

RESEARCH ARTICLE

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Environmental Exposure to Carcinogens and Cancer Incidence in Kazakhstan: Opportunities for Cancer Prevention

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Abstract

Background: Kazakhstan is a large country in Central Asia with long history of uranium and asbestos mining and nuclear testing, whose health effects have not been fully analyzed. **Objectives:** To study the geographical distribution of cancer rates in relation to toxic sites. **Methods:** We conducted an extensive review of publicly available datasets, administrative documents, and publications to assess past and active sources of exposure to carcinogens, and the geographic distribution of cancer incidence. **Findings:** Several past and ongoing sources of environmental exposures were identified. Cancer incidence is unevenly distributed, with the highest rates in the areas where nuclear testing was performed. The most frequently observed cancers are those of the lung, stomach, colorectum, and hematopoietic system. Among males, prostate cancer entered the list of the top cancers, while among females, breast, uterine, and cervical cancer were the most represented. **Conclusions:** There are relatively small, densely populated areas that are heavily impacted by reactors, previous nuclear testing, uranium mines, chemical plants, and nuclear waste facilities. The geographic distribution of cancer rates reflects, in part, the location of the polluting sites, as well as personal exposure to behavioral risk factors, such as smoking and dietary habits. Aggressive preventive measures should be put in place for those cancers that are preventable through either screening or vaccination. Because of the many radon and uranium sites, lung cancer screening should be routinely offered to high-risk populations.

Keywords: Central Asia, asbestos exposure, cancer rates

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Introduction

Kazakhstan is a large country in Central Asia with a very low population density (8 people per Km²), rich in natural resources such as minerals, metals, oil and gas that have been extensively extracted over the years. Among the important natural reserves is uranium, of which Kazakhstan owns 14% of the world's reserve. The long history of mining and milling of natural resources may have created environmental contamination and exposure of the workers and of the surrounding residents.

In addition, the former Soviet Union extensively leveraged the territory's natural resources and developed a large industrial footprint in the area, including the designation of Kazakhstan as a nuclear testing site between 1949 and 1989 [1]. Finally, Kazakhstan is home to a large active asbestos mine, and the country is one of the few left

that produces and exports asbestos, together with Brazil, Russia, China and India [2].

Kazakhstan's economy still relies heavily on industrial activities, including mining, oil and gas extraction, and the use of coal-fired power plants that are highly polluting; many of these industries and plants rely on old equipment and inefficient methods of waste disposal [3]. For all these reasons, Kazakhstan residents have likely been exposed to a large number of carcinogens over the years, and some of the environmental hazards are still present and active nowadays.

We conducted an extensive review of publicly available datasets, administrative documents and publications to assess 1) past and active sources of exposure to carcinogens, and the current status of environmental pollution, and 2) the geographic distribution of cancer incidence, overall and according to cancer types. The

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overarching goal is to identify geographic areas where environmental exposures and cancer rates are of concern, with the ultimate goal of developing appropriate plans to decrease cancer incidence.

Materials and Methods

Environmental sources of exposure

We reviewed several public documents from the Republic of Kazakhstan to assess what are the main exposures of concern in the country and developed a list of environmental sources of chemicals and carcinogens.

Uranium and Radon

The natural deposits of uranium and their geographic disposition were identified through the website of the company that extracts uranium (National JSC KAZATOMPROM). A list of legacy sites from past uranium extraction was also obtained from Kazatomprom and the World Nuclear Association website [4, 5].

Radon is naturally present in some geographic areas and is also a by-product of uranium mining. A Medline search was conducted using the key words ["Uranium" and "Kazakhstan"], and ["radon" and "Kazakhstan"] through June 30, 2025. We reviewed publications on radon levels in areas around uranium mines, and on indoor radon measures in the same areas. Gamma radiation levels were also extracted from the same publications [6, 7]. Uranium is considered a carcinogen, mainly via inhaled radioactive decay products, such as radon; radon and its decay products have been classified by the International Agency for Research on Cancer (IARC) as Group 1 carcinogens (carcinogenic to humans).

Nuclear Test Sites

Publications that conducted dosimetry around the Semipalatinsk nuclear test site were reviewed to extract relevant information [8].

Asbestos

Data on the only active mine was extracted from the Kostanay Minerals website. The internet was searched for factories using asbestos and located in Kazakhstan [9].

Other chemicals exposure

A literature search and internet search were conducted to identify chemical plants in Kazakhstan. Two main complexes were observed: an acetaldehyde production plant and a chloroalkyl plant [10-12].

Cancer rates

Age and sex standardized cancer rates for the year 2023 were obtained from the Kazakhstan Cancer Registry (KCR), which serves as a repository for all histologically confirmed cancer cases in the country and is managed by the Center for E-Health and Kazakh Institute of Oncology and Radiology (KazIOR) and maintained by the Ministry of Healthcare of the Republic of Kazakhstan [13]. Indicators were calculated based on the data of the Bureau of National Statistics of the Agency for Strategic Planning and Reforms of the Republic of Kazakhstan

on the annual average population by the administrative territory of Kazakhstan for 2023. Data are reported according to the 20 administrative regions that constitute the republic. We also report age-adjusted cancer incidence according to sex, overall and according to the 20 regions. The data were standardized on the composition of the Kazakhstan population as of 2023. Age-standardized rates were calculated based on age-specific rates (per 100,000 people), multiplied by the age composition standard divided by 100 to calculate the percentage. The resulting products were summed up to obtain age-standardized rates.

Mesothelioma rates were extracted from the National Database for Pleural Mesothelioma [14].

Results

Uranium and Radon

Uranium mines: Roughly an estimated 12 to 20% of the world's uranium is located in Kazakhstan, and this has prompted a large extraction business with conventional methods until roughly 1995, when several of the uranium mines were decommissioned, leaving abandoned contaminated sites along with tailing storage facilities. There are large tailings storage facilities which continue operation in Aksu, operated by the Stepnogorsk Mining-Chemical Combine; the existing active uranium mines use in-situ recovery (ISR) process, which is considered less pollutant (Figure 1).

The territory exposed to radioactive waste from the uranium industry enterprises is estimated to extend approximately 100,000 hectares, with a total activity of 250,000 Curie [7].

Uranium measurements in the surrounding environment

A study showed that the dose of artificial and natural radiation in the average person in Kazakhstan is about 4 mSv/year [7], which is one and a half times higher than the world's average level. Environmental measures were completed in a study conducted in two settlements "Aksu" and "Saumakol" in Northern Kazakhstan in the early-middle 2000s and showed values of about 7.9 and 8.1 mSv/year respectively [6]. Ambient gamma radiation measurements were conducted during the summer (July–August) and autumn (September–November) seasons of 2024 in Aksu, Saumakol and Arykbalyk in Northern Kazakhstan. Saumakol exhibited the highest variability, with recorded values reaching up to $0.56 + 0.19 \mu\text{Sv/h}$. Values in Aksu ($0.16 + 0.004 \mu\text{Sv/h}$) were slightly above the reference level used in the country to assess if mitigation and remediation are necessary ($0.12 + 0.003 - 0.15 + 0.004 \mu\text{Sv/h}$).

Indoor radon estimations revealed contamination in Akqsu and Saumakol. Radon accumulation in buildings could be influenced by factors such as soil permeability and characteristics [6], underground radon sources, and variations in building ventilation. Studies of groundwater sources in North Kazakhstan have shown the presence of radon in drinking water, and 15 of the 32 surveyed drinking sources (47 %) had high levels of radon [7]. Environmental measurements were also performed in the Southern part of

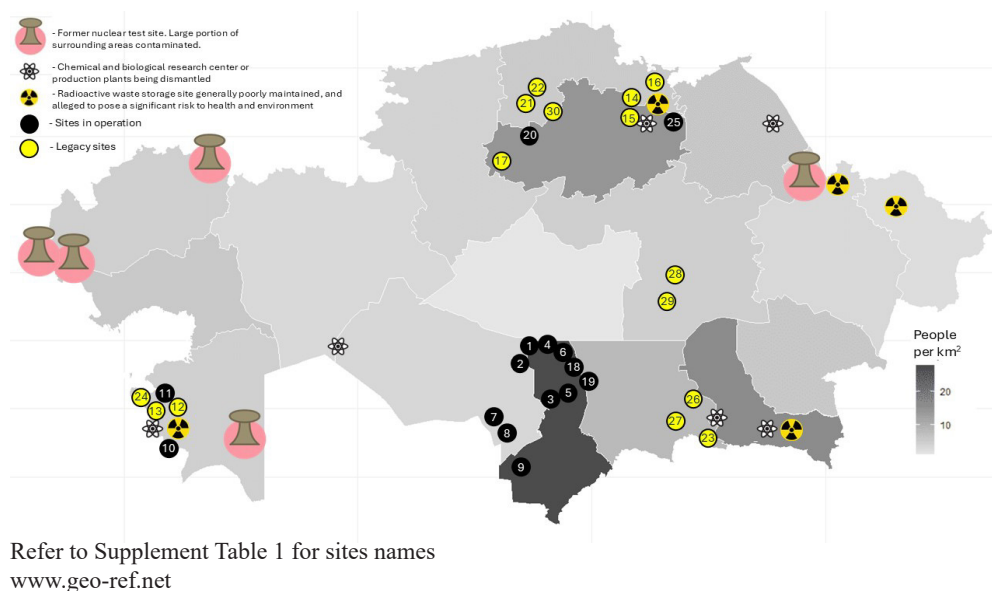


Figure 1. Uranium Mine Locations, Nuclear and Radioactive Waste Site and Chemical Plant Locations

Kazakhstan (KURDAY near Almaty) in 2013 [16], with outdoor environment measures of 0.14 ± 0.95 mGy/h, while indoor, in houses and dwellings, of 0.09 ± 0.55 mGy/h. The assessment of the annual effective dose was for outdoor about 180 mSv, for indoor about 900 mSv (0.9 mSv). The gamma ^{222}Rn and ^{220}Rn doses were in general low. It has to be emphasized that this area is characterized by several sources of contamination, from uranium legacy to radioactive waste storage, to nuclear power plants.

Nuclear testing

Nuclear test sites: The historical test site in Kazakhstan is Semipalatinsk (Pavlodar region, east of the capital Astana) where the first nuclear bomb test occurred on August 29, 1949. Subsequently, 456 nuclear detonations were carried out, including 111 atmospheric tests (86 events in air and 25 surface events) between 1949 and 1962, for a total of 6.58 megatons of TNT equivalent, which corresponds to approximately 2/3 of the overall estimated yield of Soviet atmospheric bomb tests. In 1963, the detonations at SNTS were restricted to underground shafts and tunnels. The last detonation was on 19 October 1989 (Figure 1).

There are three other known test sites: The Azgyr test site in the West Kazakhstan region, which hosted 24 underground nuclear explosions between 1966 and 1976 [18] the Lira 6 test site, located in the Ural region of Kazakhstan, specifically in the Atyrau region. Finally, the Soviet Union conducted three peaceful nuclear explosions 100–115 km south-southeast of the village of Say-Utes in 1969 and 1970 in the Mangystau region.

Dosimetry from brick samples from the Dolon village (Northeast of the site) published in 2006 [8] showed an average value of the local gamma dose due to fallout of about 220–300 mGy, after subtracting the background dose, with good concordance among the six laboratories independently testing the samples. The article reports soil contamination data, analyses of archive information and

new models that were used for refined dose calculations and estimations. The external dose for the Dolon village was estimated to be about 500 mGy. A registry that contains information on more than 300,000 individuals residing in the areas neighboring to the test site was established [17]. Multiple underground nuclear detonations in salt domes resulted in an increase in drinking water hardness up to twice the permissible limit, lead concentrations 3.0–6.3 times above, and cadmium concentrations up to 9.8 above the maximum permissible concentration [19].

Radioactive waste storage sites

Several areas have been devoted to radioactive and other chemicals waste storage. The Kurday site near Almaty was in operation during 1954–1965 as a uranium and molybdenum extraction site for the nuclear weapons program. The site was partially remediated in 2005 [20]. Just outside of Almaty there is an old radioactive waste site, managed by the Alatau Institute of nuclear physics. The institute is an isotope producer and functions as a storage facility for spent nuclear fuel. Similar deposits for spent fuel are located near Stepnogorsk and Mangyshlak; the Ulba metallurgical plant in Ust-Kamenogorsk also operates a storage facility for low activity waste [21]. Commissioned in 1995, the spent fuel storage site at the Baykal-1 reactor complex, which is located on of the former Semipalatinsk testing ground, is the only such site operating in Kazakhstan, and can safely store radioactive waste for a period up to 50 years.

Asbestos

Kazakhstan is the third country in the world in asbestos exports (18.2% of world exports in terms of value). In 2024, Kazakhstan exported in total 236781 tons of raw asbestos to the following countries (in order of quantity): Uzbekistan, Tajikistan, India, Bangladesh, Turkmenistan, Kyrgyzstan, China, Azerbaijan, Ukraine [22]. The country's asbestos industry is centered around the Zhitikarinsky deposit in the Kostanay region, with

the “Kostanay Minerals” JSC plant as the sole mining company. Kostanay Minerals enterprise operates the Zhitikara chrysotile deposit located in the Kostanay region, providing jobs for approximately 2,000 people [23]. In addition to Kostanay Minerals, three affiliated companies in the mining sector manufacture asbestos-cement products, collectively employing around 6,000 more workers [24]. In October 2024, Kazakhstan launched its first facility dedicated to the production of asbestos-cement panels.

The mineralogical identity of asbestos mined and used in Kazakhstan has been scarcely investigated, as pointed out in a recent review [24], but Public Health authorities claim it is pure chrysotile [25-27]. There is a lack of analytical data obtained through updated methods about the mineralogy of asbestos extracted in Kazakhstan. The same can be said for the measurement of dust concentration in workplaces at Kostanay Minerals [28,29]. Indeed, such assessments have been performed using a gravimetric method which is now considered outdated for asbestos monitoring.

The mineralogic nature of chrysotile mined at Zitikara is of crucial importance for public health not only in Kazakhstan, but also in the many countries which import asbestos from Kazakhstan. Chrysotile has a lower biopersistence compared to amphibole asbestos [30, 31], and this explains the generally accepted lower carcinogenic potential of chrysotile compared to amphibole asbestos. However, World Health Organization (WHO) and the International Agency for Research on Cancer (IARC) have classified all types of asbestos as Group I carcinogens. According to some authors [32, 33] the occurrence of cancer after chrysotile exposure is partly explained by amphibolic contamination of chrysotile ores. A recent study conducted in Kirghizstan on raw asbestos imported from Kazakhstan, as well as on lung tissue from the Kirghizstan general population, detected amphibole asbestos [34].

Other Chemical Exposures

Chemical plants

There are several chemical and biological centers and production plants spread around the country, now dismissed.

Pavlodar chemical plant

The Chemical Complex in Pavlodar in the northeast part of the country was a dual-purpose complex in which civilian chemical production served as a cover for chemical weapons and military activities. The chemical weapon production never took off, and the plant was completely converted to civilian chemical production. The plant began activity in 1965 and closed in 1993.

Although the main profile was that of a chlor-alkali producing plant [12], other chemicals produced here include anti-freeze, anti-icer, disinfectant and bleaching agents, plasticizers, phenol-formaldehyde resin, ammonium chloride. The plant had the highest rate of mercury use among plants with similar purpose, and contaminated water, sediments, and fish in the Lake Balkyldak as well as the whole water basin in the area.

Karaganda Plant

Another large industrial Complex was JSC “Carbide” (at present “Karaganda Plant SK Temirtau”), that produced carbide and acetaldehyde and has been the primary source of mercury contamination in Central Kazakhstan from 1950 to 1997, until its closure in 1999. The sediments and river water in the vicinity of the main discharge drain still contain high mercury concentrations; soils in the floodplain water, sediments, and fish in the River Nura are contaminated. Discharges and losses from both facilities (Padlovar and Temirtau) contained over 2000 metric tons of mercury combined and created the major contamination event in Kazakhstan’s history, still not thoroughly assessed to this date [10, 16].

Stepnogorsk plant

This chemical weapon production facility was established in 1982 roughly 10 km from the city of Stepnogorsk, and also included a biotech plant, uranium deposit and mining area, and a refinery. The facility was closed down in 1992 and dismantled in 1995 [15].

Others

Vozrozhdeniye Island in the middle of the Aral Sea was used for biological weapon testing starting from the 1920’s until 1990.

A fast-breeder reactor on the Caspian Lake’s shore in Shevchenko (later renamed Aktau) fulfilled multiple purposes, from breeding plutonium to desalinizing water and producing electricity for the town. Next to it there was a chemical-hydrometallurgical plant producing uranium oxide, scandium oxide, scandium fluoride, and other rare earth elements for export [35]. The complex also included sulfuric acid and nitric fertilizer production facilities, a Machine Building Complex (Remzavod) manufacturing equipment for the oil, mining, chemical and agricultural industries and a research laboratory. All the activities were suspended in 1994.

The Anti-Plague Scientific Research Institute was established in 1949 in the suburbs of Almaty, and had four laboratories, including one devoted to genetic research, and a vaccine preparation plant. In addition to serving civilian needs, the institute was involved in military-related research and development on defensive measures against biological warfare. In 1992, Moscow terminated funding for the institute’s research and all military-related work ceased.

The Scientific Research Agricultural Institute established in 1958 outside Otar, near Almaty also had a function in biological weapons production until 1991 [36].

Cancer Rates

The age and sex-adjusted cancer rate in Kazakhstan in 2023 was 159,6 x 100,000, with minimal change from the previous year. The list of the most common cancer types is presented in Table 1; the most common cancer site was trachea, bronchi and lung, followed by stomach, colon-rectum, and the hematopoietic system. In male’s prostate cancer entered the list of the top cancer types, while in female’s breast, uterus and cervical cancer were the most represented.

Table 1. Cancer Rates According to Cancer Site

Cancer type	Age and sex standardized rates (x 100,000)		Age standardized rates (x 100,000)	
	2022	2023	Males	Females
All	158.4	159.6	166.3	162
Lip	0.5	0.5	0.9	0.1
Oral cavity and pharynx	3.9	3.6	5.1	2.5
Esophagus	4.9	4.6	6.8	3.2
Stomach	13	12.1	19.7	7
Colon	8.7	8.6	9.9	7.8
Rectum	7.7	8.1	10.4	6.5
Liver	4.5	4.8	7.3	2.9
Pancreas	5.2	5.4	6.4	4.7
Larynx	1.7	1.9	3.9	0.4
Trachea, bronchi, lung	17.6	16.4	30.6	6.5
Bones and joints	0.9	0.8	1	0.7
Connective and soft tissue	1.9	2.1	2.4	1.9
Melanoma of skin	1.5	1.5	1.5	1.6
Kidney	6.5	6.9	8.4	5.9
Bladder	3.6	3.5	6.6	1.4
CNS	3.9	3.7	3.9	3.6
Thyroid	4.3	4.9	1.7	7.9
Lymphoid and hematopoietic	9.2	9.1	10.2	8.4
Prostate			18.8	
Breast				43.3
Uterus-corpus				10.5
Uterus-cervix				6.9

Regional differences in cancer incidence

There were distinct differences in cancer incidence across the country, with the highest rates observed in North Kazakhstan, Kostanay, Pavlodar and Karaganda, and the lowest rates in the south of the country (Figure 2).

The pattern was similar when data restricted to males was plotted (Figure 3A). The rate in females has a slightly different geographic distribution, and the regions with

highest rates were Pavlodar, Karaganda, Astana city and East Kazakhstan (Figure 3B).

Pleural mesothelioma

There were 70 pleural mesothelioma cases diagnosed in the national mesothelioma registry for 2024, 24 females and 46 males; the M/F ratio was 1·9; average age was 61·8 years (SD 11·1 y). Among females average age

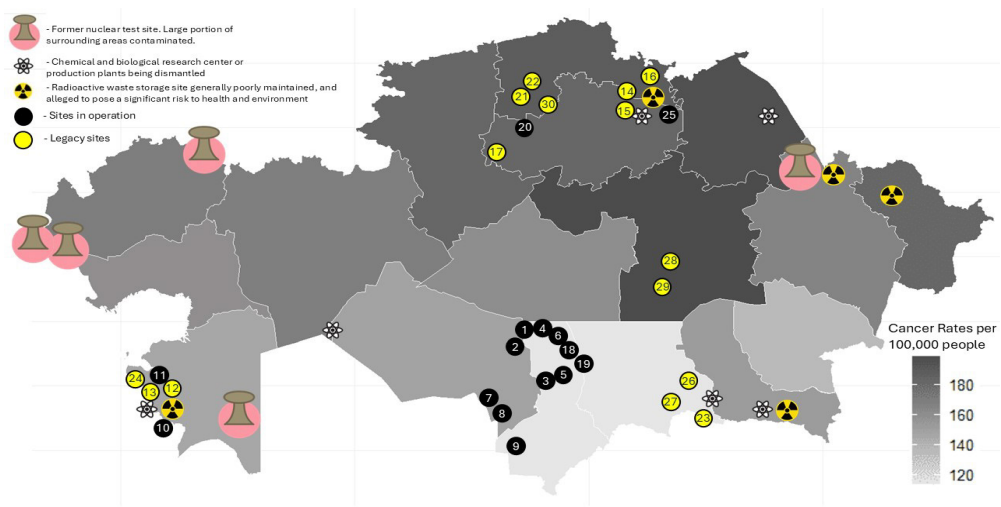


Figure 2. Regional Differences in Age-and Sex Standardized Cancer Incidence Rates. Data are presented as quartiles, from lower rates (light color) to highest rates (dark color). Uranium sites, nuclear and radioactive waste sites, chemical plants are also listed.

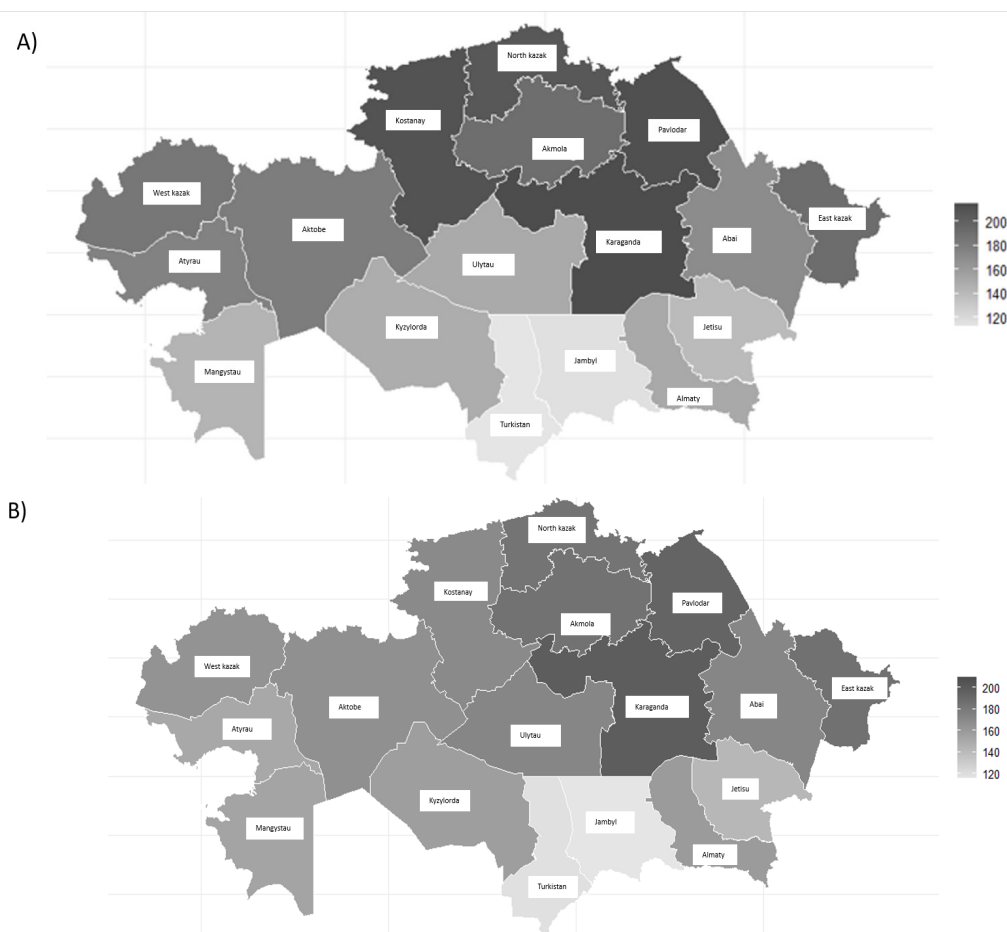


Figure 3. Age-Standardized Cancer Incidence Rates According to Sex. A: males, B: females

was 62.3 y (SD 13.7 y), with 5/24 (21%) diagnosed below age 50 y. In males average age was 61.5 y (SD 9.6 y); 7/46 (11%) were diagnosed below age 50 y. The distribution of cases x 1 million residents is presented in supplementary Figure 1, with the caveats that the rates are not standardized by age or sex.

Discussion

The assessment of the environmental sources of carcinogens and other toxicants in Kazakhstan indicates that there are areas heavily impacted by reactors, previous nuclear testing, uranium mines, chemical plants, and nuclear waste facilities, and these sources are all concentrated in relatively small areas. Thus, the overall pollution in those areas derive from multiple, diverse sources of chemicals and composite waste. The remediation operations occurred in some areas but were often partial, and even if effective, happened many years ago. From Figure 1 and supplementary Table 1, several uranium sites underwent remediation after their closure. However, there are indications that physical remediations, such as coverage with a cement blanket, have been eroded by natural events and weather.

As often happened in the past worldwide, many of the chemical plants were conveniently situated next to rivers and large water systems, to facilitate waste management,

thus polluting water, land and fish in extensive geographic areas.

Nuclear testing was conducted repeatedly in several areas around the country, and the effects on the surroundings lasted for decades. Studies on the health effects of testing are limited in the number of subjects recruited, and limited to the areas immediately surrounding the operation, thus they don't give an overall picture of the health repercussions on the residents. There is the radiation registry [17] that may contain interesting health information, but there is no recent data published, only a paper on its constitution. One aspect to note is that many of the nuclear testing sites are located in populated areas, thus increasing the number of residents potentially exposed to nuclear residues.

Despite Kazakhstan's large-scale asbestos mining and production, domestic demand for asbestos products remains low, as most of the country's asbestos output is exported to international markets. The new facility using asbestos slabs represents an effort to increase value-added manufacturing within Kazakhstan, although it also raises concerns among public health advocates and local communities due to the well-documented health risks associated with asbestos exposure, especially the increased risk for mesothelioma, a deadly disease with inefficient treatment options. The male-to-female ratio of 1.9 for mesothelioma is lower than the typical 3-5:1 ratio seen in countries with predominantly occupational

asbestos exposure. This, combined with the 21% of female cases diagnosed under age 50 years, raises concern for significant environmental or para-occupational exposure in the Kostanay region and potentially in areas where Kazakh asbestos is used in construction materials.

The finding of amphibole fibers in both raw Kazakh asbestos and human lung tissue in Kirghizstan [34] is alarming. If confirmed, it would mean that the asbestos mined in the area is not 'pure chrysotile' as claimed [25-27], but a mixture containing the more carcinogenic amphibole fibers. This has profound implications for workers in Kazakhstan and for the millions of people in importing countries like Uzbekistan, India, and Bangladesh. An urgent, independent, and transparent mineralogical analysis of the Zhitikara deposit using modern analytical methods (e.g., TEM-EDS) is a critical public health priority.

The geographic distribution of cancer rates reflects in part the location of the polluting sites, and shows high incidence in the contaminated areas, but especially where the nuclear testing happened in the 40s and 50s. It seems that nuclear testing is still the main driver of the geographic cancer hot spots. However, the list of the most common cancer sites suggests that personal behavior, such as smoking and dietary habits, may also be relevant to cancer occurrence. Another aspect to note is that for some of the commonly observed cancers, for example lung, breast, cervical, preventive measures are available, either in the form of screening or vaccination. This suggests that implementing cancer screening paradigms in Kazakhstan could substantially decrease the burden of cancer morbidity and mortality in this country.

To specifically address lung cancer prevention and early detection and establish a roadmap of activities, we have held the first Central Asian Forum on Lung Cancer took place at the National Academy of Sciences of the Republic of Kazakhstan on April 8-9, 2025 [37].

This study is the first of its type to give a comprehensive view of the major environmental hazards present in the country and the regional distribution of cancer rates. However, the study has some limitations, mainly due to its ecological nature. We cannot claim associations between cancer rates and presence of environmental carcinogens but only suggest a possible link. The primary limitation of this study, its ecological design, precludes drawing causal inferences at the individual level. The observed geographic correlations between exposure sources and cancer rates could be influenced by unmeasured confounding factors, including regional variations in smoking prevalence, diet, and access to diagnostic services.

However, this review gives an opportunity to address some future action items: it is clear that there are still contaminated sites that need remediation, along with ad-hoc studies of the amount of exposure to radiation and carcinogens in the population surrounding the contaminated sites. Data and samples from the registry created around Semipalatinsk, the main nuclear testing site, should be made widely available to the public to assess the biological effects of exposure on the residents.

Future research should move beyond this ecological overview to conduct analytic studies, such as case-

control or cohort studies, in specific high-risk regions. For example, a case-control study of lung cancer in the Pavlodar region could collect individual-level data on smoking, occupational history, and residential proximity to nuclear test sites to better quantify the independent risk associated with environmental radiation.

Studies elucidating potential genotoxic effects and health risk among exposed population in Kazakhstan are very limited or have never been conducted in specific hot-spot areas. Such studies should be conducted in a more systematic way; for example, the genotoxic effects of radon and of other radioactive exposures on the population of Kazakhstan are poorly understood, despite the fact that many regions of the country show high levels of radioactivity. Genotoxic studies could identify early areas of concerns before cancer rates climb. A nested case-control study within the Semipalatinsk registry to quantify the dose-response relationship between radiation exposure and specific cancers (e.g., thyroid, leukemia) should be designed. A biomarker study (e.g., measuring chromosomal aberrations or telomere length) in residents of high-radon communities like Aksu and Saumalkol compared to low-exposure controls would be very helpful; It would also be a priority to conduct a health impact assessment of the mercury contamination in the Pavlodar and Karaganda regions, focusing on neurological and renal outcomes in exposed populations.

Public Health Implications and Action Plan

We expect that aggressive preventive measures should be put in place for those cancers that are preventable with either screening or vaccination. Because of the many radon and uranium sites, lung cancer screening should be routinely offered to high-risk populations. We propose here a possible action plan that touches on the most evident issues observed in our ecological study.

Radon/Uranium/Nuclear Areas

Based on the high lung cancer rates and widespread radon exposure, we recommend (1) a nationwide radon mapping and home mitigation program, prioritized in the northern and central regions, and (2) the implementation of a lung cancer screening program using low-dose CT for high-risk populations (e.g., long-term residents of high-radon areas, former nuclear workers) as discussed at the recent Central Asian Forum on Lung Cancer [37].

Asbestos

Given the active asbestos mining and export industry, and the documented cases of mesothelioma in young individuals, a crucial preventive step is to (1) mandate modern, phase-contrast microscopy for workplace monitoring instead of outdated gravimetric methods, and (2) establish a national, asbestos-exposed worker cohort for long-term health surveillance.

High-Rate Cancers: The high incidence of breast, cervical, and colorectal cancers underscores the need to strengthen and expand existing screening programs. Mobile screening units could be deployed to the highly polluted but resource-limited regions identified in Figures 2 and 3.

Author Contribution Statement

Taioli, Tuminello, Smagulova, Amankulov: conceptualization and administrative support. Henschke, Yankelevitz, Turkpenova: data interpretation. Visonà: asbestos expertise. Kaidarova, Sagi, Kadyrbayeva: data acquisition and analysis

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Data availability

This article relies on publicly available datasets, listed in the references.

Ethical issues

This study was considered exempt by Mount Sinai IRB office

Conflicts of interest

None.

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