The use of digital technologies to support the identification of poor and vulnerable population groups for health coverage schemes

Insights from Cambodia, India and Rwanda

World Health Organization

The use of digital technologies to support the identification of poor and vulnerable population groups for health coverage schemes

Insights from Cambodia, India and Rwanda

World Health Organization

The use of digital technologies to support the identification of poor and vulnerable population groups for health coverage schemes. Insights from Cambodia, India and Rwanda

ISBN 978-92-4-006399-0 (electronic version)
ISBN 978-92-4-006400-3 (print version)

Suggested citation. The use of digital technologies to support the identification of poor and vulnerable population groups for health coverage schemes. Insights from Cambodia, India and Rwanda. Geneva: World Health Organization; 2022. Licence: CC BY-NC-SA 3.0 IGO.

Cataloguing-in-Publication (CIP) data. CIP data are available at http://apps.who.int/iris.

Sales, rights and licensing. To purchase WHO publications, see http://apps.who.int/bookorders. To submit requests for commercial use and queries on rights and licensing, see https://www.who.int/copyright.

Cover picture: © GIZ/Conor Wall

Contents

Acknowledgements

This paper was prepared by Maarten Oranje together with Inke Mathauer. Valuable input and comments were received from Grace Kabaniha and Jaidev Anand (WHO Country Office, India), Mai Mo (WHO Country Office, Cambodia), Ina Kalisa (WHO Country Office, Rwanda), Bruno Meessen and Fahdi Dkhimi (WHO Geneva) as well as Amit Paliwal (GIZ India) and Sabine Cerceau (GIZ Cambodia). Particular thanks go to Sabine Cerceau for her detailed explanation of the Cambodian IDPoor system.

WHO also thanks Joe Kutzin for for his helpful comments and overall inspiration as well as the WHO Health Financing Team for their inputs and reflections during a presentation of a draft version of this paper.

Finally, WHO gratefully acknowledges financial support received from the Canadian Government.

1. Introduction

Digital technologies for health financing can be considered as one specific area within digital health – an area which is described as "the field of knowledge and practice associated with the development and use of digital technologies to improve health" *(1)*. Digital technologies are understood here as electronic tools, systems and devices that generate, store, process or transmit data. When applied to health financing, these technologies may change the way in which health-financing tasks are undertaken by stewards, purchasers, providers, users and citizens in general. The ultimate question is whether and how these digital technologies do or do not contribute to health financing and to the intermediate and final objectives of universal health coverage (UHC) – i.e. efficiency, accountability, transparency, equity in access and distribution of resources, fair financing and financial protection, and quality of care *(2)*. However, it may not be easy to demonstrate such contributions or attributions because of the lack of data and because a multitude of factors that underlie progress towards UHC.

The role of digital technologies for health financing and their potential contribution to UHC progress is receiving increased attention *(1, 3, 4, 5, 6)* although the evidence base is still very small, indicating the need for further documentation and assessments of countries' practices. This paper seeks to contribute to gathering the evidence needed. Specifically, the paper assesses the experiences of three countries – Cambodia, India and Rwanda – to explore the use and role of digital technologies that support the identification of the poor and other vulnerable population groups. The focus is on the processes of targeting, identification and identity confirmation as important health financing-related tasks that cut across the revenue-raising, pooling and purchasing functions with the purpose of providing fully or partially subsidized coverage or user fee exemption via publicly funded health coverage schemes. These country examples have been chosen as they provide insights into the digital features and processes, while also illustrating critical challenges that it is important to explore. The paper is based on a document review, drawing on both published and grey literature.

The remainder of this introduction outlines the challenges in targeting and identification. Sections 2, 3 and 4 present the experience of the three countries, describing the initial identification process, outlining the introduction and evolution of digital technologies for this process, and exploring the effects on health financing and UHC objectives. The country sections conclude each with a discussion of implementation issues and remaining questions. Section 5 reflects on cross-country issues, while the final section provides lessons and conclusions on possible future developments in the use of digital technologies for the identification of the poor.

Targeting and identification

Targeting is the policy strategy of concentrating limited public resources on narrowly defined "target" groups within society *(7)* – i.e. groups that meet the eligibility criteria for receiving a targeted intervention. Targeting mechanisms are a frequent feature of health coverage schemes (e.g. health insurance-type arrangements) that receive state budget transfers for full or partially subsidized coverage of poor or otherwise vulnerable population groups *(8)*. In order to target effectively those in greatest need of financial protection, those persons need to be identified. A distinction between pre-identification and post-identification is frequently made. In pre-identification, individuals or households are identified before an episode of illness and granted coverage for a given period; in post-identification, the eligibility to the assistance is assessed at the point of use – i.e. the health facility *(9)*. One element of identification is the actual confirmation of a person's identity.

However, targeting and identification mechanisms often have shortcomings. For instance, people who are in principle eligible in accordance with the criteria may not have been identified and enrolled in a coverage scheme (exclusion error) or vice versa, some people may have been wrongly included (inclusion error) *(10)*. In the case of exclusion errors, people may forego essential health care or suffer financial hardship as a consequence of seeking it. The accurate targeting and identification of poor or otherwise vulnerable population groups as eligible beneficiaries for health coverage schemes are notoriously challenging, especially in low- and middle-income countries *(10)*. The available demographic and socioeconomic data are often not sufficiently granular to provide the necessary detailed information and fully-fledged tax databases often do not exist. Moreover, billions of people have no official identity in the absence of a national identification system *(5)*.

The application of digital technologies may support targeting and identification as well as identity confirmation processes and may thus help to reduce or avoid exclusion and inclusion errors. For instance, various health coverage schemes have shifted from paper-based to more sophisticated databases and digital systems simplify and accelerate the registration and identity confirmation process. Pictures and geographic information system (GIS) coordinates of the beneficiaries can be included, while unfalsifiable identifiers, such as iris scans or fingerprints, also help confirm to reduce errors *(5)*.

The correct targeting and identification of poor persons has much broader importance than for health-financing purposes alone. Most countries have multiple social protection schemes in place, and various government agencies need data about household or individual income and assets. Digital advances in other sectors can thus also help to optimize health-financing tasks.

2. The Health Equity Fund and the IDPoor system in Cambodia

To improve financial protection and access to health services, Cambodia introduced the Health Equity Fund (HEF), a non-contributory health coverage scheme *(11)*. The first HEF pilot was set up in 2000 as a health-financing mechanism to reimburse health facilities for exempting the poor from user fees, as well as to support poor households with transportation costs, food allowances for caregivers during hospital stays and funeral costs. Initially covering health services at referral hospitals only, the scheme was then extended to health centres and, in 2015, to all government health facilities *(11)*. At the start of the scheme, paper-based HEF identity (ID) cards were issued to enable eligible households to benefit from exemption. Identification procedures differed from one district to another as there were multiple implementing agencies. While the HEF proved effective in increasing coverage for the poor and reducing the level of catastrophic or impoverishing health expenditure *(12, 13)*, the eligibility of poor patients for fee exemptions could not always be properly verified despite the existence of paper ID cards. In the absence of a standardized approach among districts, implementation was inconsistent and there were both inclusion and exclusion errors *(14)*. A 2006 report showed that the level of fee exemptions varied widely between facilities (from 2% to 24%) *(12)*.

Introduction and evolution of the IDPoor system

Because other social sectors were experiencing similar problems with targeting and identification, the Ministry of Planning, supported by development partners, started developing a national, standardized and formalized mechanism in 2005. As of 2007 a national community-based poverty identification system – referred to as IDPoor – was introduced. This was subsequently supported digitally and was rolled out in all of Cambodia's rural districts – home to 90% of people living below the poverty line *(11)*. The IDPoor system aimed to identify households affected by multidimensional poverty through a combined process of proxy means-testing (measuring assets and objectively observable household characteristics) and community validation *(15)*.

During the first stage of the IDPoor identification process in a village, members of the community elect a village representative group of peers who are then trained to perform interviews and determine the poverty status of households. In the second stage, the draft list of poor households is publicly displayed, discussed and ratified by the (elected) commune council (the commune being the third-level administrative division in Cambodia, below the district). On average, each commune consists of 10 villages. Once consensus has been reached by the commune council, the list of identified poor households is established, indicating the status as "poor" or "extremely poor" *(11)*. In the next stage, the data on the households identified as

poor are entered into the IDPoor database at national level. Each year since 2011, one third of the provinces have taken part in the community-based process – i.e. the data have been updated every three years.

The provincial planning departments were initially given the responsibility to enter data from paper questionnaires into the database, but technical capabilities were insufficient and many data entry errors were observed. The task was subsequently outsourced to a private company at national level to speed up the process and reduce data entry errors *(16)*. Photographic prints were sent from the local communes to a central location where they had to be manually matched to the correct household file, after which the physical Equity Card could be sent back to the village.[1]

From the start, the design of the IDPoor Information system allowed a wide range of government bodies and nongovernmental organizations, as well as social protection schemes, to access the database on poor households. Nevertheless, these groups were granted different levels of access according to their needs. Thus there was a form of vetting whereby sensitive data were made available only to organizations and programmes that had undergone a special registration process *(11)*. In this first phase from 2007 to 2014, beneficiary lists for each village were provided as Excel or PDF files, burnt onto a DVD and then sent to the organization or programme in need of the data *(16)*. Up to this point, the digital technologies and software in use were relatively simple; this was a deliberate decision based on a cautious approach to advanced technologies *(16)*.

The further digitalization of the IDPoor system

Data management and use evolved over time and various digital technologies were integrated, improving the identification process of poor households. First, in 2014, the IDPoor database was made accessible online through the IDPoor Information System (IIS). Health facilities and other social service providers can now easily verify the validity of Equity Cards online when a person seeks services. Moreover, the IIS allows registered governmental and nongovernmental organizations to access a set of standard online reports, as well as tailored subsets of the raw data. For example, they can target a specific subgroup of IDPoor households with particular health or other social services. The online platform also offers geospatial visualizations of the data *(16)*.

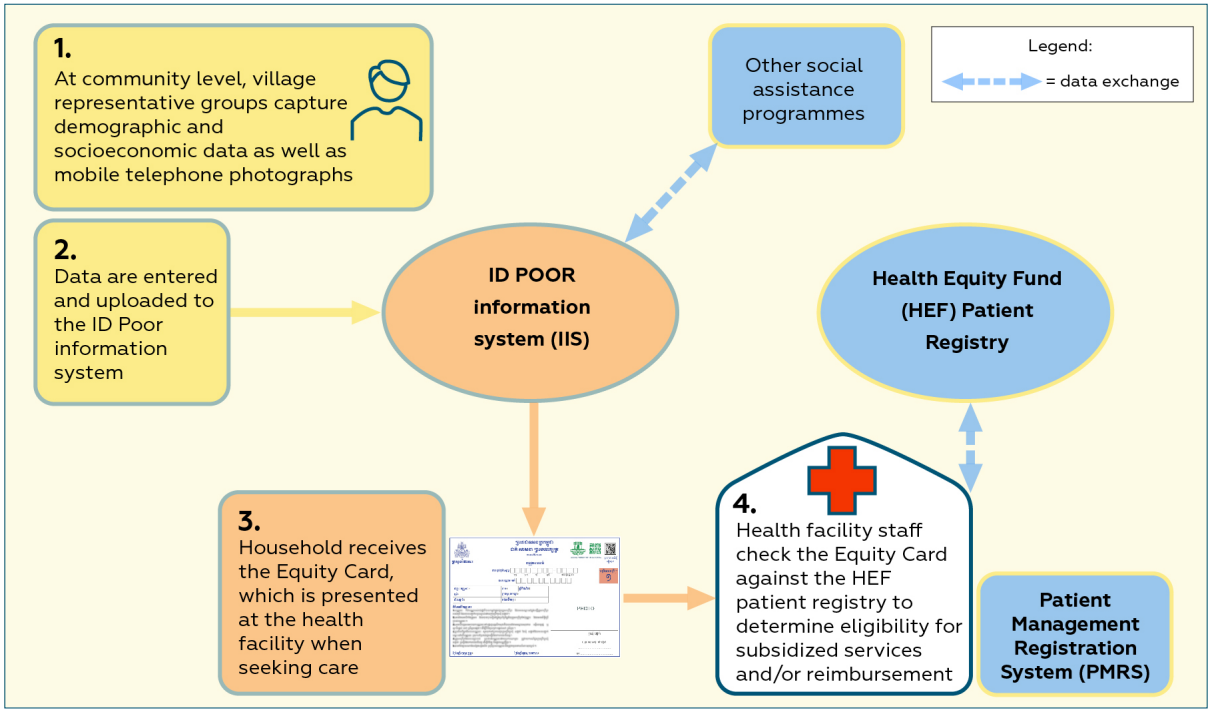
When the IDPoor approach was expanded into the urban areas (Urban IDPoor), an important new digital technology feature was introduced into the process in 2016. Using mobile telephones, designated teams take photographs of urban household members, which can then easily be uploaded into the IDPoor database. Based on its success in urban areas, this feature was subsequently adopted in the rural areas. This replaced the cumbersome process of physically sending photographic prints to the central service where they were matched manually to the correct household file. Figure 1 below shows the linkages between the ID Poor identification system and the Health Equity Fund as well as the identification process in place from 2017 onwards.

[1] Personal communication.

In 2017, another new feature was introduced. This is an "on-demand" service (first piloted in a limited number of communities), which provides the option to include households which have fallen into poverty after the most recent community-based data collection process. A household experiencing the shock of an income loss can now self-report to the commune council and request a household interview. These 'on-demand' interviews are conducted by community members who, importantly, are given tablets for data collection as a further step in the digitalization of the IDPoor process.

Also since 2017, through an Application Programming Interface (API), the IDPoor system has been connected to a new patient management and registration system in the referral hospitals, enabling the latter to verify patients' eligibility, manage patient records and register the reimbursements of food and transport costs to Equity cardholders *(11)*. In the same year, the Cambodian government declared its ambition to link the IDPoor system to other government databases so that IDPoor could be developed into a single registry for data on poor households and vulnerable population groups. Making the data systems of different schemes and ministries interoperable is a key element in this endeavour. For instance, an API was established that year to connect IDPoor with the database of the Platform for Real-time Impact and Situation Monitoring (PRISM) of the National Committee for Disaster Management (NDCM) *(16)*. An API between IDPoor and the database on people with disabilities of the Ministry of Social Affairs is expected in 2022.[2] These measures should help to reduce the duplication of data collection and to lower administration costs *(16)*. However, it is equally important to discuss and determine the desirable extent of interoperability so as to ensure confidentiality of people's information.

Figure 1. Linkage between the IDPoor information system and Health Equity Fund in Cambodia



[2] Personal communication.

Effects on health financing and universal health coverage objectives

IDPoor had been introduced in all villages in the rural areas of Cambodia by 2013. The digitalization was decisive in supporting its expansion and institutionalization. By late 2017, IDPoor was reaching 90% of all communities (covering close to 13 million people) and since then coverage has been further expanded to include the remaining urban areas *(16)*. As of November 2021, 7.4% of the Cambodian households were registered as extremely poor and another 12.6% as moderately poor *(17)*. Cambodia is the first country known to have undertaken country-wide community-based poverty identification so regularly. A 2015 World Bank study found that most countries (60% out of 155 countries monitored) do not have any poverty data available at such regular intervals *(18)*.

There were also multiple benefits of the digital technologies at operational level. The new digital features assumingly resulted in time-savings both for the community members at the commune level who were in charge of the community-based identification process as well as for government officers at the Ministry of Planning. As the digitalization of IDPoor led to the faster creation of a more precise database of the poor and enhanced transparency and stakeholder trust in the system, it also contributed to the achievements of the HEF. The digitalization of data and the direct uploading of photographs helped reduce data inaccuracies, as data obsolescence was decreased and the misuse of Equity cards was discouraged. Previously, any inaccuracy in a household's data had to be corrected through a time-consuming procedure involving the commune and the central government, whereas the IIS enabled a much smoother process. Coupled with the introduction of online access to the data system, it also led to time-savings and consequently lower costs for health-service providers and government officers alike *(16)*.

Despite the introduction of these new digital features, however, it is important to note that the analogous face-to-face approach of the community-based identification process by the village representative groups remained untouched and the commune council is still required to validate eligibility on a case-by-case basis.

Since 2018, HEF has been co-financed by the Cambodian Ministry of Finance and donors, as part of a transition towards exclusive government funding *(11)*. This political success can certainly not be ascribed to the use of IDPoor alone, but it may be assumed that the reliability and the increased administrative efficiency of the system in identifying poverty served as an enabling factor. Beyond the HEF, the IDPoor system has helped to reduce the fragmentation of programmes in the health sector more generally, as data are also used for other voucher and cash transfer schemes that focus on maternal and child health *(11)*. This harmonization in the identification processes of the poor also allows for greater (administrative) efficiency gains at the system level.

Implementation issues and remaining questions

Thanks to the initial choice for relatively low-technology solutions, some of the typical implementation challenges related to introducing digital technologies – such as insufficient technical capabilities, lack of financial and human resources and poor Internet connectivity – seem to have been manageable in Cambodia. Reportedly, for IDPoor this low-technology strategy was to some extent deliberate, based on the conviction of domestic stakeholders and development partners that "the introduction of digital data capture and other information technology solutions may increase efficiency, but may preclude the participation of community members who lack technology skills" *(16)*. Additional digital features (web-based access to the database platform, taking photographs with smartphones and sending them off directly, and the use of tablets) were then gradually introduced as connectivity, digital literacy and the uptake of these technologies improved.

Some implementation challenges were observed, however. The IDPoor system does not retain full information about who is using its data and for which purpose the data are being used, raising questions about the confidentiality of the registered household data *(18)*. Although currently there does not appear to be any evidence that the possession of an Equity Card leads to stigmatization of poor households in the Cambodian context, insufficient protection of personal data could potentially lead to breeches of privacy. For a long time, another challenge was that even the three-year data collection cycle did not reflect many of the sudden changes in household composition (e.g. the birth of a child) or poverty. In order to further reduce data obsolescence, the on-demand IDPoor has now been rolled out over the entire country. This process was greatly accelerated by the COVID-19 crisis – while roll-out was anticipated to take three years, it was eventually realized in a matter of a few months. As such, the COVID-19 pandemic did not delay innovation but served as an accelerator. In fact, the IDPoor registry, including the 'on-demand' IDPoor feature, was also an important means to identify households in need of the support of a COVID-19 emergency cash transfer *(19)*. It will still be important, however, to monitor the potential trade-off between speed and accuracy in this process.

The Cambodian government is currently in the process of entirely replacing the three-year data collection cycle by the on-demand system. This move will not change the nature of the community-based identification process, but it is expected to further reduce exclusion errors, in particular for people who fall into poverty during a three-year cycle. Nevertheless, the move may create an additional administrative burden for the chronic poor if they are required to claim their eligibility status proactively (a process which is often linked with a high rate of non-take-up). Meanwhile the shift to a complete 'on-demand' process has been enhanced with a feature which alerts commune councils six months before an Equity Card expires, and which helps them to schedule a new interview.[3]

Other anticipated innovations in the upcoming years include the shift from a poverty identification mechanism only to a system that registers all vulnerable groups, as well as the shift from identification at household level to the level of individual household members.

[1] Personal communication.

3. PMJAY and the use of the Aadhaar identification system in India

In 2018, India introduced a new national health coverage scheme called Ayushman Bharat Pradhan Mantri Jan Arogya Yojana, referred to as PMJAY. This was done by combining the previous Rashtriya Swasthya Bima Yojana (RSBY) government-run health insurance scheme and the Senior Citizen Health Insurance Scheme (SCHIS), as well as some of the state health insurance schemes. The most recent National Health Accounts of India (2017–2018) still estimate out-of-pocket (OOP) expenditure to be 48.8% of current health expenditure, down from 69.4% in 2004–2005 *(20)*. Due to the high OOP costs, an estimated 8–9% of households are being pushed into poverty annually *(21)*. It was the objective of PMJAY to further reduce catastrophic health expenditure, improve access to quality health care, reduce unmet needs and reduce the OOP expenditures of poor and vulnerable families *(22)*. Health services are offered to poor and vulnerable households at empaneled hospitals (both public and private), amounting to approximately 40% of the population. Compared to the previous RSBY scheme, the PMJAY benefit package and benefit ceilings have been expanded and governance and purchasing arrangements have been altered.

To check the eligibility of beneficiaries, hospitals make use of the PMJAY patient database. It is accompanied by clear guidelines and a visualized decision tree to help hospital staff check eligibility *(23)*. The PMJAY patient database is based on the 2011 Socio-Economic Caste Census (SECC 2011) and contains the data of all household members that met one or more of the listed deprivation criteria during that census. All members of these households are eligible for PMJAY *(22)*. By definition, all families that were previously enrolled in the RSBY are also covered under PMJAY *(22, 23)*. Nonetheless, on the basis of the existing SECC database alone, it would still have been challenging in practice to determine whether a person seeking care belonged to a household listed in the PMJAY database of eligible beneficiaries. There are multiple reasons for this, including discrepancies in the spelling of names and geographical locations or inaccuracies in a person's age. For this reason, from the start of the new scheme, PMJAY has made use of a digitally supported identification system called Aadhaar (literally "foundation"), to confirm the identity and hence eligibility of a beneficiary under PMJAY when a person seeks care at a hospital.

The linkage between the digital identity system (Aadhaar system) and PMJAY

The Aadhaar identification system provides an Aadhaar smart card (with a QR code on it) to an individual. This smart card functions as the primary identification document and is also used for the PMJAY *(23)*. In contrast to the Cambodian system, Aadhaar is a digital identification system for the entire Indian population and registers individuals. It makes use of biometric data and is also linked to a person's telephone number and bank account. Introduced in 2010, Aadhaar is the world's largest biometric identity system. It is based on the Aadhaar number, a 12-digit random number issued by the Unique Identification Authority of India (UIDAI), which is given to each individual, irrespective of age and gender, who is a resident of India and who chooses to enrol in Aadhaar. In order to identify individuals reliably, demographic data as well as extensive biometric data are captured – i.e. a photograph, 10 fingerprints and two iris scans. The 12-digit number is unique, easily verifiable online and has proved to be sufficiently robust to eliminate duplicates and fake identities.

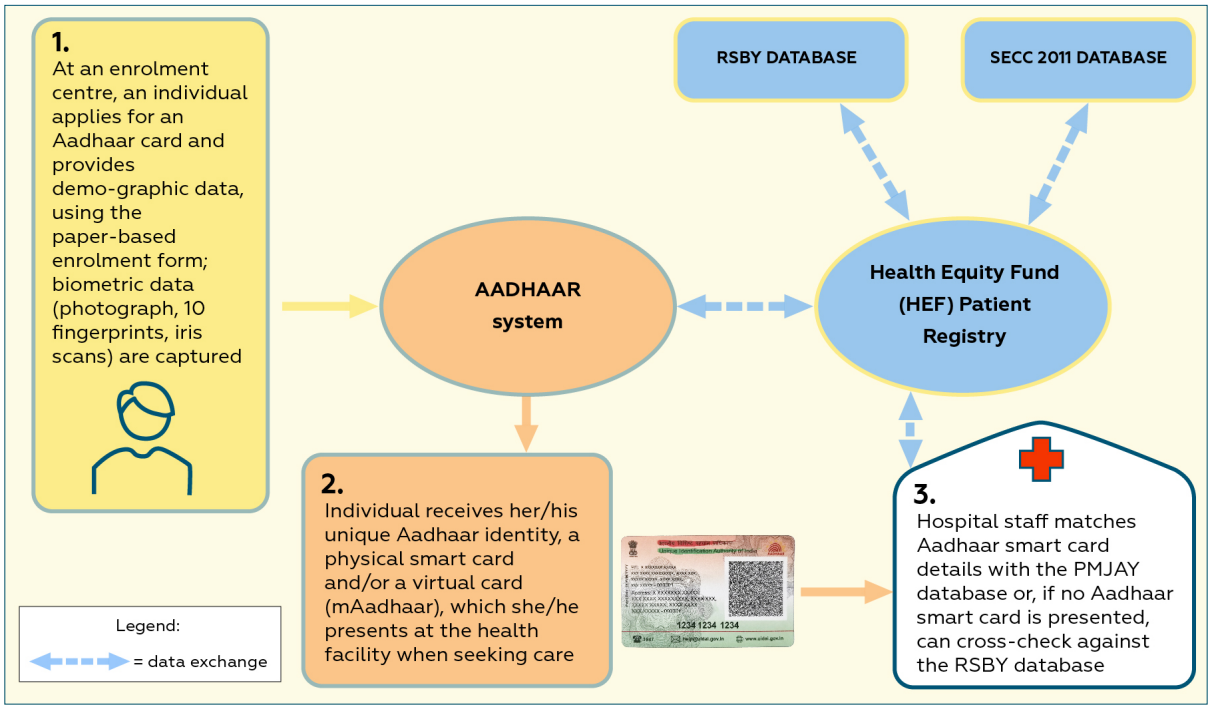
Importantly, while the Aadhaar number is a proof of identity, it does not profile people on the basis of caste, religion, income, health and geography. There is no minimum age for enlistment in Aadhaar. As one of the key pillars of the "Digital India" strategy, it supports several government welfare and social assistance schemes and service delivery programmes *(24)*. Since 2010, close to 1.3 billion Aadhaar numbers have been issued. According to the UIDAI annual report of 2019–2020, "almost the entire population" has been registered, while UIDAI is still seeking to target those who are missing – among these primarily children, women, the poor, disabled people and other marginalized groups *(25)*.

In contrast to the previous RSBY, which depended on a standalone data and smart card system (independent from other government systems), PMJAY's approach has evolved by using the existing Aadhaar system. When visiting a hospital for the first time, the person's QR code on the Aadhaar smart card is scanned to capture the identity details. The PMJAY system makes it possible to link the Aadhaar number to those household members in the PMJAY database that have been recognized as eligible, with this information being stored in the web-based PMJAY Beneficiary Identification System (BIS). This allows for future on-the-spot checking by a health-care provider of a patient's identity and eligibility for PMJAY health-care benefits. A demographic authentication is part of this linking process. Because there may be differences in spelling of names and geographical locations between the Aadhaar ID and the PMJAY databases, an algorithm computes a confidence score expressing the likelihood that this is the same person. If the confidence score is above a certain threshold, the Aadhaar code will be linked to the eligible household. Upon acceptance of eligibility, an Aayushman card (proof of entitlement under PMJAY) is also issued to the person: during a subsequent hospital visit, the person can also immediately be recognized as eligible upon presentation of this card.

If a person does not bring an Aadhaar card at all, he or she will be instructed to apply for an Aadhaar identify card at the nearest enrolment centre *(22, 23)*. In

case a person without an Aadhaar card needs emergency care, hospital staff can also cross-check the personal data (e.g. an old RSBY card or another identity card obtained from the government) against the database of the former RSBY scheme. If the person's identity information is found in that database, emergency care can be provided free of charge *(22, 23)*. Such cases are, however, increasingly rare, as the majority of Indians have by now obtained an Aadhaar identity and this is effectively mandatory in order to receive government social benefits *(23)*. Figure 2 shows the linkage between the PMJAY BIS and the Aadhaar system.

Figure 2. Linkage between the Aadhaar system and the identification process of the poor in PMJAY, India



Effects on health financing and universal health coverage objectives

Since Aadhaar had already been introduced in 2010, while the PMJAY scheme was launched in 2018, PMJAY was able to benefit from the availability of Aadhaar identification data that had been compiled over the course of almost a decade and the high degree of legitimacy that it enjoyed in government and among the public. While it is difficult to assess the specific role of the Aadhaar identity card on the PMJAY's contribution to progress in universal health coverage, we can observe a number of effects on beneficiary identification.

The link between the PMJAY and the Aadhaar has created more uniformity in the registration and confirmation of identities of beneficiaries (compared to the previous RSBY) and has reduced the administrative burden on hospitals since the personal data of beneficiaries can now immediately be captured from the Aadhaar

smart card and do not have to be entered manually into the hospital's patient registration system again. For providers, this has simplified the confirmation of eligibility, while also reducing the risk of unintentional misidentification and/or fraud by patients. Moreover, the link to Aadhaar seems to have facilitated the enrolment process of people into the PMJAY since public awareness-raising has stressed the health coverage benefits of an Aadhaar identity smart card. *(26)*.

The Aadhaar system does not itself carry out the targeting and identification, but it contributes to easing the process of confirming a beneficiary's identify at the level of the health-care provider. The Aadhaar system is claimed to have enabled enormous savings in various government subsidy and social assistance programmes through reduced leakage and increased gains in administrative efficiency *(27)*. Aadhaar has also been used to support the COVID-19 vaccination programme and to help people in need to access COVID-related health services as well as cash benefits *(28)*.

Implementation issues and remaining questions

A key implementation challenge is that not all currently eligible beneficiaries are aware of their eligibility, the benefits to which they are entitled or how to seek those benefits *(29)*. Another challenge for the PMJAY BIS has been the inaccuracy of the SECC database which is being used to determine eligibility of beneficiaries. As the last SECC was released in 2011, household poverty data are now a decade old and are often no longer correct. The obsolescence of the data is demonstrably increasing both inclusion and exclusion errors. As such, soon after the introduction of PMJAY, it became clear that some people who should not have been included appeared on the list of eligible beneficiaries (e.g. households where one of the members was a government employee or elected representative). To reduce such inclusion errors, the government developed and circulated a list of exclusion clauses and criteria *(30)*. On the other hand, changes in household composition or falling into poverty after 2011 have also led to exclusion errors.

A new survey across the country was considered impossible *(29)*. Instead, the government is now also using beneficiary data from other social assistance systems to inform the PMJAY database of eligible beneficiaries. It will be important to transform these gains into additional benefits for people rather than reduced spending. Future monitoring and evaluation of the PMJAY could look at the extent of efficiency gains and reduced inclusion errors for the PMJAY due to Aadhaar. However, two overarching questions remain, namely: how can poor people in the informal sector be identified and enrolled into PMJAY, and what role can Aadhaar play in addressing these issues?

As Aadhaar makes use of biometric data and is linked to the telephone number and bank account of the individual, it greatly enhances the potential to triangulate data. However, this may also lead to increased risks and concerns related to data privacy and confidentiality. For instance, interruptions in the treatment of patients with tuberculosis and AIDS were reported, as they feared such breaches of data confidentiality *(26)*. A future question relates to the potential linkage between Aadhaar and the Unique Digital Health card, currently introduced through the National Digital Health Mission, and the benefits and risks this may create.

4. Community-based health insurance and the Ubudehe system in Rwanda

The community-based health insurance scheme (CBHI) was introduced in Rwanda in 1999–2000 to provide coverage for the majority of the Rwandan population. Over the past two decades, the Rwandan health financing system has undergone substantial reforms and realized great improvements in health outcomes *(31)*. While called "CBHI", the Rwandan health insurance scheme shows features of a national scheme foremost due to the pooling of funds beyond the community level. The coverage rate stood at 81.6% in the fiscal year 2015–2016, with another 6% of the population covered through other insurance schemes *(31)*. State budget transfers are a key feature of the financing of the CBHI in addition to contribution payments. Since 2010, the poorest households have been provided with fully-subsidized health coverage through the CBHI – i.e. their entitlement is not linked to a contribution, whereas other household categories pay different levels of health insurance contributions based on their income and assets *(31)*. For the poorest households in Category I (accounting for 17% of the population in 2015), the contribution rate amounted to RWF 2000 (about US$ 2) per year, being fully government-funded. Category II (38%) and III (45%) households contributed RWF 3000, while category IV households (only 0.5% of the population) paid RWF 7000 per household per year *(31, 32)*. The different levels of CBHI contributions, including eligibility of households for fully subsidized contributions (and related exemptions from copayments) are determined on the basis of the Local Administrative Entities Development Agency Monitoring and Evaluation Information System (LODA MEIS), commonly referred to as the "Ubudehe system". Ubudehe is a cultural value and practice of mutual assistance which has also given its name to the system of socioeconomic categorization of households *(33)*.

The introduction and subsequent digitalization of the Ubudehe system

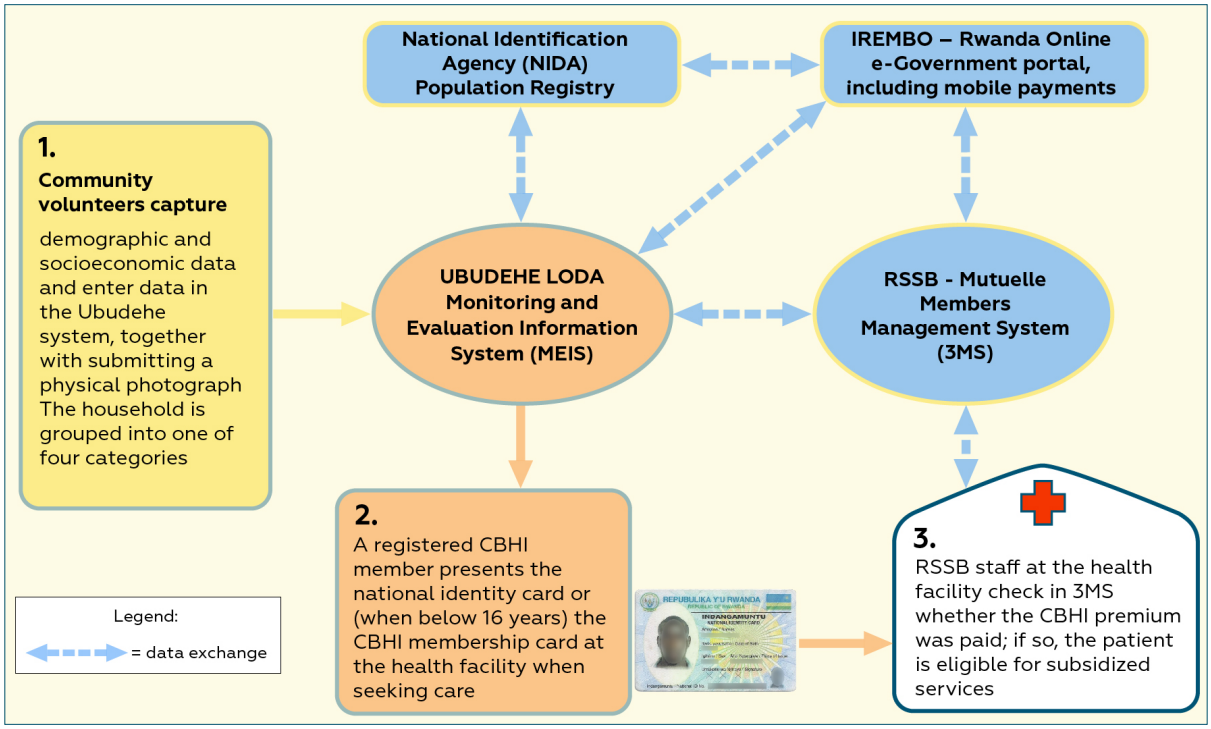
The Ubudehe system was piloted in 2001–2004 as a targeting approach used by various social protection programmes and managed by the Ministry of Local Government *(34)*. As in Cambodia, identification of the poor is undertaken at the community level, with eligibility being determined for the household. Yet, as in India, the Ubudehe categorization system is universal, registering not only the poor but all households. Through a community-based process, each household is categorized on the basis of its socioeconomic status. Community volunteers collect data on household assets, which is then checked and validated in a community assembly.

Until 2010, the recording of Ubudehe data at the local level was entirely paper-based, from where the information was copied to the central administration. When the CBHI started to stratify its contribution rates in 2011, this created a need for better data accessibility and a possibility to update household socioeconomic data more frequently. The Ministry of Local Government and the Ministry of Health joined forces to create a nationwide, web-based accessible database – the Ubudehe system which captures all relevant demographic and socioeconomic data at household level. Several rounds of data collection took place to update the process of stratifying contribution rates. The responsibility to enter the household data into the Ubudehe system lies with community representatives, thus serving to ensure local ownership and better data accuracy. Changes in the composition of a household can also be effected quickly *(33)*. Figure 3 presents the linkage between the CBHI identification process and the use of Ubudehe.

Initially, there was no interconnectivity between the Ubudehe system and the registration of CBHI membership and payment of contributions, as the latter were both paper-based. This was eventually addressed: in 2015, the management of the CBHI was transferred to the Rwandan Social Security Board (RSSB) which is now in charge of the CBHI administration. In 2018, RSSB introduced the Mutuelles Members Management System (3MS), which was subsequently linked to the Ubudehe system through an API. For the RSSB to determine which contribution rate a household should pay, the 3MS system can retrieve the information from the Ubudehe system. Moreover, the 3MS system was connected with "IREMBO-Rwanda Online", an e-Government portal that also allows for making mobile telephone-based payments of contributions. Through this enhanced interoperability, it is possible to link all necessary information in order to check whether a household has paid the correct contribution amount on time *(35)*.

In 2019, the Ubudehe system, in its turn, was connected to the Population Registry of the National Identification Agency (NIDA), which issues national identification numbers (and associated cards) to people older than 16 years. Updates in the NIDA database are transferred to the Ubudehe system on a continuous basis, thus also improving the ability of the RSSB to manage its beneficiary database *(36)*. In the same year, this interface was fully functional and 90% of all persons over 16 years in the Ubudehe database had been matched to a national identity profile *(36)*.

Figure 3. Linkage between the Ubudehe system and the other data systems used under CBHI, Rwanda



Effects on health financing and universal health coverage objectives

While stratification of CBHI contributions would, in theory, also have been possible without the use of digital technology, it was greatly facilitated in practice by the Ubudehe system. Under the previous paper-based system, the necessary exchange of information would have been far more time-consuming and labour-intensive, and thus more expensive. Where the available per capita budget for health is small, such high operational costs affect the financial sustainability of the overall scheme. Thanks to the Ubudehe system, up-to-date information on household composition and socioeconomic status was available and accessible online and in real-time at relatively lower costs. The more sophisticated data architecture, namely the 3MS system, subsequently connected to the Ubudehe system and to the IREMBO-Rwanda Online portal, has greatly enhanced the ease of tracking payments (and thereby of confirming validity of CBHI membership), resulting in fewer delays and fewer opportunities for fraud, such as the presentation of a false identity document or a false proof of payment.

It is also noted that the share of contributions collected from households increased as a source of revenue for the CBHI following the introduction of the 2010 CBHI policy (*32, 37*). By enabling the stratification of contribution rates, the Ubudehe system with its digital technology may also have helped to improve the acceptability of paying contributions as well as the financial sustainability of the CBHI scheme indirectly.

Implementation issues and remaining questions

As the first Ubudehe electronic database of 2011 lacked interoperability with the membership database on payments made, initial implementation experiences were suboptimal. Contribution payments could be tracked only through an unconnected paper-based system, leading to delays in enrolment and health provider reimbursements and cases of fraudulent benefit claims (35). The annual process of collecting contributions for household members was also more complex than it had been prior to 2010 because of the need to collect socioeconomic household data and to apply stratified contribution rates. Between fiscal years 2010–2011 and 2013–2014, the CBHI enrolment rate dropped quite substantially from 91% to 74% (38). While there are multiple causes, the lack of appropriate digital technologies in these earlier years to support the implementation of the new approach of stratifying contribution levels based on household classification may have been a contributing factor, since a complex and tailored policy response requires factoring in multiple data on individuals and households in a systematic way. These challenges were addressed inter alia by creating interoperability between the CBHI system, Ubudehe, 3MS and NIDA (36).

Under its 2020–2025 Strategic Plan, the RSSB aspires to also digitalize the provider payment system and to conduct a review of the information management systems across the RSSB and the Ministry of Health in order to assess the potential to share, interlink and analyse data (33). Efforts to set up an even more integrated social protection management information system (iSP-MIS) are under way to incorporate the data systems of other social assistance programmes (36).

5. Cross-country issues

The three country cases show that digital technologies have played an important role in supporting and improving the process of identifying the poor as well as confirming their identity and eligibility for a health coverage scheme. This was done either by strengthening an existing health financing scheme (as in Cambodia and Rwanda) or by supporting the launch of a renewed, more comprehensive scheme (as in India). Table 1 summarizes the key features of the digital technologies applied by each country.

One prominent digital enhancement which was observed in all three countries is the introduction of web-based information systems for the health coverage schemes. Equally critical is the linkage of those systems to other government databases, which register the poverty status of households (IDPoor in Cambodia), or gather the whole population's socioeconomic status (Ubudehe system in Rwanda), or confirm the identity of beneficiaries (Aadhaar in India). In Cambodia, the IDPoor system is being linked to a growing number of other government databases to help identify further vulnerable population groups in addition to the poor, with the use of tablets enhancing the speed and the accuracy of collected data. In India and Cambodia, respectively, biometric data and mobile telephone photographs are captured to confirm the identity of beneficiaries. In Rwanda, the Ubudehe system is also connected to the national population registry, enabling the validation of people's identity.

In all three countries, there are ongoing discussions about the potential of connecting to yet more government databases. This means moving in the direction of a single social registry – i.e. one information system that supports registration and determination of potential eligibility for a multitude of social programmes. While there are arguments for the potential power of social registries as gateways for inclusion *(39)*, past failure of social registries to identify the beneficiaries of social programmes accurately raise concerns, because the registries suffered from large targeting errors, a frequently static nature and high costs *(40)*. With enhanced digital features, new attempts to achieve such registries would have to demonstrate that they can address these concerns successfully. For example, targeting accuracy should increase – i.e. the number of exclusion errors as well as extreme cases of inclusion errors (i.e. particularly inclusion of people in the top income quintiles) should reduce.

Overall, positive effects of using digital technologies for various health-financing tasks can be observed – such as reduced administration costs for the purchasers, less cumbersome procedures, and time-savings for beneficiaries and health providers, as well as for other national agencies which also reduces their costs again. The availability of web-based platforms specifically created the possibility to update household composition and socioeconomic data much more frequently. Overall, this contributes to increased efficiency as well as to stronger trust and transparency.

Although each of the three health financing schemes could, in theory, also have operated without the use of digital technologies, in practice this would be very cumbersome and extremely labour-intensive, which would not have allowed for the same level of operational flexibility. In Rwanda, for instance, it is difficult to imagine how the stratification of CBHI premiums could have been implemented reliably without a data system that allowed for near real-time updating of information. The efficiency gains, of course, need to be evaluated against the investments and the costs of operating the digital technologies.

Table 1. Digital technology features used in the identification and identity confirmation processes in the three countries

	Cambodia (HEF – IDPoor)	**India** (PMJAY – Aadhaar)	**Rwanda** (CBHI – Ubudehe)
Unit of identification	Household	Individual	Household
Share of population enrolled in the health coverage scheme	Around 20% (poor and extremely poor households)	Around 40%	80–90%
Digital technologies in use	**Web-based data system** to support data management and access to household eligibility information for health-service providers (and other organizations) **Tablets** (for data entry) and **digital photographs**, to support the data collection process at community level and to speed up and secure data submission to the higher administrative levels.	**Web-based data system** to support patient data management (PMJAY eligibility) at hospitals. **Smart cards**: Aadhaar identify card, containing extensive biometric data (**digital photograph, ten fingerprints and two iris scans**) to support identity confirmation at hospitals. **Algorithm** to compute confidence score for identify confirmation.	**Web-based data system** to support household data management (information on enrolment status and payment of contributions based on socio-economic categorization).
Interoperability with other databases and systems	Yes APIs with: • Patient Management and Registration System of referral hospitals (PMRS) • databases of several other social assistance schemes, also beyond the health sector	Yes • Aadhaar and PMJAY BIS are used in conjunction with: • the Socio-Economic Caste Census (SECC) 2011 database, and • databases of other social assistance schemes	Yes Ubudehe has APIs with: • Member management system of RSSB (3MS) • e-government portal allowing for mobile payments of contributions (IREMBO-Rwanda Online) • population registry (NIDA) • other social assistance schemes beyond the health sector

6. Lessons and conclusions

Several lessons and policy recommendations can be drawn from these three country experiences. First, as demonstrated by all three country cases, there are important advantages to interoperability and a multisectoral approach between different ministries and social protection programmes. Instead of trying to set up a new data system in silo, it is clearly much more promising to identify the eligible beneficiaries for health coverage programmes by combining efforts with other social protection or social assistance schemes *(41)*. Even without a complete leap towards a unique digital identity, existing poverty data from multiple sources can be exchanged, re-used and triangulated, thus avoiding unnecessary duplication of data collection for targeting and identification. Once an interoperable and integrated database is in place, it can inform targeting of the poor for very diverse interventions. Some other countries already build on the potential of combining different databases to assess eligibility for social assistance programmes and to determine households' or individuals' ability to pay health insurance contributions *(41)*.

In the set-up of any digital register, a second important lesson is to deliberately choose context-appropriate digital technology. This is a matter of feasibility, available budget and country capacity, including available capacity of technical knowledge as well as of the digital environment and infrastructure. The most advanced technological solution is not always the best. Taking into account the country's digital capacity, and in particular the digital literacy of both the general population and government staff, as well as cultural norms and values, one may well end up with a relatively lower-technology solution to begin with, which was a deliberate choice in the case of Cambodia for instance *(16)*. Once a first-order approach has proved to be successful, there can then be a path dependency because this paves the way for gradual uptake of new applications. This also requires a dynamic mindset within government institutions and enabling learning processes that take time *(11, 16)*. At the same time, it is critical that policy determines what the digital technologies are intended for, and not that digital technologies define policy content. External partners can play an important supportive role at each step of the development process through both financial and technical support, as is illustrated by the case of IDPoor in Cambodia.

Third, beyond mere contextualization, there is a strong case to consider which parts of the process should be digitalized in the first place and which should not, and how this can be combined with the added value of inclusive, participatory, community-based processes in obtaining reliable data and building citizens' trust. As the experience in Cambodia demonstrates, the involvement of the commune councils was critical to validation of the poverty status of households in parallel to the use of digital technologies in order to enhance people's trust of in the new digital system *(16)*.

Fourth, even when the aim is to identify the poor, it may be advisable to create or build on a database for all citizens, and not just have a database for the poor. Such a universal database could allow for more flexibility, which is especially relevant to individuals and households who move in and out of poverty over time. It also enables the use of data for other social assistance programmes. Of course, this flexibility also comes with risks. Although this paper has not focused on data security and protection concerns, all data that are collected could well be put to different use, which could compromise privacy and confidentiality. These concerns are discussed in detail elsewhere *(6)*.

In summary, these three country cases demonstrate the added value of digital technology in supporting processes for confirming people's identity and identifying the poor for health coverage schemes. Specifically, such digital technologies can contribute to increased efficiency as well as to strengthened trust and transparency.

Nonetheless, further innovations undoubtedly lie ahead. One question is whether and how enhanced interoperability tools that connect different databases (e.g. on income tax, property and other taxes, household electricity bills, mobile telephone airtime) could lead to an automated process of pre-identification of poor people *(41)*. When this is coupled with "automatic" enrolment of targeted and eligible beneficiaries by government authorities, it could result in improved access to health services – so long as people are aware of their eligibility status and enrolment.

Artificial intelligence may potentially support such automated (pre-)identification processes of poor or otherwise vulnerable population groups *(4)*. As described above, India is already using an algorithm as part of its identity confirmation process. Machine learning methods may have the potential to support the precision of targeting processes further: a 2018 study in Italy found that the effectiveness of a tax rebate scheme could have increased substantially through the application of a machine learning algorithm to select beneficiaries, while a 2021 study on the targeting of social protection interventions in Pakistan presented similar findings *(42, 43)*. Yet again, there are numerous legal and ethical issues associated with such scenarios; data privacy, security and algorithmic bias are just some that could be foreseen. Consequently, it is an open question as to whether the benefits of connecting numerous databases will outweigh the risks.

In assessing any new application of digital technology, we need to ask ourselves whether it contributes to UHC objectives or whether it could potentially also be detrimental. Overall, sound and tailored health-financing policy design remains the key success factor for progress towards UHC. Digital technologies need to be designed and implemented in ways that support these policies.

7. References

1. Digital technologies for health financing: what are the benefits and risks for UHC? Some initial reflections. (Health financing working paper, No. 19). Geneva: World Health Organization; 2021 (https://apps.who.int/iris/handle/10665/343505, accessed 12 June 2022).
2. Kutzin J. Health financing for universal coverage and health system performance: concepts and implications for policy. Bull World Health Organ. 2013;91(8):602–11. doi : 10.2471/BLT.12.113985.
3. Hanson K, Brikci N, Erlangga D, Alebachew A, De Allegri M, Balabanova D et al. The Lancet Global Health Commission on financing primary health care: putting people at the centre. Lancet Glob Health. 2022;10(5):e715–72. doi: https://doi.org/10.1016/S2214-109X(22)00005-5.
4. The implications of artificial intelligence and machine learning in health financing for achieving universal health coverage: findings from a rapid literature review. Geneva: World Health Organization; 2022 (in press).
5. Meessen B. The role of digital strategies in financing health care for universal health coverage in low- and middle-income countries. Glob Health Sci Pract. 2018;6(Suppl 1):S29-40.
6. Ho CWL, Ali J, Caals K. Ensuring trustworthy use of artificial intelligence and big data analytics in health insurance. Bull World Health Organ. 2020;98(4):263–9. doi: 10.2471/BLT.19.234732.
7. Walle van de D. Targeting revisited. Washington (DC): The World Bank Research Observer. 1998;13(2);231-48 (https://documents1.worldbank.org/curated/en/250031468149103548/pdf/766220JRN0WBRO00Box374385B00PUBLIC0.pdf, accessed 4 February 2022).
8. Vilcu I, Probst L, Bayarsaikhan D, Mathauer I. Subsidized health insurance coverage of people in the informal sector and vulnerable population groups: institutional design trends in Asia. Int J Equity Health. 2016;15:165. doi: 10.1186/s12939-016-0436-3.
9. Meessen B, Criel B. Health and social protection in transitional Asia: challenges and ways forward. In: Meessen B, Pei X, Criel B, Bloom G, editors. Health and social protection: experiences from Cambodia, China and Lao PDR. Studies in Health Services Organisation & Policy, 23. Antwerp: ITG Press; 2008.

10. Gwatkin DR. Targeting health programs to reach the poor. Washington (DC): The World Bank; 2000 (https://openknowledge.worldbank.org/handle/10986/29585, accessed 22 November 2021).
11. Kaba MW, Baesel K, Poch B, Bun S, Cerceau S, Bury L et al. IDPoor: a poverty identification programme that enables collaboration across sectors for maternal and child health in Cambodia. BMJ. 2018;363:k4698.
12. Annear PL, Wilkinson D, Chean MR, van Pelt M. Study of financial access to health services for the poor in Cambodia: Phase 1: Scope, design, and data analysis; 2006. Research report (https://www.dfat.gov.au/sites/default/files/cambodia_health.pdf, accessed 17 June 2022).
13. Flores G, Ir P, Men CR, O'Donnell O, van Doorslaer E. Financial protection of patients through compensation of providers: the impact of health equity funds in Cambodia. J Health Econ. 2013;32(6):1180–93.
14. Men CR, Meessen B. Community perceptions of pre-identification results and methods in ix health equity fund areas in Cambodia. In: Meessen B, Pei X, Criel B, Bloom G, editors. Health and social protection: experiences from Cambodia, China and Lao PDR. Studies in Health Services Organisation & Policy, 23. Antwerp: ITG Press; 2008.
15. Ensor T, Chhun C, Kimsun T, McPake B, Edoka I. Impact of health financing policies in Cambodia: a 20 year experience. Soc Sci Med. 2017;177:118–26.
16. Annear P, Barrientos A. Leave no one behind: insights from Cambodia's national poverty identification system. Bonn: German Federal Ministry for Economic Cooperation and Development; 2017 (https://health.bmz.de/studies/leave-no-one-behind, accessed 12 June 2022).
17. IDPoor website (https://mop.idpoor.gov.kh/, accessed 5 November 2021).
18. Serajuddin U, Uematsu H, Wieser C, Yoshida N, Dabalen A. Data deprivation: another deprivation to end. Policy Research Working Paper 7252. Washington (DC): The World Bank; 2015 (https://openknowledge.worldbank.org/bitstream/handle/10986/21867/WPS7252.pdf?sequence=2&isAllowed=y, accessed 5 November 2021).
19. Pagnathun T, Cerceau S, De Riel E. Cambodia's social protection response to COVID-19. Brasília: The International Policy Centre for Inclusive Growth. Policy in Focus. 2021;19(1):40–2; 2021; 19; 1 (http://ipcig.org/sites/default/files/pub/en/PIF47_What_s_next_for_social_protection_in_light_of_COVID_19.pdf, accessed 17 January 2022).
20. India: National Health Accounts Technical Secretariat (NHATS). National health accounts estimates for India 2017–18. New Delhi: Ministry of Health and Family Welfare; 2021 (https://nhsrcindia.org/sites/default/files/2021-11/National%20Health%20Accounts-%202017-18.pdf, accessed 24 December 2021).
21. Choudhury M, Dubey JD, Mondal, B. Analyzing household expenditure on health from the 71st round of survey by the National Sample Survey Organization in India. New Delhi: National Institute of Public Finance and Policy (NIPFP); 2019 (https://www.nipfp.org.in/media/medialibrary/2019/12/WHO_NSSO_report_2019.pdf, accessed 4 November 2021).

22. National Health Benefit Package 2.2: User guidelines; version November 2021. New Delhi: National Health Authority; 2021 (https://nha.gov.in/img/resources/HBP-2.2-manual.pdf, accessed 16 May 2022).

23. Beneficiary identification guidelines: Ayushman Bharat – Pradhan Mantri Jan Arogya Yojana (AB PM-JAY). New Delhi: National Health Authority (https://ayushmanup.in/admin/Clients/Doc/85_Guidelines-on-Process-of-Beneficiary-Identification.pdf, accessed 16 May 2022).

24. UIDAI website. New Delhi: Unique Identification Authority of India (https://uidai.gov.in/my-aadhaar/about-your-aadhaar.html, accessed 29 September 2021).

25. Annual Report 2019–20. New Delhi: Unique Identification Authority of India; 2020 (https://uidai.gov.in/images/AADHAR_AR_2019_20_ENG_approved.pdf, accessed 29 September 2021).

26. Gopichandran V, Ganeshkumar P, Dash S, Ramasamy A. Ethical challenges of digital health technologies: Aadhaar, India. Geneva: Bull World Health Organ. 2020;98(4):277–81. (https://apps.who.int/iris/bitstream/handle/10665/331885/PMC7133485.pdf, accessed on 29 September 2021).

27. World Development Report 2016: Digital dividends. Washington (DC): The World Bank; 2016. doi: 10.1596/978-1-4648-0671-1.

28. Saini S, Hussain S. Leveraging India's Aadhaar platform to ease COVID-19 pain. EastAsiaForum. 1 October 2021 (https://www.eastasiaforum.org/2021/10/01/leveraging-indias-aadhaar-platform-to-ease-covid-19-pain/, accessed 17 January 2022).

29. Sharma NC. Govt looks beyond SECC 2011 to include more beneficiaries under Modicare. Mint. 10 June 2019 (https://www.livemint.com/politics/policy/govt-looks-beyond-secc-2011-to-include-more-beneficiaries-under-modicare-1560187873216.html, accessed 29 September 2021).

30. NHA issues circular advising states to identify eligible PMJAY beneficiaries. The Economic Times. 6 October 2018 (https://economictimes.indiatimes.com/news/politics-and-nation/nha-issues-circular-advising-states-to-identify-eligible-pmjay-beneficiaries/articleshow/66096010.cms, accessed 29 September 2021).

31. Chemouni B. The political path to universal health coverage: power, ideas and community-based health insurance in Rwanda. World Development. 2018;106:87–98.

32. Health Financing Strategic Plan 2018–2024. Kigali: Ministry of Health; 2019 (https://www.moh.gov.rw/fileadmin/user_upload/Moh/Publications/Strategic_Plan/HFSP.pdf, accessed 20 May 2022).

33. Kayira F, De Laminne de Bex A. Innovation developed in Rwanda to support social protection interventions. 2011 (https://www.social-protection.org/gimi/gess/ShowRessource.action;jsessionid=pvg-y5INj3Yg8AAQTZDhx8ooNTSAatcFkL4y9_SgttgSS_n3ia7y!445242879?lang=AR&id=23180, accessed 11 October 2021).

34. Rwanda Social Security Board Strategic Plan, July 2020–June 2025. Kigali: Rwanda Social Security Board; 2020 (https://www.rssb.rw/fileadmin/user_upload/RSSB_Strategic_Plan_2020_-_2025.pdf, accessed 11 October 2021).

35. Ntaganzwa E. Community-based health insurance (CBHI) in Rwanda: Needs assessment for the improvement of membership management systems (dissertation Ref: 217168191). Kigali: University of Rwanda; 2018 (http://dr.ur.ac.rw/handle/123456789/544?show=full, accessed 24 November 2021).

36. Implementation, completion and results report on three credits (...) to the Republic of Rwanda for a social protection system. Washington (DC): The World Bank; 2019 (https://documents1.worldbank.org/curated/en/643221556573184023/pdf/Rwanda-Social-Protection-System-Development-Policy-Operation-Projects.pdf, accessed 24 November 2021).

37. African Strategies for Health. Health Insurance Profile: Rwanda. Arlington (VA): United States Agency for International Development; 2016 (http://www.africanstrategies4health.org/uploads/1/3/5/3/13538666/country_profile_-_rwanda_-_us_letter.pdf, accessed 21 May 2022).

38. Mukangendo M, Nzayirambaho M, Hitimana R, Yamuragiye A. Factors contributing to low adherence to community-based health insurance in rural Nyanza District, southern Rwanda. J Environ Public Health. 2018. Article ID 2624591. doi: 10.1155/2018/2624591.

39. Leite P, George T, Sun C, Jones T, Lindert K. Social registries for social assistance and beyond: a guidance note & assessment tool. (Social Protection & Labor Discussion Paper, No. 1704). Washington (DC): The World Bank; 2017 (https://documents1.worldbank.org/curated/en/698441502095248081/pdf/117971-REVISED-PUBLIC-Discussion-paper-1704.pdf, accessed 26 November 2021).

40. Kidd S, Athias D, Mohamud I. Social registries: a short history of abject failure. Development Pathways and ACT Church of Sweden; 2021 (https://www.developmentpathways.co.uk/wp-content/uploads/2021/06/Social-registries-a-short-history-of-abject-failure-June.pdf, accessed 26 November 2021).

41. Packard T, Gentilini U, Grosh M, O'Keefe P, Palacios R, Robalino D, Santos I. Protecting all: risk sharing for a diverse and diversifying world of work. Washington (DC): The World Bank; 2019 (https://documents1.worldbank.org/curated/en/997741568048792164/pdf/Protecting-All-Risk-Sharing-for-a-Diverse-and-Diversifying-World-of-Work.pdf, accessed 26 November 2021).

42. Andini M, Ciani E, de Blasio G, D'Ignazio A, Salvestrini V. Targeting with machine learning: an application to a tax rebate program in Italy. J Econ Behav Organ. 2018;156:86–102.

43. Mumtaz Z, Whiteford P. Machine learning based approach for sustainable social protection policies in developing societies. Mob Netw Appl. 2021;26(1):159–73.

9789240063990