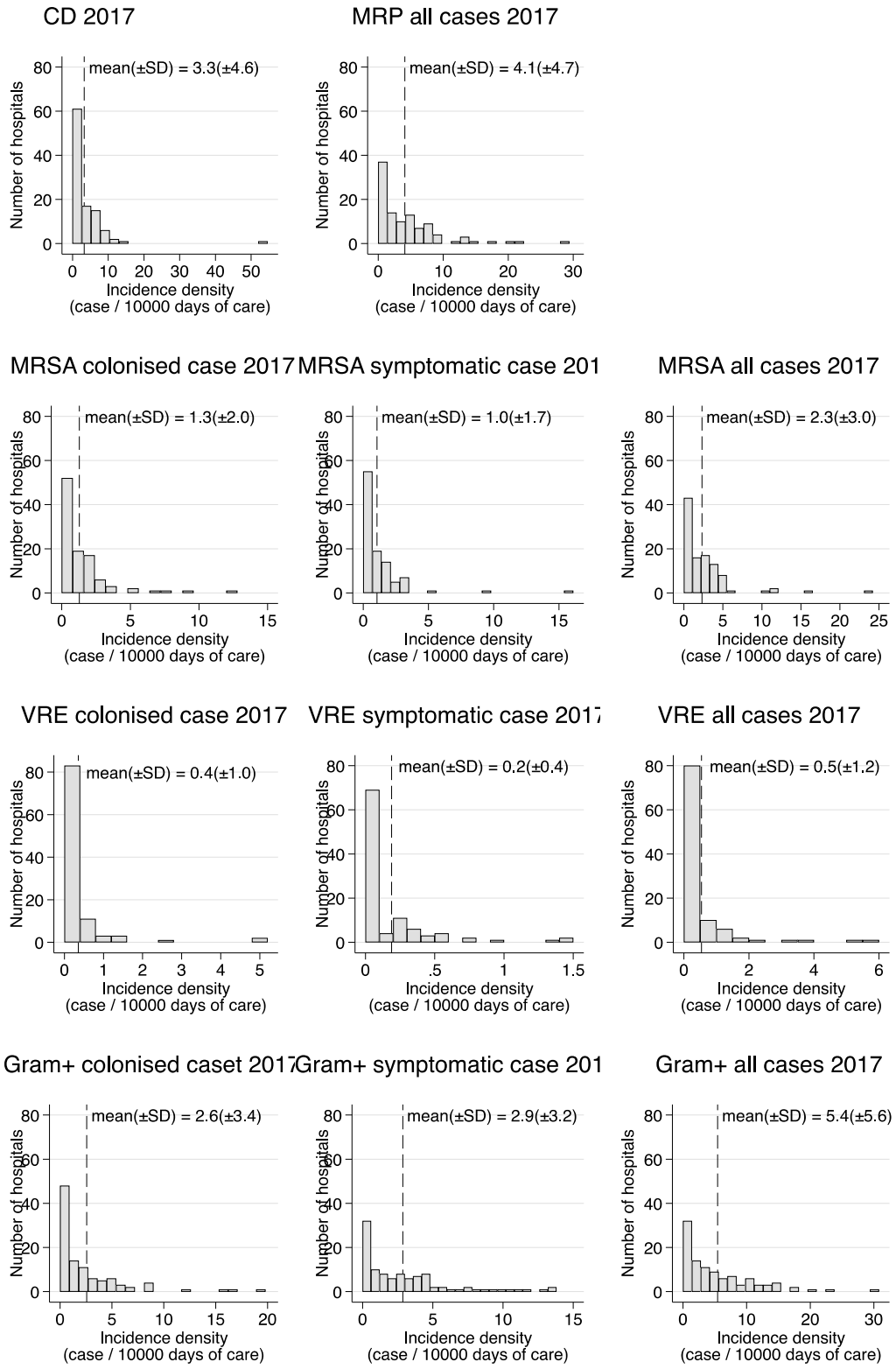


Table 23. Correlation between the compliance with certain minimum requirements and the incidence density of hospital infections (2017 / 2018)

	CD infection	MRSA colonization	MRSA symptomatic	MRSA total	VRE colonization	VRE symptomatic	VRE total	Gram+ colonization	Gram+ symptomatic	Gram+ total	MRP symptomatic
Epidemiologist	0.58**	0.55**	0.57*	0.53***	0.59	0.79	0.61	0.48***	0.62**	0.55***	0.60**
Inspector	1.01	0.88	0.94	0.83	2.84*	2.89*	2.72**	0.98	1.43	1.07	1.21
Nurse	0.87	1.04	0.68	0.85	1.2	1	1.2	1.11	0.86	0.95	0.76
Infectologist	0.77	1.90*	1.26	1.41	2.35*	2.28	2.25*	2.37***	1.35	1.65**	1.07

* p<0.05, ** p<0.01, ***p<0.001, relative frequencies (2018 vs. 2017)

Table 24. Correlation between the combined compliance with minimum requirements and the incidence density of hospital infections (2017 / 2018)

	CD infection	MRSA colonization	MRSA symptomatic	MRSA total	VRE colonization	VRE symptomatic	VRE total	Gram+ colonization	Gram+ symptomatic	Gram+ total	MRP symptomatic
All requirements met	0.34***	0.46	0.22*	0.28***	1.09	1.45	1.21	1.42	0.62	0.89	0.42**

* p<0.05, ** p<0.01, ***p<0.001, relative frequencies (2018 vs. 2017)

Table 25. Correlation between the number of minimum requirements met and the incidence density of hospital infections (2017 / 2018)

	CD infection	MRSA colonization	MRSA symptomatic	MRSA total	VRE colonization	VRE symptomatic	VRE total	Gram+ colonization	Gram+ symptomatic	Gram+ total	MRP symptomatic
Meeting +1 requirement	0.79***	0.95	0.83*	0.83*	1.45*	1.49*	1.42*	0.98	1	0.94	0.87*

* p<0.05, ** p<0.01, ***p<0.001, relative frequencies (2018 vs. 2017)

According to the Poisson regression results, employment of epidemiologist physicians according to the minimum requirement was the only personnel requirement which showed a significant correlation with the occurrence of infections. As anticipated, coefficients showed a reduction in the risk of infections for most types of pathogens investigated. When meeting additional minimum requirements, a reduction is expected in the incidence density of CD, MRSA and MRP infections. When all minimum requirements are met at the same time, incidence densities of CD infections, MRSA infections and MRP infections reduced to approximately a third, a quarter and two fifths, respectively.

Table 26 presents the coefficients of regression models investigating the correlation between the compliance with the minimum requirements and the size of the institution.

Table 26. Correlation between compliance with the minimum requirements and the size of the institution (2017/2018)

	At least one minimum requirement is met	**All minimum requirements are met**	**Quantified compliance with minimum requirements**
Model	Logistic regression	Logistic regression	Ordered logit
Annual days of care	1.000051*	0.999998	1.000003*
(Annual days of care)^2	1.000000*	1.000000	1.000000
N	206	206	206

* p<0.05, ** p<0.01, ***p<0.001, relative frequencies

As anticipated, coefficients showed a positive correlation with the annual number of days of care. Figures 18 and 19 present the estimated probabilities for different patient turnovers.

Figure 18. Probability of meeting at least one minimum requirement in relation to the days of care at 103 domestic institutions (2017–2018)

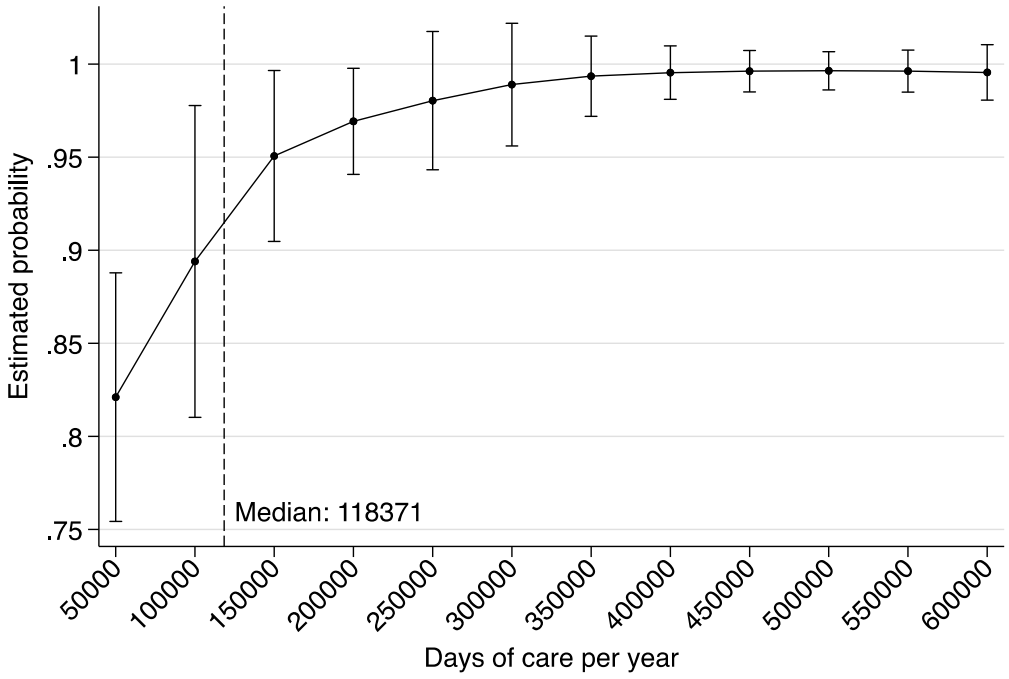
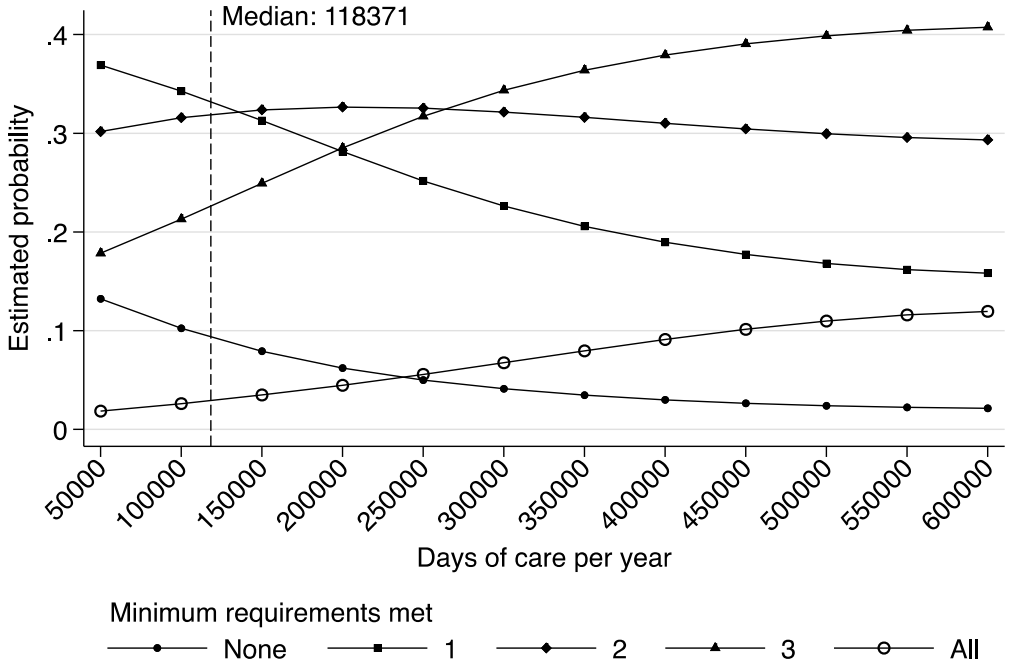


Figure 19. Minimum requirements met in relation to the days of care at 103 domestic institutions (2017)



III.4.5. Discussion and conclusions

Our results confirmed both hypotheses: (H_1) the incidence of hospital infections is lower in institutions where the minimum requirements of infection control are met. Meeting the requirement for hospital epidemiologist physician was correlated with a reduced incidence density of both CD, MRSA, Gram+ and symptomatic MRP infections. The more minimum requirements were met, the lower was the incidence density of CD, MRSA and MRP infections. The greatest decrease in infections was observed when all minimum requirements were met at the same time. Our results confirmed the second hypothesis (H_2) as well, i.e., the savings achieved by a reduced number of cases will balance out the costs associated with meeting the minimum requirements in institutions with a higher patient turnover, therefore these institutions are more likely to comply with the minimum requirements. Among the investigated domestic institutions, the probability that none of the minimum requirements was implemented was the highest in institutions with the lowest patient turnover, while the number of minimum requirements met increased with the size of the institution.

In 2018, however, all of the minimum requirements were met in only 5 out of the 103 institutions (4.8%), which is an alarmingly low rate.

Our results, in accordance with international and Hungarian studies, confirmed that infection control measures are effective tools in reducing hospital infections [2, 3, 30-32, 53, 54]. Several international studies demonstrated the cost-effectiveness of infection control measures [19, 21, 25, 55-57], which is consistent with the second hypothesis of our research, i.e. when cost-effectiveness is considered, larger institutions are more likely to meet minimum requirements. However, caution is required when interpreting the results of our research. Accurate knowledge of both the patient-level risk, as well as of the type and risk category of institution is especially important when interpreting hospital epidemiology data [30]. Furthermore, the development level of infection control activities affects the accuracy of the reported data and the number of discovered cases, therefore changes can only be followed up reliably if well-established surveillance systems are in place [30].

Further research questions rise due to the fact that only a small proportion of domestic inpatient institutions has met all minimum requirements of infection control. On the one hand, it should be investigated whether preventive and protective measures according to the international professional recommendations would prove cost-efficient from an institutional perspective in Hungary, or if their implementation is financially limited by current hospital reimbursement regulations. Additionally, research for creating an appropriate incentive system should assess which are the facilitating factors and limitations (within personal and institutional operations, as well as in the institutional structure) of implementing and efficiently operating infection control [58-60].

III.5. Institutional costs of standard and spreading-based protective regulations against multidrug-resistant pathogens, according to international recommendations

The following section is based on the following paper which has been accepted for publication: *Kopcsone Nemeth, I., M. Péntek, and Z. Zrubka, Costs of infection control and special challenges during COVID-19 pandemic: experiences in a*

military hospital. Academic and Applied Research in Military and Public Management Science, 2021. (accepted for publication) [61]

III.5.1. Background

The effectiveness of IC is supported by unequivocal scientific evidence. The resource demand and costs associated with the implementation of IC is a topic that has not been explored in detail in international literature. After reviewing the literature between 2000 and 2019, Nguemeleu et al. found seven papers which reported on an economical IC analysis [57]. Although the quality of these publications varied, overall, IC measures that follow the best practices lead to cost savings. In Canada, a cost-benefit calculation was made on a four-year regional IC program, which found that the program resulted in a 19% reduction in hospital infections with savings amounting to 9 million Canadian dollars [55]. A systematic literature review carried out by ECDC reviewed the health economic analyses of measures implemented to prevent hospital infections [62]. A total of 28 studies were identified, the majority of which were made in the USA. The authors concluded that European studies (e.g. United Kingdom, the Netherlands, Switzerland) do not provide a full-scale view on Europe. Differences between regions and countries (like the health status of the population, economical development status of the country, differences in health services) warrant analyses based on local data [63].

In Hungary, implementation of infection control activities into the NEAK reimbursement is being prepared. Our research is part of this process and has been carried out within the framework of and with financial support provided by the project EFOP 1.8.0-VEKOP-17-2017-00001 "Professional and Methodological Development of Healthcare System", sub-project D.V. "Changing the Organisational Culture, Patient Safety Culture Sub-project 4. Integration of infection Control activities into the NEAK reimbursement".

This research is intended to specify evidence-based IC funding requirements at an institutional-level and by appropriate methods. Within a pilot study, it assesses and evaluates the costs of the required practice at an institution where IC according to WHO guidelines has previously been implemented. Thereby it provides data for the clarification of estimated costs associated with the introduction of novel IC

methodologies and the personnel, material/device and financial resource requirements of the current institutional IC practices.

When selecting the institution, a key criterion was that the previous professional practices of the hospital management and the expert in charge of the hospital's infection control activities suggest that the implementation of national recommendations at the institutional level is expected to be as complete as possible, and practices are implemented at the required level. Building upon the results and experiences of the present pilot study we plan to extend it nationwide and to different types of institutions (primary, secondary, tertiary, specialised).

III.5.2. Objectives

The aim of the pilot research is to define the cost requirements of those procedures, proposed in methodology papers, which are part of the general operational costs of the hospital, and typically carried out at the bedside and as such cannot always be identified exactly based on the patient documentation.

Hypothesis

Different types of hospital departments and types of isolation require different resources for infection control, which necessitates a differentiated reimbursement system.

III.5.3. Methods

Data collection

Pilot study data collection took place during a one-week period between Monday, 30 March 2020 and Sunday, 5 April at the MHEK, involving the following departments:

a.) intensive care unit (ICU)

b) perinatal intensive care centre (PIC)

c) department of surgery

d) department of internal medicine

The survey was made for the NEAK in a manner attached to a care event of patients treated according to the authorisation defined in Decree 6/1998. (III. 11.) NM of the Minister for Public Welfare on the legal regulations governing the maintenance of

professional coding systems and reimbursement parameters applied in healthcare. Each patient who underwent in-patient care at the aforementioned departments was enrolled in the study, regardless of whether they were admitted before or during the 7-day study period or if they were discharged during or after the study.

IC activities

Microbiological screening (laboratory tests), as well as IC activities intended for the detection and treatment of hospital MRP and CD infections are regulated by professional guidelines. All patients admitted to the hospital are treated in accordance with the basic IC requirements. Our study sample was divided into four IC groups according to measures (general and transmission mode based) applied to prevent the transmission of the infection:

(1) standard care (also known as the usual isolation),

(2) contact isolation,

(3) isolation of droplet infection and

(4) mixed isolation (droplet infection and contact)

Standard care includes regular IC activities, including hand disinfection, use of personal protective equipment (gloves, gown, face mask, protective goggles) and disinfection of the frequently touched areas as per the guidelines. During contact isolation, these IC activities are performed more frequently and more extensively (e.g. surfaces are disinfected twice per day). In addition to these measures, the use of masks and protective gloves is always mandatory during isolation of a droplet infection. For mixed isolation a combination of these measures is applied.

Resource utilisation measurement and cost calculation

For the measurement and cost quantification of resources used in association with IC the so-called "bottom-up micro-costing" approach was applied [64]. This involves the recording of all items of point-of-care infection control activities (hand disinfection, isolation activities, disinfection activities) for all patients hospitalised in the specified organisational units within this one-week period of data collection. When selecting the items, one of the criteria was that they should be measurable. Events outside the point of care (e.g. operating room, lab) were not included in our

study (their costs will be estimated based on a protocol), just like pharmacological therapies.

The following items were recorded for each patient at the four departments, according to the applied IC protocol (standard, contact, droplets, mixed): aseptic hand washing, alcohol-based hand rub, examination gloves, sterile gloves, protective gown, waterproof protective gown, protective face mask, surgical mask, surface disinfection and tool disinfection, textile cleaning and final disinfection upon discharge of the patient. Furthermore, further substantial additional data on infection control were recorded for the total department time (up to 30 days) of the observed patients during the observation period:

The number of days in the study, as well as the type of isolation was recorded for each patient. Costs were estimated by the average inpatient hospitalization time of the MHEK ICU, PIC, Departments of Internal Medicine and Department of Surgery for the entire year of 2019 (pre-COVID).

Data

Standard and spreading-based isolation costs of infection control are estimated in this paper by the data provided by the MH EK departments, i.e. referring to the tertiary level care institution type. Scope of the available data is included in Table 27.

Costs were calculated from the institution's perspective. Unit costs were estimated by the weighed mean costs from the purchase prices and quantities reported by the institution. Average length and distribution of the care period were determined by the MH EK annual patient turnover data.

Table 27. Scope of data analysed in the pilot study

Variable	Category	Explanation
Department	1 Department of Internal medicine 2 ICU (Intensive Care Unit) 3 PIC (Perinatal Intensive Center) 4 Department of Surgery	Types of hospital departments that should be differentiated in terms of infection control
Patient		Unique patient ID
Hygienic hand washing	Occasions / study period Unit price: 5 ml liquid soap per occasion	With liquid soap
Alcohol-based rub	Occasions / study period Unit price: 5 ml alcohol-based disinfectant per occasion	With alcoholic disinfectant
Use of examination gloves	Occasions / study period Unit price: 1 pair of examination gloves per occasion	
Use of sterile gloves	Occasions / study period Unit price: 1 pair of sterile gloves per occasion	
Use of protective gown when contamination is expected	Occasions / study period Unit price: 1 protective gown per occasion	
Use of protective gown for contact isolation	Occasions / study period Unit price: 1 protective gown per occasion	
Use of face mask / mouth mask when aerosol splash is expected	Occasions / study period Unit price: 1 face mask per occasion	
Use of face mask / mouth mask when droplet infection is expected	Occasions / study period Unit price: 1 face mask per occasion	
Wiping the critical surface besides the patient's bed	Occasions / study period Unit price: 1 sterile wipe per occasion	
Wiping the critical surfaces on medical instruments	Occasions / study period Unit price: 1 sterile wipe per occasion	
Handling/cleaning bed and other linens	Occasions / study period Unit price: 1 sterile wipe per occasion	
Final disinfection	Occasions / study period Unit price: 1 final disinfection per occasion	
Number of days of care	Day	Total duration of hospital care, up to 30 days
Number of days spent in isolation	Day	Number of days spent in isolation out of the total hospital care
Number of study days	Day	Number of days spent in isolation during the study
Type of care	1 Standard 2 Contact 3 Droplet infection 4 Mixed (contact + droplet infection)	Type of isolation protocol applied depending on the type of the pathogen or the intervention.

Statistical analysis

The case numbers, equipment use, time spent in the study and characteristics of inpatient care are analysed with descriptive methods. Taking into consideration the small sample size included in the study and that, due to the one week observation period, complete observation data covering the entire length of the isolation periods were not available for all patients involved in the study, a Monte-Carlo simulation was used for cost analysis [65]. We use the following formula for the cost analysis of each department and type of care:

$$k_{io} = \left(\sum_{t=1}^{n} q_{iot} * d_t * p_t + z_o\right) * l_{io}$$

Where *k* is the complete cost per patient in Type *i* isolation in Department Type *o*, q_{iot} is the daily average frequency of use of Type *t=1, 2...n* cost item in the same location, d_t is the average amount of Type t cost item used on a single occasion, p_t is the unit price of Type t cost item, l_{io} is the average number of days spent in Type *i* isolation in Department *o* (which is equal to the average length of care in said Department of the patient receives standard care), and z_o is the average projected daily cost of final disinfection based on the average length of care in each Department.

In the simulated sample, the parameters *q, d, p* and *l* followed a gamma distribution based on the measured average and standard deviation of the sample, e.g. $q \sim \Gamma(\alpha,\beta)$, where $\alpha = \frac{\mu^2}{s^2}$ and $\beta = \frac{\mu}{s^2}$, μ is the daily average consumption of the given cost item and *s* is the standard deviation of the daily consumption of the cost item. Similarly, $p \sim \Gamma(\alpha,\beta)$, where $\alpha = \frac{\mu^2}{s^2}$ and $\beta = \frac{\mu}{s^2}$, μ is the average unit price of the given cost item, and *s* is the standard error of unit cost, and $l \sim \Gamma(\alpha,\beta)$, where $\alpha = \frac{\mu^2}{s^2}$ and $\beta = \frac{\mu}{s^2}$, μ is the average length of time spent in isolation, and *s* is the standard error of the isolation period. The gamma distribution ensures that both the amounts and the prices only assume positive values. Based on expert estimation a standard error corresponding to 10% of the average value was applied only to liquid soap and alcohol-based disinfectant among the average amounts used per occasion (d_t). Considering that unit prices (p_t) can demonstrate significant variations due to market processes and the institution-specific procurement policies, based on expert

estimation a standard error corresponding to 20% of the average value was applied to these parameters. To estimate the standard error of days spent in isolation (l_{io}), we used the overall patient turnover date of the institution and based our calculations on the average (μ_o), longest (max_o) and shortest (min_o) care periods and annual patient turnover (n_o) to devise the following formula based on the assumption that taking into consideration a yearly patient turnover volume of several thousands the observed range has a standard deviation of ±3.

$$s_o = \frac{max_o - min_o}{6 * \sqrt{n_o}}$$

The distribution of cost items was determined using a simulated sample of 100,000-100,000 subjects generated with the method of Cholesky decomposition that applied the correlation structure of the frequency of each intervention. For each department and isolation type we calculated the average costs and 95% confidence intervals (2.5-97.5 percentile range of simulated data) estimated from the simulated distribution. The comparison of the costs of each department and care types and thus the testing of Hypothesis 3 (H_3) was performed with a paired Welch's t-test based on the average and standard deviation of the simulated sample and the observed item number of subgroups in the sample.

III.5.4. Results

Over a 7-day observation period data from 84 patients were recorded (Internal Medicine: n=16; ICU: n=32, PIC: n=22, and Surgery: n=14). Standard care was provided to 64 patients (279 observation days) and 20 patients were in isolation for a total of 64 observation days (contact isolation: n=13, droplet infection: n=1; and mixed: n=6). Overall, 7, 7, 2 and 4 patients isolated in the Internal Medicine Department, ICU, PIC and Surgery Department, respectively, provided data for our study. The average observation period per patient was 4.4 (±2.2) days for standard care and 4.0 (±2.8) days for isolation. The parameters used for cost estimates are summarised in Table 28. The estimated costs are presented in Table 29.

Table 28. Parameters used for cost estimates

	Average daily use frequency (standard care)	SE[d] of daily use frequency (standard care)	Average daily use frequency (isolation)	Daily use frequency (isolation)	Unit cost (HUF)	SE of unit cost (HUF)	Average amount used on a single occasion	SE of amount used on a single occasion
Hygienic hand washing[a]	6.95	0.93	6.75	1.94	0.43	0.04	3 ml[e]	0.30
Alcohol-based hand rub[b]	20.64	1.22	26.12	2.98	1.72	0.17	3 ml	0.30
Use of examination gloves[c]	26.14	1.42	28.83	4.37	5.12	0.51	2 pcs[f]	-
Use of sterile gloves[c]	0.63	0.12	2.36	1.82	35.48	3.55	2 pcs	-
Protective gown (contamination)	1.33	0.22	4.03	1.36	143.82	14.38	1 pc	-
Protective gown (contact isolation)	0.61	0.20	8.77	1.55	143.82	14.38	1 pc	-
Full face mask (aerosol splash)	2.93	0.51	8.44	3.22	400.94	40.09	1 pc	-
Full face mask (droplet infection)	7.42	0.82	12.70	1.95	4.30	0.43	1 pc	-
Wiping down critical surfaces (bedside)	1.82	0.18	2.44	0.83	21.40	2.14	1 pc	-
Wiping down instruments	3.11	0.25	7.36	2.42	21.40	2.14	1 pc	-
Handling/cleaning bed and other linens	1.57	0.14	3.79	0.84	663.00	66.30	1 occ.[g]	0.10
Final disinfection (Internal Medicine, Surgery)	-	-	-	-	6800.00	680.00	1 occ.	-
Final disinfection (ICU, PIC)	-	-	-	-	19,800.00	1980.00	1 occ.	-

[a]Soap and water or other disinfecting detergent; [b]Alcohol-based liquid or solid gel preparation; [c]Single use; [d]SE: Standard error; [e]ml: millilitre, [f]pc: pieces, [g]occ.: occasion

Table 29. Parameters used for cost estimates

		Department of internal medicine	ICU	PIC	Department of surgery
Standard care	Daily average cost (HUF); average [95CI[a]]	3809 [3136 - 4596]	8589 [7190 - 10178]	4089 [3399 - 4882]	4539 [3818 - 5361]
	Care period (HUF); average [95CI]	9.1 [8.9 - 9.3]	3.6 [3.1 - 4.1]	19.3 [18.3 - 20.3]	4.6 [4.4 - 4.8]
	Total cost (HUF); average [95CI]	34,663 [28,529 - 41,819]	30,824 [26,159 - 35,920]	78,904 [65,354 - 94,615]	20,875 [17,538 - 24,677]
Isolation	Daily average cost (HUF); average [95CI]	9203 [5561 - 14,190]	11200 [7441 - 16,254]	9265 [5614 - 14,270]	9413 [5753 - 14,419]
	Care period (HUF); average [95CI]	11.4 [10.6 - 12.2]	7.8 [5.8 - 10.1]	30.6 [23.9 - 38.1]	8.5 [7.3 - 9.8]
	Total cost (HUF); average [95CI]	104,907 [63,023 - 162,334]	86,935 [55,120 - 132,809]	282,892 [163,214 - 453,760]	79,996 [47,998 - 124,730]
Isolation vs. standard care	Incremental cost / day (HUF); average [95CI]	5393 [5379 - 5407]	2612 [2597 - 2626]	5176 [5162 - 5190]	4875 [4861 - 4889]
	Incremental cost / patient (HUF); average [95CI]	61,488 [57,109 - 66,016]	20,363 [15,107 - 26,393]	158,216 [123,584 - 197,043]	41,452 [35,471 - 47,857]

[a]95CI: 95% confidence interval (2.5–97.5 percentiles of simulated distribution)

Tables 30-35 present the results of comparison of individual costs between different departments and the results of the comparison between standard care and isolation care costs in each department.

Table 30. Comparison of the daily average cost of standard care between different departments of the hospital

				Welch's t-test p value		
	Mean (HUF)	**Standard deviation (HUF)**	**Sample size**	**vs ICU**	**vs PIC**	**vs Surgery**
Department of internal medicine	3809	371	9	0.000	0.079	0.001
ICU	8589	766	25	-	0.000	0.000
PIC	4089	379	20	-	-	0.008
Department of surgery	4539	394	10	-	-	-

Table 31. Comparison of the average cost of standard care per patient between different departments of the hospital

				Welch's t-test p value		
	Mean (HUF)	**Standard deviation (HUF)**	**Sample size**	**vs ICU**	**vs PIC**	**vs Surgery**
Department of internal medicine	34,663	3388	9	0.009	0.000	0.000
ICU	30,824	2492	25	-	0.000	0.000
PIC	78,904	7464	20	-	-	0.000
Department of surgery	20,875	1826	10	-	_	-

Table 32. Comparison of the daily average cost of isolation care between different departments of the hospital

				Welch's t-test p value		
	Mean (HUF)	**Standard deviation (HUF)**	**Sample size**	**vs ICU**	**vs PIC**	**vs Surgery**

Department of internal medicine	9203	2222	7	0.035	0.945	0.839
ICU	11,200	2266	7	-	0.006	0.047
PIC	9265	2223	2	-	-	0.865
Department of surgery	9413	2228	4	-	-	-

Table 33. Comparison of the average cost of isolation care per patient between different departments of the hospital

				Welch's t-test *p* value		
	Mean (HUF)	**Standard deviation (HUF)**	**Sample size**	**vs ICU**	**vs PIC**	**vs Surgery**
Department of internal medicine	104,907	25,597	7	0.080	0.000	0.031
ICU	86,935	20,017	7	-	0.000	0.362
PIC	282,892	75,127	2	-	-	0.000
Department of surgery	79,996	19,740	4	-	-	-

Table 34. Comparison of the daily average cost of standard care and isolation care between different departments of the hospital

	Standard care			**Isolation**			**Welch's t-test**
	Mean (HUF)	Standard deviation (HUF)	Sample size	Mean (HUF)	Standard deviation (HUF)	Sample size	*p* value
Department of internal medicine	3809	371	9	9203	2222	7	0.001
ICU	8589	766	25	11,200	2266	7	0.022
PIC	4089	379	20	9265	2223	2	0.185
Department of surgery	4539	394	10	9413	2228	4	0.021

Table 35. Comparison of the daily average cost of standard care and isolation care between different departments of the hospital

	Standard care			Isolation			Welch's t-test
	Mean (HUF)	Standard deviation (HUF)	Sample size	Mean (HUF)	Standard deviation (HUF)	Sample size	*p* value
Department of internal medicine	34,663	3388	9	104,907	25,597	7	0.000
ICU	30,824	2492	25	86,935	20,017	7	0.000
PIC	78,904	7464	20	282,892	75,127	2	0.161
Department of surgery	20,875	1826	10	79,996	19,740	4	0.009

III.5.5. Discussion, conclusions

Our research has produced cost estimates of isolation care in different departments of the MH EK. Based on our results, depending on the type of department the daily cost of standard care was in the HUF 3,809-8,589 range while the daily cost of isolation care was in the range of HUF 9,203-11,200. Daily costs were highest in the ICU and lowest in the Department of Internal Medicine. The total cost was highest in the PIC due to the longest inpatient care and isolation (standard care: HUF 20,875-78,904, highest level of isolation: HUF 79,996-282,892). The incremental isolation cost per patient compared to standard care was in the range of HUF 20,363-158,216. Therefore, our results provide support for our hypothesis that the cost of IC control is significantly different depending on the type of hospital department.

The scientific literature includes only a few high quality publications discussing the costs of IC. According to a systematic literature review that included data published up to 2011, there was only a single publication that applied a micro-costing method beyond providing detailed descriptions of all the pertinent input data [66], therefore the present results are relevant at the international level. In particular, there is also a paucity of research studies performed in Hungary. Our research has produced an estimate of HUF 178,404 – 507,046 for the incremental cost of CDI (see Section III.3.).

The strength of our research is based on performing our survey in an institution with a well-functioning IC surveillance system. Therefore it is reasonable to presume that our results reflect the costs of good IC practice in terms of both guidelines and everyday practice and, consequently, they can be successfully used in other institutions to provide good estimates for the costs of introducing IC. However, when translating the results the structure of other institutions must be taken into account because overall institutional costs are highly dependent on cost differences between departments. There are limitations on our research including the relatively small patient sample included in the analysis. The simulation used for our analysis allowed more accurate estimates by combining care periods derived from a large patient sample and daily equipment use data derived from a small sample size; however, a statistical comparison of the results once again calls for further assumptions. In our study the subgroups were compared while taking into account the low sample sizes of the original sample, and since no significant results were detected even in the case of the PIC, we conclude that a large sample would be needed to produce more accurate data.

IV. DISCUSSION AND CONCLUSIONS

IV.1. Main findings of the research projects

1. Our research performed in the PIC of the MH EK has confirmed that the German NEO-KISS protocol can be efficiently used within the framework of the Hungarian national health care system, is able to measure the quality indicator and in particular the infection control indicators of pre-term care, and the prevalence of serious nosocomial infections is comparable to (does not exceed) the German data. Since national reference data are not available, the published NEO-KISS reference data can be used to very accurately assess the care and infection control practices of each PIC department and additionally serve as objective index data for the improvement of the quality of care.
2. Additionally, our experiments involving personnel in the PIC of the MH EK have confirmed that a combination of targeted educational tools and innovative technology (an instrument providing visual feedback) can successfully teach proper hand disinfection technique. The amount of disinfectant per occasion used by the research subjects had a significant effect on the results (3 mL was the threshold value where almost all personnel achieved successful hand disinfection), but the extra costs of disinfectant usage measured in parallel with the improvement of hand hygiene compliance seem insignificant when compared to the costs of the potential infections avoided.
3. We were the first to demonstrate that in Hungary (in 2011) a case of CDI has increased care costs by an average of HUF 100 to 200 thousand. The incremental cost of CDI is estimated to be in the range of HUF 130–150 thousand for each hospital admission due to CDI and this cost increases to HUF 400–500 thousand/patient/year in cases of multiple CDI episodes. The cost is greatly dependent on the duration of care and the time (measured in minutes per day) of direct care provided to the CDI patient.
4. As demonstrated by our overview analysis of the fulfilment of minimum IC requirements in Hungarian hospitals, institutions that fulfil minimum

requirements have lower prevalences of nosocomial infections. The greatest decrease in infections was observed when all minimum requirements were met at the same time. The number of fulfilled requirements increased with the size of the institution. In 2018, however, all of the minimum requirements were met in only 5 out of the 103 institutions (4.8%), which is a very low rate. In institutions with large patient turnover the savings achieved through the decrease in the number of events balance out the costs associated with meeting the minimum requirements.

5. We have demonstrated that the institutional implementation of IPC is accompanied by excess costs which can significantly vary according to department type – these costs are highest in the PIC and lowest in the Department of Internal Medicine.

IV.2. The practical significance and public policy relevance of our research results

Our research projects have provided significant proof for the clinical effectiveness of IC activities and for the feasibility of implementing institutional IC practice in a real-life practice environment in Hungary. Our results on the costs associated with CD infections and the implementation of IPC are especially important because there is a dearth of such data from both Hungary and the surrounding region. The results of our study provide essential input data for healthcare economy analyses based on local IC data and practice.

Infection control and related research studies are of particular importance to public policy and public financing, especially under the current situation. As is the case with other healthcare services, infection control is also subject to investigation of the areas covered by its related activities, the resulting public benefits and the particulars of the associated cost drivers. In general, research should also analyse the distributions of costs assumed by the individual, the insurer and the wider society.

Stiglitz took an unambiguous stance supporting the necessity and importance of state intervention in the area of healthcare. According to his position, the aim of healthcare policies (in addition to other activities) should be to devise a patient-oriented, efficient and sustainable financed healthcare system targeted to influencing health-

associated risk factors. Stiglitz believes that efforts must be made to utilize the available scarce resources to maximise societal benefits (such as the improvement of health status) [67]. Stiglitz discusses at length that the healthcare sector has numerous market failures necessitating governmental intervention, including among the most pertinent topics such as the meritorious nature of goods, the information asymmetry, the problem of public goods, externalities, and the limited competition in healthcare [67].

It must be emphasised that information asymmetry which is one of the central tenets of economics and microeconomics is an important factor in healthcare in general and especially important in infection control in particular. Information asymmetry means that healthcare providers, healthcare customers and financing entities have different up-to-date information available to them and consequently their knowledge and attitudes also assume these differences, and healthcare customers are forced to rely on the knowledge and decisions of physicians and other healthcare professionals [67].

The control of information asymmetry is in the interest of all participants of the healthcare sector as well as those of healthcare customers and there are efforts from both sides; however, these efforts to decrease information asymmetry are stymied by the lack of information about the existence of scientific proof and valid theoretical basis of the services and the benefits (in terms of quality and health gains) and economic implications of the implementations of procedures. This makes comparison (of cost, quality and efficacy) and benchmarking and ultimately effective governance and management difficult if not impossible. Stiglitz also emphasises the significance and practical difficulties of making comparisons in the healthcare sector (due to significantly different profiles of hospitals, different patient populations, geographical location and financing factors) [67].

He draws attention to the fact that since competition between service providers such as hospitals is rather limited is it unreasonable to expect that service providers with efficient, high quality care would gain competitive advantage over providers with lower quality or more expensive services. For example, many regions or municipalities are only served by a single healthcare provider, e.g. a single hospital [67]. Stiglitz writes: *"Imperfect information decreases the effective degree of competition". "By the same token, the heterogeneity of medical services makes price*

and quality comparisons difficult and thus inhibits the effective dissemination of information." [67]. *"The practices of the medical profession may compound the inevitable limitations of competition resulting from imperfect information."* [67]. *"The majority of hospitals [...] are no-for-profit institutions"* [67].

For this reason, in Hungary, similar to other countries, the provider and financing entities of healthcare services strive to measure quality and costs, and additionally, pay increasing attention to measure at the level of individual patients or patient groups the health gains patients derive from hospital care, because the financing entities increasingly turn from purchasing healthcare services to "purchasing" certain kinds of "results".

The results of the research projects presented in this thesis provide input for the multi-modal strategy of the implementation of IC in Hungary. The successful implementation of institutional IC programs requires a combination of operating effective surveillance systems, use of appropriate professional guidelines, training for personnel, ensuring personnel and financial requirements, continuous monitoring and feedback of the results, and finally, the continuous communication of the IC approach [33]. The results demonstrate that appropriate data collection and analysis are feasible under the conditions of Hungarian healthcare, and similarly to international experience, operating IC programs based on evidence promoting a decrease in the number of infections can be successfully ensured. At the same time, the dismantling of economic, personnel and organisational barriers shall require additional efforts. One of the important element in this respect is the comprehensive cost-effectiveness analysis of infection control, and the implementation of its results in Hungarian inpatient care facilities and the development of financing and incentive system matched to the characteristics of each institution.

V. SUMMARY

Healthcare associated infections and in particular, infections caused by multidrug-resistant pathogens are one of the major challenges of modern healthcare systems. Data from Hungary are less favourable compared to the European average, therefore antimicrobial resistance poses a particular public health problem.

The objective of infection control is the prevention of healthcare associated infections, a process that requires complex institutional quality and change management. The institution-level implementation of infection control consists of continuous data collection and monitoring, and supplying appropriate institutional and financial conditions.

In Hungary the volume of routine data collection supporting short and long term public health financing decisions is currently much less than would be required and both the quality and quantity of available data are inadequate.

This thesis examines the components of the multi-modal implementation strategy of institution-level infection control and in particular their economic aspects and therefore supplies research results that are unique not only in Hungary but in all of East-Central European region. Since data transferability in the area of infection control effectiveness and costs is greatly limited (cost and effectiveness data do not translate from one country to the next) and legal provisions also dictate the use of local data, locally collected research data are particularly important for making appropriate evidence-based health policy and financing decisions.

The results described here have highlighted that operation of surveillance systems that comply with international guidelines is feasible within the framework of Hungarian healthcare. While the implementation of good practices in line with international guidelines requires the provision of appropriate personnel and financial resources and training for personnel, the number of nosocomial infections can be decreased by implementing the institutional minimum requirements of infection control.

The results provide cost data that can serve as the basis for further health economic analyses of related to infection control. Appropriate public policy decisions require the knowledge of specific costs. From the standpoint of public policy, these research

data are suitable for developing transparent management and long term financing in this area.

Due to the varied characteristics of healthcare institutions we have measured different costs in different hospital departments. Financing decisions require performing analyses based on the individual characteristics of each department, which can potentially lead to optimal resource allocation and can promote the elimination of economic obstacles hindering the implementation of infection control and the implementation of an appropriate incentive system.

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VIII. APPENDIX

VIII.1. NEO-KISS Protocol

Case definitions

I. Primary bloodstream infections (secondary bloodstream infections are excluded) – Blood Stream Infection (BSI)

1. Clinical sepsis (infection without an identifiable pathogen)

All three of the following criteria are fulfilled:

a) Antibiotic therapy for at least 5 days
b) Blood culture was not performed or no pathogens were detected in blood culture
c) No apparent infection can be verified at another site

AND at least 2 criteria of the listed clinical signs:

a) Fever (>38 °C) or temperature instability or hypothermia (<36.5 °C)
b) Tachycardia (>200 /min) or new and/or worsening bradycardia (<80/min)
c) Recapillarisation time >2 s
d) New or worsening apnoea (>20 s)
e) Unexplained metabolic acidosis (BE <-10 mmol/L)
f) Emergence of new hyperglycaemia (>7.7 mmol/L)
g) Other signs of sepsis (skin colour, biochemical signs, increased oxygen requirement – intubation, unstable general condition, apathy)

2. Microbiologically verified bloodstream infection, not a coagulase negative Staphylococcus (CONS)

If a pathogen is detected in one or more blood cultures of CSF and the pathogen is not CONS

AND at least 2 criteria of the listed clinical signs and symptoms are present:

a) Fever (>38 °C) or temperature instability or hypothermia (<36.5 °C)
b) Tachycardia (>200 /min) or new and/or worsening bradycardia (<80/min)
c) Recapillarisation time >2 s
d) New or worsening apnoea (>20 s)
e) Unexplained metabolic acidosis (BE <-10 mmol/L)
f) Emergence of new hyperglycaemia (>7.7 mmol/L)
g) Other signs of sepsis (skin colour, biochemical signs, increased oxygen requirement – intubation, unstable general condition, apathy)

3. Microbiologically verified bloodstream infection caused solely by CONS

Presence of CONS is verified in at least 1 blood culture or IV device AND at least 1 of the following criteria

a) CRP >20 mg/L
b) Ratio of immature/total neutrophil granulocytes >0.2 (CBC shows left shift in excess of 20%)
c) Thrombocytopenia (<100,000/µL)
d) Leukocytopenia (<5000/µL)

AND at least 2 criteria of the listed clinical signs and symptoms are present:

a) Fever (>38 °C) or temperature instability or hypothermia (<36.5 °C)
b) Tachycardia (>200/min) or new and/or worsening bradycardia (<80/min)
c) Recapillarisation time >2 s
d) New or worsening apnoea (>20 s)
e) Unexplained metabolic acidosis (BE <-10 mmol/L)
f) Emergence of new hyperglycaemia (>7.7 mmol/L)
g) Other signs of sepsis (skin colour, biochemical signs, increased oxygen requirement – intubation, unstable general condition, apathy)

II. Pneumonia (PNEU)

At least one of the following radiological signs:

a) New or progressive infiltrate
b) Consolidation
c) Fluid in the interlobar fissures and/or the pleural space

AND worsening gas exchange or sudden oxygenation disorder

AND at least four of the following clinical signs and symptoms:

Temperature instability

a) New or worsening tachycardia (>200/min) or bradycardia (<80/min)
b) New or worsening tachypnoea (>60/min) or apnoea (> 20 s)
c) New or worsening dyspnoea (retractions, nasal flaring, moaning)
d) Increased volume of airway secretions and increased need for evacuation of airway secretions
e) Purulent discharge in trachea
f) Pathogen isolated from airway secretions
g) CRP >20 mg/L
h) Ratio of immature/total neutrophil granulocytes >0.2 (CBC shows left shift in excess of 20%)

III. Necrotizing enterocolitis (NEC)

A combination of clinical and radiological signs or a histological diagnosis (this is sufficient by itself) and one of the following criteria:

a) Pneumoperitoneum
b) Intramural bowel gas
c) Fixed loop (extended bowel loop filled with gas that appears in unchanged form in several consecutive X-rays)

AND two of the listed signs and symptoms are present and cannot be explained by anything else:

a) Vomiting
b) Abdominal bloating
c) Residue before feeding
d) Erythema on the lower abdomen
e) Repeated occult or visible blood in the faeces OR histologically confirmed NEC (this is sufficient by itself)

Specifications of interventions

CVC (central venous catheter)	Number of days when the CVC is inserted and remains in the patient for more than 12 hours. Umbilical catheters and flow-directed catheters are included
PVC (peripheral venous catheter)	Number of days when the PVC is inserted and remains in the patient for more than 12 hours. If CVC was also placed at the same time then these days are to be counted as CVC days and PVC days are not indicated in the log
Intubated status (endotracheal intubation)	Number of days when the patient spent more than 12 hours intubated and on ventilation
CPAP (Continuous Positive Airway Pressure)	Number of days when the patient spent more than 12 hours on CPAP. If the patient was also intubated, then the days are to be indicated under that category
Antibiotics	Number of days when the patient was administered parenteral antibiotic or systemic antibiotic via oral route Antimycotics, antiviral agents and locally administered antibiotics are excluded

VIII.2. Data sheet for point-of-care infection control interventions

<table>
<tr><td>Department code:</td><td colspan="2"></td><td>Department name:
Ward...../Bed.....</td><td>.../02/2020</td><td colspan="2">Shift number/Page number: ….. /…</td></tr>
<tr><td colspan="3">Patient name code:</td><td>Social Security Number:</td><td colspan="3">Registration number:</td></tr>
<tr><td colspan="7">Total score from individual risk assessment:</td></tr>
<tr><td>Type of care</td><td>☐ Standard</td><td>☐ Contact</td><td>☐ Droplet infect.</td><td colspan="3">☐ Mix (C+DI)</td></tr>
<tr><td colspan="7"></td></tr>
<tr><td colspan="7">Surveillance data of applied measures</td></tr>
<tr><td rowspan="16">Hand disinfection</td><td colspan="2">Visible contamination – hygienic hand washing</td><td colspan="4">Patient care – alcohol-based hand rub</td></tr>
<tr><td>☐☐☐☐☐</td><td>☐☐☐☐☐</td><td>☐☐☐☐☐</td><td colspan="3">☐☐☐☐☐</td></tr>
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<tr><td colspan="2">When examination gloves are put on/removed</td><td colspan="4">When sterile gloves are put on/removed</td></tr>
<tr><td>☐☐☐☐☐</td><td>☐☐☐☐☐</td><td>☐☐☐☐☐</td><td colspan="3">☐☐☐☐☐</td></tr>
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<tr><td colspan="7"></td></tr>
<tr><td>Protective gown</td><td colspan="2">Due to expected</td><td colspan="4">When contact isolation is used</td></tr>
</table>

	contamination			
	□□□□□	□□□□□	□□□□□	□□□□□
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	□□□□□	□□□□□	□□□□□	□□□□□

Surgical mask	Due to expected aerosol splash		Protection against droplet infection	
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	□□□□□	□□□□□	□□□□□	□□□□□
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	□□□□□	□□□□□	□□□□□	□□□□□
Wiping down critical surfaces (decon.)	Bed		Medical devices	
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	□□□□□	□□□□□	□□□□□	□□□□□
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	□□□□□	□□□□□	□□□□□	□□□□□
Handling/cleaning bed and other linens	□□□□□	□□□□□	□□□□□	□□□□□
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	□□□□□	□□□□□	□□□□□	□□□□□
Final disinfection	□□□□□			

Instructions for completing the log

1. Personal identification code

Social Security Number or other appropriate type identification.

2. Health service ID (Master number)

The patient's 9 digit master number.

3. Department identifier

9 character code of the provider department stated on the financing agreement.

3/A. Specialty/activity code

Code of the specialty providing care for the patient.

4. Date

Patient care day (year, month and day) when the infection control activities were observed.

5. Individual risk

6. Type of care

1. Standard

2. Contact

3. Droplet infection

4. MIX (contact + droplet infection)

7. Quantification of the applied measures – Hand disinfection

7/A. Visible contamination – quantification of hygienic hand washing
Quantity of activity on patient care day (pcs).

7/B. Quantification of alcohol-based hand rub
Quantity of activity on patient care day (number of times).

7/C. Quantity of protective gloves put on/removed
Quantity used on patient care day (pcs).

8. Quantity of protective gowns

8/A. Quantity of protective gowns - expected contamination, on given patient care day
Quantity used on patient care day (pcs).

8/B. Quantity of protective gowns - contact isolation
Quantity used for contact isolation on patient care day (pcs).

9. Quantity of full face/surgical masks

9/A. Qty. of full face/surgical masks – Expected aerosol splash.
Quantity used on patient care day (pcs).

9/B. Qty. of full face/surgical masks – Droplet infection
Quantity used on patient care day (pcs)

10. Wiping down critical surfaces
Critical surfaces include all surfaces in the patient's environment touched by the patient or the care personnel in the course of care administration (bed and accessories, bedside table, control panels of medical devices, etc.)

10/A. Wiping down critical surfaces (decon.) – Quantity – Bed
Quantity of activity on patient care day (number of times).

10/B. Wiping down critical surfaces (decon.) – Quantity – Medical device
Quantity of activity on patient care day (number of times).

11. Handling/cleaning bed and other linens (Quantity)

Calculated quantity of bed linen and other linens exchanged on patient care day as part of IC activities.

12. Final disinfection

	The completed disinfection after the patient's discharge is to be denoted with the character "1".

VIII.3. Infection control DATA SHEET

Observation unit: Patient care event in the department associated with the period of patient examination.

It serves to collate summary data from sheets 7.1.-7.3 of the Data sheet filled out in the course of patient care administered in the department. In addition to the above data, selected data (isolation, screening tests, and results) highly significant for infection control are added here.

Instructions for completing the Data sheet:

a. The identification data must be identical to those on the Hospital data sheet.
b. Data from daily infection control activities at the point-of-care summarised as part of Section 7.1 of the Data sheet are to be entered into the appropriate Sections (4 through 12).

   This part of the Data sheet can be repeated according to the number of observed days of the individual patient (up to 14 days when data are recorded in the Excel table)

c. Data in Section 7.2 (Individual risk assessment) are to be entered on the type 13 line. For a case observed in a hospital ward up to 5 repetitions are allowed.
d. Data in Section 7.3 (Priority risk assessment) are to be entered on the type 14 line. For a case observed in a hospital ward up to 5 repetitions are allowed.
e. Lines with 14 and 15 identifiers contain additional infection control data and their evaluation is also a priority. Must be determined using the patient's documentation or the HIS system. Pertinent data include screening type laboratory tests due to priority risk, test results, total duration spent in isolation, and completed aseptic interventions. The individual data items can be repeated – according to current plans the number of allowable repeats shall be indicated on the sheet.

1. Personal identification code:										**2. Health service ID (Master number):**										
3. /A Department identifier:										**3/B. Specialty/activity code:**										

Daily infection control activities completed at the point-of-care (up to 14)

4. Date:								
5. Individual risk:								
6. Type of care:								

7. Quantity of hand disinfection

7/A. Visible contamination – quantity of hygienic hand washing:			
7/B. Quantity of alcohol-based hand rub:			
7/C. Protective gloves put on/removed:			
7/D. Sterile gloves put on/removed:			

8. Quantity of protective gowns

8/A. Quantity of protective gowns – on the patient care day, due to expected contamination:			
8/B. Quantity of protective gowns – for contact isolation:			

9. Quantity of full face/surgical masks

9/A. Expected quantity full face mask / surgical masks in case of aerosol splash:			
9/B. Expected quantity full face mask / surgical mask in case of droplet infection:			

10. Wiping down critical surfaces (quantity)

10/A. Wiping down critical surfaces (decon.) Bed:			
10/B. Face Wiping down critical surfaces (decon.) medical devices:			

11. Handling/cleaning bed and other linens (Quantity)

Handling/cleaning bed and other linens:			

12. Final disinfection

Final disinfection:	

Individual risk assessment

13. Healthcare-associated infection – risk analysis (up to 5)

Date of risk assessment:	**A**	**B**	**C**	**D**	**F**	**G**	**H**	**I**	**J**	**K**	**L**	**M**	**N**	**P**	**R**	**S**	**E**

14. MRP/CDI infection risk analysis (up to 5)

Date of risk assessment:	**A**	**B**	**C**	**D**	**F**	**G**	**H**	**I**	**J**	**K**	**L**	**M**	**N**	**P**	**E**

Supplementary data

15. Screening tests (up to 5)

Description:	**A**	**B**	**OENO code:**	**Date of sampling:**	**Results received (date):**	**F**

16. Aseptic interventions (up to 40)

Description:	**Date of intervention:**	**OENO code:**	**Qty.**

17. Isolation (up to 5)

Description:	**A**	**Start of isolation:**	**End of isolation:**

Purpose of test according to microorganisms

Name	Code
MRSA	1
CRE	2
MPAE	3
VRE	4
MACI	5
ESBL-producing Enterobacterale	6
CDI	7

OENO code of screening test

Identical to the intervention code applied to medical interventions in the Accounting Report of Outpatient Care.

Instructions for completing the log

1. Personal identification code

Social Security Number or other appropriate type identification.

2. Health service ID (Master number)

The patient's 9 digit master number.

3. Department identifier

9 character code of the provider department stated on the financing agreement.

3/A. Specialty/activity code

Code of the specialty providing care for the patient.

Daily infection control activities completed at the point-of-care (up to 14)

To determine the cost, an itemised survey of infection control activities for all patient care days of all patients in a given organisational unit must be prepared for the defined time period. The defined survey period is 14 days, therefore daily infection control activities completed at the point-of-care for up to 14 patient care days can be entered.

4. Date

Patient care day (year, month and day) when the infection control activities were observed.

5. Individual risk

In all inpatient departments, when admitting patients the risk assessment and evaluation of healthcare-associated infection must be completed within 72 hours of the time of admission; additional risk assessment and evaluation must be carried out upon patient transfer in both the transferring and the admitting institution, monthly during extended patient care, if there is a significant change in the risk factors of the patient such as catheter removal or insertion, wound formation, fever, etc. The score of risk assessment must be calculated.

6. Type of care

1. Standard
2. Contact
3. Droplet infection
4. MIX (contact + droplet infection)

7. Quantity of hand disinfection

7/A. Visible contamination – quantity of hygienic hand washing

Quantity of activity on patient care day (number of times).

7/B. Quantity of alcohol-based hand rub

Quantity of activity on patient care day (number of times).

7/C. Protective gloves put on/removed – Quantity

Quantity used on patient care day (pcs).

7/D. Protective gloves put on/removed – Quantity

Quantity used on patient care day (pcs).

8. Quantity of protective gowns

8/A. Quantity of protective gowns – on the patient care day, due to expected contamination

Quantity used on patient care day (pcs).

8/B. Quantity of protective gowns – for contact isolation

Quantity used for contact isolation on patient care day (pcs).

9. Quantity of full face/surgical masks

9/A. Qty. of full face/surgical masks - Due to expected aerosol splash

Quantity used on patient care day (pcs)"

9/B. Qty. of full face/surgical masks - in case of droplet infection

Quantity used on patient care day (pcs)."

10. Wiping down critical surfaces

Critical surfaces include all surfaces in the patient's environment touched by the patient or the care personnel in the course of care administration (bed and accessories, bedside table, control panels of medical devices, etc.)

10/A. Wiping down critical surfaces (decon.) – Bed

Quantity of activity on patient care day (number of times).

10/B. Wiping down critical surfaces (decon.) - Medical devices

Quantity of activity on patient care day (number of times).

11. Handling/cleaning bed and other linens (Quantity)

Calculated quantity of bed linen and other linens exchanged on patient care day as part of IC activities.

12. Final disinfection

The completed disinfection after the patient's discharge is to be denoted with the character "1".

Instructions for completing the log

Individual risk assessment

13. Healthcare-associated infection – Risk assessment (up to 5)

During the period of patient care in the department up to 5 risk assessments for healthcare-associated infection can be entered.

Date of risk assessment

Time (hours and minutes) when risk assessment for healthcare-associated infection was carried out.

Risk factor qualification

If the patient has a certain risk factor it is to be denoted with code 1, otherwise enter code 0.

Urinary catheter exposure during current hospitalisation (A)

Central venous catheter exposure during current hospitalisation (B)

Mechanical ventilation exposure during current hospitalisation (C)

Admitting patient from intensive therapy department or intense care during current hospitalisation (D)

Weakened immunity, immunodeficiency (F)

Premature infant (G)

Elderly (>65 years) (H)

Malnutrition (I)

Diabetes (J)

Obesity (K)

Decompensated chronic condition (L)

Multiple organ failure (M)

Antibiotics exposure within the last 3 months (N)

Surgical intervention within the last 12 months (P)

Minimum of 1 night stay in a healthcare institution during the past 12 months (R)

Smoking (S)

Results of risk assessment (E)

1. Low
2. Medium
3. High

14. MRP/CDI infection – Risk assessment (up to 5)

During the period of patient care in the department up to 5 risk assessments for MRP/CDI infection can be entered.

Date of risk assessment

Time (hours and minutes) when risk assessment for MRP/CDI infection was carried out.

Risk factor qualification

If the patient has a certain risk factor it is to be denoted with code 1, otherwise enter code 0.

Patient's medical history includes infection or colonisation by a multidrug-resistant pathogen (MRP) (A)

Patient's medical history includes C. difficile (B)

Intensive care during the path 12 months (C)

Direct transfer from foreign hospital (D)

Direct transfer from domestic inpatient institution / nursing home (F)

Chronic dialysis within the last 12 months (G)

Cancer and chemotherapy during the past 12 months (H)

Patient has symptoms suggestive of infection (e.g. fever or enteral symptoms) (I)

Patient has an invasive device (e.g. urinary catheter, venous catheter, feeding tube) (J)

Patient had a surgical intervention within the past 3 months (K)

Antibiotic therapy currently or within the past 4 weeks (L)

Antacid therapy currently or within the past 4 weeks (M)

Epidemiological connection between know MRP carrying/infected or C. difficile infected person (N)

Instructions for completing the log

Surgical intervention within the last 12 months (P)

Minimum of 1 night stay in a healthcare institution during the past 12 months (R)

Smoking (S)

Minimum of 1 night stay in a healthcare institution during the past 12 months (P)

Results of risk assessment (E)

1. Low
2. Medium
3. High

Supplementary data

15. Screening tests (up to 5)

For pre-operative patient s or high risk, appropriate microbiological screening tests according to hospital's MRP screening protocol must be completed. During the period of patient care in the department up to 5 screening tests can be entered.

15/A Purpose of the tests

To determine the target pathogen of the screening test.

1. MRSA
2. CRE
3. MPAE
4. VRE
5. MACI
6. ESBL-producing Enterobacterale
7. CDI

15/B Reason for test

1. First screening
2. Follow-up

15/C OENO code of test

OENO code of microbiological screening test.

15/D Sampling time

Date of microbiological sampling completed according to hospital's MRP screening protocol.

15/E Date of receipt of the test results

Date of results of MRP screening.

15/F Test results

1. MRSA
2. CRE
3. MPAE
4. VRE
5. MACI
6. ESBL-producing Enterobacterale
7. CDI

16. Aseptic interventions (max. 40)

Aseptic interventions completed during the period of patient care in the department. Up to 40 interventions can be entered during the period of patient care in the department.

16/A Date of aseptic intervention

The date of the aseptic intervention.

16/B OENO code of aseptic intervention

OENO code of aseptic interventions completed during the period of patient care in the department.

16/ C Quantity of aseptic intervention

The number of aseptic interventions performed.

17. Isolation (up to 5)

Isolation period during the period of patient care in the department. Up to 5 periods can be entered during the period of patient care in the department.

17/A Type of isolation

1. Contact
2. Droplet infection
3. MIX (contact + droplet infection)

17/B Start of isolation

Start date of isolation

17/C End of isolation

End date of isolation.