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Dynamics of the Prostate Cancer Burden in Ukraine Against General European Trends: A Comparative Analysis, 1990–2023

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Динаміка епідеміологічного тягаря раку передміхурової залози в Україні на тлі загальноєвропейських трендів: порівняльний аналіз за 1990–2023 роки

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Introduction

Prostate cancer (PCa) is currently the most common solid malignancy among men in European countries [1]. Over the past three decades, the epidemiological landscape of the region has undergone profound changes. The principal driver of these processes is the demographic transition: owing to advances in medicine, life expectancy in Europe has been steadily increasing, which in turn expands the population of men aged 65 years and older – the age group at the highest risk of developing PCa [2]. Consequently, population ageing transforms prostate cancer from a purely medical issue into a global economic challenge, necessitating the reallocation of public funds toward long-term treatment and palliative care [3].

Traditionally, the effectiveness of cancer control has been assessed primarily through mortality indicators. However, this approach is now considered outdated and incomplete in the 2020s. The introduction of innovative treatment modalities – such as targeted therapy, new-generation antiandrogens, radioligand therapy, and robotic surgery – has enabled many countries to stabilise mortality rates, while the life expectancy of patients diagnosed with cancer has increased substantially [4; 5].

This has given rise to a new phenomenon: patients are living with the disease for decades. Prolonged treatment is often accompanied by significant adverse effects, ranging from erectile dysfunction and urinary incontinence to psycho-emotional disorders and loss of work capacity [4; 6]. Therefore, it is critically important to analyse not only mortality but also the Disability-Adjusted Life Years (DALYs) metric, which integrates years of life lost due to premature mortality (YLLs) and years lived with disability (YLDs). This comprehensive approach makes it possible to capture the true scale of resources consumed by the disease and to assess the burden on the healthcare system, which often remains "invisible" when analyses are limited to mortality alone [7].

Assessing the burden of disease at the pan-European level is complicated by differences in approaches to cause-of-death coding and the quality of national cancer registries. The use of data from the Global Burden of Disease (GBD) project helps to mitigate these discrepancies through the application of a unified statistical modelling framework. Analysis of the period from 1990 to 2023 enables the tracking of economic crises and technological breakthroughs in medicine that have influenced men's health across different parts of the continent [8–10].

A further focus of this study is the identification of geographical inequalities. Despite the existence of pan-European clinical recommendations (e.g., the EAU Guidelines), the actual burden of disease varies across countries with different income levels [3; 11]. This variation is driven by differences in national screening programmes (particularly the ongoing debate surrounding PSA testing), access to modern radiotherapy, and the overall level of public awareness [12–14].

The aim of this study is to conduct a retrospective analysis of long-term trends (1990–2023) in the key epidemiological indicators of prostate cancer in Europe, to assess the dynamics of the overall disease burden (DALYs), and to identify critical disparities between subregions in order to provide an evidence-based foundation for the development of targeted public health programmes.

Object, materials and research methods

The object of the study comprised the epidemiological patterns underlying the formation and transformation of the population-level burden of prostate cancer among the male population of European countries over the past three decades.

The informational basis of the study was formed by systematised data from the Global Burden of Disease, Injuries, and Risk Factors Study 2023 (GBD 2023), administered by the Institute for Health Metrics and Evaluation

(IHME, University of Washington) [8; 15]. Use of this platform ensured a high level of comparability across countries through a standardised methodology for the collection and processing of statistical data.

The analysis covered the period from 1990 to 2023, encompassing the transition from the initial widespread implementation of PSA testing to the current era of innovative therapeutic approaches. The study focused on three geographical subregions of Europe: Eastern, Central, and Western Europe. To capture national specificities, 15 representative countries were selected, with particular emphasis placed on Ukraine as a central object of analysis in the context of its integration into the European healthcare space.

The burden-of-disease assessment was based on the use of age-standardised rates (ASRs) per 100 000 male population, which allowed for the elimination of the influence of differences in age structure between countries [16]. The primary analytical metrics included:

• Disability-Adjusted Life Years (DALYs) – an integral indicator combining losses due to premature mortality and years lived with disability;

• Years Lived with Disability (YLDs) – an indicator of functional limitations and patients' quality of life;

• Mortality rates (Deaths) – used to assess the effectiveness of medical care.

Statistical analysis included the calculation of the total percentage change to assess cumulative variation over the entire study period. To determine the magnitude and direction of epidemiological trends, the Average Annual Percent Change (AAPC) was applied. The AAPC was calculated using a geometric mean growth rate model, which allows for the assessment of trend stability over time [17].

To ensure scientific robustness, results were accompanied by 95% uncertainty intervals (95% UIs). In cases of statistical asymmetry in the source data for individual countries (notably Slovakia), a standard error symmetrisation method based on the weighted mean amplitude of the uncertainty interval was applied to enhance the comparability of estimates. Data processing and visualisation were performed using MS Excel software and the GBD Results Tool.

Research results

The first stage of the analysis involved an assessment of the overall disease burden using the Disability-Adjusted Life Years (DALYs) indicator. As illustrated in the figure, regional trends exhibit fundamentally different trajectories of development (Fig. 1).

In the early 1990s, Eastern Europe (blue line) had the lowest DALY rates among the three subregions (approximately 190 per 100 000 population). However, over the subsequent 33 years, a continuous linear increase was observed, which by 2023 had substantially narrowed the gap with Western Europe. Central Europe (grey line) demonstrated a parallel upward trend, occupying an intermediate position throughout the study period. In contrast, Western Europe (orange line), despite having the highest baseline values, reached a plateau and exhibited relative stability in DALY rates over the entire observation period.

A similar pattern is observed in the analysis of mortality rates (Fig. 2). The mortality curve for Eastern Europe shows a steep upward trajectory, increasing from approximately 8,3 per 100 000 population in 1990 to more than 24 per 100 000 in 2023.

This contrasts with the situation in Western Europe, where the mortality curve is the flattest, indicating effective

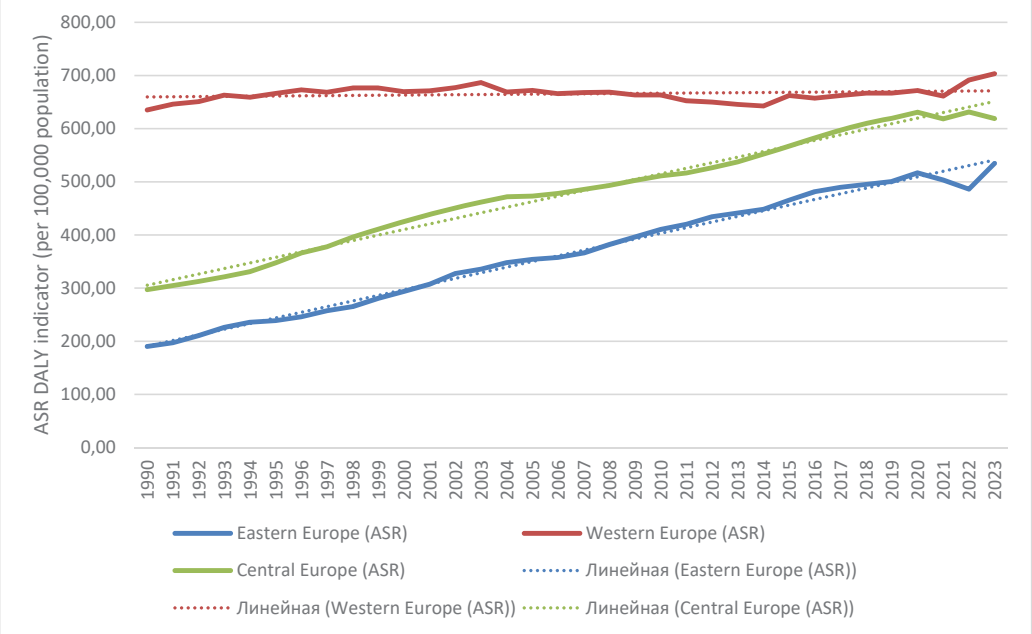

Fig. 1. Trends in the age-standardised DALY rate (per 100 000 population) for prostate cancer across European regions, 1990–2023

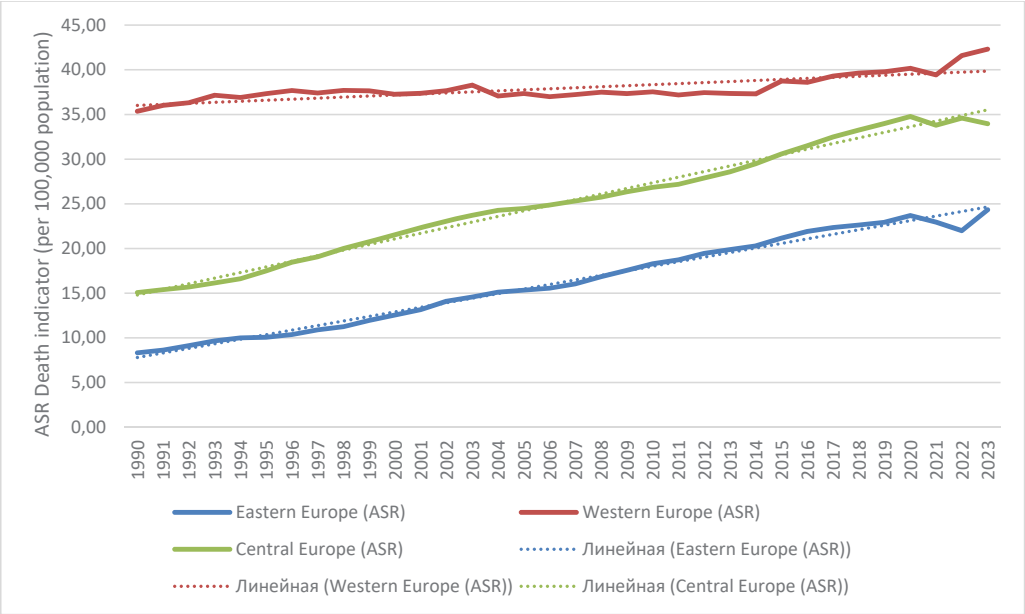

Fig. 2. Trends in the age-standardised mortality rate (ASR Death) from prostate cancer, 1990–2023.

containment of fatal outcomes despite population ageing and high incidence rates. Central Europe demonstrates steady growth, with mortality rates approximately doubling over the analysed period.

The most dramatic changes were observed in the analysis of the YLD indicator (Fig. 3)

Figure 3 illustrates the substantial increase in the number of patients living with a diagnosis and its associated disability.

In Eastern Europe, the steepest rise among all indicators was recorded: the curve starts at minimal values in 1990 and shows an exponential increase, crossing the Central Europe line around 2011–2012. This reflects both a significant improvement in the detection of previously undiagnosed cases and an extension of survival for patients with the disease.

To quantify the magnitude of these changes, the percentage growth between 1990 and 2023 was calculated for each region (Table 1). The data indicate that the overall DALY increase in Eastern Europe reached a critical +181.27%. Even more striking is the growth in the YLD component in this region, which rose by +365.30%, several times higher than that observed in Western Europe (+93.87%). At the same time, Western Europe exhibited the smallest increase in mortality (+19.63%), confirming the effectiveness of modern treatment protocols.

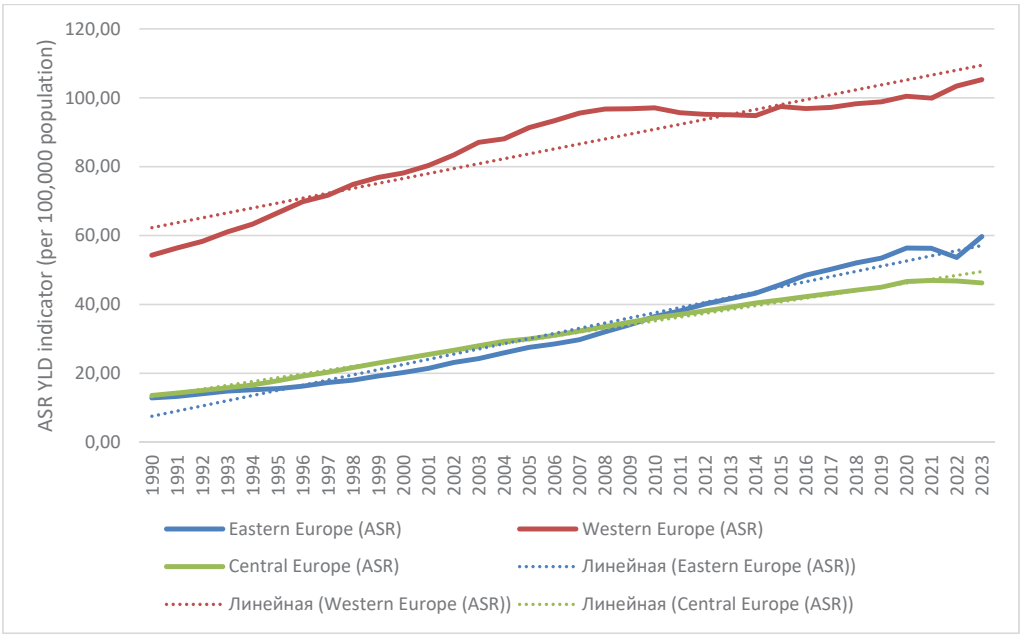

Fig. 3. Trends in the age-standardised YLD rate (years lived with disability) from 1990 to 2023

The calculation of the Average Annual Percent Change (AAPC) revealed a clear division of countries into two groups. The first group comprised Eastern and Central European countries with pronounced increases in disease burden. Moldova emerged as the clear leader (AAPC = 3.28%), followed by Poland (2.78%) and Ukraine (2.49%). Notably, the 95% uncertainty intervals for these countries are narrow and do not cross zero, indicating a high statistical significance of the observed growth.

The second group includes countries in Western and Northern Europe, where the situation has stabilised or improved (Table 2).

In particular, Sweden (–0.48%) and Denmark (–0.34%) exhibit negative AAPC values, indicating a genuine reduction in disease burden. In France, the indicator remains statistically stable (–0.15%), as the 95% uncertainty interval (–0.42 to 0.01) includes zero.

Discussion of the research results

The results obtained in this study confirm the hypothesis of a profound divergence in prostate cancer (PCa) epidemiological trends across Europe. The sharp increase in DALYs in Eastern Europe (+181.27%), against the background of stabilisation in Western Europe (+10.78%), reflects the so-called "epidemiological transition" effect.

The low indicators observed in Eastern Europe in the 1990s were most likely not the result of genuinely low incidence but rather of underreporting and the absence of systematic screening programmes. The current surge in YLDs (+365.30%) reflects the widespread implementation of prostate-specific antigen (PSA) testing, which has led to the detection of a substantial pool of previously hidden cases [18].

The high average annual growth rates identified in Moldova (3.28%) and Ukraine (2.49%) require particular attention. Unlike Western European countries, where rising incidence is accompanied by declining or plateauing mortality, Eastern Europe demonstrates a parallel increase in both indicators. This phenomenon may be explained by several factors. One is late diagnosis: despite the availability of PSA testing, a significant proportion of cases in Ukraine are still diagnosed at stages III–IV [19]. Another is limited access to innovative therapies. In contrast to countries such as France or Sweden, where advanced approaches (robotic surgery, modern antiandrogens) have become standard of care, access to these modalities in Eastern Europe is often constrained by economic factors [3; 20; 21].

Negative AAPC values observed in Sweden (–0.48%) and Denmark (–0.34%) are particularly important for understanding the long-term prospects of PCa control. These countries experienced the peak of the "PSA epidemic" as early as the 2000s and now demonstrate the outcomes of mature healthcare systems [22; 23].

The success of these countries is based on a multidisciplinary approach and optimisation of treatment strategies for metastatic disease. The implementation of well-defined Active Surveillance protocols for low-risk patients has helped to avoid overtreatment [24; 25]. In addition, the widespread use of new therapeutic lines has significantly prolonged patient survival, transforming prostate cancer from a fatal disease into a chronic, manageable condition [2; 8; 11; 15].

We acknowledge that the present study is based on GBD estimates, which depend on the quality of primary national data. In Eastern European countries, particularly under the conditions of martial law in Ukraine, some inaccuracies in case registration are possible. Nevertheless,

Table 1

Comparative assessment of changes in the burden of prostate cancer (ASR per 100 000) across European subregions

European Region	Indicator	1990 (95% UI)	2005 (95% UI)	2023 (95% UI)	Overall change (%)
Eastern Europe	DALY	190,12 (172,18; 213,30)	354,20 (331,71; 380,49)	534,75 (490,18; 587,19)	181,27%
	YLD	12,84 (8,95; 18,66)	27,56 (18,69; 36,51)	59,72 (42,61; 81,61)	365,30%
	Death	8,32 (7,51; 9,24)	15,33 (14,44; 16,38)	24,34 (22,28; 26,63)	192,39%
Western Europe	DALY	635,05 (595,70; 669,90)	672,13 (627,13; 713,19)	703,51 (621,89; 767,56)	10,78%
	YLD	54,31 (38,97; 74,57)	91,35 (67,62; 116,80)	105,29 (76,19; 143,87)	93,87%
	Death	35,37 (33,60; 36,84)	37,34 (34,74; 39,25)	42,31 (37,69; 45,90)	19,63%
Central Europe	DALY	297,16 (277,60; 314,35)	472,92 (443,40; 494,23)	618,86 (577,15; 655,55)	108,26%
	YLD	13,59 (9,72; 18,74)	30,00 (21,71; 39,59)	46,26 (32,82; 62,52)	240,56%
	Death	15,07 (14,13; 15,97)	24,49 (23,01; 25,57)	33,97 (31,42; 35,96)	125,40%

Table 2

Average annual percent change (AAPC) of the DALY rate for prostate cancer in European countries, 1990–2023

European Region	Country	1990 (95% UI)	2023 (95% UI)	AAPC, % (95% UI)
Eastern Europe	Ukraine	231,33 (211,92; 257,89)	520,44 (469,54; 583,34)	2,49 (2,44; 2,50)
	Moldova	156,74 (137,95; 176,12)	454,74 (390,33; 525,71)	3,28 (3,20; 3,37)
	Latvia	462,47 (426,98; 498,70)	1065,97 (953,87; 1182,33)	2,56 (2,47; 2,65)
	Lithuania	425,53 (399,33; 525,71)	916,54 (830,12; 1005,26)	2,35 (2,24; 2,44)
	Estonia	446,89 (394,50; 509,02)	934,10 (841,51; 1042,89)	2,26 (2,20; 2,32)
Western Europe	Germany	594,36 (557,56; 634,58)	844,21 (750,18; 924,44)	1,07 (0,90; 1,15)
	France	708,36 (654,58; 767,10)	673,22 (569,77; 769,12)	-0,15 (-0,42; 0,01)
	Austria	578,31 (536,70; 620,06)	648,63 (558,69; 725,46)	0,35 (0,12; 0,48)
	Sweden	983,72 (919,89; 1037,86)	840,23 (730,71; 931,79)	-0,48 (-0,70; -0,33)
	Denmark	1198,61 (1119,15; 1274,91)	1072,40 (944,77; 1199,48)	-0,34 (-0,51; -0,18)
Central Europe	Poland	271,83 (249,18; 299,59)	671,80 (623,39; 716,03)	2,78 (2,68; 2,82)
	Czech Republic	464,53 (429,99 ; 497,45)	631,91 (568,78; 666,01)	0,85 (0,81; 0,89)
	Slovakia	331,56 (266,57; 467,28)	589,11 (442,11; 685,94)	1,76 (1,70; 1,82)*
	Hungary	473,82 (447,74; 502,87)	617,41 (552,91; 679,35)	0,81 (0,64; 0,92)
	Slovenia	399,89 (365,78; 434,15)	845,03 (773,61; 916,25)	2,29 (2,28; 2,30)

Note: *The 95% UI for Slovakia was symmetrized based on the average uncertainty magnitude to account for baseline data variability.

the overall direction of the observed trends is unequivocal and statistically robust.

Prospects for further research

The pronounced divergence in prostate cancer epidemiological trends across Europe identified in this study opens several strategic directions for further scientific investigation.

The critical increase in DALYs and mortality in Ukraine, contrasted with their stabilisation in Western European countries, underscores the need for an in-depth examination of factors influencing the stage at initial diagnosis. Particularly promising are comparative studies assessing the effectiveness of regional screening programmes, as well as evaluations of the impact of socio-economic determinants on male population compliance with preventive health examinations.

The anomalously high growth rate of the YLD indicator in Eastern European countries calls for a more detailed analysis of patients' health-related quality of life (HRQoL). Future research should focus on assessing the prevalence of adverse effects associated with radical treatment and on developing personalised rehabilitation programmes aimed at reducing disability and the overall population-level disease burden.

Another important avenue for future research is the investigation of genomic and molecular characteristics of prostate cancer in the Ukrainian population. Given the aggressive disease course observed in this region, the identification of specific biomarkers capable of predicting responses to contemporary hormonal and chemotherapeutic regimens is of particular relevance.

Further attention should also be devoted to the development and validation of prognostic mathematical models based on GBD data for medium-term forecasting of the burden on oncological care systems. Such models would facilitate more efficient resource allocation and enable the adaptation of best practices from "green zone" countries (e.g., the Scandinavian region) to national clinical practice, taking into account local specificities.

Conclusions

1. A critical disparity in the growth rates of the prostate cancer burden across European regions was identified: the increase in DALYs in Eastern Europe is approximately 18 times higher than that observed in Western Europe.

2. Ukraine and Moldova are the leading countries in terms of average annual growth of disease burden (AAPC > 2.4%), highlighting the need to revise early detection strategies and to improve access to modern treatment modalities.

3. The experience of Northern European countries demonstrates the feasibility of successfully reducing the population-level burden of prostate cancer through a balanced implementation of screening programmes and advanced medical technologies.

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Мета: Провести комплексний порівняльний аналіз динаміки епідеміологічного тягаря раку передміхурової залози (РПЗ) в Україні та країнах європейського регіону за період 1990–2023 рр., оцінити регіональні відмінності та визначити середньорічні темпи зміни ключових показників.

Матеріали та методи. Джерелом інформації слугували дані Глобального дослідження тягаря хвороб (GBD 2023). Аналізувалися стандартизовані за віком показники (ASR) на 100 000 населення: роки життя, скориговані за непрацездатністю (DALY), роки, прожиті з інвалідністю (YLD), та показники смертності. Математична обробка включала розрахунок загального відсоткового приросту та середньорічної відсоткової зміни (AAPC) на основі експоненціальної регресії з використанням 95% інтервалів невизначеності (UI).

Результати. Встановлено різку дивергенцію епідеміологічних трендів між субрегіонами Європи. У Східній Європі зафіксовано критичне зростання DALY на +181,27%, тоді як у Західній Європі цей показник стабілізувався на рівні +10,78%. Найбільш динамічним виявився показник YLD у Східній Європі (+365,30%). На національному рівні Україна та Молдова продемонстрували найвищі темпи середньорічного приросту тягаря (AAPC = 2,49% та 3,28% відповідно). На противагу цьому, у країнах Скандинавії (Швеція, Данія) зафіксовано статистично значуще зниження показників (AAPC < 0).

Висновки. Дослідження виявило глибоку нерівність у тягарі РПЗ в Європі. Стрімке зростання показників у країнах Східної Європи, зокрема в Україні, свідчить про активну фазу епідеміологічного переходу та потребує негайної оптимізації стратегій раннього виявлення. Досвід Північної Європи доводить можливість успішного стримування тягаря хвороби через інтегровані підходи до лікування та моніторингу.

Ключові слова: епідеміологічні тренди, роки життя з інвалідністю (DALY), показники смертності, середньорічна зміна (AAPC), епідеміологічний перехід, урологічна онкологія, інтервали невизначеності.

Purpose. The study aims to investigate the long-term dynamics and regional disparities of the prostate cancer (PCa) burden across Europe from 1990 to 2023. By comparing Ukraine with other European subregions and representative countries, the research seeks to quantify annual trends in disability-adjusted life years (DALYs), mortality rates, and years lived with disability (YLDs), providing a comprehensive epidemiological outlook.

Materials and methods. This study utilized data from the Global Burden of Diseases, Injuries, and Risk Factors Study (GBD 2023). The analysis focused on age-standardized rates (ASR) per 100,000 population to ensure cross-country comparability regardless of demographic differences. The study examined three major European subregions (Eastern, Central, and Western) and 15 selected countries. Key metrics included DALYs, YLDs, and mortality rates. Statistical significance was evaluated using 95% uncertainty intervals (UIs). The Average Annual Percent Change (AAPC) was calculated using an exponential regression model to determine the velocity of epidemiological shifts.

Results. The findings reveal a profound divergence in prostate cancer trajectories. Since 1990, Eastern Europe has experienced a dramatic epidemiological shift, with DALY rates surging by 181.27%, contrasted sharply with a modest 10.78% increase in Western Europe. The most significant component of this growth in the East was the YLD index, which skyrocketed by 365.30%, reflecting both improved diagnostic detection and an increasing prevalence of patients living with the disease. In contrast, Western European mortality rates remained relatively stable (+19.63%), suggesting higher therapeutic efficacy. Country-specific analysis identified Moldova and Ukraine as leaders in the annual growth of disease burden, with AAPC values of 3.28% and 2.49%, respectively. Central European countries like Poland (AAPC 2.78%) also showed strong upward trends. Conversely, Northern European countries demonstrated a "maturation" of their epidemiological curves; Sweden (-0.48%) and Denmark (-0.34%) achieved statistically significant annual reductions in their PCa burden. France maintained a stable trend (AAPC -0.15%), indicating a successful plateau in disease impact.

Conclusions. The research highlights a critical "East-West" gap in prostate cancer control within the European healthcare landscape. The rapid escalation of DALYs and mortality in Ukraine and Moldova suggests an urgent need for healthcare policy revisions, focusing on earlier stage detection and wider access to innovative hormonal and surgical therapies. The stark contrast between the rising trends in Eastern Europe and the declining burden in Scandinavia underscores the potential of mature screening programs and active surveillance protocols. This study confirms that while PCa remains a significant public health challenge, the experience of Northern Europe serves as a benchmark for achieving sustainable reductions in population-level disease burden. These results provide a vital evidentiary base for national oncology programs in Eastern European countries to mitigate the ongoing epidemiological crisis.

Key words: epidemiological trends, disability-adjusted life years (DALYs), mortality rates, average annual percent change (AAPC), epidemiological transition, urological oncology, uncertainty intervals.

Conflict of interest: absent.

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