Increasing Access to Imaging for Addressing the Global Cancer Epidemic

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The global cancer burden, sometimes referred to as an epidemic, is growing rapidly (1–4). The estimated annual number of newly diagnosed cancer cases worldwide reached 19.3 million in 2020 and is expected to rise by 47%, to 28.4 million, by 2040 (2). Even more alarmingly, this rise is occurring fastest in low- and middle-income countries (LMICs), which lack comprehensive services for cancer care (4). It has been estimated that roughly 80% of the disability-adjusted life-years lost to cancer are in LMICs, where only 5% of the world's resources for cancer care are spent (5). Moreover, cancer survival rates around the world correlate strongly with national economic indicators, and per capita health expenditures rise exponentially along the trajectory from low to high survival rates (6). To grasp the heartbreaking injustice of this situation, it is only necessary to consider that the estimated 5-year net cancer survival rate is 79.8% for children born in high-income countries but just 7.4% for children born in low-income countries (7). Action is needed to address major inequities in access to cancer care and survival. Now, for the first time, research has quantified the substantial contributions that investments in radiology and nuclear medicine could make to improving global cancer survival, especially in LMICs (8).

Imaging has well-established roles in cancer screening, diagnosis, staging, treatment planning and guidance (including radiation therapy targeting), monitoring of treatment response, and posttreatment surveillance. Reports on the global status of oncologic surgery and radiation therapy, published in 2015 as part of the *The Lancet Oncology* Commission series, noted that imaging is critical to ensure the effectiveness of those treatment modalities (8–10). However, because cancer care is a complex, multidisciplinary process, research aimed at quantifying and attributing the impact of imaging on cancer survival has rarely been performed (8). Furthermore, data on the availability of cancer imaging resources in LMICs have not been systematically collected.

The Lancet Oncology Commission on Medical Imaging and Nuclear Medicine, established in 2018, was charged with assessing global access to imaging and nuclear medicine resources. In addition, it was charged with providing new evidence of the value of these services for cancer care and survival and offering recommendations for strategically increasing access to them, particularly in LMICs. The Commission developed into a multinational, multidisciplinary effort. It included, among others, representatives of the International Atomic Energy Agency (IAEA), leading academic institutions, and professional organizations from six continents (8).

As part of this effort, the IAEA led the creation of the first-ever database tracking imaging and nuclear medicine equipment and workforce capacity worldwide: the IAEA Medical Imaging and Nuclear Medicine (IMAGINE) database (11). When stratified according to World Bank country income groups, data from the IMAGINE database highlight stark inequalities in access to imaging equipment. The numbers of imaging equipment shrink markedly with each step in the descent from highest to lowest country income group or remain extremely low across multiple groups (Table). This is true even for CT, the most widely available of the imaging modalities assessed: The mean number of CT scanners per million inhabitants falls from 38.8 in high-income countries, to 12.1 in upper-middle-income countries, to 4.3 in lower-middle-income countries, and to just 0.7 in low-income countries. The mean numbers of SPECT and PET units per million population are 18.2 and 3.6, respectively, in high-income countries. However, they fall below one for all other income groups, with the only exception being SPECT in upper-middle-income countries. Disparities in the availability of radiologists and nuclear medicine physicians between country income groups are likewise vast and follow similar patterns (Figs 1, 2). Notably, the data in the IMAGINE database also reveal substantial variations in the amounts of equipment and personnel within income groups. These variations are greater among LMICs than among high-income countries. Furthermore, it is known that within nations, resources are often concentrated in urban areas or private practice settings, making them especially difficult or even impossible for portions of the population to access. This is a problem in many LMICs and even in some high-income countries, such as the United States (8).

Number of Different Types of Scanners Per Million Inhabitants according to Country Income Group

Country Group and Parameter	CT	MRI	SPECT	PET
High-income countries				
Range	6.3–42.3	0.0–34.3	0.0–20.5	0.0–4.3
Mean ± standard deviation	38.8 ± 16.0	27.3 ± 10.4	18.2 ± 7.5	3.6 ± 3.4
Median	20.5 (14.4–32.7)	12.6 (8.5–19.2)	5.4 (2.4–9.7)	1.2 (0.6–2.5)
Upper-middle-income countries				
Range	0.0–29.8	0.0–16.0	0.0–5.2	0.0–0.7
Mean ± standard deviation	12.1 ± 10.1	5.4 ± 4.8	1.6 ± 1.8	0.3 ± 0.5
Median	7.8 (4.8–16.2)	3.4 (1.3–7.2)	0.9 (0.0–2.5)	0.2 (0.0–0.4)
Lower-middle-income countries				
Range	0.0–7.8	0.0–3.3	0.0–0.9	0.0–0.2
Mean ± standard deviation	4.3 ± 3.2	1.1 ± 1.2	0.3 ± 0.3	0.2 ± 0.3
Median	1.4 (0.9–3.9)	0.4 (0.1–1.4)	0.1 (0.0–0.4)	0.0 (0.0–0.1)
Low-income countries				
Range	0.0–1.1	0.0–0.3	0.0–0.01	0.0–0.0
Mean ± standard deviation	0.7 ± 0.8	0.2 ± 0.5	0.1 ± 0.1	0.0 ± 0.0
Median	0.4 (0.2–0.9)	0.1 (0.0–0.2)	0.0 (0.0–0.0)	0.0 (0.0–0.0)

Note.—Numbers in parentheses are the interquartile range. Data source: International Atomic Energy Agency Medical Imaging and Nuclear Medicine global resources database. Adapted, with permission, from reference 8.

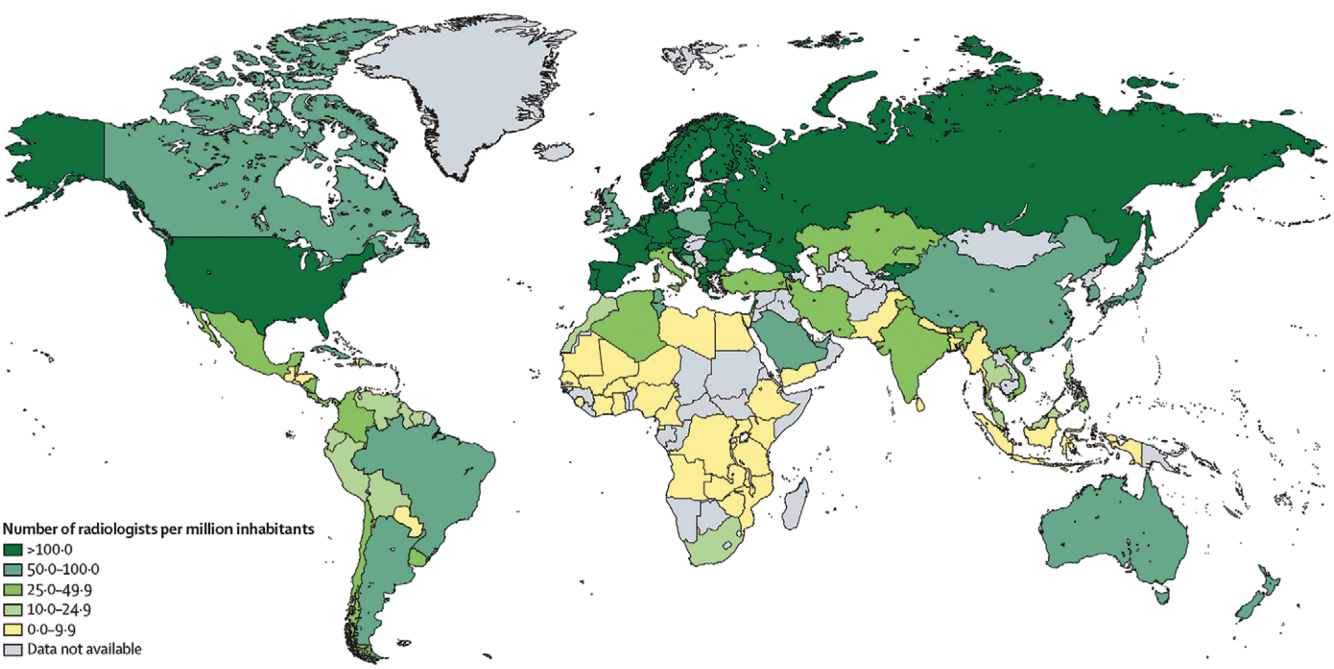

Figure 1: Estimated number of radiologists per million inhabitants from the International Atomic Energy Agency (IAEA) Medical Imaging and Nuclear Medicine, or IMAGINE, global resources database. The figure was created by the IAEA and adapted by *The Lancet Oncology* for publication in reference 8. It is reprinted with permission.

Using a novel microsimulation model of global cancer survival, a landmark analysis estimated the health benefits and economic impact that would result from globally scaling up imaging and other facets of cancer care, including treatment availability and quality (8,12). The analysis, which covered the period 2020–2030, spanned 200 countries and territories and incorporated 11 common cancer types that account for 60% of all cancers diagnosed. The scenarios modeled included *(a)* scale-up of imaging (US, radiography, CT, MRI, PET, and SPECT), *(b)* scale-up of treatment (chemotherapy, radiation therapy, surgery, and targeted therapy), *(c)* scale-up of treatment and quality of care (a variable accounting for health system and facility-level factors, eg, laboratory and pathology diagnostics, nursing standards), and *(d)* comprehensive scale-up including imaging, treatment, and quality of care. The analysis showed clearly, and, to our knowledge, quantified for the very first time, that access to imaging contributes substantially to cancer survival and yields very large health and economic benefits.

According to the modeling, the scale-up of imaging alone would prevent 2.46 million cancer deaths (3.2% of the projected

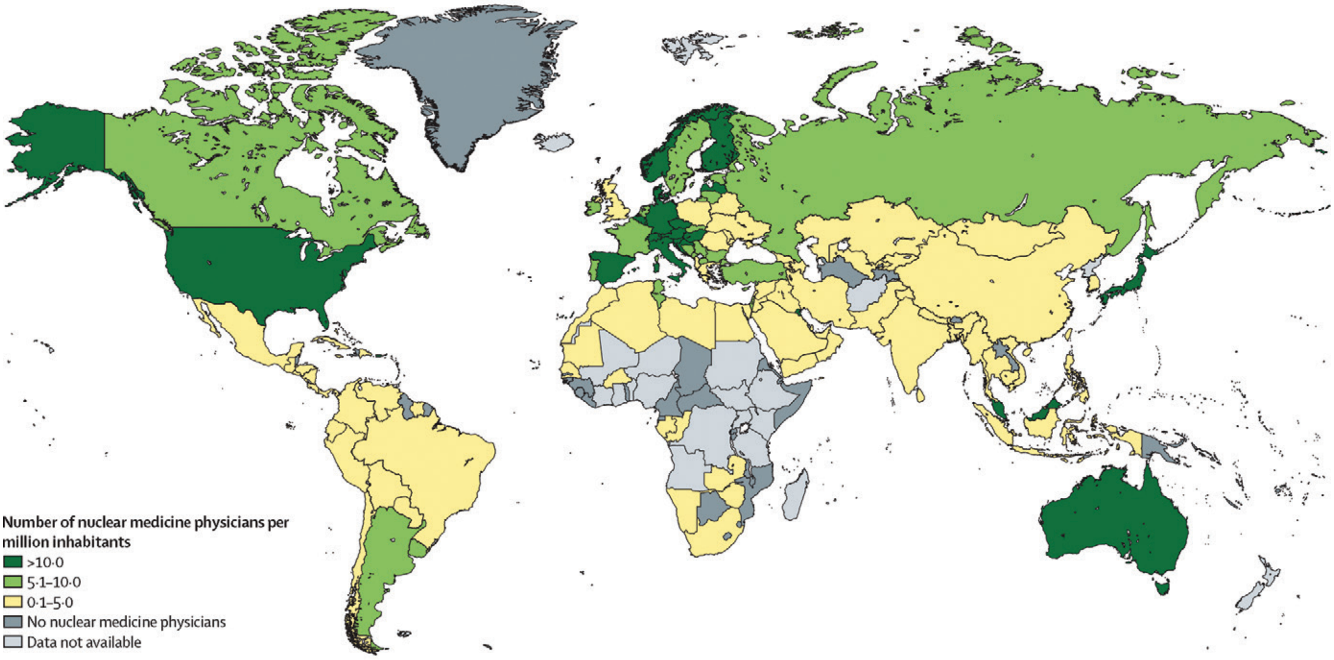

Figure 2: Estimated number of nuclear medicine physicians per million inhabitants. Data are from the International Atomic Energy Agency (IAEA) Medical Imaging and Nuclear Medicine, or IMAGINE, global resources database. The figure was created by the IAEA and adapted by *The Lancet Oncology* for publication in reference 8. It is reprinted with permission.

total of 76 million worldwide deaths from 2020 to 2030) and save 54.92 million life-years (8,12). Even more strikingly, the analysis indicated that imaging amplifies the benefits of other cancer services: The model estimated that while scale-up of treatment and quality of care alone would prevent 5.37 million deaths (7% of the worldwide total), adding imaging to achieve comprehensive scale-up would prevent 9.55 million deaths (12.5% of the worldwide total, including 38.2% of cancer deaths in low-income countries) and save 232.30 million life-years (8,12). Thus, the estimated gains that could be achieved by comprehensive scale-up are larger than the sum of the estimated gains from scaling up imaging alone or treatment and quality of care alone.

With respect to economic impact, the analysis showed that a global scale-up of imaging from 2020 to 2030 would cost $6.84 billion (discounted at 3% annually). This would lead to productivity gains of $1.23 trillion for the cancer cases diagnosed in 2020–2030 and a net benefit of $1.22 trillion, yielding a return of $179.19 for every dollar invested (8,12). A comprehensive scale-up approach combining imaging, treatment, and quality of care would cost $232.9 billion (a 6.9% increase over the current global cost of cancer care) but would lead to productivity gains of $2.89 trillion, a net benefit of $2.66 trillion, and a return of $12.43 for every dollar invested. Scale-up of treatment and quality of care without imaging would produce a markedly lower net economic benefit of $1.16 trillion and a lower return on investment of $6.15 for every dollar invested. In other words, including imaging in the scale-up could double the estimated global return on investment.

Together, these data make a compelling case that comprehensive scale-up of cancer services—including imaging—in LMICs is not only a moral imperative, but also sound economic policy.

Designing comprehensive national strategies for improving cancer care is far from easy, but the new data and recommendations put forth by the Commission should help. The main Commission report (which can be downloaded for free from *The Lancet Oncology*) provides general recommendations as to which imaging modalities should be adopted at specific World Health Organization (WHO)–designated levels of care. In addition, related studies, supporting the goals of the Commission and also published in *The Lancet Oncology*, provide more detailed analyses of which imaging modalities and/or treatments are likely to contribute most to survival in different settings and for specific cancers (13,14). For example, a detailed, simulation-based analysis of 5-year net survival of 11 cancers in 200 countries found that, among imaging modalities, the biggest gains in survival would come from scale-up of US in low-income countries (where it is particularly valuable due to its relatively low cost and broad scope of applications); MRI, PET, and CT in middle-income countries; and PET, CT, and SPECT in high-income countries (13). Another analysis, which focused solely on cervical cancer, found that among imaging modalities, the largest gains in 5-year survival would come from scale-up of MRI globally, US in low-income countries, CT and radiography in Latin America and Oceania, and PET in high-income countries (14). Notably, however, the analyses consistently found that expanding access to any single treatment or imaging modality would produce only relatively small survival gains, highlighting the importance of taking a comprehensive, multidisciplinary approach to scale-up of services (13,14).

International efforts to improve health in low-income countries have mostly focused on reducing the burden of communicable diseases, with the need for cancer care often being dismissed as too complex and costly to address (8). Yet, as pointed out by Farmer et al (5) more than a decade ago, pilot programs have shown that it is possible to improve cancer outcomes through international collaborations, even in very low-resource settings where no clinical cancer specialists or specialty centers are available. For instance, collaborating with national ministries of health, Partners In Health has helped run health care facilities in Haiti, Rwanda, and Malawi, serving rural areas with populations as large as 1.2 million. Support and training from Harvard-affiliated centers has enabled local health care providers to administer effective chemotherapies to patients with various cancers at these facilities (5). During scale-up, the resources allocated for each stage of cancer care must be aligned with each other to be effective (8). By enabling earlier detection and more precise disease localization, increasing access to imaging could help expand the range of treatments that could be used successfully in low-resource settings. The recent analyses conducted for the Commission suggest that, in general, investing in traditional imaging modalities (US and radiography) as well as CT, along with chemotherapy, radiation therapy, and surgery, could be a feasible initial strategy for improving cancer outcomes in low-income countries and that improving access to MRI, SPECT, and PET in middle-income countries will also have a major impact on outcomes (12). Access to and availability of radiopharmaceuticals for SPECT and PET imaging will be important issues to address to achieve the latter goal. In addition, workforce training and digital technology access will play a major role in improving access to timely and accurate imaging information for patients with cancer in LMICs. The WHO and IAEA offer LMICs education and training in radiation safety and other skills needed to establish imaging facilities. In addition, international professional imaging societies have initiated programs that provide remote training in image interpretation (8).

The various strategies for advancing cancer care in LMICs include investments in expansion of universal health coverage and partnerships to establish national centers of excellence. Such centers can provide high-level care to patients with cancer from across a country while offering training and support to disseminate knowledge and practice standards (5,7,8). Examples of national centers of excellence include the King Hussein Cancer Center in Jordan and the International Cancer Research Center, now being constructed in Kyebi, Ghana, with philanthropic funding (5,8). The WHO and IAEA can play key roles in supporting and coordinating large-scale collaborative efforts to strengthen cancer care (5,8).

Increased international and domestic funding will be necessary to scale up imaging and other cancer care services worldwide. But that is not an insurmountable problem. The Commission report outlines many potential sources of financing (8). And as large-scale efforts to combat communicable diseases have shown, with collaboration of multiple stakeholders, funding can be raised and solutions found to tackle vast and complex health problems when there is a shared conviction that success is both necessary and possible. For instance, thanks to effective international collaborative strategies, HIV services were widely expanded and antiretroviral medications made available at low cost; as a result, HIV is now a largely manageable chronic disease around the world. With determination and collaboration, it will surely also be possible to find ways to expand access to cancer drugs and imaging agents, create programs for imaging equipment maintenance that combine remote assistance with in-person visits, develop lower-cost imaging devices, and create larger telemedicine networks that use e-health tools for remote support. Equally important, it should be feasible to establish more educational programs that bring health care providers from low-income regions to specialty centers, in their own countries or abroad, for training.

As practitioners, researchers, educators, and concerned global citizens, there is much that radiologists, nuclear medicine physicians, and others in the imaging communities of advanced countries can do to help. To start with, we hope you will join us in adopting the conviction that introducing comprehensive cancer care that includes cancer imaging worldwide is not just a worthwhile goal, but also an attainable one.

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