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ЕЖЕМЕСЯЧНЫЙ НАУЧНЫЙ ЖУРНАЛ

Медицинские новости Грузии

საქართველოს სამედიცინო სიახლენი

GEORGIAN MEDICAL NEWS
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GMN: Georgian Medical News is peer-reviewed, published monthly journal committed to promoting the science and art of medicine and the betterment of public health, published by the GMN Editorial Board since 1994. GMN carries original scientific articles on medicine, biology and pharmacy, which are of experimental, theoretical and practical character; publishes original research, reviews, commentaries, editorials, essays, medical news, and correspondence in English and Russian.
GMN is indexed in MEDLINE, SCOPUS, PubMed and VINITI Russian Academy of Sciences. The full text content is available through EBSCO databases.

GMN: Медицинские новости Грузии - ежемесячный рецензируемый научный журнал, издаётся Редакционной коллегией с 1994 года на русском и английском языках в целях поддержки медицинской науки и улучшения здравоохранения. В журнале публикуются оригинальные научные статьи в области медицины, биологии и фармации, статьи обзорного характера, научные сообщения, новости медицины и здравоохранения. Журнал индексируется в MEDLINE, отражён в базе данных SCOPUS, PubMed и ВИНИТИ РАН. Полнотекстовые статьи журнала доступны через БД EBSCO.

GMN: Georgian Medical News – საქართველოს სამედიცინო სიახლენი – არის ყოველთვიური სამეცნიერო სამედიცინო რეცენზირებადი ჟურნალი, გამოიცემა 1994 წლიდან, წარმოადგენს სარედაქციო კოლეგიისა და აშშ-ის მეცნიერების, განათლების, ინდუსტრიის, ხელოვნებისა და ბუნებისმეტყველების საერთაშორისო აკადემიის ერთობლივ გამოცემას. GMN-ში რუსულ და ინგლისურ ენებზე ქვეყნდება ექსპერიმენტული, თეორიული და პრაქტიკული ხასიათის ორიგინალური სამეცნიერო სტატიები მედიცინის, ბიოლოგიისა და ფარმაციის სფეროში, მიმოხილვითი ხასიათის სტატიები.
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WEBSITE
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К СВЕДЕНИЮ АВТОРОВ!

При направлении статьи в редакцию необходимо соблюдать следующие правила:

1. Статья должна быть представлена в двух экземплярах, на русском или английском языках, напечатанная через **полтора интервала на одной стороне стандартного листа с шириной левого поля в три сантиметра**. Используемый компьютерный шрифт для текста на русском и английском языках - **Times New Roman** (**Кириллица**), для текста на грузинском языке следует использовать **AcadNusx.** Размер шрифта - **12**. К рукописи, напечатанной на компьютере, должен быть приложен CD со статьей.

2. Размер статьи должен быть не менее десяти и не более двадцати страниц машинописи, включая указатель литературы и резюме на английском, русском и грузинском языках.

3. В статье должны быть освещены актуальность данного материала, методы и результаты исследования и их обсуждение.

При представлении в печать научных экспериментальных работ авторы должны указывать вид и количество экспериментальных животных, применявшиеся методы обезболивания и усыпления (в ходе острых опытов).

4. К статье должны быть приложены краткое (на полстраницы) резюме на английском, русском и грузинском языках (включающее следующие разделы: цель исследования, материал и методы, результаты и заключение) и список ключевых слов (key words).

5. Таблицы необходимо представлять в печатной форме. Фотокопии не принимаются. **Все цифровые, итоговые и процентные данные в таблицах должны соответствовать таковым в тексте статьи**. Таблицы и графики должны быть озаглавлены.

6. Фотографии должны быть контрастными, фотокопии с рентгенограмм - в позитивном изображении. Рисунки, чертежи и диаграммы следует озаглавить, пронумеровать и вставить в соответствующее место текста **в tiff формате**.

В подписях к микрофотографиям следует указывать степень увеличения через окуляр или объектив и метод окраски или импрегнации срезов.

7. Фамилии отечественных авторов приводятся в оригинальной транскрипции.

8. При оформлении и направлении статей в журнал МНГ просим авторов соблюдать правила, изложенные в «Единых требованиях к рукописям, представляемым в биомедицинские журналы», принятых Международным комитетом редакторов медицинских журналов - http://www.spinesurgery.ru/files/publish.pdf и http://www.nlm.nih.gov/bsd/uniform_requirements.html
В конце каждой оригинальной статьи приводится библиографический список. В список литературы включаются все материалы, на которые имеются ссылки в тексте. Список составляется в алфавитном порядке и нумеруется. Литературный источник приводится на языке оригинала. В списке литературы сначала приводятся работы, написанные знаками грузинского алфавита, затем кириллицей и латиницей. Ссылки на цитируемые работы в тексте статьи даются в квадратных скобках в виде номера, соответствующего номеру данной работы в списке литературы. Большинство цитированных источников должны быть за последние 5-7 лет.

9. Для получения права на публикацию статья должна иметь от руководителя работы или учреждения визу и сопроводительное отношение, написанные или напечатанные на бланке и заверенные подписью и печатью.

10. В конце статьи должны быть подписи всех авторов, полностью приведены их фамилии, имена и отчества, указаны служебный и домашний номера телефонов и адреса или иные координаты. Количество авторов (соавторов) не должно превышать пяти человек.

11. Редакция оставляет за собой право сокращать и исправлять статьи. Корректура авторам не высылается, вся работа и сверка проводится по авторскому оригиналу.

12. Недопустимо направление в редакцию работ, представленных к печати в иных издательствах или опубликованных в других изданиях.

При нарушении указанных правил статьи не рассматриваются.

REQUIREMENTS

Please note, materials submitted to the Editorial Office Staff are supposed to meet the following requirements:

1. Articles must be provided with a double copy, in English or Russian languages and typed or compu-ter-printed on a single side of standard typing paper, with the left margin of **3** centimeters width, and **1.5** spacing between the lines, typeface - **Times New Roman** (**Cyrillic**), print size - **12** (referring to Georgian and Russian materials). With computer-printed texts please enclose a CD carrying the same file titled with Latin symbols.

2. Size of the article, including index and resume in English, Russian and Georgian languages must be at least 10 pages and not exceed the limit of 20 pages of typed or computer-printed text.

3. Submitted material must include a coverage of a topical subject, research methods, results, and review.

Authors of the scientific-research works must indicate the number of experimental biological species drawn in, list the employed methods of anesthetization and soporific means used during acute tests.

4. Articles must have a short (half page) abstract in English, Russian and Georgian (including the following sections: aim of study, material and methods, results and conclusions) and a list of key words.

5. Tables must be presented in an original typed or computer-printed form, instead of a photocopied version. **Numbers, totals, percentile data on the tables must coincide with those in the texts of the articles.** Tables and graphs must be headed.

6. Photographs are required to be contrasted and must be submitted with doubles. Please number each photograph with a pencil on its back, indicate author's name, title of the article (short version), and mark out its top and bottom parts. Drawings must be accurate, drafts and diagrams drawn in Indian ink (or black ink). Photocopies of the X-ray photographs must be presented in a positive image in **tiff format**.

Accurately numbered subtitles for each illustration must be listed on a separate sheet of paper. In the subtitles for the microphotographs please indicate the ocular and objective lens magnification power, method of coloring or impregnation of the microscopic sections (preparations).

7. Please indicate last names, first and middle initials of the native authors, present names and initials of the foreign authors in the transcription of the original language, enclose in parenthesis corresponding number under which the author is listed in the reference materials.

8. Please follow guidance offered to authors by The International Committee of Medical Journal Editors guidance in its Uniform Requirements for Manuscripts Submitted to Biomedical Journals publication available online at: http://www.nlm.nih.gov/bsd/uniform_requirements.html
http://www.icmje.org/urm_full.pdf
In GMN style for each work cited in the text, a bibliographic reference is given, and this is located at the end of the article under the title "References". All references cited in the text must be listed. The list of references should be arranged alphabetically and then numbered. References are numbered in the text [numbers in square brackets] and in the reference list and numbers are repeated throughout the text as needed. The bibliographic description is given in the language of publication (citations in Georgian script are followed by Cyrillic and Latin).

9. To obtain the rights of publication articles must be accompanied by a visa from the project instructor or the establishment, where the work has been performed, and a reference letter, both written or typed on a special signed form, certified by a stamp or a seal.

10. Articles must be signed by all of the authors at the end, and they must be provided with a list of full names, office and home phone numbers and addresses or other non-office locations where the authors could be reached. The number of the authors (co-authors) must not exceed the limit of 5 people.

11. Editorial Staff reserves the rights to cut down in size and correct the articles. Proof-sheets are not sent out to the authors. The entire editorial and collation work is performed according to the author's original text.

12. Sending in the works that have already been assigned to the press by other Editorial Staffs or have been printed by other publishers is not permissible.

Articles that Fail to Meet the Aforementioned Requirements are not Assigned to be Reviewed.

ავტორთა საყურადღებოდ!

რედაქციაში სტატიის წარმოდგენისას საჭიროა დავიცვათ შემდეგი წესები:

1. სტატია უნდა წარმოადგინოთ 2 ცალად, რუსულ ან ინგლისურ ენებზე,დაბეჭდილი სტანდარტული ფურცლის 1 გვერდზე, 3 სმ სიგანის მარცხენა ველისა და სტრიქონებს შორის 1,5 ინტერვალის დაცვით. გამოყენებული კომპიუტერული შრიფტი რუსულ და ინგლისურენოვან ტექსტებში - **Times New Roman (Кириллица)**, ხოლო ქართულენოვან ტექსტში საჭიროა გამოვიყენოთ **AcadNusx.** შრიფტის ზომა – 12. სტატიას თან უნდა ახლდეს CD სტატიით.

2. სტატიის მოცულობა არ უნდა შეადგენდეს 10 გვერდზე ნაკლებს და 20 გვერდზე მეტს ლიტერატურის სიის და რეზიუმეების (ინგლისურ,რუსულ და ქართულ ენებზე) ჩათვლით.

3. სტატიაში საჭიროა გაშუქდეს: საკითხის აქტუალობა; კვლევის მიზანი; საკვლევი მასალა და გამოყენებული მეთოდები; მიღებული შედეგები და მათი განსჯა. ექსპერიმენტული ხასიათის სტატიების წარმოდგენისას ავტორებმა უნდა მიუთითონ საექსპერიმენტო ცხოველების სახეობა და რაოდენობა; გაუტკივარებისა და დაძინების მეთოდები (მწვავე ცდების პირობებში).

4. სტატიას თან უნდა ახლდეს რეზიუმე ინგლისურ, რუსულ და ქართულ ენებზე არანაკლებ ნახევარი გვერდის მოცულობისა (სათაურის, ავტორების, დაწესებულების მითითებით და უნდა შეიცავდეს შემდეგ განყოფილებებს: მიზანი, მასალა და მეთოდები, შედეგები და დასკვნები; ტექსტუალური ნაწილი არ უნდა იყოს 15 სტრიქონზე ნაკლები) და საკვანძო სიტყვების ჩამონათვალი (key words).

5. ცხრილები საჭიროა წარმოადგინოთ ნაბეჭდი სახით. ყველა ციფრული, შემაჯამებელი და პროცენტული მონაცემები უნდა შეესაბამებოდეს ტექსტში მოყვანილს.

6. ფოტოსურათები უნდა იყოს კონტრასტული; სურათები, ნახაზები, დიაგრამები - დასათაურებული, დანომრილი და სათანადო ადგილას ჩასმული. რენტგენოგრამების ფოტოასლები წარმოადგინეთ პოზიტიური გამოსახულებით **tiff** ფორმატში. მიკროფოტოსურათების წარწერებში საჭიროა მიუთითოთ ოკულარის ან ობიექტივის საშუალებით გადიდების ხარისხი, ანათალების შეღებვის ან იმპრეგნაციის მეთოდი და აღნიშნოთ სურათის ზედა და ქვედა ნაწილები.

7. სამამულო ავტორების გვარები სტატიაში აღინიშნება ინიციალების თანდართვით, უცხოურისა – უცხოური ტრანსკრიპციით.

8. სტატიას თან უნდა ახლდეს ავტორის მიერ გამოყენებული სამამულო და უცხოური შრომების ბიბლიოგრაფიული სია (ბოლო 5-8 წლის სიღრმით). ანბანური წყობით წარმოდგენილ ბიბლიოგრაფიულ სიაში მიუთითეთ ჯერ სამამულო, შემდეგ უცხოელი ავტორები (გვარი, ინიციალები, სტატიის სათაური, ჟურნალის დასახელება, გამოცემის ადგილი, წელი, ჟურნალის №, პირველი და ბოლო გვერდები). მონოგრაფიის შემთხვევაში მიუთითეთ გამოცემის წელი, ადგილი და გვერდების საერთო რაოდენობა. ტექსტში კვადრატულ ფჩხილებში უნდა მიუთითოთ ავტორის შესაბამისი N ლიტერატურის სიის მიხედვით. მიზანშეწონილია, რომ ციტირებული წყაროების უმეტესი ნაწილი იყოს 5-6 წლის სიღრმის.

9. სტატიას თან უნდა ახლდეს: ა) დაწესებულების ან სამეცნიერო ხელმძღვანელის წარდგინება, დამოწმებული ხელმოწერითა და ბეჭდით; ბ) დარგის სპეციალისტის დამოწმებული რეცენზია, რომელშიც მითითებული იქნება საკითხის აქტუალობა, მასალის საკმაობა, მეთოდის სანდოობა, შედეგების სამეცნიერო-პრაქტიკული მნიშვნელობა.

10. სტატიის ბოლოს საჭიროა ყველა ავტორის ხელმოწერა, რომელთა რაოდენობა არ უნდა აღემატებოდეს 5-ს.

11. რედაქცია იტოვებს უფლებას შეასწოროს სტატია. ტექსტზე მუშაობა და შეჯერება ხდება საავტორო ორიგინალის მიხედვით.

12. დაუშვებელია რედაქციაში ისეთი სტატიის წარდგენა, რომელიც დასაბეჭდად წარდგენილი იყო სხვა რედაქციაში ან გამოქვეყნებული იყო სხვა გამოცემებში.

აღნიშნული წესების დარღვევის შემთხვევაში სტატიები არ განიხილება.

Содержание:

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ASSESSING THE INFLUENCE OF MEDICAL EDUCATION REFORMS ON ONCOLOGIST WORKFORCE AND LUNG CANCER MORTALITY IN KAZAKH-STAN: AN INTERRUPTED TIME SERIES ANALYSIS WITH PREDICTIVE MOD-ELING OF NATIONWIDE DATA FROM 1998 TO 2023

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Abstract.

Background: Lung cancer continues to be a significant global health challenge, accounting for the highest cancer-related mortality worldwide. Despite considerable advances in understanding the disease and improving treatment modalities, survival rates remain alarmingly low, largely owing to the high incidence of lung cancer, which is predominantly attributable to smoking. In Kazakhstan, key reforms in oncologist training were introduced in 2008 and 2020 - replacing short-term oncology courses with a standardized multi-year clinical residency program - in an effort to improve the quality and availability of specialized cancer care. This study evaluates the impact of recent reforms in oncologist training in Kazakhstan on the number and distribution of oncologists and examines the correlation between these changes and lung cancer mortality rates from 1998-2023.

Methods: Interrupted time series analysis (ITSA) using best-fit epidemiological model was conducted to examine the impact of medical education reforms on the number and PMP rates of oncologists in Kazakhstan, as well as their impact on the mortality of lung cancer patients.

Results: The lung cancer mortality rates per 100,000 population ranged from 20.24 to 10.12, with a consistent downward trend observed throughout the study period. The total number of oncologists ranged from 499 to 1219, reflecting an increasing trend throughout the study period. Significant disparities were observed between urban and rural areas, with the number of oncologists in urban settings being six times greater than that in rural areas.

Conclusion: This study underscores the urgent need for continued reforms in medical education and training to strengthen the oncology workforce in Kazakhstan. The findings reveal pronounced disparities between urban and rural regions, as well as the adverse effects of abolishing short-term training programs on rural areas. To address these challenges, targeted policies are required to mitigate rural shortages, expand flexible training opportunities, and introduce incentives that support the recruitment and retention of specialists in underserved regions. Such measures are critical to improving equity in access to oncological care and reducing lung cancer mortality.

Key words. Oncologists, residency training, mortality of lung cancer, interrupted time series analysis, Kazakhstan.

Introduction.

Lung cancer continues to pose a significant global health challenge, remaining the leading cause of cancer-related mortality due to its high incidence and poor prognosis [1-3]. In 2022, nearly 2.5 million new cases were diagnosed worldwide, with smoking accounting for approximately 85% of them [4-6]. Central Asia, including Kazakhstan, bears a particularly high burden of lung cancer, with notable gender and regional disparities [7-9].

In response to increasing cancer incidence and workforce demands, Kazakhstan has implemented reforms in medical education. Since 2008, oncology residency programs have been introduced, and in 2020, short-term oncology courses were discontinued, leaving residency as the only qualification route [12-13].

This study aims to evaluate the impact of these reforms on the number of oncologists and examine their relationship with lung cancer mortality from 1998 to 2023. The findings are intended to guide future policy decisions in oncology workforce planning and cancer care delivery

The introduction should briefly place the study in a broad context and highlight why it is important. It should define the purpose of the work and its significance. The current state of the research field should be carefully reviewed and key publications cited. Please highlight controversial and diverging hypotheses when necessary. Finally, briefly mention the main aim of the work and highlight the principal conclusions. As far as possible, please keep the introduction comprehensible to scientists outside your particular field of research. References should be numbered in order of appearance and indicated by a numeral or numerals in square brackets—e.g., [1] or [2,3], or [4-6]. See the end of the document for further details on references.

Materials and Methods.

Study Design and Data Sources:

This retrospective study analyzed nationwide data covering the years 1998-2023. The primary data source was official statistical reports published annually by the Ministry of Health (MoH) [14]. The secondary data source comprised the "Electronic Register of Cancer Patients" database and the statistical and analytical materials titled "Indicators of the Oncology Service of the Republic of Kazakhstan," published by the Scientific Council of the Kazakh Institute of Oncology and Radiology [15]. Since the extracted data were reported in absolute numbers, population estimates from demographic yearbooks published by the Bureau of Statistics [16] were used to compute per capita rates.

Study units:

The study focused on two main units: the number of practicing oncologists and the number of lung cancer deaths. Data on the total number of oncologists practicing in Kazakhstan were collected for the period 1998–2023. Information was also obtained for oncologists working in urban and rural settings, covering the years 2000–2023. Data on the total number of cases of lung cancer death were similarly collected for the period 2006–2023.

Study Formulas:

The per capita rate of oncologists was calculated on the basis of the number of oncologists per million people in the population. To determine this, the total number of oncologists was divided by the midyear population and then multiplied by one million. Similarly, the lung cancer mortality rate was calculated by dividing the number of lung cancer deaths occurring annually by the midyear population, followed by multiplying the result by 100,000.

In addition, the number of lung cancer deaths per oncologist was computed by dividing the annual number of lung cancer deaths by the total number of practicing oncologists in the same year.

To assess the impact of interventions, the mean change was derived by subtracting the preintervention mean value from the postintervention mean. This mean change, when expressed as a percentage relative to the preintervention period, was calculated by dividing the mean change by the before intervention mean and multiplying the result by 100.

Statistical analysis:

IBM SPSS Statistics version 24.0 was used for the statistical analyses, including time series tests [17]. The average annual change and corresponding 95% confidence intervals were computed to track variations over the study period. Interrupted time series analysis (ITSA) was employed to evaluate the influence of two key interventions: the introduction of a residency program in 2008 and the discontinuation of short-term training courses in 2020.

The ITSA model was applied to identify statistically significant changes in the level and trend of the indicators before and after key time points-namely, the introduction of the oncology residency program in 2008 and the discontinuation of short-term training in 2020. This method allows for the evaluation of whether there was a shift in trend (e.g., acceleration or deceleration in the growth of specialist numbers) and/or an immediate change in the level of the indicator following the implementation of educational reforms.

ITSA is particularly effective when long-term data are available and the timing of the intervention is clearly defined. These interventions were assessed for their impact on both the number and per capita rate of oncologists. The Expert Modeler function in SPSS identified the most suitable epidemiological model, with the interventions classified as 'events' and adjustments made on the basis of the model parameters. The percentage point change (PPC) was extracted to quantify the effect of each intervention.

For future projections of oncologist numbers and lung cancer mortality rates until 2030, the Expert Modeler function was again employed to forecast values on the basis of the best-fitting model [17]. Geographic visualizations of the mean oncologist numbers and per capita rates, as well as lung cancer mortality rates, were generated via QGIS 3.26 "Buenos Aires." Bivariate Pearson correlation analysis was performed via SPSS to explore the relationship between the mean number of oncologists and the mean number of lung cancer-related deaths, with the correlation coefficient 'r' and corresponding p- value reported. A p- value of 0.05 or less was considered statistically significant.

Ethics statement:

Prior to the beginning of the study, the Ethics Committee of Semey Medical University reviewed the study protocol and waived the requirement for informed consent (Minutes of meeting #2 dated 12 December 2023).

Results.

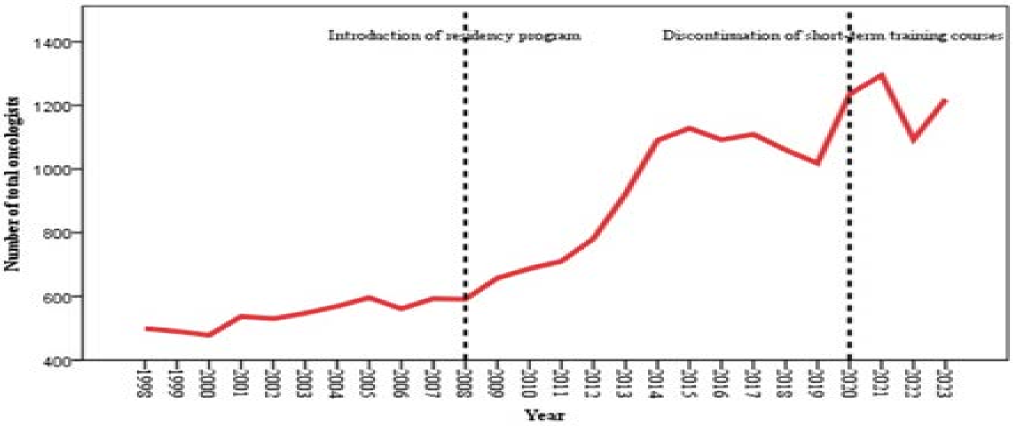
Figure 1 shows a general upward trend in the total number of oncologists as well as those practicing in urban areas since 2009 (A and B). After a period of temporary decline starting in 2017, these numbers sharply increased in 2019 but experienced a notable decrease from 2021 onward. In contrast, the number of rural oncologists (C) showed a rising trend from 2011-2018, followed by a temporary dip, and then stabilized from 2019 onward.

Figure 1 Figure 1 illustrates the trends in the total number of oncologists (A) and their per million population rates (B) from 1998-2023. Two key interventions are marked: the introduction of the residency program in 2008 and the discontinuation of short-term training courses in 2020, shown by gray dashed lines. These points indicate shifts in both the total number of oncologists and their availability relative to the population.

The number of oncologists practicing in rural areas (C) showed a gradual increase from 42 in 2000 to 167 in 2023, with the most notable growth occurring between 2011 and 2018, followed by stabilization after 2019. The per million population rate of oncologists in rural areas (D) demonstrated a similar pattern, reflecting persistent shortages compared with urban settings despite moderate growth. In contrast, the number of oncologists in urban areas (E) fluctuated more significantly, ranging from 436 in 2000 to 1,052 in 2023, with marked increases after 2009 and again in 2019. The per million population rate of oncologists in urban areas (F) consistently exceeded rural levels, underscoring the pronounced disparity in the distribution of oncology specialists between urban and rural regions.

Between 1998 and 2023, the total number of oncologists in Kazakhstan exhibited significant variation, ranging from 499 in 1998 to 1,219 in 2023. An analysis of the periods before and after the two major interventions revealed a notable increase in the overall number of oncologists, with upward trends observed in both urban and rural settings as well as in their corresponding PMP rates (Table 1).

Interrupted time series analysis (ITSA) employing ARIMA models revealed that the introduction of the oncology residency


Introduction of residency program
Discontimation of short-term training courses
Number of total oncologists
Year

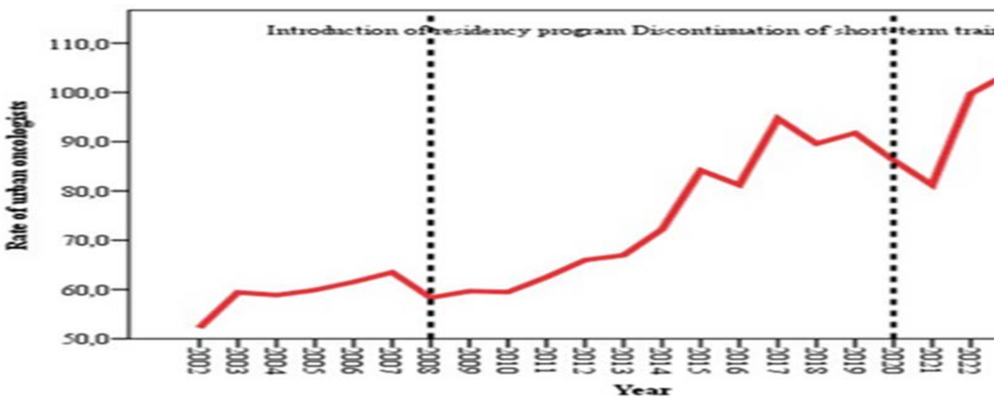
A


Introduction of residency program
Discontimation of short-term training courses
Number of urban Oncologists
Year

B


Introduction of residency program
Discontimation of short-term training courses
Number of rural oncologists
Year

C


Introduction of residency program
Rate of urban oncologists
Year

D

E

F

Figure 1. *Oncologists' numbers and per million population rates (1998–2023).*

Table 1. *Descriptive statistics on the number of oncologists and their rates per million people are provided, and the effects of the introduction of the residency program in 2008 and the cessation of short-term training courses in 2020 are examined.*

Oncologists		**Mean before intervention**	**Mean after intervention**	**Mean change**
Introduction of residency program				
Number	Total Oncologists	540.00	964.4	424.4
	Urban Oncologists	502.37	840.62	338.25
	Rural Oncologists	49	129.62	80.62
Per million population rates	Total Oncologists	35.87	54.44	18.57
	Urban Oncologists	59.18	81.64	22.46
	Rural Oncologists	7.44	17.08	9.64
Discontinuation of short-term training courses				
Number	Total Oncologists	738.36	1207.33	468.97
	Urban Oncologists	662.9	1052.75	389.85
	Rural Oncologists	91.8	157.5	65.7
Per million population rates	Total Oncologists	44.81	63.22	18.41
	Urban Oncologists	70.48	92.55	22.07
	Rural Oncologists	12.67	19.86	7.19

program had a negative, though not statistically significant, effect on the overall number of oncologists and their per capita rates. This finding is underscored by the low stationary R-squared value, indicating limited explanatory power. In contrast, the discontinuation of short-term training programs had a significant and adverse impact, particularly in rural areas, where it led to a 3.2% reduction in the number of oncologists and a 0.18% decrease in per million population (PMP) rates. However, this intervention did not have a notable negative effect on the total number of oncologists or their PMP rates in urban areas or overall, as summarized in Table 2.

Projections for the total number of oncologists, number of urban oncologists and number of rural oncologists to 2030 suggest that they will experience an upward trend, whereas the number of lung cancer deaths in Kazakhstan is likely to trend downward (Figure 2).

Table 3 indicates that Kazakhstan is projected to have 1421 oncologists (95% CI: 975;1866) managing 3653 lung cancer patients annually (95% CI: 2348;4958). Among these, 1300 oncologists (95% CI: 837;1940) are expected to be based in urban areas, whereas 237 oncologists (95% CI: 119;428) are expected to serve rural regions.

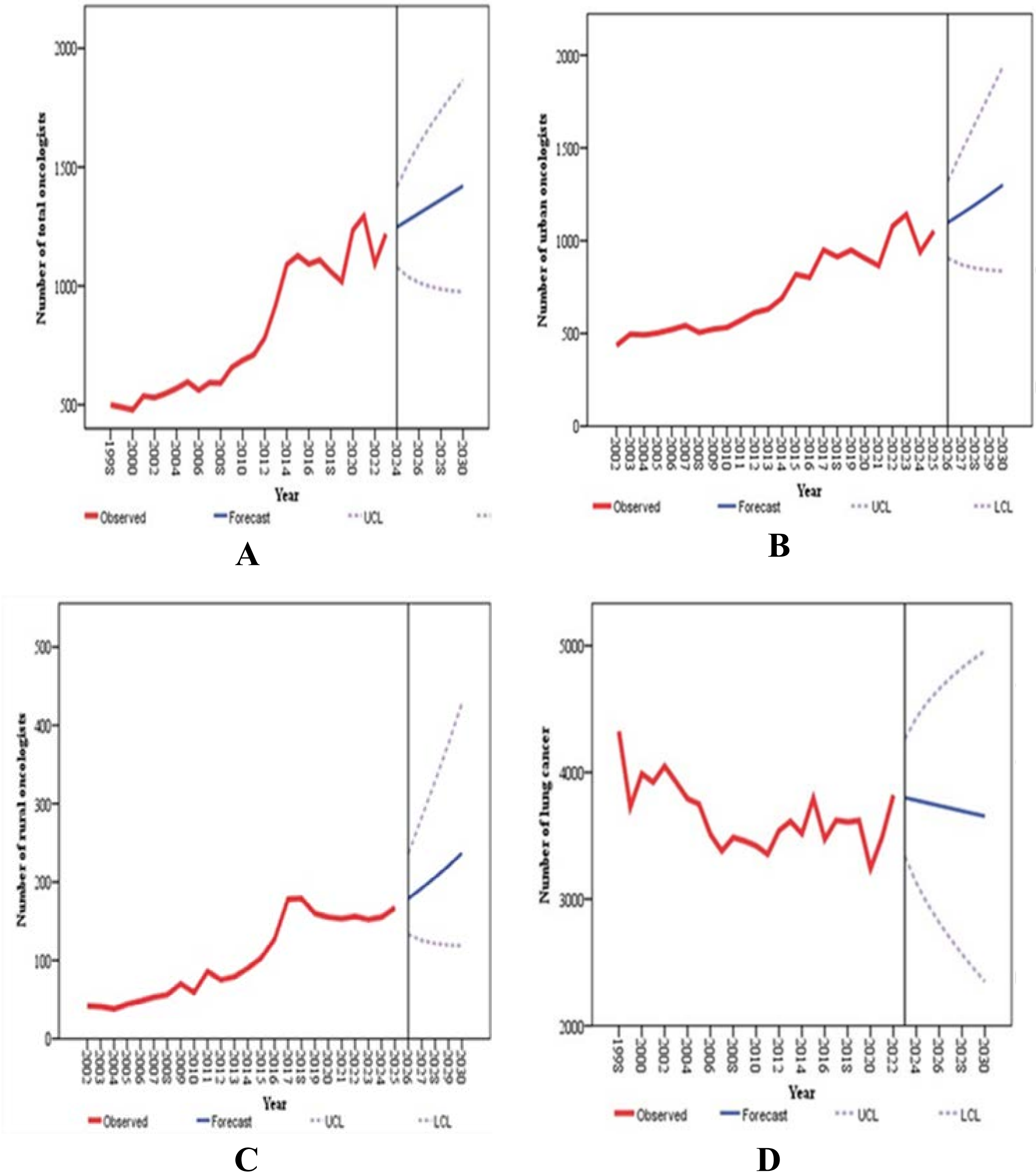


Figure 2. The observed an projected rates of total oncologists (A), the rate of urban. oncologists (B), the rate of rural oncologists (C) and the lung cancer mortality rate.

Table 2. *Descriptive statistics of lung cancer mortality and deaths per oncologist: the impact of the introduction of the residency program (2008) and discontinuation of short-term training courses (2020).*

Indicator	Mean before intervention	Mean after intervention	Mean change	Mean change related to preintervention period, %
Introduction of residency program				
Number of lung cancer deaths	3045.5	2567.75	-477.75	-15.69
Lung cancer mortality rate	19.78	14.68	-5.1	-25.78
Rate of total oncologists	35.87	54.44	18.57	51.77
Rate of urban oncologists	59.18	81.64	22.46	37.95
Rate of rural oncologists	7.44	17.08	9.64	129.57
Number of lung cancer deaths per oncologists	5.64	2.66	-2.98	-52.84
Number of lung cancer mortality rate per rate of total oncologists	0.55	0.27	-0.28	-50.91
Number of lung cancer mortality rate per rate of urban oncologists	0.33	0.18	-0.15	-45.45
Number of lung cancer mortality rate per rate of rural oncologists	2.66	0.86	-1.80	-67.67
Discontinuation of short-term training courses				
Number of lung cancer deaths	2757.93	2141.00	-616.93	-22.37
Lung cancer mortality rate	16.44	11.07	-5.37	-32.65
Rate of total oncologists	44.81	63.22	18.41	41.08
Rate of urban oncologists	70.48	92.55	22.07	31.31
Rate of rural oncologists	12.67	19.86	7.19	56.72
Number of lung cancer deaths per oncologists	3.73	1.77	-1.96	-52.52
Number of lung cancer mortality rate per rate of total oncologists	0.37	0,18	-0.19	-52.27
Number of lung cancer mortality rate per rate of urban oncologists	0.23	0.12	-0.11	-48.72
Number of lung cancer mortality rate per rate of rural oncologists	1.3	0.56	-0.74	-57.04

Table 3. *The projected numbers and rates of total oncologists, urban oncologists, rural oncologists and lung cancer mortality for the years 2026 and 2030, accompanied by 95% confidence intervals.*

Number	**Year**		**Model parameters**		
	2026 Rate (95% CI*)	2030 Rate (95% CI)	Type of model	Alpha (level) t	 p value
Total oncologists	1305 (1014; 1597)	1421 (975;1866)	ARIMA (0.1.0)	1.765	0.090
Urban oncologists	1098 (906; 1319)	1300 (837; 1940)	ARIMA (0.1.0)	2.025	0.055
Rural oncologists	179 (133; 236)	237 (119; 428)	ARIMA (0.1.0)	2.079	0.049
Lung cancer mortality	1846 (1433; 2259)	1596 (965; 2226)	ARIMA (0.1.0)	-2.296	0.036
Rate of total oncologists	63.96 (47.66; 80.27)	68.37 (43.47; 93.28)	ARIMA (0.1.0)	1.208	0.239
Rate of urban oncologists	90.60 (64.33; 124.41)	100.09 (58.73; 160.83)	ARIMA (0.1.0)	1.082	0.291
Rate of rural oncologists	23.46 (17.39; 31.03)	34.30 (14.90; 68.91)	ARIMA (0.1.0)	1.839	0.079
Rate of lung Cancer mortality	8.33 (6.01; 10.66)	5.95 (2.40; 9.50)	ARIMA (0.1.0)	-3.878	<0.001
*95% CI – 95% Confidence Interval					

Discussion.

This study aimed to assess the impact of medical education reforms on the number of oncologists in Kazakhstan and associated per capita indicators from 1998-2022. Specifically, the analysis focused on the introduction of a routine oncology program and the discontinuation of short-term advanced training courses. Additionally, this study sought to examine the relationship between lung cancer mortality and the distribution of oncologists across the country. Overall, the number of oncologists per capita ranged from 33.12-60.66, indicating an increasing trend over the study period. Additionally, by 2023, the total number of oncologists had increased 2.44-fold compared with that in 1998, with the number of urban oncologists increasing by 2.41 times and that of rural oncologists nearly quadrupling. A comparison of the mean values before and after the two intervention periods revealed positive changes in both the total number of oncologists and the number of urban specialists, as well as in their respective per capita indicators. After the introduction of the residency programs, the number of oncologists in both urban and rural areas shifted from the prior growth trend, without showing a true decline in absolute figures.

The adverse impact following the two interventions was observed among rural oncologists. The findings of our study should be integrated with those of other studies to achieve a more comprehensive understanding of the issue.

The WHO Global Strategy on Human Resources for Health: Workforce 2030 and the 2023 Global Health Workforce Network reports emphasize integrated approaches to health workforce development, calling for intersectoral collaboration, long-term planning, and the alignment of educational outputs with population health. These principles are highly applicable to Kazakhstan's efforts in strengthening oncology services and should be considered in future national strategies [18]. The implementation of measures proposed in this study to optimize the distribution of oncologists and improve the accessibility of oncological care can contribute not only to a reduction in mortality rates, but also to an increase in patient satisfaction with the quality of medical services. This is especially relevant given the low level of patient satisfaction with healthcare, including in specialized areas, identified in Kazakhstan. Thus, according to the study by Dauletyarova et al., only 65% of women in Eastern Kazakhstan remained satisfied with the quality of inpatient obstetric care, despite the reforms, which indicates the need for systemic improvement in the organization of medical services and orientation to the needs of patients [19].

The per capita rate of oncologists in Kazakhstan surpassed the estimated global average. According to 2018 statistics, the number of oncologists per million population was 141 in the United States, 115 in Germany, 60 in Australia, 52 in Spain, 43 in Canada, 40 in the Russian Federation, 21 in Poland, 18 in China, and 7 in Turkey [20].

Several studies have documented similar problems in Armenia, Kyrgyzstan, and Moldova, where medical education reforms, migration of specialists, and funding constraints have influenced the availability and geographic distribution of oncologists and other specialized personnel. For example, in Armenia, oncology workforce shortages are exacerbated by urban concentration and weak incentives for rural practice, despite national cancer control initiatives [21]. Similarly, Georgia has seen growth in the number of oncologists, but issues of uneven access and delayed diagnosis remain due to fragmented service delivery [22]. These findings underline the importance of comprehensive and context-specific human resources policies.

Mathew A. and coauthors conducted a comprehensive global survey of clinical oncology personnel, compiling data on the number of professionals in this field across 93 countries from 30 different sources. The survey revealed that eight countries lack a clinical oncologist to assist cancer patients. Alarmingly, in 27 countries (29%), a single clinical oncologist cares for more than 1,000 cancer patients [24]. According to our study, in 2018, the number of oncologists was 58 per million people. Overall, the per capita number of oncologists ranged from 499-1219, reflecting an increasing trend throughout the study period. Significant disparities were observed between urban and rural areas, with the number of oncologists in urban settings being six times greater than that in rural areas.

Furthermore, we incorporated international evidence to contextualize our findings. Drawing on the experience of South Korea, we note that the integration of WFME-aligned standards into medical training, alongside national cancer strategies, led to notable improvements in the quality of cancer care and lung cancer survival rates. For instance, Korea has more than doubled its five-year survival rate for lung cancer since the early 2000s, partially attributed to improved training and early detection initiatives [25,26]. These examples underscore the importance of linking education reforms with broader system-wide policies, including infrastructure investments and rural workforce support.

Based on this comparative perspective, we now offer forward-looking recommendations tailored to Kazakhstan's context, including the integration of oncology simulation training, rural clinical rotations during residency, and continuous monitoring of training outcomes.

An interesting finding is the presence of a strong and statistically significant positive correlation between the average number of oncologists and lung cancer mortality in Kazakhstan during the period from 2006 to 2023 ($r = 0.814$, $p < 0.001$). While this result may initially appear paradoxical, it warrants careful interpretation. One possible explanation is that the increase in the number of oncologists may have been a response to persistently high incidence and mortality rates of lung cancer, rather than a factor contributing directly to their reduction [27]. The observed correlation between oncologist numbers and lung cancer mortality should be interpreted with caution. This relationship may reflect a temporal delay before new specialists influence outcomes, improved diagnostics and registration practices that increase reported mortality, and persistently high smoking prevalence sustaining incidence. Thus, workforce expansion is important but represents only one element of a multifactorial strategy to reduce lung cancer mortality.

Moreover, an increase in the number of specialists does not necessarily correlate with improved quality of care or its equitable distribution, especially in rural and remote areas [28]. These observations highlight the need for a comprehensive strategy to reduce lung cancer mortality - one that extends beyond workforce expansion to include active prevention, reduction of exposure to major risk factors (particularly tobacco use and air pollution), enhanced public awareness, and improved access to screening programs [29].

Lung cancer is a significant public health concern, causing a considerable number of deaths globally. The global 2020 estimates of cancer incidence and mortality produced by the International Agency for Research on Cancer (IARC) show that lung cancer remains the leading cause of cancer death, with an estimated 1.8 million deaths (18%) in 2020 [30]. In 2020, the global lung cancer mortality rate was 23 per 100,000 people. However, country-specific rates varied significantly: China reported 49.4 per 100,000 people, Germany reported 60 per 100,000 people, Poland reported 72.5 per 100,000 people, Italy reported 55.6 per 100,000 people, the USA reported 41.8 per 100,000 people, Canada reported 56.6 per 100,000 people, and South Africa reported 13 per 100,000 people [1].

Baizhumanova A. et al. reported that in 2006, 17,608 Kazakhs died of cancer, accounting for 11.5% of all deaths in Kazakhstan that year. Lung cancer was identified as the leading cause of cancer-related mortality among both men and women, accounting for 17.6% of these deaths. Additionally, the authors reported a 25% decrease in cancer mortality over a relatively short period, which the authors attributed to changes in the socioeconomic conditions of the country. Between 1992 and 2000, Kazakhstan underwent a severe crisis following the collapse of the Soviet Union, which led to significant cuts in healthcare funding. These cuts resulted in a shortage of doctors, a reduction in primary healthcare centers - particularly in rural areas—and limited access to medical services, all of which likely contributed to the increase in cancer mortality during that time. However, from 2001-2006, Kazakhstan experienced greater stability and implemented new healthcare reforms, which likely contributed to the observed decrease in cancer mortality during this period [31].

In studies conducted by Kaidar D. et al. in the Republic of Kazakhstan, nationwide lung cancer mortality has decreased by 17% since 2014, from 15.8 to 13.1 per 100,000 people. This consistent year-over-year decline reflects the systematic approach and effectiveness of the measures implemented. The early detection of cancer has been identified as a key factor contributing to the reduction in cancer mortality [29]. In another study covering the period from 2009-2019, lung cancer mortality in both sexes decreased significantly, by 38.8%, from 20.1 per 100,000 in 2009 to 12.3 per 100,000 in 2019. This decline was nearly consistent on an annual basis, with the exception of 2012 [31]. For comparison, this study demonstrated that the lung cancer mortality rates per 100,000 population ranged from 20.24-10.12, with a consistent downward trend observed throughout the study period. Additionally, a strong and significant correlation was identified between the average number of oncologists and lung cancer mortality.

Following its independence, Kazakhstan initiated reforms in medical education, transitioning to the Bologna system. A key aspect of this transition was the introduction of residency programs in 2008. Another significant intervention was the discontinuation of short-term training courses in 2020. The transition to the oncology residency program raised concerns about a potential decline in the number of specialists nationwide, particularly in rural areas. Our study confirmed that, after the introduction of the residency programs, the number of oncologists in both urban and rural settings deviated from the previous upward trend, rather than showing a sustained decrease in absolute terms. Thus, while the long-term trajectory remained upward, ITSA revealed a short-term deceleration in growth immediately after the implementation of the residency program in 2008. Additionally, the discontinuation of short-term training courses negatively affected both the number and per capita availability of rural oncologists, although the impact was not statistically significant. The main strength of this study is that it represents the first investigation into the effects of medical education reforms on the number and density of the oncology workforce in Kazakhstan. Additionally, this study provides a comprehensive analysis of both the national and provincial contexts of lung cancer mortality. A major limitation of this study is the aggregate nature of the data, which limits the ability to conduct more detailed analyses and does not allow for the inclusion of a number of significant factors at the individual or institutional level.

Conclusion.

This study revealed substantial disparities in the distribution of oncologists in Kazakhstan, with rural areas experiencing a persistent shortage. Although the overall number of oncologists increased during the study period, deviations from the growth trajectory were observed after key reforms, particularly affecting rural regions. To address these challenges, specific policies are required to strengthen the oncology workforce: expanding training opportunities, introducing flexible educational formats, and providing targeted incentives for rural practice. These measures are essential to improve equity in access to oncological care and to support long-term reductions in lung cancer mortality.

Author Contributions.

Conceptualization, Sh.A. and T.B.; methodology, Sh.A. and G.O.; software, A.U.; validation, A.M. and T.A.; formal analysis, G.O., K.A. and Zh.A.; investigation, Sh.A.; resources, T.B. and T.A.; data curation, M.A., M.K. and G.B.; writing—original draft preparation, Sh.A.; writing—review and editing, Sh.A. and A.M.; visualization, Sh.A.; supervision, A.U.; project administration, T.B.; funding acquisition, Sh.A. All authors have read and agreed to the published version of the manuscript." All authors have read and agreed to the published version of the manuscript.

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Institutional Review Board Statement.

This study received permission from the Ethics Committee of Semey Medical University (Protocol # 2 of 12.12.2023).

Informed Consent Statement.

Not applicable.

Ethics, Consent to Participate, and Consent to Publish Declarations.

Not applicable.

Clinical Trial Number.

Not applicable.

Data Availability Statement.

The datasets used and/or analyzed during the current study are available from the corresponding author upon reasonable request.

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