Complex infection control strategies at the neonatal intensive care unit with a special focus on hand hygiene

Ph.D. thesis

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List of Abbreviations

AHR	alcohol-based hand rub
BPA	Bisphenol A
CDC	Centers for Disease Control and Prevention
CI	confidence intervall
CLSI	United States Clinical and Laboratory Standards Institute
ECDC	European Centre for Disease Prevention and Control
ESBL	extended-spectrum beta-lactamase
EU	European Union
EUCAST	European Committee on Antibiotic Susceptibility Testing
HAI	Healthcare-associated infections
HCW	healthcare worker
HH	hand hygiene
IC	infection control
ICU	intensive care unit
INSURE	intubation, surfactant therapy and extubation
MDR	multi-drug-resistant
MIC	minimum inhibitory concentration
MRSA	Methicillin-resistant *Staphylococcus aureus*
NICU	neonatal intensive care unit
OR	odds ratio
PFGE	pulsed field electrophoresis method
SD	standard deviation
SP	standard precautions
UV	ultraviolet
WHO	World Health Organization

Introduction

According to the Luxembourg declaration on patient safety, access to high-quality healthcare is a key human right that is recognized and valued by the European Union (EU), and also by its institutions and citizens [1]. Healthcare-associated infections (HAIs), also termed nosocomial infections, are complications of healthcare provision that contribute to increased patient morbidity and mortality [2]. HAIs lead to increased healthcare costs for patients, their insurers and hospitals, due to unanticipated duration of hospital stay and associated treatment. There is also a psychological burden placed on patients, their carers, and their families, in addition to opportunity costs arising from patients and their carers' inability to work, attend school, etc., while hospital capacity impacts the efficiency of healthcare [3].

In England alone, over 6% of hospital patients acquire an infection during their hospital stay (i.e. not present at the time of admission) with projected costs to the National Health Service reaching nearly £1 billion annually [4]. Internationally, 5–10% of patients admitted to acute care hospitals in developed countries will acquire an infection, while the rate for developing countries can exceed 25% [4]. According to the estimation of Stone et al., in the USA about two million patients are involved annually by HAI, of whom approximately 90.000 die [5]. This corresponds with the data gathered by Walker et al. stating that in 2014 an estimated 2 million patients will acquire an infection during their hospital stay that might have been easily prevented [6]. Also the numbers are not showing much improvement in the consequence of HAI since Klevens et al. years before Stone estimated and published the burden of HAI on pateins' lifespan accounting for approximately 100.000 deaths annually [7]. In the EU, based upon the data of the European Centre for Disease Prevention and Control (ECDC), approximately 4.1 million patients in acute care facilities acquire a HAI annually, with the number of deaths directly related to HAI estimated to be at least 37.000 [8].

Thus HAIs pose a serious public health issue and not only have adverse effect on patients' health, but also place a significant economic burden on an already taxed healthcare system [9–10]. In order to prevent the formation of HAIs and reduce occupational health hazards in healthcare facilities, the utilisation of standard precautions (SPs) is mandatory. SPs are motivated by the principal that all patients are potentially infectious, and therefore precautions should be used to manage risk. SPs guidelines contain several protective measures such as hand hygiene (HH) procedures; the use of protective barriers, e.g.: gloves, masks, and goggles; appropriate handling

and disposal of sharps and other contaminated or infectious waste; and furthermore, the use of aseptic techniques [11]. Although not all HAIs are preventable [12], HH is considered to be the most effective way of preventing microbial transmission and to reduce the spread of antimicrobial resistant bacteria [13]. Studies are revealing negative correlations between the HH of healthcare workers (HCWs) and HAIs, estimating that HCWs' correct hand sanitation could prevent up to 50% of HAIs [4]. Since Ignaz Semmelweis demonstrated dramatic reductions in puerperal sepsis after instituting a disinfectant hand-washing regimen in 1847, HH has been known to reduce HAIs and is recommended by the Centers for Disease Control and Prevention (CDC) as the single most effective method of preventing the spread of nosocomial infections [14]. Aiming to reduce both HAIs and to decrease the spread of antimicrobial resistance, the World Health Organization (WHO) World Alliance of Patient Safety launched the first Global Patient Safety Challenge in October 2005 under the banner, 'Clean Care is Safer Care'. A major element of the challenge is the development of new, evidence-based guidelines for the promotion of HH in healthcare. Given the growing evidence it became obvious that preventing the spread of infection requires performing HH properly and at key moments during patient care as the critical preventive measure [15].

After the introductions of international HH campaigns and guidelines [16], the Hungarian guideline was launched in 2009 [17], which recommends the proper surgical skin scrubbing technique and other important HH rules, such as the indications, when and how should HH be performed. The "5 moments of Hand Hygiene" protocol describes five fundamental indications to when should HH performed (Figure 1.). Simultaneously "How to rub" protocol was formed to demonstrate the essential hand cleaning technique (Figure 2.).

Figure 1. The 5 moments of Hand Hygiene

Figure 2. Protocol for demonstrating the essential hand cleaning technique.

Hand-washing and hand disinfection with alcohol-based hand rubs (AHRs) removes microrganisms effectively, and is the reference standard for effective HH. Although the mentioned procedures are quite simple and easily accomplishable, HH compliance remains low among HCWs, with reported adherence rates ranging from 20% to 50% [18–19]. This was confirmed by Pittet et al. stating that most HCWs practice HH less than half as often as they should [20]. These data are in accordance with the findings of the WHO [16]. Still today, despite being aware of the prevalence of HAIs, HCWs' compliance remains suboptimal, therefore it is highly important to continuously monitor this problem and improve compliance, possibly leading to increased number of HH events. Besides monitoring HCWs compliance, emphasis should be put on proper education for all students in related to healthcare studies or teaching programs in order to eliminate inadequate compliance before it even develops in the younger generation. This is a highly relevant issue since students learning to become nurses perform various nursing tasks and procedures to a large number of patients during their clinical practice, requiring extensive patient contact. It is crucial that they learn and practice correct HH to develop a good compliance in order to prevent HAIs. Monitoring the adherence to HH guidelines has become inculcated into the standard expectations and requirements of a majority of hospitals in the world, and data on rates of HH are routinely reported to administrative groups and infection control (IC) or quality monitoring committees [21]. Ultimately, the goal of any monitoring is to improve performance. In Hungary, IC practitioners regularly measure the HCWs's HH compliance in all healthcare facilities and forward the data to the National Center for Epidemiology.

To increase HH compliance among HCWs, direct observation combined with feedback data has been described as the best way to convince staff of the need for improvement and motivate them to achieve and sustain best practice targets [13]. In the literature 'direct participant observation' is considered the gold standard in measuring HH compliance [22], but it has several drawbacks. The limitations of this supervision technique are the following: the observation is time and resource intensive, also when interpreting findings, the Hawthorne effect and the potential for bias must be considered. The Hawthorne effect means that when the observer enters the patient room or the HCW is aware of the fact that he is being watched, compliance may be overestimated because of the change in HCW behaviour when being observed. Last but not least, direct observation is often not performed in a standardized way, making interhospital comparison difficult. Ensuring the comparability of results depends, to a great degree, on the types of observer, the level and type of training that the observers receive, the duration of observation

periods, and the number of HH opportunities observed [13, 23]. Given these limitations, there is considerable interest in new technologies for audit and feedback of HH compliance, including electronic and video monitoring systems [24]. These new systems vary widely, ranging from simple systems that track only the number of times that soap or hand sanitizer is dispensed to complex systems that integrate information on the timing of HH dispensing events and the location of the HCW in order to provide an estimate of HH compliance [24]. Video monitoring means continuous monitoring of the patient environment via a video camera, with human reviewers assessing compliance. The advantage of both systems are their ability to monitor HH on a continuous basis, allow measurement of compliance and even feedback at the individual level.

Measuring AHR consumption for HH performance is a simple way to be able to describe and calculate the frequency of HH actions and also to compare them between units or hospitals [25]. Good correlations have been found in studies between AHR consumption and HH compliance rates, and also between AHR consumption and HAI reduction [26–27].

AHR consumption is calculated and reflected on 1000 patient days, which represents a standard population and time period for interpretation of the usage. From this value we can easily calculate how many times were HH performed at one patient during 24 hours [17, 28]. This data does not contain the amount of used surgical hand scrubs. In Hungary, the national average of AHR consumption has improved in all healthcare facilities due to national HH campaign (from an average 7L/1000 patient days in 2011–2012 to 9.9L/1000 patient days in 2015) [29]. Despite the above mentioned increase in AHR consumption, compliance still cannot be deemed acceptable. As listed by Davis and colleagues, barriers to correct HH practices include forgetfulness, lack of knowledge about expected standards, low priority, time constraints and inaccessible HH supplies [4]. IC professionals must analyse each system or workflow at the wards in order to identify critical points in patient care. This is also recommended by Song et al. [30] (Figure 3.).

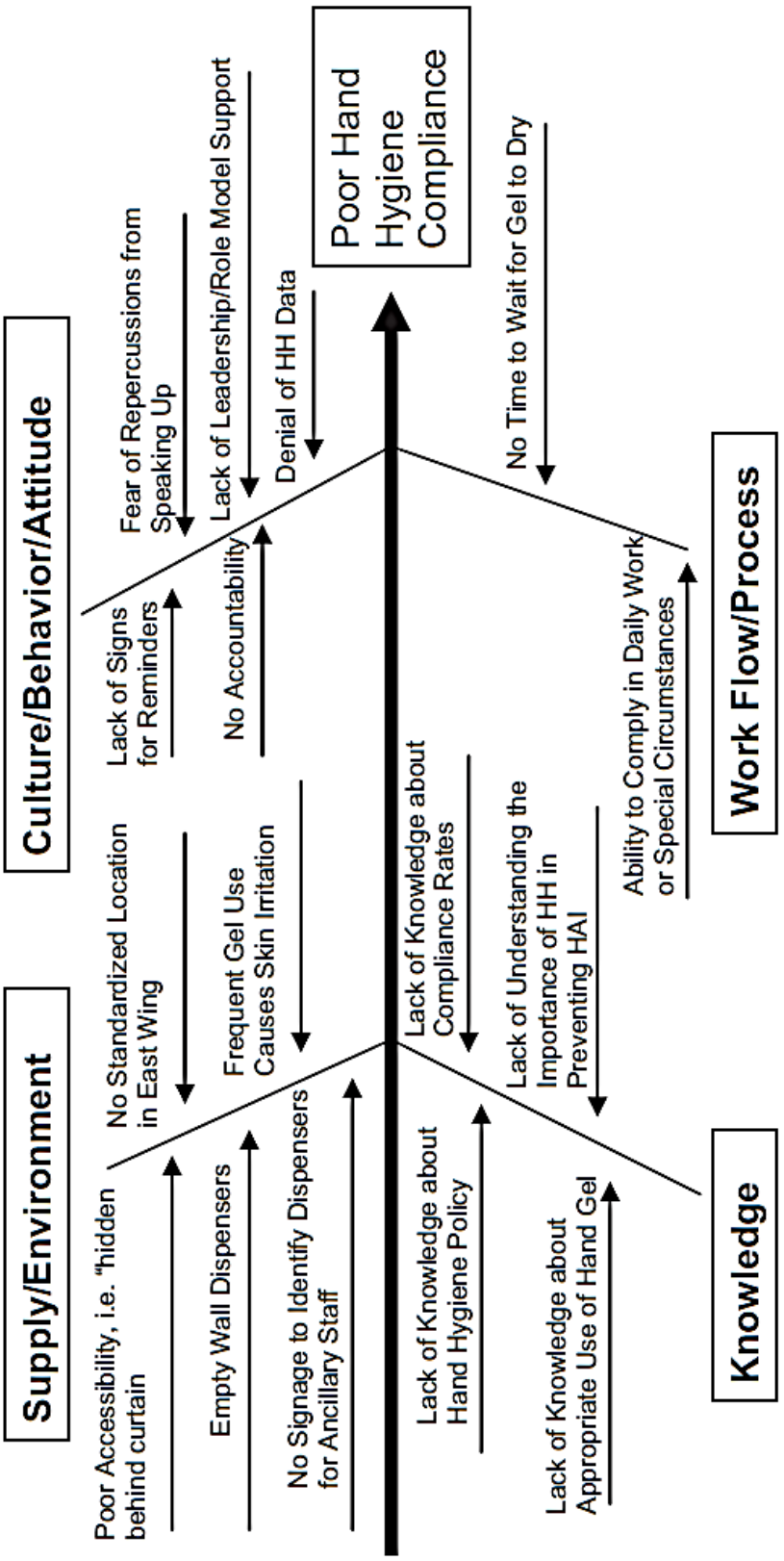

Figure 3. An example of a failure mode effect analysis findings (fishbone diagram) by Song et al.

There are further factors which can reduce the pace of improvements in HH compliance despite all efforts, i.e. differences in gender [31], differences between doctors and nurses [32], when working at intensive care unit (ICU) [33], working on weekdays or on weekend [26] and also time limit [34]. Regarding the difference between doctors and nurses, the findings are controversial. Similar to many studies in the literature [35–36], compliance with HH among nurses was reported to be better than doctors by Karaaslan et al. [37]. These results contradict the findings of Song et al. stating that when compared with physicians, nursing staff consistently had lower HH compliance rates and lower improvement rates [30]. Interestingly, despite continued efforts from infection prevention teams, hospital systems across the United States continue to struggle with HH participation, with a reported national compliance rate of <50% [6, 38].

It is important to note that findings gathered from surveys and questionnaires on HH practice of HCWs often shed light to the existence of behaviours or attitudes, which are originated from inadequate knowledge in this topic. Such behaviours are clearly not a consequence of indiscipline but a misconception based on faulty information and lack of knowledge or previous erroneous beliefs. Improving HH compliance and sustaining a positive behavioural change remains a significant challenge, given the complexities of the healthcare environment and the difficulty of changing behaviour [15].

Besides the fact that the level of HH is not perfect among HCWs partly due to misbeliefs or deficient information and partly due to their inadequate compliance originating from multiple factors, the occurrence of multi-drug-resistant (MDR) bacteria is even aggravating the situation since the handborne route is of critical importance in nosocomial cross-infections.

The appearance of MDR bacteria is a major concern among medical care providers all over the world [39–41]. MDR Gram-negative bacterial infections have become prevalent already in some European countries. Moreover, increased use of broad-spectrum antimicrobial agents selects organisms with resistance and, by increasing their numbers, increases their chance of spread [42]. Of these, extended-spectrum beta-lactamase (ESBL)-producing Gram-negative bacteria are especially problematic, as they are becoming increasingly resistant [43–44]. The group of ESBL-producing bacteria typically includes *Escherichia coli*, *Enterobacter cloaceae* and *Klebsiella pneumoniae*. Once involved in HAI, the situation can become quite dangerous.

Nosocomial infections are one of the leading causes of mortality and morbidity in the neonatal intensive care unit (NICU) [14].The young patients' low level passively acquired antibodies,

along with the diminished functional capacity of many components of the immune system, thinness and poor keratinization of skin, colonisation of mucous membranes and skin with endemic microorganisms present in the NICU, exposure to antibiotics, frequently insufficient gastrointestinal feeding and insufficient supply of mother's milk, invasive procedures and the frequent contacts with HCWs, expose these newborns to high risk of infection [45]. Neonatal nosocomial infections are late-onset infections (appearing after the first 72 h of life) in hospitalised infants. Based upon the data provided by Edwards [46] and Adams-Chapman et al. [47] the incidence of infections (7–24.5%) at the NICUs depends on environmental factors and on differences in clinical practice.

The above mentioned ESBL-producing bacteria are highly dangerous to neonates, especially low-birthweight preterm infants, and their nosocomial persistence may lead to prolonged hospital stay, higher mortality and growing costs [43, 48–49]. Gram-negative organisms account for 18 to 31.2% of infections at the NICU. Therefore, their increasing presence is a significant risk factor in NICU, which must be dealt with [50–51].

The NICU of the Department of Paediatrics at the University of Szeged at the time of the study was a 17-bed tertiary care centre, with annual admissions of 210-250 newborns with the most severe perinatal conditions from the Southeast region of Hungary (with a population of almost 1.5 million). At this unit, the first ESBL-producing infection was detected in 2002. By 2008, ESBL-producing bacteria became standard nosocomial bacteria, and a total eradication was never achieved. The problem became critical in the second half of 2011, when more than half of the neonates on the ward were colonised, which called for immediate intervention. In the following I would like to describe a complex, multitask infection control (IC) project highlighting the period January 2011–September 2012, which finally led to successful IC management at our NICU.

Aims

I. Reaching a significant increase in the number of HH events in case of HCWs at the NICU by implementing a multimodal strategy.

II. Reducing the number of future infections and colonisations by identifying and subsequently eliminating all potential sources of infection.

III. Implementing non-invasive treatments at the ward which would possibly lead to the reduction of device-related infections.

IV. Assessing the current knowledge of nurse students on HH in order to identify potential factors related to future insufficient HH compliance.

Methods

As a consequence of the spread of ESBL-producing bacteria, a specific IC task force was formed, with representatives from the NICU, the Institute of Clinical Microbiology and the IC Unit. The group met weekly to discuss the situation. A three-step complex management plan was devised in September 2011, which involved retrospective data analysis aimed at identifying risk factors, education of staff and introduction of new hygienic measures based on the retrospective analysis, and a follow-up phase. We conducted the retrospective study from January 2011 to September 2011 and the prospective study from January 2012 to September 2012. Between the two periods we allowed the staff three months to become accustomed to the new protocols and strategies introduced. Patient-days/month [52] were calculated by the electronic patient documentation system (eMedSolution® by T-Systems Hungary Ltd, Budapest), which provides up-to-date data and automatically generates statistical information upon the user's request.

Retrospective Analysis

Data were gathered retrospectively from the January-September 2011 period regarding HH compliance among HCWs and ESBL colonisation/infection data among patients treated at the NICU. HH compliance was assessed indirectly, based on the recorded use of AHR, from which the average number of HH procedures could be estimated according to the WHO Guidelines on Hand Hygiene in Health Care [53].

Indirect HH compliance, which refers to the number of HH procedures performed in the case of one patient during one day at hospital, was calculated as follow: the quantity of HH liquid (total millilitres) supplied to the clinic per month was checked. At the end of the month the quantity of HH liquid remaining in the dispensers was evaluated (dispensers were marked at the level of remaining product at the end of the month). This way we managed to count the monthly consumption of AHR. This amount was divided by 3mL, because our dispensers provide 3mL AHR with each hit. According to multiple studies 3mL of AHR is adequate to insure proper HH [54–55] for the user. This calculated number is an indirect measure of the number of HH procedures performed. This was further divided by patient-days regarding the same month, which is continuously generated by software (eMedSolution®) at our facility. With this formula we are able to calculate the number of HH procedures performed in the case of one patient during one patient-day at hospital. According to our observations these dispensers are only used by staff, so the number of visitors does not cause a distortion in the results. Patient files were surveyed

for microbiological documentation, in an attempt to determine the types of ESBL-producing bacteria on the ward, and the findings were recorded.

Preventive Measures and Prospective Analysis

Based on the findings of the retrospective phase, a number of preventive measures were introduced in the October–December 2011 period.

First of all, in September 2011, the intubation, surfactant therapy and extubation (INSURE) protocol was introduced [56]. With INSURE, the mechanical ventilation time can be reduced, which helps reduce the number of ventilation-associated infections. Monthly mechanical ventilation days/ ventilated patient numbers were calculated from data acquired from the medical software database (eMedSolution® by T-Systems Hungary Ltd, Budapest).

The antibiotic protocol was also modified. On admission, blood culture and gastric aspirate were collected from each new patient. Ampicillin or a combination of ampicillin and tobramycin was started as primary antibiotic therapy, but the administration of these antibiotics was stopped after 48 hours if the cultures taken on admission proved to be negative and the inflammatory markers were also negative. Similarly, if surface cultures were positive without an elevation of inflammatory markers (i.e. C-reactive protein <10 mg/dL and procalcitonin <10 ng/mL at the age of 24 hours) and the patient did not show clinical signs of infection, positive surface cultures were considered as colonisation and the course of antibiotics was discontinued [57]. If late onset sepsis was suspected, the choice of antibiotics was changed. Third-generation cephalosporines and a combination of amoxicillin and clavulinate, which are reported to be the strongest inducers of ESBL-production [58], were banned from the ward. In suspected cases of Gram-negative sepsis, meropenem was administered. If there was a predisposition to Gram-positive sepsis (e.g. central venous line inserted), vancomycin was also started and the therapy was changed according to the results of the blood culture. Progressive feeding was started within the first two hours after admission. The neonates received their own mother’s breast milk through a gastric tube, if available. If not, premature and neonatal formulae were administered. Probiotics containing both Bifidobacteria and Lactobacilli were also provided.

As a new preventive measure the neonates were bathed every four days, which is in accordance with the latest guidelines [59–60]. Immersion baths were stopped. This was important because the risk of infection by biofilm-forming bacteria (i.e. on the surface of the basin or in the waterlines) could thus be reduced [61–62].

Due to the potential risk of cross-infection with ESBL-producing *Klebsiella pneumoniae* transferred via the hands of HCWs at the NICU [63] our team has put great emphasize on proper HH. HH training was a central step in the complex intervention. Multiple education sessions were provided for all staff, including video-assisted instruction and hands-on practice. Disinfected hands were also examined under UV light to ascertain efficacy (Figure 4).

Figure 4. Evaluation of hand hygiene technique with a software based UV lamp (Hand in Scan® Semmelweis Scanner). The area remained untreated is presented in red.

The data collected in the retrospective phase were shared with the staff and information posters were placed at the NICU (Figure 5 and 6). The aim was to draw attention to the growing problem of ESBL-producing bacteria in the ward so as to enhance compliance with the IC and prevention protocol [64].

Figure 5. Hand hygiene poster, which was placed in the nurses' room.

The poster says the following: "*Almost 1000 patients die due to healthcare-associated infections! The possibility of prevention is in our hands!"*

Figure 6. Hand hygiene poster, which was placed near the infant incubators.

The poster says the following: *"Do you know, that hundreds of germs can be spread via your hands? This can be prevented by hand sanitizing. We use alcohol-based hand rub before and after touching a patient!"*

In order to identify potential reservoirs and risk factors, environmental screening was performed and samples were taken from various surfaces. ESBL-producing bacteria were first detected in these samples in October 2011. Multiple surfaces and areas were colonised, including in the wash basins and taps and a tray used for drying dishes in the nurses' room. Previously, *Pseudomonas aeruginosa* was detected from samples taken from these taps and wash basins. As part of the preventive intervention, samples were taken more frequently (every second month instead of semiannually).

New filters were used on taps and the sinks were regularly dismounted and disinfected, while the staff was instructed that hand-washing with soap and water should be done as far as possible at the wash basins outside the hospital rooms. This was important since germs may be emitted as aerosols from the siphon traps into the ambient air during water drainage [65]. Additionally, new AHR dispensers were placed in the ward wherever healthcare procedures are performed. The quality of cleaning was also evaluated and monitored. In this specific ward the cleaning staff is only allowed to perform cleaning on "non-critical surfaces" (e.g. floor, walls, wash basins), whereas the "critical surfaces" (e.g. therapeutic devices, infant incubator, respiratory devices) are cleaned by the nurses responsible for the care of a particular neonate. The term "critical surface" in this context refers to surfaces which are highly important in terms of the potential spread of HAIs. The cleaning of these surfaces is performed multiple times a day according to a more frequent schedule (twice per shift, instead of once per shift).

In order to stop the spread of ESBL-producing bacteria, patients were screened for these on admission, and if the patient presented symptoms of infection at any time during treatment, multiple samples were taken (rectal swab, blood, urine and nasopharyngeal swab). Samples were collected from every patient in contact with an infected patient. Rectal swabs were performed on all neonates not only on admission, but also every other week thereafter. Once colonisation or infection was detected, contact precautions were implemented and maintained throughout the hospital stay. Furthermore, colonised and non-colonised babies were nursed separately by individual nurses. Since the ward contains separated boxes for the treatment of the patients, it was easy to implement the separated nursing.

So as to monitor the efficacy of our interventions, the number of newly infected and newly colonised patients, monthly costs of antibiotics and monthly mechanical ventilation days were analysed throughout the prospective period and compared with the data derived from the retrospective interval.

Microbiological Analysis

Identification of isolates was carried out with the conventional biochemical identifications and VITEK GN (bioMérieux, France). Antibiotic susceptibility testing to different antibiotics was performed with a disk diffusion method in line with the CLSI EUCAST recommendation. If necessary, antibiotic MIC value was determined with gradient MIC test strips (Liofilchem, Roseto, Italy), and the results were evaluated according to the EUCAST guidelines [66]. The putative production of an ESBL was detected with the ESBL Detection Set (MAST Diagnostica, Reinfeld, Germany) or the modified double-disk synergy test using ceftazidime (30µg), cefotaxime (30µg), aztreonam (30µg) and cefepime (30µg) disks opposite an amoxicillin (20mg)/clavulanic acid (10 mg) disk. The *bla*$_{\text{CTX-M}}$, *bla*$_{\text{SHV}}$ genes were detected and characterised as described previously (ESBL-PCR) [67]. Genetic relationships between *Klebsiella pneumoniae* and *Enterobacter cloacae* isolates were investigated with the pulsed field electrophoresis method (PFGE) using *Xba*I restriction endonuclease according to the standardized PulseNet protocol [68]. Results were interpreted and pulsotypes were assigned in line with the criteria set by Tenover et al. [69]. The selected *K. pneumoniae* blood isolate was subjected to multilocus sequence typing (MLST) according to Diancourt et al. [70].

Statistical Analyses

The Mann-Whitney U-test, Wilcoxon- test, and Student's t-test were used, as appropriate. Level of significance was set at $p<0.05$. Statistical analyses were performed with SPSS 19 (IBM Corp., Armonk, NY).

Knowledge Survey for Students

Also within the mentioned retrospective period, simultaneously with the multitask IC intervention at the NICU, knowledge assessment was performed via a questionnaire on HH among nurse students. The students who participated in the assessment were already involved in patient care during their practice, therefore they hold the possibility of spreading pathogens in the healthcare environment. The questionnaire aimed to assess the basic knowledge regarding HH among the participating students attending at higher and lower educational courses. These students had active gradual student status in the 2011–2012 autumn semester either at the Faculty of Health Science and Social Studies in the BSc Nursing and Patient Care nursing specialization program (college students) or at the Secondary Vocational School (certification course students).

All together 126 questionnaires could be evaluated. All of the participating students have already attended at practices at healthcare facilities by the time of our knowledge survey. The participants were selected in a non-randomized manner, namely the students who were present on the specific day when the IC unit visited the Faculty and Secondary Vocational School and agreed to fill in the questionnaire were included in the study. This meant a total of 48 college students and 78 certification course students). The questions were gathered from the „Hand Hygiene Self-Assessment Framework 2010" and the „Hand Hygiene Knowledge Questionnaire for Health-Care Workers" published by the WHO and were mixed with our own questions. Both above mentioned official questionnaires are available on the webpage of the WHO. A total of 20 points could be reached on the questionnaire with each good answer giving one point. The questions which were adapted from the two WHO questionnaires are related to the following topics:

- Assessment of knowledge on HH
- Knowledge regarding the potential materials and tools to clean hands and their usage
- Preventive measures against nosocomial infections
- HH promoting techniques

Our own questions aiming to supplement the WHO questions:

- Questions dealing with compliance
- Questions dealing with everyday HH practice

Results

Compared to the retrospective period, in the prospective period the average number of patient-days decreased from 343.72 days per month to 292.44 days per months, though this difference is not significant (p=0.058). In the prospective period a significant reduction was observed both in the number of colonised (from 72/188 to 26/167; p=0.029) and infected patients (from 9/188 to 3/167; p=0.033) when compared to the retrospective examination interval. It is worth mentioning that in the retrospective period five infected patients died, while no deaths occurred after the introduction of the new measures.

The number of invasive mechanical ventilation days per patient care days was also decreased significantly, almost by 50% (Table I).

Table I. Descriptive statistics of the study parameters from the two examined periods.

Variables	2011 January–September Retrospective period	2012 January–September Prospective period
Patient day /month	324.50 (306.00-403.5)	296.00 (175.50-376.50)
Admitted patients/month	22 (14-28)	19 (15-22)
ESBL colonised patients	7 (1-15)	2 (0-8)*
ESBL nosocomial infected patients	2 (0-4)	0 (0-1)*
ABHR consumption/L	26.5 (19.5-34.5)	32.5 (23.0-46.4)*
Monthly mechanical ventilation days / ventilated patients	9.77 (5.88-18.11)	5.00 (3.24-8.88)**
Performed hand hygiene/patient/day [*average*]	27.39 (17.22-31.08) [*26,02*]	39.17 (33.28-44.07)*** [*33,6*]

Values are given as median (minimum-maximum). The significance of the given parameter between the two periods is indicated at: *p<0.05; **p<0.01; ***p<0.001

There was no statistically significant difference between the two examination phases in terms of the cost of antibiotic consumption related to patient-days (from 7.5 euros/patient-day to 6.3 euros /patient-day, p=0.519).

Regarding the samples taken from the ESBL-positive patients, during the whole interval, 26 out of 29 *Klebsiella pneumoniae* isolates exhibited pulsotype Z, and the remaining three isolated were of the KP083, KP085 and L pulsotypes. The pulsotype Z isolate belonged to sequence type 525 and harboured the $bla_{\text{CTX-M-15}}$ ESBL gene. As for the 25 *Enterobacter cloacae* isolates studied, 23 belonged to bla_{SHV}-bearing pulsotype EbC052, one to EbC054 and another to EbC038.

170 environmental swab samples were taken during the intervention period (October to December 2011). These samples were collected from 107 critical and 63 non-critical surfaces. 25 out of 107 critical and 14 out of 63 non critical surface samples were culture positive, respectively, thus highlighting inadequately cleaned areas. Of these samples, a few were taken from a wash basin, three taps, a common warming bath for feeding bottles and the dish tray in the nurses' room; all of these contained ESBL-producing *Enterobacter cloacae*, belonging to pulsotype EbC052. In February 2012, we also took samples from HCWs' stool in search of ESBL-producing bacteria and further potential sources of infection because these caregivers are in close, direct contact with the infants. Two samples from 32 HCWs showed ESBL-producing *Escherichia coli* positivity; however, no infants showed ESBL-producing *Escherichia coli* positivity at the ward.

In a comparison of the two periods under examination, a significant increase can be seen in the prospective period regarding the consumption of AHR solutions (p=0.03). In the first phase this represented an average of 77.90 L AHR per 1000 patient-days, while in the second interval this figure increased to 114.96 L per 1000 patient-days. Compared to the baseline data at the beginning of the retrospective period under examination (81 infected and colonised patients out of 188 inpatients leading to 26.18 ESBL-positive patients per 1000 patient-days), a significant reduction can be seen in the incidence of ESBL-positive patients by the end of the prospective phase (only 29 infected and colonised patients out of 167 inpatients leading to 11.01 positive patients per 1000 patient-days, p=0.02), as it is clearly visible from Figure 7.
Indirect HH compliance showed a significant increase in the prospective examination period compared to the retrospective examination period ($p< 0.001$) (Figure 7).

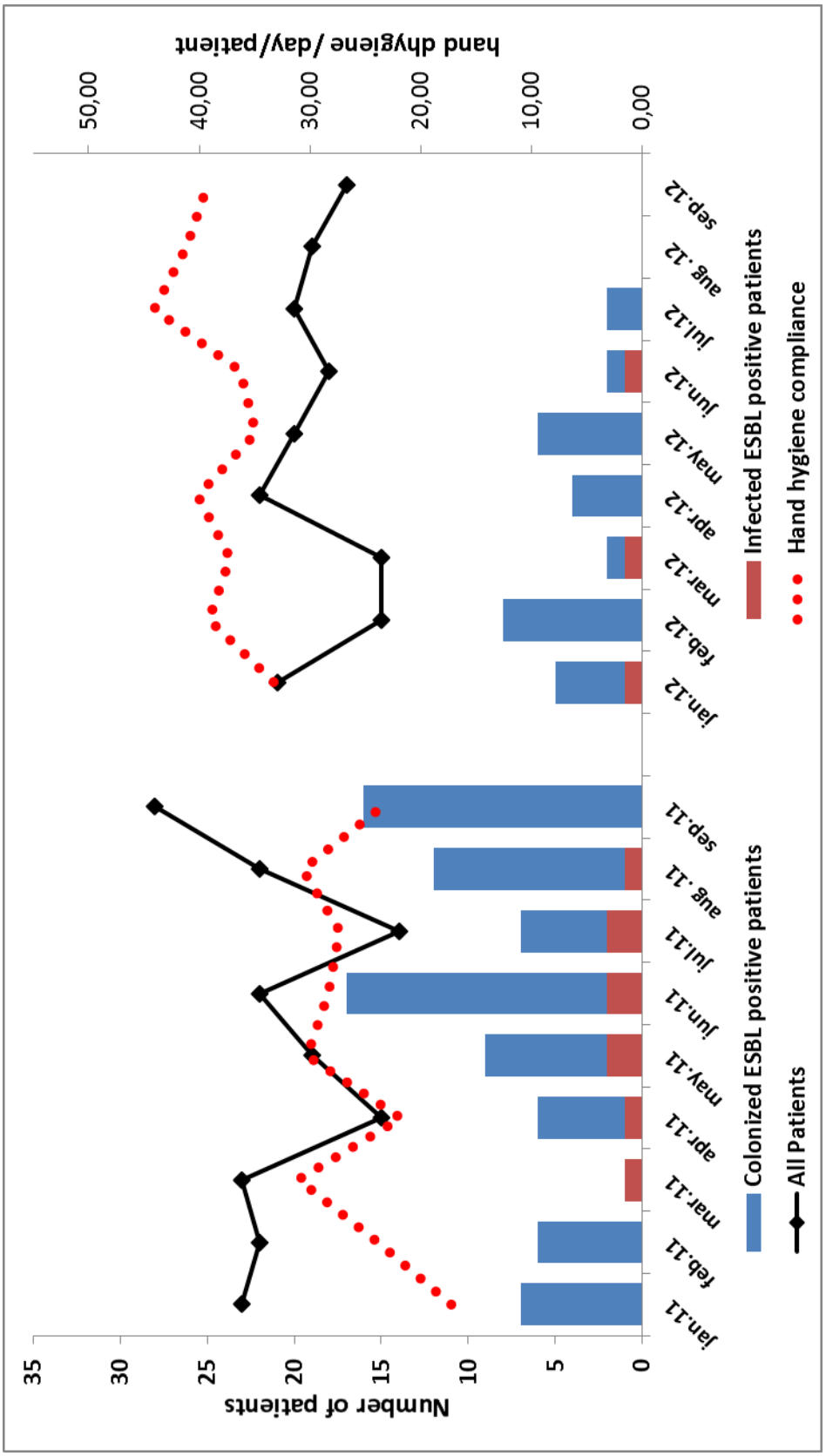

Figure 7. Comparison of the retrospective and prospective periods in terms of colonisation, infection and hand hygiene compliance "hand hygiene/day/patient" refers to the number of hand hygiene procedures performed in the case of one patient during one day at hospital.

In the retrospective phase, 26.02 HH procedures were performed on average per patient per hospital day, and this increased to 33.6 in the prospective phase**.** As a result of the HH education performed for the staff and with the useful aid of a UV lamp for supervision, the efficacy of hand cleaning among HCWs also improved significantly. In the retrospective period, when HH practice was examined, the nail beds and dorsal surfaces of the thumbs were usually missed (perfect results were only achieved in 14% of the cases). During a three-week period, staff was supplied with a UV lamp for detecting fluorescent AHR to provide them with an opportunity to practice and evaluate their own HH technique. During the UV lamp-supported training, perfect HH practice increased to 77%.

Regarding the knowledge test among students there was no significant difference between the levels of correct answers between the two students groups, thus their knowledge regarding basic HH seemed to be similar. (OR: 0.984 95%; CI: 0.954–1.016). Only 41.3 % of the students recognised the contaminated hands as the main source of cross-infection in patient care. Only 19% of the responders identified the patient as one of the potential sources of HAIs, which is deemed the most important source by the WHO. Fortunately 83% of the responding students are aware of the fact HH with AHRs is more effective against pathogens than hand-washing with soap and water. In respect to this a lot of students could give correct answer to the question dealing with which HH technique (hand-washing with soap and water or HH with AHR) to use in different situations (OR: 0.721 95%; CI: 0.535–0.972). On average the reached value was 60.36% (SD: 11.57%). The worst values were 30% (for 3 students), but there was one who managed to reach 90 % with his answers.

Discussion

IC has a remarkable historical connection with the paediatric population. Ignác Semmelweis already found a link between HH and perinatal infection rates in the nineteenth century [71].

The aim of our intervention was to roll back colonisation and infections caused by ESBL-producing bacteria at our NICU, and as our results suggest, we have managed to reach that aim. Most importantly, there was a sharp decrease in the number of patients colonised and infected with ESBL-producing bacteria after the above mentioned steps were implemented. Invasive mechanical ventilation days were successfully reduced almost by half. This result is mostly due to the introduction of INSURE therapy [72–73]. However, INSURE not only caused a decrease, but also reduced the chance of ventilator-associated infections and so contributed to the drop in late bacterial colonisations and the occurrence of late onset sepsis and thus may have contributed to the fall in late invasive ventilatory support demand [74].

ESBL-producing Gram-negative bacteria can survive on environmental surfaces, preferably in moist sites, for weeks; environmental decontamination is therefore a highly important issue in ICUs [75]. In accordance to other studies [76–78], we also detected ESBL-producing bacteria on moist surfaces and places. After an evaluation of the results and an identification of possible sources, the usage of wash basins was minimised and the dish tray was removed permanently from the nurses' room. Also, the local specific warming method (i.e. that all feeding bottles were warmed in a common warming bath) was immediately banned from the ward and the bottles were warmed individually from that point on. As a further preventive measure, the water in these new individual warming devices was also changed several times a day, and devices were cleaned with disinfectant solutions after use and stored dry. This intervention caused a remarkable reduction in the number of new ESBL-positive patients.

In the study carried out by Lin et al. the potential sources of infection at the NICU were the gastric tubes, the incubators and the healthcare personnel [63]. Although none of the mentioned surfaces or the care providing staff were justified as real sources of infection, with the multistep intervention we managed to improve these fields also. The quality of cleaning critical surfaces near the patients improved, as none of these surfaces have produced positive samples after the introduction of the new cleaning regimen.

We also carried out faecal sampling from HCWs' stool in search of ESBL-producing bacteria. Although two samples from 32 HCWs exhibited ESBL-producing Escherichia coli positivity, no infants showed positivity with this specific species at the ward. Therefore, the two positive cases cannot be regarded as potential sources of the infection, which occurred among the infants.

Patients in the NICU are more likely to be infected by MDR microorganisms and most of these infections are spread by carriage of microorganisms on the HCWs' hands, thus outbreaks of infections resulting from cross-transmission are frequent here [38]. This is justified by several studies pointing out that microorganisms that cause nosocomial infection in NICU are most commonly transmitted by the hands of physicians, nurses, physiotherapists, and other hospital personnel [79–82].

It has been emphasized that HCWs' compliance with HH protocols in the NICU is highly important to limit the spread of pathogens by the hands of HCWs and thus to prevent nosocomial infections [83]. In the process of improving HH compliance it is a key element to clarify those essential questions in the field of HH which could either cause confusion among HCWs or they were under the influence of anecdotal misbeliefs regarding these questions or topics, inhibiting them from reaching adequate HH compliance. By analysing the collected questionnaires from nurse students, knowing the possible weak points in HH from previous surveys, reviewing current evidence in the literature in this topic, and also with the experience gathered on the field during the direct observations and regular supervisions in practice, 10 key questions were highlighted and discussed thoroughly:

1. Is it really true that we do not have enough time for HH in practice?

HCWs many times state that there is no time for HH due to the stressful environment and excessive workload. Nurses also tend to say that the reason behind the inadequate HH rates is the not enough nurses for the number of patients needing treatment, which leads to inappropriate HH practices. According to the recommendation of the WHO, the key element of hand sanitizing is the usage of AHRs [16].

During this the disinfectant is spread onto the hands of the individual who rubs them together till the product dries, producing its antibacterial effect and eliminating all pathogens (approximately within 20-30 seconds). This technique is used during patient care in every situation when the hands are not visibly contaminated or dirty, and also before putting on or removing gloves. The newest HH regulations and recommendations have been adapted to the raised time problem, since the previous recommendation of at least 2 minutes of hand rubbing has been modified to 20 seconds [17]. This is in accordance with the study of Voss et al. who demonstrated that at their ICU, the usage of disinfectant soap for HH took 17% of their total working time compared

to the usage of AHRs for the same amount of HH events, which only took 3% of their working time [34]. If the infection control team provides access to and education on the latest HH guidelines, and simultaneously the HCWs adapt to these, they will have enough time to perform HH adequately whenever necessary.

2. Do AHRs dry the hands?

According to the guideline developed by the WHO, when HCWs do patient care, they must perform HH in the following 5 cases: before and after direct contact with patients, after having direct contact with patients' discharge, before performing aseptic intervention, and after having direct contact with the surroundings of patients [16]. If the hands of HCWs are not visibly covered with blood or discharge, then the adequate HH procedure in these cases means the usage of AHRs. Some HCWs admit that they intentionally avoid using AHRs, since they think that no matter which type they use, all AHRs would damage their skin. This can only happen if the management thinks that there is no difference among AHRs, and they buy the cheapest ones, which can lead to skin damage for some HCWs. Several studies have shown that the quality of the used AHRs influence whether it damaged the skin or not. It is interesting to note that the potential harmful effect on the skin is not caused by the active agent in the solution, but by the additives (e.g.: colorant) and impurities. Products of good quality are free of these and even contain emollients [75, 84].

If the application of AHRs causes pain, then it is not surprising that HCWs will try to avoid its usage in a way that they simply wash their hands with water and soap instead of the use of AHRs. This violation of IC regulations can pose great threat to all participants in the healthcare sector, since in this specific case the HH event performed by the HCW will not guarantee patient safety as hand-washing only reduces the number of bacteria and pathogens on the hand. But hand-washing removes the emollients and moisturising factors of the skin which jeopardises the safety of HCWs. If we list the most frequent occupational diseases among HCWs, skin diseases are in the second place, right after musculoskeletal abnormalities [85]. 80% of occupational skin diseases are contact dermatitis [86].

Damaged skin can get invaded and colonised by pathogens easier than intact skin [87]. In the study of Larson et al. samples were collected from nurses' hands on which dermatitis has developed earlier and *Staphylococcus hominis*, *Staphylococcus aureus*, Gram-negative bacteria, *Enterococci* and *Candida* species could be identified from the samples [88]. Therefore when trying to choose the proper AHR, the HCWs' individual sensitivity, should be the most

important factor rather than the price of each product, which means the provision of those product for the staff that their skin could tolerate the most. This is the first principle, which can improve those HCWs' HH compliance who use these products many times during their work [89]. It is advisable to keep multiple AHR products in healthcare facilities with many employees, providing a choice for each HCW based on their own perception and sensitivity. In practice, this is accomplished by firstly collecting the names of the already tried and preferred products from the staff, and then competing them in order to choose the ones with the best value for money. Professionals should encourage the management team to do so in the future.

3. Is it true that the alcohol within AHRs could reabsorb through the skin and the airway, and even alcohol abuse may develop?

Studies dealing with this matter found no or barely traceable amount of alcohol in the blood as a result of using AHRs, and also no accompanying symptoms were documented [90–92]. In the study of Turner et al. it was pointed out that by the frequent use of AHRs containing 52.6% isopropyl alcohol (in every 10 minutes for 4 hours) the collected blood samples showed 0.005-0.18 mg/dL isopropyl alcohol levels in 9 out of 10 cases. However, in order to form a mild intoxication, at least the level of 50 mg/dL of alcohol is necessary [91]. Also the reabsorption of propanol is negligible, so it cannot produce acute toxic symptoms, and since the human metabolism can rapidly process propanol, it cannot accumulate in the body. Although Brown and his colleagues found that by the use of ethanol-containing AHRs intensively and frequently (in their study it was 30 HH events in 1 hour), mild amount of ethanol could reabsorb through the skin. Some amount could also be inhaled from the solution, while it had been evaporating from the hands, in cases when the operator had been in closed places [90]. These amounts were not enough for ethanol probes to indicate alcoholic influence during roadside surveys. Interestingly, Kinnula et al. showed that AHRs were even safe to be used by children in kindergarten, which could aid the prevention of viruses transmitted via hands in this specific community [93].

4. Is HH truly responsible for the elevated Bisphenol A (BPA) levels in the human body?

BPA is one of the chemical agents that are produced in the greatest amounts in the world, and its hazardous effects on general health (leading to e.g. hormonal disorders, heart disease, asthma,

obesity, etc.) are well documented. It is clear that AHRs or soaps do not contain BPA. The misconception of linking AHRs to BPA is related to the fact that the surface of the receipts from cash terminals, cash registers, fax machines and medical analysing machines are covered with BPA. The study by Hormann et al. found that if AHRs were used to clean hands, and subsequently thermal receipt paper had been held for more than 45 seconds, the penetrating agents within the AHR solution could aid the dissolution of the BPA from the paper [94]. If this was followed by eating with hands, BPA could get into the individual's mouth and be reabsorbed through the oral mucosa. This was the basis for the rumour that was spread in social media encouraging people to not use AHRs anymore. Clearly, this reflects the complete lack of knowledge or even the most basic understanding of HH regulations in healthcare, or even the most fundamental regulations of basic personal hygiene. Albeit the mentioned social media reaction is not only not evidence-based, but also a distortion of misunderstanding and lack of knowledge, still it holds some useful information for HCWs, namely to avoid unnecessary touching of these thermal receipts, or if someone is working with these constantly then protective gloves should be worn.

5. Should the hands be washed first, and then disinfected or should it be the other way around? Is the order of hand-washing and hand disinfection important at all?

There are two ways to do HH procedures: either washing hands with disinfectant soap and water, or disinfecting the hands by rubbing them together with AHRs [16, 55]. While the purpose of applying AHRs is to eliminate the transient flora from the hands, the aim of using disinfectant soap with water is not just the elimination of this flora, but to remove the impurities and dirt from the hands as well. This is possible due to the unique composition of these disinfectant soaps (which contain surface-active agents). The same effect can be attained in 2 steps when there is a separate hand-washing with regular soap and water prior to the use of AHRs. The order of these two steps has changed many times in the past few years, making it extremely difficult to be incorporated into everyday practice. In 1973 only regular soap was available for cleaning hands, thus the HH procedure then was performed using the two separate steps mentioned above. Back then the Ministry of Health ordered in their official recommendation titled "Personal disinfection" that when dealing with communicable diseases hand disinfectant solution should be used prior to performing hand-washing with soap and water to avoid the contamination of the soap, tap and sink. This was to be followed by another hand rubbing with AHRs to eliminate any

potential remaining pathogens on the otherwise clean hands. This time consuming and complicated procedure was rationalized by the National Center for Epidemiology in their official recommendation, which applies to and is compulsory for all healthcare facilities [95–97]. It states that hands should be disinfected with AHRs at first, and what was eliminated by this solution should be washed off with soap and water. Currently, it is strictly forbidden to use any bar soap in healthcare. From 2009, according to the recommendation of the WHO, the usage of AHRs is the preferred choice for HH and hand-washing with soap and water should only be performed in exceptional situations, e.g. if the hands are covered with visible amount of organic materials (blood or discharge) [16]. Interestingly, in these exceptional cases the order of HH steps have been changed once more, namely the hands need to be cleaned with soap and water, and only after this should AHRs be applied. There is a logical explanation for this, since the perfect level of HH cannot be reached else way due to the fact that the highly and rapidly volatile AHR solutions are unable to get into direct contact with the surface of the skin because of the presence of organic materials on it. This is in accordance with the Hungarian National Guideline [17] and the Recommendation published by the National Center for Epidemiology [98].

Despite the fact that currently there are disinfectant wipes on the market in order to provide a solution to keep the frequently contaminated surface of taps and sinks promptly germ free, the WHO has not incorporated their usage as an alternative into their guideline. The reason behind this is the following: the sink and its surrounding is the most contaminated part of the care giving zone, enabling quite easy recontamination through the splashing water even in cases of elbow operated taps. It could be helpful to HCWs for maintaining the correct order of HH steps to provide them disinfectant soap instead of plan liquid soap, with which the procedure of HH could be performed in one session, if needed. This way the mix-up of these steps would be impossible, and performing hand-washing with soap and water instead of performing adequate hand disinfection could also be prevented.

6. When should we perform hand-washing with soap and water, and when should we perform just hand rubbing with AHRs?

Washing hands with soap and water is a mechanical cleaning action in a 0.5–1 minute long session, during which we just rub our hands together with the liquid soap in order to spread it evenly on the surface of the hands. Extra attention should be paid to the nail beds, fingertips and thumbs during this session [99]. After this the hands should be washed with running water and thoroughly dried by disposable paper towels. It is of key importance that by performing hand-

washing with soap and water we are not able to reach the sufficient reduction of bacterial counts, which is still not reachable through the extension of the time spent with the hand-washing [100]. The hands can easily become contaminated by water favouring bacteria (e.g. *Pseudomonas aeruginosa*) again when we touch the handles of the tap to close it, or even from the splashing water itself [101]. This is one of the reasons why AHRs should be used in all situations after hand-washing with soap and water (HH in two sessions). It should be emphasized that in case of treating patients with *Clostridium difficile* infection, mechanical cleaning of the hands by hand-washing is mandatory before using AHRs, since the AHRs are not capable to destroy the spores of this bacteria [102].

7. Do protective gloves provide perfect protection against pathogens? Is it really necessary to disinfect the hands before putting on or after removing the protective gloves? Can we extend the lifespan of protective gloves by disinfecting them while wearing, and can we use them again after removal?

The usage of protective gloves provides an important protective barrier for HCWs from the patients' blood or discharge, and from direct contamination from patients' skin or oral mucosa [103]. Wearing protective gloves can influence HH compliance, since it provides a safe sensation for the operator, which could easily lead to not changing the gloves between treating different patients, and it may potentially lead to cross-infection [104–105]. The study by Loveday et al. highlighted that missing HH events was frequently caused by HCWs wearing gloves, and also gloves were worn unnecessarily leading to a 37% increase in the risk of cross-infection [106]. Some HCWs previously thought that if gloves are worn to cover and protect the whole hand, then there is no need to use AHRs before putting them on. This doubt was shared by Rock and colleagues in their study [107], in which they took samples from the hands of HCWs before putting their gloves on. The two sampled group included one using AHRs and one omitting it before putting the gloves on. Their results showed no significant difference between the two test groups. Although another study showed that even an opened box containing unworn gloves can become contaminated (most frequently with Gram-positive bacteria) from HCWs' hands, if they touch the new gloves without a preceding hand disinfection [108]. These "new" gloves can be a potential source of infection regarding patient care. Therefore, it is fundamental to disinfect the hands before inserting them into this open box to remove a new pair of protective gloves. During their removal, both the environment [109], the hands and neighbouring parts, such as the wrist or forearm of the operator, [110] could easily become contaminated. It is also possible that the gloves become accidentally damaged (e.g. torn) or liquid (e.g. blood, discharge or bathwater)

can run down on the arm of the operator into the glove leading to the contamination of the hands. Thus, after the removal of the gloves, the hands need to be disinfected. Based on the current recommendations, it is strictly forbidden to reuse or disinfect the gloves [11]. According to the WHO regulations, only third world countries may be exceptions [16] due to their extremely poor financial resources. It is highly important that HCWs should be aware of and use correctly protective glove wearing indications, and they need to know the type of gloves they should use in different situations (e.g. sterile gloves or protective gloves), and they definitely should be aware of the fact that both before putting on and after removing gloves, disinfection must be performed [16, 111].

8. Is the spread of infections via a contact pathway (i.e. with the hands) related only to the HH compliance of the HCWs?

Several studies draw the attention to the fact that not only the hands of HCWs, but also the hands of patients can play a potential role in the spread of infections [112–114]. After sampling the hands, mostly Gram-negative [113–114] and *Staphylococcus aureus* among Gram-positive bacteria were identified [112]. HH performed after the fifth moment of HH, namely after the contact with patients' surroundings is very important, since most of the pathogens present in the body or on the skin of the patient can usually be found within the patient's zone, which is a spherical area of 3 metres in diameter centred around the patient. The reason for its existence is the fact that patients during their everyday movement often touch the surrounding surfaces around the bed, which can harbour germs for a long time [115]. Many of these surfaces (e.g. the handles and other surfaces of the bed and bedside desk) are often touched by the HCWs, which can lead to hand contamination by the bacteria mentioned above, originated from patients. This leads to the conclusion that simultaneously with doing HH education for the staff, the education must emphasize patient HH as well [116]. The patient zone is often "invaded" by visitors, even their hands can become contaminated. This was the finding of Birnbach and colleagues who took samples from visitors' hands at an intensive care department [117]. In this study the samples gathered from visitors who performed HH was negative in all cases, whereas the ones gathered from patients not cleaning their hands showed positive results for culturing. Among the detected bacteria from visitors' hands, 12 different species were pathogens, mostly those that are related to HAI (mostly Gram-negative bacteria, but MRSA was also spotted in one case). HH compliance of patients and visitors are sensitive issues, therefore, despite its importance, only limited amount of research has been dealing with it. However, it was already noted in 1996 that

only 7% of visitors perform HH before touching an ill child [118]. Later, Randle et al. received better results in this field with 56% of patients, and 57% of visitors performing HH [119]. There is a theory that in order to increase the HH compliance of HCWs, patient should be encouraged to draw the HCWs' attention to disinfect their hands before performing patient care [4].

9. Can it be allowed for HCWs to wear artificial nails or nail polish during work?

Artificial nails and long nails can tear protective gloves. Artificial nails not only lead to the thinning of the underlying normal nail structure, but tapping their tips to hard surfaces can also cause slight, unnoticeable detachments in the underlying nails, leading to the development of a gap between them. This gap can be contaminated by dirt or hand cream, and once this happens, it is impossible to remove them from the gap, leading to the colonisation and spreading of bacteria and fungi in this narrow area [120].

Several studies indicate that there is an epidemiological connection between wearing artificial nails and spreading infections and outbreak caused by Gram-negative pathogens (especially *Pseudomonas aeruginosa)* [121–123].

The study by Moolenaar et al. conducted in a neonatal intensive care centre showed that not only the artificial nails, but natural long nails of HCWs could also play a role in the occurrence of *Pseudomonas aeruginosa* outbreak [124]. In order to reach both patient safety and HCW safety, HCWs (especially surgical staff) must not wear artificial nails, and their nails must not be longer than the tip of their fingers [125].

Regarding the usage of nail polish, some studies showed no significant difference between the amounts of pathogens on the hands of HCWs using nail polish compared to the ones without the use of it [125]. Although another study found a significant difference in nail contamination between those HCWs who used nail polish and kept it in a good condition, and those who used nail polish and let its condition deteriorate (e.g. cracked upper layer, or some parts missing) and those HCWs who did not use nail polish. From these groups bacteria mostly favoured the damaged or incomplete nail polish layer [126]. It is important to note that the nail polish can obscure any impurity or dirt stuck beneath the nails. Furthermore, nail polishes are not for single use, meaning the whole bottle can become contaminated, especially in beauty salons, where they use the same bottle and applicator for multiple customers. Wearing artificial nails or using nail polish is strictly banned from healthcare by the recommendation of the WHO [16] and the CDC [127]. The Association of periOperative Registered Nurses even advises HCWs to avoid the use

of new nail solutions (e.g. gel or shellac) due to the limited empirical evidence on them, and because of the potential similarity with the compounds found in acrylic artificial nails [128].

10. Can it be allowed for HCWs to wear rings (e.g. wedding ring) during patient care?

HCWs usually give the following explanations for not removing their ring during patient care: "I do not want to lose it, and if I removed it, I would surely do so" or "It is stuck and I cannot remove it" or "This is my wedding ring, therefore I must not remove it". According to the literature, wearing a ring during patient care is a well-known source of potential cross-infection in healthcare [129–130]. Since the adequate cleaning of the nails and nailbed is a difficult task, this is one of the main focus in teaching how to perform adequate HH with AHRs. If the HCW is wearing a ring, it is likely that we will find more microorganisms on his hand compared to someone not wearing a ring. Hoffman et al. managed to show that even *Enterobacter cloacae, Klebsiella pneumoniae, Acinetobacter calcoaceticus* and *Pseudomonas aeruginosa* can be present on HCWs hands, if they wear rings, and if rings are worn constantly, this will lead to such severe contamination of the hands that could not be removed with routine HH procedures [130]. This is in accordance with other studies stating that *Enterobacteriacae* species frequently and significantly colonise the hands of HCWs wearing rings [131–132], and consequently can easily lead to HAIs. Moisture can get trapped under the rings serving as a potential nutritional source for bacteria and even for irritating agents (e.g. particles from the powdered protective gloves) can get trapped under it, leading to contact dermatitis. Furthermore, rings can tear the gloves hinder their protective barrier function and diminish the barrier between the skin and the touched surfaces or materials, etc. [133]. Moreover, wearing rings can even cause occupational accidents, for instance, when the ring adheres to or sticks to something. Therefore both the WHO and the National Center for Epidemiology advises HCWs to stop wearing rings during patient care [16–17].

The above detailed correct answers were explained to the HCWs in small groups, and they have been published in order to aid the education of all healthcare personnel in our healthcare facilities and other Hungarian ones also [29]. As a result of the hygienic interventions, namely the examination of hands under UV light and small-group training sessions for clinicians and staff, including instruction on correct HH procedure, indirect HH compliance showed a significant

increase. Our results are in accordance with Zahar et al. [134], who also found a significant rise in AHR use in the period following interventions.

If looking at international data, Hansen et al. analysed data from 24 countries and 309 hospitals on AHR availability and consumption, to determine the structure and performance of HH in hospitals in Europe [13]. Their findings on AHR consumption showed a median hospital-wide consumption of 21 mL/patient-days, which is in accordance with the Point Prevalence Survey of HAI and Antimicrobial Use in Europe showing an average 18.7 mL/patient-days in 805 hospitals in 2011–2012 [135]. This low data must be considered with caution since AHR usage varies by hospital type, with lower consumption in primary and secondary hospitals, which is not surprising, given that there are fewer HH opportunities per patient-days in such hospitals. At ICU and NICU level this amount is usually much higher. Moreover AHR consumption among the ICU data varied between countries: consumption was higher in Western Europe (average 81 mL/patient-days) than in Eastern Europe (average 48 mL/patient-days). In the same study, the supervised ICU's in Hungary presented an average 49 mL/patient-days in AHR consumption. This is lower than even our initial AHR consumption before the interventions (in the first phase this represented an average of 77.90 mL/patient-days), showing that the reached AHR consumption at our NICU can be considered superior (in the second interval the amount increased to 114.96 mL/patient-days). Though it must be mentioned that the provided and mentioned data by Hansen et al. are for ICU departments and not specifically for NICU [13]. Variations in key IC practices in Europe have been reported in the literature, and could be explained by differences in resources, social and legal perspectives, and cultural norms [136–137].

Currently it is clear that HH is recognized as the single most important measure for preventing the spread of HAIs [16, 127] and has been embraced as a standard for healthcare settings by the CDC, the WHO and The Joint Commission as a critical component of IC programs [138]. Such standards mandate that to promote HH compliance, HH resources must be made readily accessible at critical locations, and behaviour change must be supported through the use of a multimodal strategy that includes education, training, monitoring, feedback, and organizational support [16, 139]. These principles are reflected by evidence reported in the literature [140]. Previously published HH programs typically consist of some combination of the following: education, engaging HCWs accountability, visual cues, reminders, convenience, availability and

easy access of hygiene products, warning signs, electronic surveillance, alarm systems, and even the use of family and patients as monitors [6].

HCW compliance with HH is universally acknowledged as one of the most important tools in preventing transmission of HAIs [16, 141]. However, compliance has still not risen to acceptable levels. Inadequate HH compliance is a multifactorial phenomenon. In order to achieve better results in this field, one should be aware of the potential burdens at each healthcare facility (e.g.: lack of knowledge about expected standards, low priority, forgetfulness, time constraints and inaccessible HH supplies, etc.) [142].
Regarding the problem of inaccessibility to HH supplies, the WHO recommends a 'system change', which includes the availability of AHRs at the point of care as one key component of its 'Clean Care Is Safer Care' campaign. Dispensers should be located at the point of care to assure access to AHRs, and make HH moments easier to perform [16, 143]. Though this key element cannot be implemented without involving the management in this fundamental issue. IC professionals play an essential role in bringing different stakeholders and interests together in order to improve HH and IC [144]. During our multimodal intervention greater accessibility has been achieved by placing AHR dispensers in the vicinity to the infant incubators and by distributing individual bottles of AHR to HCWs. According to Thomas et al. the location of the AHR dispenser is more important than the quantity of dispensers on an ICU [145]. In their study, the AHR dispensers were secured at the end of the patient's bed with a special apparatus in a way that the dispenser remains at eye level for attendants standing at bedside. This location led to a higher volume of use for AHRs compared to placing dispensers at the customary locations. This was confirmed by Birnbach et al. who found that if the location of an AHR dispenser was in clear view of the physicians this resulted in better compliance [146].

Furthermore it is well known that globally, the level of SPs compliance, knowledge, and attitudes among HCWs is considered to be low [147–149]. Nurses are frontline HCWs and have the most direct contact with patients, thus their compliance towards and knowledge on HH and IC is of pivotal importance [150]. Previous studies by Efstathiou et al. and Gammon et al. indicated that the compliance rates of SPs among nurses ranged from 9.1%-73% [151–152] necessitating improvement in this field. Pereira et al. showed that the compliance rate was 69.4% among 560 nurses in Brazil and 57.4% among 260 nurses in Hong Kong [153]. Irrevocably lack of knowledge of SPs is directly related to nurses' noncompliance [154]. Ideally, SPs training should be completed early in nurses' training as part of a formal education curriculum. This was the

reason why we included nurse students in our knowledge survey. The use of evaluation questionnaires is an important feature, especially in educational programs, because it permits measuring the effects of teaching and learning and possible changes in attitudes toward the discussed topic [155]. Our results showed that the knowledge of nurse students on HH and SPs is also low on general. The reasons for this must be identified and future improvements are needed in this field, though the results of our questionnaire should be considered carefully due to the limited number of students attending in this trial knowledge survey on HH and SPs. Also further specific education should be delivered and the results should be monitored with another questionnaire later on.

This is in accordance with the results of Xiong et al. showing that nursing students demonstrated low levels of knowledge and application of SPs, further highlighting the need to implement interventions to improve SPs uptake [2]. It is mandatory for nurse students to receive adequate information in these fundamental safety measures and the adverse consequences of neglecting them. Moreover it could be much easier for students to adapt to new requirements than to integrate them into the daily routine of someone who has not shown enough interest or compliance to these precautions or guidelines throughout the years of work. This corresponds also with the study of Xiong et al. demonstrating the significant effect of a mixed media intervention for nursing students applied at the beginning of clinical training [2]. This is confirmed by the finding that their compliance during the intervention was high. Trying to modify the behaviour of healthcare personnel has been a long battle.

As stated by Whitby et al., current models and theories that help to explain human behaviour related to health education can be directed at the level of: (1) the individual (intrapersonal); (2) interactions between individuals (interpersonal); (3) the community [156]. Intrapersonal factors are individual characteristics that influence behaviour such as knowledge, attitudes, beliefs, and personality traits. Interpersonal factors implicate primary groups that provide social identity, support and role definition, i.e. family, friends, and peers. Last but not least social cognitive models attempt to relate both intra- and interpersonal determinants of behaviour. Our understanding of behavioural theories and also the inability over several decades to motivate HCWs to achieve a consistently high level of compliance with HH suggests that changing HH behaviour is a complex task [156–157]. In our proposed multistep intervention, posters were placed at the ward to draw the attention to current, specific IC problems. The posters as reminders address the issue of ‘forgetting’, which has been identified as a common cause of missed HH

opportunities [127, 158]. The efficacy of posters have been confirmed by Nevo et al. reporting that compliance was improved when such posters were in the line of sight on entering the room [159].

Furthermore, aiming to produce peer and even leader pressure or motivation, the head of the NICU on purpose continuously paid attention to show a good example for the HCWs at the Unit. Marra et al. demonstrated that setting a good example for others as positive deviance was associated with a 2-fold increase in the use of HH products with significant reductions in HAI; and these gains were sustained over several years [160–161]. Positive deviants are usually frontline staff members who have been already recognized as having consistent and effective HH and therefore serve as role models. So far positive deviance has been used successfully to improve weight loss, student performance, and, more importantly in our case, adherence to HH practices [162].

Traditionally, strategies aimed at improving HH focused on the HCWs themselves, and typically involved behavioural modification or several observational techniques [163]. Unfortunately these strategies have yielded only short-term success [164–165], and the longer-term impact was negligible with often returning to baseline values [166]. In order to sustain the reached superior results compared to the baseline ones, continuous feedback was and is still provided by the IC task force to the wards.

Numerous strategies to increase and later maintain the frequency and effectiveness of HH indicate that education in combination with performance feedback is the most successful approach [82, 167]. A study by Conly et al. showed that when an education program was introduced the hand-washing compliance increased from 28% to 81% [172]. This increase was accompanied with a significant drop in the number of nosocomial infections. However, 3 years after the intervention (education), the number of nosocomial infection rose again, and the repeated survey draw light on a significant decrease in hand-washing compliance.

The same phenomena was discovered by Mayer et al. in an ICU showing improved compliance by providing performance feedback in the form of a daily memo to HCWs on their hand-washing frequency [169]. After 6 months a washout effect was noted, indicating the need to repeat the previous intervention. This leads to the recognition that in order to modify human behaviour such as HH habit, it is mandatory for interventions to be more specific and ongoing at regular intervals. This is supported by a later work of the same group who developed an intervention bundle that explicitly addressed cognitive behavioural factors and positive reinforcement with annual changes in incentives, resulting in significant improvements in HH sustained over 6 years

of follow-up [170]. Hysong et al. explored the characteristics of successful feedback associated with high levels of adherence to clinical practice guidelines [171]. He showed that the four important characteristics associated with high adherence were that feedback given was timely, nonpunitive, individualized, and customizable therefore it was meaningful to staff [171]. These principles are always integrated in our continuous feedback events, aiming to provide motivation and improvement. This is supported by multifaceted approach to HH which including education, reminders and feedback was effective in increasing HH compliance and improving rates of HAIs [172].

As stated earlier, currently direct observation of HH practices by a trained observer is still considered the gold standard for evaluating compliance [16]. Haynes and Horn were the first to investigate the reactive effects on behaviour improvement when subjects are being observed [173]. These findings have been consistently supported over the last 25 years, demonstrating that HH compliance improves when participants are aware of being under observation [174–175].Albeit as pointed out by Ward et al., covert direct observation of HH by a trained observer can be time-consuming, costly, limited, and subject to bias [176]. Direct observation is limited, however, providing only a "snapshot" of compliance behaviour and quality control. Deficiency in standardised criteria in the observation techniques for compliance permit variability, making interfacility comparisons impossible or misleading if carried out [177]. An alternative to human observers could be the use of video monitoring or other indirect monitoring using electronic surveillance, counting devices, and product volume tracking to improve assessment measurements [6]. Nowadays a wide-range of electronic or electronically assisted HH monitoring systems are being developed [178]. New technologies include automated counting systems (e.g., counters in pump bottles), video monitoring, and fully automated monitoring systems. The later mentioned surveillance technologies minimize human resources, feedback time, human error, and observation bias. Fully automated systems generally include a wearable/mobile component, ways to record all HH opportunities, provision of a feedback or reminder system, and, ideally, responses to HCWs' behaviour and actions [176, 179]. Video audits using computer software programs can provide immediate compliance data for feedback on performance to HCWs. Some studies found that immediate feedback coupled with direct monitoring effectively increases HH compliance [175, 180]. In one study video cameras were placed in ICU rooms with views of the sink and sanitizer dispensers. HCWs were made aware of round-the-clock video observations 16 weeks before feedback was provided. As a result HH compliance rates increased significantly, from 6.5% to 89% [181].

The video monitoring technology may create an enhanced Hawthorne effect as HCWs become aware that they are being monitored on a continuous basis [158]. Additionally, the ability to provide more frequent and individual level feedback should improve compliance [182].

At our healthcare facilities video monitoring has not been adapted due to possible incompatibility with personality rights, however, another electronically assisted HH monitoring system named Semmelweis Scanner has been launched. Since its introduction the Semmelweis Scanner has been involved in the daily IC supervision and education routine to aid evaluation and interpretation of HH practice for the HCW and for students also. This system consists of a monitoring device giving immediate feedback of the untouched areas of the hand after performing HH procedure [183].

Performance feedback is a core behaviour improvement strategy in healthcare and HH promotion [184]. With this specific system if an area remained untreated, it presented in red on a digital image which also calculates the extension of the untreated area making the efficacy of the HH procedure measurable and comparable. HH was considered sufficient if at least 95% of the hand's surface were covered with the hand rub solution, on the palmar and dorsal sides of both hands. As a valuable tool in this system a personalized card allowed to monitor the participant's improvement by saving the individual's HH data for future comparisons with himself/herself and other HCWs. Already known from the work of Ivers et al. [182] performance feedback is most effective when it is personalised, immediate, and accompanied by goal setting, this is fortunately integrated in this new system. With the aid of using the Semmelweis Scanner at the ward we managed to see and show the individual improvements to each HCW.

Conclusion

During our work, we could reach the aims of the study:

I. There was a significant increase in the number of HH events in case of HCWs at the NICU by implementing a multimodal strategy.
II. We could reducing the number of HAI and colonisations by identifying and subsequently eliminating all potential sources of the infections.
III. We implemented non-invasive treatments at the ward which lead to the reduction of device-related infections.
IV. We assessed the actual knowledge of nurse students on HH and identified potential factors related to future insufficient HH compliance.

It is universally agreed that the prevention of HAIs is an important patient safety activity, and good HH has both a financial and ethical imperative. Therefore hospitals are under enormous pressure to improve HH and reduce HAIs. In our proposed case, rolling back ESBL-producing bacteria at our NICU was successful. We attribute this success mainly to the multidisciplinary approach, the continuous feedback and monitoring, and the high compliance of the staff. Although the staff of a NICU is in closer contact with neonates, compared to a ward with older patients, colonisation of HCWs did not play any role in the nosocomial persistence of ESBL-producing bacteria. Applying a multimodal approach involves the use of multiple strategies simultaneously. Our proposed multimodal IC strategy process constituted of 3 critical steps: measuring baseline compliance rate, identifying barriers, and instituting measures to remove barriers prohibiting effective HH. This multimodal intervention is verified by multiple studies proving that behaviour change must be supported through the use of a multimodal strategy that includes education, training, monitoring, feedback, and organizational support. Despite the diversity of participants in our case, the data collected from HCWs was useful to identify focused areas for improvement and eventually led to improvements in compliance. As stated by Pittet parameters for noncompliance with HH are not just related to individual health professionals, but also to the team and the institution they belong to. HAI prevention is the responsibility of everyone, and cannot be delegated to experts in the field of IC and prevention. However, IC activities need to be organized and managed by competent experts in the field.

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APPENDIX

I.

NAGY KAMILLA
SZÉL BORBÁLA

Kézhigiénés compliance fejlesztése a Szegedi Tudományegyetemen

Improving hand hygiene compliance at the University of Szeged

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Összefoglalás: A világ fejlett országainak egészségügyi ellátásában egyre nagyobb hangsúlyt kap a betegek biztonságának kérdése, melyben kiemelt téma az egészségügyi ellátással összefüggő fertőzések megelőzése. A kézfertőtlenítés jelentőségét nem lehet eléggé hangsúlyozni ebben a prevencióban, mivel a szakma által leginkább ajánlott alkohol alapú kézfertőtlenítőszerek higiénés kézfertőtlenítésre előírt behatási ideje mindössze harminc másodperc és a hatékony kézfertőtlenítés technikájának elsajátítása is egyszerű. Ezt felismerve a WHO a „Tiszta betegellátás – biztonságosabb betegellátás" (CLEAN CARE IS SAFER CARE PROGRAM) részeként meghirdette a „Ments életeket: moss kezet!" (SAVE LIVES: CLEAN YOUR HANDS!) szlogenű kampányt, mely a kézhigiéne fejlesztését tűzte ki célul. A „Kézhigiéne az egészségügyi ellátásban" című, 2009-ben megjelent WHO irányelv [1] és az ennek alapján készült Országos Epidemiológiai Központ [2] által készített módszertani levél tudományos bizonyítékokon alapuló ajánlásokat tartalmaz az egészségügyi szolgáltatásban szükséges kézhigiéne gyakorlatához. Szerzők e szakmai irányelvek mentén szervezik intézményükben a betegellátásban résztvevők kézhigiénés compliance-ének fejlesztését.
Kulcsszavak: egészségügyi ellátással összefüggésben kialakuló fertőzések, kézfertőtlenítés, alkohol alapú kézfertőtlenítőszerek, biztonságosabb betegellátás, kézhigiénés compliance fejlesztése

Summary: Recently in the developed countries patient safety is highly emphasized in healthcare settings, particularly the issue of preventing healthcare associated infections. Hand hygiene is essential in the above mentioned prevention process because not only the contact time of alcohol-based hand disinfectants, wich are the materials of choice for most of the professionals, is only 30 seconds, but also the application is easy to learn and to carry out. This was recognized by the WHO and as a result of this, as part of the „CLEAN CARE IS SAFER CARE" program the „SAVE LIVES: CLEAN YOUR HANDS!" campaign was introduced. The aim was to improve hand hygiene. The guideline published by the WHO in 2009 titled „Hand hygiene in healthcare settings" and the guideline made by the National Center for Epidemiology in Hungary based on the WHO guideline contain evidence based recommendations for the necessary hand hygiene practice in healthcare. The authors organize and improve the hand hygiene compliance of healthcare workers based on the mentioned principles and guidelines in their institutions.
Keywords: healthcare associated infections, hand disinfection, alcohol-based hand rub, safer care, improvement of hand hygiene compliance

BEVEZETÉS

Sebille és munkatársai tanulmánya [3] egyértelműen bizonyítja a hatékony kézhigiéne jelentőségét a fertőzés megelőzésben. Kimutatta, hogy az egészségügyi személyzet pusztán kézhigiénés gyakorlatának a javításával (azaz, ha csak 60%-ban emelné a kézhigiénés compliance-ét), az általa ellátott betegek között pl. az MRSA terjedését akár 20%-kal is tudná csökkenteni.

Ez a lehetőség igen nagy felelősséget ró az egészségügyi személyzetre, hiszen annak a betegellátónak a kezében, aki nem eléggé eredményes a kézhigiénében, – még ha jó szakember is – nincs biztonságban a beteg!

Nagy a felelőssége e téren a menedzsmentnek is, a hatékony kézhigiéne személyi és tárgyi feltételeit minden esetben biztosítani kell.

A legnagyobb a felelősség talán mégis a kórházhigiénés szakembereké. A Szegedi Tudományegyetem Kórházhigiénés Osztályának dolgozói szerint, a kórházhigiénés szakemberek szakterülete meghatározni azokat a munkamódszereket és eszközöket, amelyek segítségével a betegellátás higiénés feltételei megvalósulnak és a betegellátó tevékenység e tekintetben is megbízhatóvá válik. Ezeknek a szakembereknek olyan képességgel is rendelkezniük kell, hogy eredményesen át tudják adni a fertőzések megelőzéséhez szükséges ismereteket a kollégáiknak, úgy a közvetlen betegellátóknak, mint a háttér szolgáltatásokat nyújtóknak, és fel kell tudni hívni az intézményük betegellátását irányítók figyelmét is a kézhigiénés szabályok betartásának és betartatásának létfontosságára.

Az egészségügyi ellátással összefüggő fertőzések megelőzésének létfontosságát hirdeti az Egészségügyi Világszervezet Londoni Nyilatkozata is, amikor kimondja: „Az egészségügyi ellátás során elkövetett hibák csökkentését alapvető emberi joggá tesszük, mely világszerte védi az emberi életet" [4].

A figyelemfelhívás pedig az oktatásnak olyan formája, mely alapismeretekre támaszkodik, feleleveníti és kiegészíti azokat a legfrissebb idevonatkozó kutatások eredményeivel.

MÓDSZER

A Szegedi Tudományegyetem Kórházhigiénés Osztályának dolgozói igyekeznek ezt az ún. „higiénés figyelem felhívást" a betegellátás minden szereplőjére kiterjeszteni, így az ápolókra, orvosokra, a háttérszolgáltatást nyújtók közül az infekciók szempontjából kritikus területeken dolgozókra (takarítókra, étkeztetőkre, textiltisztítókra), a betegellátásban résztvevő ápoló-, fogorvos-, orvos- és gyógyszerész hallgatókra és nem utolsó sorban a menedzsmentre, sőt a betegekre is.

Ezen oktató tevékenységünk során igyekszünk minimális forrásból is megvalósítható módszereket alkalmazni, melyek a következők.

- Az új belépő dolgozók számára készítettünk egy rövid, az alapvető higiénés szabályokat tartalmazó, akár a szakképzetlenek által is megérthető oktató anyagot, melyet az intranet segítségével az egész klinikai központ területén elérhetővé tettünk. Az oktatóanyag arra a gondolatmenetre épül, hogy a betegek védelme és a dolgozók egészségvédelme egyaránt elvárja a jó kézhigiénés gyakorlatot. Összeállításánál az ápoló hallgatóknál 2012-ben alkalmazott tudásfelmérő kérdőívekre adott válaszokra támaszkodtunk Az oktatóanyagot az új dolgozó felvételekor az intézetvezető főnővér kinyomtatja és átadja az érintett dolgozónak, aki aláírásával igazolja az oktatás e formájának megtörténtét.
- Intézményi Infekciókontroll Kézikönyvet készítettünk az intézményben már régebb óta dolgozók számára. Ez a könyv tartalmazza az infekciókontroll valamennyi elemét, így a kézhigiéne szabályait is részletesen leírja. Ezt is feltettük az intranetre.
- Szóbeli oktatást is tartunk rendszeresen a közvetlen betegellátók számára elektronikus prezentációk segítségével az évente megtartott tűz-, munka-, környezetvédelem és minőségfejlesztés témakörű kötelező oktatással egy időben. Ez az oktatás általában klinikánként történik, így a higiénikus főorvos a klinikára vonatkozó éves jelentésről számol be, melynek során a klinika dolgozóinak a kézhigiénés szabályok is ismertetésre kerülnek, kiegészítve azzal, hogyan lehet javítani a kézhigiénés compliance-üket.
- A háttérszolgáltatást nyújtó takarítók, mosodai dolgozók kézhigiénés oktatását mindig összekötjük a munkaterületükön általunk esetleg észlelt higiénés vonatkozású problémák megbeszélésével. Alkalmanként írásos oktató anyagot (1 oldalas szöveggel kísért képes tájékoztató) készítünk és átadjuk a területi képviselőjüknek azzal, hogy személyenként ossza szét tanulmányozás céljából.
- Az orvos-, fogorvos- és gyógyszerészhallgatók a népegészségtan című kurzus keretében, negyedéves korukban hallanak az infekciókontroll jelentőségéről. A két elméleti órát a higiénikus főorvos tartja, melynek során részletesen beszél a kézfertőtlenítés, a kesztyű-, a köröm- és ékszerviselet szabályairól is. A gyakorlati órán kiscsoportos oktatás keretében gyakoroltatjuk a kézfertőtlenítés technikáját a látványos, önellenőrzés lehetőségét biztosító fluoreszkáló kézfertőtlenítőszer és UV lámpa segítségével. Az orvostanhallgatók V. éves korukban az infektológia tantárgy keretében újabb 2 órás előadást hallanak e témában a higiénikus főorvostól. Az órát egy „Higiénés alapismeretek"

kérdőív kitöltésével kezdjük, hogy a már megszerzett kézhigiénés tudásukat lemérjük a hallgatóknak, majd részletesen átismételjük a kézhigiénés szabályokat is.

- Kézhigiénés témájú oktató filmekkel is színesítjük mind a dolgozóknak, mind a hallgatóknak tartott szóbeli oktatásainkat.
- Intézményünk szakoktatási csoportja által szervezett továbbképzéseken a WHO oktató filmje és oktató tesztje segítségével szimuláljuk a betegellátás egyes folyamatai során a kézhigiéne 5 momentumát. Elértük azt, hogy bármilyen témakörből és bármelyik szakmacsoportnak szól a továbbképzés, annak mindig része az infekciókontroll.
- A menedzsmentet az Infekciókontroll és Antibiotikum Bizottság ülésein szóban is tájékoztatjuk az éves jelentés anyagáról és ebben a dolgozók kézhigiénés compliance-éről, továbbá arról, milyen teendői vannak aktuálisan a menedzsmentnek a fejlesztés érdekében (ez évben az időközben tönkrement karos adagolók beszerzését céloztuk meg).
- A betegek részére is készítettünk egyszerű tájékoztatót leporelló formájában, hiszen ők is jelentősen csökkenthetik a kórokozók terjesztését, ha a WC használata után, a katéterük, vagy a sebük érintése előtt és után is fertőtlenítik a kezüket. A leporelló kiosztása és az ún. elégedettségi kérdőív elkészítése folyamatban van (ez utóbbi segítségével tervezzük a tájékozódást arról, mi a betegek véleménye a nekik készült szórólapról).
- Saját készítésű kézhigiénés piktogramokat helyeztünk ki a betegellátási pontokra és ezeket időnként lecseréljük. A figyelem hatékony felébresztése érdekében készített piktogramjaink egymástól különbözőek, mert más – más céljuk van. A nővérdolgozókba és a kezelőkbe készített piktogramunk protokollként működik: minden fontos információt tartalmaz a kézhigiénéről (az 5 momentumot, hogy mikor kell megmosni a kezet és mikor kell fertőtleníteni, hogy tilos a műköröm és az ékszerviselet, stb.). De készítettünk a szokásosnál meglepőbb, talán kissé provokatívabb piktogramokat is. A jól megszokott kézbedörzsölő mozdulatok helyett ezeken inkább fontos információkat, megdöbbentő adatokat közölünk. A céltól függően ezek közül az egyik fajtát a kórtermekben helyeztük ki, hogy ne csak a betegellátók, hanem a betegek is lássák. Ezzel, bár még csak óvatosan, de a betegek figyelmét is szeretnénk felhívni arra, hogy kezet kell fertőtleníteni annak, aki hozzájuk akar nyúlni (1. ábra).

A nővérdolgozókba és az orvosi szobákba szánt provokatívabb piktogramokat igyekeztünk úgy elhelyezni, hogy csak a dolgozók láthassák. (2. ábra)

A kihelyezett kézhigiénés protokoll, piktogramok és oktatások segítségével átadott ismeretek elsajátításának mértékét többféleképpen is ellenőrizzük és az eredményeket vissza is jelezzük a dolgozók felé:

- Kérdőíveket készítettünk az alapvető kézhigiénés ismeretek feltérképezésére. Ahhoz, hogy megtudjuk, milyen mélységben kell beszélnünk az ápolóinknak a kézhigiéne fontosságáról, meg kell ismernünk ugyanis, milyen tudással rendelkeznek e téren a képzések befejezése után.
- Direkt megfigyeléssel olyan speciális osztályokon ellenőrizzük a dolgozóink kézhigiénés compliance-t, mint pl. a koraszülött intenzív osztály, vagy a gyermekgyógyászat szeptikus intenzív osztálya
- Indirekt módon a kézfertőtlenítőszer fogyást figyelve is vizsgáljuk a kézhigiénés compliance trendjét

1. ábra
Kórtermekbe kihelyezett piktogram

2. ábra
Nővér dolgozóba kihelyezett piktogram

2010 óta, aminek eredményéről az elmúlt évtől a Népegészségügyi Szakigazgatási Szervnek is beszámolunk az ún. éves jelentés keretében.
- Célzott kórházhigiénés környezetbakteriológiai vizsgálat keretében rendszeresen mintát veszünk a betegellátók kezéről olyan helyzetben, amikor már a beteghez készül nyúlni, tehát a kezének fertőtlenítettnek kell lennie.
- UV lámpás kézhigiénés gyakorlatokat is tartunk az egyes betegellátó részlegeket meglátogatva.

A kapott eredményeket statisztikai módszerrel dolgozta fel Kórházhigiénés Osztályunk népegészségügyi szakokleveles dolgozója. A statisztikai elemzés módja ANOVA, χ^2-próba, esélyhányados, logisztikus regresszió, melyet az SPSS 19. Statistics programcsomag segítségével elemeztünk ($p<0,05$ értékben határoztuk meg).

EREDMÉNYEK

Kérdőíves tudás felmérést az ápoló hallgatóknál végeztünk az ún. alaptudás megismerése céljából. A 2011–2012-es tanév I. félévében aktív hallgatói jogviszonnyal rendelkező nappali képzésen résztvevő ápoló hallgatók (Ápolás és betegellátás BSc. – ápoló szakirány) és az iskolarendszerű ápoló egészségügyi szakképzés (OKJ: 54 723 01 0010 54 01) diákjai körében végeztünk ilyen vizsgálatot. összesen 126 fő vett részt benne (ők már rendszeresen részt vettek szakmai gyakorlatokon egészségügyi intézményekben). A célcsoportot alkotó mintába való bekerülés egyszerű, nem-véletlenszerű mintavétellel történt. A kérdőívek kiosztása során jelenlévő populáció került be mintába.

A World Health Organization (WHO) által kibocsátott „Hand hygiene self-assesment framework 2010" és „Hand hygiene knowledge questionnaire for helathcare workers" kérdőív egyes kérdéseit adoptáltuk a saját kérdéseinkhez. A World Health Organization honlapjáról elérhető és letölthető mindkét kérdőív. A kérdőívben szereplő – kézhigiénés tudást felmérő – teszten összesen 20 pontot lehetett elérni. Minden helyes válasz egy pontot ért.

A standardizált kérdőívből származó kérdéscsoportok melyeket adoptáltunk a következők:
- kézhigiénés tudás vizsgálata,
- kéztisztításhoz használt eszközök ismerete és alkalmazási módja,
- nozokomialis fertőzések megelőzésének módszerei,
- kézhigiénét népszerűsítő eszközök vizsgálata.

Az átvett kérdéscsoportokat kiegészítettük saját kérdésekkel:
- compliance-re vonatkozó kérdések,
- mindennapos kézhigiénés szokásokra vonatkozó kérdések.

Az egészségügyi ellátás során a betegek között kialakult súlyos keresztfertőzések fő terjesztő tényezőjeként a válaszadók mindössze 41,3%-a jelölte meg a baktériumokkal kontaminált kezet (I. táblázat).

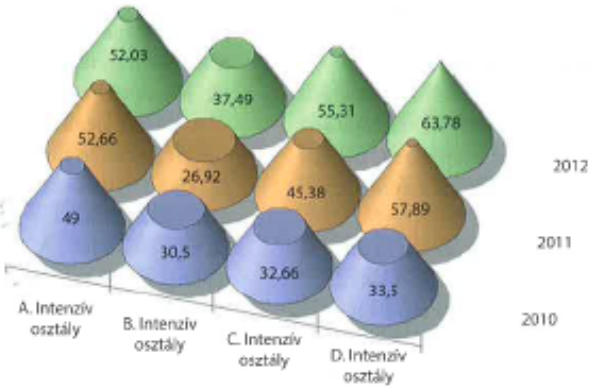
A nozokomiális fertőzések fő fertőző forrására vonatkozó kérdésnél csak 19%-ban jelölték meg a WHO által legfontosabbnak tartott forrást – magát a beteget (II. táblázat).

I. táblázat
A hallgatók válasza a nekik szóló kérdőív 10. kérdésére (n= 126)

Az egészségügyi ellátás során mi lehet a fő terjesztő tényezője a páciensek közötti kereszt-fertőzéseknek?	Gyakoriság	Százalék (%)
Egészségügyi dolgozók szennyezett keze	52	41,3
A kórházban található levegőforgató rendszer	2	1,6
A betegek által elérhető kolonizált felszínek, területek (pl.: ágy, szék, asztal, padlózat)	43	34,1
Nem invazív beavatkozásoknál használt eszközök alkalmazása több betegnél	29	23,0
Total	126	100,0

II. táblázat
A hallgatók válasza a nekik szóló kérdőív 11. kérdésére (n=126)

Mi a fő fertőző forrása a nozokomiális fertőzéseknek?	Gyakoriság	Százalék (%)
A betegben vagy a betegen jelenlévő kórokozó	24	19,0
A kórházi környezet (felszínek)	46	36,5
A látogatók által behurcolt kórokozók	23	18,3
Az ellátó személyzet által behurcolt kórokozók	33	26,2
Total	126	100,0



3. ábra
1 beteg 1 ápolási napjára eső kézfertőtlenítések számának alakulása az SZTE SZAKK intenzív osztályain 2010-2012

A hallgatók 83%-a gondolja helyesen úgy, hogy az alkoholos kézbedörzsölés sokkal hatékonyabb a kórokozók ellen, mint a szappanos kézmosás.

Ennek tükrében nagy számban adtak helyes választ arra a kérdésre, hogy egyes szituációkban melyik kéztisztítási technika alkalmazása (szappanos-vizes kézmosás vagy alkoholos kézbedörzsölés) szükséges (OR= 0,721 95%CI: 0,535-0,972).

A hallgatók átlagosan 60,36%-os (SD=11,57%) eredményt értek el. A legrosszabb eredményt (30%) három hallgató érte el, de volt egy, aki viszont 90%-ot teljesített.

Az elvégzett évfolyamok számának növekedésével egyre jobb (60% feletti) teszteredményt értek el a megkérdezett tanulók (χ^2=0,036).

Direkt megfigyeléssel mi az egyik intenzív részlegünkben közel 100%-osnak, a másikban 69%-osnak találtuk a dolgozóink kézhigiénés compliance-ét, de nem tudjuk biztosan, van-e ezekben az eredményekben pozitív irányú torzítás (Hawthorne hatás) [5] és ha igen, mekkora. Ugyanakkor ennek a vizsgálatnak a folyamatos végzése igen nagy munka [6]. A betegellátó intézmények nagy része pedig még nem rendelkezik az infekciókontroll tevékenységet előíró rendeletben [7] javasolt létszámmal.

A kézhigiénés compliance indirekt vizsgálatával (azaz a felhasznált alkoholos és egyfázisú kézfertőtlenítőszerek mennyiségének felmérésével) kiszámoltuk, hogy a fekvőbeteg ellátó osztályainkon átlagosan mennyi kézfertőtlenítési tevékenység jutott 1 fekvőbeteg 1 ápolási napjára. Valamennyi intenzív osztályunkon a kézhigiénés compliance emelkedő tendenciáját láttuk ebben a vizsgálatban (3. ábra).

Egy aacheni egyetemi kórház három különböző jellegű (sebészeti, idegsebészeti és belgyógyászati intenzív) osztályán is javulást mutatott az indirekt kézhigiénés compliance egy hasonló vizsgálatban 2003 és 2008 között [8].

Összehasonlítva a két – fertőtlenítőszer felhasználáson alapuló – vizsgálatot, láthatjuk, hogy a mi intenzív osztályos betegellátóink jobb eredményeket értek el. Ez a pozitív visszacsatolás, kórházhigiénés osztályunk munkatársainak fejlesztő munkáját is kifejezetten motiválja.

Célzott kórházhigiénés környezetbakteriológiai vizsgálattal is rendszeresen ellenőrizzük kollégáink kézhigiénés compliance-ét. Az elmúlt évben a levett kézminták száma jelentősen megnőtt, ami azt jelzi, hogy a kézhigiénére való odafigyelés a kórházhigiénikusok által készített infekciókontroll tervnek a költségigényesebb pontjaiban is egyre előrébb kerül. A kapott eredmények szerint a kifogástalan minták aránya javult (2010-ben 87%, 2011-ben 90% 2012-ben már 91%-os) és szakmai véleményünk szerint elfogadható szintet ért el.

A környezetbakteriológiai kézvizsgálatok jelentősége kettős: objektív ellenőrzési módszere a hatékony kézhigiénének és emellett segít a betegellátók számára is nyilvánvalóvá tenni a kézfertőtlenítés jelentőségét azzal, hogy megmutatjuk nekik, milyen mikroorganizmusok tenyésztek ki a kezükről akkor, amikor éppen a beteghez akartak nyúlni.

Az UV lámpás kézvizsgálat során a vizsgálatban részt vevő saját szemével győződhet meg arról, mennyiben

III. táblázat
UV lámpás kézhigiénés gyakorlatok közben feltett kérdések és megfigyelt szokások

UV lámpás vizsgálat során megfigyelt szempontok	Igen
Mindig fertőtleníti a kezét a beteg érintése előtt?	65%
Mindig fertőtleníti a kezét a beteg érintése előtt és után is?	53,17%
Felsorolja-e mind az 5 kézhigiénés momentumot, amikor a klinikai tartózkodása alatti kézhigiénés szituációkról nyilatkozik?	0%
Műkörmöt viselő hallgatók	2,31%
Kézfertőtlenítés közben is gyűrűt viselő hallgatók	47%
A kézfertőtlenítéshez a gyűrűt levette, de a karkötőjét, karóráját magán hagyta	26%

sikeres az alkoholos kézbedörzsölésben. Az orvostanhallgatók körében oktatás céljából ezt a vizsgálatot a 2012/2013-as tanévben a Népegészségtan gyakorlati oktatása keretében kezdtük el, és azóta is rendszeresen végezzük.

A vizsgálat során megkérjük a hallgatókat, hogy úgy végezzék el az alkoholos kézbedörzsölést, ahogyan azt a klinikai gyakorlatuk során szokták. A gyakorlat közben ki is kérdezzük a kézbedörzsölést végzőt arról, hogy:

- milyen szituációkban fertőtlenít kezet a klinikai tartózkodása alatt.

Feljegyeztük, hogy:

- leveszi-e a kézbedörzsölésre készülő hallgató az ékszereket a kezéről,
- visel-e hosszú, lakkozott, vagy műkörmöt.

A kézbedörzsölésből kimaradt területeket:

- szubjektív megfigyeléssel jegyeztük le.

Erre a módszerre már létezik objektív megfigyelési módszer [9] is, a jövőben tervezzük a klinikáinkon a bevezetését.

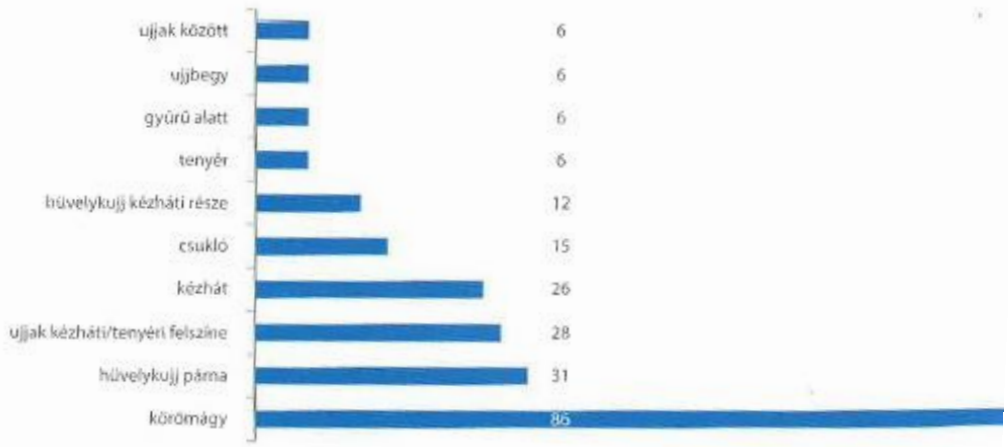
A 2012/2013-as tanévben összesen 173 fő IV. éves orvostanhallgató vett részt ebben a vizsgálatban (közülük 24 fő angol nyelvű orvos képzésben résztvevő volt).

A vizsgálat során azt tapasztaltuk, hogy a hallgatókban még nem rögzültek a WHO által előírt kézhigiénés alapszabályok (III. táblázat).

Az alkoholos kézbedörzsölés technikáját mindössze 33 hallgató (19, 07%) tudta kifogástalanul elvégezni.

A fertőtlenítőszeres bedörzsölésből főleg a körömágyak és a hüvelykujj területét hagyták ki a hallgatók (4. ábra).

A dolgozóink körében is rendszeresen végzünk UV lámpás kézvizsgálatot. 2013 év elején az egyik oktatás alkalmával 84 dolgozó végezte el UV lámpa alatt a kézfertőtlenítést.



4. ábra
Az alkoholos kézfertőtlenítés technikájának gyakorlása során a fertőtlenítésből kimaradt kézfelületek esetszámainak megoszlása az orvostanhallgatók (n=173) körében

IV. táblázat
Az betegellátó személyzet UV lámpás kézvizsgálata során megfigyelt körömviselet és a kezeken viselt ékszerek gyakorisága (n=84)

UV lámpás kézvizsgálat során az egészségügyi személyzet köröm- és ékszerviselete (No: 84 fő)		
Körömviselet	Megfelelően rövid köröm	63 fő
	Hosszú köröm	15 fő
	Lakkozott köröm	3 fő
	Műköröm	3 fő
Kezeken található ékszerek és karóra	Gyűrű	13 fő
	Karkötő	5 fő
	Karóra	8 fő
	Gyűrű és karkötő	1 fő
	Karóra és karkötő	1 fő
	Karóra és gyűrű	2 fő

E vizsgálat során is tapasztaltuk, hogy vannak dolgozók (a vizsgáltak 25%-a), akik még mindig követik az egyre terjedő műköröm divatot [10], és nehezen fogadják el, hogy rájuk vonatkozik Hippokrátesz tanítása, miszerint a betegellátóknál „A köröm nem érhet túl az ujjak begyén!" Minden vizsgálatkor elmondjuk, hogy tanulmányok bizonyítják: a műkörmökön rajta maradnak a patogén kórokozók, akár alkoholos kézbedörzsölést-, akár fertőtlenítő szappanos kézmosást végez a műkörmöt viselő dolgozó [11].

A kézen viselt ékszerek tekintetében a dolgozók úgy látszik, már jobban betartják a szabályokat, 54 fő (64,3%) nem viselt a kezén ékszereket (IV. táblázat).

Amikor a fertőtlenítésből kimaradt területeket vizsgáltuk, azt láttuk, hogy a dolgozóknál már szinte eltűnt a hüvelykujj a fertőtlenítésből kimaradt területek közül, és a dolgozók a diákokhoz képest többen (22%) végezték el hibátlanul a kézbedörzsölést.

Azok az ápolók, akiknek a körme rövidre volt vágva és a kezükön nem viseltek semmit, eredményesebben végezték el a helyes kézbedörzsölést, mint azon kollégáik, akik nem feleltek meg a kezek állapotát illető elvárásoknak (OR=2,619, 95% CI:1,077-6,372).

MEGBESZÉLÉS

Eredményeink alapján kimondhatjuk, hogy javító szándékú lépéseink bár nem hiábavalók, de nem lehet abbahagyni egy pillanatra sem a kézhigiéne fontosságára vonatkozó figyelemfelhívást.

A hatékony figyelem felhíváshoz ismerni kell a dolgozóink higiénés tudásának szintjét, a higiénés szabályok betartására vonatkozó hajlandóságukat, viselkedésük változásának szintjét és hangsúlyozni kell az egészségügyi személyzet felelősségét is.

Nem szabad azonban elfelejteni az olyan objektív akadályokat sem, mint a nem megfelelő beteg-nővér arány, mely az egészségügyi ellátással összefüggő fertőzések keletkezésében komoly rizikófaktor, a minőségi betegellátás elvárásakor ezt is figyelembe kell venni [12].

Elengedhetetlen a kézfertőtlenítés tárgyi feltételeinek maximális biztosítása is. Ideális lenne pl. a külföldön már elterjedt, ún. zsebpalackok alkalmazása, mely remek lehetőség az egészségügyi dolgozók kézhigiénés compliance fejlesztésben való aktív részvételének elősegítésére[13, 14].

A kéztisztító- és kézfertőtlenítőszerek, valamint azok adagolóinak kiválasztását is az infekciókontroll szakemberekre kell bízni. E tárgyi feltételeknek olyannak kell lenniük ugyanis, amit nagyon egyszerűen lehet használni, és amit szeretnek a dolgozók, mert nem károsítja a bőrüket. Ezen is múlhat a kézhigiénés compliance mértéke [15].

Szükség van kreativitásra is a kézhigiénés hajlandóság terén az attitűdbeli változások pozitív irányú elősegítésére [13].

A szűkös anyagi források nem biztosítanak nagy lehetőségeket az egészségügyi személyzet motiválására. Fontosabbnak tartjuk a jó példa erejét, éppen ezért az oktatásaink során először mindig a főnővér, vezető

asszisztens, klinika igazgató orvos figyelmét hívjuk fel a helyes higiénés magatartásra. Továbbá mi, kórházhigiénikusok sem viselünk festett, vagy műkörmöt (pedig nem nyúlunk a beteghez) és nem hordunk a klinikák látogatása közben ékszereket sem.

A kórházakban a minőségfejlesztés egyik legfőbb támasza a kórházhigiénés team, akik jártasak az infekciókontrollban, ők végzik a betegellátás higiénés körülményeinek folyamatos ellenőrzését, az esetleges hibák feltárását.

A higiénés hibák miatt esetleg kialakuló fertőzések – amellett, hogy a beteg- és a dolgozói elégedetlenséget jelentősen fokozzák –, a betegellátás komoly költségnövekedésével is járnak. Ezért a megelőzést irányító infekciókontroll team alkalmazása és a tárgyi feltételek biztosítása miatt közép- és hosszútávon felmerült költségeket ellensúlyozza a prevenció eredményessége [16].

A kézhigiénés compliance fejlesztése tehát nemcsak a tárgyi és személyi feltételek költségei miatt nehéz feladat. A Szegedi Tudományegyetem egykori neves közegészségtan professzora Berencsi György azt mondta, hogy egy higiénikus szakembernek, aki kórházban akar dolgozni orvosok, nővérek, közgazdászok, jogászok, takarítók és betegek között, és közülük mindnek segíteni akar a prevencióban, annak nem is annyira higiénikusnak, mint inkább diplomatának kell lennie!

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II.

Successful elimination of extended-spectrum beta-lactamase (ESBL)-producing nosocomial bacteria at a neonatal intensive care unit

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Background: **Extended-spectrum beta-lactamase (ESBL)-producing Gram-negative bacteria are highly dangerous to neonates. At our Neonatal Intensive Care Unit (NICU), the presence of these bacteria became so threatening in 2011 that immediate intervention was required.**

Methods: **This study was conducted during a nearly two-year period consisting of three phases: retrospective (9 months), educational (3 months) and prospective (9 months). Based on retrospective data analysis, a complex management plan was devised involving the introduction of the INSURE protocol, changes to the antibiotic regimen, microbiological screening at short intervals, progressive feeding, a safer bathing protocol, staff hand hygiene training and continuous monitoring of the number of newly infected and newly colonized patients. During these intervals, a total of 355 patients were monitored.**

Results: **Both ESBL-producing *Enterobacter cloaceae* and *Klebsiella pneumoniae* were found (in both patients and environmental samples). In the prospective period a significant reduction could be seen in the average number of both colonized (26/167 patients; *P*=0.029) and infected (3/167 patients; *P*=0.033) patients compared to data from the retrospective period regarding colonized (72/188 patients) and infected (9/188 patients) patients. There was a decrease in the average number of patient-days (from 343.72 to 292.44 days per months), though this difference is not significant (*P*=0.058). During the prospective period, indirect hand hygiene compliance showed a significant increase (from the previous 26.02 to 33.6 hand hygiene procedures per patient per hospital day, *P*<0.001).**

Conclusion: **Colonizations and infections were rolled back successfully in a multi-step effort that required an interdisciplinary approach.**

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Key words: **hand hygiene;**
INSURE protocol;
interdisciplinary approach;
neonates;
polyresistance

Original article

Introduction

The appearance of polyresistant bacteria is a major concern among medical care providers all over the world.[1-3] Of these, extended-spectrum beta-lactamase (ESBL)-producing gram-negative bacteria are especially problematic, as they are becoming increasingly resistant.[4,5] The group of ESBL-producing bacteria typically includes *Escherichia coli*, *Enterobacter cloaceae* and *Klebsiella pneumoniae*. These bacteria are highly dangerous to neonates, especially low-birthweight preterm infants, and their nosocomial persistence may lead to prolonged hospital stay, higher mortality and growing costs.[4,6,7] The increasing presence of nosocomial bacteria is a significant risk factor in neonatal intensive care, which must be dealt with.[8,9]

The Neonatal Intensive Care Unit (NICU) of the Department of Pediatrics at the University of Szeged is a 17-bed tertiary care centre, with an annual admission of 210-250 newborns with the most severe perinatal conditions from the Southeast region of Hungary (with a population of almost 1.5 million). At this unit, the first ESBL-producing infection was detected in 2002.

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By 2008, ESBL-producing bacteria became standard nosocomial bacteria, and a total eradication was never achieved. The problem became critical in the second half of 2011, when more than half of the neonates in the ward were colonized, which called for immediate intervention. In this study, we described this complex project in the period January 2011-September 2012, which finally led to successful infection control management at our NICU.

Methods

As a consequence of the spread of ESBL-producing bacteria, a specific infection-control task force was formed, with representatives from the NICU, the Institute of Clinical Microbiology and the Infection Control Unit. The group met weekly to discuss the situation. A three-step complex management plan was devised in September 2011, which involved retrospective data analysis aimed at identifying risk factors, education of staffs and introduction of new hygienic measures based on the retrospective analysis, and a follow-up phase. We conducted the retrospective study from January 2011 to September 2011 and the prospective study from January 2012 to September 2012. Between the two periods we allowed the staff three months to become accustomed to the new protocols and strategies introduced. Patient-days/month[10] were calculated by the electronic patient documentation system (eMedSolution® by T-Systems Hungary Ltd, Budapest), which provides up-to-date data and automatically generates statistical information upon the user's request.

Retrospective analysis

Data were gathered retrospectively from the January-September 2011 period regarding 1) hand hygiene compliance among healthcare workers and 2) ESBL colonization/infection data among patients treated at the NICU. Hand hygiene compliance was assessed indirectly, based on the recorded use of alcohol-based hand rub (ABHR), from which the average number of hand hygiene procedures could be estimated according to the WHO Guidelines on Hand Hygiene in Health Care.[11]

Indirect hand hygiene compliance, which refers to the number of hand hygiene procedures performed in the case of one patient during one day at hospital, was calculated as follows. The quantity of hand hygiene liquid (total millilitres) supplied to the clinic per month was checked. At the end of the month the quantity of hand hygiene liquid remaining in the dispensers was evaluated (dispensers were marked at the level of remaining product at the end of the month). We managed to count the monthly consumption of ABHR. This amount was divided by 3 mL, because our dispensers provide 3 mL ABHR with each hit. According to studies 3 mL of ABHR is adequate to insure proper hand hygiene[12,13] for the user. This calculated number is an indirect measure of the number of hand hygiene procedures performed. This was further divided by patient-days regarding the same month, which is continuously generated by software (eMedSolution®) at our facility. With this formula we are able to calculate the number of hand hygiene procedures performed in the case of one patient during one patient-day at hospital. According to our observations these dispensers were only used by staff, so the number of visitors did not cause a distortion in the results.

Patient files were surveyed for microbiological documentation, in an attempt to determine the types of ESBL-producing bacteria in the ward, and the findings were recorded.

Preventive measures and prospective analysis

Based on the findings of the retrospective phase, a number of preventive measures were introduced during October-December, 2011.

First of all, in September 2011, the intubation, surfactant therapy and extubation (INSURE) protocol was introduced.[14] With INSURE protocol, the mechanical ventilation time can be reduced, which helps reduce ventilation-associated infections.

The antibiotic protocol was also modified. On admission, blood culture and gastric aspirate were collected from each new patient. Ampicillin or a combination of ampicillin and tobramycin was started as primary antibiotic therapy, but the administration of these antibiotics was stopped after 48 hours if the cultures taken on admission proved to be negative and the inflammatory markers were also negative. Similarly, if surface cultures were positive without an elevation of inflammatory markers (i.e. C-reactive protein <10 mg/dL and procalcitonin <10 ng/mL at the age of 24 hours) and the patient did not show clinical signs of infection, positive surface cultures were considered as colonization and the course of antibiotics was discontinued.[15] If late onset sepsis was suspected, the choice of antibiotics was changed. Third-generation cephalosporines and a combination of amoxicillin and clavulinate, which are reported to be the strongest inducers of ESBL-production,[16] were banned from the ward. In suspected cases of gram-negative sepsis, meropenem was administered. If there was a predisposition to gram-positive sepsis (e.g. central

venous line inserted), vancomycin was also started and the therapy was changed according to the results of the blood culture.

Progressive feeding was started within the first two hours after admission. The neonates received their own mother's breast milk through a gastric tube, if available. If not, premature and neonatal formula were administered. Probiotics containing both bifidobacteria and lactobacilli were also provided.

As a new preventive measure, the neonates were bathed every four days, which is in accordance with the latest guidelines.[17,18] Immersion baths were stopped. This was important because the risk of infection by biofilm-forming bacteria (i.e. on the surface of the basin or in the waterlines) could thus be reduced.[19,20]

Due to the potential risk of cross infection with ESBL *K. pneumoniae* transferred via the hands of healthcare personnel at the NICU,[21] our team has put great emphasize on proper hand hygiene. Hand hygiene training was a central step in the complex intervention. Multiple education sessions were provided for all staff, including video-assisted instruction and hands-on practice. Disinfected hands were also examined under ultraviolet (UV) light to ascertain efficacy. The data collected in the retrospective phase were shared with the staff and information posters were placed at the NICU. The aim was to draw attention to the growing problem of ESBL-producing bacteria in the ward so as to enhance compliance with the infection control and prevention protocol.[22]

In order to identify potential reservoirs and risk factors, environmental screening was performed and samples were taken from various surfaces. ESBL-producing bacteria were first detected in these samples in October 2011. Multiple surfaces and areas were colonized, including in the wash basins and taps and a tray used for drying dishes in the nurses' room. Previously, *Pseudomonas aeruginosa* was detected from samples taken from these taps and wash basins. As part of the preventive intervention, samples were taken more frequently (every second month instead of semiannually).

New filters were used on taps and the sinks were regularly dismounted and disinfected, while the staff was instructed that hand washing with soap and water should be done as far as possible at the wash basins outside the hospital rooms. This was important since germs may be emitted as aerosols from the siphon traps into the ambient air during water drainage.[23] Additionally, new ABHR dispensers were placed in the ward wherever healthcare procedures are performed.

The quality of cleaning was also evaluated and monitored. In this specific ward the cleaning staff was only allowed to perform cleaning on "non-critical surfaces" (e.g. floor, walls, wash basins), whereas the "critical surfaces" (e.g. therapeutic devices, infant incubator, respiratory devices) were cleaned by the nurses responsible for the care of a particular neonate. The term "critical surface" in this context refers to surfaces which are highly important in terms of the potential spread of healthcare-associated infections. Cleaning of these surfaces was performed multiple times a day according to a more frequent schedule (twice per shift, instead of once per shift).

In order to stop the spread of ESBL-producing bacteria, patients were screened for these on admission, and if the patient presented symptoms of infection at any time during treatment, multiple samples were taken (rectal swab, blood, urine and nasopharyngeal swab). Samples were collected from every patient in contact with an infected patient. Rectal swabs were performed on all neonates not only on admission, but also every other week thereafter. Once colonization or infection was detected, contact precautions were implemented and maintained throughout the hospital stay. Furthermore, colonized and non-colonized babies were nursed separately by individual nurses. Since the ward contained separated boxes for the treatment of the patients, it was easy to implement the separated nursing.

For monitoring the efficacy of our interventions, the number of newly infected and newly colonized patients, monthly costs of antibiotics and monthly mechanical ventilation days were analyzed throughout the prospective period and compared with the data derived from the retrospective interval.

Microbiological analysis

Identification of isolates was carried out with the conventional biochemical identifications and VITEK GN (bioMérieux, France). Antibiotic susceptibility testing to different antibiotics was performed with a disk diffusion method in line with the CLSI EUCAST recommendation. If necessary, antibiotic minimum inhibitory concentration (MIC) value was determined with gradient MIC test strips (Liofilchem, Roseto, Italy), and the results were evaluated according to the EUCAST guidelines.[24] The putative production of an ESBL was detected with the ESBL Detection Set (MAST Diagnostica, Reinfeld, Germany) or the modified double-disk synergy test using ceftazidime (30 μg), cefotaxime (30 μg), aztreonam (30 μg) and cefepime (30 μg) disks opposite an amoxicillin (20 mg)/clavulanic acid (10 mg) disk. The bla_{CTX-M}, bla_{SHV} genes were detected and characterised as described previously (ESBL-PCR).[25] Genetic relationships between *Klebsiella pneumoniae* and *Enterobacter cloacae* isolates were investigated with the pulsed field electrophoresis method (PFGE) using *Xba*I restriction

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endonuclease according to the standardized PulseNet protocol.[26] Results were interpreted and pulsotypes were assigned in line with the criteria set by Tenover et al.[27] The selected *K. pneumoniae* blood isolate was subjected to multilocus sequence typing (MLST) according to Diancourt et al.[28]

Statistical analyses

The Mann-Whitney *U*-test, Wilcoxon-test, and Student's *t*-test were used, as appropriate. Level of significance was set at $P<0.05$. Statistical analyses were performed with SPSS 19 (IBM Corp., Armonk, NY, USA).

Results

Compared with the retrospective period, during the prospective period the average number of patient-days decreased from 343.72 days per month to 292.44 days per month, though this difference is not significant ($P=0.058$). During the prospective period, a significant reduction was observed both in the number of colonized (from 72/188 to 26/167; $P=0.029$) and infected patients (from 9/188 to 3/167; $P=0.033$) when compared to the retrospective examination interval. It is worth mentioning that in the retrospective period five infected patients died, while no deaths occurred after the introduction of the new measures.

The number of invasive mechanical ventilation days per patient care days was also decreased significantly, almost by 50% (Table). There was no statistically significant difference between the two examination phases in terms of the cost of antibiotic consumption related to patient-days (from 7.5 euros/patient-day to 6.3 euros/patient-day, $P=0.519$).

Regarding the samples taken from the ESBL-positive patients, during the whole interval, 26 out of 29 *K. pneumoniae* isolates exhibited pulsotype Z, and the remaining three isolated were of the KP083, KP085 and L pulsotypes. The pulsotype Z isolate belonged to sequence type 525 and harboured the $bla_{CTX\text{-}M\text{-}15}$ ESBL gene. As for the 25 *E. cloacae* isolates studied, 23 belonged to bla_{SHV}-bearing pulsotype EbC052, one to EbC054 and another to EbC038.

Totally 170 environmental swab samples were taken during the intervention period (October to December 2011). These samples were collected from 107 critical and 63 non-critical surfaces. Twenty-five out of 107 critical and 14 out of 63 non-critical surface samples were culture positive, respectively, thus highlighting inadequately cleaned areas. Of these samples, a few were taken from a wash basin, three taps, a common

Table. Descriptive statistics of the study parameters from the two examined periods

Variables	2011 January-September retrospective period	2012 January-September prospective period
Patient day	324.50 (306.00-403.50)	296.00 (175.50-376.50)
Admitted patients/mon	22 (14-28)	19 (15-22)
ESBL colonized patients	7 (1-15)	2 (0-8)*
ESBL nosocomial infected patients	2 (0-4)	0 (0-1)*
ABHR consumption/L	26.50 (19.5-34.5)	32.50 (23.0-46.4)*
Monthly mechanical ventilation day/ventilated patients	9.77 (5.88-18.11)	5.00 (3.24-8.88)†
Performed hand hygiene/patient/day	27.39 (17.22-31.08)	39.17 (33.28-44.07)‡

Values are given as median (minimum-maximum). *: P<0.05; †: P<0.01; ‡: P<0.001. ESBL: extended-spectrum beta-lactamase; ABHR: alcohol-based hand rub.

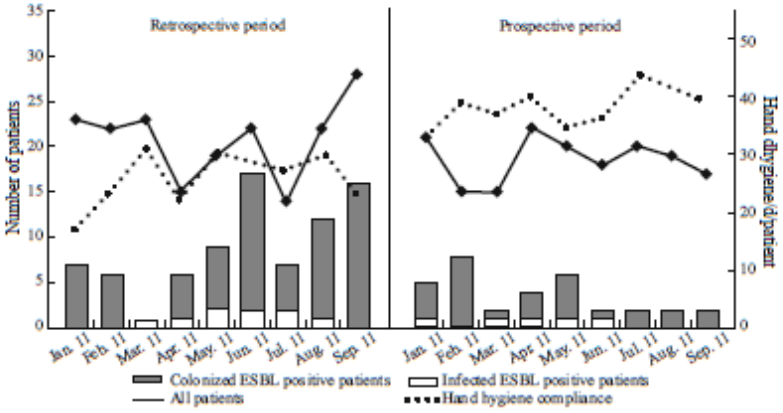

Fig. Comparison of the retrospective and prospective periods in terms of colonization, infection and hand hygiene compliance "hand hygiene/d/patient" refers to the number of hand hygiene procedures performed in the case of one patient during one day at hospital.

warming bath for feeding bottles and the dish tray in the nurses' room; all of these contained ESBL *Enterobacter cloacae*, belonging to pulsotype EbC052. In February 2012, we also took samples from healthcare workers' stool in search of ESBL-producing bacteria and further potential sources of infection because these caregivers are in direct close contact with the infants. Two samples from 32 healthcare workers showed ESBL *E. coli* positivity; however, no infants showed ESBL *E. coli* positivity at the ward.

In a comparison of the two periods under examination, a significant increase can be seen during the prospective period regarding the consumption of ABHR solutions (P=0.03). In the first phase, this represented an average of 77.90 L ABHR per 1000 patient-days, while in the second interval, this figure increased to 114.96 L per 1000 patient-days. Compared with the baseline data at the beginning of the retrospective period under examination (26.18 ESBL-positive patients per 1000 patient-days), a significant reduction can be seen in the incidence of ESBL-positive patients by the end of the prospective phase (11.01 positive patients per 1000 patient-days, P=0.02). Indirect hand hygiene compliance showed a significant increase in the prospective examination period compared to the retrospective examination period (P<0.001) (Fig.). During the retrospective period, 26.02 hand hygiene procedures were performed on average per patient per hospital day, and this increased to 33.6 during the prospective period. As a result of the hand hygiene education and with the useful aid of a UV lamp for supervision, the efficacy of hand cleaning among healthcare workers also improved significantly. In the retrospective period, when hand hygiene practice was examined, the nail beds and dorsal surfaces of the thumbs were usually missed (perfect results were only achieved in 14% of the cases). During a three-week period, staff was supplied with a UV lamp for detecting fluorescent ABHR to provide them with an opportunity to practice and evaluate their own hand hygiene technique. During the UV lamp-supported training, perfect hand hygiene practice increased to 77%.

Discussion

Infection control has a remarkable historical connection with the pediatric population. Ignác Semmelweis already found a link between hand hygiene and perinatal infection rates in the nineteenth century.[29]

The aim of our intervention was to roll back colonization and infections caused by ESBL-producing bacteria at our NICU, and as our results suggest, we have managed to reach that aim.

Most importantly, there was a sharp decrease in the number of patients colonized and infected with ESBL-producing bacteria. Invasive mechanical ventilation days were successfully reduced almost by half. This result is mostly due to the introduction of INSURE therapy.[30,31] However, INSURE not only caused a decrease, but also reduced the chance of ventilator-associated infections and so contributed to the drop in late bacterial colonizations and the occurrence of late onset sepsis and thus may have contributed to the fall in late invasive ventilatory support demand.[32]

ESBL-producing Gram-negative bacteria can survive on environmental surfaces, preferably in moist sites, for weeks; environmental decontamination is therefore a highly important issue in intensive care units.[33] In accordance to other studies,[34-36] we also detected ESBL-producing bacteria on moist surfaces and places. After an evaluation of the results and an identification of possible sources, the use of wash basins was minimized and the dish tray was removed permanently from the nurses' room. Also, the local specific warming method (i.e. that all feeding bottles were warmed in a common warming bath) was immediately banned from the ward and the bottles were warmed individually from that point on. As a further preventive measure, the water in these new individual warming devices was also changed several times a day, and devices were cleaned with disinfectant solutions after use and stored dry. This intervention caused a remarkable reduction in the number of new ESBL-positive patients.

In the study carried out by Rong et al,[21] the potential sources of infection at the NICU were the gastric tubes, the incubators and the healthcare personnel. Although none of the mentioned surfaces or the care providing staff were justified as real sources of infection, with the multistep intervention we managed to improve these fields too. The quality of cleaning critical surfaces near the patients improved, as none of these surfaces have produced positive samples after the introduction of the new cleaning regimen.

We also carried out faecal sampling from healthcare workers' stool in search of ESBL-producing bacteria. Although two samples from 32 healthcare workers exhibited ESBL *E. coli* positivity, no infants showed ESBL *E. coli* positivity at the ward. The staff members, who were colonized with ESBL *E. coli*, therefore, cannot be regarded as potential sources of the infection under examination.

Finally, as a result of the hygienic interventions, namely the examination of hands under UV light and small-group training sessions for clinicians and staff, including instruction on correct hand hygiene procedure, indirect hand hygiene compliance showed a significant increase. Our results are in accordance

with Zahar et al,[37] who also found a significant rise in ABHR use in the period following interventions.

In conclusion, rolling back ESBL-producing bacteria at our NICU was successful. We attribute this success mainly to the multidisciplinary approach, the continuous feedback and monitoring, and the high compliance of the staff. Although the staff of a NICU is in closer contact with neonates, compared to a ward with older patients, colonization of health care workers did not play any role in the nosocomial persistence of ESBL-producing bacteria.

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III.

ÖSSZEFOGLALÓ KÖZLEMÉNY

Hitek és tévhitek, azaz vitatott esszenciális kérdések a kézhigiénéről az evidencia tükrében

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Az egészségügyi ellátás során szerzett fertőzések kialakulásában nagymértékben szerepet játszhat a kontaminált kéz. A megfelelő időben és technikával elvégzett kézhigiéné a betegbiztonság elengedhetetlen eszköze, ugyanakkor, ha az egészségügyi dolgozót téves meggyőződései és hiedelmei meggátolják a magas szintű kézhigiénés compliance megvalósításában, akkor ez jelentősen ronthatja a betegellátás minőségét. Számos vélt gondolat és téves tudás befolyásolhatja a dolgozói attitűdöt, és gyakran alaptalan meggyőződések állnak a nem megfelelő kézhigiénés compliance hátterében. Az evidenciák felkutatása, elemzése és közérthető ismertetése rendszeres oktatás és továbbképzés formájában – kiemelve a kézhigiéné elméleti és gyakorlati aspektusait – segíthet elsajátítani és rögzíteni a helyes technikát és az evidencián alapuló ismereteket. Orv. Hetil., 2017, *158*(6), 212–219.

Kulcsszavak: kézhigiéné, kézhigiénés compliance, alkoholos kézfertőtlenítés, infekciókontroll

Beliefs – Misbeliefs, answering essential questions about hand hygiene from the view of the evidences

Contaminated hands can play pivotal role in the development and spread of healthcare-associated infections. Consequently hand hygiene practice performed with adequate technique and with adequate timing is an essential implement for patient safety. Inhibition of the practice of high level hand hygiene by the misconceptions or deficient knowledge of healthcare workers may lead to negative influence on the quality of patient care. Erroneous beliefs or "rumourous knowledge" acquired from colleagues can not only influence the attitude of healthcare workers, but can also give rise to insufficient hand hygiene compliance. Finding, interpreting and imparting the related evidence by delivering continuing education and lectures, highlighting the theoretical and practical know-how on hand hygiene could help to understand and imprint the evidence-based practice and adequate technique in the essential issue of hand hygiene.

Keywords: hand hygiene, hand hygiene compliance, alcohol-based hand rub, infection control

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Rövidítések

BPA = biszfenol A; KC = kézhigiénés compliance; OEK = Országos Epidemiológiai Központ; WHO = Egészségügyi Világszervezet

Az egészségügyi ellátással összefüggő fertőzések világszerte nagy problémát jelentenek [1], mivel hatalmas terhet rónak mind a megbetegedett személyre, annak családjára, mind a betegellátást nyújtó egészségügyi in-

tézményekre [2]. A kézhigiéné az egyik legfontosabb eszköze az infekciókontroll-tevékenységnek, amelynek segítségével megakadályozhatók a keresztfertőzések [3], ami az egészségügyi ellátással összefüggő fertőzések közel felének megelőzését jelentené.

Bár a kézhigiéné fontosságára *Semmelweis Ignác* már az 1800-as évek végétől felhívta a figyelmet, és mára széles körben felismerték, hogy a sebészi kézfertőtlenítés (bemosakodás) mellett a műtőn kívüli sokrétű betegellátás során is megfelelő higiénés kézfertőtlenítést kell alkalmazni a kórokozó mikroorganizmusok terjedésének megakadályozásához, mégis az egészségügyi dolgozók kézhigiénés compliance-e világszerte igen alacsony (átlagosan <40%) [4, 5].

A nemzetközi kézhigiénés kampányok és irányelv [5] megjelenését követve Magyarországon is kiadtak egy módszertani levelet [6], amely rögzítette a betegellátás területén a bemosakodáson kívül alkalmazandó kézhigiéné szabályait és azokat az indikációkat, hogy mikor és hol kell elvégezni azt. Magyarországon a betegellátó intézmények kórház-higiénikusai rendszeresen kötelesek mérni intézményük betegellátóinak higiénés kézfertőtlenítéshez való hozzáállását, azaz a kézhigiénés compliance-t (KC) és az eredményeikről évente tájékoztatniuk is kell az Országos Epidemiológiai Központot (OEK). A KC mérése történhet direkt módon a kézhigiénés tevékenység megfigyelésével, de ami objektív és az országos, illetve a nemzetközi adatokkal is egyszerűen összehasonlítható, az az indirekt vizsgálat. Ennek során az intézmény által felhasznált kézfertőtlenítő szer mennyiségét adjuk meg 1000 ápolási napra vonatkozóan, és ebből kiszámolható az is, hány kézfertőtlenítést végeznek az adott betegellátó helyen átlagosan egy betegnél 24 óra alatt (ez az adat nem tartalmazza a sebészi kézfertőtlenítéshez, azaz a műtőkben a be-, át- és kimosakodáshoz használt kézfertőtlenítő szer mennyiségét) [5, 6].

Magyarországon a betegellátó intézmények egymás után csatlakoztak a kézhigiénés kampányokhoz, aminek eredményeként az országos átlagos KC az elmúlt években jelentősen javult, míg 2011–2012-ben 7 liter/1000 ápolási nap volt, addig 2015-ben már 9,9 liter/1000 ápolási nap. Ugyanakkor a kézhigiénés hozzáállás további fejlődését minden erőfeszítés ellenére lassíthatják bizonyos tényezők, mint például a nemek közötti különbség [7], az orvosok és ápolók közötti különbségek [8], az intenzív osztályon való munkavégzés [9], a munkavégzés hétköznap vagy hétvégén történik [10], valamint a szabályok betartására rendelkezésre álló idő [11]. Sőt a dolgozói kézhigiénét vizsgáló kérdőívek és interjúk a fent felsorolt tényezők mellett gyakran olyan attitűdök megjelenésére is rávilágítanak, amelyek feltehetőleg a nem megfelelő ismeretek talaján alakultak ki. Ezek olyan magatartásformák, amelyeket jól láthatóan nem a fegyelmezetlenség, hanem az ismeretek hiányán alapuló félreértés, tévhit irányít.

Jelen kézirat szerzőinek célja, hogy a higiénés kézfertőtlenítés területén az evidenciák tükrében olyan kulcsfontosságú kérdéseket tisztázzanak, amelyekkel kapcsolatosan az egészségügyi dolgozók körében féligazságokon vagy félreértésen alapuló tévhitek terjednek, amik akadályozhatják őket abban, hogy a KC-jük az elvártnak megfelelő legyen.

Az alábbiakban 10 kérdésre kerestük a választ:

1. Valóban nincs idő a higiénés kézfertőtlenítésre?

A dolgozók gyakran arra hivatkoznak, hogy nincs idő a kézhigiénére a feszített, stresszes helyzetekben. Az időhiányt az ápolószemélyzet olyan viszonylatban is emlegeti, hogy kevés a betegápoló és sok a beteg, így a teendők sűrűjében nincs elég idő minden szükséges esetben a szabályosan kivitelezett kézhigiénére.

A betegellátásban a higiénés kézfertőtlenítés középpontjában az Egészségügyi Világszervezet (WHO) javaslata alapján [4] az alkoholtartalmú kézfertőtlenítő szer használata áll.

Az alkoholos kézbedörzsölés módszere során a fertőtlenítőszert eloszlatjuk a kezünkön dörzsölő mozdulatokkal addig, amíg a fertőtlenítőszer kifejti kórokozóölő hatását, majd elpárolog (körülbelül 20–30 másodperc). Ezt a technikát alkalmazzuk a betegellátás során minden olyan esetben, amikor kezünk szemmel láthatóan nem szennyezett, illetve a védőkesztyű felvétele előtt és levétele után is.

E legfrissebb kézhigiénés szabályok már tökéletesen illeszkednek az időhiányhoz, mivel a minimum 2 percig tartó kézmosás helyett a mindössze 20 másodpercig tartó fertőtlenítőszeres kézbedörzsölést ajánlják [6]. Ezt támasztja alá a *Vossémtsai* által végzett vizsgálat, amelyben egy intenzív osztályon, ha a kézhigiénét fertőtlenítő hatású szappannal végzik, akkor a munkaidő 17%-át töltik el fertőtlenítő kézmosással, míg ha a kezeket alkoholos kézbedörzsölővel fertőtlenítik, akkor az ugyanannyiszor elvégzett kézhigiénés tevékenység kevesebb, mint 3%-át teszi ki a munkaidőnek [11]. Ha a dolgozóinkkal ismertetjük a legfrissebb kézhigiénés ajánlásokat és következetesen be is tartják azt, akkor lesz elegendő idejük a szükséges esetekben a kézfertőtlenítésre.

2. Kiszárítja a kezeket az alkoholos kézfertőtlenítő szer?

Az egészségügyben a munkavállalónak, ha közvetlenül beteget lát el, kézhigiénét kell alkalmaznia a WHO által kiadott szakmai ajánlásban szereplő öt kézhigiénés momentum szerint: a beteg érintése előtt és után, a váladékkal történő expozíciók után, az aszeptikus beavatkozások előtt és a beteg környezetének érintése után minden esetben [4]. Ha ilyenkor a betegellátó keze szemmel láthatóan nem véres vagy váladékos, alkohol hatóanyagú kézfertőtlenítő szeres bedörzsölést jelent a kézhigiéné.

A betegellátók egy része azonban kerüli a fertőtlenítőszeres kézbedörzsölést, mert azt gondolja, hogy mindegy, milyen kézfertőtlenítő szert kap, mindegyik árt a kézbőrének.

Ha ugyanakkor a munkáltató is azt gondolja, mindegy, milyen kézfertőtlenítő szert ad a dolgozójának és ezért a legolcsóbbat szerzi be neki, valóban azt fogja látni, hogy a dolgozó kézbőre károsodik. Több tanulmány is igazolja, hogy a kézfertőtlenítő szerek minősége döntően befolyásolja azt, hogy okoz-e a szer bőrkárosodást, kimutatták ugyanis, hogy a károsodást nem maga a hatóanyag okozza, hanem a szerben található adalékanyagok (például színezékek) és szennyeződések. A jó minőségű termékek ezektől mentesek, sőt bőrvédő összetevőt is tartalmaznak [12, 13].

Ha a dolgozónak fáj a keze a fertőtlenítőszertől, nem meglepő, ha igyekszik elkerülni annak használatát és például a fertőtlenítőszeres kézbedörzsölés helyett kezet mos.

Ennek a higiénés szabályszegésnek a betegellátás minden résztvevőjére nézve súlyos következményei lehetnek: az ilyen dolgozó kézhigiéniéje nem garantálja a betegbiztonságot, mivel a szappanos kézmosás csak csíraszámcsökkentő. A szappanos kézmosás ugyanakkor eltávolítja a kézbőr nedvesítő-zsírzó faktorait, ami már a dolgozói biztonságot is veszélyezteti. Az egészségügyi személyzet leggyakrabban előforduló foglalkozási megbetegedései rangsorában, a mozgásszervi megbetegedések után, valóban a bőr betegségei állnak a második helyen [14]. A foglalkozási bőrbetegségek 80%-át a kontaktdermatitis teszi ki [15].

A sérült bőrön ráadásul könnyebben megtelepszenek a kórokozók, mint az ép bőrön [16]. Egy, nővérek körében végzett vizsgálat során olyan betegellátók kezét mintázták meg, akiknél már kialakult a dermatitis; a mintákból *Staphylococcus hominis, Staphylococcus aureus*, Gram-negatív baktériumok, *Enterococcus*ok és *Candida* is kimutatható volt [17].

A kézfertőtlenítő szerek kiválasztásánál ezért nem az árverseny a helyes megoldás, hanem az egyéni érzékenység figyelembevétele, azaz a dolgozó számára annak a fertőtlenítőszernek a biztosítása, amelyet az ő bőre a legjobban elvisel. Ez az első aranyszabály, amely jelentősen képes javítani annak a dolgozónak a KC-jét, akinek az egészségügyben a betegellátás során a kézfertőtlenítő szert éveken át, folyamatosan és óránként akár többször is rá kell dörzsölnie a saját bőrére [18]. A nagy létszámú dolgozót foglalkoztató intézményekben többféle kézfertőtlenítő szert is javasolt biztosítani, hogy az egyéni érzékenységet is figyelembe véve legyen választási lehetősége a dolgozóknak. Ez a gyakorlatban úgy valósítható meg, hogy a dolgozók által kipróbált és a gyakorlatban már bevált szereket versenyeztetik és ezek közül választják ki az árban is legmegfelelőbbeket. A szakma képviselőinek erre kellene a jövőben bátorítania a menedzsmentet.

3. Igaz-e, hogy felszívódik a bőrön és a légutakon át a kézfertőtlenítéskor az alkohol, és akár alkoholabúzus is kialakulhat?

Az e területen végzett vizsgálatok semmilyen, vagy alig kimutatható mértékben találtak véralkoholszint-emelkedést kézfertőtlenítő szer használata következtében, és ezzel kapcsolatos tüneteket sem tudtak feljegyezni [19–21].

Egy tanulmányban olvasható, hogy az 52,6%-os izopropiltartalmú kézfertőtlenítő szer gyakori használata – 4 órán át 10 percenként alkalmazott kézfertőtlenítés – után önkéntesek levett vérmintáiban 10 esetből 9-nél 0,005–0,18 mg/dl izopropilszint volt kimutatható, ugyanakkor enyhe mértékű izopropilintoxikációhoz legalább 50 mg/dl véralkoholszint szükséges [20]. Egy 2012-es tanulmány is azt mutatta be, hogy a propanol vegyülete jelentéktelen mértékű felszívódásra képes, akut toxikus tünetet nem tud létrehozni, és mivel az emberi anyagcsere gyorsan feldolgozza, nem tud a vegyület akkumulálódni [21].

Bár *Brown és mtsai* vizsgálatukban azt találták, ha intenzíven és gyakran végzik az etanoltartalmú kézfertőtlenítő szeres kézbedörzsölést (az említett tanulmányban 1 óra alatt 30 kézfertőtlenítés történt), akkor csekély mennyiségű etanol felszívódhat a bőrön keresztül, illetve egy zárt légterű helyiségben be is lehet lélegezni a kézről elpárolgó alkoholt. Ezek a mennyiségek azonban a közúti ellenőrzésnél alkalmazott alkoholszintmérő szondán nem mutatnak eltérést [19].

Kinnula és mtsai kutatásukban bemutatták, hogy a gél állagú alkoholtartalmú kézfertőtlenítő szer (amely nem szívódik fel a kéz bőréről) használata még az óvodások körében is teljesen veszélytelen, miközben megelőzheti a közösségben gyorsan terjedő vírusok kéz útján való továbbadását [22].

4. Valóban a kézfertőtlenítés a felelős a szervezet biszfenol A (BPA) -tartalmának esetleges emelkedéséért?

A legnagyobb mennyiségben előállított kémiai anyagok közé tartozik a BPA, és jól ismert egészségkárosító hatása (hormonális zavarok, szívbetegség, asztma, elhízás), azonban az alkoholos kézfertőtlenítők és szappanok kémiai összetevői között nincs BPA.

Az ezzel kapcsolatos tévhit onnan származik, hogy BPA-val vannak bevonva a banki automatákból, pénztárgépekből, faxgépekből, illetve tesztgépek/orvosi analizátorokból származó bizonylatok. Egy 2014 végén publikált cikk [23] arról számolt be, ha a hőpapírra nyomtatott bizonylat megfogása előtt közvetlenül kezet fertőtlenítünk és 45 másodpercen keresztül kezünkben tartjuk a hőpapírt, a kézhigiénés szerekben lévő penetrációt fokozó anyag elősegítheti a BPA ujjainkon való kioldódását, és ha ezzel a kézzel eszünk, annak szájnyálkahártyán keresztül történő felszívódását. Ebből azt a következtetést vonta le néhány közösségi oldal és blog, hogy soha többé ne fertőtlenítsünk kezet. E javaslatok nélkülözik a betegellátás higiénés szabályainak ismeretét, sőt az alapvető személyhigiénés szabályokét is. Bár az evidenciát mellőző internetes reakciók eltorzítják az említett kutatás üzenetét, annyi hasznos információval szolgálhatnak akár egészségügyi dolgozók számára is, hogy a

hőpapír nyomtatású bizonylatokat feleslegesen nem kell megfogni, a munkahelyen pedig – ha ezzel dolgozik valaki – használjon védőkesztyűt, de a szükséges kézhigiénét semmiképpen se hagyja el.

5. Először kell kezet mosni és utána fertőtleníteni vagy fordítva? Fontos egyáltalán a kézmosás és a kézfertőtlenítés egymást követő sorrendje?

Kétféle higiénés kézfertőtlenítés létezik: víz hozzávételével történő fertőtlenítő hatású folyékony szappanos kézmosás és kézfertőtlenítés alkoholbázisú, fertőtlenítő hatású szer kézbőrre történő bedörzsölése útján [4, 24].

Míg az alkoholos kézbedörzsölés célja az úgynevezett átmeneti (tranziens) mikroflóra elpusztítása, a fertőtlenítő hatású folyékony szappanos kézmosás során a készítmények összetételéből adódóan (a készítmények tenzidtartalmának köszönhetően) a tranziens mikroflórán kívül a szennyeződések eltávolítása is megtörténik. Ugyanezt el lehet érni két fázisban is, amikor külön végezzük el a szappanos vizes kézmosást és külön a kézfertőtlenítő szeres kézbedörzsölést a tisztítás és a megfelelő csíraszám-csökkentés érdekében. Ennek a két fázisnak a sorrendje a mindenkor érvényes kézhigiénés szabályokban többször is változott az elmúlt években, ami megnehezíti a kézhigiéné egyes lépéseinek rutinná válását. 1973-ban, amikor még hagyományos szappant használtak a kéz megtisztítására, csak a kétfázisú kézfertőtlenítés jöhetett szóba, ha a kéz tisztítására és fertőtlenítésére is szükség volt. Ekkor az Egészségügyi Minisztérium II. Oktatási Főosztálya – az általa kiadott jegyzet (1973, Budapest) „Személyi fertőtlenítés" című részében – azt írta elő, hogy a járványügyi gyakorlatban a kézmosás előtt kell a kézfertőtlenítő szert használni azért, hogy a kórokozók ne kontaminálják a szappant, a kézmosó csapját, a mosdókagylót. Majd a szappanos kézmosás után egy újabb kézfertőtlenítés következzen, amelynek célja, hogy a már megtisztított kezeken esetleg visszamaradó kórokozókat elölje. A sok időt igénylő és bonyolult kézhigiénét egyszerűbbé és logikusabbá tette az Országos Epidemiológiai Központ (OEK) a következő években a betegellátó intézményekben kötelezően alkalmazandó ajánlásában [25–27], amikor azt írta, hogy a kétfázisú higiénés kézfertőtlenítés során először történjen a kézfertőtlenítés alkoholos kézbedörzsölő szerrel, és amit elpusztított a kézfertőtlenítő szer, azt mossuk le utána szappannal és vízzel. Napjainkban már a szilárd szappan alkalmazása az egészségügyben tilos. 2009 óta a WHO kézhigiénés irányelve [4] az alkoholbázisú kézfertőtlenítő szeres kézbedörzsölést önmagában preferálja és csak kivételes esetekben javasolja a szappanos kézmosást is, például, ha szemmel látható mennyiségű szerves anyag (vér, váladék) van a kézen. Ezekben a kivételes esetekben azonban megfordította a fertőtlenítés és a tisztítás sorrendjét, azaz először kell szappannal és vízzel megtisztítani és csak utána fertőtlenítőszerrel bedörzsölni a kezet. A magyarázat ez esetben is logikus, mert a kézfertőtlenítés hatékonysága nem valósítható meg tökéletesen másképpen, a gyorsan párolgó alkoholos kézfertőtlenítő szer ugyanis el sem tud jutni a kéz bőréhez, ha akadályozza az ott lévő szerves anyag. Ezt az elméletet követi és ezt a sorrendet írja elő már a hazai módszertani levél [6] és az OEK *Tájékoztató a fertőtlenítésről* ötödik kiadása [28] is.

Annak ismeretében, hogy mára már forgalomba kerültek felületfertőtlenítő kendők is, amelyekkel gyorsan és hatékonyan lehet csíramentesen tartani a folyamatosan kontaminálódó kézmosó csapok és mosdókagylók felületét, érthető a WHO új álláspontja, ami nem építi be ezt a szempontot a kézhigiéné lépéseibe. A kézmosó kagyló és a szerelvénye ugyanis a legszennyezettebb része egy betegellátó helynek, ahonnan még akkor is a kézre kerülhetnek kórokozók a víz csapódása miatt, ha a szabályoknak megfelelően könyökkel nyitható csapokat használnak. A kéztisztítás és kézfertőtlenítés ma érvényes sorrendjére vonatkozó szabály betartását segíti, ha a dolgozók számára a kéz tisztításához folyékony szappan helyett fertőtlenítő hatású kéztisztítószert biztosítunk, és akkor indokolt esetben egy fázisban végeztethetjük el a kéz tisztítását és fertőtlenítését is. Így fel sem merülhet a kéztisztítás és a kézfertőtlenítő szeres bedörzsölés sorrendjének kérdése, és az sem fordulhat elő, hogy a hatékony kézhigiéné helyett csak szappanos kézmosást végeznek a betegellátók.

6. Mikor kell szappannal kezet mosni és mikor kell csak kezet fertőtleníteni?

A kézmosás szappannal mechanikus kéztisztítást jelent, miközben 0,5–1 percig dörzsöljük rá a folyékony kéztisztítószert a kézre úgy, hogy az a kéz minden területét egyenletesen bevonja – ügyelve a körömágyakra, ujjbegyekre és hüvelykujjakra is [29] –, majd folyó vízzel leöblítjük és alaposan megszárítjuk eldobható papírtörlővel. A szappanos vizes kézmosással azonban nem tudunk elérni megfelelő kórokozószám-csökkenést, még a kézmosás időtartamának növelésével sem [30]. A kéz a nem lengőkaros csap elzárásakor a gomb érintésétől, vagy a vízkedvelő baktériumok (például *Pseudomonas aeruginosa*) által kolonizált visszacsapódó víz cseppektől újra kontaminálódhat [31]. Ezért fontos, hogy a kézmosás után megtörténjen az alkoholos kézbedörzsölés is (kétfázisú kézfertőtlenítés).

Feltétlenül szükség van az alkoholos kézbedörzsölés előtt a kéztisztítás mechanikus eltávolító hatásának kihasználására a *Clostridium difficile*-fertőzött beteg ellátása után, mivel a fertőzést okozó baktérium spóráit nem képes elpusztítani az alkoholos kézfertőtlenítő szer [32].

7. A védőkesztyű tökéletes védelmet nyújt a kórokozók terjesztése ellen? Szükséges-e egyáltalán kezet fertőtleníteni a védőkesztyű felvétele előtt és a levétele után? A kesztyű viselésének élettartamát meghosszabbíthatjuk a lefertőtlenítésével vagy újrafelvételével?

A védőkesztyű használata védelmet nyújt az egészségügyi dolgozó számára a potenciális vérrel, váladékkal történő expozícióval szemben, valamint a beteg sérült

bőrének vagy nyálkahártyájának érintése által létrejövő kontaminációval szemben [33]. A kesztyűhasználat befolyásolhatja a KC-t, mivel biztonságot nyújt, így két beteg között elmaradhat a kesztyű cseréje és könnyen létrejöhet egy keresztfertőzés [34, 35]. Egy átfogó tanulmány rávilágított arra, hogy gyakran a kesztyű viselete miatt elhagyták a kézhigiénét, továbbá előfordult az is, hogy szükségtelenül vették fel a védőeszközt, és a vizsgált esetek 37%-ában a nem megfelelő kesztyűhasználat növelte a keresztfertőzés kialakulásának kockázatát [36]. Azt is gondolhatják a védőkesztyűt felvevők, hogy felesleges a kesztyűfelvétel előtti kézfertőtlenítés, hiszen úgyis befedi az egész kezüket a kesztyű. *Rock és mtsai* is megkérdőjelezik a védőkesztyű felvétele előtti kézfertőtlenítés indokoltságát. Mikrobiológiai mintavételezéssel vizsgálták a dolgozók kezét és a felvett kesztyűket úgy is, hogy a kesztyű felvétele előtt történt kézfertőtlenítés és úgyis, hogy kihagyták az előzetes kézfertőtlenítés lépését. Vizsgálatuk során a két csoport között nem találtak szignifikáns különbséget [37].

Ugyanakkor egy másik vizsgálat azt mutatta ki, hogy a több dolgozó által használt és a számukra központi helyre kirakott nyitott tetejű kesztyűsdobozban lévő, még használatlan kesztyűk is képesek kontaminálódni, ha fertőtlenítés nélküli kézzel nyúlnak hozzá a dolgozók (leggyakrabban Gram-pozitív baktériumok által) [38]. Ezek a kesztyűk a betegellátáskor már fertőzőforrásként jelenhetnek meg. Ezért a kesztyűk felvétele (már a dobozából való kivétele) előtt szükséges kezet fertőtleníteni. A védőkesztyű levétele közben könnyen kontaminálódhat a környezet [39], vagy akár a kesztyű viselőjének kézfeje, csuklója, alkarja is [40], sőt úgy is bekövetkezhet a kéz kontaminációja, hogy viselet közben megsérül (kiszakad) a kesztyű, vagy a kesztyű szárán át folyadék (vér, váladék, mosdatásnál használt víz stb.) csorog a kesztyű belsejébe. Ezért a védőkesztyű levétele után mindig kezet kell fertőtleníteni. A védőkesztyűk fertőtlenítését és újrahasználatát a módszertani levelek egyértelműen tiltják [41], egyedül a fejlődő országok számára engedélyezi a WHO [4], ahol igen szűkös a forrás.

Nagyon fontos tehát, hogy a dolgozók tudják és tudatosan alkalmazzák a helyes kesztyűhasználati indikációkat, mikor milyen típusú kesztyűt (steril kesztyű vagy védőkesztyű) kell viselni a különböző beavatkozásoknál, és tudják, hogy a kesztyű felvétele előtt is és a levétele után is minden esetben el kell végezniük a kézfertőtlenítést [4, 42].

8. Csak az egészségügyi személyzet kézhigiénés compliance-én múlik, hogy mennyire terjednek a betegellátó osztályokon a – kontakt úton (például kéz útján) továbbadható – fertőzések?

Néhány tanulmány rávilágított arra, hogy nemcsak az egészségügyi dolgozó keze játszhat szerepet a fertőzések továterjedésében, hanem a betegeké is [43–45]. A kezeken főként Gram-negatív baktériumokat [44, 45] és a Gram-pozitív baktériumok közül *Staphylococcus aureus*-t mutattak ki [43]. A kézhigiéné ötödik momentuma, azaz a beteg környezetének érintése után elvégzendő kézhigiéné ezért is fontos, mivel a beteg szervezetében és a bőrén lévő kórokozók többsége megtalálható a beteg zónájában, amely mintegy 1,5 méteres hatósugarú gömbként öleli körül a beteget. A beteg ugyanis az ágyában, illetve az ágya körül mozogva gyakran érinti a környezetében lévő élettelen felületeket, amelyeken a kórokozók hosszú ideig életképesek maradhatnak [46]. Mivel a betegzónában lévő berendezési tárgyak (például: ágyvég, éjjeliszekrény, kapaszkodók) felületeit nemcsak a beteg, hanem a betegellátók is rendszeresen érintik (például az ápolás során), a rajtuk lévő kórokozók könnyen kontaminálhatják a betegellátók kezét is.

Ezért a betegellátók kézhigiénés oktatásával párhuzamosan szükség van betegoktatásra is, amelyben ki kell térni a betegek jó kézhigiénéjének fontosságára is [47]. Mivel a betegzónába rendszeresen belépnek a betegekhez érkező látogatók is, az ő kezük is kontaminálódhat az itt élő kórokozókkal. Ezáltal potenciális fertőzőforrás lehet a látogató is. *Birnbach és mtsai* [48] intenzív osztályra érkező látogatók kezéről vettek mikrobiológiai mintát. A vizsgálatban a kézhigiénét végzőknél negatív volt az eredmény, míg azok esetében, akik nem végezték el a kéz megtisztítását, az összes mintából kórokozó tenyészett ki. A kitenyészett minták 26%-ából 12-féle patogén kórokozó is kimutatható volt. Ezek olyan kórokozók voltak, amelyek egészségügyi ellátással összefüggő fertőzéseket okozhatnak (többnyire Gram-negatív baktériumokat, de egy esetben meticillinrezisztens *Staphylococcus aureus*-t is találtak a látogató kezén).

A betegek és a látogatók KC-jének vizsgálata kényes kérdés, így a jelentősége ellenére kevés kutatás foglalkozott eddig vele, pedig már 1996-ban is megállapította egy tanulmány, hogy mindössze 7%-ban végzik el a látogatók a szükséges kézhigiénét a beteg gyermek megérintése előtt [49].

Egy későbbi vizsgálatban *Randle és mtsai* [50] már jobb eredményt kaptak. Az utóbbi vizsgálatban a betegek esetében 56%-os, a látogatók esetében 57%-os compliance-t figyeltek meg.

A betegellátók hatékony oktatásának módjáról létezik olyan elképzelés is, amelyben egyszerre történne a betegellátás két legfontosabb szereplőjének figyelemfelhívása a kézhigiéné súlyára, ugyanis a betegek bátorítása – arra, hogy emlékeztessék betegellátójukat, hogy fertőtlenítsék a kezüket, mielőtt hozzájuk érnek – növelheti az egészségügyi dolgozók KC-jét [51].

9. Lehetséges-e műköröm, körömlakk viselete az egészségügyben dolgozók számára?

A műköröm és hosszú köröm a védőkesztyű sérülését, kiszakadását okozhatja. A műköröm amellett, hogy elvékonyítja a természetes körmöket, a körömvég kemény felülethez való ütközése, koccantása hatására elválhat a megmaradt vékony körömlemeztől, és a keletkezett résbe szennyeződés vagy kézápoló krém juthat be, amit

nem lehet onnan kitisztítani, így baktériumok és gombák is elszaporodhatnak ezeken a területeken [52].

Számos tanulmány szól arról, hogy epidemiológiai összefüggés van az egészségügyi dolgozók műkörme és a Gram-negatív kórokozók (főként *Pseudomonas aeruginosa*) és élesztőgombák által okozott infekciók, járványok között [53–55].

Egy 2000-ben publikált tanulmány az ápolók műkörme mellett felelősnek találta az ápolók hosszú természetes körmét is egy neonatalis intenzív centrumban kialakult, *Pseudomonas aeruginosa* okozta járványban [56]. A betegbiztonság és a dolgozói biztonság is azt kívánja, hogy az egészségügyi dolgozók, kiemelve a műtéti team tagjait, ne hordjanak műkörmöt, továbbá az ujjbegynél tovább érő körmöt se [57].

A körömlakkokkal kapcsolatban egyes tanulmányok azt találták, hogy nincs jelentős eltérés azon nővérek kezén lévő kórokozó-mennyiség között, akiknek lakkozott a körme, szemben azokéval, akiké nem lakkozott [57]. Ugyanakkor egy másik tanulmány szignifikáns különbséget közölt a lepattogzott lakkos körmű nővérek körmeinek kontaminált sága, a frissen festett körmű nővérek körme és azoknak a körme között, akik egyáltalán nem viseltek lakkot; a nem frissen lakkozott körmökön találták a legtöbb mikroorganizmust [58]. Az is figyelemre méltó, hogy a lakkozott körmök elfedhetik a köröm alá szorult szennyeződést, továbbá a körömlakkok többször használatosak és befertőződhet az egész üvegcse, főként, ha szépségszalonban használják, ahol több vendég körmére festik ugyanazt a lakkot. A lakkozott köröm és műköröm viseletét a betegellátásban mind a WHO [4], mind a Betegségellenőrzési és Megelőzési Központ (CDC) [59] megtiltja. Az Association of periOperative Registered Nurses (AORN) szervezet az újfajta lakkok (géllakk, shell-lakk) használatának mellőzésére is felszólítja az egészségügyi dolgozókat a rendelkezésre álló nagyon kevés evidencia és az akril műkörmök kémiai összetevőihez való hasonlósága miatt [60].

10. A gyűrű (például karikagyűrű) viselete megengedhető a betegellátás során?

A betegellátói munka közbeni gyűrűviseletet a dolgozók azzal magyarázzák, hogy nem akarják elveszíteni az ékszert, vagy rászorult az ujjukra és nem tudják levenni, vagy egyszerűen érzelmi okok (jegygyűrű) miatt mindig fent hagyják az ujjukon.

A szakirodalomban megjelenő tanulmányok szerint potenciális fertőzőforrás a gyűrű az egészségügyben munka közben [61, 62]. Mivel a körmök, körömágyak megtisztítása nehéz, erre fókuszálunk a fertőtlenítőszeres kézbedörzsölés technikájának oktatása során. Ha gyűrűt is visel a dolgozó, akkor nála jóval több mikroorganizmusra (akár patogén kórokozóra) kell számítani, mintha ékszertelen lenne a keze. *Hoffman és mtsai* kimutatták, hogy a gyűrűs kezeken *Enterobacter cloacae, Klebsiella pneumoniae, Acinetobacter calcoaceticus* és *Pseudomonas aeruginosa* kórokozók lehetnek, illetve a tartós gyűrűhasználat olyan mértékű kontaminációhoz vezet, amely rutin kézhigiénével nem távolítható el [62]. Más tanulmányok is megerősítik, hogy jelentős mértékben kolonizálják a gyűrűs kezeket az *Enterobacteriacae* speciesek [63, 64], és egészségügyi ellátással összefüggő fertőzések kialakulásához vezethetnek. A gyűrű felülete alá szorult nedvesség például táptalajként szolgál a kórokozóknak, de az ékszer alá irritatív anyagok is beragadhatnak (például a púderes kesztyűből) és a gyűrű levetése nélküli rutin kézmosás ellenére a gyűrű alatt továbbra is ott maradhatnak, és kontaktdermatitist okozhatnak. Továbbá a gyűrű átszakíthatja a kesztyűt, megszüntetve ezzel a barriert a kéz bőre és az éppen tapintott felületek, anyagok stb. között [65]. Mindezek mellett az egészségügy területén is okozhat munkahelyi balesetet a gyűrűviselet, ha például az ékszer beakad valamibe. Éppen ezért mind a WHO, mind pedig az OEK állásfoglalása az, hogy az egészségügyi dolgozók a betegellátás során ne viseljenek gyűrűt [4, 6].

Következtetés

A betegellátás területén nélkülözhetetlen a helyes és megfelelő kézhigiéné. Törekedni kell arra, hogy a betegellátásban részt vevők minden szükséges helyen és esetben alkalmazzák a kézhigiénét, és hogy azt a legjobb gyakorlat szerint végezzék el. Jelen közlemény szerzői azzal a céllal gyűjtötték össze a kézhigiénével kapcsolatos leggyakoribb félreértéseket, hogy eloszlassák azokat, és megakadályozzák az említett tévhitek és rossz berögződések továbbterjedését a köztudatban. Az evidenciaalapú tudást oktatások és továbbképzések keretében szükséges ismertetni, mivel a tiszta kezek életet menthetnek.

Anyagi támogatás: A közlemény megírása anyagi támogatásban nem részesült.

Szerzői munkamegosztás: A szerzők egyenlő mértékben járultak hozzá a közlemény elkészítéséhez. A cikk végleges változatát mind a négy szerző elolvasta és jóváhagyta.

Érdekeltségek: A szerzőknek nincsenek érdekeltségeik.

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