ORIGINAL ARTICLE

CONTENTS

Forecasting the need for palliative and hospice care using the creeping trend method with segment smoothing

Valentyna G. Nesterenko[1], Iryna V. Redka[2], Roman O. Sukhonosov[1], Sergiy M. Grygorov[1], Alexander S. Shevchenko[1, 3], Tarana D. Aliieva[1]

[1]KHARKIV NATIONAL MEDICAL UNIVERSITY, KHARKIV, UKRAINE

[2]V.N. KARAZIN KHARKIV NATIONAL UNIVERSITY, KHARKIV, UKRAINE

[3]KHARKIV REGIONAL INSTITUTE OF PUBLIC HEALTH SERVICES, KHARKIV, UKRAINE

ABSTRACT

Aim: To determine the limits of refinement of the forecast of the need for palliative and hospice care (PHC) among adults and children, made by the methods of linear, logarithmic and exponential trends, using the improved forecasting method.

Materials and Methods: Based on the calculated demand for 2018-2020, a demand forecast was made using the linear trend method for 2021 and 2022, which was verified by comparing it with the calculation based on available statistical data for 2022. To improve the forecasting result, the creeping trend method with a smoothing segment was used.

Results: The estimated need for PHC by the linear trend method for 2022 was 87,254 adults and 46,122 children. The predicted need for this year by the linear trend method was 172,303 for adults and 45,517 for children. The prediction using the sliding trend method with segment smoothing was found to be 4.7 times more accurate and reliable for adults and all age groups combined, but was less accurate and not reliable for children. It was found out that in order to achieve a reliable forecast, it is necessary to clarify the data of medical statistics regarding of malignant neoplasms and congenital malformations, as well as demographic statistics.

Conclusions: The method of a creeping trend gave more accurate results and made it possible to determine the reliability of the forecast, allowed to take into account the simultaneous influence of various input parameters.

KEY WORDS: demographic statistics, improved forecasting methods, congenital malformations, malignant neoplasms in children, temporarily occupied territories

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INTRODUCTION

The Quality of Death Index of Ukraine in October 2015 was 25.5, which ranked the country 69th out of 70 countries that participated in the rating that year [1]. In the 2021 rating, in which 81 countries have already participated, Ukraine remained in the 69th place, but already with an indicator of 53.7 [2]. In part, this change in the number of points is associated with a change in the calculation method developed in 2010 [3, 4], partly with the improvement of the palliative and hospice care financing system [5]. But it should be noted that there are a number of unsolved problems in the PHC system of the country, including insufficient integration of the PHC system into the general system of medical care; permanent shortage of personnel (lack of doctors and nurses) in hospices, palliative departments and wards; lack of adequate analgesia for the vast majority of palliative patients with chronic pain; imperfection of training programs on palliative care in medical education institutions; low awareness of the population and medical professionals about many PHC problems; insignificant influence of non-government organizations on PHC policy in the country; lack of euthanasia system for palliative patients with chronic pain; lack of a state-recognized methodology for determining the need for PHC (both calculation based on available data and forecasting) [6, 7].

AIM

To determine the limits of refinement of the forecast of the need for palliative and hospice care among adults and children, made by the methods of linear, logarithmic and exponential trends, in accordance with the list of palliative diagnoses recommended by the WHO, using the improved forecasting method.

MATERIALS AND METHODS

The list of palliative diseases of adults and children, included in the forecast, corresponds to the recommendation of the WHO and the "best practices" of countries with a developed PHC system, fully integrated into national health care systems in countries of group *4b* according to the classification of Lynch T., Wright M., and Clark D. [8] (Table 1). The given list was followed by the researchers of the Ukrainian Center for Public Data, who developed a methodology for calculating the need for PHC for Ukraine in 2018 [9]. We used this methodology to determine the need for PHC for Ukraine for 2019 and 2020 [10]. Based on this calculation, a forecast of the need for PHC for 2021 and 2022 was also made [11], which was verified in 2023.

The verification of the forecast by comparison with the result of the calculation based on the available data showed a significant discrepancy with the forecast of the need for PHC for 2021 and 2022 [11]. An important factor that had an impact on the collection of medical statistics data was the full-scale war in Ukraine that began in 2022. In 2022, the official medical statistics data for 2021 were not made public, so we considered the estimated data to be equal to the projected linear trend method. In 2023, data from official medical statistics were released, which led to the search for a more accurate forecasting method.

ICD-10 – International Statistical Classification of Diseases and Related Health Problems 10th Revision [12].

HIV/AIDS – human immunodeficiency virus/acquired immunodeficiency syndrome.

The search for literature sources to compare the obtained results with the data of other researchers was conducted in the PubMed, Google Scholar and Scopus databases retrospectively up to the year 2000 inclusive. Processing of digital results was carried out in Excel (Microsoft, USA). Statistical data obtained from open databases of official statistics ec.europa.eu/eurostat; ukrstat.gov.ua; medstat.gov.ua; tbc.gov.ua; ncru.inf.ua; WHO [13]. The study was approved by the Bioethics Commission of the Kharkiv National Medical University (Protocol No.10 on September 12, 2023).

RESULTS

The choice of the linear trend method (mathematically corresponds to the regularity of $y=ax+b$) for forecasting the need for PHC for 2021 and 2022 was associated with a steady tendency to decrease the determined need during 2018-2020. We attributed this decline to a number of objective and subjective factors. Among the first were the phenomena of the growing demographic crisis, among the second – the deterioration of the quality of data collection of medical statistics. Checking the results of forecasting by the linear trend method using the calculation of the need for PHC according to the available statistical data showed a discrepancy of 76.74% among adult palliative patients and 1.86% among children (Table 2).

The accuracy of the forecast by the creeping trend method with a constant smoothing segment is higher due to the built-in multifactor dispersion load [14, p. 57-60; 15, p. 76], the physical meaning of which is the mutual influence of variances and standard errors of various calculated factors. In our case, it was the number of available population and the number of patients with palliative diagnoses who were discharged from medical institutions at the end of the year. The forecasting took into account the variance of samples and patients with palliative diagnoses, and checked for reliability according to the Student's test and adjusted to 95% CI. The prognosis for children was outside the 95% CI for some of the palliative diagnoses, among which the group of congenital malformations (Q00-Q99 according to ICD-10) was noted to have the most statistically significant standard error. For each diagnosis, the forecast for 2022 was also calculated using the methods of logarithmic (mathematically corresponding to the pattern $y=R\times ln(x)+b$) and exponential (mathematically corresponding to the pattern $y=ge^{hx}$) trends. All values within the 95% CI did not fall outside the "linear trend– logarithmic trend" or "linear trend – exponential trend" intervals. For adult palliative patients, the forecast using the creeping trend method turned out to be 4.7 times more accurate compared to the forecast using the linear trend method. The "smoothing" effect shows an exception to the 2021 forecast, for which Ukraine did not release data in early 2022 due to the outbreak of a full-scale war. At the same time, the forecast for adults and in total for all age categories was reliable.

Thus, it was the statistics regarding children with palliative diagnoses that needed correction. In our opinion, the collection of statistical information regarding this category of palliative patients was influenced by the following factors: the reform of the genetic service of Ukraine on the eve of the war; significant migration of children during full-scale war (both overseas and internal displacement). Verification of the data by methods of standardization of samples of children with palliative diagnoses according to the number of available population in the regions with temporarily occupied territories that were liberated already in 2022 (Zhytomyr, Kyiv, Chernihiv, Sumy, Kharkiv regions) showed a decrease in the standard error of the average samples to the levels of variance 0.70-0.84 (for diagnoses of groups Q00-Q99 and C00-C97 with weighting coefficients in the total population of children requiring PHC, 0.1648 and 0.1348, respectively), which allows us to consider the adjustment sufficient to match the result adjusted by the creeping trend method forecast in 95% CI. That is, in order to obtain a reliable forecast for children who need PHC, in the next forecast for 2024, it is enough to specify data on 1/3 of palliative patients of this profile with diagnoses of malignant neoplasms and congenital malformations.

Table 1. Palliative diseases of adults and children according to WHO recommendations

Palliative diagnoses of adults		Palliative diagnoses of children	
Group of diseases, nosology	ICD-10 code	Group of diseases, nosology	ICD-10 code
Malignant neoplasms * ***	C00-C97, D00-D48	Malignant neoplasms **	C00-C97
Cardiovascular diseases *	I00-I99	Cardiovascular diseases **	I00-I99
Tuberculosis * **	A15-A19	Tuberculosis **	A15-A19
Diabetes * **	E10-E14	Diabetes **	E10-E14
HIV/AIDS *	B20-B24	HIV/AIDS **	B20-B24
Dementia **	F00-F03	Mental retardation (heavy and deep) **	F72-F79
Fibrosis and liver cirrhosis *	K74	Chronic hepatitis **	K73, K75.2, K75.3
Rheumatoid arthritis **	M05-M06	Congenital malformations **	Q00-Q99
Chronic obstructive lung diseases *	J43-J47	Perinatal conditions **	P05-P96
Kidney disease *	N00-N15, N20-N23	Children's cerebral palsy **	G80
Notes: categories of patients taken into account when calculating the need		Inflammatory diseases of the central nervous system **	G00, G03, G04, G06, G08, G09
** – dead persons;*		E70.0	
*** – discharged from a medical institution with a corresponding diagnosis at the end of the year;*		E84	
**** – registered for the first time.*			
Phenylketonuria **		E76	
Cystic fibrosis **			
Mucopolysaccharidoses **			

Notes: data of national medical statistics, if they are collected for the specified diagnoses, are multiplied by coefficients determined by an expert (they are multiples of such parts of the total population of patients as 1/10, 1/5, 1/4, 1/3 and 1/2). The categories of patients listed as discharged at the end of the year receive treatment on an outpatient basis or in an inpatient basis, and for children with palliative diagnoses, in most cases, they are associated with a disability due to a palliative diagnosis. For adult palliative patients with tuberculosis, one of the categories of patients is counted in the presence of a multiresistant form of the disease.

Table 2. Calculation and forecast of the need for palliative and hospice care in Ukraine among adults and children in 2019, 2020 and 2022

Method calculation or forecasting	Year	Adults		Children	
		Number of patients	Certainty [+/0/–] and (deviation [±%])	Number of patients	Certainty [+/0/–] and (deviation [±%])
Calculation according to available data	2019	245,070	+	53,133	+
	2020	213,739	+	49,000	+
	2022	87,254	–	46,122	–
Linear trend	2022	172,303	0 (+97.47%)	45,517	0 (–1.31%)
Creeping trend	2022	105,341	+ (+20.73%)	44,660	– (–3.17%)

Notes: the credibility score is defined for calculation based on available statistical data as high (+) or low (–), for prediction – as sufficient (+) within the 95% confidence interval (CI), insufficient (–), or not estimated (0). The deviations of the predicted values for 2022 using the linear trend and creeping trend methods are calculated as a percentage of the value for 2022 calculated from available statistical data. It should also be noted that the calculation based on the available data was carried out without taking into account the temporarily occupied territories of Ukraine: in 2019 and 2020 – 2 regions and the Autonomous Republic of Crimea, in 2022 – 9 regions and the Autonomous Republic of Crimea.

DISCUSSION

The situation regarding inaccurate forecasting in Ukraine since the beginning of a full-scale war is not unique. During the last 20 years, more than 10 countries that were in a state of war, natural disasters or migration crises faced similar problems, and at the same time worked on improving national PHC systems [16]. Political support and minor additional efforts can allow Ukraine to collect the necessary medical statistics data to obtain a reliable result necessary for the calculation of PHC funding for health guarantee programs.

According to its developers, the methodology for calculating the need for PHC at the national level proposed by the Ukrainian Center for Public Data can be improved and revised. Therefore, when calculating the need for PHC for 2019 and 2020 [10], we previously excluded adult dementia and severe

and profound mental retardation in children from the list of palliative diagnoses due to the fact that Ukraine stopped collecting statistical data on these categories of patients. At the next stage of the research, we resumed the calculation of these palliative diagnoses, listing them based on indirect data, and made a forecast for 2021 and 2022, taking into account the incidence [11]. When performing the forecast, another category raised doubts about the reliability of the result: the number of patients with chronic obstructive pulmonary disease in 2019 and 2020 increased significantly due to the COVID-19 pandemic. But according to the method of calculating patients with coronavirus infection, it was necessary to calculate them separately. The problem of inaccurate forecasting disappeared after the end of the pandemic.

Another difficult category for clarifying the prognosis was a large group of children with severe perinatal conditions. According to the UN Sustainable Development Goals, child mortality by 2030 should be reduced to 12 per 1,000 live births among children under 1 month of age, and to 25 per 1,000 live births among children under 5 years of age. In the WHO European Region, both indicators were the lowest for 19 years (2000-2019). In 2019, the last year analyzed in the WHO Global Levels of Disease and Health Report 2023, the under-5 mortality rate in the WHO European Region was 7-8 per 1,000 live births. However, global under-5 mortality still remains high, with 1.1 million deaths, with the highest relative rates in the African region. According to forecasts, 54 countries in the world will not reach the goals regarding the levels of maternal and child mortality [13, p. 6, 110]. The mortality of children under 5 years of age in the world is primarily related to infectious diseases (acute respiratory infections, diarrhea, and malaria) [17]. But in the European Region of the WHO, among the factors causing the death of children, along with respiratory infections, neonatal sepsis, meningitis (corresponding to the categories of palliatively ill children with inflammatory diseases of the central nervous system), the consequences of premature birth, asphyxia during childbirth, birth trauma and congenital malformations are important. That is, child disability and mortality are closely related to the condition of pregnant women, the course of childbirth and the level of maternal mortality.

Regarding the three groups of children with palliative diagnoses (I00-I99, A15-A19 and F72-F79), the relative weight of which in the overall prognosis was 0.37%, 1.05% and 5.23% (or 166, 469 and 2 338 out of 44,660 of all children with palliative diagnoses in the one-year forecast), it should be noted that adjusting the forecast by balancing the variances and standard errors was not effective in increasing the reliability of the forecast.

CONCLUSIONS

The choice of the creeping trend method with a segment of constant smoothing turned out to be justified: it made it possible to determine the reliability of the forecast, was more accurate compared to the linear trend method, supplemented by the methods of logarithmic and exponential trends, made it possible to reduce the forecasting error associated with the lack of official medical statistics data in Ukraine for 2021. The forecast for 2022 for Ukraine using the creeping trend method allowed to obtain a reliable (within 95% confidence interval) for adults and for palliative patients of all age groups, but did not allow to obtain a reliable result for children with palliative diagnoses. It was determined that in order to achieve a reliable result, it is necessary to improve the collection of medical statistical data on children with palliative diagnoses of groups of malignant neoplasms and congenital malformations, as well as demographic statistical data on children in temporarily occupied territories after their liberation.

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CONFLICT OF INTEREST
The Authors declare no conflict of interest

CORRESPONDING AUTHOR
Alexander S. Shevchenko
Kharkiv Regional Institute of Public Health Services
8/5 Rymarska str., 61057 Kharkiv, Ukraine
e-mail: as.shevchenko@knmu.edu.ua

ORCID AND CONTRIBUTIONSHIP
Valentyna G. Nesterenko: 0000-0002-3773-9525 A B C D F
Iryna V. Redka: 0000-0002-9620-9452 E F
Roman O. Sukhonosov: 0000-0002-5177-2970 E F
Sergiy M. Grygorov: 0000-0001-9527-8408 E F
Alexander S. Shevchenko: 0000-0002-4291-3882 A B C D F
Tarana D. Aliieva: 0000-0002-3002-667X E F

A – Work concept and design, B – Data collection and analysis, C – Responsibility for statistical analysis, D – Writing the article, E – Critical review, F – Final approval of the article

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