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Intelligent Expert System for Assessing the Epidemiological Situation Related with Catheter-Associated Urinary Tract Infections in A Health Care Setting

Dmytro Chumachenko., PhD[1*], Tetyana Chumachenko., MD, PhD[2]

[1]*Associate Professor of Informatics Department, National Aerospace University, Kharkiv, Ukraine*

[2]*Full Professor, Head of Epidemiology Department, Kharkiv National Medical University, Kharkiv, Ukraine*

Corresponding Author:** ***Dmytro Chumachenko, *Associate Professor of Informatics Department, National Aerospace University, Kharkiv, Ukraine,* ***Email:*** *dichumachenko@gmail.com*

Abstract: *The method of epidemiological diagnosis of catheter-associated urinary tract infection (CAUTI) in a health care setting includes the definition of a single integral indicator of epidemiological well-being relative to CAUTI. Epidemiological diagnosis of CAUTI is performed by evaluating such indicators as the percentage of positive patients with bacteriuria, the duration of the patient's bladder catheterization, the characteristics of the urinary catheter and the drainage system used for catheterization, the type of hospital wards and duration of staying of patients in hospital, the total number of patients with urinary catheters and the number of patients with various types of catheters (silicone, latex, etc.), sex and age of patients. First, the duration of the catheterization of the bladder is determined, then, depending on the data obtained, the desired formula is chosen and the obtained values of the indices are introduced into the formula. If the integral indicator of well-being is less than 0.001, then the CAUTI epidemiological situation is assessed as welfare and safe, if the integral indicator of well-being is from 0.001 to 0.5, then the epidemiological situation is assessed as unstable, and if the integral indicator of well-being reaches more than 0.5, the epidemiological situation is assessed as unfavorable.*

Keywords: *Health-care associated infections, urinary catheter, bacteriuria, a single integrated indicator*

1. INTRODUCTION

Ensuring quality of care and creating a safe environment for patients and medical staff in health-care facilities is a strategic public health objective. Health-care associated infections (HAI) have a negative impact on the quality of care and the safety of patients and staff [1 – 4]. It is known that the death rate in the group of hospitalized patients with developed HAI is 8-10 times higher than in the group of hospitalized patients without infection [3 – 5]. In the European Union, 4.1 million cases of HAI are reported each year, of which 37,000 are fatal. According to the World Health Organization (WHO) in South-East Asia, the most frequent outbreaks occur (10% of patients develop HAI). Among all of the HAI, the most common are urinary tract infections (UTI), proportion of which are about 40% of all nosocomial infections and which cause significant economic, medical and social harm [5, 6] The vast majority of UTI are catheter-associated urinary tract infections (CAUTI) associated with bladder catheterization - a common procedure administered to patients. Up to 25% of all hospitalized patients require indwelling bladder catheters during of their hospitalization [6, 7]. Approximately 15-25% of all hospitalized patients undergo short-term urethral catheterization. The prevalence of long-term urethral catheterization remains unknown. There is disparate evidence that in the United States the prevalence of long-term urethral catheterization in patients with long-stay in the ward is about 5% with the presence of about 50,000 catheterized patients at any one time. CAUTI are an important problem of the patient's safety and should be the focus of attention, as are any invasive interventions that pose a risk to the patient [8 – 11].

At the same time, according to various estimates, from 17 to 69% CAUTI can be prevented by the infection prevention and control programs, which means that around 380 000 infections and 9000 deaths related with CAUTI can be prevented yearly. In order to develop effective, efficient and cost-effective strategies for the prevention of these infections

is necessary to know the presence and severity of risks, the extent of the epidemic well-being of health care facilities that may be not the same in different hospitals [5, 6, 12 – 20]. Assessment of the epidemiologic situation allows rational allocation of resources, use the most effective measures to prevent cases of CAUTI.

2. Matherials and Methods

We conducted an integral assessment of the conditions for the occurrence and spread of CAUTI in hospitals of various types. To this end, factors that contributed to or hampered the emergence and spread of CAUTI were identified [8 – 20], since different groups of factors with different intensity of exposure may be possible in different hospitals and specific conditions. The contribution of each specific indicator to the integral assessment of the risk of occurrence of CAUTI was justified and calculated. The influence of such indicators as percentage of patients with bacteriuria, the lenght of catheterization of the bladder in days, the diameter of the urinary catheter, the risk of occurrence of CAUTI depending on the type of hospital wards, the length of stay of the patient in hospital, the type of drainage system, the number of patients with a silicone catheter, the number of patients with a latex catheter, the number of patients with other types of urinary catheter, the total number of patients with urinary catheters, sex, age of the patient were studied.

3. Results

The utility model refers to medicine, namely, the epidemiology of infections related to the provision of HAI, and can be used to assess the epidemic situation with CAUTI in health care facilities.

An epidemiological situation is an indicator of the well-being of a territory (object) at a certain time, characterized by the level and dynamics of people's morbidity due to infectious diseases, the presence or absence of appropriate factors of transmission of infection and other circumstances that affect risk of drift and the spread of infectious diseases.

These criteria make it possible to judge the welfare or unhappiness of the epidemiological situation and the severity of the problem. Conditionally it is possible to allocate safe, unstable, unsuccessful and extreme epidemiological situations. The probability of occurrence of an emergency in relation to CAUTI is unlikely and is not considered in this work.

We say about a welfare epidemiological situation when cases of infectious diseases are not registered or their sporadic cases are reported, there are no favorable conditions for the spread of these diseases. We say about an unstable epidemiological situation when the level of people's morbidity due to infectious diseases does not exceed the average long-term indicators, but there are favorable conditions for the spread of these diseases. We say about an adverse epidemiological situation when the level of peoples' morbidity due to infectious diseases in excess of normal expectancy, outbreaks of infectious diseases are recorded.

A comprehensive assessment of the degree of epidemiological well-being or disadvantage of a certain population or territory usually is based on a comparison of certain specific statistical indicators, such as quantity of cases, incidence, prevalence. However, in practice the epidemic situation with respect to CAUTI is determined by other determinants (for example, sex, age, duration of catheterization, etc.) With indicators that vary in different directions, a reliable conclusion about epidemiological well-being or adverse-being is based, in addition to logical analysis, on the use of a single integrated indicator.

To calculate a single integrated indicator, we selected the main determinants that contribute to the emergence and spread of CAUTI. They included the percentage of positive patients with bacteriuria, the duration catheterization of the patient's urinary bladder, characteristics of the urinary catheter and drainage system used, type of hospital and duration of catheterization, the total number of patients with urinary catheters and the number of patients with different types of catheters (silicone, latex, etc.), sex and age of patients. First, the duration of the bladder catheterization is determined, then, depending on the data obtained, the desired formula is chosen (if the length of catheterization of the bladder is between 1 and 3 days, we choose the first formula; if the length of catheterization of the bladder is more than 3 and less than 23 days,

we choose the second formula; if the length of catheterization of the bladder is more 23 days, we choose the third formula) and the obtained values of the indices are introduced into the formula:

$$I=\begin{cases}(\frac{B}{100\%}+0{,}01)\times\frac{0{,}1\times KS+0{,}5\times CL+CD}{C}\times H\times\frac{\sum_{i=1}^{K}DC_i\times LH_i\times D_i\times S_i\times A_i\times 0{,}01}{C}, LC\in[1,3];\\ (\frac{B}{100\%}+0{,}01)\times\frac{0{,}1\times CS+0{,}5\times CL+CD}{C}\times H\times\frac{\sum_{i=1}^{K}DC_i\times LH_i\times D_i\times S_i\times A_i\times(LC-3)\times 0{,}05}{C}, LC\in(3,23];\\ (\frac{B}{100\%}+0{,}01)\times\frac{0{,}1\times CS+0{,}5\times CL+CD}{C}\times H, LC\in(23;\infty);\end{cases}$$

where I is the integral indicator of well-being relative to CAUTI, B is the percentage of patients with bacteriuria, LC is the lenght of catheterization of the bladder in days, DC is the indicator of the diameter of the urinary catheter, H is the risk of occurrence of CAUTI depending on the type of hospital, LH is the length of stay of the patient in hospital, D – indicator depending on the type of drainage system, CS – the number of patients with a silicone catheter, CL – the number of patients with a latex catheter, CD – the number of patients with other types of urine, C – the total number of patients with urinary catheters, S – the indicator depending on the sex, A – the indicator depending on the age of the patient.

Some parameters of the formula take fixed values depending on expert estimates. These values include DC (Table 1), LH (Table 2), D (Table 3), H (Table 4), S (Table 5), A (Table 6).

Table1. *The value of DC in accordance with the diameter of the urinary catheter.*

Sex	Catheter diameter (*Fr*)	Value of *DC*
male	5-10	0,4
male	12-14	0,1
male	16-18	0,4
male	20	0,5
male	22	0,6
male	24	0,7
male	26-28	1
female	5-8	0,4
female	10-12	0,1
female	14-16	0,4
female	18	0,5
female	20	0,6
female	22	0,7
female	24-28	1

Table2. *The value of LH in accordance with the length of stay in the hospital.*

Length of stay in hospital	Value of *LH*
Less than 48 hours	0,01
From 2 to 7 days	0,2
From 8 to 14 days	0,4
From 15 to 29 days	0,6
More than 30 days	1

Table3. *The value of D depending on the type of drainage system.*

Drainage system	Value of *D*
Open	1
Close	0,032

Table4. *The value of H depending on the type of hospital*

Type of hospital wards	Value of *H*
Therapeutic units	0,2
Surgical units	0,4
Urological units	0,6
Nursing home	0,8
Intensive care units	1

Table5. *The value of S depending on gender.*

Sex	Value of *S*
Female	1
Male	0,7

Table6. *Value of A, depending on age.*

Age	Value of *A*
Less than 65 years old	1
From 65 to 75 years old	1,1
Older than 75 years	1,2

If the integral indicator of well-being is less than 0.001, then the epidemiological situation in CAUTI is assessed as welfare and safe, if the integral indicator of well-being is from 0.001 to 0.5, then the epidemiological situation is assessed as unstable, and if the integral indicator of well-being reaches more than 0.5, the

epidemiological the situation is assessed as unfavorable.

The single integral indicator includes all the factors that determine and contribute to the occurrence of CAUTI and provides the expansion of the arsenal of methods for epidemiological diagnosis of the epidemiological situation of CAUTI in the health care setting.

The developed method allows assessing the epidemic situation with CAUTI in health care facilities. The method is tested in various hospital wards in the Kharkiv region, Ukraine.

4. Conclusion

Thus, the proposed assessment of the epidemiological situation with regard to CAUTI can provide a comprehensive risk assessment for the generalized indicator, taking into account the main determinants of the CAUTI epidemic process, forecast the epidemiological situation based on the obtained generalized data taking into account the integral risk index; to develop, based on the data obtained, measures to eliminate or reduce the negative impact of unfavorable factors; to prioritize measures to improve the safety of inpatient visits to patients and medical staff.

References

[1] Bennett and Brachman's Hospital Infections – 5th ed / edited by William R. Jarvis., 2007 – Lippincott Williams & Wilkins, Philadelphia, USA. – 832 p.

[2] Guidelines on core components of infection prevention and control programmes at the national and acute health care facility level. World Health Organization; 2016; ISBN 978-92-4-154992-9.

[3] Report on the endemic burden of healthcare-associated infection worldwide. Geneva: World Health Organization; 2011.

[4] Allegranzi B, Bagheri Nejad S, Combescure C, Graafmans W, Attar H, Donaldson L, et al. Burden of endemic health-care-associated infection in developing countries: systematic review and meta-analysis. Lancet. 2011; 377(9761):228-41.

[5] Klevens RM, Edwards JR, Richards CL, et al. Estimating health care-associated infections and deaths in U.S. hospitals, 2002, Public Health Rep, 2008, vol. 122: 160-7.

[6] Saint S, Kowalski CP, Kaufman SR, et al. Preventing hospital-acquired urinary tract infection in the United States: a national study. Clin Infect Dis. 2008 Jan 15; 46(2):243-50. doi: 10.1086/524662.

[7] Saint S, Wiese J, Amory JK, et al. Are physicians aware of which of their patients have indwelling urinary catheters? , Am J Med, 2000, vol. 109: 476-80.

[8] Chenoweth, C.E. and Saint, S. Urinary tract infections. Infect Dis Clin North Am. 2011; 25: 103–117.

[9] Burton, D.C., Edwards, J.R., Srinivasan, A. et al. Trends in catheter-associated urinary tract infections in adult intensive care units-United States, 1990-2007. Infect Control Hosp Epidemiol. 2011; 32: 748–756.

[10] Chenoweth C1, Saint S. Preventing Catheter-Associated Urinary Tract Infections in the Intensive Care Unit. Crit Care Clin. 2013 Jan; 29(1):19-32. doi: 10.1016/j.ccc.2012.10.005.

[11] Nicolle, L.E. Urinary catheter-associated infections. Infect Dis Clin North Am. 2012; 26: 13–27

[12] Rebmann, T. and Greene, L.R. Preventing catheter-associated urinary tract infections: an executive summary of the Association for Professionals in Infection Control and Epidemiol. Am J Infect Control. 2010; 38: 644–646

[13] Gould CV, Umscheid CA, Agarwal RK, Kuntz G, Pegues DA. Guideline for Prevention of Catheter-Associated Urinary Tract Infections 2009. Infect Control Hosp Epidemiol 2010; 31(4):319-326.

[14] Lo, E., Nicolle, L., Classen, D. et al. Strategies to prevent catheter-associated urinary tract infections in acute care hospitals. Infect Control Hosp Epidemiol. 2008; 29: S41–S50

[15] Nicolle LE. The prevention of hospital-acquired urinary tract infection. Clin Infect Dis 2008; 46(2):251-253.

[16] Nizam Damani Chapter 18 Prevention of Catheter-Associated Urinary Tract Infections IFIC Basic Concepts of Infection Control, 3rd edition, 2016

[17] Elimination Guide: Guide to Preventing Catheter-Associated Urinary Tract Infections. Association for Professionals in Infection Control and Epidemiology, Washington, DC: 2014.

[18] CDC/HICPAC. Guideline for prevention of catheter-associated urinary tract infections 2009. CDC, Atlanta: 2010.

[19] Epic3: National Evidence-Based Guidelines for Preventing Healthcare-Associated Infections in NHS Hospitals in England. J Hosp Infect 2014; 86 (Supplement 1): S1–S70.

[20] Stone, P.W., Pogorzelska-Maziarz, M., Herzig, C.T., Weiner, L.M., Furuya, E.Y., Dick, A., Larson, E. State of infection prevention in US hospitals enrolled in the National Health and Safety Network. Am J Infect Control 2014, 42(2), 94-99.

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