Perspective

Strengthening health systems through informatics capacity development among doctors in low-resource contexts: the Sri Lankan experience

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Abstract

In the process of strengthening health systems, a lack of health-informatics capacity within low- and middle-income country settings is a considerable challenge. Many capacity-development initiatives on health informatics exist, most of which focus on the adoption of eHealth tools by front-line health-care workers. By contrast, there are only a few programmes that focus on empowering medical doctors in low- and middle-income countries to become champions of digital health innovation and adoption. Sri Lanka has a dynamic eHealth ecosystem, resulting largely from the country’s community of medical doctors who are also health informaticians. They are the result of a decade-long programme centred on a Master of Science degree course in biomedical informatics, which has trained over 150 medical doctors to date, and has now been extended to a specialist training programme. This paper evaluates this unique capacity-development effort from the perspective of strengthening health systems and how those in other low- and middle-income country contexts may learn from the Sri Lankan experience when implementing capacity-development programmes in health informatics.

Keywords: capacity development, eHealth ecosystem, health informatics, health information systems, medical education

Background

Strengthening health systems encompasses activities that enhance any or all of the core service functions of human resources for health: health finance; health governance; health information; medical products, vaccines and technologies; and service delivery. As defined by the National Library of Medicine of the United States of America, health informatics is the interdisciplinary study of the design, development, adoption and application of innovations based on information technology (IT) in health-care services delivery, management and planning.1 Health informatics is an essential component of strengthening health systems, as it can contribute to all of the core functions.2 This understanding led to the adoption of the World Health Assembly resolution on digital health in 2018, which emphasized the need to build capacity in human resources for digital health, across both health and technology sectors.3

In both high-income and low- and middle-income country settings, doctors play the vital roles of providing not only medical care but also key decision-making on many aspects related to health.4 Their presence in leadership positions as health administrators and team leaders means that they have the power to make decisions and gather support, particularly when organizational changes are expected.5 When it comes to technology adoption, doctors can be powerful champions or detractors of such changes.6 Doctors in low- and middle-income countries are likely to be aware of the health-care needs of the population, the informational needs of the health system and the constraints on adopting technologies in low-resource health contexts. When health information systems (HISs) are developed and implemented without much understanding of these aspects, many are bound to fail.7 In theory, doctors in low- and middle-income countries are well positioned to become health informaticians who bridge the knowledge gap between fellow health-care professionals and IT personnel, thereby minimizing the design–reality gap.7

This paper describes a capacity-development effort in biomedical informatics in Sri Lanka that, for the reasons outlined above, intentionally targeted medical doctors. This started as a Master of Science degree course, which was then extended to a specialist training programme at Doctor of Medicine (MD) level, with the possibility of board certification as a specialist in health informatics following further local training and training abroad. This programme has so far trained over 150 medical doctors in health informatics in Sri Lanka and has changed how doctors are involved in digital health initiatives, giving rise to an exponential growth in low-cost, sustainable HISs.
There are few empirically supported models or examples to guide capacity-development efforts in health-system informatics. This perspective paper discusses the development and nature of this programme, its effects on the eHealth ecosystem in Sri Lanka and the key lessons learnt that may be instructive for similar programmes in other low- and middle-income country contexts. The aim of the paper is to contribute to policy and practice on strengthening health systems in other low- and middle-income country contexts by describing the approach taken to developing health-informatics capacity and the investments made.

Sri Lanka’s master’s programme in biomedical informatics

The master’s programme in biomedical informatics was established in 2008 as a collaboration between the Postgraduate Institute of Medicine (PGIM) at the University of Colombo and the Department of Informatics at the University of Oslo, Norway. The programme was supported by a grant funded by the Programme for Master Studies of the Norwegian Agency for Development Cooperation (Norad) and administered by the Norwegian Centre for International Cooperation in Higher Education. The funding extended from 2008 to 2014. The aim was to produce health-informatics expertise within the country to facilitate the adoption of digital technologies to improve health services.8

The master’s programme was established at the PGIM under a committee – the Specialty Board in Biomedical Informatics – that consisted of experts in clinical medicine and public health, IT and computer science, health informatics, medical administration, medical education and bioinformatics. These experts represented the universities, the Ministry of Health (MoH), interest groups such as the Health Informatics Society of Sri Lanka, and the private sector, creating a forum in which stakeholders could express their views and negotiate the best means of training the doctors and utilizing the skills gained by them. The board representatives and their expected contributions are listed in Table 1.

Making use of the existing collaborations and traditional linkages between the PGIM and the MoH, the board designed a curriculum and a training programme of 2 years’ duration. Almost all trainees were doctors from the MoH who had been granted 2 years’ leave to undergo training on full pay. The course fees of these doctors were also reimbursed by the ministry in accordance with its policy of supporting the postgraduate education of its medical officers. The structure of the training programme, alongside the key content areas, is set out in Table 2.

In addition to classroom and laboratory training and research, trainees were also required to conduct research based on a practice-oriented problem. The trainees were placed in government health institutions, which provided them with real-life problem scenarios. The research activities were action oriented and interventional. The trainee projects were financially supported by the Norad programme fund (around US$ 1000 to US$ 2000 per selected project) in the beginning. This allowed trainees to collaborate with state institutions and carry out small-scale infrastructure upgrades, software development, implementation and staff training. The funds were also utilized to provide trainees with the relevant exposure in foreign countries in the form of short courses, study tours or conference attendance, with the aim of facilitating networking and collaborative learning. This was especially important during the initial stages of the programme, when the country lacked health-informatics capacity. When the Norad programme project timeline was completed, trainees were able to take up their placements in settings that already had systems up and running or that were more predisposed towards digital health innovations.

In parallel with the academic activities, many other initiatives were directly facilitated by the board and its stakeholders. These included an annual conference driven by the trainees and graduates of the programme, an online journal, and partnerships with expert groups and networks such as the Health Information Systems Program, the District Health Information Software 2 (DHIS2) community, the Open Medical Record System (OpenMRS) community, the Asia

Table 1. Overview of the board representatives and their expected contributions

<table>
<thead>
<tr>
<th>Board representation</th>
<th>Expected contribution to the programme</th>
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<tbody>
<tr>
<td>PGIM (hosting organization and LMIC partner)</td>
<td>Academic inputs, provision of course administration infrastructure, accreditation and statutory frameworks for the programme</td>
</tr>
<tr>
<td>Ministry of Health (main stakeholder and client)</td>
<td>Training placements, insights into training needs, mapping learning with developmental needs, garnering state support, facilitating institutionalization of the specialty, skills utilization</td>
</tr>
<tr>
<td>Associations (e.g. Health Informatics Society of Sri Lanka)</td>
<td>Professional inputs, opportunities for collaboration, interprofessional working, industry exposure and networking, reaching global and regional organizations and networks</td>
</tr>
<tr>
<td>Private health sector</td>
<td>Inputs on the needs of the private sector health institutions, opportunities for collaboration, recognition of skills gained by the trainees</td>
</tr>
<tr>
<td>IT and computer science professionals</td>
<td>IT expertise, access to resource personnel, facilitating collaborations between IT and health domains</td>
</tr>
<tr>
<td>Clinical, public health and bioinformatics professionals</td>
<td>Aligning the informatics programme with the clinical needs of the country, maintaining the clinical relevance of the learning, facilitating the translation of technology into actual practice, providing feedback on challenges and pitfalls during and after training</td>
</tr>
<tr>
<td>University of Oslo (high-income country partner)</td>
<td>Subject matter expertise, funding support, collaborative opportunities for faculty development</td>
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IT: information technology; LMIC: low- and middle-income country; PGIM, Postgraduate Institute of Medicine.
eHealth Information Network and the Commonwealth Digital Health Initiative of the Commonwealth Medical Association.

From its inception, the programme has produced over 150 graduates, and only a few have chosen to pursue other careers or migrate. The master’s programme has also enabled the PGIM to design a doctoral-level MD programme, which has ensured that graduates have a career path that allows them to achieve the highest possible recognition, as is the case with any other medical specialty. Consequently, as of early 2019, 35 graduates had enrolled on the MD programme, expecting to be board certified within a few years. At present, the programme is fully funded by the MoH, which pays the entire course fees of the master’s and MD students. There is no dependence on any external funds. The MoH makes its training facilities available to the students free of charge and actively engages them in its development initiatives.

**Development of the eHealth ecosystem: success factors**

The evolution of the programme over the last 10 years has enabled us to identify the overarching themes that have made the programme impactful in terms of both producing graduates and contributing to the eHealth ecosystem in the country. These themes are (i) achieving a “critical mass” in relation to health informatics; (ii) proactively linking the capacity-development programme with the ongoing and proposed eHealth developments within the state sector; (iii) generating measurable contributions to science and practice; (iv) creating an organizational culture that ensures that health informatics is a core area of expertise within the health sector; and (v) facilitating “frugal innovations”. As outlined next, these may serve as key design principles for successful capacity-development efforts in health informatics in other low- and middle-income country contexts.

**Achieving a “critical mass” in relation to health informatics**

Critical mass refers to a size, number or amount large enough to bring about a particular result.9,10 In capacity development, critical mass usually refers to the number of trained people needed to achieve a particular objective.9,11 It is usual to assume that reaching a critical mass of trained personnel, especially in a technology-related field such as informatics, facilitates the adoption of innovations within a social system at a self-sustaining pace and thereby contributes towards further growth. This is a desirable outcome for any health-informatics capacity-development effort.12 Notably, the goal of many capacity-development efforts is achieving a critical mass in the end-users of HISs, such as front-line health-care workers.13,14 By contrast, ensuring a critical mass of researchers may be less of a priority, particularly in low- and middle-income country contexts, and thus opportunities to research health-informatics solutions directly targeting local problems may be missed.

More than 150 graduates of health-informatics courses are now working in almost all major health institutions and participating in national-level programmes in Sri Lanka. They are involved in national-level HIS developments, training health staff, advocacy programmes and research, as well as in providing human resources to sustain the master’s programme. The programme has also triggered a considerable number of digital health interventions, which now provide a platform for learning and further research. Consequently, critical mass in Sri Lanka was reached not only by training a certain number of personnel but also by achieving a multidimensional scenario comprising graduates, resource persons, functional HISs and researchers in health informatics. The authors’ experience

<table>
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<tr>
<th>Semester</th>
<th>Classroom- and laboratory-based teaching</th>
<th>Field attachments</th>
<th>Research</th>
<th>Assessment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Semester 1</td>
<td>Mathematics for computing and object-oriented programming</td>
<td>Ministry of Health and its various programmes (e.g. maternal and child health, epidemiology, health education, malaria, tuberculosis) and faculties of medicine</td>
<td>Research methodology training</td>
<td>Semester assessments</td>
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<tr>
<td>Semester 2</td>
<td>Basic epidemiology and statistics</td>
<td>Identifying research areas</td>
<td>Semester assessments</td>
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<tr>
<td>Semester 3</td>
<td>Management</td>
<td>Development and submission of proposals</td>
<td>Semester assessments and proposal assessments</td>
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<tr>
<td>Semester 4</td>
<td>Research</td>
<td>Research placement and thesis submission</td>
<td>Final assessment and thesis assessment</td>
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Graduation: Placement of graduates as “medical officers in medical informatics” within the Ministry of Health.
is that the creation of such a healthy eHealth ecosystem is essential for sustainable capacity development in low- and middle-income country contexts.

**Linking capacity development with eHealth activities within the state sector**

A challenge in many country contexts is that academic capacity-development programmes in health informatics may exist entirely independently of efforts to implement digital solutions at the health-system level. Close collaboration may be possible only if the key stakeholders – academia and the MoH, in this instance – are jointly responsible for the design and implementation of such programmes. The master’s programme provided this platform by establishing a board that was entrusted with all aspects related to the programme within the recognized academic frameworks of the university. One of the key manifestations of this collaboration was the ability to map student competencies and preferences to the digital health development needs of the MoH.

The role of the board was to facilitate student engagement with the MoH by assigning students to accredited trainers: consultants capable of supervising students to fulfil specific information needs of the MoH. The students were given the power to negotiate and agree on a suitable project, based on the needs of the particular unit under the guidance of their trainers. To facilitate this process, the students were also expected to conduct an analysis of the development needs of the training units during their placements. In instances in which such units already had an HIS, or were in the process of developing one, the students were expected to actively take part in these efforts. This resulted in a healthy dependency between academia and the MoH in fulfilling each other’s objectives. When the students graduated, the MoH gained the services of a dedicated group of professionals without any additional investment, creating continuity in their involvement in digital health developments, from studentship (as health-informatics students) to graduation and beyond. Table 3 outlines some of the significant HISs and other digital health efforts that can be linked to student projects or graduates of the master’s programme.

**Generating measurable contributions to science and practice**

In low- and middle-income country contexts, research capacity can be constrained. Thus, available evidence generated from...
research elsewhere may not be adopted, because it is unsuited to the local context.\textsuperscript{25} This is true for information-system research as well as for strengthening health systems as a whole. In our experience, it is particularly true, given the intricate differences and complexities within the health systems of different countries.\textsuperscript{26}

Those involved in the master’s programme realized this need early on and incorporated several measures that would establish research capacity in health informatics within the state health sector. These measures included (i) research methods, including action research, being part of the core curriculum; (ii) the mandatory inclusion of a research project; (iii) research projects being based on the developmental needs of the MoH; and (iv) the implementation of strategies to disseminate and share research findings (e.g. dedicated journals, annual conferences, local and regional networks).

The focus of these research endeavours was not just the development of software systems or technical details. In addition, students were encouraged to adopt a systems-thinking approach through which they would see HISs as complex sociotechnical systems rather than software artefacts.\textsuperscript{27,28} Understanding the interconnectedness of various components within an HIS and the complexities therein led students to research a wide range of issues related to HIS functioning, such as policies, governance, human behaviour, resource management, infrastructure and training, in addition to the technical aspects.

Since the research projects were designed and implemented at least on a small scale in real-life systems, students discussed not only the success stories but also the challenges and failures, thus enabling much of the knowledge that would otherwise have remained tacit to become more explicit and shareable.

**Establishing health informatics as a core area of expertise within the health sector**

Health informatics is not a well-recognized specialty in medicine, except in a handful of high-income countries.\textsuperscript{29} For example, in the USA, clinical informatics was recognized as a board-certifiable medical subspecialty in 2011.\textsuperscript{30} Nevertheless, we understand that in low- and middle-income country contexts, apart from becoming competent in using electronic information systems, health professionals may not be expected to become experts in designing and implementing these systems. The organizational culture of a health-care institution may reinforce such notions through dominant beliefs, values and social norms.\textsuperscript{31} Consequently, gaining recognition for health informatics as an area of expertise among medical professionals is invariably challenging, especially in the context of low- and middle-income countries.

Organizational change management is an approach often advocated to tackle such cultural obstacles and facilitate the
adoption of new digital health technologies. This approach entails disrupting the organizational culture to such an extent that new technologies and innovations can be mainstreamed, or made part of everyday practices. However, master’s students had to engage in a process of gaining acceptance for themselves as well as for the systems within their placement organizations. The process was therefore more of a “nudge” than a “disruption”.

By design, the master’s programme may have facilitated the creation of a conducive organizational culture in several different ways. The programme’s collaboration with the MoH paved the way for recognition of the master’s degree as a legitimate specialization for doctors and laying the foundation for further career development. The creation of designated posts for those who are awarded the master’s degree also enabled the graduates and their skills to be recognized within the organization. In addition, the mutually beneficial dependence achieved between the master’s programme and the MoH may have also facilitated acceptance of health informatics as a core area of expertise within the health sector.

**Facilitating “frugal” innovations**

In low- and middle-income country contexts, one of the key barriers encountered in implementing and sustaining HISs is the cost. Even with the support of funding agencies and development partners, many endeavours are expected to fail because of the complexities associated with the dynamic needs of low- and middle-income countries. “Frugal” innovations – defined as less complicated and less costly solutions – may seem to be the way forward but are likely be difficult to implement in real-life health systems in low- and middle-income country settings.

The master’s programme, in this case, facilitated a conducive environment for frugal innovations in many ways. Firstly, the programme emphasized the importance of embracing open-source platforms in the development of HISs. It facilitated this by introducing students to the global DHIS2 and OpenMRS networks and projects – the nodes. This created a culture of open innovation that is driven by sharing experiences and technologies between different nodes – the master’s programme being one such node. Secondly, the students were supported to carry out action research that focused on resolving real-life problems using simple digital solutions, which are codesigned with the participation of the users of such systems. To an extent, this created multiple living laboratories where innovations could be fostered. Thirdly, the students and graduates were supported in such a way that communities of practice could be cultivated among the doctors – another avenue for open innovation.

While it is true that the scaling up of even the most frugal of innovations may require extensive resources, the nature of such innovations – lean, cheap, simple and social – allows them to survive in low- and middle-income country contexts and enrich the eHealth ecosystem.

**Key lessons learnt, remaining challenges and future directions**

The Sri Lankan experience provides key insights in terms of how similar programmes may be implemented to achieve high impacts on HISs in low- and middle-income country contexts. On the one hand, the programme seems to have succeeded in creating a critical mass of graduates, information systems, researchers and resource personnel. On the other hand, continued expansion may mean that academia and the MoH have less and less control over how the eHealth ecosystem evolves.

Uncontrolled growth has led to challenges. One example involves tracking activities: multiple HISs that were and are being developed by the master’s students and graduates remain invisible until they are ready to be scaled up, leading to misalignments with health sector priorities. In addition, a lack of sharing of information between vertical “silos” in the health sector (e.g. maternal and child health information, patient morbidity and mortality data, HIV and tuberculosis control programme data) seems to have been replicated within the eHealth ecosystem, probably as a result of a lack of centralized coordination and policy. This is evidenced by the existence of multiple, operationally isolated, open-source HISs such as DHIS2-based systems and other proprietary software. Furthermore, the organizational structure established within the health sector, which has given rise to quasi-independent programmatic governing bodies (e.g. the National Programme for Tuberculosis and Chest Diseases, the Family Health Bureau, the National STD/AIDS Control Programme), has also meant that it has become impossible to control many of the HISs and other digital interventions centrally. Nevertheless, from an eHealth ecosystem point of view, this is a “good” problem to have and it may be rectified within the system itself. We have identified several ways in which a runaway eHealth ecosystem could be structured in low- and middle-income country contexts and provide direction for HISs through well integrated capacity-development programmes such as the master’s degree.

Evidently, the master’s programme facilitated students to engage not only in systems development but also in developing policies, governance structures, high-level eHealth architecture, education and training, as well as ways and means of integration and interoperability. Such an approach seems to have enabled a balanced evolution of the eHealth ecosystem rather than a narrow public health or clinical informatics agenda. However, the contextual realities are such that it may be difficult to prevent research and development agendas tending towards bureaucratically and politically defined health-system “priorities”, as dictated and supported by the MoH and development partners. In such instances, the MoH should take the lead and provide the necessary platform for stakeholders of the eHealth ecosystem to find solutions to achieve such a balance.

For instance, the eHealth policy documents developed by graduates several years ago would require updates to capture realities on the ground and current health sector needs. The policies should align with the national health priorities and investment strategies, while clearly defining the need for interoperability and integration. The stakeholders of the eHealth ecosystem should also become knowledgeable about the digital health tools that are already available and how to fulfil their information needs in an increasingly complex environment. While these may be considerable challenges in any other setting, Sri Lanka finds itself in a privileged position, given that many of the stakeholders in its national
eHealth ecosystem are now represented by the graduates of its master’s programme, who are capable of guiding the stakeholders towards better integration and interoperability. Setting up an eHealth forum in which all graduates, ministry officials and academia are represented may provide the platform needed to discuss these issues. A move towards centrally coordinating the placement of students and their projects would also prevent mushrooming of misaligned eHealth interventions.

Capacity-development programmes may be challenged at times by rapid developments in a wide range of areas, such as digital technologies, global policies and country priorities, and even by the burden of disease. Therefore, programmes such as the master’s need to be flexible and adaptable in terms of curriculum, training strategies, resource utilization and networking. For example, it may be necessary to shift the focus from open-source tools for public health to those for big data analysis and artificial intelligence. However, the bureaucratic nature of academic and state institutions and their capacity to change may not allow easy adaptations, creating a lag between the needs of the health system and the focus of capacity development. Overcoming this may require innovative approaches, including digital health awards, such as those organized by the Commonwealth Centre for Digital Health, to provide opportunities for cutting-edge frugal digital health innovations and public–private partnerships, together with a vision that extends into the foreseeable future.

These factors are being taken into account during the revision of the curriculum, which is currently under way in Sri Lanka. Another avenue that is being explored is the possibility of creating a master’s programme that can cater for broader regional needs, catalysing a south–south dissemination of knowledge and expertise. The revised programme would allow doctors or other health professionals from the region to complete the taught component of the programme in Sri Lanka and move to their own settings to carry out their research. At the same time, the partnership with the Commonwealth digital fellowship programme for health-care professionals, launched by the Commonwealth Centre for Digital Health in partnership with the University of Colombo and the University of Southampton in the United Kingdom of Great Britain and Northern Ireland, may also allow MD graduates in health informatics to work in high-income settings prior to their board certification, thereby creating a south–north–south exchange of knowledge and expertise.

However, in the Sri Lankan context, the process of training doctors to become health informaticians is a key factor in both the evolution of this programme and many of its implications. To an extent, the master’s programme has empowered doctors to become champions in digital health and to provide leadership in eHealth innovations. This did not disrupt either the existing institutions within the state sector (e.g. hierarchy of leadership and administration) or the organizational culture through which medical professionals are able to govern themselves and make decisions about overcoming issues related to healthcare delivery. This does not mean that capacity development in health informatics in low- and middle-income countries should target only doctors; however, the case exemplifies the potential contribution that doctors qualified as health informaticians can make to strengthening health systems in such settings.

Conclusion

This paper highlights a novel capacity-development effort in biomedical informatics in the form of a master’s in biomedical informatics and an MD in health informatics for medical doctors in Sri Lanka, which has led to sustainable development of the eHealth ecosystem in the country over the past decade. Key contributors to strengthening health systems and effects on health outcomes have been achieving a critical mass in relation to health informatics, proactively linking the capacity-development programme with the ongoing and proposed eHealth developments within the state sector, generating measurable contributions to science and practice, creating an organizational culture that ensures that health informatics is a core area of expertise within the health sector and facilitating frugal innovations. However, unless such capacity-development efforts become flexible, adaptable and less disruptive to existing institutions and organizational cultures, the expected strengthening effect on the health system may either be short-lived or not manifest at all. While acknowledging that different low- and middle-income country contexts would encounter different challenges in terms of implementing similar capacity-development efforts, our experience from the Sri Lankan programme convinces us of its ability to positively impact the eHealth ecosystem through local capacity development and of its potential to do so in many other low- and middle-income countries. The revisions to the programme that are currently under way take into consideration this potential, as those involved prepare to fulfil the health-informatics capacity needs in the region and beyond.

Acknowledgements: We would like to acknowledge all the trainees and graduates of the PGIM Masters programme in biomedical informatics who provided us with information related to projects/systems that they are engaged in.

Source of support: None.

Conflict of interest: None declared.

Authorship: PS, RH, SS and VHWD contributed to the conceptualization of the paper; PS, RH and AUJ gathered data for the work; PS and VWHD analysed the data; PS was responsible for writing the manuscript; RH and AUJ designed the tables; SS and VWHD reviewed the paper.


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