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Harnessing the potential of digital technologies: sustaining, accelerating and innovating for better health

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Editorial office

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Harnessing the potential of digital health in the WHO South-East Asia Region: sustaining what works, accelerating scale-up and innovating frontier technologies

Digital health is in the news everywhere, and this complex field is expanding rapidly, with new innovations in all aspects of clinical medicine and public health emerging at lightning-fast speed. The World Health Organization (WHO) South-East Asia Region has been a notable hub of innovation and implementation in digital health, and this issue of the *WHO South-East Asia Journal of Public Health* focuses on exploring and reporting on progress to date. Digital health technologies are recognized as an essential enabling factor for achieving the region's own Flagship Priority Programmes, as well as the ambitious "triple billion" targets outlined in the WHO *Thirteenth General Programme of Work (2019–2023)*[1] – ensuring 1 billion more people benefit from universal health coverage, 1 billion more people are better protected from emergencies and 1 billion more people enjoy better health and well-being.

"The future of health care is digital"

WHO Director-General Tedros Adhanom Ghebreyesus[2]

The appropriate use of digital health offers exciting new opportunities to accelerate progress towards achieving universal health coverage and Sustainable Development Goal (SDG) 3,[3] alongside other global, regional and national public health priorities. The application of digital solutions to health systems can help address constraints that have hindered the optimal delivery of equitable and high-quality care. For example, health workers are often burdened by paper-based ledger systems that require the manual tabulation of data for summary reporting – a cumbersome process that can inhibit service delivery. Progress on the core principles of universal health coverage – quality, coverage and affordability – is thus undermined by the very tools that health systems rely on to track needs, services and client outcomes.

The strategic implementation of digital technology reverses this situation. Automated processing can produce data for interpretation by health workers to support, monitor and inform health service improvements. The health sector has increasingly turned to digital technologies to help scale up and integrate efficacious public health interventions, rectify weaknesses in health system performance and empower individuals to become active participants in their health care. The number and scope of digital innovations, applications and services is vast, and these technologies address many priorities. Innovations include preventive services provided through basic SMS messaging and health apps on mobile phones; care and diagnostics using "smart" technology devices that share data; patient management using electronic medical records; public health initiatives using all types of data platforms and health information systems; and rapidly emerging innovations in the use of artificial intelligence, robotics and big data predictive analytics.

As the following pages demonstrate, despite significant financial and human resource constraints, countries in the WHO South-East Asia Region have shown considerable expertise and success in rapidly adopting, piloting and implementing a range of digital health solutions. The initiatives have focused on sustainable, locally serviceable and "frugal" innovations that are tailored to local needs and aimed at improving access to health care for all. Countries in the region have recognized the value in bottom-up, scalable and proven technologies that are driven by local innovators, and they have derived benefits from adopting and repurposing home-grown and open-source digital solutions that can be serviced, adapted and maintained by local partners. Bottom-up technology innovations consisting of affordable solutions, innovative business models and processes that facilitate health service delivery allow more people to benefit from socioeconomic development.

The WHO South-East Asia Region is sustaining and accelerating its innovative work on digital health to improve the health and well-being of the people. Boxes 1–3 illustrate just a few examples of how digital health technologies are progressing and having an impact across the region. Countless digital health solutions are being implemented, and lessons can be learnt from both what has worked and what has not.

Sustaining current investments and planning for the future

Advancing digital health sustainably with realistic and comprehensive strategies, plans and effective implementation has been challenging for all countries. In May 2018, the Seventy-first World Health Assembly adopted resolution WHA71.7 on digital health.[4] The resolution urged Member States "to assess their use of digital technologies for health, including in health information systems at the national and subnational levels, in order to identify areas of improvement, and to prioritize, as appropriate, the development, evaluation, implementation, scale-up and greater utilization of digital technologies, as a means of promoting equitable, affordable and universal access to health for all, including the special needs of groups that are vulnerable in the context of digital health".

The implementation of resolution WHA71.7 should help Member States better harness the potential of digital health. The sustainable use of digital health technologies will be facilitated by developing sound policies and guidance,

implementing effective strategies and action plans, enabling good digital architectural design, and linking current and planned technologies and solutions to enable the frictionless exchange of information. Ten of the region's eleven countries have digital health strategies, plans and architecture blueprints at various stages of development, revision and implementation. WHO has supported many of these efforts through the WHO–International Telecommunication Union (WHO-ITU) *National eHealth strategy toolkit*.[5] Countries in the region are assessing which digital health solutions (i) are currently working effectively; (ii) have the capacity to be scaled up and sustained; and (iii) are sufficiently flexible to be linked together to promote interoperability. Use of the evidence accrued will be essential to inform plans and decisions such that future digital health expansions achieve the intended benefits.

Box 1. Sustain and enhance what works

The Democratic People's Republic of Korea adopted telemedicine in 2010 and maintains a national eHealth centre. This facilitates digital consultations, enabling specialist doctors to advise on diagnosis and treatment for patients in remote areas who would otherwise have difficulty in accessing care. A telementoring system for surgery is available to all provincial, city and county hospitals.

Maldives has been using and sustaining the WHO South-East Asia Regional Office integrated data analysis system (SIDAS) since 2007 for case-based reporting of all notifiable diseases. Information, including reports received by fax and email, is recorded using a web-based electronic data entry system. SIDAS will be integrated with a digital health management information system platform, which has recently been launched and is under active development, with training rolled out to all stakeholders.

Sri Lanka has deployed and fully scaled up an electronic reproductive health management information system (eRHMIS), first introduced in 2016. This has resulted in complete, timely and high-quality data collection, analysis and use across Sri Lanka at all levels of the health system. Use of eRHMIS has facilitated the efforts that have ensured continued reductions in maternal and child mortality and improved island-wide reproductive, maternal, newborn, child and adolescent health service delivery.

Timor-Leste has harnessed and enhanced several digital health interventions that have worked well. These include the Liga Inan mHealth programme, which connects expectant mothers with health providers; the 2015 launch and ongoing use of a computer training lab supported by WHO within the Institute of Health Sciences; and learning labs to empower and train midwives.

Accelerating scale-up of appropriate digital health interventions

All too often, a "cutting-edge" digital health technology will be launched, and a pilot project started, only for the initiative to end in failure. While there are many reasons why these innovations do not succeed, several factors are common. For example, the intended users or beneficiaries may not have been consulted during the planning and design stages. Doing so would have ensured that the intervention was suitable and user-friendly from the outset. Likewise, while the technology may have appeared to work, its scale-up may have been too expensive, and maintenance may have been possible only with unrealistic levels of technical support. New technologies are therefore more likely to succeed if the blueprint is based on digital health interventions that the evidence suggests are effective or promising.

In April this year, the *WHO guideline: recommendations on digital interventions for health systems strengthening*[6] was released based on a critical evaluation of the evidence on digital health interventions aimed at improving health systems. The guideline makes recommendations on a subset of 10 prioritized digital health interventions for which sufficient evidence is available on benefits, harms, acceptability, feasibility, resource use and equity considerations. The evidence is emerging rapidly, and subsequent versions of the guideline will therefore gradually cover a broader set of emerging digital health interventions.

It is recognized that the fast-moving nature of the field risks excluding health policy- and decision-makers without a background in informatics and that the lack of a "common language" may impede uptake. To remedy this situation, WHO has created a classification system that categorizes 83 discrete digital health interventions through which digital and mobile technologies are being used to support health system needs. The creation of this taxonomy aims to promote the use of language that will be accessible to health programme planners.[7]

Many factors influence what is scalable and sustainable in digital health. In large part, there is adequate infrastructure – including electricity, internet connectivity and mobile phone coverage – in the region. There is typically at least one mobile phone available in each household or community, meaning applications or mobile apps can be used to deliver multiple health services in nearly any context or setting. The digital divide is narrowing, costs are reducing and the enabling environment is growing to underpin better, cheaper and faster digital health solutions that are fit for scale.

Box 2. Accelerate and scale appropriate solutions

Bangladesh has customized and taken to scale a large range of interoperable open-source technologies that have facilitated the collection and reporting of nationwide aggregate data and public health information, health facility management and electronic medical records.[8] Another example is the deployment of the WHO Open Smart Register Platform (OpenSRP) to track mothers and their children from antenatal care to delivery of immunizations for the child. OpenSRP has helped streamline data collection and aggregation and has enabled instantaneous communication between health workers, thereby improving not only service delivery but also the reliability of national health indicators.

India has embraced the WHO-ITU *Be he@lthy, be mobile* initiative to roll out an mHealth tobacco cessation programme. The initiative was further scaled up with the launch of a second version of this programme, which delivers the content through text messages or interactive voice responses in 12 languages. To date, the programme

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has reached more than 2.1 million self-registered users.[9] Another technology being scaled up is the Integrated Health Information Platform, launched in several states, which is a fully integrated disease surveillance and response system for real-time data collection, visualization, mapping and decision support.

Myanmar is equipping front-line health workers with tablets loaded with content to improve the efficiency and quality of their work and foster greater compliance with care guidelines. eLearning modules and other content is available for health promotion and education. Data collection and reporting can be done more effectively. Approximately 12 000 tablets have been deployed already and more than 30 000 will be issued to reach national scale. The tablets are extending the reach and increasing the capacity of front-line service delivery.

Nepal is strengthening health systems through a revitalized primary health-care approach. The implementation of policies intended to achieve universal health coverage has included the introduction of a health insurance programme. Technology has facilitated taking this to scale by deploying an open-source insurance management information system (OpenIMIS), which links patient, provider and payee data in one integrated platform. OpenIMIS was initially implemented in 2016 in three districts, rapidly expanding to more than 30 districts in 2017–2018. It currently has nearly 1 million enrolled, actively insured members, has processed over 600 000 claims and has paid more than US$ 5 million to health-care facilities.

Innovating through disruptive and frontier digital technologies

The story of digital health in the WHO South-East Asia Region is not just one of adopting and adapting solutions from higher-income settings. Many countries are "leap-frogging" earlier, slower changes in digital health and moving directly to implementing novel solutions. Advances in robotics, the use of artificial intelligence, machine learning, big data analytics, blockchain technology – all of these frontier and disruptive innovations are potentially powerful tools to transform how health services are delivered and inefficiencies in health systems addressed. The onus is on countries to embrace innovation strategically while acknowledging that digital health is inherently dynamic and that new technologies that address present-day challenges could be just around the corner.

Box 3. Innovate and disrupt for effective change

Bhutan is taking an innovative digital approach to improving services for blood donation. The Blood4Life app for mobile phones was launched in 2018. It enables registered potential donors to receive blood donation requests; potential recipients can also log a request for blood. Registrants can view all blood donation camps and events. The app also shares motivational stories on the benefits of blood donation.

Indonesia is embracing artificial intelligence and preparing to initiate big data analytics using the enormous data sets associated with the national insurance programme, Jaminan Kesehatan Nasional (JKN), the ongoing longitudinal Indonesian Family Life Survey and other data sources on household health status. The data will be used to predict the future burden of diseases and to anticipate demands on the health system and JKN.

Thailand has been at the forefront of the development and use of medical robotics surgery, diagnosis, rehabilitation and services. Earlier this year, the ministries of science and technology, public health and education jointly set up a committee with a key responsibility to promote medical and health-related innovations. In addition, the award-winning Khon Kaen city smart health project includes innovations such as a smart ambulance, preventive health care through the use of wearable devices, and blockchain and big data analytics to develop a medical data-sharing platform.

Conclusion

Digital health professionals in the WHO South-East Asia Region are actively learning from each other through peer-to-peer knowledge exchange and technical assistance. This networking allows practitioners to address common issues around digital health governance, architecture, the use of standards and cost-effective implementation support. There are two major platforms for cross-country learning, sharing and collaboration across the region. The Asia eHealth Information Network,[10] which was started by WHO in 2012, now has over 1200 members, mainly from government and academia. The Global Digital Health Partnership[11] was launched in 2017 with several countries from the region and WHO as charter members. These initiatives provide opportunities for digital health professionals to work together to address common technical barriers and challenges.

Although the speed, levels of sophistication and services targeted may vary, all countries of the region are on a common pathway to improving health by exploiting the opportunities that new technologies bring. The Member States of the WHO South-East Asia Region are therefore poised to contribute to and benefit from the strategic objectives of the WHO *Global strategy on digital health 2020–2024*.[12] At a regional consultation on digital health policy and practice in February 2019, common issues and challenges were identified. Countries recognized that strengthening capacity in many areas will be essential if complex digital health systems are to be deployed and sustained. Also clear was the critical importance of considering the perspectives and needs of the users and beneficiaries of digital health. Maintaining data security, privacy and confidentiality in the digital health sphere is a challenge all countries must address. Despite these challenges, the strong political support for digital health was clear.

Countries of the region can therefore learn much from one another. Crucially, these discussions cannot be limited to tech-savvy digital enthusiasts. The sharing of knowledge and good practices on how to use digital technologies to sustain, accelerate and innovate for better health needs to happen at all levels of the health system and within every cadre of the workforce involved in improving health – from community

health workers to national policy-makers. The collection of papers featured in this issue of the journal will contribute to that process.

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Bangladesh's digital health journey: reflections on a decade of quiet revolution

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Abstract

Bangladesh has made remarkable progress in digital health in recent years. Through one of the world's largest deployments to date of the open-source District Health Information Software 2 (DHIS2), the country now has a national public sector health data warehouse. Information from previously fragmented data systems is now unified in a common data repository, enabling data exchange for health information systems and decision-making. Work is ongoing to create lifetime electronic health records for all citizens that can be transferred between health facilities. Extensive customization of open-source software has laid the foundations for a national digital networking system. Initiatives have focused on producing digital solutions to aid priorities such as strengthening the health system as a whole as well as supporting specific technical interventions, for example improving the civil registration and vital statistics system. Digital solutions have also supported the Bangladesh health workforce strategy through a set of registries that electronically captures and maintains human resource information for the entire public health sector, including monitoring staff attendance through the use of low-cost biometric fingerprint time-attendance machines. Citizens are encouraged to engage in shaping health services via a web-based complaints and suggestions system, and a new system to raise health awareness via public digital displays has started in Dhaka. Strong support at the highest political level has been critical to the success of efforts to introduce these innovations. The endeavour has also generated a cadre of enthusiastic eHealth proponents, who are focused on further strengthening and expanding the existing systems and on harnessing the vast amount of information amassed at the central data repository through big data analysis, artificial intelligence and machine learning.

Keywords: Bangladesh, digital health, eHealth, DHIS2, electronic health records, health information system

Background

It is nearly 22:30 when Rahim Mia returns home from his small grocery shop in the village market. He finds his home abnormally quiet and becomes worried: his 5-year-old only daughter has had a low-grade fever since yesterday. In the small tin-shade house, he finds his wife anxiously sitting beside her daughter, crying and trying to cool the girl's head with a wet cloth to reduce her temperature. "Her temperature has been going up this evening and she is not taking anything," his wife explains. "Where can I find a doctor now in the middle of the night?" Rahim Mia exclaims, now extremely concerned about his daughter.

After a short silence, his elder son says, "Papa, I have seen on television that by calling the number 16263, anyone can get a doctor any time to discuss health problems. You should call them." Rahim Mia immediately dials 16263. Someone answers, "I am Dr Salma. How can I help you?" After talking for a few minutes with Rahim Mia, the doctor advises him to buy and use a paracetamol suppository to reduce the girl's temperature, and to give her more fluid to drink. The doctor continues, "It would be wise to take her to the nearest upazila health complex tomorrow morning. I am sending the prescription by SMS. Please show the SMS to a medicine shop to get the paracetamol suppository."

This story illustrates the impact that one of the innovations of Bangladesh's digital health revolution is having on access to health care. Launched in 2015, the Shastho Batayon 16263 platform uses advanced interactive voice response digital technology as part of a one-stop integrated national health call centre. The internal mechanism works using advanced information technology integrated with automatic voice recognition, human interfacing, big data solutions and e-prescriptions issued by qualified doctors sent to a patient's

mobile phone to minimize communications errors. Anyone anywhere in the country can call the number any time 24 hours a day, 7 days a week to receive free instant advice and services. The platform fulfils several functions, including: (i) providing a doctor's advice and a prescription; (ii) reserving ambulances for callers; (iii) providing health information; (iv) receiving and resolving complaints about any public or private health-care provider; and (v) coordinating a response in the event of an emergency health situation. There are also other eHealth services such as telemedicine, bulk SMS for disseminating health awareness information, and a text-based grievance redress system mediated by mobile phone.

As a lower-middle-income country, Bangladesh made remarkable progress in public health during the Millennium Development Goal era, particularly in significantly reducing the infant and under-5 mortality rates and the maternal-mortality ratio; improving immunization coverage; and reducing the incidence of communicable diseases.[1] Through the fourth *Health, population and nutrition sector program (HPNSP) 2017–2022*,[2] the country is now building on these achievements to improve equity, quality and efficiency, with a view to moving towards universal health coverage and achieving Sustainable Development Goal (SDG) 3.[3] The HPNSP, in turn, is guided by Bangladesh's overarching *Vision 2021*, which aims to transform the country from a lower-middle-income economy to having crossed the threshold and become a middle-income nation by 2021.[4] A key strategy and policy focus of *Vision 2021* is exploiting information and communications technology (ICT) to the full to help steer the country's development. As a result of this strong political and policy focus, significant work has been done to introduce digital solutions to challenges facing the health sector. This has been led by the Management Information System unit in the Directorate General of Health Services (MIS-DGHS), which is the digital health hub of the Government of Bangladesh. MIS-DGHS has fostered a supportive environment for digital innovation, and progress has been rapid. This perspective paper briefly summarizes progress to date.

Enabling an integrated health information system

The year 2009 saw the start of "a quiet revolution" to harmonize the complex array of health information systems (HISs) underpinning the overall management of Bangladesh's health sector. At that time, reflecting the country's pluralistic health service delivery arrangements, Bangladesh's HISs were highly fragmented. Data generated by private and public sector providers were not linked and, in the public sector, data from urban and rural areas, and from family planning programmes, were handled separately. Multiple overlapping reporting systems made it extremely difficult to collect comprehensive and reliable data about the coverage of health services and the health status of the population.[5] With technical support from the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ), MIS-DGHS implemented the open-source District Health Information Software 2 (DHIS2). DHIS2 is a modular web-based package for the collection, validation, analysis and presentation of aggregated statistical data, tailored to integrated health information management activities. The development

of DHIS2 is coordinated by the Health Information Systems Program network established by the Department of Informatics at the University of Oslo, Norway.[6]

The introduction of DHIS2 to Bangladesh catalysed the prioritization of data standardization and interoperability in eHealth software and database development. A draft guideline, the *Health informatics standards and data structure for Bangladesh*, was developed by MIS-DGHS to define standards and interoperability procedures for existing and future database systems under the Ministry of Health and Family Welfare (MoHFW), and for other ministries, nongovernmental organizations, development partners and the private sector.[7] Bangladesh also led on the 2013 World Health Assembly resolution on eHealth standardization and interoperability, which emphasized that the lack of a seamless exchange of data within and between HISs hinders care and leads to fragmentation of HISs and that improvement in this is essential to realize the full potential of ICT in health system strengthening.[8]

A decade after the first steps were taken, almost all government-run health services have either fully or partly implemented DHIS2 and progress is being made with implementation in the private sector and nongovernmental organizations. For example, the Institute of Epidemiology, Disease Control and Research, the country's disease surveillance focal point, uses DHIS2 for inputting, processing, analysing and reporting data for disease surveillance. The real-time disease surveillance and reporting system was established in 2009; it has been implemented down to the upazila (subdistrict) level countrywide and uses standard, web-based forms based on DHIS2. Notably, under the Communicable Disease Control unit, the visceral leishmaniasis (kala-azar) elimination target of less than 1 case per 10 000 population was achieved in 2018,[9] using a DHIS2 tracker for case-based surveillance, treatment and follow-up, including adverse drug reactions. Similarly, DHIS2 is being used for tracking data on screening, treatment and follow-up for cervical and breast cancers.

With about 50 000 end-users using the database software to push and pull data and reports, mostly through wireless modems, the MoHFW is the country's single largest mobile subscriber, and the deployment of DHIS2 in Bangladesh has been one of the world's largest and most extensive to date. Bangladesh has invested in building local capacity to maintain, develop, promote and expand the use of DHIS2 and overall HIS governance. All health sector partners have been brought together under the leadership of the DGHS to use its eHealth resources, including DHIS2 as common property, and to invest in further development. This collective vision has resulted in the continued thriving and expansion of DHIS2 and other eHealth resources, despite GIZ's assistance ending in 2015. In Bangladesh, DHIS2 has therefore become the national health data warehouse for the public sector, helping to bridge data gaps by bringing together information from previously fragmented data systems in a common data repository for all stakeholders. The system's rich data-mining functions enable the generation of reliable and accurate data for evidence-based decision-making and for planning and monitoring health interventions.

Accessibility has been greatly enhanced by the development of a user-friendly, integrated dashboard, which

pulls data in real time from all the various databases.[10] For this purpose, in addition to using DHIS2 analytics tools, the dashboard uses business intelligence tools including Tableau, Jaspersoft, Google Chart and Highcharts for in-depth analysis and visualization. Since the SDGs emphasize measurement and accountability using reliable data,[11] a real-time SDG health indicator tracker has been developed and incorporated into the central dashboard on the DGHS website.[12]

Towards citizens' lifetime electronic health records and networked health facilities

MIS-DGHS is working on an ambitious shared health record (SHR) project, with the aim of creating a national electronic archive of citizens' lifetime electronic health records that can be accessed during any patient encounter anywhere in the country. Patients will not need to carry a personal health file, and doctors and health facilities will be able to retrieve and update an individual's medical record on demand. A digital gateway, the health information exchange, allows data to be transferred between health facilities and health-care providers. Adequate provisions regarding permission, credentials, privileges, confidentiality and data security are built into the system. Having been piloted in few hospitals, the SHR is now being rolled out across the country.

Preference has been given to open-source nonproprietary software, which has made software acquisition affordable and has allowed ownership of the system to be established. OpenMRS is a software platform and reference application that enables the design of a customized medical records system.[13] OpenMRS has been extensively improved to create a robust and complete solution for hospital automation and to build a national electronic hospital networking system. The Bangladeshi version, known as OpenMRS+, is a composite of modules from OpenMRS, Odoo (previously OpenERP, a business applications suite), OpenELIS (a software and business-process framework for public health laboratories) and dcm4chee (an application for the management and archiving of clinical images). OpenMRS+ is integrated into the SHR system, so that they can work interactively through the health information exchange in transporting patients' electronic files to a central repository where up-to-date versions are stored and to the health facilities or providers that require them. A number of health facilities are currently using the system. Others, both public and private, are being encouraged to take a free copy of the software and join the national health facility automation system network.

Digital aids to health system strengthening

Health facility performance measurement
An initiative was started in 2014 to promote more structured and regular routine online reporting mechanisms and to allow for more effective measurement of the performance of public health facilities. The aim was to incentivize health managers by scoring the performance of health facilities annually, with recognition for the highest-ranking in the form of national awards from the health minister. The dashboard of the health system strengthening tool is publicly available as part of the

DGHS dashboard. This performance management tool is aligned with the six building blocks of health systems as defined by the World Health Organization (WHO): (i) health services; (ii) health workforce; (iii) health information; (iv) medical products, vaccines and technologies; (v) health financing; and (vi) leadership and governance.[14] The tool is based on the WHO guidance on monitoring and evaluating health system strengthening, adapted to the local context.[15] Indicators at the input, output and outcome levels, and, to some extent, at the impact level, were selected to allow assessment of the performance of facilities and community health services. Data are derived from four sources. First, scores are automatically generated from the routine health data provided by the health facilities through DHIS2 and the MoHFW human resource information system (HRIS). Second, there are on-site physical inspections using a structured data collection form to validate the routine data collected. Third, a further physical inspection by a semi-independent team of assessors of the short-listed facilities takes place. The fourth source of data is a patient satisfaction survey.[16] The tool is supported by WHO, the United Nations Children's Fund, the Health Information Systems Program Bangladesh and the International Centre for Diarrhoeal Disease Research, Bangladesh.

Standardized local health bulletins
Local health bulletins have been an innovation allowing health managers easy, structured access to facility data without the need for complex searches. In 2016, re-engineering by the software development team at MIS-DGHS allowed visitors to access aggregated indicator information for any facility, from community clinic to specialized hospital. The intelligent tool mines data across all the integrated databases and compiles them into a standardized local health bulletin. The bulletins can be downloaded and can also be printed and distributed locally.

Facilitating civil registration and vital statistics

The Commission on Information and Accountability (CoIA) for Women's and Children's Health was created by WHO in 2010 as part of a broader effort to accelerate progress on the Millennium Development Goals concerned with improving maternal health and reducing child mortality. A CoIA report in 2011 emphasized the primary importance of a robust civil registration and vital statistics (CRVS) system to determine where investments should be focused and whether or not progress is being made.[17] The Commission also noted the potential for information technology to overcome obstacles in developing birth and death registration systems. The importance of this was further reinforced in the SDGs, and target 16.9 is "to provide legal identity for all, including birth registration" by 2030.[18]

In 2012, with technical assistance from WHO, Bangladesh started to address the challenge of incomplete civil registration, resulting in a strategic action plan aligned with the CoIA recommendations.[19] A CRVS steering committee, headed by the Cabinet Secretary, was established in 2014, and it has been leading a whole-of-government approach to establishing CRVS in Bangladesh. Use of the International Form of Medical Certificate of Cause of Death was introduced in four hospitals

in 2017, and it is being piloted at a further 19 hospitals. Training in mortality coding has been carried out as part of an initiative to develop a new cadre of statistical coders for cause of death analysis. Verbal autopsy has also been introduced in selected areas of the country for community deaths for which there is no medical certificate identifying the cause of death.[20] A module on medical cause of death has been developed and integrated into the national DHIS2 platform.

From the digital health perspective, an enterprise architecture for the CRVS has been developed and the MoHFW has started to notify birth and death events taking place in the community and in health facilities, with cause of death, to the Office of the Registrar General. Progress is being made on improving the links between the health sector and registration services, as well as on improving the quality and collection of verbal autopsy data by incorporating key variables into the DHIS2 to enable near-real-time community mortality data analysis. The strategic action plan is currently under revision to take account of these developments.

Supporting the Bangladesh health workforce strategy

Human resource information system

Bangladesh suffers from both a shortage of and geographical maldistribution of human resources for health. There are only 8.3 doctors, nurses and midwives per 10 000 population,[21] which is substantially below the WHO recommended threshold. In November 2018, of more than 100 000 sanctioned posts under the DGHS, nearly 28% were vacant, with almost 20% of doctors' posts unfilled.[20] The *Bangladesh health workforce strategy 2015* addresses five priority areas: planning; development; distribution, retention and professional engagement; performance standards; and information systems.[22] There is a strong focus on developing digital solutions to support these objectives. The MoHFW HRIS is a key milestone in this endeavour. HRIS electronically captures and maintains human resource information for the entire health sector. Developed and anchored by MIS-DGHS, HRIS comprises four registries that capture data on geolocation, facilities, sanctioned posts and providers. All human resource-related functions, such as new appointments, postings, transfers, promotions, deputations, leave, annual confidential reports and disciplinary actions are recorded, processed and reported through the platform.

One function of HRIS is monitoring nationwide staff attendance through a biometric system. Like other countries, Bangladesh faces the challenge of absenteeism among service providers in the public sector; this is a particular problem for health facilities in rural and remote areas. In 2012, the MoHFW started rolling out use of remote low-cost biometric fingerprint time-attendance machines in all public facilities. Staff are required to touch the sensor on the machine on arrival and departure. All the touch information is collected in a central server so that local and national authorities, as well as the general public, can view aggregated staff attendance data through the DGHS dashboard. The local authority can access detailed attendance information for individual staff. The MoHFW is now working to link this attendance tracking with career planning and incentive mechanisms for staff.

Videoconferencing

Three times a month, the Director General of Health Services meets with all the eight divisional and 64 district health managers, and about 500 subdistrict health managers join the meeting once per month. The Director General also meets all the principals of medical colleges and directors of postgraduate institute hospitals and medical college hospitals twice a month. No travel is involved in attending these meetings, as they are all conducted by videoconference. These meetings include discussions on management issues, reviews of progress towards health targets and dissemination of information such as new guidelines. These videoconference meetings have had a significant impact in areas such as improving health managers' communication skills, creating a positive environment for supportive supervision and closing the relationship gaps between the senior and junior managers. Staff from Bangladesh's telemedicine centres also meet weekly by videoconference. Telemedicine in Bangladesh has grown: in 2009, there were only eight centres; today, there are around 100 in medical college hospitals, district hospitals and subdistrict hospitals across the country. Videoconferencing is now used to facilitate large, medium or small group meetings, seminars and training sessions; it is also being used in emergency health situations, such as accidents, fires and natural disasters.

Engaging the community through digital pathways

Bangladesh's digital innovations underpin the country's goal of ensuring that all citizens of Bangladesh enjoy health and well-being by expanding access to high-quality and equitable health care in a healthy environment. Citizens are also encouraged to participate in service improvements through a digital complaints and suggestions management system that was launched in 2012. In each of the 739 public hospitals and health organizations, there is a display board mounted on the wall in a prominent place. The display board describes how to send, by SMS, complaints about the quality of services or suggestions to improve them. As soon as an SMS is sent, a web server instantly receives, processes and displays it on the web portal for public viewing. One person is dedicated to following up each text message and contacts both the complainant and the complainee to resolve the issue, providing full feedback to the complainant.

The MoHFW recently installed several large digital displays in various locations in Dhaka to raise public awareness on health, nutrition and family planning issues and to disseminate important health information and success stories. Video clips and extracts from Microsoft Office files, such as PowerPoint slides, are also shown. The data they show are remotely controlled and pushed via the internet from a common location at the DGHS.

Big data, artificial intelligence and robotics

The rapid expansion of the eHealth programme has resulted in a vast amount of data being amassed at the central data repository of the DGHS. As a result, the DGHS is now looking

at opportunities to harness this information to improve health service delivery using big data analysis, artificial intelligence and machine learning. The DGHS is keen to collaborate with potential partners to work in this new area. In February 2019, the MoHFW held an international conference in Dhaka on big data for health. This allowed local and international experts to examine (i) international experiences with big data applications that have led to improvements in health outcomes; (ii) existing and potential big data sources for health-related applications in Bangladesh; and (iii) strategies for building capacity to develop health-related big data applications. For example, public sector health services in Bangladesh are operating with substantial shortages of human resources, and workload is high. Research has estimated that, even if vacant positions were filled, staff gaps in terms of demand and supply relative to workload would remain high in most facilities.[23] One option may be for robotics and bots to have a role in mitigating the country's severe shortages in the health workforce.

Conclusion and next steps

The past decade has been exciting, with remarkable achievements in digital health being made in Bangladesh. The stimulus and inspiration came from national policy in the form of *Vision 2021*, based on the aspirations of the Honourable Prime Minister Sheikh Hasina. The achievements were recognized when Bangladesh was awarded a United Nations Digital Health for Digital Development Award in 2011. Undoubtedly, very strong support at the highest political level has been critical to the success of efforts to introduce digital health innovations.

In common with other countries, several priorities will need to be addressed as Bangladesh continues to scale up digital health, such as strengthening governance and regulation of technologies, including data privacy and security and accreditation of health apps for consumers.[24] Continued investment will be needed to support the capacity to maintain, develop, promote and expand the use of DHIS2, as well as sustaining the coordination of health partners and programmes towards an integrated system.

There are opportunities for greater capitalizing on digital health advances to obtain disaggregated data for decision-making in line with the SDG commitments. In turn, robust evidence will be needed on the relevance, effectiveness and appropriateness of different information modalities for front-line services, to explore the potential for greater integration and scalability. Efforts to further strengthen accountability will continue to emphasize health managers' understanding of and commitment towards more effective measurement of health facilities performance. These, and other future initiatives, will be enhanced by fostering greater networking opportunities among countries through south–south and triangular collaborations.

Bangladesh's decade of "quiet revolution" has generated a strong cadre of enthusiastic eHealth proponents. Supported by the visionary leadership shown thus far, they will be instrumental in ensuring that digital health continues to yield dividends for Bangladesh and also in providing an example for other countries.

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Transforming health care through Bhutan's digital health strategy: progress to date

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Abstract

Bhutan, a landlocked country in the eastern Himalayas with some of the most rugged and mountainous terrain in the world, is actively engaged in digital health strategy reforms aimed at improving the efficiency of the health information system. Aligned with Bhutan's *e-Government master plan*, the *National eHealth strategy and action plan* aims to improve health by empowering health-care providers and citizens through technology and by enabling data exchange for service delivery. The strategy has four primary areas of focus: (i) ensuring digital health governance arrangements; (ii) concentrating on strong foundations in terms of infrastructure and standards; (iii) prioritizing improvements in the current health system in a phased, selective manner; and (iv) building the digital skills and knowledge of health workers. With support from the Asian Development Bank and the World Health Organization, phase 1 of the strategy has been completed and the blueprint for the digital health information system is in development. Phase 2 of the strategy will be implemented during 2020–2023 and will include work on (i) identity management for the health workforce; (ii) the implementation of a master patient index and a secure longitudinal patient information system; and (iii) enabling all health facilities to access the systems. Bhutan's eHealth strategy has the potential to fundamentally transform the delivery of health services, strengthen primary health care and enable the development of a "One Health" public health surveillance system.

Keywords: Bhutan, digital health, electronic health records, health information system, health information technology

Background

Bhutan is a landlocked South-East Asian country in the eastern Himalayas with some of the most rugged and mountainous terrain in the world and a population of around 736 000, according to the census in 2017.[1] The health indicators in Bhutan are among the best in the low- and middle-income countries; in 2017, average life expectancy was 70.2 years, sustained child immunization coverage was above 95% and household out-of-pocket expenditure on health was low.[1–3] The Royal Government of Bhutan provides a comprehensive range of free health services to all its citizens. In 2015, Bhutan spent 3.6% of its gross domestic product on total health expenditure, including expenditure on the largely publicly financed and managed health-care system,[2] which includes free air travel for citizens seeking health care not available in the country.[2] Despite the relative generosity of the government, there are concerns about the sustainability of health finances, and there has been a realization that methods of reducing waste and increasing efficiency are needed. This is especially urgent because the country is facing a growing double burden of communicable and noncommunicable diseases, including challenges such as increases in substance use, suicide and other mental health problems.[4]

A key component in increasing the resilience of a health system to new challenges is improving and upgrading the health information system (HIS).[5] Management and governance of health information in Bhutan are, overall, highly disjointed.[6] Fragmentation in HISs within the Ministry of Health is a particular challenge, preventing efficient data sharing and analysis. This has direct and indirect effects on all aspects of health care. For example, the lack of an accurate, timely and reliable patient information system makes it difficult to track and refer patients and to coordinate the continuum of care between primary health care and higher-level hospital care.[7] A particular problem is reliance on paper-based medical records, which is resource intensive and often inefficient in monitoring, evaluating and delivering optimal health services. For instance, the inordinate complexity of quantifying the burden of patient care when relying on paper-based records can be a barrier to the efficient provision of health services, which a recent study has shown to be suboptimal.[8]

The Royal Government of Bhutan has recognized the potential of information and communication technology (ICT)

to have a positive impact on health care and in 2018 launched the *National eHealth strategy and action plan*.[9] This perspective paper provides a report on progress to date on digital health strategy reforms aimed at improving the efficiency of the HIS in Bhutan.

National eHealth strategy and action plan

The mission of the *National eHealth strategy and action plan* is to support the provision of better health care by empowering health-care providers and citizens through technology and by enabling data exchange.[9] The strategy was developed with support from the Asian Development Bank and the World Health Organization,[10] based on a national digital health vision, action plan and monitoring framework. The chronology of the reforms that led to the current aspirations with regard to digital health reforms in Bhutan is shown in Table 1.

The digital health strategy reforms aim to improve the efficiency of the HIS in Bhutan by refining governance mechanisms, supporting patient management and care delivery at all health facilities, and improving the efficiency of disease surveillance through the "One Health" approach. The goal is to deliver sustainable, free and high-quality health-care services closer to the doorstep of every citizen. The 2018 *National eHealth strategy and action plan* has four primary areas of focus: (i) ensuring digital health governance arrangements; (ii) concentrating on strong foundations in terms of infrastructure and standards; (iii) prioritizing improvements in the current health system in a phased, selective manner; and (iv) building the digital skills and knowledge of health workers.[9] The overall budget for the current phase is US$ 52.5 million.[9]

Phase 1
Phase 1 of the digital health strategy was implemented during 2018–2019. This phase comprised the following components.

Governance
A steering committee was established, comprising 12 permanent members under the chairmanship of Dasho Secretary, Ministry of Health. The committee's role is to evaluate, direct and monitor the implementation of the strategy and action plan to ensure that the expected benefits are realized, with a reduction in risks and resources optimized. The committee also approves new digital health projects to ensure interoperability and sustainability. Critical leadership is provided by a technical working group with overall responsibility for creating an ecosystem addressing people, data and system issues, in alignment with the strategic objectives for the health sector.
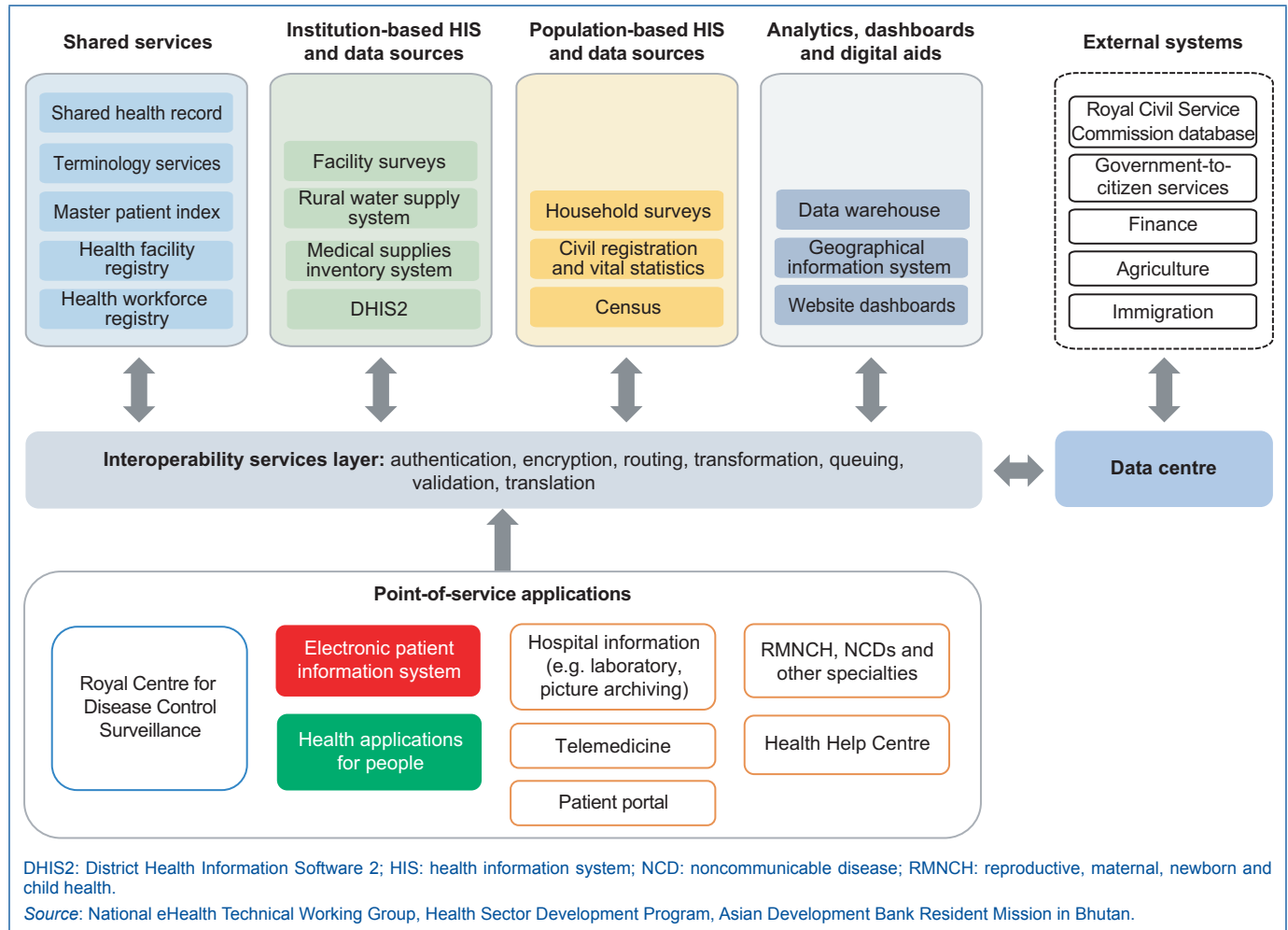
Infrastructure development and integration
The eHealth enterprise architecture – the blueprint for the HIS – is currently in development and will encompass IT infrastructure development, data integration and technical standards for health data exchange.[15] Both the *National health policy[16]* and the *Healthcare ICT master plan[13]* advocate an electronic medical records system in every health facility. The first iteration of this information system, along with an electronic patient information system, has been completed by Bhutanese experts. Strong technical leadership is required in developing the architecture for a state-of-the-art strategic information system. It is envisaged that the electronic health records will retrieve data prospectively, ensuring patient monitoring across several providers from different information systems integrated with the District Health Information Software 2 (DHIS2). The core platform, a centralized national health data warehouse, will link data from multiple sources and present it in a standard format via the electronic portal, thereby ensuring that all aspects of health data are interoperable. These sources will both feed data into and be able to extract data from the national warehouse (see Fig. 1).

Table 1. Timeline of digital health reforms in Bhutan, 1984–2023

Year(s)	Initiative	Outcomes/goals
1984–2002	Bhutanese Health Information Unit[3]	• Data on morbidity and mortality from health facilities collected and compiled by hand
2003–2013	Transition from a paper-based to an electronic database of morbidity and mortality data[3]	• Stand-alone database compiled in Microsoft Access
2006	Bhutan Information, Communications and Media Act 2006[11]	• Transition from Microsoft Access to the current web-based system initiated
2014	*e-Government master plan[12]*	• Ensuring universal access to safe and secure government e-services by facilitating the provision of citizen-centric services
2014	*Healthcare ICT master plan[13]*	• Strengthening fragmented systems in terms of infrastructure, internet connectivity, human resources, financial investments, data collection and reporting, and integration
2014–2017	Implementation of District Health Information Software 2 (DHIS2)[14]	• Web-based aggregate health data collection established using DHIS2, a free open-source health management data platform
2018–2019	Phase 1 of the national eHealth strategy	• Select and prepare systems to be improved in years 3–5 • Deliver low-risk, low-cost eHealth services • Prepare for the long term with a focus on identifiers, standards and networks • Capacity-building
2020–2023	Phase 2 of the national eHealth strategy	• Maintain and increase momentum from phase 1 • Roll out key identifiers and standards and upgrade networks • Implement key improvements in the more complex systems • Continue capacity-building

Fig. 1. Planned digital health architecture for Bhutan

DHIS2: District Health Information Software 2; HIS: health information system; NCD: noncommunicable disease; RMNCH: reproductive, maternal, newborn and child health.

Source: National eHealth Technical Working Group, Health Sector Development Program, Asian Development Bank Resident Mission in Bhutan.

Services and applications

Bhutan aims to deliver low-risk, low-cost digital health services to its citizens to achieve universal health coverage. Health-care providers with smartphones will be assisted by specially designed mobile apps and knowledge support systems under a central licensing arrangement. Improvements in routine web-based data collection and the implementation of interoperable technologies have already enhanced both disease surveillance and health security in the country. For example, Bhutan's National Early Warning Alert and Response Surveillance system enables reporting to the Royal Centre for Disease Control through an easy-to-use web-based information system.[17]

Workforce capacity development

The Ministry of Health has assessed the ICT education needs. Training programmes for all health professionals to increase capacity and fill specific digital health gaps are planned. The training will be delivered through online modules and apps, and audiovisual materials, and will include continuing medical education. In addition, online educational and behaviour-change communications will be used to target patients and citizens.

Phase 2

Phase 2 of the digital health strategy will be implemented during 2020–2023, with a focus on maintaining and increasing the momentum of digital health reforms. Further work includes identity management for the health workforce, the effective implementation of a master patient index, facilitation of longitudinal health records, clinical system linkage and improved access to patient health information. By 2023, it is expected that web services offering interoperability among platforms will be extended to other services such as the Health Help Centre for health information and ambulance services, the national blood transfusion service, and facilities such as district hospitals, primary health-care units and outreach clinics. Training of the current and new cadres of digital health experts will be sustained through online training programmes.

Future directions in digital health for Bhutan

The digital health strategy is ambitious and requires sustained governance and management commitment, user support and

the collective effort of all stakeholders. These stakeholders include government entities such as the Cabinet, the Gross National Happiness Commission, the Royal Civil Service Commission, the National Institute of Traditional Medicine Services and the administrations of the dzongkhags (provinces). Stakeholders at the Ministry of Health level include the Jigme Dorji Wangchuck National Referral Hospital, the hospital network and the basic health units. The primary goal of the digital health strategy is to enable increased access to quality health care for all. The plan is to achieve this by influencing positive changes in health-related knowledge, behaviour and practice among the public, health-care professionals and policy-makers. The use of an information management system should improve health-related decision-making and thus perceptibly improve the quality of integrated and timely care of patients.

The Royal Government of Bhutan aims to integrate all the digital services related to health-care service delivery into a single efficient platform. As previous case-studies have shown, robust planning will be essential to ensure successful implementation and that consideration is given to factors influencing adoption, such as cultural norms, management structures and the adaptability of users.[18] For example, research on cybersecurity in Bhutan has highlighted the need for government organizations to create a culture of security among all IT users as a means of protecting the confidentiality, integrity and availability of information systems and networks.[19] A systematic review of evaluations of health data management found that poor quality of health data, low levels of health information use and poor management were the main hindrances to the implementation of HISs in low- and middle-income countries.[20] The effectiveness of lay health workers depends on how quickly and efficiently they can adapt to HISs, and, therefore, is critical to any attempt to integrate data collection platforms into HISs.[21] In addition, the sustainability of finances for maintaining and improving HISs remains a key challenge in most low- and middle-income countries.

There is mixed evidence of the success of HIS interventions in low- and middle-income countries. Electronic health records as the core clinical application in an HIS can prove to be challenging, owing to the intricacies involved in recording data and a lack of scientific rigour.[22,23] However, changing from pen and paper to the use of personal digital assistants to collect data in a survey across 21 000 scattered rural households in the south of the United Republic of Tanzania saved time and improved the quality of the data recorded.[24] There is clear evidence that the use of personal digital assistants, tablets or mobile devices improves the timeliness of data collection and the quality of the data.[24] Similarly, separate studies on antenatal care in Indonesia have shown a willingness on the part of midwives to adopt digital methods[25] and a positive response to the use of electronic pregnancy registers that improved capture of routine antenatal data.[26] Using open-source platforms to collect data on more than 25 000 patients for a complex randomized controlled trial in low-income settings in Nepal proved efficient and feasible.[27] A review of Population Health Implementation and Training Partnerships in five sub-Saharan African countries suggests that the best HISs not only are flexible but also follow an iterative approach in designing and refining the development of new tools and

approaches.[28] Therefore, rigorous trials, routine data-quality audits and troubleshooting, incorporating timely feedback to improve HISs based on health system performance, are key attributes in the design and development of HISs. Investments in data audits and feedback activities intended to improve HIS data have resulted in significant improvements in data quality in low- and middle-income countries such as Mozambique.[29] Health systems in low- and middle-income countries need internal mechanisms to develop performance targets, track progress, and create and manage knowledge for continuous improvement. Using evidence-based recommendations such as the Performance of Routine Information System Management (PRISM) framework can help considerably in designing, strengthening and evaluating an HIS.[30] Frameworks such as this can help in focusing on performance, incorporating organizational and behavioural determinants, and ensuring accountability in HISs.[30]

The implementation of the eHealth strategy and interoperable HIS is reflected in the forthcoming Royal Government of Bhutan Gross National Happiness Commission 12th 5-year plan (2018–2023).[31] The focus of the HIS is developing ICT-literate cadres in the health workforce by improving workers' learning and competencies, and encouraging behaviour change. Confronted with a progressive decline in overall external assistance to the country, the Royal Government of Bhutan is striving to generate resources to sustain the digital health initiatives and incremental reforms. The Asian Development Bank, as a part of its wider health sector support, is also providing budgetary support to the government to drive its agenda with regard to improving strategy and governance; information technology infrastructure, services and applications; data standards for interoperability; and workforce capacity development. Given the substantial investments being made in digital health, it is essential to quantify the impact and outcomes. A monitoring and evaluation framework should be put in place to assess progress and identify where improvements in the delivery of projects and systems can be made.

Concerns have been reported regarding the use of electronic health records (i) prolonging working hours because of the time spent on tasks such as data entry;[32,33] and (ii) reducing professional satisfaction because of issues such as time directed away from patient interaction and the inflexibility of using templates for notes.[34–36] It is, therefore, essential that the desired eHealth outcomes are defined and measured to inform improvements to the system. In addition, it is vital that there is a focus on the citizen-centricity of the health-care system, to enable the end-users to actively take control of their health and well-being. In the implementation phase, it is important to deal with barriers to the adoption of digital health services, by ensuring that the finances are sustainable[37,38] and by addressing users' concerns.[38,39]

Through mobile apps and tracking systems, personal health information management can be implemented in creating and sustaining healthy communities. Furthermore, digital health platforms should focus on catching up with the dynamic pace of technological advances and the proliferation of online social networks. The full impact of digital health can be realized beyond its direct clinical impact; for example, it can facilitate preventive, long-term outpatient care. Developing digital health solutions for complex health systems is an ongoing

cyclical process, guided by health system strategies and policies. Multisectoral collaboration is essential for the success of a programme involving several stakeholders, including laypersons, health-care providers, health service managers, policy-makers, researchers and donors.

Conclusion

Bhutan envisages the nationwide deployment of an advanced HIS that will significantly scale up the implementation of the Ministry of Health's ambitious digital health strategy. The current partners are committed to supporting infrastructure solutions, migration planning and the implementation of governance mechanisms to bring about these reforms. If successfully implemented, Bhutan's HIS has the potential to improve patient safety outcomes, inform policy and transform health-care services. Thus, the Royal Government of Bhutan is on the path towards implementing a streamlined, interoperable, comprehensive HIS.

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Working towards a master patient index and unique identifiers to improve health systems: the example of Myanmar

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Abstract

In the health systems of many countries, there is neither a requirement to collect a minimum set of demographic information during patient registration nor a standard way of identifying patients. This impedes the provision of integrated, good-quality care for individual patients and, at the system level, prevents generation of the high-quality data necessary for effective management and continuous improvement. Assigning each patient a unique identifier (UID) to create a master patient index (MPI) is therefore essential to ensure data interoperability across all the points of patient care within a health system. Although advances in technology are shifting the boundary between civil registration and personal identification, the additional value of an MPI/UID system lies in the technical and operational capacity to ensure that clinical data are safely and securely managed. Moreover, operationalization of MPI/UID data enables the establishment of an evidence-based, constantly improving "learning health system" with feedback loops that allow measurement, evaluation and visualization of performance over time. The Ministry of Health and Sports of Myanmar is actively engaged in a multistakeholder collaborative process working towards a nationwide MPI/UID system. Demonstration pilots are planned for both online and offline modes of operation for HIV/AIDS, mother and child health (including eliminating mother-to-child transmission of HIV and syphilis) and hospital settings, which are expected to open up the potential for expansion to all health interventions and facilities. With the implementation of the MPI/UID system under way in Myanmar, the Ministry of Health and Sports is laying the foundation to put individuals at the centre of care and deliver a lifelong service for all.

Keywords: civil registration system, digital health, master patient index, Myanmar, unique health identifier

Background

An estimated 1.1 billion people, the majority living in Africa and Asia, are unable to prove who they are.[1] A disproportionate number of these people are children and women in poor rural areas, and their inability to prove their identity is a barrier to accessing the rights and services, including health care, to which they are entitled.[1] It is now well established that transforming identification systems to support universal and equitable access to health care represents not only a moral necessity but also an opportunity to improve the quality and efficiency of services. Unique identifiers (UIDs) are fundamental to achieving equity and universal health coverage, from drafting new identity management policies and legal frameworks to investing in cutting-edge information, communications and technology for digital health and interoperability and generating the high-quality data necessary for effective management and continuous improvement.

In many countries, at the clinical level, there is currently no standard way of identifying or managing the identity of the patients interacting with the health system. There is also no requirement to collect a minimum set of demographic information during patient registration. As a result, multiple identifiers may be assigned to an individual by different service providers, making patient-focused care and monitoring difficult, especially among individuals who seek care at multiple health facilities. These issues can be tackled by establishing a master patient index (MPI), a repository containing a registry of all the citizens in a health-care system, through which the demographic and clinical data of every patient can be safely accessed.[2] In an MPI, each citizen has a UID, enabling health records to be linked across multiple settings and facilities and ensuring data interoperability in different institutions across the health-care system.

The learning health system as prerequisite for good-quality health care

The strategic value of a UID to all stakeholders within a health system cannot be overemphasized. It is the foundational and critical component of a patient-focused national digital health architecture (see Fig. 1).[3] It enables the individual to be identified, to align service delivery so that all interactions across the continuum of care can be optimized, thereby contributing to better health outcomes.

The MPI and UID together provide the tools and information needed to make the shift to a patient-centred digital health system, which is in turn essential for establishing a "learning health system". This is a proven path to achieving and managing continuous evidence-based transformation and innovation in health care.[4] More specifically, transformative models of care, in areas including prevention, telemedicine, home-based care, artificial intelligence, predictive analytics, the use of data science and secondary analysis of clinical data become possible and/or more easily achievable. The ability to uniquely identify and integrate health information enables the adoption of patient-focused digital solutions that ultimately enable health-care workers to focus on delivering the best care possible. An MPI and a UID in essence constitute the "DNA" for building resilient health systems that learn and go on learning.

The operationalization of an MPI supports the establishment of an evidence-based, constantly improving learning health system that can provide feedback loops to measure, evaluate and visualize performance over time. Current health systems and digital health solutions tend to be focused on pre-set indicators because, understandably, administrators seek key performance indicators in order to measure and manage health system performance. These indicators dictate the data that are collected, which in turn heavily influences the data tools or digital health solutions that front-line health-care workers use to report on the care provided. However, services are frequently provided for which there is no indicator, meaning that key aspects of care go unrecorded and unreported. Using an MPI/UID system helps make the shift from an indicator-focused to a patient-focused digital health system that can generate indicator data as a by-product of care delivery. Fig. 2 illustrates how an MPI and a UID play a central role in supporting the establishment of evidence-based feedback loops and shifting from a focus on aggregate indicators to patient-centred digital health systems.

Measuring and accounting for the SDGs

The importance of identifier systems is inscribed in the Sustainable Development Goals (SDGs). SDG target 16.9 is "By 2030, provide legal identity for all, including birth registration".[5] States are encouraged to provide people with free or low-cost access to widely accepted, robust credentials that facilitate the achievement of SDGs in areas including social protection, health, finance, energy and governance.[6] In the SDG era, therefore, efforts to improve data collection and capacity are inseparable from the broader effort to build strong service delivery systems. Investing in strategies to enhance the quality, coverage and coordination of governments' data systems must be a priority. It is useful to consider what monitoring and achieving the SDGs could look like in 5 or

Fig. 1. The components of a patient-focused national digital health architecture


EHR: electronic health record; ID: identifier.

Amended, with permission, from: Digital health blueprint: enabling coordinated & collaborative health care. Montreal: Canada Health Infoway/Inforoute Santé du Canada; 2016 (https://www.infoway-inforoute.ca/en/component/edocman/resources/technical-documents/architecture/2944-digital-health-blueprint-enabling-coordinated-collaborative-health-care).[3]

10 years, if person-centred digital health investments, including use of an MPI/UID system, were the primary goal.

Relationship with civil registration and vital statistics

There are inherent connections between national identity, health identity and civil registration and vital statistics.[7] Usually, the system for civil registration and collecting vital statistics, primarily via the birth certificate, serves as the basis for individual identification, which in turn allows data to be recorded in population registries. The birth certificate is considered the foundational document for all individual identity systems and fulfils multiple purposes.

Likewise, death certificates allow official recording of a death in the continuous and permanent record, or registry. A continuously updated registry is important for updating electoral rolls, pensions and other social security mechanisms for the distribution of goods and services, including health care. Advances in technology including biometrics and digital identity are shifting the boundary between civil registration and personal identification within national, health and insurance domains. This raises the question, given the complexity of maintaining civil registration and vital statistics systems, why is operationalizing an MPI/UID system still advantageous? There are several reasons, most notably the critical considerations

Fig. 2. Shifting the paradigm to patient-focused data collection
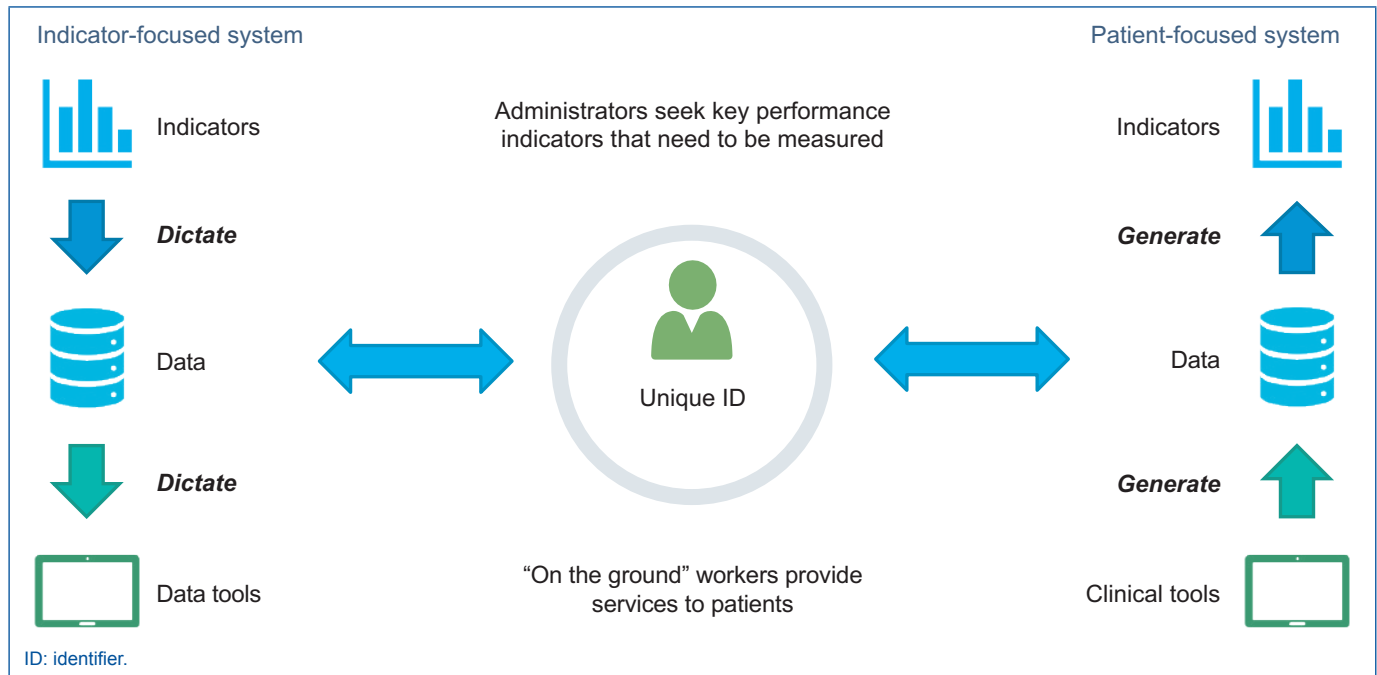
and risks associated with privacy, safety, data ownership, human capacity and sharing of data within the varied contexts of a health system. The MPI provides the strategic tools needed for implementing privacy and security. In practical terms, the MPI helps to define and implement the required privacy and security framework for clinical computing and interoperability. This includes policy and practices, technical and operational readiness and maturity to ensure that person-centred data are safely and securely managed.

The strategic value of an MPI is multiplied when its operationalization involves a stepwise, agile process with multistakeholder collaboration. An exemplar of this approach is Myanmar, a country that for the past 5 years has been taking a system-wide approach, including collaboration with multiple stakeholders, towards implementing an MPI/UID system.

Myanmar's Ministry of Health and Sports' strategic investment in a master patient index and unique health identifier system

Health care in Myanmar comprises a mix of public and private systems. The Department of Public Health of the Ministry of Health and Sports (MoHS), is the service provider and also takes the regulatory functions of the ministry in protecting the health of the people. A network of hospitals and health centres, which extends down to village level, provides preventive and curative services ranging from primary to tertiary care.[8] To resolve the fragmented nature of the health information systems, the MoHS is working towards a cohesive national information system. It is envisaged that this will increase operational efficiencies and improve decision-making at every level of care, leading to better health outcomes. The efforts of the MoHS to achieve MPI operationalization have

involved a multi-stakeholder, collaborative process for moving towards rolling out UIDs at the national scale, while aiming to link together existing systems (i.e. paper and digital) and future software applications, digital identity and biometrics linked to civil registration and vital statistics into an integrated system.

The analysis, design and planning of this integrated system, including the MPI, of the scale and complexity of the MoHS health information system, posed unique and complex challenges. After numerous rounds of separate meetings with stakeholders, the MoHS held its first convergence workshop for eHealth in 2015, the first in the region. Based on Myanmar's eHealth vision,[9] a detailed road map to maximize digital priority actions and investments to improve health was introduced, and UIDs were deemed essential to facilitate the development of longitudinal medical records and allow users to be tracked across health-care sectors and other social services. Initial plans for a national-scale MPI and UID system soon followed, as part of Myanmar's overarching *Strategic action plan for strengthening health information 2017–2021*.[10]

With the development of the MPI/UID system well under way, in November 2018, the MoHS organized a second national convergence workshop to advance development of the eHealth blueprint, hosted by Dr Myint Htwe, the Union Minister of Health and Sports. This was led by a high-level team from the MoHS, comprising Ms Aye Aye Sein, Deputy Director-General of Planning and Finance, Dr Thet Thet Mu, Deputy Director-General of Health Information Systems, and Dr Thandar Lwin, Deputy Director-General of Disease Control. Participants represented a wide range of health-care areas – including HIV/AIDS, tuberculosis, malaria, mother and child health, and immunization – and settings, including laboratory, outpatient and inpatient services. Notably, the Central Statistics Office, civil society organizations and development partners supporting the MoHS in the development of sustainable

point-of-care services also participated. The MoHS eHealth convergence workshop spawned a number of activities that served to enhance the health information system, eHealth governance and actions towards implementing the eHealth blueprint. They built upon ongoing commitment to and expansion of the MPI/UID system. The main sources of financial support for the MPI/UID work in Myanmar have been the United Nations Office for Project Services, Save the Children and the Joint United Nations Programme on HIV/AIDS. The United Nations Children's Fund and the World Health Organization have provided technical support.

For Myanmar, operationalizing the MPI is expected to contribute to developing the country's digital health system in the policy, technical and operations areas listed next.

- *Privacy and security policy and compliance*: adapting and implementing the minimum privacy and security policies and standards necessary will support demonstration pilots for workflows and pave the ground for establishing comprehensive national policies and standards.
- *Standards and interoperability*: open, international standards exist that allow users to copy, distribute and use technology, free of charge or at low cost, that is necessary for establishing and managing unique identity. By identifying and implementing these standards, Myanmar can share and merge patient health data cost-effectively.
- *Applications and tools*: pilots and subsequent national deployment will be supported by the adaptation, development and implementation of tools and software components.

MPI/UID demonstration pilots are being planned for both online and offline modes of operation for HIV/AIDS, mother and child health (including elimination of mother-to-child transmission of HIV and syphilis) and hospital settings, which are expected to open up the potential for expansion to all health interventions and facilities. The "system perspective" also provides important underpinning for newer solutions in the digital health arena to be introduced. It is yet another opportunity where the effort to implement an MPI/UID system at scale will spawn system-wide efforts toward larger nationwide health impacts.

These demonstration pilots are providing a "learning by doing" opportunity to operationalize the MPI in a health-care setting, to guide the development of policy, workflow, procedures for longer-term scale-up and sustainability. For example, the MPI demonstration pilot under consideration for mother and child health, starting with the childhood immunization programme, is expected to make good use of the many tablets recently purchased for health-care workers, designed to leverage the MPI with digital identity/biometric solutions, which enable authentication of a person's identity, together with electronic primary health-care records.

With the implementation of the MPI/UID system under way in Myanmar, the MoHS is laying the foundation to advance development of the country's eHealth blueprint. An MPI/UID system puts individuals at the centre of care, moving the health system away from episodic interventions to delivery of a lifelong service for all. An MPI/UID system therefore plays a critical part in strengthening health outcomes, health-system reporting, measuring the SDGs and maximizing sound health investments, as countries progress towards universal health coverage.

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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

Board representation	Expected contribution to the programme
PGIM (hosting organization and LMIC partner)	Academic inputs, provision of course administration infrastructure, accreditation and statutory frameworks for the programme
Ministry of Health (main stakeholder and client)	Training placements, insights into training needs, mapping learning with developmental needs, garnering state support, facilitating institutionalization of the specialty, skills utilization
Associations (e.g. Health Informatics Society of Sri Lanka)	Professional inputs, opportunities for collaboration, interprofessional working, industry exposure and networking, reaching global and regional organizations and networks
Private health sector	Inputs on the needs of the private sector health institutions, opportunities for collaboration, recognition of skills gained by the trainees
IT and computer science professionals	IT expertise, access to resource personnel, facilitating collaborations between IT and health domains
Clinical, public health and bioinformatics professionals	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
University of Oslo (high-income country partner)	Subject matter expertise, funding support, collaborative opportunities for faculty development

IT: information technology; LMIC: low- and middle-income country; PGIM, Postgraduate Institute of Medicine.

Table 2. The master's programme course content and organization

Semester	Classroom- and laboratory-based teaching	Field attachments	Research	Assessment
Semester 1	• Mathematics for computing and object-oriented programming • Database management systems • Data mining and web programming • Soft skills, professional practice and ethics • Networking, computer hardware, operating systems and application packages • Software engineering and software project management	Ministry of Health and its various programmes (e.g. maternal and child health, epidemiology, health education, malaria, tuberculosis) and faculties of medicine	Research methodology training	Semester assessments
Semester 2	• Basic epidemiology and statistics • IT law and information security • Public health informatics • Bioinformatics • IT for health education		Identifying research areas	Semester assessments
Semester 3	• Management • Health management information systems, IT governance and organizational management • Medical data and information management • Disease surveillance and IT for population genomics • Logic, clinical reasoning and decision-making		Development and submission of proposals	Semester assessments and proposal assessments
Semester 4	• Research	Research placement and thesis submission		Final assessment and thesis assessment
Graduation	• Placement of graduates as "medical officers in medical informatics" within the Ministry of Health			

IT: information technology.

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

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.[15] 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.[16] 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

Table 3. Examples of student- or graduate-led projects and their impact on the health system in Sri Lanka

Project	Impact on the national health system
National eHealth base documents	The national eHealth base documents comprise the *National policy on health information*[17] and the *National eHealth guidelines and standards*.[18] These documents are aligned with the national e-government policy of Sri Lanka.[19] The documents identified several areas of eHealth that should be aligned with national needs. They were developed by a group of medical/dental officers in medical informatics (M/DOMIs), in collaboration with health administrators and other key stakeholders. Revision of these documents is currently under way, and the process is being led by the MDs in health informatics, who pioneered the development of the *National eHealth guidelines and standards*.[18]
Personal health number and Master Patient Index	The personal health number (PHN) and the national Master Patient Index (MPI) were designed by M/DOMIs in collaboration with medical administrators. The MPI using the PHN was piloted using the Hospital Information System (see below) in three hospitals, including a tertiary-care hospital. Implementation will be carried out in stages, once stakeholders agree on the technical, policy and ethical issues. However, once fully implemented with a cloud-based personal health record and integrated with hospital-based information systems, it is envisaged that it would allow the unique identification of every individual in the country and enable each citizen to seek health care without the need for paper-based medical records.
Hospital Information System	The Hospital Information System, including an electronic medical record system for the public health sector, was developed by an in-house team of developers in the MoH under the guidance of a team of M/DOMIs. This system was developed in response to the identification of national needs. The system is being implemented in general hospitals in the country. It is funded by the MoH from domestic funds. The system is currently running in 12 tertiary-care hospitals, two secondary health-care facilities and 60 primary health-care facilities in the country, with plans to scale up the system to 300 primary health-care institutions within the next couple of years. Approximately 30% of the patient population seeking care in the government health sector at present is covered through this system.
Electronic Indoor Morbidity and Mortality Registry (eIMMR)	The eIMMR system was developed and implemented to collect inpatient morbidity and mortality data from health-care institutions in the country. It was developed as a master's project with a grant of only US$ 500. At present, it has been scaled up to 85% of all hospitals (including those in the military and private sector) in the country, capturing more than 90% of all discharge summaries. It holds around 25 million records at present. The information captured in the system can be visualized through dashboards at institutional, district, provincial and national levels. The system is currently being managed by an MD graduate and serves as the backbone to several other systems (e.g. the injury surveillance system of the Noncommunicable Disease Unit, the obstetric information system of the Family Health Bureau). The eIMMR is also integrated with the Hospital Information System described above.
e-Registry of the National Programme for Tuberculosis Control and Chest Diseases	This public health information system was developed and implemented to capture information related to tuberculosis and other respiratory diseases from clinics run by the programme across the country. This system was funded by the Global Fund to Fight AIDS, Tuberculosis and Malaria (GFATM). Out of the 26 chest clinics, 15 have started entering data into the system, including three clinics that handle around 60% of the patient population. Further modules are being designed by graduates of the master's programme, including a module to capture multidrug-resistant turberculosis patients. A connection has been established between the PHP-based capturing tool used in the clinics and the DHIS2-based reporting system used in the national programme, allowing integration between the two systems.
Malaria Information System (MIS)	Sri Lanka was certified malaria free in 2016, having had zero cases since 2013. The MIS was developed and implemented to facilitate vector control and case identification by the Anti Malaria Campaign of the MoH to help maintain this status. This system is funded by the GFATM. It is a national-level system covering all 25 districts in Sri Lanka and 100% of the population. It has recorded all reported cases of malaria in Sri Lanka since 2018, including 64 imported cases in 2019. It also captures the entomological, parasitological, vector control and stock management data from all regional malaria officers across the island.

Project	Impact on the national health system
National Nutrition Monitoring System	Developed and implemented to support the *Multi-sector action plan for nutrition*,[20] the project consists of two components. The first is a mobile app and its web-based information system, which acts as its backbone. This is known as the District Nutrition Monitoring System (DNMS). This system enables registration and monitoring of malnourished children identified by midwives in the field. The second component is the Nutrition Intervention Tracking System, which triggers non-health sector agencies, such as social services, to take action regarding the families of the malnourished children (e.g. providing food supplements) to help the children attain a better nutritional status. This system aims to tailor the intervention to children in need, rather than carrying out large-scale population-based interventions, the benefit of which is doubtful. In 2016, the DNMS system won the award for the best mobile app in the health and wellness category at the World Summit Award from among submissions from 178 countries.[21] This project was funded by UNICEF, and at present there are more than 15 000 malnourished children being actively monitored in four districts where malnutrition has been recognized as prevalent. The scaling up of the system is challenged by the resource requirements (e.g. tablets, PCs) and its multisectoral nature.
Essential drug stock alert tracker	This system was designed to enable the tracking of essential drugs stocks in hospitals, to mitigate shortages. This project was initiated with domestic funds and has not yet been introduced into different provinces.
Disaster Management Health Information System (DMHIS)	The DMHIS is an inventory management system to facilitate the emergency operations of preventive and curative health institutions during disaster situations. The project was funded by domestic funds, with graduates of the master's programme undertaking its design, implementation and scaling up. To the authors' knowledge, this is South Asia's first free-of-charge and open-source DMHIS system. Based on DHIS2, it is aligned with the *Sendai Framework for Disaster Risk Reduction 2015–2030*,[22] the *2030 Agenda for Sustainable Development*[23] and the Post-Disaster Needs Assessment and Recovery Framework.[24] GIS mapping of risks, hazards and vulnerabilities in all 365 MoH regions in Sri Lanka has been done using this system, with funding from WHO. Through the use of geolocation, DMHIS allows real-time monitoring of camps for internally displaced people during disaster situations; this was piloted during the floods in Kalutara district in 2017. An outcome evaluation is being conducted by an MD graduate.
Cause of death (COD) system and Smart Verbal Autopsy	Smart Verbal Autopsy is a mobile app designed to allow public health midwives to gather information in the community to identify probable CODs and improve the quality of data collected. This project was funded by Bloomberg Philanthropies through Vital Strategies, with technical support provided by the University of Melbourne, Australia. The COD system was successfully piloted in 25 hospitals, and a scale-up of the system across the island is currently being planned.
Electronic Reproductive Health Management Information System (eRHMIS)	This DHIS2-based system was designed and implemented to capture maternal and child health data from all field-level medical officers at health offices in the country. This project was funded domestically, with the graduates of the master's programme taking on key roles in design, development and implementation. The system currently covers all aggregated maternity and child health data from all 350 medical officers at health offices across the island. It captures around 40 million data records per year and is being expanded to capture the individual data of pregnant mothers and children under 5 years old. The same DHIS2 configuration is being used to develop two more programmes for (i) environmental and occupational health data management; and (ii) health promotion and health education information management.

DHIS2: District Health Information Software 2; GIS: geographical information system; MD: Doctor of Medicine; MoH: Ministry of Health; PHP: hypertext preprocessor (programming language); UNICEF: United Nations Children's Fund; WHO: World Health Organization.

research elsewhere may not be adopted, because it is unsuited to the local context.[25] This is true for information-system research as well as for strengthening health systems as a whole. In our experience, it is preferable to focus on creating empirical evidence targeted at local needs. In terms of HISs, this may be particularly true, given the intricate differences and complexities within the health systems of different countries.[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.[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.[29] For example, in the USA, clinical informatics was recognized as a board-certifiable medical subspecialty in 2011.[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.[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.[32] However, master's students had to engage in a process of gaining acceptance for themselves as well as for their systems within their placement organizations. The process was therefore more of a "nudge"[33] than a "disruption".[31]

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.[26] "Frugal" innovations – defined as less complicated and less costly solutions[10] – 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.[34]

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[35] and OpenMRS[36] networks and projects – the nodes. This created a culture of open innovation[37] 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[38] where innovations could be fostered. Thirdly, the students and graduates were supported in such a way that communities of practice[39] 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[10] – 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, inpatient 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.[40] 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 health-care 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.

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Digital possibilities in the prevention and early detection of oral cancer in the WHO South-East Asia Region

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Abstract

Cancers of the lip and oral cavity are the most common cancers among men in the World Health Organization (WHO) South-East Asia Region. Most cancers of the oral cavity are attributable to tobacco smoking, smokeless tobacco use and areca-nut product use, alone or in combination, and excessive consumption of alcohol. These risk factors are highly prevalent in parts of the region. This paper outlines an integrated framework for oral cancer prevention, which includes a strengthened primary health-care workforce, enhanced community engagement and a positive policy environment. Operationalizing this framework could be greatly facilitated by the application of digital technologies. Robust evidence exists for the effectiveness of using appropriately trained primary health-care workers to screen for oral cancer by oral visual examination; this can be combined with counselling for risk-behaviour modification as part of an overall strategy on noncommunicable diseases. This needs to be supported by greater overall community engagement, for example to tackle low levels of awareness of the harmful effects of smokeless tobacco and areca-nut products. A strong policy environment that supports and promotes these efforts is essential, along with the enforcement of the measures required by the WHO Framework Convention on Tobacco Control. Despite the burden of disease, oral cancer has been a neglected area of public health. This paper considers how the positively disruptive effects of digital technology may enable much-needed acceleration in prevention and control efforts.

Keywords: areca nut, digital health, oral cancer, oral visual examination, tobacco, South-East Asia

Oral cancer in the WHO South-East Asia Region and current service delivery

The burden of cancers of the lip and oral cavity is high in the World Health Organization (WHO) South-East Asia Region. The Globocan data sets report that cancers of the lip and oral cavity were the fourth most common of the 2 003 789 new cancer cases in the region in 2018.[1] In men in the WHO South-East Asia Region, neoplasms of the lip and oral cavity have the highest incidence of all cancers.[1] The buccal mucosa is the most common site for oral cancer in south and south-east Asia.[2] More than 75% of oral cancers are attributed to use of tobacco, areca-nut products and alcohol, which are endemic risk behaviours in many parts of the region.[3] Other risk factors include use of hookahs/waterpipes, consumption of nitrosamine-rich foods, infection with human papillomavirus, exposure to ultraviolet light and a diet low in fruits and non-starchy vegetables.[3]

In the region, most people with oral cancer present at advanced stages, which necessitates expensive and aggressive treatment and results in low cure rates. By contrast, the treatment for early-stage oral cancer is simple and effective, with survival rates exceeding 90% at 5 years.[4]

Visual screening of the oral cavity has been widely evaluated for its feasibility, safety, acceptability, accuracy in detecting oral potentially malignant lesions and oral cancer, and efficacy and cost-effectiveness in reducing oral cancer mortality. Visual screening involves systematic visual and physical examination of the intraoral mucosa under bright light, followed by inspection and digital palpation of the neck for any enlarged lymph nodes.[5]

In 2017, we investigated the current service delivery mechanisms in the region for early detection and prevention of oral cancer; the national focal points for the oral health services of Bhutan, Nepal and Sri Lanka completed an open-ended digital questionnaire. The responses, together with our knowledge of the situation in India, were categorized as positive factors, barriers and opportunities for improving oral cancer prevention, screening and early detection (see Box 1).

The Integrated Framework for Oral Cancer Prevention

This Integrated Framework for Oral Cancer Prevention in the WHO South-East Asia Region has been developed by the

Centre for Dental Education and Research, All India Institute of Medical Sciences, New Delhi, which is a WHO Collaborating Centre for Oral Health Promotion. The regional guidance on which the framework is based was put together in consultation with the WHO Regional Office for South-East Asia and built on the operational guidelines and implementation framework developed for the Government of India.[7,8] A training module was developed for primary health-care workers on early detection and referral of suspected oral cancers as part of the WHO *Package of essential noncommunicable disease interventions and healthy lifestyle interventions*.[9]

As shown in Fig. 1, the framework comprises three independent but mutually reinforcing components: a strengthened primary health-care workforce; greater community engagement; and a positive policy environment. Operationalizing this framework will be greatly facilitated by the application of digital technologies. Digital technologies are rapidly changing the composition and delivery of health services. Introducing these technologies can be positively disruptive, in that it opens up new ways of delivering community-based services that are more suited to an era of rising noncommunicable diseases and ageing populations than the traditional hospital-based service model.[10] Digital interventions to improve public health can be exploited for oral cancer screening and early detection, with the aim of reducing the burden of oral potentially malignant lesions and oral cancer. A number of web platforms and mobile health applications offer interventions for early detection and screening of oral cancer. These involve training and empowerment of health-care providers, machine learning to interpret images for diagnosis, the creation of digital hubs for screening, and patient education. The countries in the region are at different stages in relation to the various aspects of the framework and in terms of adopting digital solutions to improve the delivery of health services. This perspective paper briefly describes the framework and illustrates how digital technology might be used to amplify and accelerate results.
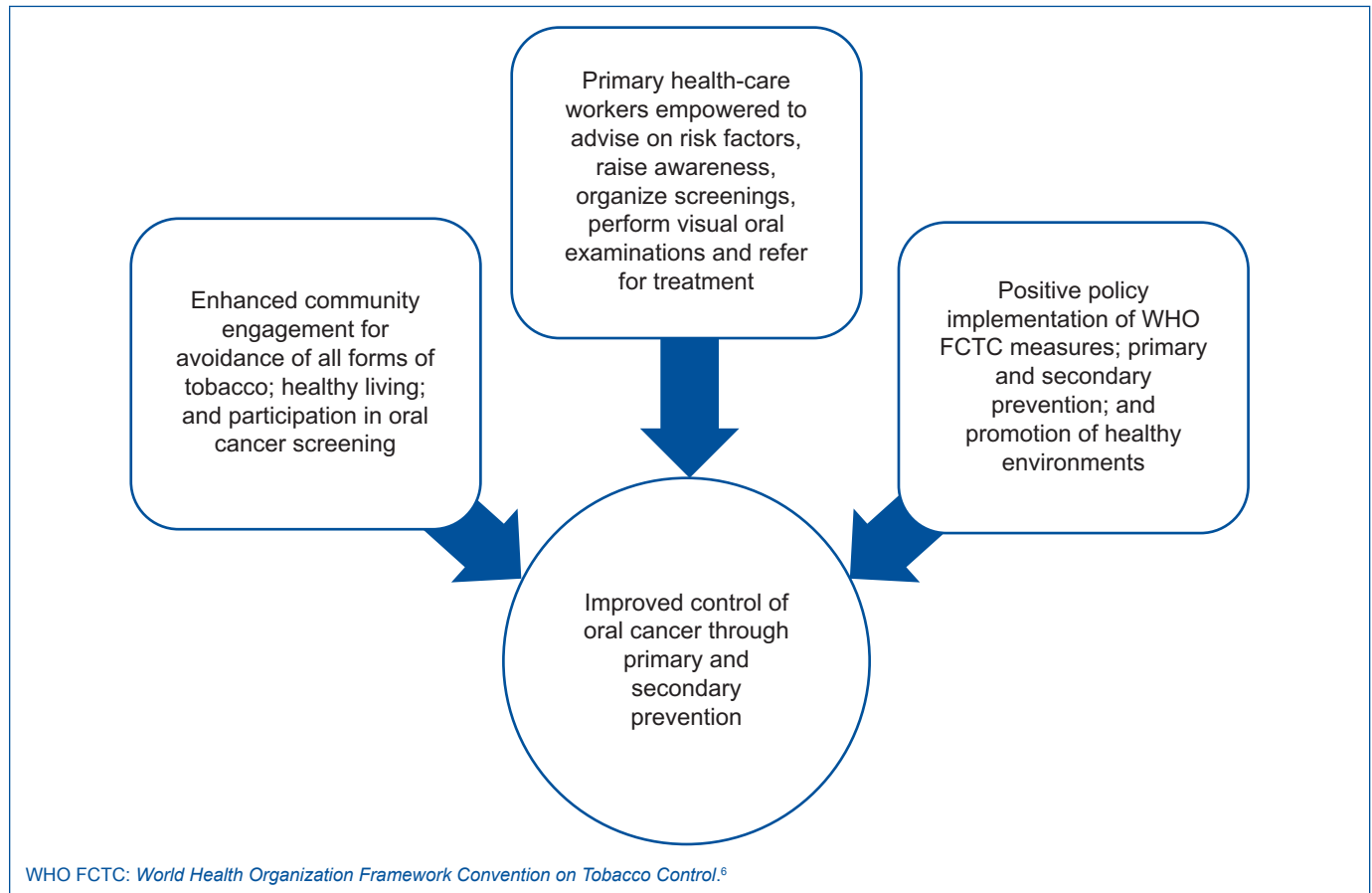
Strengthening the primary health-care workforce

All the countries in the region have cadres of health-care workers providing front-line services, including auxiliary nurse midwives, staff nurses, community health workers, lady health visitors and multipurpose workers. These primary health-care workers are ideally placed to implement risk reduction through behavioural interventions and to conduct visual oral examinations and teach oral self-examination. Their role may include the direct provision of behavioural interventions for tobacco use or harmful use of alcohol, or referral for such interventions. As the primary health contact point at household level, these health-care workers are best placed to coordinate, document and report on the care pathway for patients.

Evidence base

Research carried out over the past three decades has demonstrated the feasibility of using front-line health workers to screen for oral cancer. In a study in the 1980s in Sri Lanka, 34 primary health-care workers were trained to examine the mucosa of the oral cavity. In return for an incentive per case, they were asked to perform the examination on people aged 20 years and over as part of their routine work, which included house-to-house visits. In a year, the primary health-care workers examined almost 30 000 people and demonstrated a very satisfactory level of diagnostic accuracy. This study showed that use of primary health-care workers for the early detection of oral cancer and oral potentially malignant lesions was feasible and provided a valuable example of the community-based approach for early detection of oral cancer.[11]

A study in 1982–1983 in rural Kerala, India, found that incorporating an early oral cancer detection programme into the existing health-care infrastructure was feasible and beneficial. Basic health workers responsible for household visits to help control communicable diseases and implement family planning were trained to identify individuals at high risk for oral cancer, perform visual oral examinations and refer appropriately.[12] A 10-year study in the same location involved a range of tobacco-cessation interventions delivered annually to individuals and small groups, including one-to-one

Fig. 1. The integrated framework for oral cancer prevention

Enhanced community engagement for avoidance of all forms of tobacco; healthy living; and participation in oral cancer screening

Primary health-care workers empowered to advise on risk factors, raise awareness, organize screenings, perform visual oral examinations and refer for treatment

Positive policy implementation of WHO FCTC measures; primary and secondary prevention; and promotion of healthy environments

Improved control of oral cancer through primary and secondary prevention

WHO FCTC: *World Health Organization Framework Convention on Tobacco Control.*[6]

counselling, a film, posters and messages broadcast on the local radio station. The educational interventions reduced both tobacco use and the incidence of oral potentially malignant disorders.[13]

A large cluster randomized controlled trial in Kerala, India, involved trained health workers screening high-risk tobacco and alcohol users during home visits. Visual oral inspection was undertaken in bright daylight with the additional use of a flashlight. Screening was repeated every 3 years for a maximum of four cycles. The 15-year follow-up data showed a 38% reduction in oral cancer incidence and an 81% reduction in mortality in participants who complied with all the screening rounds.[14]

Visual oral examination is therefore an established method of detecting oral potentially malignant disorders and early stages of oral cancer when delivered by trained caregivers. The sensitivity and specificity of visual oral examinations are moderately high. Based on the evidence, the recent report of an expert group recommended visual oral examination by well-trained auxiliary health workers combined with tobacco and alcohol reduction counselling as the primary screening strategy in India. The expert group noted that, because tobacco users are a high-risk group for noncommunicable diseases generally, this strategy offers an opportunity to address multiple noncommunicable diseases in the same setting. The expert group recommends that oral cancer screening should target adults aged 30–60 years in high-risk populations, with the aim of screening once every 3 years.[15]

Implementation strategies using digital solutions

All the countries in the region are affected by epidemiological transition, characterized by a greater need for prevention and management of noncommunicable diseases. Therefore, the challenge is how to sensitize a front-line health workforce traditionally focused on maternal, child and communicable diseases to the requirements of the evolving disease burden, such as oral cancer screening and early detection.[16] Training primary health-care workers in early detection and prevention of oral cancer has been incorporated into the national cancer control strategies of India and Sri Lanka. In India in 2016, for example, robust guidelines and capacity-building plans were developed. These were integrated into the population-based screening programme for noncommunicable diseases. Thus, as part of the strategic shift to comprehensive primary health care, oral cancer has been included in the screening and prevention programme for noncommunicable diseases, along with cervical cancer, breast cancer, and hypertension and diabetes.[6] A framework has been developed to guide local implementation and capacity building at state and district levels.[7] Sri Lanka has an integrated programme for cervical, breast and oral cancer,[17] with mobile units for oral cancer screening.

Primary health-care workers may be engaged in behavioural interventions for cessation of use of tobacco, areca-nut products or alcohol, conducting visual oral examinations or teaching oral self-examination. All these tasks can be facilitated using digital technologies. For example, visual oral

examinations can be accompanied by showing a video on self-examination, oral hygiene and warning signs that should be reported. Coordination, documentation and reporting are also some of the tasks that the primary health-care care workers take on to ensure continuity of service delivery. These can be digitized using portable devices to monitor coverage, problem areas, feedback and various other aspects of service delivery. Portable devices such as tablets may also be used for community education and for collecting data for monitoring and evaluation of services.

The National Informatics Centre and Government of Tamil Nadu have set up an innovative digital screening strategy that has accelerated screening, diagnosis, follow-up and treatment for oral cancer and oral potentially malignant lesions.[18] A mobile app developed by the National Informatics Centre was loaded onto tablets that have been issued to every primary health-care centre to be used by dental surgeons or assistants. The app prompts the collection of registration details, provides information on risk factors and symptoms, and allows images of lesions to be captured. Cases are referred to higher-level institutions as required. Follow-up and treatment are also tracked by the app. Dental surgeons and assistants and other health-care workers in the network can share and discuss cases digitally.

India's Ayushman Bharat comprehensive primary health-care initiative is undertaking a population-based noncommunicable diseases programme. This is a referral-based programme where health workers screen all individuals aged 30 years and over for hypertension, diabetes and oral, breast and cervical cancers. At-risk individuals are progressively referred to higher public facilities, diagnosed, treated and then managed for life at the primary health-care level. In this programme, community health workers will be issued with tablets with preloaded screening algorithms designed to help in collecting data, recording findings and making referrals.[19] The portable devices will also be used to monitor coverage, detect problems and collect feedback. The digital link will enable faster and uninterrupted communication between the primary and the tertiary health-care levels.

Digital technologies have been essential for scaling up to roll out population-based screening training, for which in-person training is neither feasible nor economically viable. To date, the Extension of Community Outcomes project has been successful in India; in this hub-and-spokes model, experts (the hub) provide a virtual training course for community health-care workers (the spokes).[20] Further efforts to harness digital technology to link experts with front-line health workers also show promise, and initiatives using Massive Open Online Courses and teleconsultations are in development.

The use of machine learning (also known as deep learning) for medical image interpretation is an area of intense research in many medical specialties. Research is under way in several institutions to investigate the potential of this technique to facilitate classification of oral lesions. The policy think tank of the Government of India, NITI Aayog, is at an advanced stage of launching a programme to develop a national digital repository of annotated and curated cancer pathology images. Another related project under discussion is an imaging biobank for cancer, which would provide an unprecedented opportunity for use of artificial intelligence to inform decision-making in cancer treatment at low cost.[21]

Enhanced community engagement

The empowerment and engagement of communities will be essential to reduce the burden of oral cancer in the region. Information, education and communication strategies should follow a life-course approach, whereby materials on risk factors and early detection are targeted at different age groups, including school children, adolescents, parents, adults and older people. Digital media sent via text, voice or multimedia messages have a powerful role to play in reaching these different population segments. For example, communication materials aimed at changing attitudes and behaviours in relation to tobacco use can be tailored to different populations. Through the *Be he@lthy, be mobile* initiative, WHO and the International Telecommunication Union promote noncommunicable disease prevention using mobile technology.[22] There is extensive evidence that mobile phone-based support for smoking cessation is effective, and the initiative provides guidance on the development and deployment of national tobacco cessation programmes.[23]

In India, the National Tobacco Control Programme and the Ministry of Health and Family Welfare, with support from the *Be he@lthy, be mobile* initiative, implemented a tobacco cessation programme. Two-way mobile phone messaging between the individual seeking to quit and programme specialists provides dynamic support for those who wish to quit. The government has recently released a second version of the platform, which delivers the content through text messages or interactive voice responses in 12 languages. The programme's progress is monitored in real time through an online dashboard that records the number of registrations, disaggregated by factors such as gender, geography and type of tobacco use. To date, the programme has over 2.1 million self-registered users.[24] A *Be he@lthy, be mobile* handbook on the use of mobile technology for oral health is in development. Digital communications could also be deployed to break down barriers to visiting health-care providers, explain the benefits of early detection and remove the stigma about a diagnosis of oral cancer.

Digital communications also have an important role to play in addressing the urgent need to educate the public on the dangers associated with tobacco, areca-nut products and alcohol and on early signs of oral cancer. A particular focus of health promotion campaigns should be tackling the lack of understanding of the harsh realities of the harms associated with using tobacco and areca-nut products.

Positive policy environment

A conducive policy environment is essential for health systems to deliver the continuum of prevention, early detection and treatment initiatives that must be implemented if reductions in oral cancer morbidity and mortality are to be achieved. One key policy requirement is empowering and deploying front-line health workers to carry out screening. In addition, strong policies to reduce preventable risk behaviours are essential. These should be embedded within robust overall policies that promote and facilitate healthy lifestyle choices.

Tackling the tobacco epidemic is an urgent priority, since one in four smokers globally and more than 80% of the world's smokeless tobacco users reside in the WHO South-East Asia Region.[25] In 2008, WHO introduced a package of six evidence-based tobacco control demand reduction measures that have

been proven to reduce tobacco use and assist countries in fulfilling their obligations under the WHO Framework Convention on Tobacco Control (FCTC).[6] These measures, known as the MPOWER package, reflect one or more provisions of the framework: M, monitoring tobacco use and prevention policies; P, protecting people from tobacco smoke; O, offering help to quit tobacco use; W, warning about the dangers of tobacco; E, enforcing bans on tobacco advertising, promotion and sponsorship; and R, raising taxes on tobacco.[26] Countries in the WHO South-East Asia Region have achieved various levels of success in implementing the FCTC and the MPOWER package, but many challenges remain. These include the continued relative affordability of tobacco products, despite tax and price rises; use of multiple and diverse tobacco products; high use of smokeless tobacco; interference by the tobacco industry; the introduction of new tobacco products; and the accessibility of these products to young people. The PRACTICAL guidance for policy-makers was launched in 2017 to further accelerate the implementation of the WHO FCTC throughout the region.[27] As noted by the guidance, the tobacco industry is using the internet and social media to market its products in a powerful way. It is therefore worth considering how digital solutions can be exploited to support the policy measures recommended by the PRACTICAL guidance. For example, campaigns can help to generate public support for various tobacco control policies, such as smoke-free legislation and tobacco cessation, so social media and other digital platforms could be used strategically to counteract the tobacco industry's narrative.

Anticipated roadblocks and ways forward

Controlling oral cancer requires prevention measures that are focused on tobacco, areca-nut products and alcohol use and on early detection at the primary health-care level. Without organized prevention and early detection and treatment efforts, oral cancer will continue to be a dominant public health problem across the region. Efforts need to be made to improve the currently low levels of advocacy for visual oral examination and early detection efforts for the prevention of oral cancer. While programmes on maternal and child health and communicable diseases may continue to be the focus at the primary-care level, priorities are shifting towards noncommunicable diseases, and oral cancer must be included in policy planning. A key concept to communicate is the lead time gained through early detection of oral potentially malignant lesions and oral cancer. Equally important is the need to tackle tobacco and areca-nut product use among primary health-care workers, which detracts from health promotion activities.

Nevertheless, progress is being made in some parts of the region; this may serve as a model for others to adopt and adapt to their local circumstances. Such adaptations should consider the positively disruptive effects that digital technology may have for the much-needed acceleration of efforts to prevent and control oral cancer.

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BehavioR: a digital platform for prevention and management of behavioural addictions

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Abstract

Behavioural addictions have been identified as an emerging public health problem. The unprecedented pace of the digital revolution, resulting in an ever-increasing use of internet-based technologies, provides the opportunity to create a unique resource to assist in offering public health interventions in the World Health Organization South-East Asia Region. The ability to deliver evidence-based treatment and preventive programmes that can be accessed by mobile phones, for example, increases access to a wide range of populations, including hidden or hard-to-reach populations. BehavioR (the Behavioral addictions Resource hub) has been established with the aim of offering a one-stop resource centre for behavioural addictions. The expected end-users of this digital platform include patients, caregivers, the general public, health-care providers, academics, researchers and policy-makers. The platform can be used to offer digital health interventions to patients; strengthen the capacity of health-care providers for early detection of, screening for, intervention in and management of behavioural addictions; and serve as an online repository for reliable information on behavioural addictions for the general public.

Keywords: behavioural addictions, digital health, digital health interventions, gaming disorder

Behavioural addictions and digital interventions

In the 11th revision of the World Health Organization (WHO) *International Statistical Classification of Diseases and Related Health Problems* (ICD-11), the number of diagnosable addictive disorders that do not involve use of a psychoactive substance has increased from one to two.[1,2] The inclusion of gaming disorder in addition to gambling disorder in ICD-11 reflects and validates the growing concern regarding behavioural addictions as a major public health problem. Behavioural addictions are characterized by an irresistible urge, impulse or drive on the part of individuals to repeatedly engage in certain behaviours (not involving psychoactive substance use) that produce a feeling of transient euphoria or a high.[3] This is combined with a loss of control, that is, the inability to reduce or stop the behaviour despite its causing serious adverse consequences to the person's physical, psychological, social and/or financial well-being.[3] In addition to gaming disorder and gambling disorder, other behavioural addictions, for example internet addiction and compulsive buying, have been proposed and are being actively researched.[3]

There has been an exponential increase in the use of and ease of access to the internet worldwide, including in the WHO South-East Asia Region. Indeed, data show that some countries of the region are among the most digitally active worldwide. For example, in 2017, India and Indonesia were the countries with the second- and third-highest annual growths in the proportion of the population using social media, and Thailand had the highest average time per day spent on the internet worldwide.[4] The unprecedented pace of the digital revolution, resulting in an ever-increasing use of internet-based technologies, provides the opportunity to create a unique resource to assist in offering public health interventions in the region.

The World Health Assembly resolution WHA58.28 of 2005 defines eHealth as "the cost-effective and secure use of information and communications technologies in support of health and health-related fields, including health-care services, health surveillance, health literature, and health education, knowledge and research".[5] The *Third global survey on eHealth* identified it as one of the integral components that health-care systems would require to achieve the Sustainable Development Goals.[6] Recent WHO guidance emphasizes that digital technologies provide opportunities to strengthen health systems and can thus contribute to achieving universal health coverage.[7] Digital health interventions can target various stakeholders, including patients, health-care providers, and managers, resource managers and data service managers in health systems.[8]

The application of various digital and internet-based interventions has been shown to be feasible, acceptable and effective in the management of various noncommunicable diseases, such as diabetes and obesity, as well as mental health

disorders, such as depression, anxiety, bipolar disorder and substance use disorders.[9–12] Furthermore, there is promising evidence for the feasibility and effectiveness of delivering behavioural interventions to patients across different cultures and health-care settings using digital technology.[13] The use of digital platforms to deliver mental health interventions via mobile phones, computers or other hardware provides a unique opportunity to deliver evidence-based treatment and preventive programmes to a wide range of populations, including hidden or hard-to-reach populations. There are several advantages to using digital platforms to deliver mental health interventions, such as their ability to reach at-risk populations in remote locations with internet access, at any time of the day, without relying on costly and scarce mental health professionals.[14] In addition, these interventions can be easily scaled up in a cost-effective manner to address the rapidly increasing unmet mental health needs of the growing population of young people.[14]

Digital interventions, including online, text-messaging and telephone support interventions have been found to be effective in the treatment and prevention of mental disorders in low- and middle-income countries. While most studies to date have been preliminary evaluations,[14] they demonstrate that digital technology has been used for various types of interventions. Examples include technology for supporting clinical care and educating health workers, mobile tools for facilitating the diagnosis and detection of mental disorders, technology for promoting treatment adherence and supporting recovery, online self-help programmes for individuals with mental disorders, and programmes for prevention and treatment of substance misuse.[14]

BehavioR

BehavioR (the Behavioral addictions Resource hub)[15] is a new online resource that is being developed by the Behavioral Addictions Clinic at the All India Institute of Medical Sciences (AIIMS), New Delhi,[16] with support from the WHO Regional Office for South East Asia. The aim is to develop BehavioR into a digital platform that is a one-stop resource centre for behavioural addictions. The expected end-users include patients, caregivers, the general public, health-care providers, academics, researchers and policy-makers.

Potential BehavioR content for patients
The platform can be used to offer digital health interventions to patients, including online self-help interventions and internet technology-mediated therapy (online counselling). Another option is internet-operated therapeutic software, which uses advanced computer capabilities such as artificial intelligence principles for various intervention types. These include robotic simulation of therapists to engage in dialogue-based therapy with patients; rule-based expert systems, whereby algorithms enable tailored assessment, treatment selection and progress monitoring; and therapeutic gaming and three-dimensional virtual environments.[17] Web-based self-help interventions, including information- and education-based interventions, self-guided therapeutic interventions, human-supported therapeutic interventions and therapeutic education systems, have shown promise in treating mental and behavioural disorders,[18] and such interventions will be

developed for behavioural addictions as part of the BehavioR project.

Potential BehavioR content for health-care workers
In the WHO South-East Asia Region, the mental health-care workforce has been extremely limited, as evidenced by the large treatment gap, that is, the proportion of patients in need who are not receiving appropriate medical care. A 2004 WHO study estimated the gap to be between 76% and 85% for mental and neurological disorders in low- and middle-income countries; the corresponding range for high-income countries was 35–50%.[19] The WHO Mental Health Gap Action Programme (mhGAP) recommends training non-specialist health-care providers (primary care physicians and health-care workers) to deliver effective, evidence-based treatments at community level.[20] This could be achieved by building capacity among health-care providers at community level through the use of internet-based technology. It is envisaged that the BehavioR digital platform could be used to strengthen the capacity of health-care providers for early detection of, screening for, intervention in and management of behavioural addictions. The possible approaches include use of BehavioR as a learning management system and telemedicine-based learning platform.

Potential BehavioR content for researchers, policy-makers and the public
The BehavioR platform could also be developed further to provide information on the ongoing research into behavioural addictions, as well as the findings of such work. This would help to bring together up-to-date information for researchers, academics and policy-makers. In addition, the vast array of health content on the internet, of varying suitability and quality, can overwhelm people seeking help.[21] BehavioR could therefore also serve as an online repository for reliable information on behavioural addictions for the general public.

Current and future developments with regard to BehavioR

Recommendations on identification and management of behavioural addictions have been developed by the WHO Regional Office for South-East Asia and will be made available via the platform.[22] In addition, a basic online course on behavioural addictions involving internet use has been developed. Problematic internet use has been identified as an emerging problem among school pupils.[23–25] The basic online course on behavioural addictions involving internet use is intended to build the capacity of schoolteachers and school counsellors with regard to early identification and detection of, and intervention in, behavioural addictions involving internet use. The course is offered through a learning management system and uses video presentations, online quizzes, online assignments, a multimedia discussion board, group work, journal activity, suggested readings and online real-time face-to-face sessions. The course is offered over a 10-week period and is free of charge to the end-user. The participants are expected to invest around 90 minutes every week. The findings from the first batch of participants report a statistically significant increase in knowledge, skill and confidence in

relation to behavioural addictions involving internet use. There was a significant increase in capacity to screen, offer brief interventions and offer referral services for cases of behavioural addiction involving internet use.[26]

In conclusion, BehavioR is planned to be a digital platform that will serve as a resource hub for behavioural addictions. There is a need and vision for developing and strengthening the platform further in order to offer these resources more widely. This will help to address behavioural addictions comprehensively and effectively from a public health perspective.

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Gendered perceptions of physical activity and diabetes in rural Bangladesh: a qualitative study to inform mHealth and community mobilization interventions

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Abstract

Background Diabetes prevalence is increasing rapidly in Bangladesh, and there is an urgent need to promote preventive behaviours for type 2 diabetes, such as maintaining a healthy body weight, eating healthily, avoiding tobacco and being active for 150 minutes per week.

Methods We used a qualitative methodology informed by the capability, opportunity, motivation theory of behaviour change to explore the factors affecting physical activity among men and women in rural Bangladesh. We conducted semi-structured interviews and focus group discussions with 64 purposively sampled participants with and without diabetes, and five health workers. From the results of descriptive content analysis, we identified key capabilities, opportunities and motivations to engage with in our mHealth and community mobilization interventions.

Results Men and women without diabetes lacked awareness about the need to remain physically active to prevent diabetes, and most felt that their activity levels were sufficient. Housework was not commonly perceived as physical activity among all respondents. These knowledge and capability gaps could be addressed through mHealth messaging and community mobilization providing information on sufficiency and types of physical activity to prevent and control diabetes. Men were physically active while working outside the home, whereas women felt unsafe and conspicuous, and were constrained by family commitments and social expectations of appropriate behaviour. Women engaged in strategies to protect their own and their family's reputations. These opportunity factors affecting physical activity indicated the need for strategies developed through participatory processes to challenge unhealthy gender norms and increase women's safety.

Conclusion Formative research data can enable the development of contextually relevant interventions. Data show that mHealth interventions should consider gendered barriers to physical activity, tailoring information to meet men's and women's needs, and that community mobilization interventions should enable unhealthy, gendered community norms to be challenged. Participatory interventions can enable communities to push the boundaries of socially acceptable behaviours to increase physical activity, helping to prevent and control diabetes.

Keywords: Bangladesh, behaviour change, exercise, gender, noncommunicable diseases, physical activity, type 2 diabetes

Background

An estimated 422 million people worldwide have diabetes,[1] around 90% of whom have type 2 diabetes, which can be largely prevented by maintaining a healthy body weight, eating a healthy diet, avoiding tobacco and doing at least 150 minutes of moderate-intensity aerobic physical activity throughout the week.[2] In adults aged 18–64 years, physical activity includes leisure time physical activity (e.g. walking, dancing, gardening, hiking, swimming), transportation (e.g. walking or cycling), occupational activity (i.e. work), household chores, play, games, sports or planned exercise, in the context of daily, family and community activities.[2] An estimated 23% of the world's population are not meeting the minimum requirements for physical activity, and progress is particularly slow in low- and middle-income countries.[3,4] Diabetes prevalence is

increasing rapidly in Bangladesh, with levels expected to reach 23.6% in men and 33.5% in women by 2030,[5] and there is an urgent need to develop and test population-level interventions. Our research explored the factors affecting physical activity in rural Bangladesh to inform the development of interventions to prevent and control diabetes. We consider how gender interacts with these factors and make recommendations for the development of behaviour-change interventions.

Physical activity in Bangladesh

The gender differential in physical activity in Bangladesh has been well documented. Men are generally more active than women, and urban women are least likely to be sufficiently active.[6–8] Most physical activity occurs during work, or, for men, travelling to work.[9–11] Only a small proportion of men and women are physically active in their leisure time.[9] Gender differences are most evident in young and old people.[10,12] Studies largely concur with our recent epidemiological survey of adults aged 30 years and above in rural Bangladesh,[13] which found that men and women aged 30–39 years engaged in adequate physical activity but that physical activity decreased sooner and to a greater extent among women as they got older. Less than 30% of women aged 70 years or more maintained adequate levels of physical activity, compared with approximately 60% of men in the same age group. Few studies have explored the reasons for physical inactivity among adult men and women in Bangladesh.[14] A study of seven female and five male patients with diabetes attending a hospital in Dhaka found that time and place to exercise were barriers to physical activity.[15]

Gender and behaviour change

Gender is the socially constructed roles, behaviours, activities and attributes that a given society considers appropriate for men and women.[16] Gender inequalities limit men's and women's health in multiple ways. Women's unequal access to services and resources and their increased likelihood of being poor and being exposed to violence negatively affect their health, while cultures of masculinity that encourage risk taking are harmful to men's health.[17–19]

Health promotion strategies have been accused of focusing on individual behaviour change instead of addressing gendered, structural barriers.[20] Individual, skills-based and informational approaches to prevention and intervention are unlikely to be effective or sustained if they fail to create enabling community and familial contexts for men and women.[21] In Bangladesh, interventions should acknowledge that it is a patriarchal society, with patrilocal marital practices whereby women come under the guardianship of their husband's family after marriage.[22] Moreover, in Bangladesh, purdah (female seclusion) restricts women's freedom of movement and their access to public spaces. Women must behave appropriately, avoid attracting attention from men and uphold family honour. Norms about the division of labour within and outside the household, as well as norms about movement outside the household, are highly gendered.[23]

Our research partnership between the University College London Institute for Global Health and the Diabetic Association of Bangladesh conducted formative research to inform the development of two interventions that have been evaluated through a three arm cluster randomized controlled trial testing their effectiveness on noncommunicable disease risk factors, including lack of physical activity, overweight and obesity, and intermediate hyperglycaemia and diabetes.[24] One intervention was a mobile health (mHealth) intervention informed by the capability, opportunity, motivation theory of behaviour change (COM-B),[25,26] and the other was a group-based community mobilization intervention using participatory learning and action (PLA) cycles to promote healthy behaviours and transform communities.[27,28] Both approaches (COM-B and PLA) acknowledge the socially constructed nature of behaviours, social constraints on behaviour and the need to address these to enable behaviour change. We found that there was a 20% reduction in diabetes and intermediate hyperglycaemia prevalence and a 10% reduction in the 2-year cumulative incidence of diabetes among those with intermediate hyperglycaemia in the PLA arm versus the control arm. There was no effect of mHealth on the combined prevalence of intermediate hyperglycaemia and diabetes, or the incidence of diabetes.[29]

This paper reports on the pre-trial formative research to inform the development of PLA and mHealth interventions. We used a qualitative methodology to explore community and individual perceptions of diabetes and associated risk factors (including physical activity) with men and women with and without diabetes, and health workers, in rural Faridpur, in order to design contextually appropriate content and methods for the mHealth and PLA interventions.

Methods

Setting

The pre-trial formative phase took around 10 months, from September 2015, and the interventions were implemented from June 2016 to December 2017. The trial was conducted in four upazilas (subdistricts) of Faridpur district in central Bangladesh. Faridpur is around 2000 km² and has a population of over 1.7 million, with a mainly agricultural economy of jute and rice farming. Our baseline data show that the overall prevalence of intermediate hyperglycaemia and diabetes is 17.2% and 8.9% among men and 23.4% and 11.5% among women, respectively.[30] The population can access low-cost health services from the Diabetic Association of Bangladesh hospital in Faridpur district headquarters, but in rural areas remoteness and flooding affect access to services, and the quality of health services is variable. The population is mainly Bengali and almost 90% are Muslim.[31]

Sampling

We purposively sampled 21 women and 13 men who had been diagnosed with type 2 diabetes, and 15 women and 15 men who had not been diagnosed with type 2 diabetes, in villages in Boalmari, Nagarkhanda and Saltha upazilas (*n* = 64). We did not collect data in Madhukhali, the fourth upazila included in the trial, as it was socioeconomically and sociodemographically similar to other trial upazilas, and we had reached data saturation. We purposively sampled participants over the age of 30 years, as risk of diabetes increases with age. To explore barriers to behaviour change in diverse groups, we purposively sampled participants from better-off and poor households, estimated by observing participant house construction materials based on a classification used in previous studies.[32] This method allows purposive sampling in

a less intrusive way than asking directly about socioeconomic status.[33] We also purposively sampled five health workers from different upazilas who treated diabetes patients. The health workers were male, as there were very few female providers. Three were health workers who had received government-accredited diabetes training and worked in an upazila health complex, a family welfare centre and a local nongovernmental organization clinic. Two were male village doctors, also known as rural medical practitioners, who provided treatment and blood glucose testing through their private medicine shops. In Bangladesh, village doctors are unregistered and unregulated. Although some may have received some training on common illnesses such as diarrhoea, fever, cough and cold,[34] the village doctors in this study had not received any training on diabetes treatment and referral.

Data collection

Participants with and without diabetes were approached in their homes, and health workers in their workplaces, by a trained, experienced Bangladeshi female qualitative researcher (KAk) and invited to participate. KAk conducted all the data collection in Bangla. The research team was not familiar with the villages and therefore KAk used snowball sampling to locate people with diabetes. The data collection is summarized in Table 1. Semi-structured interviews with six people with diabetes (three men and three women), and five people without diabetes (three women and two men), were conducted in or around their homes to explore their personal experiences of diabetes and risk factors. Care-seeking for diabetes and risk factors was explored in semi-structured interviews with five health workers. These interviews were conducted in their workplaces. Focus group discussions were conducted with five groups of people with diabetes (three groups of women and two groups of men) and four groups of people without diabetes (two groups of men and two groups of women) to explore community perceptions of diabetes and risk factors. Focus group discussions were conducted at a place of convenience for participants, in or around a participant's home. No one refused to participate.

Informed written or thumb-print consent was taken from all participants. Thumb-print consent is usual in this context, where there are high levels of illiteracy, and this procedure was approved by both ethics committees. The COM-B theory

Table 1. Data collection

Respondents	Method	Number of interviews or discussions	Number of participants
Women without diabetes	SSI	3	3
	FGD	2	12
Men without diabetes	SSI	2	2
	FGD	2	13
Women with diabetes	SSI	3	3
	FGD	3	18
Men with diabetes	SSI	3	3
	FGD	2	10
Health workers	SSI	5	5
Total		25	69

FGD: focus group discussion; SSI: semi-structured interview.

of behaviour change was used in the development of topic guides, which explored the factors affecting participants' ability to carry out the WHO recommended behaviours to prevent and control diabetes. The topic guides were developed in English in discussion with KAk and the research team (the coauthors of this paper), translated into Bangla, and piloted by KAk in a suburb of Dhaka with two participants without diabetes (one woman and one man) and one health worker, and with one woman with diabetes at the Bangladesh Institute of Research and Rehabilitation in Diabetes, Endocrine and Metabolic Disorders hospital in Dhaka; these participants were not included in the subsequent study.

Data management and analysis

Data were digitally recorded and directly translated into English for analysis by trained and experienced translators, who were not part of the research team. Sections of transcripts were back-translated by KAk and checked against the recordings. KAk, HJ and JM conducted preliminary analysis while data collection was ongoing. When themes were recurring, data collection ceased.

Three researchers (JM, HJ and KAk) conducted descriptive content analysis.[35] KAk and HJ spoke English and Bangla, and all three were familiar with the south Asian context. We familiarized ourselves with the data, independently made lists of emergent themes and then discussed these together. We presented and discussed themes with the research team before finalizing the coding structure and coding transcripts in NVivo qualitative data analysis software (QSR International Pty Ltd, Version 11, 2015). Data were tabulated to compare barriers to and enablers of healthy behaviours within and among transcripts, and to compare data from participants of different genders and diabetes statuses. We then used the COM-B framework to analyse capability, opportunity and motivational domains that could be addressed in our interventions.

Development of recommendations for mHealth and community mobilization interventions

The mHealth intervention provided voice messages to mobile phone users who had voluntarily consented to receive the messages. We sought to make the messages contextually relevant and to ensure that they addressed barriers to healthy behaviours. The process of developing content for the mHealth intervention was informed by French et al.[36] and is detailed elsewhere.[26] HJ, JM and KAk participated in six steps to develop recommendations: (i) analysing the context of the intervention; (ii) detailing the intended outcomes and focus areas (based on the risk factors for diabetes – care-seeking, diet, physical activity, smoking and stress); (iii) listing enablers and barriers; (iv) categorizing these enablers and barriers according to COM-B; (v) suggesting relevant and feasible approaches for each barrier and (vi) producing a table of message content.

The PLA intervention used a paid group facilitator to stimulate discussion following a manual. Community members plan and implement locally prioritized actions on the basis of group and community discussions.[37] We followed a similar process of recommendation development as for the mHealth intervention, but, instead of producing a table of message content, we developed example strategies to insert in the manual and use in training and supporting group facilitators.

Ethical approval

All procedures performed in this study were approved by the University College London Research Ethics Committee (4766/002) and the Ethical Review Committee of the Diabetic Association of Bangladesh (BADAS-ERC/EC/t5100246).

Results

We identified three main themes in our data relating to gendered definitions of physical activity, and to cultural and structural barriers restricting women's movement outside the home and restricting the type of physical activity that men and women felt they could undertake. Following the presentation of these themes, we describe how the interventions were informed by our findings.

Gendered definitions of physical activity

More participants with than without diabetes were aware that they should be physically active, to control their diabetes and their weight. Walking and working were the most common forms of physical activity for men with diabetes. Swimming was not considered to be physical activity by men or women and was perceived instead to refresh the body. Women considered praying and walking to be physical activity, and a routine of exercise signified discipline, moderation and religious commitment, which resulted in good health.

> People who work diligently keep themselves healthy. If people ignore their work, they will become ill … If someone is ill, then they need to work diligently and do their daily prayers, then they will be fine. (focus group discussion 021, women with diabetes)

Participants without diabetes felt sufficiently active in their everyday work or daily activities, and believed that only those with diabetes, high blood pressure or overweight needed to exercise. Women worked in their homes but did not necessarily define this as physical activity. One woman without diabetes said:

> No, I don't do any kind of physical exercise ... I am usually busy doing housework like sweeping the floor or washing clothes. These are my activities. (semi-structured interview 027, woman without diabetes)

Men without diabetes described walking or cycling to work, and walking during work, as well as the work itself as physical activity.

> The work we do for our living is enough exercise. I think we do not need to do anything else for the sake of exercise. (focus group discussion 024, men without diabetes)

"Moving carefully"

All respondents discussed the social acceptability of women walking or doing other physical activity outside their homes. Women with diabetes discussed the need to protect their reputation and that of their family when going outside their homes.

> She should move carefully … in a village [a wife's movement] affects family honour and people criticize her and her family … people will ask, "Where are you going so early?" (focus group discussion 029, women with diabetes)

A common perception was that women should not be outside the home unaccompanied and without purpose.

> We don't usually go anywhere for an outing. I only go to places where I need to go. Like I have to take my daughter to the teacher's house for her tuition. (focus group discussion 012, women without diabetes)

Several men (including one male health worker) suggested that the places where men walked were unsuitable for women. Because women's work tended to be at home, it was more difficult to integrate physical activity into their daily activities, and they felt exposed when they went out walking.

Women with diabetes dealt with this conspicuousness by walking when they would not be seen.

> I usually follow the doctor's suggestions about exercise in the early morning when there is no one in the road. I feel shy to do this in front of other people. (semi-structured interview 025, woman with diabetes)

Women with diabetes revealed that they dealt with the "fear of public disgrace" by not walking in the road. Others preferred to walk when men were not present.

> If there are no men in the road, everyone likes walking, it's good to feel the breeze. (focus group discussion 011, women with diabetes)

Most women with diabetes preferred walking in groups; they felt safer and more motivated, and they enjoyed the exercise.

> Yes, open space is good for us, but only if other people are there too. It does not feel good being there alone. (focus group discussion 021, women with diabetes)

Women reported that it was considered inappropriate for them to walk on muddy roads and that they were afraid of slipping.

Time poverty and gendered responsibilities

Women with diabetes felt "too busy" to exercise, particularly in the morning, when it was more socially acceptable to exercise. A male health worker said:

> It is easier for men because they have less work to do in the morning than women. After the morning prayers men can go for 40–60-minute walk, but women are generally busy doing housework or making breakfast. Because they are busy, they can't walk or do any kind of physical exercise. (semi-structured interview 009, health worker)

When their housework and family responsibilities increased, women with diabetes stopped walking. Men found it easier to

prioritize exercise, whereas women were expected to prioritize their families.

> A man thinks about his body before anything, but women don't have time to do this. (semi-structured interview 010, health worker)

One woman gave an example of how it was difficult to exercise and look after the family:

> One day I left rice to cook in the rice cooker and then I set out to walk … but the electricity went off just after I left, so the rice wasn't cooked and I was late sending the rice to the field. My husband scolded me, and I haven't walked since then. (semi-structured interview 004, woman with diabetes)

Social acceptability prevented men and women from participating in sports. Many men used to play football, cricket or hadudu when they were younger but, as they aged, they perceived sport to be a futile and inappropriate use of time.

> I have my own business now, so it's hard to find time for sports. The young guys have enough time for that. (focus group discussion 014, men without diabetes)

It wasn't socially acceptable for women to participate in sports, particularly in rural areas. One woman said:

> I used to play badminton with my son or daughter or other kids when we were living in Dhaka. But the environment to play here doesn't exist. (focus group discussion 029, women with diabetes)

Table 2 describes how interventions could address capability, opportunity and motivational barriers to behaviour change relating to physical activity.

Discussion

Our study highlights the importance of having a gendered, contextual understanding of health-related behaviours. We discuss how interventions could address the key capabilities, opportunities and motivations to promote physical activity.

Capability

Capability refers to the knowledge (psychological capability) or skills (physical capability) required to do the recommended behaviour. Our study, and others,[38,39] found that participants without diabetes lacked knowledge that physical activity could prevent diabetes, and believed that only people with diabetes needed to do "extra" physical activity. mHealth messages could increase knowledge about the need to exercise for diabetes prevention, and increase understanding among people with and without diabetes about what is sufficient exercise to prevent diabetes. PLA interventions could discuss this information through open questions such as "How do

Table 2. Barriers to healthy behaviours and implications for interventions

Barriers to healthy behaviours	Suggestions for what group-based interventions could do	Suggestions for what mHealth messages could provide
Capability • Perceptions of leisure time physical activity as just for people with diabetes and disciplined men • Existing levels of physical activity among people without diabetes are perceived sufficient to stay healthy	*Engage communities* • Raise awareness among men and women of the need to be physically active, through public events and family discussions • Provide information on risk factors and prevention • Integrate specific information regarding sufficiency of physical activity for health	• Information about risk factors, prevention, and sufficiency of physical activity in daily tasks
Opportunity • Lack of appropriate places to walk for women • Women are perceived as not prioritizing their family and are suspected of dishonour if physically active • Women do not feel safe to walk unaccompanied and in the same space as men • Sports perceived as only for younger men with free time • Walking perceived as the pursuit of disciplined men • Women work at home and therefore have limited opportunities for physical activity while travelling to work	*Engage community leaders* • To improve facilities and safety for women • To challenge harmful gender norms • To lead on behaviour change, including walking at different times of the day to emphasize variation in routine as acceptable *Engage men, women and families* • Encourage men and women to challenge gender norms, providing particular support to women to be physically active • Encourage walking in groups • Encourage families to ensure time is managed for women to be physically active • Conduct participatory mapping of places to walk • Raise awareness among men and women of the need to be physically active, through public events and family discussions	• Information and examples of home-based physical activity • Information and examples of how women and men can challenge gender norms • Encouragement to women to seek support from family and friends when engaging in physical activity • Examples of "normal" men and women who have busy and/or erratic lifestyles but are able to integrate physical activity into their lives • Examples of role models in the form of men and women doing physical activity while travelling to work
Motivation • Perceived lack of control over diabetes and health	*Engage communities* • Raise awareness about prevention and control of diabetes • Encourage active ageing for men and women through families	• Information about strategies to prevent and control diabetes • Examples of role models in the form of active men and women who are in older age brackets

you know when you have done enough exercise?" and discuss how information about the need for physical activity, and sufficiency of physical activity, can be disseminated and further understood. This could include discussion with non-group members or implementing public physical activity events. Farming, physical labour and housework are all forms of physical activity,[2] but the last was not often recognized as such. Messaging could equip women and men with the skills to estimate the sufficiency of their physical activity to prevent or control diabetes in relation to the exercise that they normally do, while going beyond reinforcement of gendered constructs of women as caregivers doing household work and men as doing work outside the home.[40]

Opportunity

Opportunity refers to social influences, environmental context and resources that constrain or enable recommended behaviours. Key elements of this domain were socially endorsed behaviours, time poverty and the gendered division of labour, and safety and social change.

Socially endorsed behaviours

Some women identified features of the external environment, such as muddy roads and uneven paths, as preventing them from being physically active. They feared falling over and the resultant embarrassment. PLA interventions could invite groups and communities to map and assess community spaces for physical activity, considering their suitability and sufficiency, and take action to improve these spaces if necessary. PLA interventions could also encourage communities to address local norms about appropriate behaviour, through dialogue or through engaging with community leaders. The need to behave appropriately curtailed physical activity in both men and women. Dominant perceptions of walking as being practised by disciplined men only, and sports as an activity for young men, restricted physical activity. mHealth messages could provide examples of older, "normal" men and women, illustrating how they cope with or seek to change established social rules.

Time poverty

Advice about physical activity should acknowledge the different time constraints and daily routines of men and women, and the gendered division of labour.[41–43] Men were more likely to do manual work outside the home than women, and it would be easier for men than women to increase their physical activity within their daily routines. We found that health workers often advised walking as a form of physical activity, without acknowledging that this was particularly difficult for women or those with a high workload. Giving advice that cannot be followed may induce guilt or stress,[18,44] and interventions should emphasize the important role of family and community social support in behaviour change.[45] PLA interventions could engage with health workers to encourage them to be mindful of gender issues when giving advice. PLA interventions could also ensure that members of the wider family are made aware of their role in enabling physical activity for all family members, whether by accompanying female family members to enable them to exercise outside the home or by allocating time for physical activity within the household. mHealth messages could provide examples of feasible and acceptable physical activity for both men and women.

Safety and social change

Purdah affected women's physical activity. Women were concerned about their own safety and engaged in strategies to protect their family's reputation and protect themselves. They walked in groups, they walked at times when others couldn't see them or when men were not around, and they walked in private places or in open spaces depending on which they perceived to be safer. A national survey on gender-based violence in 2015 found that 73% of married women had experienced violence from their husband in their lifetime and 55% had experienced violence in the past year. Twenty-eight per cent of women had experienced non-partner violence.[46] PLA and mHealth messaging could encourage women to walk in groups and invite communities to develop strategies to reduce gender-based violence to increase physical activity.

Men and women may make strategic choices not to challenge community and household norms to control or prevent diabetes.[47] They may seek to avoid retribution or be influenced by adaptive preferences[48] that legitimize women's restricted opportunities, and shape how men and women engage in and evaluate social change.[49] While transformation of harmful norms is necessary, incremental change in gender norms through engaging with men, families, communities and local power structures may be a safer option for many women and families. PLA approaches can enable women and men to push the boundaries of what is socially acceptable to the extent that they are comfortable and challenge social norms as a group.[50]

Motivation

Motivation refers to the brain processes that energize and direct behaviour.[51] Many participants with diabetes felt incapable of controlling their diabetes and unable to maintain a routine of exercise. Increased awareness about the possibilities for integrating exercise into everyday activities would help develop confidence and capability. Women's caring and household management role and men's role as economic provider were important to their identities,[52,53] and we found that they prioritized these roles. Interventions should recognize the effect of diabetes and ageing on self-esteem, and support men and women to feel more in control of their health as they age. This could be facilitated by using positive role models in mHealth messages, and by implementing locally defined community and family actions to encourage older adults to be physically active.

Limitations

Gender is embodied in institutions, policies and systems, and we did not engage adequately with these in our study. All the researchers leading the study design, developing the topic guides, collecting data, and carrying out the preliminary analysis and interpretation of the data were women. We addressed the potential bias resulting from this by presenting and discussing the research with the mixed-gender trial research team, after piloting and during the initial and latter stages of data analysis. The gender of the researcher may have affected the willingness of men to disclose information.

Conclusion

To inform the development of interventions to promote physical activity and to prevent and control diabetes, it is important to consider the contextual influences on physical activity and

how they are experienced by different genders. Our research has highlighted key capabilities, opportunities and motivations that could be addressed through interventions. Community-based groups working through PLA cycles and mHealth messaging may improve knowledge and motivation to change behaviour, as well as enabling engagement with community or opportunity barriers to behaviour change. Messaging and groups have been designed to stimulate discussion about locally appropriate action to challenge unhealthy, gendered norms, and to promote contextually relevant physical activity. Interventions seeking to encourage community-wide efforts to increase women's safety, work towards gender equality and challenge negative concepts of masculinity will have multiple benefits, not least in increasing men's and women's ability to be physically active to prevent and control diabetes.

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Measuring outcomes of hypertension treatment in primary care in resource-limited settings

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Cardiovascular disease is the leading global cause of death,[1] and hypertension is one of the major risk factors for cardiovascular disease.[2] Approximately 80% of the attributable burden of hypertension is in low- and middle-income countries.[3] The health systems in these countries are often under strain because of limited financial resources and historically have prioritized maternal and child health and infectious diseases over noncommunicable diseases and their risk factors, such as hypertension.[4]

Data from low- and middle-income countries on trends in population blood pressure distribution and on hypertension prevalence, awareness, treatment and control in representative populations over time are scarce owing to a lack of active surveillance and to poor follow-up mechanisms.[5] A meta-analysis estimates that about 33% of urban and 25% of rural Indians have hypertension, and that only 25% of rural and 42% of urban Indians are aware of their hypertensive status; only 25% of rural and 38% of urban Indians with hypertension are being treated, with blood-pressure control occurring in only 11% of the rural and 20% of the urban Indian hypertensive population.[6] In India, the National Program for Prevention and Control of Cancer, Diabetes, Cardiovascular Disease and Stroke advocates screening of individuals aged more than 30 years for hypertension, as well as free treatment for patients with a confirmed diagnosis and monitoring of treatment outcomes.[7] However, currently, health facilities are reporting only the number of patients diagnosed and initiated on treatment, and there is no proper system of follow-up for long-term monitoring of patients' disease status.[8]

Control rates, follow-up rates and complication rates are the recommended indicators for monitoring treatment of hypertension. There is a need for a system to integrate these indicators into routine reporting by primary health centres. A good monitoring system should be simple and aligned with routinely generated data. In 2016, the World Health Organization (WHO) launched the HEARTS technical package for cardiovascular disease management in primary health care.[9] The HEARTS technical package comprises six modules and an implementation guide to strengthen cardiovascular disease management in primary care; it is aligned with the WHO *Package of essential noncommunicable disease interventions for primary health care in low-resource settings*.[10] The HEARTS technical package provides guidance on outlining clear roles for health-care workers (team-based care); incorporating processes for ensuring access to core medicines and technology (access to essential medicines and

technology); strengthening referral mechanisms to secondary and tertiary levels of care (evidence-based treatment protocols); and developing patient monitoring systems and preparing for future impact evaluations based on patient outcomes (systems for monitoring). Indicators recommended by HEARTS for monitoring hypertension include treatment initiation rate, control rate, cumulative control rate, follow-up examination rate and complications rate.[11] According to the HEARTS technical package, patients' hypertension control should be recorded at a post-registration time point of 6–9 months, depending on the local context, and then annually thereafter. Health facilities should produce quarterly reports on the proportion of patients whose blood pressure is controlled at 6–9 months and annually after treatment initiation.

This letter reports on a simple tool for calculating indicators for monitoring hypertension, which is based on the treatment card suggested by HEARTS. The tool was used to estimate the control rates of patients with hypertension attending an urban clinic. The aim of the letter is to provide information on the feasibility of tracking hypertension treatment, control and follow-up rates in low-resource settings using existing resources.

Developing the tool

A tool was created in Microsoft Excel containing the variables required to generate hypertension indicators and other variables.[12] Patients' data are to be entered at the time of registration and on follow-up visits. At the time of registration, patients' identification, demographic and clinical history details are to be entered from the data source, which could be a treatment card or noncommunicable disease register. Systolic blood pressure and diastolic blood pressure, collected at monthly visits, and information on the occurrence of new complications are entered in separate columns. If the blood-pressure data for a patient are not available for a particular month, then "999" is entered. Data entry errors, such as improper cell references, were expected to be a major problem for this Excel-based tool. Therefore, precautions were taken to restrict erroneous data entry; editing of cells, rows, columns and sheets was disabled and only numbers could be entered in the columns recording blood pressure.

Longitudinal records of the hypertension control status of individual patients can be stored for many years. In addition, facility-level reports showing 3-month, 6-month and annual control rates and rates of loss to follow-up can be generated

automatically. The tool also makes it possible to calculate annual complication rates for coronary artery disease, stroke, nephropathy, retinopathy and lower limb amputation.

Testing the tool

Data from patients attending the Jawaharlal Institute of Postgraduate Medical Education and Research (JIPMER) Urban Health Centre in Pondicherry were used. The centre is run by the Department of Preventive and Social Medicine, JIPMER, Puducherry, India. It provides holistic care to around 9000 people in four urban wards. The centre's workforce comprises a medical officer, senior resident, junior residents, interns and other health-care providers, as per the Indian Public Health Standards for primary health centres.[13] There is a dedicated weekly noncommunicable disease clinic that offers consultation, investigation and free pharmacological and non-pharmacological treatment to registered patients. Patients' blood pressure is measured and recorded at every visit. Patient-related data are collected at the facility as a routine activity and are also routinely collated to generate reports to be sent to the higher level. Consequently, ethical clearance was not required to collect the relevant data. However, strict confidentiality was maintained and all personal identifiers were stripped out before analysis.

Data from patients who were on treatment for hypertension from January to July 2017 were entered into the Excel tool and outcome indicators were calculated. The control rate was defined as the proportion of patients registered with the facility for treatment of hypertension with blood pressure lower than 140/90 mm Hg. For the purposes of this test, facility control rates were calculated at 3 and 6 months after treatment initiation; loss to follow-up rates were defined as the proportion of patients who did not report to the facility for monitoring at 3 months and at 6 months. Data on complications were not available. Of the 343 patients in treatment for hypertension, blood pressure control rates were 55.1% and 49.6% at 3 months and at 6 months respectively. Loss to follow-up rates were 19.0% and 19.2% at 3 months and at 6 months respectively.

Discussion

To supplement the paper-based systems common in low-resource settings, there is a need for a computerized system for recording patients' data longitudinally. For India, phasing in of digital health records is planned for the health and wellness centres under the Ayushman Bharat initiative; these records will be interoperable with the overall eHealth architectures planned at the state and national levels.[14] It is important that the tool is simple, so that anyone with a basic knowledge of computers can be trained to enter the data, which can then be used to monitor the outcomes of treatment at a health facility. Since this tool also displays the control status of each patient, it will help with the management of individual cases. As the data are stored in Excel, a text message reminder service can be introduced. This should reduce loss to follow-up and increase compliance. Since the tool makes it easy to generate indicator data for monitoring hypertension, comparisons can be made among multiple facilities. The tool can also be used

to track the performance of a facility over a period of time and can be integrated with the monthly reporting mechanisms at a primary health centre. The current tool offers the option to record indicators for monitoring blood glucose and lipids. We have demonstrated the utility of the hypertension component of the tool, but there is clearly scope to expand the tool for holistic monitoring of other noncommunicable diseases in a primary health-care setting.

However, since the data source may be a treatment card, it is crucial that the treatment card is properly filled in and regularly updated. Ideally, for proper tracking of patients, the treatment card should be kept in the health facility, so that data can be entered into the computerized system at regular intervals. This will also help in identifying patients who do not return for follow-up visits. Data input errors are likely to happen, and therefore care with data entry and the implementation of a checking process are essential.

A lack of computers poses a challenge to the successful implementation of this tool in resource-poor settings. In addition, it is anticipated that patients may move from one facility to another in seeking treatment for noncommunicable diseases. Therefore, there should be strong linkages between health facilities to ensure that patients can be identified using unique numbers. Nevertheless, all the countries in the WHO South-East Asia Region have at least begun to move towards using electronic health records and digital health systems. Appropriate digital solutions are needed in different contexts, and this tool is an example of a means of bridging the paper-to-electronic transition.

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Follow-up data on patent expiry and atorvastatin price: experiences in Brunei Darussalam, Malaysia, the Philippines and Thailand

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We wish to follow up on our paper "Pricing policies for generic medicines in Australia, New Zealand, the Republic of Korea and Singapore: patent expiry and influence on atorvastatin price", published in the September 2018 edition of this journal.[1] This paper examined the price per defined daily dose (DDD) of atorvastatin supplied in four countries of the World Health Organization (WHO) Western Pacific Region (Australia, New Zealand, Republic of Korea and Singapore) in the years before and after atorvastatin's patent expired in each country. It reported that atorvastatin prices, converted to international dollars, fell in all of these countries in the years after patent expiry; however, there was a large variation in prices throughout the study period. At the end of the study (2014/2015), New Zealand's tendering system and use of preferred medicines had resulted in the lowest price per DDD for atorvastatin ($0.03). By contrast, mandatory price cuts as the sole measure in the Republic of Korea resulted in a price of $1.15 per DDD.

Since publication of that paper, data have been received from an additional four countries: Brunei Darussalam, Malaysia, the Philippines and Thailand. Atorvastatin's patent expired in the Philippines in 2008; however, no pricing data were available for the years before that. Generic atorvastatin became available in Thailand in 2010. No patent was ever in place for atorvastatin in Brunei Darussalam, and no patent data were available for Malaysia. However, it was possible to compare the price per DDD of atorvastatin, converted to international dollars,[1] for the period 2006–2015 (see Fig. 1).

Fig. 1. Annual price of atorvastatin (international dollars) per defined daily dose supplied or sold in Brunei Darussalam, Malaysia, the Philippines and Thailand

Data were not available for Thailand for the years 2008–2010. The year of generic entry was 2008 in the Philippines and 2010 in Thailand. For Brunei Darussalam, no patent was ever in place; for Malaysia, no patent data were available.
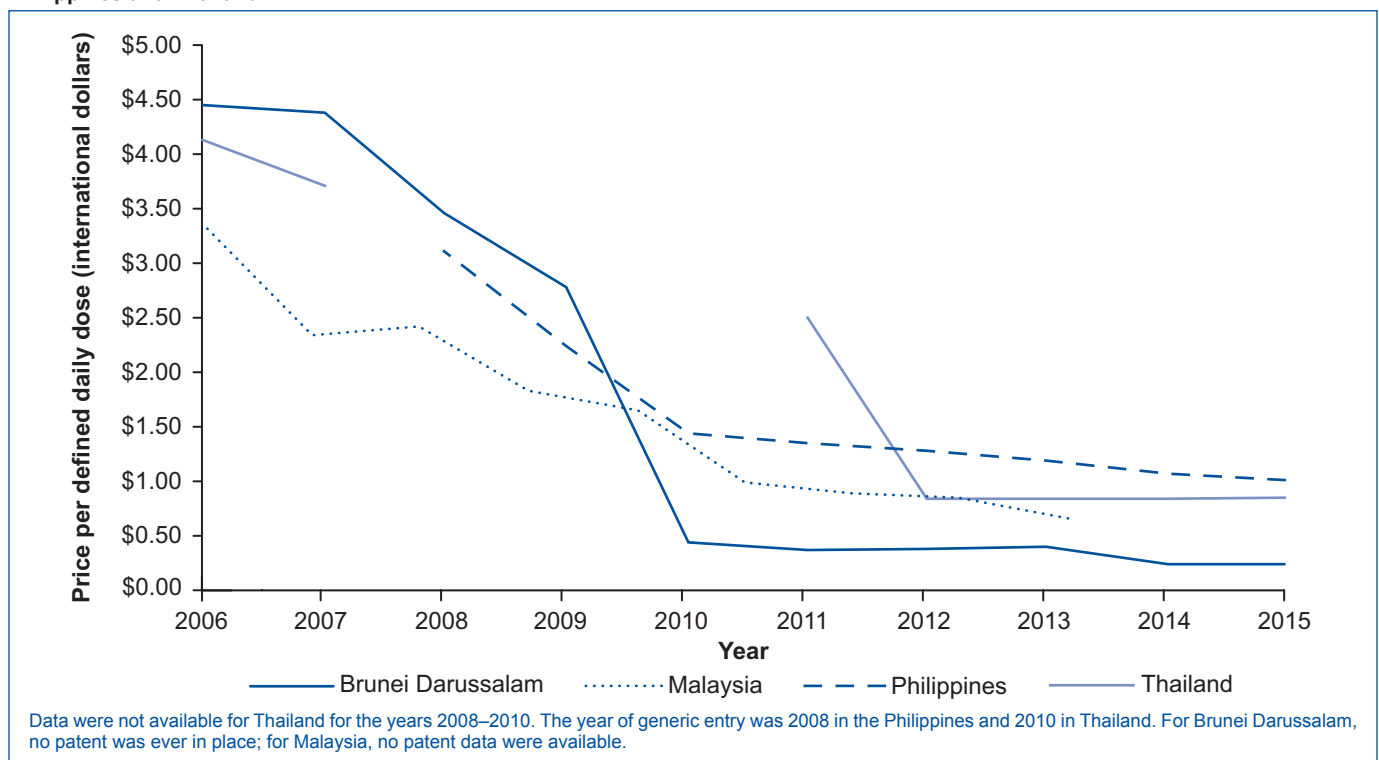
Pricing policies differ across the countries. In Brunei Darussalam, free pricing is used, and manufacturers are able to set their own prices.[2] Competitive tender procurement is used in Malaysia.[3] A variety of price regulations are employed in the Philippines and Thailand. In 2008 and 2009, the Government of the Philippines subjected five medicines (including atorvastatin) to mandatory price control (i.e. a maximum drug retail price, or MDRP), which cut the retail prices of those medicines by half. A voluntary drug price-reduction scheme was also introduced for 24 drugs from several manufacturers (i.e. a government-mediated access price, or GMAP). Both the MDRP and the GMAP are implemented across the market to control the retail prices of medicines sold to patients. The wholesale procurement prices of all essential medicines procured through government tenders and public hospitals is controlled through the Drug Price Reference Index.[4,5] For government tenders, drug prices are negotiated when products are from a single source and/or patented. The prices of other medicines are currently negotiated between suppliers and manufacturers, although new price reviews are currently under way.[4] In the Thai public sector, price ceilings are in place and hospitals negotiate prices with manufacturers.[2,6,7] Since 2012, changes to the essential medicines list have encouraged greater competition between pharmaceutical companies and increased manufacture and import of generic medicines. The prices of private sector medicines are not regulated in Malaysia or Thailand.[2,3]

At the end of the study period, the price per DDD for atorvastatin was $0.24 in Brunei Darussalam, $0.66 in Malaysia, $1.07 in the Philippines and $0.84 in Thailand. All have decreased substantially in price since data first became available: 95% in Brunei Darussalam, 80% in Malaysia, 68% in the Philippines and 79% in Thailand. While prices fell substantially in the four countries over the study period, there remained a wide price variation at the end of the study, with the Philippines paying a little over four times more than Brunei Darussalam in 2015.

It is not clear why recent atorvastatin prices were lower in Brunei Darussalam than in the other countries. It might be expected that Brunei Darussalam's small population and free pricing policy would lead to higher prices, although the historical absence of an atorvastatin patent might be expected to have the opposite effect. One possible explanation for the low prices is the combination of public sector dominance and free pricing. The public sector in Brunei Darussalam pays for 90% of pharmaceutical expenditure, compared with only 15% in the Philippines.[2] Although manufacturers are free to set their own prices, there is likely to be strong price competition to supply the public sector.

When compared with the prices in the higher-income countries reported in the previous paper, the prices in the four countries reported here were also high (see Table 1). Prices were compared for 2014, which was the last year of comparable data for all countries. The price in the Philippines was 30-fold higher than in New Zealand, 3-fold higher than in Australia and 2-fold higher than in Singapore. Malaysia's price was 20-fold higher than New Zealand's, double that of Australia and 1.4-

Table 1. Price of atorvastatin per defined daily dose supplied, by country

Country	2014 price (international dollars)
Australia	0.28
Brunei Darussalam	0.24
Malaysia	0.66
New Zealand	0.03
Philippines	1.07
Republic of Korea	1.15
Singapore	0.47
Thailand	0.84

fold higher than Singapore's price. The lower-income countries in this study are paying a higher price per DDD of atorvastatin than the higher-income countries, suggesting that there is still room for improvement in pricing policy in these countries.

Ethics approval was not deemed necessary for this study.

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