Access to diagnostic imaging and radiotherapy technologies for patients with cancer in the Baltic countries, eastern Europe, central Asia, and the Caucasus: a comprehensive analysis

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Summary

Background Only 10–40% of patients with cancer in low-income and middle-income countries were able to access curative or palliative radiotherapy in 2015. We aimed to assess the current status of diagnostic imaging and radiotherapy services in the Baltic countries, eastern Europe, central Asia, and the Caucasus by collecting and analysing local data.

Methods This Access to Radiotherapy (ART) comprehensive analysis used data from 12 countries: the three Baltic countries (Estonia, Latvia, and Lithuania), two countries in eastern Europe (Moldova and Ukraine), four countries in central Asia (Kazakhstan, Kyrgyzstan, Tajikistan, and Uzbekistan), and three countries in the Caucasus (Armenia, Azerbaijan, and Georgia), referred to here as the ART countries. We were not able to obtain engagement from Turkmenistan. The primary outcome was to update the extent of shortfalls in the availability of diagnostic imaging and radiotherapy technologies and radiotherapy human resources for patients with cancer in former Soviet Union countries. Following the methods of previous similar studies, we developed three questionnaires—targeted towards radiation oncologists, regulatory authorities, and researchers—requesting detailed information on the availability of these resources. Authors from participating countries sent two copies of the appropriate questionnaire to each of 107 identified institutions and coordinated data collection at the national level. Questionnaires were distributed in English and Russian and responses in both languages were accepted. Two virtual meetings held on May 30 and June 1, 2022, were followed by an in-person workshop held in Almaty, Kazakhstan, in September, 2022, attended by representatives from all participating countries, to discuss and further validate the data submitted up to this point. The data were collected on a dedicated web page, developed by the International Cancer Expert Corps, and were then extracted and analysed.

Findings Data were collected between May 10 and Nov 30, 2022. 81 (76%) of the 107 institutions contacted, representing all 12 ART countries, submitted 167 completed questionnaires. The Baltic countries, which are defined as high-income countries, had more diagnostic imaging equipment and radiotherapy human resources (eg, Latvia [1·74] and Lithuania [1·47] have a much higher number of radiation oncologists per 100 000 population than the other ART countries, all of which had <1 radiation oncologist per 100 000 population) and greater radiotherapy technological capacities (higher numbers of linear accelerators and, similar to Georgia, high total external beam radiotherapy capacity) than the other ART countries, as well as high cancer detection rates (Latvia 311 cases per 100 000 population, Lithuania 292, and Estonia 288 *vs*, for example, 178 in Armenia, 144 in Ukraine, and 72 in Kazakhstan) and low cancer mortality-to-cancer incidence ratios (Estonia 0·43, Latvia 0·49, and Lithuania 0·48; lower than all but Kazakhstan [0·41]). The highest cancer mortality-to-cancer incidence ratios were reported by Moldova (0·71) and Georgia (0·74).

Interpretation Our findings show that the number of cancer cases, availability of diagnostic imaging equipment, radiation oncologists and radiotherapy capacity, and cancer mortality-to-cancer incidence ratios all vary substantially across the countries studied, with the three high-income, well resourced Baltic countries performing better in all metrics than the included countries in eastern Europe, central Asia, and the Caucasus. These data highlight the challenges faced by many countries in this study, and might help to justify increased investment of financial, human, and technological resources, with the aim to improve cancer treatment outcomes.

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Introduction

Cancer is the second leading cause of death globally among non-communicable diseases,[1–3] with the number of new cancer cases worldwide projected to increase to 27·5 million per year, with 16·3 million deaths, by 2040.[4–7] Since the publication of the *Lancet Oncology* Commission on expanding global access to radiotherapy in 2015,[6] little progress has been made in closing the gap between needed and available radiotherapy capacities in low-income and middle-income countries (LMICs).[5–7] Only about 10–40% of patients with cancer in LMICs who would have benefited from radiotherapy in 2015 were able to access such treatment.[4,8–10]

A 2018 study[11] by the International Atomic Energy Agency (IAEA) provided information on the status of radiotherapy in the non-Baltic post-Soviet countries and, to some extent, Russia. The study concluded that, in most of these countries, there was a need to modernise radiotherapy equipment and infrastructure, increase staff numbers, and update staff education programmes.

On the basis of experience gained from conducting surveys in Africa[12,13] and southeast Europe,[14,15] the International Cancer Expert Corps (ICEC) was engaged by the US Department of Energy's National Nuclear Security Administration's Office of Radiological Security (ORS) to undertake a similar, but more targeted and detailed, study—termed the Access to Radiotherapy (ART) study—to assess the current status of radiotherapy and diagnostic imaging services in 13 countries: Armenia, Azerbaijan, Estonia, Georgia, Kazakhstan, Kyrgyzstan, Latvia, Lithuania, Moldova, Tajikistan, Turkmenistan, Ukraine, and Uzbekistan. Making use of existing collegial relationships, we aimed to build collaborations to gather data on the status of cancer care, the availability of diagnostic imaging technology, the availability and use of current radiotherapy technology, the current level of radiation oncology human resources, and the challenges in transitioning from cobalt-60 machines to linear accelerators. We also aimed to identify cancer incidence rates per 100 000 population and the number of patients treated with radiotherapy and to assess the existing radiotherapy infrastructures in participating countries.

A secondary purpose of this study was to gather data to improve our understanding of the transition from cobalt-60 machines to linear accelerators and to develop a plan to overcome challenges when making this transition. Except for the Baltic countries (Estonia, Latvia, and Lithuania), the countries in this study have a paucity of medical linear accelerators and a disproportionately large share of the world's cobalt-60 machines. Although cobalt-60 machines are less expensive and less demanding in terms of operation, service, and necessary personnel training, the technological capabilities of

Research in context

Evidence before this study

We searched PubMed and Google, using "radiotherapy", "cobalt-60", "cancer rates", "technology", "diagnostic capacities", and the countries of interest (Armenia, Azerbaijan, Estonia, Georgia, Kazakhstan, Kyrgyzstan, Latvia, Lithuania, Moldova, Tajikistan, Turkmenistan, Ukraine, and Uzbekistan) as search terms, for English-language records published between April 1, 2011, and April 30, 2021. Relevant articles and files from the authors' own collections were also considered. Two relevant articles were retrieved: the 2012 HERO study and the 2018 International Atomic Energy Agency (IAEA) survey on the quality of radiotherapy services in post-Soviet countries. Both articles showed shortfalls in radiotherapy services in most of the surveyed countries and the need to modernise radiotherapy infrastructure and develop evidence-based education and training programmes for staff.

Added value of this study

This study made use of existing relationships with professionals in the participating countries to build extensive collaborations, which gathered current and relevant data regarding radiotherapy services in an interactive process from May 5, 2021, to March 30, 2023. Data were obtained not only from post-Soviet countries in eastern Europe, the Caucasus, and central Asia, which were covered by the IAEA survey, but also from the Baltic countries, which left the Soviet Union in the early 1990s. This study, which also includes the status of diagnostic imaging services, shows that the widely differing financial, technical, and human resources among the included countries affect the level of care provided to patients with cancer. The study provides an understanding of the challenges currently faced by countries with inadequate financial resources in trying to improve their radiotherapy and other cancer-related services and shows that such services could be improved with adequate funding.

Implications of all the available evidence

We show the importance of having sufficient financial resources to acquire the desired capacity of current diagnostic imaging and radiotherapy technologies and to increase the capabilities of the technical staff. These data could help many, if not all, of the countries included in this study to justify additional financial resources to augment their diagnostic imaging and radiotherapy equipment capacities and human resources, with the aim of improving cancer treatment outcomes. The International Cancer Expert Corps is following up on the recommendations in this study by helping many of the included countries to implement the recommendations.

Figure 1: **Map showing the participating countries**

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linear accelerators favour their use in the treatment of patients. Linear accelerators enable the delivery of high radiation doses—not achievable with cobalt-60 machines—for the treatment of prostate, brain, early lung, and bone cancers, among others, using advanced technologies such as volumetric-modulated arc therapy and intensity-modulated radiotherapy.

Specific information on radiotherapy practices and challenges in the studied countries—in addition to information from the IAEA Directory of Radiotherapy Centres (DIRAC) database on globally available radiotherapy equipment and our previous studies on overcoming shortages[16–18]—could help to improve cancer outcomes, especially in LMICs.

Methods

Study design

This comprehensive analysis used data from the three Baltic countries (Estonia, Latvia, and Lithuania), two countries in eastern Europe (Moldova and Ukraine), four countries in central Asia (Kazakhstan, Kyrgyzstan, Tajikistan, and Uzbekistan), and three countries in the Caucasus (Armenia, Azerbaijan, and Georgia), hereafter referred to as the ART countries. The data collection took place between May 10 and Nov 30, 2022. The project team (MD, VG, DAP, PG, MR, and ECW) addressed the existing ICEC collaborators from each participating country and requested that they identify all relevant institutions and ensure their participation in the study. A map of the participating countries is shown in figure 1 and the list of participating institutions is provided in the appendix (pp 8–12). We were not able to obtain engagement from Turkmenistan.

Procedures

Three questionnaires requesting detailed information were developed by MD, VG, DAP, PG, MR, and ECW, following the methods used in previous similar studies.[12–15] Each questionnaire was targeted to one of three audiences: radiation oncologists, regulatory authorities, and researchers. An overview of the structure of the three questionnaires is shown in the panel; for the full questionnaires, see the appendix (pp 13–21). Questionnaires were distributed in English and Russian and responses in both languages were accepted. The term regulatory authority refers to a legally established regulatory body that has responsibilities for and functions to ensure radiation protection and safety in the country, whereas the category of researchers comprises people

Panel: Questionnaire structure and number of participating sites for each of the specialties surveyed

Radiation oncologists
- Human capacity (nine questions)
- Available equipment for treatment (45 questions)
- Cancer statistics (18 questions)
- Problems and challenges (seven opinions)
- 43 hospitals participated; 79 questionnaires received

Regulatory authorities
- Number of diagnostic and radiotherapy equipment (15 questions and 15 comments)
- Safety and security (four questions and four comments)
- 13 regulatory bodies participated; 16 questionnaires received

Researchers
- Research affiliation (four questions and four comments)
- Experience in accelerated particles-related research (19 questions and 19 comments)
- Future research possibilities (19 questions and 19 comments)
- 25 research institutes participated; 72 questionnaires received

For the **IAEA DIRAC database** see https://www.iaea.org/resources/databases/dirac

See **Online** for appendix

who are directly or indirectly involved in research fields related to radiotherapy and cancer care. Each of 107 previously identified institutions was sent two copies of the questionnaire most appropriate for their staff (ie, 214 questionnaires were sent in total), with the aim of receiving two responses per institute to improve the accuracy of the data. Some centres that were initially sent the questionnaire targeted to radiation oncologists additionally requested the questionnaire designed for researchers, as some of their staff were also involved in research. Questionnaires were sent on May 10, 2022, and participating sites were initially given a deadline of Aug 30, 2022; however, this deadline was later extended to Nov 30, 2022.

Early identification of relevant partners from each of the participating countries provided an opportunity to engage all relevant stakeholders and radiotherapy institutions. Rigorous engagement of participants throughout the study ensured that responses from all the institutions were addressed. Authors from the participating countries sent out the questionnaires; secured the commitment of radiation oncologists, regulatory authorities, and researchers; and coordinated data-collection activities at the national level.

Russian translators and interpreters increased the efficacy of data gathering and sharing and participated in meetings with the collaborators. The armed conflict in Ukraine prevented us from holding an in-person kick-off meeting in Kyiv, Ukraine, which was planned for March, 2022; this was replaced by two virtual kick-off meetings—one in English, one in Russian—held on May 30 and June 1, 2022, for attendees from the participating sites to discuss the terminology and collection methods. An in-person close-out workshop, organised by ICEC, was held in Almaty, Kazakhstan, from Sept 13 to Sept 15, 2022. Participants from each country presented key elements of their research regarding data collection, validation, and analysis, as well as additional data on challenges faced by radiotherapy services (including their general economic situation) and the existence of national cancer screening programmes, cancer plans, and cancer registries. After the close-out workshop, we followed up with participants through emails to ensure data validation, acquire missing information, and rectify any discrepancies that arose from multiple respondents from the same institution. Participants provided information either from national cancer registries or, if none, from local institutional databases, therefore introducing a degree of

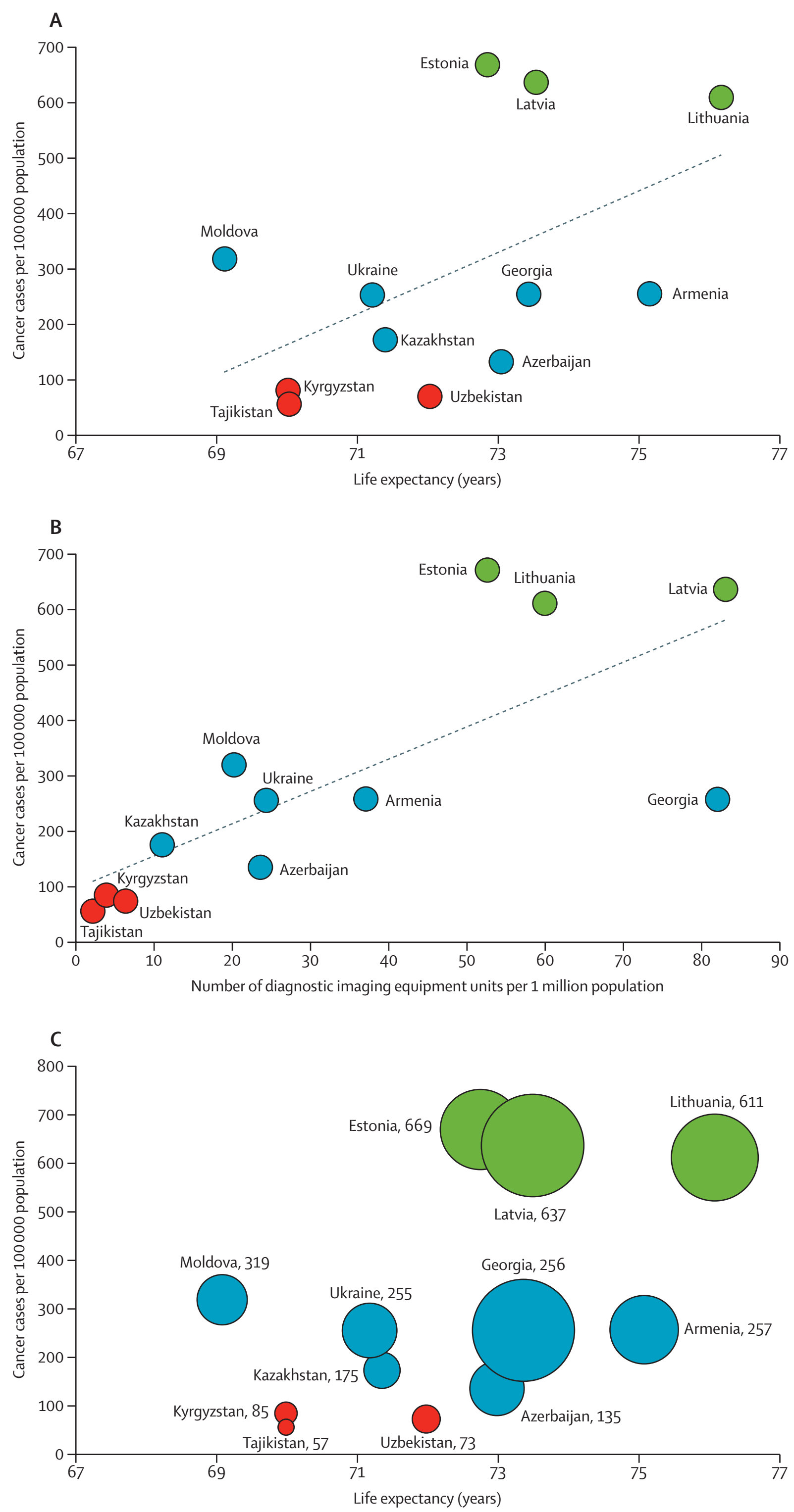

***Figure 2:* Relationships between number of cancer cases, life expectancy, and number of diagnostic imaging machines**

Cancer cases per 100 000 population versus life expectancy (A), versus the total number of diagnostic imaging machines per 1 million population (B), and versus life expectancy and number of diagnostic imaging machines per 1 million population (C) for each country. In C, the circles are sized according to the total number of diagnostic imaging machines per 1 million population, and are labelled with the number of cancer cases per 100 000 population for the given country. The dashed lines in A and B are trendlines. Circles are coloured by quartile for cancer cases: ≤Q1 (≤123), red; >Q1 to Q3 (>123 to 392), blue; and >Q3 (>392), green.

uncertainty within the data. However, owing to constant engagement with multiple participants from each of the countries and data validation procedures, the uncertainty in the overall data for the countries as a whole was reduced.

Outcomes

The primary outcome of this study was to update the extent of shortfalls in the availability of diagnostic imaging and radiotherapy technologies and radiotherapy human resources for patients with cancer in former Soviet Union countries. Because of their key role in cancer detection, treatment planning, and patient follow-up, we collected information on the availability of diagnostic imaging equipment—for our purposes comprising CT, mammography, MRI, single-photon emission CT (SPECT)–CT, and PET–CT units.

Statistical analysis

ICEC developed a dedicated web page for the ART study to facilitate management of the collected information from all participating institutions. A Python code using version 3.9.13 was developed for data extraction from questionnaires and data were analysed with Microsoft Excel for Microsoft 365 MSO (version 2308).

For the **ART study web page** see https://www.iceccancer.org/artstudy/

Role of the funding source

The funder of the study had no role in study design, data collection, data analysis, data interpretation, or writing of the report.

Results

Of the 107 institutions that were contacted, each of which were sent two copies of the questionnaire most appropriate for their staff, 81 responded (76% response rate) by returning 167 questionnaires, representing all the countries surveyed between May 10 and Nov 30, 2022. In some cases, staff provided responses as both oncologists and researchers if they had been involved in both activities. The high response rate and grassroots participation resulted from engagement with the International Science and Technology Center, the Science and Technology Center in Ukraine, country representatives, governments, relevant institutes, individuals from radiotherapy facilities, the ORS, and contacts in the countries.

For the **International Science and Technology Center** see https://www.istc.int/mission

For the **Science and Technology Center in Ukraine** see http://www.stcu.int/

The ART countries vary considerably in terms of total population, gross domestic product (GDP) per capita, cancer deaths per 100 000 population, and cancer mortality-to-cancer incidence ratios (appendix p 2). The three Baltic countries (Estonia, Latvia, and Lithuania), with a GDP per capita of US$20 000 or more, are classed as high-income countries whereas the other nine countries are considered LMICs (appendix p 2).

The Baltic countries and Georgia have greater diagnostic imaging equipment capacities than the other ART countries (appendix p 3). The Baltic countries have both high total diagnostic imaging equipment capacities per 1 million population and high incidences of cancer compared with the other ART countries (appendix p 4).

We plotted the number of cancer cases per 100 000 population against life expectancy (figure 2A) and against the total number of diagnostic imaging machines per 1 million population (figure 2B). Among all the ART countries, the Baltic countries have the highest number of diagnostic imaging machines per 1 million population, the highest cancer rates, and relatively long life expectancies (figure 2C). Countries with the lowest diagnostic imaging capacities have the lowest reported incidence of cancer and low life expectancies. An exception is Georgia, which has the second highest diagnostic imaging equipment capacity and a relatively long life expectancy compared with the other ART countries, but a low incidence of cancer—similar to that of the eastern European and other Caucasian countries. Moldova, despite having a low diagnostic imaging

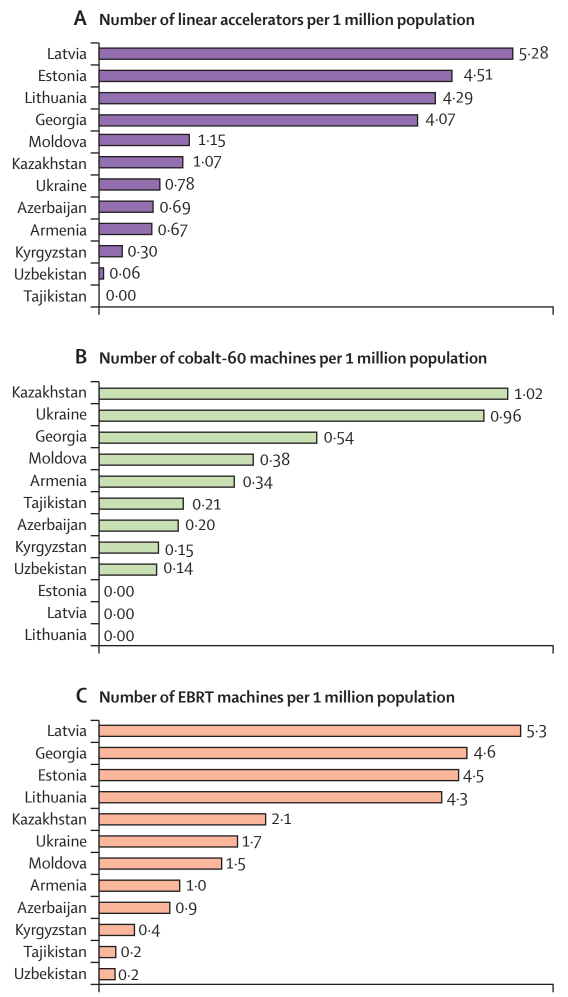

***Figure 3:* Availability of linear accelerators, cobalt-60 machines, and EBRT machines**
Number of linear accelerators (A), cobalt-60 machines (B), and EBRT machines (C) per 1 million population for each country. EBRT=external beam radiotherapy.

equipment capacity, has the highest number of cancer cases among the non-Baltic countries.

As discussed at the meeting in Almaty, Kazakhstan, most of the ART countries have established screening programmes for breast, cervical, and colorectal cancer. Exceptions are Azerbaijan, Moldova, and Uzbekistan, which have no screening programmes for colorectal cancer, and Kyrgyzstan and Tajikistan, where there are no screening programmes for any cancers. Additional screening programmes for prostate cancer were reported by Azerbaijan, Georgia, and Lithuania.

Figure 3 shows radiotherapy equipment capacity in terms of linear accelerators, cobalt-60 machines, and total external beam radiotherapy (EBRT) machines per 1 million population. The Baltic countries have only linear accelerators and, similar to Georgia, high total EBRT capacity. Kazakhstan and Ukraine both have a similar number of cobalt-60 machines and linear accelerators. Kyrgyzstan, Tajikistan, and Uzbekistan have very low EBRT capacities. The radiotherapy equipment capacity of the other ART countries is varied.

The reported cancer mortality-to-cancer incidence ratio is low in the Baltic countries (Estonia 0·43, Latvia 0·49, and Lithuania 0·48) and Kazakhstan (0·41; appendix p 5). The highest cancer mortality-to-cancer incidence ratios were reported by Moldova (0·71) and Georgia (0·74). Values for all ART countries are shown in figure 4.

Countries with the lowest GDPs and lowest EBRT capacities have the lowest reported cancer death rates

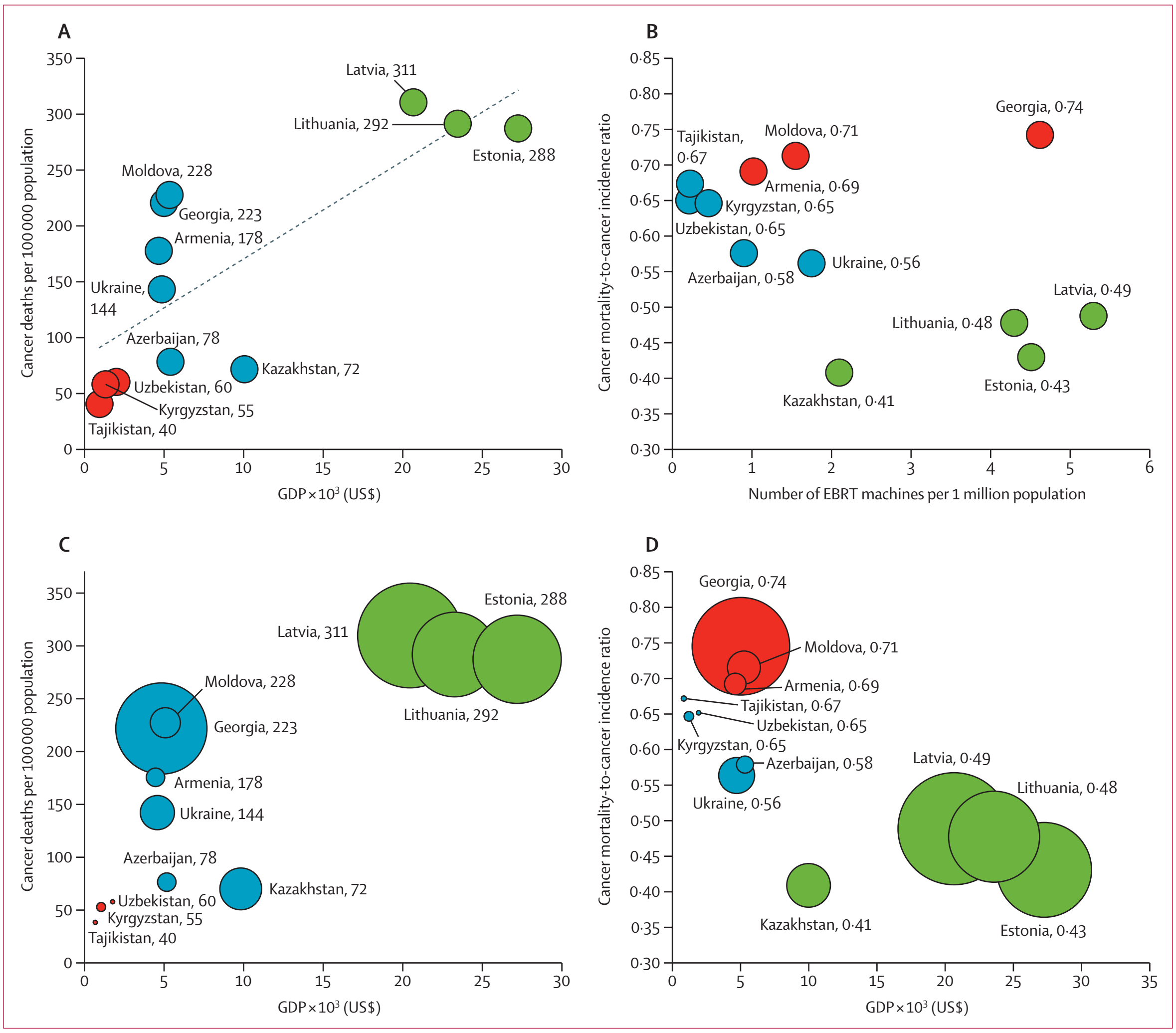

Figure 4: **Relationships between cancer deaths, GDP, cancer mortality-to-cancer incidence ratio, and number of EBRT machines**
(A) Cancer deaths per 100 000 population versus GDP. The dashed line is a trendline. (B) Cancer mortality-to-cancer incidence ratio versus the number of EBRT machines per 1 million population. (C) Cancer deaths versus GDP and the number of EBRT machines per 1 million population. (D) Cancer mortality-to-cancer incidence ratio versus GDP and the number of EBRT machines per 1 million population. In C and D, the circles are sized according to the total number of EBRT machines per 1 million population, and are labelled with the number of cancer deaths per 100 000 population (C) or cancer mortality-to-cancer incidence ratio (D) for the given country. EBRT=external beam radiotherapy. GDP=gross domestic product. The circles are coloured by quartile for cancer deaths (A, C; ≤Q1 [≤69], red; >Q1 to Q3 [>69 to 243], blue; and >Q3 [>243], green) or cancer mortality-to-cancer incidence ratio (B, D; ≤Q1 [≤0·49], green; >Q1 to Q3 [>0·49 to 0·68], blue; and >Q3 [>0·68], red).

(figure 4A, C). The countries with the highest GDPs and highest EBRT capacities have the highest reported death rates and the most favourable cancer mortality-to-cancer incidence ratios—except for Georgia, which has a high EBRT capacity and the highest cancer mortality-to-cancer incidence ratio (74%; figure 4B). Kazakhstan has a low EBRT capacity, but the lowest cancer mortality-to-cancer incidence ratio (41%; figure 4B). No pattern was evident in the distribution of the cancer mortality-to-cancer incidence ratio among the other ART countries (figure 4B, D).

Latvia (1·74) and Lithuania (1·47) have a much higher number of radiation oncologists per 100 000 population than the other ART countries, all of which had fewer than one radiation oncologist per 100 000 population (appendix p 6). The three Baltic countries also have higher relative numbers of medical physicists, radiotherapy technologists, and total radiotherapy personnel—resulting in more than double the total radiotherapy human capacity of the other ART countries.

The number of patients with cancer treated with radiotherapy annually per 100 000 population and per EBRT machine, and workload per radiation oncologist, are shown in the appendix (p 7).

Figure 5 summarises the equipment and staffing capacity of the ART countries. The Baltic countries are above average in terms of both EBRT capacity and number of oncologists. Georgia has above average EBRT equipment capacity, and Kazakhstan and Ukraine have above average numbers of oncologists. The other ART countries have low radiotherapy equipment capacity and low staffing levels. Distribution of the EBRT and imaging equipment per 1 million population and the number of experts (oncologists, medical physicists, and radiotherapy technologists) per 100 000 population are shown in the appendix (pp 23–24).

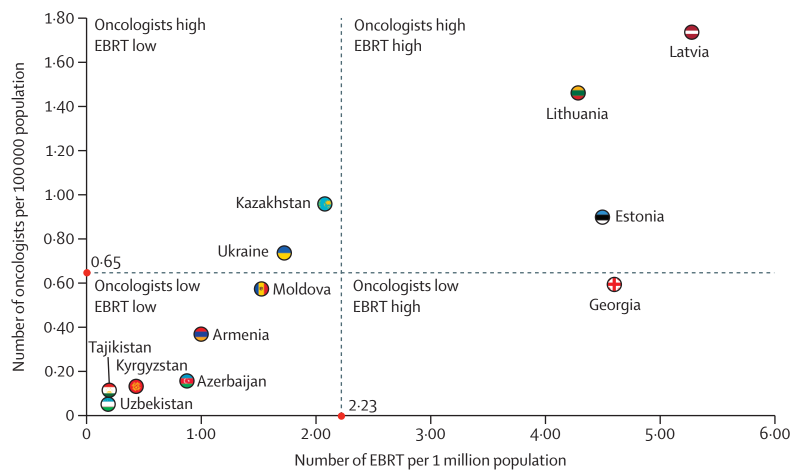

Figure 5: **Countries categorised by available EBRT machines and oncologists**
The dashed lines indicate the average values, shown as red dots. EBRT=external beam radiotherapy.

Discussion

This comprehensive study includes data from many of the countries that became independent of the Soviet Union in 1991 and now have widely differing financial, technological, and human resources for cancer care. The Baltic countries became members of the EU in 2004 and are now better funded and have better diagnostic imaging equipment and radiotherapy technical and human resources than most of the other ART countries. As reported at the meeting in Almaty, Kazakhstan, in September, 2022, Georgia had enhanced its diagnostic imaging and radiotherapy equipment capacities over the previous 5 years to levels seen in the Baltic countries. Conversely, Tajikistan has a very low GDP, no linear accelerators, only one cobalt-60 radiotherapy machine, scarce diagnostic imaging equipment, and little oncological expertise for its 9·75 million people. The Baltic countries also have more favourable cancer mortality-to-cancer incidence ratios than most other ART countries.

The Baltic countries report the highest number of cases of cancer per capita. These data suggest that greater diagnostic imaging equipment capacity might allow for more extensive cancer screening and the detection of more cancers. The four central Asian countries report the lowest diagnostic imaging equipment capacities, three of which report the lowest incidence of cancer.

The number of reported deaths due to cancer varies greatly among the ART countries. The four low-resourced central Asian countries reported low cancer death rates, whereas the Baltic countries, with high diagnostic imaging capacities, reported high cancer death rates. The Baltic states also reported high cancer incidence rates, but had lower cancer mortality-to-cancer incidence ratios than all other ART counties except for Kazakhstan. The lower cancer mortality-to-cancer incidence ratios might be related to greater diagnostic imaging equipment and radiotherapy capacities. Improved diagnostic imaging equipment capacity can lead to the diagnosis of more patients with cancer at an earlier stage, potentially leading to more successful treatment and fewer deaths.

The Baltic countries have far greater linear accelerator-based external beam radiotherapy capacities than most other ART countries, which have a paucity of linear accelerators and comparatively more cobalt-60 radiotherapy machines. At the meeting in Almaty, Kazakhstan, representatives from the non-EU countries expressed a desire to acquire more linear accelerators and to have staff trained to maintain them and to deliver high-quality treatments using them. The quality of radiotherapy greatly depends on the capabilities of oncologists, medical physicists, dosimetrists, and radiotherapy technologists who deliver the treatment. This ART study shows that the total radiotherapy human capacity in the financially well resourced Baltic countries is more than double that of the other ART countries.

During the discussions at the meeting in Almaty, Kazakhstan, education and training were among the greatest needs expressed by participants from the ART countries, even those from the Baltic countries. Most countries expressed a need for more medical physicists and for training programmes for medical physicists, radiotherapy technologists, and engineers to maintain radiotherapy equipment. Similar challenges exist in other regions globally, as exemplified by the study of gaps and availability of radiotherapy in the Asia-Pacific Region[19] and the *Lancet Oncology* Commission on radiotherapy and theranostics.[20] Such studies, including ours, highlight the widespread disparities in access to radiotherapy for cancer treatment and show that global action is needed to address these gaps.

The study did not obtain information on the scope nor the quality of the national cancer plans of the ART countries. Only Tajikistan reported not having a national cancer plan. In most of the ART countries, the national cancer policies and strategies are not generally based on data such as those presented in this study. Because of major differences in the types and capacities of equipment and human resources, each ART country needs to develop a specific roadmap to improve its cancer programme. This study could be beneficial to these countries by providing data to illustrate their equipment and staffing shortfalls and to define the resources needed to review and improve their national cancer plans, including cancer registries. In addition, the establishment of national radiation oncology and physics societies that could engage government agencies and stakeholders to support and promote the roles of diagnostic imaging, radiotherapy, and the oncology care system in general is highly recommended.

One limitation of the data collection was the absence of reliable national cancer registries in most ART countries. Uzbekistan and Tajikistan do not have national cancer registries. Collecting the data therefore required great effort. Substantial follow-up with individual participants was needed to obtain missing data and to rectify any apparent discrepancies. Many questionnaires were completed in Russian, greatly increasing the level of complexity involved in compiling and analysing the submitted information. We found that when dealing with surveys across language barriers, reducing ambiguity by developing yes or no questions and, wherever feasible, asking for numerical answers was helpful. Further detailed local data collection and analysis would be needed to assess both the shortfalls in equipment and the necessary training of personnel in the ART countries.[16]

The data in this study were provided by people currently working in the radiotherapy field, showing the challenges faced by countries with inadequate resources and the opportunities through which adequate funding could improve their radiotherapy and other cancer-related services. Our findings suggest that medical and technical staff in these countries will need considerable education, training, and mentoring to fully utilise linear accelerators.

ICEC is following up on the recommendations presented in this study by assisting institutions in the ART countries in planning and implementing various aspects of their cancer care programmes, including establishing robust cancer registries.

Contributors

MD, VG, ECW, CNC, and DAP conceptualised the study, developed the methods and software, collected the data, conducted the formal analysis, assessed the reliability of the data, prepared the presentation of the results, and wrote the original draft of the manuscript. All authors curated and validated the data, supervised the project, and reviewed and edited the manuscript. ECW provided oversight and management of the project. ECW, MD, DAP, VG, and CNC drafted a proposal for funding the workshop in Almaty, Kazakhstan, for presenting, gathering, and reviewing all surveys and directly accessed and verified all the underlying data. All authors had full access to all the data in the study and had final responsibility for the decision to submit for publication.

Declaration of interests

We declare no competing interests.

Data sharing

Aggregated data, questionnaires, and a list of participating institutions are available in the appendix (pp 8–22).

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