Doctoral School of
Business and Management

PHD THESIS

ECONOMICAL IMPLICATIONS OF THE INSTITUTION-LEVEL IMPLEMENTATION OF EVIDENCE-BASED INFECTION CONTROL

Written by: Irén Anna Dr. Kopcsóné dr. Németh
as part of completing the requirements for PhD degree

Supervisors:
Prof. Márta Péntek Phd, Professor
Dr. Zsombor Zrubka, PhD, associate professor

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1 BACKGROUND

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. 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%, leading 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. (WHO 2016). Depending on the patient population, mortality rate attributable to nosocomial infections varies between 12% and 80%. (WHO 2016)

Infection control (IC) 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. The principle of general precautions and regulations was created in 1985 in connection with the spread of AIDS and starting from the 1990s, supplementary regulations based on the known modes of pathogen transmission – contact, droplets or respiratory – were developed and implemented; this is the transmission-based approach for prevention.

Just as a number of areas relating to the economic aspects of IC remain to be explored in the international scientific literature, to the best of our knowledge Hungarian studies on this subject also remain scarce. Additionally, there are no nation-wide data on the degree of applying isolation protective regulations, which might be different in different institutions, because it is highly impacted by local surveillance activities, the existence of an appropriate laboratory background, willingness to take microbiological samples, etc.

My research projects evaluated clinical evidence for the efficacy of IC and the challenges of implementing IC in practice, and also assessed the funding requirements of implementing IC at an institutional level and the related costs. My research can be divided into five topics:

1. Implementation and efficiency of IC in a Perinatal Intensive Care Centre
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

I briefly describe these investigations in the next chapter.

2 MY OWN RESEARCH IN THE FIELD OF INFECTION CONTROL

2.1 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 Centre

In 2009, a complex project was launched to reorganize the operation of the Military Hospital – State Health Centre (MHEK) Department of Obstetrics and Gynaecology, Perinatal Intensive Care Centre (PIC), aiming to transform care with the introduction of non-invasive family-friendly pre-term care as well as to reduce nosocomial infections. (Sweet 2010) Within the framework of this project an up-to-date protocol on antibiotic use 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. Local protocols for surveillance-based interventions and point-of-care focused isolation regulations were introduced in 2011.

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

Data collection was performed over 6 months between October 2012 and March 2013. Data on categories of infections and interventions were collected using the German NEO-KISS Protocol in a population of pre-term infants born with less than 1500 grams body mass divided into 3 groups (<499 grams, 500–999 grams, and 1000–1499 grams) and the results were compared to the published NEO-KISS reference values.

In the two evaluable groups, our infection rates were between the 25% and 75% quartiles, which indicates that the frequency of severe nosocomial infections at our PIC is similar to the German figures, which are not exceeded. Our research has highlighted that infection rates comparable to the German reference figures were achieved by using our strategy refined via professional development. Additionally, instead of the missing national reference data, published NEO-KISS reference data enable the quantification of the care and infection control practices of each PIC with a high probability and may provide objective markers for improving the quality of care.

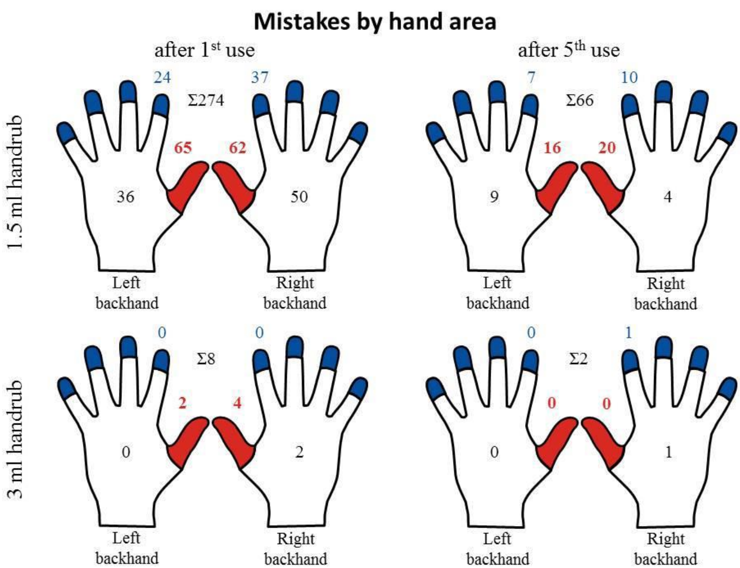
2.2 Learning model of acquiring appropriate hand hygiene techniques

The MHEK PIC infection control program described in the previous subsection included regular training of the department personnel on appropriate hand hygiene technique. 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 MHEK. 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. (Tompkins 2005)

The purpose of our research was to investigate how quickly the hand disinfection movements producing a perfect result with 1.5 mL or 3 mL disinfectant could be learned (these are the average disinfectant amounts per occasion used in the MHEK PIC Department).

In 2016, 39 employees of the MHEK PIC Department took part in this 8-week research. Each employee was issued a radiofrequency identification (RFID) tag. After an introductory training, hand hygiene technique of the employees was reviewed before the end of each shift, following an RFID identification. During the first three weeks, 1.5 mL disinfectant was allowed to be used at each hand disinfection, which was afterwards increased to 3 mL. Effectiveness of hand disinfection was assessed using a Markov learning model. We defined two statuses: appropriate (>95% of the hands are covered with disinfectant) and inappropriate. Successful learning outcome was defined as two subsequent occasions of appropriate hand disinfection.

Figure 1. Disinfection errors affecting specific touch zones of the hand when 1.5 mL and 3 mL of disinfectant was used



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 in the following figure.

Neither the age of the participants (p=0.25) nor the hand size (p=0.90) had an impact on training success. The number hospital infections per day of care showed a marked and significant decrease between the year before the study, the year of the study (2015-2016) and the years following the study (2017-2018). When the study started, 1 L of hand disinfectant cost approx. HUF 807, accordingly the estimated annual cost increase is HUF 304,800 annually when projected to the average 4336 patient days during the four years investigated.

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. The visual feedback accelerated the learning process, 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.

2.3 Disease burden and costs of Clostridium difficile infections (CDI) in Hungary

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. Based on international publications the cost burden and disease burden of

CDI are both high; however, no Hungarian data on the costs of CDI are available.

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

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. From the start of the study 151 consecutive patients (58.3% female, average age 74.1 years, SD=15.2 years) were included. The costs related to patient isolation were calculated as per the institutional quality system procedures, i.e. separately for the Intensive Care Unit (ICU) and for the internal medicine departments, from the institution’s perspective. In addition to isolation costs, the costs of the medicines used and the investigations performed were also calculated. Incremental costs were calculated by the difference in the daily costs of mean time in isolation, standard isolation and CDI-warranted contact isolation.

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. The total number of days spent in isolation in 2011 was 17.56 days (SD=13.36 days) and the length of the average episode was 12.57 days (SD=8.31 days). The costs are shown in

Table 1. .

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.

Table 1. Average incremental costs of an average hospital episode of a CD patient (Year 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*	5,943	11,886	8,915
Hygiene costs*	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**

* Difference between standard and CDI contact isolation

Our research has provided essential input data for health economic analyses reflecting the conditions and costs of the disease burden of CDI in Hungary.

2.4 Investigation on meeting the professional minimum requirements of infection control in domestic healthcare institutions

Personnel and material minimum requirements of infection control 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.

The purpose of our research was to investigate the relationship between meeting the infection control minimum requirements and the incidence of healthcare associated infections (inverse correlation) and the size of the institution (larger institutions are expected to provide higher compliance, and the decrease in the number of events in response to IC activity balances out the costs associated with meeting the minimum requirements).

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. The effect of meeting the minimum requirements for infection control on the frequency of hospital infections is investigated using panel data regression method. Correlations between the compliance with the minimum criteria and the institution category are also investigated using panel regression.

The annual number of days of care was 178,474 in the 103 institutions, with a standard deviation of 167,710.

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. 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. As anticipated, coefficients showed a positive correlation with the annual number of days of care.

Our results supported both hypotheses. The greatest decrease in infections was observed when all minimum requirements were met at the same time. The savings achieved by a reduced number of cases will balance out the costs associated with meeting the minimum requirements at these institutions with a higher patient turnover, therefore these institutions are more likely to comply with the minimum requirements. Since only a small proportion of Hungarian inpatient care institutions meet all the minimum requirements of IC further health economic and health policy research is warranted.

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

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. In Hungary, implementation of infection control activities into the basic NEAK reimbursement is being prepared. Differences between regions and countries (such as the health status of the population, economical development status of the country, differences in health services) warrant analyses based on local data. (Drummond 2009)

The aim of our research is to arrive at the most accurate definition of the cost requirements of the procedures proposed in IC methodology papers that are part of the general operational costs of the hospital, and as such cannot be typically determined from the patient care records. According to our hypothesis, different types of hospital departments and types of isolation require different resources for infection control, which necessitates the implementation of a differentiated reimbursement system.

Data collection was carried out over a one week period (30 March 2020 to 5 April 2020) in the MHEK Intensive Care Unit (ICU), Perinatal Intensive Care Centre (PIC), and the Departments of Surgery and Internal Medicine. All patients who received in-patient care in the above departments during this period were included in the study. Depending on the transmission characteristics of the infection, our study patient sample was categorised into four IC groups: (1) standard care (also known as general procedure or standard isolation); (2) contact isolation; (3) droplet isolation; (4) mixed isolation (droplet infection and contact). Measurement of materials and devices used at the point-of-care was carried out using the so-called “bottom-up micro-costing” approach. (Spacirova 2020) Additionally, further substantial supplementary data on infection control were recorded for the total department time (up to 30 days) of the observed patients during the observation period. 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 MHEK annual patient turnover data. Taking into consideration the small sample size included in the study and the short observation period, a Monte-Carlo simulation was used for cost analysis.

Data from a total of 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).

Parameters used for cost estimates shown in Table 2.

Table 2. Parameters used for cost estimates

		Department of internal medicine	ICU	PIC	Department of surgery
Standard care	Daily average cost (HUF); average [95CI[a]]	3,809 [3,136 - 4,596]	8,589 [7190 - 10,178]	4,089 [3,399 - 4,882]	4,539 [3,818 - 5,361]
	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]	9,203 [5,561 - 14,190]	11,200 [7,441 - 16,254]	9,265 [5,614 - 14,270]	9,413 [5,753 - 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]	5,393 [5,379 - 5,407]	2,612 [2,597 - 2,626]	5,176 [5,162 - 5,190]	4,875 [4,861 - 4,889]

	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]

Depending on the type of department the cost of standard care was in the HUF 3,809-8,589 range while the 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. 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 cost of introducing IC.

3 PRACTICAL UTILITY AND PUBLIC POLICY RELEVANCE

Our research has 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 IC 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.

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