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Incidence and prevalence of the most socially impactful types of cancer in Dnipro region in 2009-2019

Introduction. Cancer is the second most frequent cause of death, being outnumbered only by cardiovascular diseases – worldwide and in Ukraine. The problem of cancer monitoring and care requires close attention from the point of view of multiple stakeholders.

Objective. To investigate incidence and mortality of the most impactful types of cancer in Ukraine and Dnipro region in 2009-2019.

Material and methods. Data about cancer incidence and mortality in Ukraine in 2014-2019 was obtained from archives of the National Cancer Registry of Ukraine. Cancer incidence and mortality in the Dnipro region were calculated using a database of patients from Dnipro Regional Cancer Registry, which is a regional office of the National Cancer Registry of Ukraine. For the study were selected all cancer cases and the cases with cancer that were responsible for the top five causes of death for the patients with cancer in Ukraine of both sexes (breast, colon, trachea, bronchus and lung, ovary, prostate, and rectum/anus cancer). Time series analysis of cancer incidence and mortality was performed using annual average growth rates and linear regression models in R (version 4.4.0).

Results and discussions. Total cancer incidence had an increasing trend both for Ukraine ($p<0.01$) and the Dnipro region. Total cancer mortality trend in Ukraine was decreasing ($p=0.01$), in the Dnipro region it was increasing. In Ukraine, mortality from all types of cancer, except prostate cancer, gradually decreased over the time of observation. While mortality from breast cancer in Ukraine was decreasing ($p=0.02$), in the Dnipro region it was increasing ($p=0.03$). Total and site-specific cancer incidence and mortality rates in Ukraine were mostly lower than in the Dnipro region (except for ovary and prostate cancer incidence).

Conclusion. There was an increase in total and site-specific cancer incidence in Ukraine and Dnipro region in 2009-2019. Total and site-specific cancer mortality in Ukraine was declining, except for prostate cancer. Cancer mortality in the Dnipro region was not decreasing in 2012-2019, and was even increasing for breast and prostate cancer. The need for the systemic approach to cancer prevention and treatment both at national and regional levels was identified, with a special attention to primary prevention.

Key words: cancer, incidence, mortality, risk factors, primary prevention, health policy recommendations.

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Захворюваність та смертність найбільш соціально-значущих типів раку в Дніпропетровській області в 2009-2019 роках

Вступ. Рак є другою за частотою причиною смерті, поступаючись лише серцево-судинним захворюванням – у світі та в Україні. Проблема моніторингу та лікування раку потребує пильної уваги з точки зору багатьох зацікавлених сторін.

Мета. Дослідити захворюваність та поширеність найбільш значущих видів раку в Україні та Дніпровському регіоні у 2009-2019 рр.

Матеріали та методи. Дані про захворюваність і смертність від раку в Україні в 2014-2019 отримано з архіву Національного канцер-реєстру України. Захворюваність та смертність від онкологічних захворювань у Дніпровському регіоні розраховувалися на підставі бази даних пацієнтів Дніпровського регіонального канцер-реєстру, який є регіональним відділенням Національного канцер-реєстру України. Для дослідження були відібрані всі випадки раку та випадки раку, які відповідали за п'ять основних причин смертності хворих на рак в Україні обох статей (молочної залози, товстої кишки, трахеї, бронхів і легені, яєчників, передміхурової залози та прямої кишки/ануса). Аналіз динамічних рядів захворюваності і смертності від раку проводився з використанням середньорічних темпів зростання та лінійних регресійних моделей за допомогою програми R (версія 4.4.0).

Результати та обговорення. Загальна захворюваність на рак мала тенденцію до зростання як для України ($p<0.01$), так і для Дніпропетровської області. В Україні спостерігалась тенденція до зниження загальної смертності від раку ($p=0.01$), у Дніпровській області – до зростання. В Україні за час спостереження поступово знижувалася смертність від усіх видів раку, крім раку передміхурової залози. Якщо смертність від раку молочної залози в Україні знижувалася ($p=0.02$), то в Дніпровській області – зростала ($p=0.03$). Загальна та орган-специфічна захворюваність і смертність від раку в Україні були переважно нижчими, ніж у Дніпровському регіоні (за винятком захворюваності на рак яєчників і простати).

Висновок. У 2009-2019 роках в Україні та Дніпропетровській області спостерігалося зростання загальної та орган-специфічної онкологічної захворюваності. Загальна та орган-специфічна смертність від раку в Україні знижувалася, за винятком раку простати. Смертність від онкологічних захворювань у Дніпровському регіоні в 2012-2019 роках не знижувалася, а навіть зростала для раку молочної залози та простати. Визначено необхідність системного підходу до профілактики та лікування раку як на державному, так і на регіональному рівнях, приділяючи особливу увагу первинній профілактиці.

Ключові слова: рак, захворюваність, смертність, фактори ризику, первинна профілактика, рекомендації щодо політик в охороні здоров'я.

Introduction. Non-communicable diseases are responsible for 74% of deaths worldwide [1]. Cancer is the second most frequent cause of death (18%), being outnumbered only by cardiovascular diseases [1]. The same applies to years of life lost and disability adjusted years of life – by these parameters cancer in 2019 cancer was second only to cardiovascular diseases [2]. Ukrainian demographic statistical reports show the same pattern of mortality – cancer has the second most important cause of death in Ukraine [3]. The impact of age and other risk factors of cancer on the population worldwide is progressively increasing: in the last 20 years risk factors of non-communicable diseases, including cancer, have reached the highest ranks by impact on the population's health. Therefore, the problem of cancer monitoring and care requires close attention from the point of view of multiple stakeholders.

On top of the above mentioned reasons, Ukraine is facing unique challenges regarding cancer care due to the russian military aggression. Wars are known to impact all spheres of life, including healthcare. According to the historical data, an increase in cancer incidence and mortality may be expected in countries at war [4]. Understanding of the historical data is crucial for the most precise possible prognosis of cancer epidemiology in upcoming years. Also, investigation of local trends in cancer epidemiology will be useful for developing local healthcare policies for targeting patients with cancer. Despite publicly available data from National Cancer Registry of Ukraine [5] and sporadic grey-literature publications [6], the systematic peer-reviewed publication on the subject is absent.

The aim of the study is to investigate incidence and mortality of the most impactful types of cancer in Ukraine and Dnipro region in 2009-2019.

Materials and methods.

Data source

Data about cancer incidence and mortality in Ukraine in 2014-2019 was obtained from archives of the National Cancer Registry of Ukraine [5]. Cancer incidence and mortality in the Dnipro region were calculated using a database of patients from Dnipro Regional Cancer Registry, which is a regional office of the National Cancer Registry of Ukraine. For the study were selected all cancer cases and the cases with cancer that were responsible for the top five causes of death for the patients with cancer in Ukraine of both sexes. The cases with the following types of cancer were analysed: breast (C50 according to International Classification of Diseases, 10th modification [7]), colon (C18), trachea, bronchus and lung (C33-C34), ovary (C56), prostate (C61) and rectum/anus cancer (C19-C21). Gastric cancer (C16) was not included, despite being among top contributors to mortality in Ukraine, as trends for gastric cancer in Dnipro region were extensively described in previous publication [8].

Incidence was calculated for 2009-2019. Mortality was calculated for 2012-2019. Incidence and mortality for breast and ovary cancer were calculated for the female population of Ukraine. Male patients with breast cancer were excluded from the study. Incidence and mortality for prostate cancer were calculated for the male population of Ukraine.

Years 2009-2011 were omitted from mortality calculation in the Dnipro region, due to the fact that authors had access to the database of patients, who were enrolled to the registry since 2009. Therefore, it was impossible to calculate mortality properly for 2009-2011, as patients enrolled before 2009 would not be detected in case of death in consecutive years. Authors suggested that after three years of observation (starting from 2012) the influence of the mentioned phenomenon would be minimal and would allow to perform mortality calculations. Data after 2019, despite being available both for National Cancer Registry Archives and Dnipro Cancer Registry, were not used due to the significant distortion of the data caused by COVID-19 pandemic.

Statistical analysis

Data management was performed using LibreOffice software, data analysis was performed using R (version 4.4.0). Incidence and mortality were calculated per 100,000 population. Annual average growth rate was calculated in the frame of time series analysis. Temporal trends were assessed using linear regression models. Critical value of p during the verification of statistical hypotheses was set <0.05.

Results. Total cancer incidence had an increasing trend both for Ukraine and Dnipro region (Figure 1). For Ukraine the trend was statistically significant: $y = -6062.6 + 3.2$ ($p<0.01$). Mortality trend in Ukraine was statistically significantly declining – $y = 5071.2 – 2.4x$ ($p=0.01$). For the Dnipro region mortality trend was increasing, but it was not statistically significant. Both total cancer incidence and mortality in Dnipro region were higher than in Ukraine.

Incidence of breast, colon, lung and rectum cancer in Ukraine was generally lower in Ukraine than in Dnipro region in 2014-2019 (Table 1). Incidence of ovary and prostate cancer in Ukraine was slightly higher than in Dnipro region in 2014-2019. Breast cancer incidence showed an increasing trend both for Ukraine in 2014-2019 and for Dnipro region in 2009-2019. Noteworthy, that the increase in breast cancer incidence in Dnipro region was rapid in 2009-2012 – from 77.1 to 84.6 per 100,000, followed by a decrease to 79.9 per 100,00 in 2014, with the subsequent returning to the level of 84.7 per 10,00 in 2019. Similar pattern was observed for colon cancer incidence, with a gradual increase from 24.2 to 26.1 per 100,000 in Ukraine in 2014-2019, and rapid increase from 24.9 to 29.2 per 100,000 in Dnipro region in 2009-2013, with subsequent fluctuation at the level of 29-30 per 100,000.

Trachea, bronchus and lung cancer incidence in Ukraine in 2014-2019 gradually decreased from 36.7 to 35.7 per 100,000. In the Dnipro region in 2009-2019 trachea, bronchus and lung cancer incidence remained relatively stable

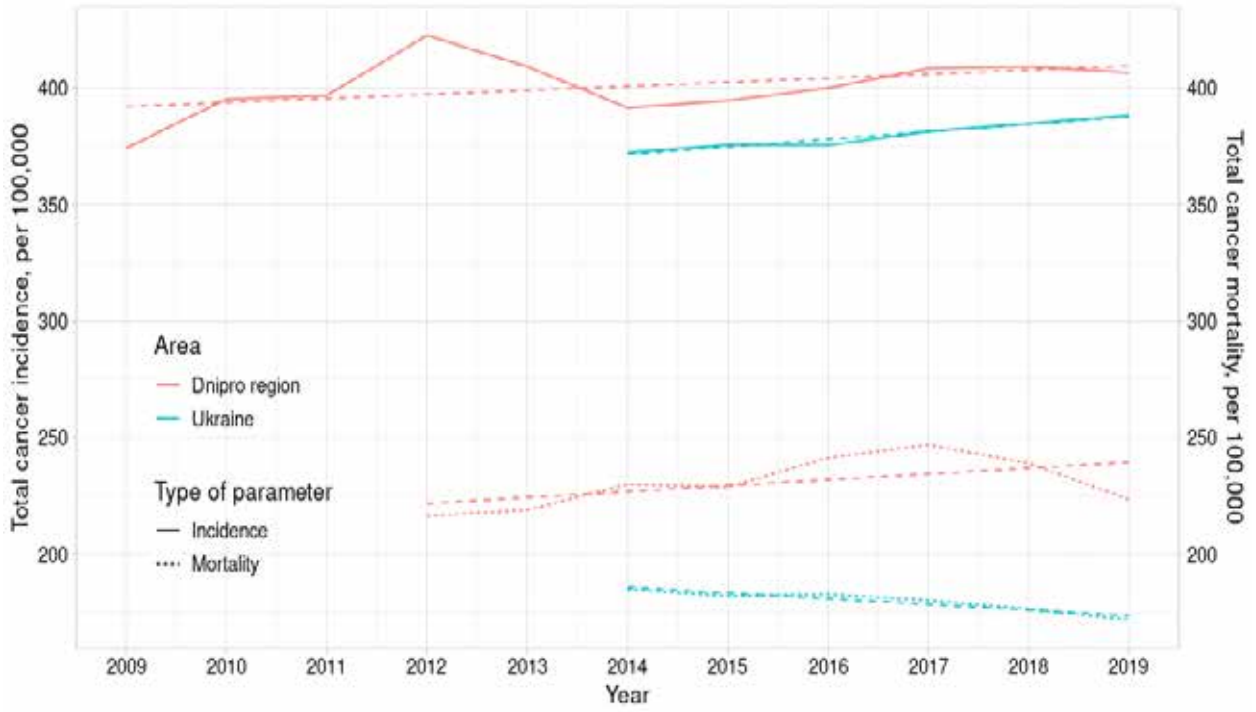

Fig. 1. Dynamics of total cancer incidence and mortality in Ukraine and Dnipro region in 2009-2019 with the corresponding linear trends

Note: dashed line of corresponding colour – linear trend line

Table 1

Dynamics of cancer incidence in Ukraine and Dnipro region in 2009-2019 by site, per 100,000

Location	Year										
	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
	Breast cancer										
Ukraine	-	-	-	-	-	70.0	73.8	74.4	74.7	77.5	77.1
Dnipro region	77.1	80.1	80.8	84.6	83.2	79.9	80.9	82.9	82.1	87.2	84.7
	Colon cancer										
Ukraine	-	-	-	-	-	24.2	24.5	24.3	25.5	25.6	26.1
Dnipro region	24.9	28.2	25.6	27.9	29.2	28.0	29.3	28.5	29.7	30.8	29.1
	Trachea, bronchus and lung cancer										
Ukraine	-	-	-	-	-	36.7	35.8	35.5	36.2	35.0	35.7
Dnipro region	42.4	43.7	44.2	45.5	43.4	41.4	40.6	42.9	42.9	41.5	42.3
	Ovary cancer										
Ukraine	-	-	-	-	-	17.9	17.9	17.5	17.6	18.4	18.6
Dnipro region	15.1	15.4	17.4	16.6	16.8	17.5	15.2	15.6	17.6	16.0	17.0
	Prostate cancer										
Ukraine	-	-	-	-	-	40.6	41.0	41.2	44.8	47.6	49.3
Dnipro region	32.1	33.3	31.8	36.7	40.0	39.6	40.9	36.9	40.7	48.9	46.8
	Rectum/anus cancer										
Ukraine	-	-	-	-	-	20.6	20.7	20.5	21.1	20.9	21.5
Dnipro region	22.8	22.4	24.0	25.7	24.8	23.8	24.9	25.1	25.6	22.2	23.9

at the level of 41-42 per 100,000, however there was an increase up to 45.5 per 100,000 in 2010-2014.

Ovary, prostate and rectum cancer incidence in Ukraine in 2014-2019 gradually increased from 17.9 to 18.6, from 40.6 to 49.3, and from 20.6 to 21.5 per 100,000 correspondingly. Ovary and prostate cancer incidence in the Dnipro region in 2009-2019 also increased, but the increase in ovary cancer incidence was non-linear. The increase in rectum cancer incidence also was non-linear and was followed by a decrease in 2018-2019, as compared to 2012-2017.

Breast, colon, prostate and rectum cancer (for Ukraine only) cancer incidence had statistically significant ($p<0.05$) linear trends over the study period (Table 2). The largest annual average growth rates were observed for prostate and

Table 2

Linear regression trends and annual average growth rate of cancer incidence in Ukraine and Dnipro region in 2009-2019 by site, per 100,000

Cancer site	Location	Annual average growth rate	Linear regression equation
Breast	Ukraine	1.42	y = -2627.53 + 1.34x (p=0.01)
	Dnipro region	0.76	y = -1111.51 + 0.59x (p=0.02)
Colon	Ukraine	0.38	y = -781.57 + 0.4x (p=0.01)
	Dnipro region	0.42	y = -806.71 + 0.41x (p<0.01)
Trachea, bronchus and lung	Ukraine	-0.2	y = 421.83 – 0.19x (p=0.20)
	Dnipro region	-0.01	y = 423.92 – 0.19x (p=0.16)
Ovary	Ukraine	0.14	y = -275.85 + 0.15x (p=0.18)
	Dnipro region	0.19	y = -150.68 + 0.08x (p=0.40)
Prostate	Ukraine	1.74	y = -3810.31 + 1.91x (p<0.01)
	Dnipro region	1.47	y = -2971.35 + 1.49x (p<0.01)
Rectum/anus	Ukraine	0.18	y = -307.52 + 0.16x (p=0.05)
	Dnipro region	0.11	y = -127.64 + 0.08x (p=0.55)

Table 3

Dynamics of cancer mortality in Ukraine and Dnipro region in 2009-2019 by site, per 100,000

Cancer site	Year							
	2012	2013	2014	2015	2016	2017	2018	2019
	Breast cancer							
Ukraine	-	-	30.2	30.2	30.2	29.3	29.6	28.4
Dnipro r.	24.9	29.2	32.2	34.4	36.0	34.9	38.0	32.5
	Colon cancer							
Ukraine	-	-	13.3	13.4	13.4	13.4	13.1	12.8
Dnipro r.	16.6	18.9	18.4	18.5	19.6	18.9	19.5	18.2
	Trachea, bronchus and lung cancer							
Ukraine	-	-	29.0	28.2	27.8	27.6	26.6	26.2
Dnipro r.	39.7	36.5	39.1	36.2	36.7	38.7	36.8	35.9
	Ovary cancer							
Ukraine	-	-	9.7	9.6	9.4	9.5	9.4	9.0
Dnipro r.	8.9	9.1	10.9	9.1	10.5	10.9	10.8	9.5
	Prostate cancer							
Ukraine	-	-	18.5	18.7	19.2	19.7	19.3	20.0
Dnipro r.	15.2	19.0	21.2	22.6	23.0	24.6	24.1	24.0
	Rectum/anus cancer							
Ukraine	-	-	12.4	11.7	11.7	11.7	11.7	11.0
Dnipro r.	14.8	15.3	16.9	15.5	16.5	17.3	15.8	14.9

breast cancer. Annual average growth rates of cancer incidence in Ukraine and Dnipro region were similar, except for breast cancer, where the value for Ukraine was twice as high as for Dnipro region (1.42 and 0.76 per 100,000).

Mortality from all types of cancer in Ukraine was generally lower in Ukraine than in Dnipro region in 2012-2019 (Table 3). In Ukraine, mortality from all types of cancer, except prostate cancer, gradually decreased over the time of observation. Mortality from prostate cancer increased from 18.5 per 100,000 in 2014 to 20.0 per 100,000 in 2019. By contrast, for most of the studied types of cancer in the Dnipro region there was an increase in mortality in 2012-2019. Notably, that for all studied types of cancer mortality in 2019 was lower than in 2018 regardless of the preceding trend. Colon cancer mortality rapidly increased from 16.6 per 100,000 in 2012 to 18.9 per 100,000 in 2013 and remained roughly the same until 2018. Trachea, bronchus and lung cancer was the only type of cancer, mortality form which has declined over the time of observation.

Mortality trends for all types of cancer in Ukraine, except colon cancer, had statistically significant ($p<0.05$) and declining linear trends over the study period (Table 4). In the Dnipro region linear trends were statistically significant ($p<0.05$) for breast and prostate cancer. The largest positive annual average growth rate was observed for prostate cancer in the Dnipro region – 1.3 per 100,000. The largest negative annual average growth rate was observed for trachea, bronchus and lung cancer in Ukraine, and equalled -0.6 per 100,000.

Discussion. The presented study showed that total and site-specific cancer incidence in Ukraine and Dnipro region tends to increase in 2009-2019. Total cancer mortality in

Table 4

Linear regression trends and annual average growth rate of cancer mortality in Ukraine and Dnipro region by site, per 100,000

Cancer site	Location	Annual average growth rate	Linear regression equation
Breast	Ukraine	-0.4	y = 703.74 – 0.33x (p=0.02)
	Dnipro region	1.1	y = -2546.85 + 1.28x (p=0.03)
Colon	Ukraine	-0.1	y = 209.12 – 0.1x (p=0.09)
	Dnipro region	0.2	y = -387.8 + 0.2x (p=0.18)
Trachea, bronchus and lung	Ukraine	-0.6	y = 1122.24 – 0.54x (p<0.01)
	Dnipro region	-0.5	y = 648.12 – 0.3x (p=0.20)
Ovary	Ukraine	-0.1	y = 239.89 – 0.11x (p=0.02)
	Dnipro region	0.1	y = -333.02 + 0.17x (p=0.25)
Prostate	Ukraine	0.3	y = -545.39 + 0.28x (p=0.01)
	Dnipro region	1.3	y = -2329.2 + 1.17x (p<0.01)
Rectum/anus	Ukraine	-0.3	y = 415 – 0.2x (p=0.03)
	Dnipro region	0.01	y = -118.31 + 0.07x (p=0.68)

Ukraine was decreasing, whereas in the Dnipro region there was an increasing trend (non-significantly). Despite the decreasing trend in total cancer mortality in Ukraine, an increase in prostate cancer mortality in Ukraine was identified (p=0.01). Also, mortality trends increase for breast and prostate cancer in the Dnipro region was statistically significant (p<0.05).

First of all, the increase in total cancer incidence reflects the rising burden of cancer on the national healthcare system. It may be explained by the increased cancer awareness from the side of primary care practitioners. However, at the moment authors are lacking proof for this hypothesis. Potentially, it could be confirmed by an increase in the number of cancer cases diagnosed at early stages, but this will be a subject of another study. Importantly, Ukraine faces ageing of population [3], and in such conditions an increase in cancer incidence may be expected. Noteworthy, that trachea, bronchus and lung cancer incidence both at the country and regional levels remained roughly stable. It is of a special interest for the Dnipro region, which is among the regions of Ukraine with the largest atmospheric industrial emissions [9].

Secondly, the decrease in cancer mortality at the country level is an optimistic and solid indicator of improvement in cancer care quality. With this regard, the increase in prostate cancer mortality requires further investigation. In 2018 and 2023 national guidelines were introduced, where instructions on prostate cancer screening and treatment are presented [10,11]. The impact of that is to be investigated. Interestingly, that 2019 was the year when mortality from all the studied types of cancer were lower than in 2018. It can possibly be due to the fact that in 2018 national guidelines for primary care physicians were updated [10], which included screening guidelines for breast, colon and prostate cancer. Earlier detection could have resulted in better treatment results. Patients with prostate cancer or at risk of this disease may require special measures, for example, offering prostate specific antigen measurement for patients at risk free of charge. Currently, prostate specific antigen measurement is not included in the guaranteed free-of-charge list of medical interventions [12].

Finally, in Dnipro regions there were types of cancer without a declining trend in mortality, when it was declining at the country level – trachea, bronchus and lung, ovary and rectum/anus. Moreover, the trend in breast cancer mortality in the Dnipro region was increasing (p<0.05), whereas at the country level it was decreasing (p<0.05). These findings may be considered as points for action, with a subsequent investigation of underlying reasons of deviations from the national levels and targeting policy recommendations for improving cancer epidemiology in the Dnipro region.

The National Strategy for Control of Malignant Neoplasms until 2030 was issued by the Cabinet of Ministers of Ukraine in 2024 [13]. The Strategy provides an extensive description of the current state of cancer epidemiology in Ukraine with the account for the COVID-19 pandemic and ongoing russian aggression. Few comments may be added to the already published document. It is worth mentioning that cancer literacy of the population is presented in the beginning of the list of pressing problems in cancer care in the Strategy [13]. An emphasis should be made on primary prevention actions, as risk profiling and management have large potential benefits [14]. Close cooperation of citizen-centred initiatives with involvement of diverse stakeholders might be beneficial for the creation of a health-promoting environment at individual, group and population levels.

Given the ecological background of the Dnipro region, and overall devastating impact of the war on ecology in Ukraine, measures for the control of environmental pollution may be beneficial. For example, it could be the development of citizen air monitoring networks [15]. Region-specific measures should be discussed with a wider introduction of personalised medicine principles, as a universal principle "one-size-fits-all" may not always lead to optimal outcomes [16].

One of the complexities in early cancer management is the potential of cancer to affect different body sites. Due to this fact cancer screening programs currently utilise a site-oriented approach, which is reflected in the recent recommendations [10]. Understandably, applying such a strategy to all possible cancer sites is difficult. However, novel technologies in cancer diagnostics and treatment, such as multiomics, liquid biopsies as a part of precision medicine

approach may be useful in overcoming existing problems [17,18]. As for today such methods may be not available or too costly. But there is a hope that with technical development of the society such novel instruments will become widely available and facilitate wider implementation of evidence based prevention principles.

Strengths and limitations. The strength of the presented study includes the analysis of a region in Ukraine with a population of around 3 million people. The data about the total population number in Dnipro region in 2009 and 2010 was not available, this is why population data from 2011 was used instead. Additionally, the demographic data by sex was not available for all the studied years. Therefore, male and female population was recalculated based on mean sex proportions in the years with available data. The study doesn't analyse recent data on cancer epidemiology due to distorted trends introduced by COVID-19 pandemic and complexities of data analysis of 2023-2024 due to the full-scale war in Ukraine. Therefore, the limitations in prognostic potential of the presented data should be taken into account.

Conclusions. There was an increase in total and site-specific cancer incidence in Ukraine and Dnipro region in 2009-2019. Total and site-specific cancer mortality in Ukraine was declining, except for prostate cancer. Cancer mortality in the Dnipro region was not decreasing in 2012-2019, and was even increasing for breast and prostate cancer. The need for the systemic approach to cancer prevention and treatment both at national and regional levels was identified, with a special attention to primary prevention.

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