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ORIGINAL RESEARCH

Equipment in the Global Radiology Environment: Why We Fail, How We Could Succeed

Kristen DeStigter[1]*, Susan Horton[2], Omolola Mojisola Atalabi[3,4], Ricardo D. Garcia-Monaco[5], Hassen A. Gharbi[6], Linda Tebogo Hlabangana[7,8], Harvey L. Nisenbaum[9], Christian Pállson Nolsøe[10,11], Jeffrey B. Mendel[12]

1. Larner College of Medicine, University of Vermont, Burlington, VT, USA
2. School of Public Health and Health Systems, University of Waterloo, Ontario, Canada
3. College of Medicine, University of Ibadan, Nigeria
4. University College Hospital Ibadan, Oyo State, Nigeria
5. Hospital Italiano de Buenos Aires, Buenos Aires, Argentina
6. 12 Rue Mohamed Salaheddine Mutuelleville, 1082 Tunis, Tunisia
7. University of the Witwatersrand, Johannesburg, South Africa
8. Conidaris and Partners, Johannesburg, South Africa
9. Department of Medical Imaging, Penn Presbyterian Medical Center, Philadelphia, PA, USA
10. Division of Surgery, Department of Gastroenterology, Herlev Hospital, Herlev, Denmark
11. Copenhagen Academy for Medical Education and Simulation (CAMES), University of Copenhagen, Copenhagen, Denmark
12. Partners in Health, Boston, MA, USA

* **Corresponding author.** Current address: University of Vermont Health Center, 111 Colchester Ave, Burlington, VT, 05401. Kristen.destigter@uvmhealth.org

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Abstract

Purpose: This research aims to understand key problems and identify possible solutions in the market for radiology equipment in low- and middle-income countries.

Methods and Materials: This paper uses simple descriptive statistics to summarize the results of responses from 574 radiologists from 52 countries surveyed in April-May 2017, and 15 hardware and software vendors from six countries surveyed in September-October 2017.

Results: Radiologists surveyed came from both public and private sectors and were drawn from Radiological Society of North America (RSNA) members who, according to the survey results, appear to represent sites with more advanced technology. Virtually all the radiologists worked at sites where both X-ray and ultrasound were available, and the overwhelming majority (93%) had access to CT. Digital technology has gone worldwide: radiologists in all countries reported that digital radiography was either equally or more available than analog technologies. Sixty percent of radiologists said that they were "always" or "often" involved in the purchasing decisions in their institutions, but only 35% reported that they had the final say. According to the radiologists surveyed, the era of donated equipment is ending. Ninety-five percent felt that the disadvantages of donated equipment outweighed the cost savings. Training was a key concern both for radiologists and vendors. Radiologists felt that training was insufficient, materials left behind too complicated, online materials too limited, and follow-up from vendors insufficient. Vendors pointed out that the bidding process often excluded the cost of training and support and that many purchases are made through local distributors and they lack direct contact with vendors.

Conclusion: While digital radiology is spreading throughout the surveyed countries, access to advanced imaging remains limited. Donated equipment is no longer a major solution to limited equipment availability. There is an opportunity for vendors and radiologists to work together to ensure that training, service and support are always included in purchases.

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Introduction

Medical imaging plays a key role in diagnosis, treatment, and prognosis of disease with imaging required for 30 percent of all medical conditions (1). Despite the growth in medical imaging there remains considerable global inequality in access. The most recent published available comprehensive global estimates for medical diagnostic radiological examinations (2), show that in 2007 the number of such examinations annually per 1,000 population was 1,332 in high-income countries (HIC) (24% of the global population), 332 in countries with medium development of their healthcare systems (49% of the global population), and only 20 in countries with the lowest healthcare development (27% of the global population). Usage rose by 62% in HIC between 1970-79 and 2007, by almost 1,300% in the countries with medium development of healthcare, and barely changed in those with the most limited healthcare systems. These statistics suggest widespread problems with access in low-resource countries, although there are no recent published data. While recent developments in low-cost digital radiography and hand-held ultrasound may positively affect access in low-income countries, no current data exist on their global impact. Key barriers to access to medical imaging for those in low- and middle-income countries (LMICs) include the limited resources for purchase, maintenance, and operation of radiological equipment as well as imaging being seen as peripheral to the delivery of healthcare by LMIC healthcare planners (3).

This study aimed to increase understanding the market forces that contribute to gaps in the availability of medical imaging in LMICs, since this is one step towards improving access, which is vital for quality health care. The Radiological Society of North America (RSNA) undertook a survey, utilizing its global membership (over 54,000 members from 136 countries) which is broader than that of any other radiology membership organization. The purpose was to examine the challenges of buying, operating, and maintaining radiology equipment in LMICs, and to suggest possible solutions. This paper presents some of the findings, focusing on areas more amenable to action by radiologists. This survey does not assess the geographic availability of medical imaging in LMICs.

Methods and materials

Two authors (KKD and JBM) wrote the survey questions with modifications by the RSNA Survey Research Team, a team of four people with experience in survey methodology. Three surveys were prepared targeting sample groups: 1) radiologists working in LMICs, 2) vendors who sell radiology equipment (hardware) in LMICs, and 3) vendors who sell radiology software in LMICs. RSNA survey software was employed.

The RSNA Board of Directors via the Board Liaison to the RSNA Committee on International Radiology Education (CIRE) approved the methodology and surveys prior to distribution. The lead author's Institutional Review Board reviewed the survey methodology and determined it to be exempt for the purposes of publication.

The Radiologist Survey consisted of 59 questions, including a mixture of close-ended multiple-choice questions, both Yes/No questions, and 5-point Likert scale questions (Always, Often, Sometimes, Rarely, Never), as well as comment boxes where respondents were asked for open-ended responses. Post-survey, the open-ended responses were categorized into smaller lists by the authors based on frequency and similarity.

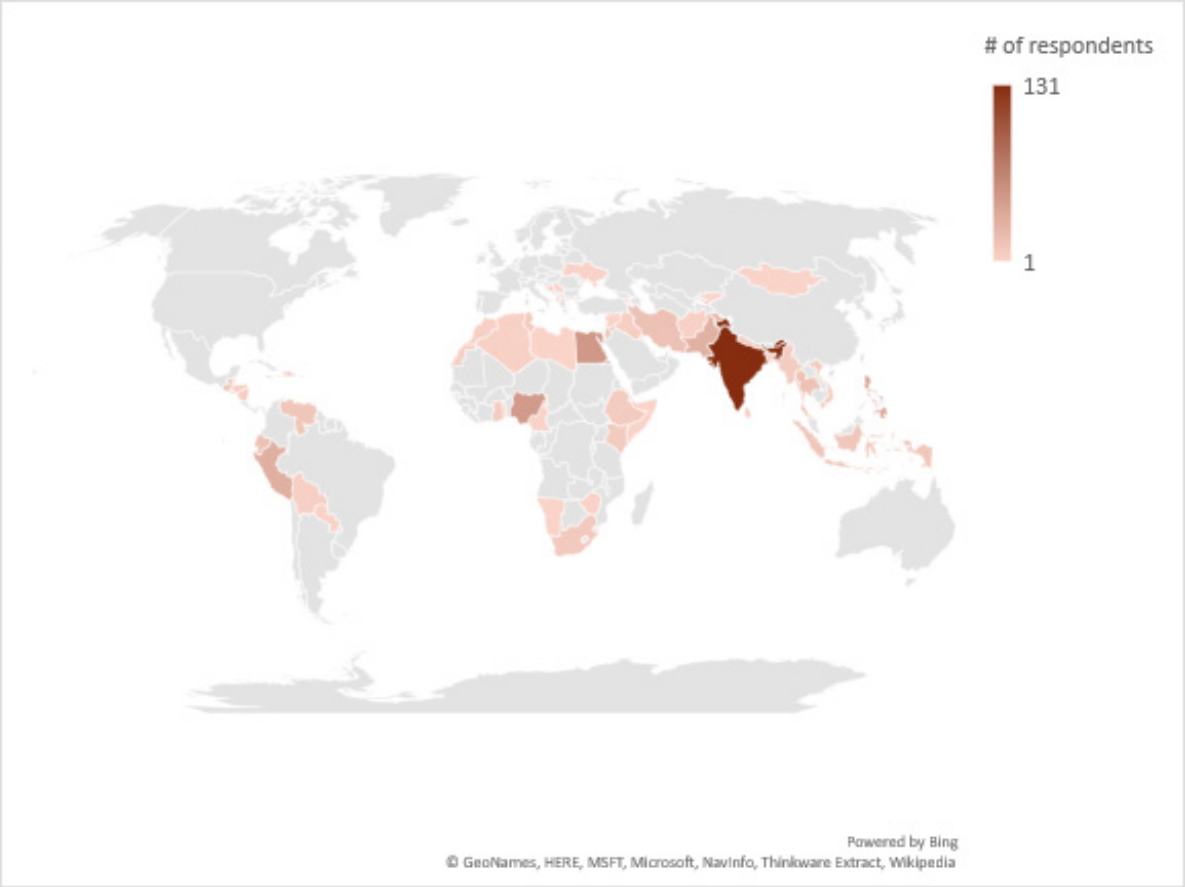
The RSNA Information Management Team distributed the Radiologist Survey by email to 2,384 member radiologists at institutions in LMICs (based on the 2017 World Bank list). This large number was chosen since it was desired to obtain experience from a broad range of countries and the response rate could not be predicted. The RSNA Information Management Team confirmed that the list was a random representative sample of members from RSNA Discounted Dues-eligible countries in each region. The authors were blinded to this list. The RSNA Survey Research Team tracked how many were sent to evaluate response rate. The survey was open from April 25 – May 31, 2017.

The Hardware and Software Vendor Surveys each consisted of 54 questions, including a similar mixture of close-ended multiple-choice questions, both Yes/No questions, and 5- point Likert scale questions (Always, Often, Sometimes, Rarely, Never). The survey also included comment boxes where respondents were asked for open-ended responses. Post- survey, these responses were categorized into smaller lists by the authors based on frequency and similarity of responses.

The RSNA Information Management Team initially sent the Vendor Surveys in their Exhibitor Newsletter to 700+ contacts and also to 1,300+ contacts in the Corporate Partners Newsletter. It was determined, based on zero responses, that the audience through this methodology was not the target audience engaged in LMICs. Subsequently, the CIRE working group, through their international contacts, reached out to individuals, radiological societies and organizations working in LMICs for vendor contacts and a central list was created (Snowball Sampling). The list included major vendors as well as vendors known to work exclusively in LMICs and emerging markets. For the larger companies, regional sales and marketing personnel were targeted. Both surveys were sent as links in a single email, in the event that a vendor sold both hardware and software. The vendor surveys were returned to the RSNA Survey Research Team. The authors were blinded to the respondents. The vendor surveys were open from September 14 – October 31, 2017.

A cover letter for the online surveys notified the recipient of the background and goals of the survey. It informed recipients that the responses would be anonymized, processed confidentially, and that only summary data would be reported. No incentives were offered for completion of

Figure 1. Heat map of number of radiologist survey respondents by country.



the surveys. Recipients were directed to contact RSNA via phone or email for any questions. Response to the survey indicated consent to participate.

The authors received anonymized and de-identified raw data from the RSNA Survey Research Team. Open-ended comments were scrubbed of identifiers prior to review by the authors. The authors performed analysis of the data with assistance from the RSNA Survey Research Team.

Results

There was a total of 574 respondents to the Radiologist Survey, corresponding to a 24.1% response rate and representing 52 LMICs (Figure 1). Ten countries (20% of the sample) were represented by only one respondent, and at the other extreme there were 131 respondents from one country (India). An equal number of public and private facilities were represented. Many radiologists in LMICs work at both public and private facilities and may have different experiences at each place, but it is uncertain how this might have impacted the results. In addition, the results represent only the perception of radiologists. While virtually all sites surveyed offered ultrasound (99%) and radiography (99%), 93% offered CT and over 50% of sites offered ultrasound, radiography, CT, MRI, and fluoroscopy. In contrast, only 35% of sites offered nuclear medicine or PET (Figure 2), despite the cost of PET being similar to higher-end MRI and CT. Digital technology is widely available according to respondents, and in almost all countries availability of digital imaging exceeds that of analog (Figure 3). Although not a uniform survey of imaging available in LMICs, the results likely represent the best of what is available in LMICs.

Responses were received from 21 vendors from 15 different companies, since some companies sell both hardware and software. Respondents were nine US-based companies, two from German companies, and one each from companies based in Belgium, China, Japan and Nigeria. The supply of medical imaging equipment is highly concentrated: the largest five equipment vendors globally (all with headquarters in the US or Germany) supplied 78% of the equipment market in 2018 (4).

Procurement

Sixty percent of radiologists said that they were "always" or "often" involved in the purchasing decisions in their institutions, but only 35% reported that they had the final say. Vendors confirmed that hospital administrators and Ministries of Health had a greater role in final decision-making. Initial costs are a primary concern for purchasers, taking priority over quality and cost of ownership. Only 25% of sales are direct from vendor, with local distributors and third-party vendors accounting for the majority of sales. This limits the ability of vendors to have direct influence on the conditions of sales.

Survey findings show that 85% of hardware and software

vendors offer service contracts yet they are included in less than 40% of purchases. Service contracts are outsourced in over 50% of purchases. Internet access offers the opportunity to improve remote diagnosis and support for both hardware and software vendors. Radiologists and vendors agreed that the addition of telephone and email communication could work to increase the chances for success (Table 1).

Donated equipment

For the purposes of the survey, we did not strictly define equipment donation. Donated equipment is typically used, occasionally refurbished, and often donated by facilities directly without vendor assistance. The donation of new equipment with a plan for installation, support and service would be equivalent to the very best equipment purchases and would not be subject to the failure modes associated with most donated equipment. However, the responses in this survey were primarily targeted at the donation of used or refurbished equipment.

The era of donated equipment is ending, according to the radiologists surveyed. Ninety-five percent felt that the disadvantages of donated equipment outweighed the cost savings. Respondents cited multiple issues with donated equipment including no installation or applications support, incomplete parts (cassettes, transducers, etc.), lack of user manuals, no service contract or warrantee, no local qualified service and spare parts. Donation of used or refurbished equipment has been a longstanding method for facilities in LMICs to acquire imaging equipment. The survey found that most sites no longer accept such donations and respondents noted that 10% of countries now have a national policy limiting such donations. Of the sites that would accept donations, most say any such equipment should be five years old or newer (Table 1) which would be rare in this age of lengthening replacement cycles for imaging equipment in HIC.

Implementation and utilization: Role of training

There are multiple well-known challenges to the siting, installation, usage, and maintenance of radiology equipment in LMICs, including inconsistent power, poor network connectivity, inadequate site infrastructure, inadequate service organizations, and delays due to geographic distance (5). Applications training was a key concern both for radiologists and vendors. Radiologists felt that applications training was insufficient, materials left behind too complicated, online materials too limited, and follow-up from vendors insufficient. Vendors pointed out that the bidding process often drove down the cost of purchase by excluding training. They also noted that online training was more frequently available for software than hardware. Comments from both radiologist and vendor respondents highlighted the need for a collaborative approach to training (Table 3).

Table 1: Challenges with donated used or refurbished radiology equipment in LMIC based on survey responses.

Challenges described by respondents
• Incomplete parts on arrival (e.g. one transducer, one cassette, mismatched)
• Suboptimal site preparation
• Poor quality or no installation
• Lack of user manuals
• Limited or no applications training
• Lack of appropriate training materials
• No service contracts or plan for servicing
• Limited availability of spare parts
• Limited qualified service engineers, physicists, other staff
• Longer replacement cycles in HIC put donations well beyond end of service
• National policies may preclude acceptance of older equipment (many less than 5 years old)
• Modern (new) equipment designed for LMIC is increasingly more available

Table 2: Suggestions for successful applications training on radiology equipment.

Suggestions for training from both radiologist and vendor surveys
• Assess local competencies and adjust extent and length of training during bidding
• Standardize training and support materials in the local language
• Offer pre- and post-training written and on-line resources, tailored to available local access (internet, etc.)
• Encourage local train-the-trainer programming
• Proactive vendor follow-up after purchase
• Offer second-look training, 2-3 months after installation
• Offer effective after-installation communication, based on local conditions
• Vendors should favor improved training and support over equipment add-ons

Figure 2. Distribution of modalities not available to respondents (n=572).

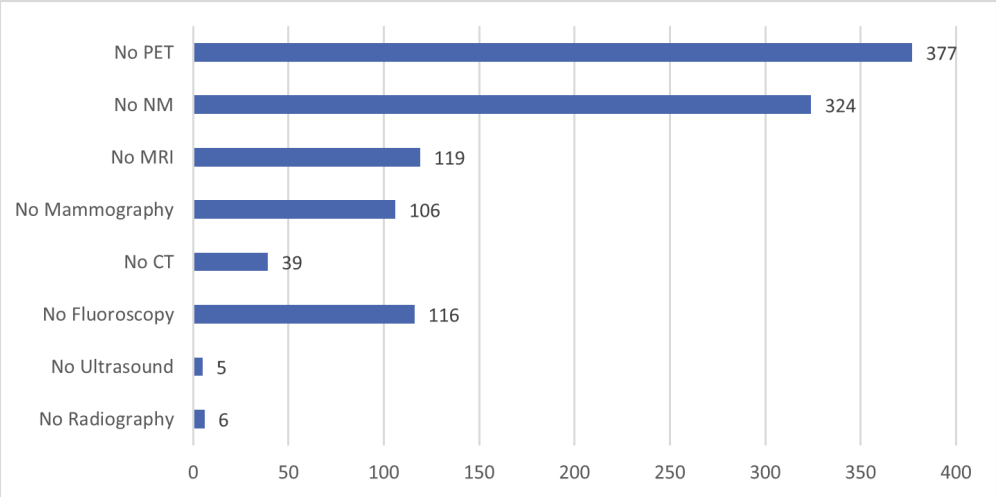
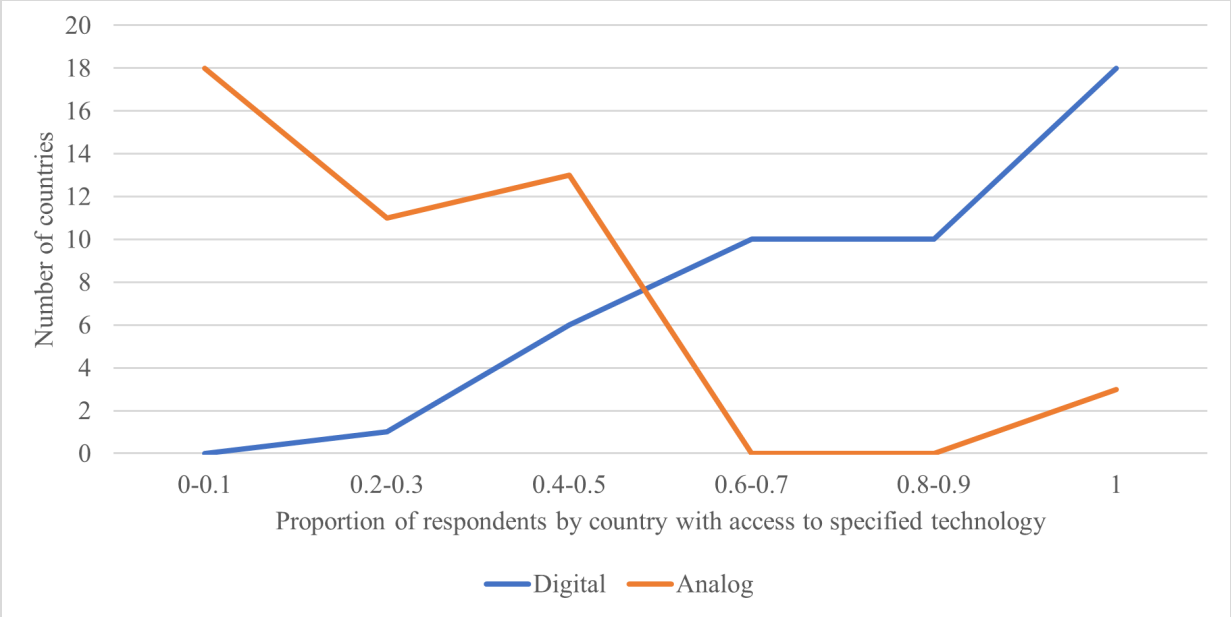


Figure 3. Numbers of countries according to proportion of respondents reporting access to digital and analog radiography.

Note: *Proportions were calculated for 45 countries; most respondents had access to one or other technology, but some respondents had access to both.*



Discussion

Medicine requires accurate imaging results for diagnosis and treatment. While there remain multiple barriers to access, particularly for patients seeking treatment in the public sector, the survey underscores that digital imaging availability is widespread throughout LMICs, and, while access is markedly limited, virtually all the countries surveyed now have some sites offering advanced imaging. The more limited access to nuclear medicine is consistent with a survey by the International Atomic Energy Agency which concluded that there were multifactorial reasons including insufficiencies in equipment, training and education, staffing, and radioisotopes (5).

This qualitative survey provided an up-to-date snapshot of availability for 52 LMICs but is not a substitute for accurate quantitative data on access to imaging in LMICs, of which there is a dearth. The UNSCEAR (2008) report has cross-country and time-series analysis for diagnostic radiological imaging, however, in a field that is rapidly evolving, no updated analysis has been published (2). The World Health Organization Atlas of Medical Devices (which became an annual survey as of 2013) covers three modalities (CT, PET, and MRI) with useful measures per 1,000 population (6).

There are individual studies regarding availability, but for relatively few countries. A detailed study of radiological imaging in Tanzania (7) reports that the number of

radiography units is lower than the WHO-recommended minima, but there is relatively homogeneous availability, reflecting the central government's commitment in essential resources South Africa is reported to have a higher average level of availability, exceeding the WHO minimum recommendations, but access for the poor is limited by disparity by region and between public and private sectors (8). This is consistent with a study of purchase decisions for CT scanners in Brazil that showed, similar to South Africa, a wide disparity in availability of scanners both geographically and between public and private facilities (9).

The lack of a holistic approach to purchasing is evident from both the vendors' and radiologists' perspective and leads to a vicious cycle of poor equipment performance (Figure 4). NGOs face similar challenges wherein it is typically easier to raise money for a capital purchase than for operating expenses. The lack of planning for service and support can be medically and financially devastating to any imaging venture. Estimates suggest that the 10--year cost service and support for advanced imaging equipment is about equal to the purchase cost (10). A recent systematic review of purchasing of medical devices in LMICs noted that device cost is the most-cited factor in procurement planning and that "suboptimal device use is directly linked to incomplete costing and inadequate consideration of maintenance services and user training during procurement planning" (11), very consistent with the findings from the survey.

The survey found that radiologists usually have input into the purchasing decision, but not generally the final say. In the Brazilian study discussed above, purchase of scanners depended neither on radiologist advice, nor health prioritization efforts; rather, providers in private facilities lobbied the hospital administrators to buy such machines, citing competition with other private hospitals. The acquisition of new machines in the public sector was often based on manufacturers who leverage university hospitals as regional or international show sites (9). Vendors confirm that hospital administrators and the Ministry of Health are more likely to have primary responsibility for hardware purchases but less often with software purchases, possibly because the technology is newer and radiologists have unique expertise in such purchases.

Table 3: Suggestions for holistic purchasing practices, based on radiologist and vendor survey respondent comments.

Suggestions for holistic purchasing, from both radiologist and vendor surveys
• Only sell/buy equipment that has local qualified service personnel & parts availability
• Provide LMIC-focused written guides for site assessment
• Warrantee should start with completion of successful installation
• Require distributors / 3rd party vendors who bid to maintain seller-neutral standards for sales, installation, and support
• Encourage longer service contracts at time of purchase by offering uptime commitments, extended training, and basic updates
• Develop regionally-focused training materials
• Offer extended training with service contracts
• Offer multiple methods for support & service contacts
• Include basic Quality Assurance program with installation

The survey showed that the acquisition of used equipment, whether donated or purchased, has almost completely lost favor in LMICs, with respondents citing problems with applications support, user manuals, service contracts, and spare parts. The national policies that donated equipment should be less than five years old is well-aligned with recommendations for replacement of radiology equipment in HIC in which the European Society of Radiology states that only properly maintained equipment is suitable for use beyond 5 years and that replacement of all imaging equipment is recommended after year 10 (12). Decreased popularity of donated equipment may be associated with the lengthening replacement cycle of equipment in HIC. Both in the U.S. and abroad pressure on hospital and healthcare budgets has slowed the replacement cycle of radiology equipment so that used equipment is likely to be of increasing age (12).

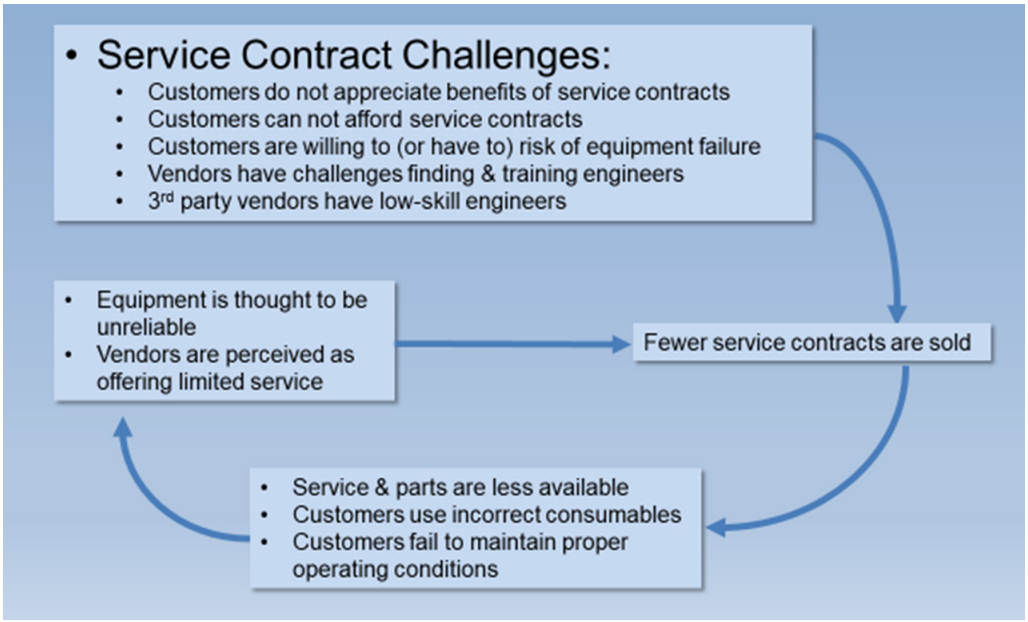
Additionally, equipment specifically designed for LMICs, such as the WHIS-RAD radiography unit (Optia BRS, Sedecal, Madrid, Spain), low-cost point of care ultrasound units, commoditization of advanced imaging equipment, and IT-based solutions can offer better alternatives to used equipment. This aligns with results from a study of hospital equipment inventories in 15 LMICs (the majority in Latin America) which found that 47% of donated radiography equipment was nonfunctional (13). While the survey likely underrepresents the faith-based/NGO sector, many such organizations are also turning to lower-cost new equipment, particularly for radiography and ultrasound.

Limitations of this study include that it is not a random sample of radiologists in LMICs but a survey of RSNA members, concentrated on better-resourced sites (this survey was not designed to assess the overall access to or geographic disparities in medical imaging in LMICs), and that it was not possible to separate information about public and private facilities because many of those surveyed work in both sectors. A more complex survey design would be required to analyze sectorial differences.

Conclusions

There are five key conclusions from the survey: radiography, ultrasound, and CT are available almost everywhere RSNA members work in LMICs (99, 99, & 93% of sites); digital radiography has broad penetration both among and within

Figure 4. The "No service contract vicious circle".



surveyed countries; the majority (60%) of radiologists report that they are always or often consulted about equipment purchase, but less frequently have the final say in purchase; vendors report that radiologists were more involved (79%) where software was purchased; and the era of donated equipment has passed, with 95% of radiologists responding that the disadvantages of donated equipment outweigh the cost savings. Both radiologists and vendors agreed that training was a major area of concern and had a number of specific suggestions for improvements, although radiologists and vendors differed as to what improvements should be implemented.

Availability of equipment cannot be equated with local access. Updated global information on access is much needed. The last well-documented description of imaging access is an article in 1982 (14). While several organizations working in global health have published that 66-70% of the world's population lacks access to basic imaging services, a search cannot locate any source or statistics to support this claim (15-19).

While this statistic may have reflected the state of global medical imaging at some point, the publication of authoritative, updated statistics on both availability of and access to imaging, particularly in rural areas, would be invaluable in optimizing imaging care delivery.

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