



Leveraging Technology to Enable Effective Preventive Screening of NCDs at Population Scale: Initial Observations

Sunita Nadhamuni^{1*}, Garima Gupta², Ramdas Mullath¹ and Sruti Sridhar¹

Abstract | India is undergoing an epidemiological transition to non-communicable diseases (NCDs), with NCDs contributing to nearly 60 percent of all deaths in India. NCDs are challenging to manage given their silent onset, low health awareness, significant informational asymmetry, and low health-seeking behavior among the rural population and the poor in India. The Ministry of Health and Family Welfare (MoHFW), Government of India, launched Ayushman Bharat to move from a sectoral and segmented approach of health service delivery to a more comprehensive one. As part of this effort, a program was launched for population-based screening (PBS) and management of five common NCDs—hypertension, diabetes, oral, breast, and cervical cancers. The success of the program, among other things, will be determined largely by the early detection, timely treatment, and diligent follow-ups to manage the five NCDs. In line with WHO's *Global action plan for the prevention and control of NCDs 2013–2020*, India is the first country to develop specific national targets and indicators aimed at reducing the number of global premature deaths from NCDs by 25% by 2025. However, challenges like human resource shortfall, limited capacities of the health workers, heavy burden of managing multiple health priorities, and poor utilization of public health facilities may affect the outcomes of this ambitious initiative. Technology can serve as an enabler in solving some of these problems. Dell Technologies and Tata Trusts have partnered with the Ministry of Health and Family Welfare, Government of India, to develop a technology solution for the PBS NCD initiative. It consists of a suite of mobile and web apps on a cloud platform for health workers, doctors, and health administrators to enable care delivery for people across the country. The solution has been deployed in states across the country with adoption gaining momentum amongst health care providers. While early process indicators are encouraging, it is important to examine individual clinical outcomes, population outcomes and cost effectiveness which are the primary objectives of such a program. The learnings from this digital health program can then be transposed to similar healthcare settings. The paper covers four challenges commonly encountered in the context of running large-scale digital health programs in a multi-state, multi-facility, and multi-stakeholder system. These are adoption of

¹ Dell Technologies, Bengaluru, Karnataka, India.

² National Health Systems Resource Center, New Delhi, India.

*sunita.nadhamuni@dell.com

technology by health workers with low digital literacy, feasibility of running tech solutions in remote areas, value proposition of the solution for users and finally the know-how on building and rolling-out technology at scale to reach millions of people.

1 Introduction

India, like the rest of the world, has been going through an epidemiological transition with growing burden of non-communicable diseases (NCDs) like heart diseases, cancers, and stroke over the last couple of decades.^{1,2} Nearly 60 percent of all deaths in India today are due to NCDs with one in every four Indians at risk of dying of an NCD before reaching the age of 70.³

The socio-economic impact of NCDs in developing economies can be large; it is estimated that NCD-related loss amounted to approximately 4% of the GDP in developing countries.⁴ The financial burden of NCDs is significantly high on the poor.^{5,6} High out-of-pocket expenditure along with loss of productivity due to disability and reduction of income can be catastrophic for many households.^{4,7}

NCDs are challenging to manage because of three key reasons. First, their onset is silent and people are often diagnosed at advanced stages of these diseases, when the outcomes are life threatening.^{8–10} They are chronic and conditions like hypertension and diabetes mellitus require management for life involving lifestyle changes, adherence to medication regimen, and diligent follow-ups. Third, the poor are disproportionately impacted due to an elevated risk of NCDs and their risk factors. The problem is compounded because of gaps in public health infrastructure, low awareness on NCDs, and weak health-seeking behavior amongst the poor. But these are certainly not insurmountable. India had its own public health success stories under similar contexts—polio eradication has been achieved overcoming these resource shortages.

The globally accepted strategy for NCDs is to undertake proactive and preventive screening of individuals to detect the disease in its early stages, reduce risk exposure and finally manage the disease with right treatment and regular follow-ups.¹¹

In line with WHO's Global action plan for the prevention and control of NCDs 2013–2020, India is the first country to develop specific national targets and indicators aimed at reducing the number of global premature deaths from NCDs by 25% by 2025.¹² In India, the Ministry of

Health and Family Welfare (MoHFW) launched the population-based screening (PBS) and management of NCDs under the Ayushman Bharat initiative. Under this program, every individual over the age of 30 will be screened for hypertension, diabetes and oral cancer while women will be additionally screened for breast and cervical cancers.¹³

Population-based screening, as a strategy, has several benefits as it addresses the issues of low health awareness which often leads to significant informational asymmetry and affects healthcare seeking behavior of the communities. Availability of screening and management services closer to community also improves access to care without impacting the livelihood activities of the individuals, which is often a key deterrent for seeking care.

Program activities start at the home of the individuals, with community health workers or ASHAs visiting all households for enumeration of families and individuals. They conduct a risk assessment for NCDs and mobilize people over 30 to go for NCD screening. At the Health and Wellness center, the health staff including the female health worker or ANM, conducts screenings for hypertension, diabetes, oral, breast, and cervical cancer. Following the screening, those at risk and suspected for any of these NCDs are referred to higher levels of care for diagnosis, treatment, and management. Follow-ups are carried out by the health workers to ensure treatment compliance and counseling on lifestyle modifications (Fig. 1).¹³

The current process has several challenges frequently resulting in suboptimal implementation of the program. Among these are limited availability and capacities of the health workers, heavy burden on them managing multiple health priorities, poor utilization of public health facilities, and administrative difficulties in the last-mile delivery of services.^{7,14}

Technology can be an enabler in solving some of these issues affecting service delivery at large scale; there are lessons to be drawn from successful initiatives carried out in the country over the last 2 decades. Technology has been used effectively with remarkable success in revolutionizing

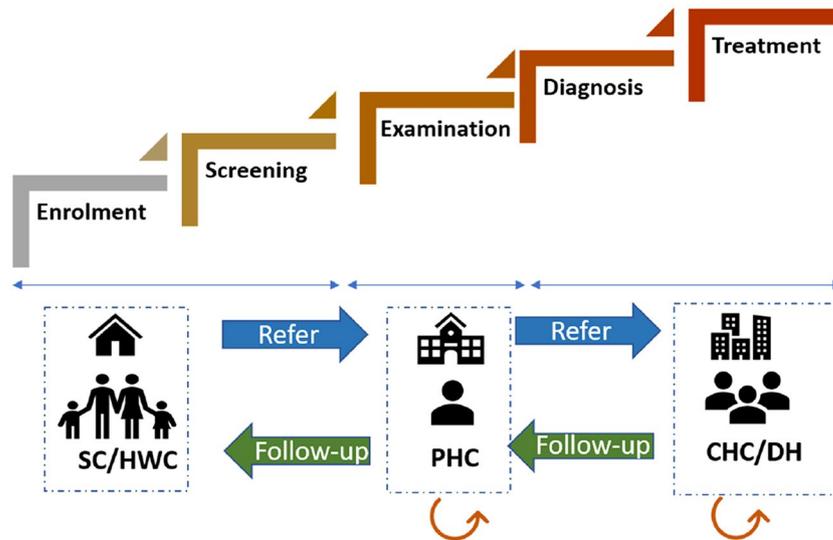


Figure 1 The workflow for continuum of care for individuals across levels of care.

areas like identity, banking, payments, taxation, and education.^{15, 16} We believe the time has come for digital transformation of the Government health sector at scale and the end-to-end digitization of this NCD program is one such example.

While the IT solution for the NCD program covers all phases from enrolment and screening to diagnosis, treatment and management, this paper will focus on the initial observations and experiences from the first part—the use of technology at scale in population-based enrolment, screening, and referral for NCDs.

We address these four challenges commonly encountered in the context of running large-scale digital health programs in a multi-state, multi-facility, and multi-stakeholder system by

1. enabling health workers with basic education and minimal digital literacy to embrace technology;
2. making technology solutions work in remote rural areas;
3. motivating health workers and doctors to use a digital healthcare system;
4. building and deploying healthcare technology to reach hundreds of millions of people.

2 The NCD IT Solution

Dell Technologies and Tata Trusts have partnered with the MoHFW, Government of India, to develop a technology solution for the PBS NCD program, and help deploy it across the country.¹⁷ The technology solution by Dell Technologies, called Digital LifeCare consists

of a suite of mobile and web apps on a cloud platform for health workers, doctors, and health administrators. The solution has been customized for the needs of the Government public health delivery system and reflects the facility and health staff hierarchy from village up to the state and national levels. It includes a health record for each individual, mobile app for the ASHA, a tablet app for the sub-center health workers, web portals for doctors at the primary, secondary and tertiary levels, an Admin Portal and Dashboards for Health Officials.¹⁷ This NCD IT system has inbuilt protocols based on Government of India guidelines to guide the users on diagnosis, treatment, and referrals at the primary level. The ultimate objective is to provide continuum of care where the individual is enrolled into the system and helped right through her lifetime to manage NCDs.

Digital LifeCare is Dell Technologies' CSR contribution to the Government of India NCD program. It was developed in collaboration with experts from National Health Systems Resource Center (NHSRC), All India Institute of Medical Sciences (AIIMS), the Directorate General of Health Services (DGHS), World Health Organization (WHO) India, the Indian Council for Medical Research (ICMR) and National Institute of Cancer Prevention Research (NICPR). Tata Trusts, as implementation partner for the NCD program is supporting the Government in deployment, user training, and progress monitoring. Technical inputs were also provided by experts at National Informatics Center (NIC), Center for Health Informatics (CHI), the India

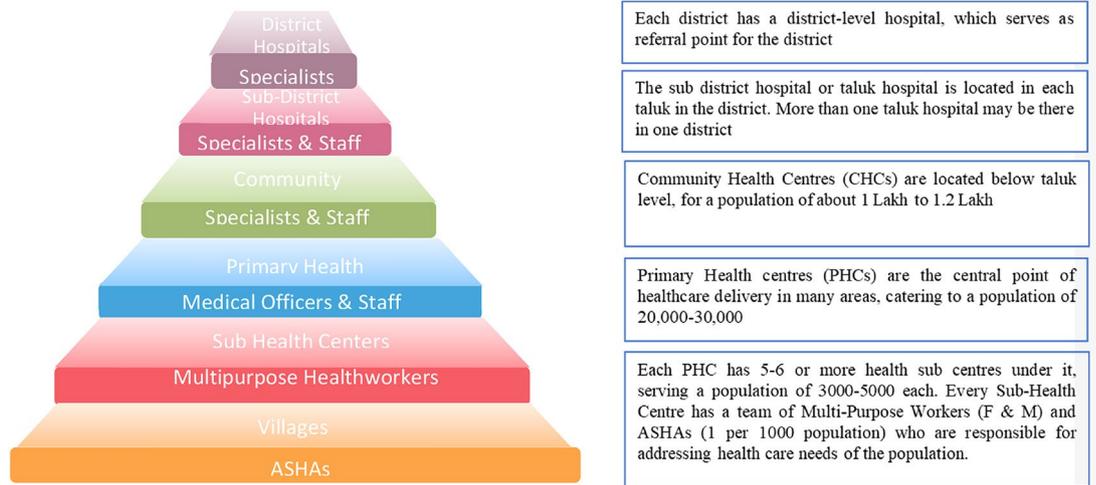


Figure 2 Organization of Government health service delivery (Adapted from: NRHM Framework for implementation <https://nhm.gov.in/WriteReadData/1892s/nrhm-framework-latest.pdf>).

Stack team at iSPIRT, Harvard, and various State Health Departments.^{18, 19}

The NCD IT system has been deployed centrally by the Ministry and is being used in 21 States and Union Territories across the country. State Governments drive the implementation of the NCD program and the adoption of the IT solution through their State, district, and block level administrative staff. As of May 2019, more than 67 lakh individuals have been enrolled in the NCD IT system.²⁰

The value proposition of technology is increasingly being accepted by all stakeholders. Governments regard technology as an enabler to increase efficiencies of program managers and help tide over shortage of professionals through task shifting. There is a growing recognition among all these stakeholders that continuum of care, with all its complexities can be highly error prone and expensive without technology. Through their NCD campaigns, states like Odisha have shown promising outcomes in adoption of the application, and increased numbers for enrolment and screening within a limited period of time.²¹ This has been acknowledged as one of the best practices by the Ministry.²²

2.1 Organization of Government Health Service Delivery

The National Health Mission has designed a layered primary healthcare system with ASHA workers at the village level, the multi-purpose workers (MPWs)/auxiliary nurse midwives (ANMs) at the

health sub-centers and medical doctors with staff at the primary health centre (PHC) (Fig. 2).

Under the recent Ayushman Bharat Guidelines, the health sub-centers, rural, and urban PHCs are being upgraded to Health and Wellness centers (HWC) with improved infrastructure, services, and equipment. A new cadre of mid-level health providers known as Community Health Officers (CHO), who have higher levels of skills and certification is being added at SHC-HWC.²³

The female MPW/ANM often has a 12th grade education with 2 years of paramedical training. The ASHA is a community health worker who is likely to have an 8th or 10th grade education and who is trained to improve access to range of health services at the community level.²⁴ Together, this team of CHO, MPW/ANMs and ASHAs are responsible for primary health care services for a population of 5000 in the catchment of the HWC.

3 Deployment Experience

There are certain fundamental challenges that need to be addressed when discussing large-scale digital health programs. This article will attempt to respond to these in the context of the NCD program.

3.1 Enabling Health Workers with Basic Education and Minimal Digital Literacy to Embrace Technology

Several transformational changes have brought technology closer to rural communities in the

last decade. The accelerating spread of the telecom network complemented by the smartphone or tablet with touch sensitive hi-res displays and high-quality sound feedback combined with communication capability can deliver a highly intuitive interface for illiterate/semi-literate users.^{25–27}

The lynchpin of the NCD solution is the mobile application for frontline health workers. The foundation of a digital system is only as strong as the quality of the data coming in; in this case, it is the data captured through the health workers' mobile apps as they enroll and screen community members. Hence, adoption of these mobile apps by the ASHAs and ANMs is essential to the success of the digitalization of the program.^{28, 29} The adoption in the NCD program has been very good on the ground with more than 10,000 Active ANMs by May 2019.²⁰

A significant amount of effort and thought has been invested by all stakeholders over several years to refine the mobile solutions for the NCD program over multiple iterations. There are three broad takeaways:

First, design with the active participation of the end user. The Dell Technologies team and Tata Trusts team had continual interactions with the health workers initially on a weekly basis, conducting trainings, reviewing mock designs, listening to their concerns and incorporating their feedback. Interactions become fortnightly once the adoption gathers pace and eventually the cadence becomes quarterly.

Second, keep usability at the centre of the design. The app must support user in fulfilling her responsibilities, fit smoothly into her daily routine without becoming an added burden. It must assume that she may make mistakes while entering data and must make it easy for her to know that and fix them. Typing is a new, unnatural thing for her, so the apps have very little of it; the data entry is mostly through selecting drop-downs, buttons, clicks, and swipes. The design is pictorial with icons for each function. The apps are in ten local languages, making it comfortable for her to read.^{17, 19} A well-designed tablet app that eliminates the need for filling out registers and reports makes the change to a digital system attractive for the rural health worker. The above are in line with the recommendations made by the National Task force of state and central government officers for an IT solution for Comprehensive Primary Health Care.³⁰

Finally, adoption takes time and a strategy for change management with clear processes must be put in place. States like Odisha & Chhattisgarh,

through strong leadership and robust planning, have demonstrated successful adoption and usage of the app by health workers.^{21, 31} Health workers are trained and re-trained periodically; they need support and response to their issues in a reasonable time. The field trainers are equipped with videos and manuals to clarify doubts of usage. One of the challenges is that many ANMs have been in their jobs for a couple of decades and are reluctant to learning new technology at this stage in their career.³² They need to be convinced about the value of technology and supported in adopting the apps.

3.2 Making Technology Solutions Work in Remote Rural Areas, in the Last Mile

Improving mobile connectivity, reducing cost of smart phones and inexpensive data plans have increased digital adoption in rural India. However unreliable mobile networks with rapidly increasing adoption and low investment in telecom infrastructure have resulted in slow connections, which make use of mobile applications cumbersome in rural areas. Lack of manpower to repair the hardware and service centers result in long lead times to get damaged devices operational again. Geographical diversity of the country and hilly regions is also a challenge to adoption.^{26, 33} As part of BharatNet, one of the world's biggest rural broadband projects, provision of broadband connectivity is being extended to all Government Institutions at Gram Panchayat level across the country.

To address current connectivity challenges, the NCD IT system has been developed as a cloud-based solution separating the simple apps for end users from the complex server software running on the cloud.¹⁷ There are no local servers that need to be running and no IT system administrators required to maintain them. Riding the telecom and smartphone wave, the solution includes mobile apps for health workers on devices that are affordable, easily available and familiar. In addition, these apps work in an offline mode so that lack of 24/7 connectivity does not hamper their work. Health workers can use apps to enroll individuals, screen them, do the follow-ups and check their reminders all without being connected to the internet all the time. At the end of a day's work, they can sync their device to the cloud server and upload their data while also getting updates from the system.

The health worker uses multiple applications on an Android device for different health programs. Doctors and administrators use web portals, which again require no maintenance or management.

3.3 Motivating Health Workers and Doctors to Use a Digital Healthcare System

The health worker's job is not easy. They are often inundated with field activities for these programs and have a full weekly calendar with specific days allocated for immunization, etc. Reporting for these programs is a major time sink; they maintain up to 40 registers, with one or more register for each program they support. They are often asked for data from one of their programs by health officials and must painstakingly dig through their registers to get the details. These care providers are already under heavy time pressure and carry a substantial caseload. The prospect of going digital and taking on another responsibility is not appealing to them. So, understandably, there is resistance to using these apps. Technology adoption can be achieved and sustained only if there is genuine value addition for the users across the system.³²

The process of designing this solution has been deep, engaging and insightful, and has led to good usage and acceptance across the country. We have adopted the standard design thinking model of Dell Technologies with some customization for the public health context in India.³⁴ There are three key elements of design thinking that we employ

- *Empathy and user-centric design* A key highlight of this process of empathizing and working collaboratively with end users. Dell & Tata Trusts teams spend time with the health workers (ASHAs, ANMs), Medical officers & program co-coordinators through regular field visits every month and there is a proactive effort for seeking inputs that influence the solution in the right direction. Meticulously planned pilots of major features are done with end users, as these feature roll-outs impact tens and thousands of users. Over time, the teams have gained deep understanding of public health systems and the local context of the end users that we are designing for.
- *Research and deep collaboration* Designing a nation scale health care solution requires thorough research and frequent collaboration with multidisciplinary experts. We have regu-

lar interactions with clinical and public health experts from institutions like AIIMS, ICMR & NICPR and policy-makers and domain experts in organizations like NHSRC, WHO and the NCD division at MoHFW at least once a month. These are focused discussions that range from clinical protocols, program guidelines to nuances of input data fields in the application. This is a continuous engagement where after each discussion, we conceptualize the solution, validate it with state deployment teams and then present it back to the experts with additional findings. The typical lead time from conceptualizing and defining a feature is between 1 and 3 months. As a digital health platform developer, we also collaborate with the ecosystem partners towards aligning the IT system with national standards like National Digital Health Mission,³⁵ EHR standards³⁶ and upcoming laws like the Personal Data Protection Bill, 2019.³⁷

- *Rapid build, validate, iterate loops* Another characteristic of our development is the build, validate and iterate approach. The approach has always been to start small, deploy it, understand the adoption and then continue to evolve the feature/ solution. The idea is to fail fast and learn from the mistakes for rapid course correction. The build step involves careful scoping of the feature to include the key features and its development. The validation step involves a structured process of gathering inputs from end users and program implementers to incorporate back into the solution. This iteration continues till the objectives of the feature are met.

A few of the solution features which are most appreciated by users are:

Local dashboards with instant update Health workers carry a heavy load of reporting and may spend up to 1–2 h a day doing paperwork (maintaining registers & compiling reports), which in turn eats into their time for core activities like home visits etc.^{38, 39} Health workers highly value the dashboards where they can see their latest counts of their work with a click of a button. Reporting becomes painless; they can easily comply with their reporting responsibilities and respond to specific queries from health officials.

Job support The search feature with multiple parameters makes it easy for doctors and health workers to quickly locate an individual's record. Built-in Government protocols guide the user

on various functions along the care journey from screening and referral to diagnoses and treatment, offering recommendations that the user can follow or choose to override.^{17, 19} Health workers can readily access training manuals, help screens for using the apps, video links for support.

Workplans A health worker managing a population of around 5000 people relies on her memory and paper registers to know which individual needs what kind of follow-up and when. This is time-consuming and error prone. Workplans for ANM, CHOs, ASHAs and Medical Officers are scheduled reminders for pending tasks that are generated based on standard Government care protocols.

Examples are a monthly follow-up visit of a hypertensive patient, a reminder to complete the screening of an individual partially screened or an incomplete referral of an uncontrolled diabetic.

Health workers have anecdotally stated that using a digital device adds to their confidence and the perception of dignity from the community. For many, this is the first time they have used a digital product and they feel a sense of pride and accomplishment at having developed the ability to use technology for their work.

In early stages of implementation, we have already observed that younger health workers are keen to adopt digital options compared to paper format and this is increasing usage of the applications. In some instances, their enthusiasm is rubbing off on older workers too.

The value addition of this solution for State and district officials is in performance monitoring and program administration. Dashboards not only provide the latest status of the program, but also allow for easy comparison of progress over time and between facilities. The Health Ministry and State health departments use the NCD dashboards for reviewing progress and monitoring performance during National and regional NHM consultations.^{21, 22, 31, 40} State officials conduct program reviews based on dashboard data and this provides a common, shared platform with their teams to monitor progress and address issues.

3.4 Building and Deploying Technology at Scale to Reach Hundreds of Millions of People

Often digitization projects fail to deliver on their promise of large-scale transformation. Common underlying causes for this include:^{41, 42}

1. overhauling the whole set up instead of focusing on specific areas;
2. lack of shared digital infrastructure for foundational elements like identity and consent⁴³;
3. Infrastructure constraints and lack of process adaptation;
4. weak technology capacity, lack of good user training and support for first-time users.

There have been several successful models to learn from across different sectors, and the program stakeholders worked on incorporating these as well as new innovations to address these problems. A few interventions to highlight are:

Layered platform architecture with modular, open design The IT system is designed for scale, performance, interoperability and security. The microservices architecture and a clustered deployment setup allow smooth scaling up of services based on load. The design is modular with API-based services available for consumption by other systems to enable interoperability. Security and privacy concepts like data encryption at rest and in transit, 2-factor authentication and role-based access control are built into the system. Health ID, health records, consent and registries form the foundational layer.

Support The support model encourages resolution 'as close to the problem origin' to save time, increase productivity, and build expertise. The standard three-tier model of support, L1, L2 and L3 is being followed by Tata Trusts team.¹⁹ End users adopt a standard operating procedure for their routine work as well as to trouble shoot common problems. They escalate issues to their supervisors and trainers who form the state-based field L1 team. All unsolved problems beyond that get referred to a central L1 team. This multilingual team is assigned responsibilities for different geographies and operates by clearly defined Service Level Agreements. Issues which need technical inputs are passed to L2 team within the TSU (Technical Support Unit) that also manages the system in the cloud data center. Majority of the reported issues are resolved by TSU and solution is provided to end users through either field teams or state health officials. Bugs, fixes and enhancement requests are passed on to Dell Technologies software development team, which is the L3 level of support, and regularly releases new versions of the software.

Application training and support There are apprehensions regarding technology use among doctors and health workers.⁴⁴ This is addressed through hands-on training where they get an opportunity to use the application in presence of an experienced trainer; often the trainer is a senior health worker or an official they are already familiar with. An efficient support structure is set up which they can access for help once they begin using the application. Training and support processes elaborated earlier make the adoption seamless.¹⁹

Health officials play an important role in increasing adoption—hands-on officials who set clear and ambitious targets, monitor adoption and actively support health workers have created tremendous impact in increasing adoption.

4 Conclusion

The MoHFW has leveraged technology in a very significant way to rapidly expand its NCD program in reach and scope. The experience of the NCD IT system implemented by the states with the support of Dell Technologies and Tata Trusts over the last 3 years sheds light on approaches towards common challenges related to development, deployment and adoption of large-scale IT systems.

Technology is at best an enabler While early data on process measures are encouraging, the successful outcome measures will also depend on a range of social, behavioral, political, and economic determinants. Usage by health workers for enrolment and screening is increasing; capacity building through training and app deployments has gone smoothly in multiple states. As the NCD program rolls forward, it will be important to examine individual clinical outcomes, population outcomes and cost effectiveness which ought to be some of the key objectives of such a program. Operational research by Government and other stakeholders to demonstrate impact will need to be carried out at the appropriate time. The learnings from this digital health program can then be transposed to similar healthcare settings.

Publisher's Note

Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

Received: 21 August 2020 Accepted: 14 September 2020
Published online: 8 October 2020

References

1. India State Level Disease Burden Initiative Collaborators (2017) Nations within a nation: variations in epidemiological transition across the states of India, 1990–2016 in the Global Burden of Disease Study. *Lancet*. [https://doi.org/10.1016/S0140-6736\(17\)32804-0](https://doi.org/10.1016/S0140-6736(17)32804-0)
2. Institute for Health Metrics and Evaluation (IHME). Institute for Health Metrics and Evaluation (IHME) INDIA Profile. https://www.healthdata.org/sites/default/files/files/country_profiles/GBD/ihme_gbd_country_report_india.pdf
3. WHO (2018) Noncommunicable Diseases (NCD) Country Profiles
4. World Health Organisation (WHO). NCDs, Poverty and Development, WHO. <https://www.who.int/global-coordination-mechanism/ncd-themes/poverty-development/en/>
5. Wagstaff A (2002) Poverty and health sector inequalities. *Bull World Health Org* 80(2):97–105
6. Niessen LW, Mohan D, Akuoku JK, Mirelman AJ, Ahmed S, Koehlmoos TP, Trujillo A, Khan J, Peters DH (2018) Tackling socioeconomic inequalities and non-communicable diseases in low-income and middle-income countries under the sustainable development agenda. *Lancet*. [https://doi.org/10.1016/S0140-6736\(18\)30482-3](https://doi.org/10.1016/S0140-6736(18)30482-3)
7. Hazarika I (2013) Health workforce in India: assessment of availability, production and distribution. *WHO South-East Asia J Public Health*. <https://doi.org/10.4103/2224-3151.122944>
8. Anchala R et al (2014) Hypertension in India: a systematic review and meta-analysis of prevalence, awareness, and control of hypertension. *J Hypertens* 32:1170
9. WHO. Noncommunicable diseases: the slow motion disaster. World Health Organisation (WHO). <https://www.who.int/publications/10-year-review/ncd/en/>. Accessed 4 Sept 2020
10. Indian Council of Medical Research (ICMR) (2016) Consensus Document for the management of Cancer Cervix. Indian Council of Medical Research (ICMR). https://main.icmr.nic.in/sites/default/files/guidelines/Consensus%20Document%20for%20The%20Management%20of%20Cancer%20Cervix_0.pdf
11. World Health Organization (WHO) (2013) Global Action Plan for the Prevention and Control of NCDs 2013–2020. https://apps.who.int/iris/bitstream/handle/10665/94384/9789241506236_eng.pdf?sequence=1
12. World Health Organisation (2015) India: first to adapt the global monitoring framework on noncommunicable diseases (NCDs). <https://www.who.int/features/2015/ncd-india/en/>. Accessed 3 Sept 2020
13. National Health Mission. Operational Guidelines on Prevention, Screening and Control of Common NCDs. Ministry of Health & Family Welfare. https://main.mohfw.gov.in/sites/default/files/Operational%20Guidelines%20on%20Prevention%2C%20Screening%20and%20Control%20of%20Common%20NCDs_1.pdf

14. Sharma R, Webster P, Bhattacharyya S (2014) Factors affecting the performance of community health workers in India: a multi-stakeholder perspective. *Glob Health Action*. <https://doi.org/10.3402/gha.v7.25352>
15. OECD. Case study- Aadhar, India. <https://www.oecd.org/gov/innovative-government/India-case-study-UAE-report-2018.pdf>
16. PwC. UPI 2.0: Towards a complete digital ecosystem. *PwC India*. <https://www.pwc.in/consulting/financial-services/fintech/fintech-insights/upi-2-0-towards-a-complete-digital-ecosystem.html>
17. National Health Mission. Presentations, National Consultation on Road for CPHC- through Health and Wellness Centres 8th April 2019, PPT on PBS. National Health Mission. <https://nhm.gov.in/index1.php?lang=1&level=1&sublinkid=1304&lid=688>. Accessed 2 Sept 2020
18. YourStory (2020) How Dell is helping India on its mission to bring preventive healthcare to 800 million people in rural India. *YourStory*. <https://yourstory.com/2020/01/dell-helping-india-mission-healthcare-800million-rural>
19. National Health Mission (2019) Presentations, Ayushman Bharat—Health and Wellness Centre, Third Regional Workshop, Amritsar Punjab 5th & 6th Sept 2019, CPHC NCD. *National Health Mission*. Sept 2019. <https://nhm.gov.in/index1.php?lang=1&level=1&sublinkid=1304&lid=688>. Accessed 2 Sept 2020
20. National Health Mission (2019) Presentations, National Health Mission Orientation Workshop (13th and 14th May 2019) NCD Interventions. National Health Mission. <https://nhm.gov.in/index1.php?lang=1&level=1&sublinkid=1304&lid=688>. Accessed 2 Sept 2020
21. National Health Mission (2019) Presentations, National Consultation on Road for CPHC- through Health and Wellness Centres 8th April 2019, NCD Screening Odisha Experience. National Health Mission <https://nhm.gov.in/index1.php?lang=1&level=1&sublinkid=1304&lid=688>. Accessed 2 Sept 2020
22. National Health Mission (2019) Presentations, first quarterly review meeting, Dr. Ambedkar International Centre, New Delhi, 19th & 20th September 2019, First Quarterly Review Meeting -MoHFW. National Health Mission. <https://nhm.gov.in/index1.php?lang=1&level=1&sublinkid=1304&lid=688>. Accessed 2 Sept 2020
23. National Health Systems Resource Centre (NHSRC). Comprehensive Primary Health Care. National Health Systems Resource Centre. <http://nhsrcindia.org/sites/default/files/Operational%20Guidelines%20For%20Comprehensive%20Primary%20Health%20Care%20through%20Health%20and%20Wellness%20Centers.pdf>
24. National Health Mission (NHM). Community Process. National Health Mission. https://nhm.gov.in/images/pdf/communitisation/asha/Orders-Guidelines/Guidelines_for_Community_Processes_2014_English.pdf
25. GSMA (2017) Accelerating affordable smartphone ownership in emerging markets. GSMA. https://www.gsma.com/mobilefordevelopment/wpcontent/uploads/2018/08/Accelerating-affordable-smartphone-ownership-in-emerging-markets-2017_we.pdf
26. Gupta S (2015) Telecommunication at the crossroads in India. *IIMB Manag Rev* 27:196
27. Jacob C, Sanchez-Vazquez A, Ivory C (2020) Understanding clinicians' adoption of mobile health tools: a qualitative review of the most used frameworks. *JMIR mHealth Uhealth* 8:e18072
28. Modi D et al (2019) mHealth intervention "ImTeCHO" to improve delivery of maternal, neonatal, and child care services-A cluster-randomized trial in tribal areas of Gujarat. India. *PLOS Med* 16(10):e1002939
29. Modi D et al (2015) Development and formative evaluation of an innovative mHealth intervention for improving coverage of community-based maternal, newborn and child health services in rural areas of India. *Glob Health Action* 8:26769
30. National Health Mission (2018) Presentations, workshop on operationalising health and wellness centres through comprehensive primary healthcare 1st–2nd May 2018, Group3 -IT. National Health Mission. <https://nhm.gov.in/index1.php?lang=1&level=1&sublinkid=1304&lid=688>. Accessed 2 Sept 2020
31. National Health Mission (2019) Presentation, Ayushman Bharat - Health and Wellness Centre, Third Regional Workshop, Amritsar Punjab 5th & 6th Sept 2019, Chhatisgarh. National Health Mission. <https://nhm.gov.in/index1.php?lang=1&level=1&sublinkid=1304&lid=688>. Accessed 2 Sept 2020
32. Moola S, John O, Bhaumik S (2020) Encouraging health workers to use mHealth for delivering primary healthcare services: policy brief. The George Institute for Global Health. https://cdn.georgeinstitute.org/sites/default/files/documents/encouraging-health-workers-to-use-mhealth-_policy-brief_v01.pdf. Accessed 1 Sept 2020
33. Feroz A, Jabeen R, Saleem S (2020) Using mobile phones to improve community health workers performance in low-and-middle-income countries. *BMC Public Health*. <https://doi.org/10.1186/s12889-020-8173-3>
34. Dell Technologies (2016) Utilizing Design Thinking for Digital Transformation. http://i.dell.com/sites/doccontent/business/solutions/whitepapers/en/Documents/Design_Thinking.pdf
35. Ministry of Health and Family Welfare, Government of India. Final report on National Digital Health Blueprint (NDHB). Ministry of Health and Family Welfare. <https://main.mohfw.gov.in/newshighlights/final-report-national-digital-health-blueprint-ndhb>. Accessed 3 Sept 2020
36. Ministry of Health and Family Welfare, GoI (2016) Electronic Health Record (EHR) Standards for India. <https://main.mohfw.gov.in/sites/default/files/17739294021483341357.pdf>. Accessed 3 Sept 2020
37. Data Protection Framework (2018) Ministry of Electronic and Information Technology (MeitY). https://www.meity.gov.in/writereaddata/files/Personal_Data_Protection_Bill,2018.pdf. Accessed 4 Sept 2020

38. Singh S et al (2018) Functioning and time utilisation by female multi-purpose health workers in South India: a time and motion study. *Hum Resour Health*. <https://doi.org/10.1186/s12960-018-0327-3>
39. Bhombe I et al (2019) Time-motion study of auxiliary nurse midwives of a primary health center from Wardha District of Maharashtra. *Int J Adv Med Health Res*. https://doi.org/10.4103/IJAMR.IJAMR_50_18
40. National Health Mission (2019) Presentations, Ayushman Bharat - Health and Wellness Centre, Third Regional Workshop, Amritsar Punjab 5th & 6th Sept 2019, Haryana. <https://nhm.gov.in/index1.php?lang=1&level=1&sublinkid=1304&lid=688>. Accessed 4 Sept 2020
41. Mourtada R et al (2018) How to Supercharge Your National Digital Transformation. Boston Consulting Group (BCG). <https://www.bcg.com/publications/2018/how-supercharge-your-national-digital-transformation>. Accessed 4 Sept 2020
42. Unlocking success in digital transformations (2018) McKinsey & Company. <https://www.mckinsey.com/business-functions/organization/our-insights/unlocking-success-in-digital-transformations#>. Accessed 4 Sept 2020
43. Jones GL et al (2020) Healthcare systems & services. McKinsey & Company. <https://www.mckinsey.com/industries/healthcare-systems-and-services/our-insights/promoting-an-overdue-digital-transformation-in-healthcare>. Accessed 4 Sept 2020
44. Christine J, Antonio S-V, Chris I (2020) Social, organizational, and technological factors impacting clinicians' adoption of mobile health tools: systematic literature review. *JMIR* 8(2):e15935



Sunita Nadhamuni is Head of Digital LifeCare at Dell Technologies, India, leading the development of a nation-scale technology system for Government of India's Ayushman Bharat's NCD (Non-communicable Diseases) program for management of

diabetes, hypertension and cancers. This is a social impact CSR initiative of Dell Technologies. Sunita has a unique combination of more than a decade of IT experience from the Silicon Valley in the US at companies like Sun Microsystems, SGI and Healtheon/WebMD and a decade in India leading social impact initiatives. Prior to Dell, she was founder-CEO of Arghyam, a leading charitable foundation on water and sanitation driving projects across 20 states in India. Sunita has an MS in Electrical Engineering from Rensselaer Polytechnic Institute in NY and a BE degree from Andhra University in India. She was a TED India Fellow, founder of two voluntary initiatives in education and rural development and a member of several national committees and non-profit boards.



Garima Gupta Senior Consultant Community Processes (CP) and Comprehensive Primary Healthcare (CPHC), National Health Systems Resource Centre. Key areas of work include supporting development of programme guidelines as well as supporting

states in implementation of ASHA programme and roll out of comprehensive primary health care through Health and Wellness Centres. She has also been a lead member of various assessments and largescale evaluations in areas of human resources for health, ASHA and primary health care at NHSRC.



Ramdas Mullath handles deployment enablement for Digital LifeCare, at Dell Technologies, India. Digital LifeCare is a nation-scale technology system for Government of India's Ayushman Bharat's NCD (Non-communicable Diseases) program for management of

diabetes, hypertension and cancers. This is a social impact CSR initiative of Dell Technologies. Ramdas has commercial experience of two decades in United Kingdom, India and United States working with organizations like Tata Consultancy Services, Cap Gemini and Mindtree. He was a health-care entrepreneur before joining Dell. He has an MBA from London Business School and Cochin University and graduate degree in Chemical Technology from Osmania University.



Sruti Sridhar is part of the Product Management team of Digital LifeCare at Dell Technologies. Digital LifeCare is the technological platform under Ayushman Bharat's Health and wellness centers (HWCs) for population-based screening and manage-

ment of the common Non-communicable Diseases (NCDs). Sruti is a digital health professional with a niche in building EMR/EHRs and technological solutions for the public health ecosystem. Her core competencies include a strong understanding of health systems, health informatics and designing user-centric appropriate technologies. She has in the past worked with ThoughtWorks Technologies in their Global health team and Health Practice, dealing extensively with various national & international NGOs, Ministries of Health and not-for-profit hospitals. She has a Master's in Public health (Health Administration) from Tata Institute of Social Sciences, Mumbai and a B. Tech in Biomedical Engineering from Dr. D. Y Patil University, Mumbai.