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Imaging inequality: Exploring the differences in Radiology between high- and low-income countries

Introduction

Since the birth of radiology from the X-ray in 1895, imaging the human body has become an indispensable means to diagnose and treat patients. Whilst a basic level of radiological surveillance is now considered necessary for safe primary healthcare, the evolution of high-quality modalities into standardised care have varied throughout the globe[1].

The World Health Organisation definition of low, middle and high countries is based on Gross National Income(GNI)-per-capita[2]. The disparities in healthcare between low-income-countries(LICs) and high-income-countries(HICs) has been long researched. Radiology is at the forefront of the imbalance of resource distribution, with HICs typically having wide access to state-of-the-art devices whilst low- and middle-income countries(LMICs) face the greatest need, in a phenomenon coined the 'radiology divide'[3–5]. This lack of access to appropriate radiological care in LMICs can have severe effects on mortality rates with an estimated 3.2%(2.46 million) of all cancer deaths attributed to a lack of access to imaging[6].

In order to narrow this gap, high standards of care are set out by bodies such as the International Society of Radiology aiming to promote the role of imaging in global health[7]. Additionally, Non-Governmental organisations such as RAD-AID International focus on improving access to radiology in LMICs[8]. These organisations form a part of a wider network setting out Sustainable Development Goals(SDGs) such as Universal Health Coverage(UHC) which aims to guarantee access to healthcare for the entire world population[9].

Imaging ecosystem

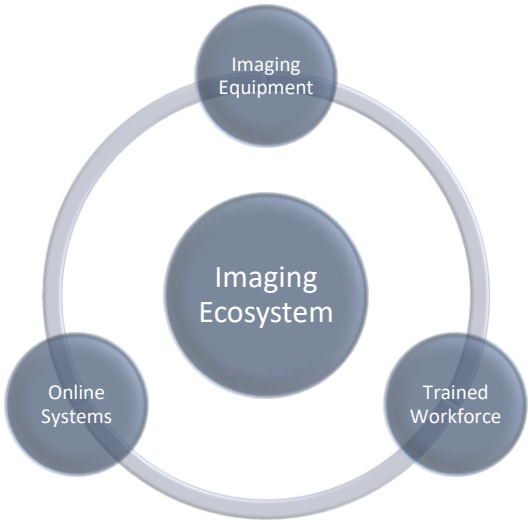

Fig. 1 Schematic illustrating the Imaging ecosystem: Imaging equipment, trained workforce, and online systems.

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Successful delivery of radiology can be thought of as the union of the imaging ecosystem which is composed of imaging equipment, a trained workforce, and online systems, as depicted in Figure 1. Examining the literature there are economic, political, social, and environmental factors creating facilitators and barriers to adequate radiological care in both HIC and LICs.

Economic factors create significant facilitators in HICs for procurement of imaging modalities. However, this does not mean HICs are without their challenges. For example in countries such as the US there is a surplus of high-quality imaging modalities, likely owing to their huge healthcare spend which is nearly twice as much as 10 other HICs[10]. Despite the benefits of widely available imaging, the overuse can cause harm. In attempts to curb over-diagnosing, the American Royal College of Radiologists joined the 'Choosing wisely' initiative[11]. In countries like Canada and UK, targets are put in place for patient diagnostic imaging times. Despite the UK having the sixth biggest economy, its radiology services are not without their own problems. In 2017 the UK spent 9.6% of GDP on health, which was ranked as the second-lowest of the Group of Seven(G7)[12], with the BMA reporting a cumulative underspend of £322 billion since 2009[13]. The UK have struggled to tackle the backlog following the COVID-19 pandemic and currently 30.8% of patients are having to wait over 6 weeks for a diagnostic test[14]. Similarly, the Canadian Association of Radiologists set out a 60- day target for patients to receive a non-urgent scan, which has also not been met[15].

Country	**GNI per capita (2022)**[16]	**CT scanner per million of population**[17]	**MRI scanner per million of population**[17]
Japan	42,440	111.69	55.31
United States	76,370	44.56	40.11
Ireland	81,070	21.26	15.8
Spain	31,680	19.14	17.22
Canada	52,960	14.76	10.31
Malaysia	32,259	6.43	2.89
Israel	54,650	9.72	5.2
Kenya	5,680	0.25	0.16
Ghana	6,380	0.35	0.23
Pakistan	6,350	0.33	0.22
Malawi	1,700	0.31	0.06

Table 1. Showing comparing Countries GNI per capita with CT and MRI units per million of the population

Political and economic factors create major drawbacks for LMICs to acquire imaging modalities. Steep procurement costs is one of the main barriers[18]. For example across West Africa, there is as low as one MRI scanner available per country[19]. Key suppliers of medical imaging devices are based in high income regions: Dutch conglomerate Philips and German manufacturing giant Siemens are the main suppliers of medical devices to Europe with Hitachi and Canon supplying Japan and other parts of Asia[20]. Shipping costs from these areas to developing nations such as Sub-Saharan Africa or South America inflates the already costly price tag, further inhibiting access to equipment. Moreover, due to political tensions powerful countries such as the US have previously placed sanctions on LMICs preventing them from purchasing high-tech equipment, further pushing them out of the market[21].

Where political and economic barriers have been overcome, around 40-70% of donated health technology to LICs remain out of service[22]. Environmental factors such as unreliable electricity supplies, adverse weather, and limited physical space prevent the use of medical devices not designed

to withstand them. Social factors also create barriers, for example in LICs most of the population reside in rural regions with poor transport infrastructure, rendering centrally located services even further inaccessible[23].

Trained workforce

A skilled workforce carrying out patient care requires a comprehensive clinical radiology education programme and acceptable working conditions. In HICs radiology training typically allows for research opportunities to develop knowledge and competencies, and trainees are supported to subspecialise and develop their own personal interests[24,25]. For example in the US there are over 1000 diagnostic radiology programs with a 97.3% 'match-rate'[26]. That said, being a HIC does not guarantee an adequate workforce, with the Royal College of Radiologists in the UK suggesting there is a 41% shortfall in the radiology workforce. For every clinical training post in the UK there are up to 10 applicants, with a 100% post fill rate however NHS trusts are unable to provide training posts because of insufficient funding[27].

In LMICs such as Ghana and Cameroon there are no radiology training programs[28], whilst in Pakistan, Syria and Bangladesh there are between 1-5[29]. In addition to low training posts, large attrition rates for specialist trainees plague healthcare systems in LICs, likely due to an interplay between social, economic, and political reasons. In Ethiopia, there is only 1 radiologist per 350,000 population, speculated to be partially due to the alluring private sector. Shielded from bureaucratic control, this offers new radiology trainees greater authority over their practice, thus removing them from the public sphere[30,31]. The 'brain-drain', is a term defined by the United Nations as the unidirectional movement of highly skilled individuals from the developing to the developed world[32]. A WHO report revealed that between 2005 and 2015, there was a 70% increase in trainees from Africa entering the US workforce[33], with 67% of South-African radiologists considering emigration[34]. Significant push factors for leaving include lack of mentors and residency programs, creating perpetuating cycles of a weakening workforce. Whilst the brain drain worsens LIC outcomes, it tends to benefit HICs. For example, in the UK, where international recruitment is being seen as a short-term solution to the workforce crisis on a 'earn, learn and return' basis[27].

There are efforts to bridge this gap, particularly in the emerging field of Interventional Radiology(IR). For example partnership training programs between HICs and LMICs facilitated by RAD- AID have been introduced in Kenya[28] and Tanzania[35]. Further longitudinal studies are required to assess the implementation of these programs.

Online systems

The implementation of Radiological Information Systems(RIS) and Picture Archiving and Communication Systems(PACS) has accelerated radiology workflows promoting safe patient care. In HICs these have become a necessity to provide primary care. By contrast in many LMICs technical issues such as a shortage of high-quality monitors, technicians, and low speed of connectivity limit its use[36]. Outreach to radiology-scarce areas is being made, for example by RAD-AID. The Radiology-Readiness assessments schemes work to provide LICs with PACS and RIS, with successful implementation already in Nigeria[37]. Once PACS is established, it has been shown to increase utilisation rates and reduction in CT reporting time in Iran[38] and Lao Peoples Democratic republic[39].

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Online systems also facilitate teleradiology, which gained large interest over the past two decades and was accelerated during the COVID era. Teleradiology allows flexibility to augment interpretation capacity of radiological images using outsourcing services, and is widely utilised in HICs[40]. 25.4% of American radiologists reported that teleradiology represents a majority of their annual imaging volumes[41], whilst in the UK, 93% of radiology departments relied on outsourcing for reporting[27].

Conclusion

Overall, there remains a clear imaging inequality between high- and low-income countries characterised by disparities in the imaging ecosystem. Economic factors clearly dominate in LICs however there are political, environmental, and social factors which should also be considered. Of the factors which are amenable to change, a combination of short-and-long-term strategies should be explored. Short-term strategies such as financial aid will enable implementation of infrastructure in the form of training technicians and creating facilities. The retention of radiologists should be prioritised by using a multifaceted approach targeting workplace autonomy, quality of life and financial incentives. Longer term solutions targeting political factors such as government fiscal allocation should also be considered, whilst trade deals for equipment should be protected and regulated. It will require a multifactorial global approach to stem the radiology divide and reach the SGD of UHC, though a goal which is both reachable and will improve both patients and radiologists lives worldwide.

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