Transforming the health information system using mobile and geographic information technologies, Papua New Guinea

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Abstract In the context of declining economic growth, now exacerbated by the coronavirus disease 2019 pandemic, Papua New Guinea is increasing the efficiency of its health systems to overcome difficulties in reaching global health and development targets. Before 2015, the national health information system was fragmented, underfunded, of limited utility and accessed infrequently by health authorities. We built an electronic system that integrated mobile technologies and geographic information system data sets of every house, village and health facility in the country. We piloted the system in 184 health facilities across five provinces between 2015 and 2016. By the end of 2020, the system’s mobile tablets were rolled out to 473 facilities in 13 provinces, while the online platform was available in health authorities of all 22 provinces, including church health services. Fractured data siloes of legacy health programmes have been integrated and a platform for civil registration systems established. We discuss how mobile technologies and geographic information systems have transformed health information systems in Papua New Guinea over the past 6 years by increasing the timeliness, completeness, quality, accessibility, flexibility, acceptability and utility of national health data. To achieve this transformation, we highlight the importance of considering the benefits of mobile tools and using rich geographic information systems data sets for health workers in primary care in addition to the needs of public health authorities.

Introduction

Achievement of universal health coverage (UHC) and the sustainable development goals are currently unattainable in the fragile state of Papua New Guinea. 1 Total health expenditure as a percentage of gross domestic product remains low in real terms and has been declining since 2004, while several key health access and quality indicators declined between 2006 and 2015. The World Bank has reported that donors provide about 20% of the country’s total annual spending on health but that the sources, amounts and recipients of funding are volatile. 2 In the context of declining economic growth, development partners were urging the government of Papua New Guinea to increase the efficiency of current spending to create a stronger health system and better prepare itself for transition from the Global Fund to Fight AIDS, Tuberculosis and Malaria.

Good health information is crucial for understanding and improving the efficiency of health-care delivery. Yet this core building-block of a robust health system is frequently absent in fragile settings. Despite donor partners’ investment of more than 182 million United States dollars in key disease programmes in Papua New Guinea before 2015, 3 the national health information system was not benefiting to any extent. The system had become fractured, was difficult for users to access and was performing poorly. 4 This deterioration meant that modelling, rather than disease reporting, was being used to understand the disease burden for priority disease programmes such as those for human immunodeficiency virus (HIV) control. 5 Improvements to the country’s disparate, weak health information system for different health programmes and service-delivery levels was needed.

In this context, the Asian Development Bank’s National Health Services Sector Development Program conducted a pilot of mobile device technologies and geographic information systems in the capture and reporting of health data. Initially conducted in 184 health facilities in five provinces, the pilot was expanded following independent reviews in 2017–2018 6 to become the national system in all 22 provinces. Mobile tablet devices for the electronic national health information system were supplied to 473 facilities across 13 provinces by the end of 2020. The electronic system aimed to repair the fractured health information system by integrating separate data collection systems into the one system to enable future disease-specific investments to benefit a larger number of health programmes. We describe the 6-year transformation of Papua New Guinea’s health information system over 2015–2020 and the implications for policy and practice.

System description

Papua New Guinea’s electronic national health information system is based on a password-protected mobile application that provides an interface to the system (Box 1). Health-care workers access the system on tablet computers and the data provided feed into an online platform accessed by health authority staff. The application includes modules for data entry, automated summary data, a repository of national and international guidelines, a data dictionary and an automatically updating contact list. The frequency of user logins to the online platform is captured by the system.

Monthly reporting covers outpatients, inpatients, well-baby services, immunizations, malaria, leprosy, HIV, tuberculosis, school health services, family planning, antenatal care, deliveries and drug shortages. The system also reports how many outreach clinics were planned and implemented and which programme staff from provincial authorities conducted

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supportive supervision. Every household, village and health facility in the country is geolocated within the system using geographic information systems overlaying high-resolution satellite imagery. The data captured by the system integrate with the geographic information system for analysis, visualization and reporting. Different types of health data have different levels of granularity; for example, tuberculosis is mapped to the house, malaria to the village or slum, vaccinations to the health facility. Individual patient data-captures enable the continuous updating of the geo-coded village list of more than 20,000 villages. Registered tuberculosis patients are now remotely geolocated to their household using searchable high-resolution satellite images. These data automatically feed into programme management tools, including dashboards, live maps and reports that automatically prioritize the required public health follow-up. To plan outreach services and campaigns, users can visualize and manually count every house in the country or in user-defined areas, using mapping tools that overlay onto high-resolution satellite images accurate to about 30 m.

Improved data collection

Mobile technologies and geographic information systems are increasing the timeliness, completeness, quality, accessibility, flexibility, acceptability and utility of national health data in Papua New Guinea.

Accessibility

Access to the old data platform was available up to two health information staff in each province and a small team of about nine people in the national health authority. The new electronic information system has expanded user access to data and tools beyond these traditional users to programme managers and technical staff within national and subnational health authorities (Fig. 1). Faith-based health services provide the majority of primary health care in the country and previously had no access to their own data or analysis tools. The electronic system now enables church health service staff to access data and tools themselves, as illustrated by 556 logins to the new system in the past 12 months. Feedback to end-users has shifted from the manual production of one annual national paper report with an unclear distribution to automated
monthly feedback to tablet devices in every reporting facility.

The new system tracks the adoption and use of health information across the various health programmes. The number of logins to the health information system by health authority staff and partners has risen from 4103 in 2017 to 24,334 in 2020 (Fig. 2). In 2019, there was a median of 101 monthly logins by health authorities and partners in provinces using mobile tablets versus 43 where data were entered from paper into the online portal within the provincial health authorities. The new system can therefore provide health authority management teams with a single metric on the degree to which programme staff at all levels engage with their programme data. The new system has important implications for public health practice through improving the efficiency of health programmes.

Completeness

The electronic information system will help the government to better allocate its national health budget. Health authorities can now identify gaps in the completeness of national health data and the indicators used to inform health planning and budget allocation. For example, more than 4 years of data from the national tertiary referral hospital were missing from the national health information system, and service delivery data were not being captured by Mercy hospital ships and other mobile health-service providers. To highlight the implications using 2019 data, the national referral hospital’s inpatient caseload alone represented 17.5% (14,938) of the country’s 85,323 inpatients. These data would previously have been missing from the health indicators used for planning and budgeting.

Timeliness

Monthly reporting from the electronic system is faster than before (10 versus 90 days), and enables near real-time use of hospital data, overcoming a 4-year delay in making these data available for use (Matheson D, et al., Asian Development Bank, Port Moresby, unpublished data, 2016). The increased timeliness of data has many benefits for public health practice, including that authorities and partners can monitor near real-time data from 473 clinical sites that were previously unavailable. In a country vulnerable to infectious disease outbreaks, this has important practice implications for outbreak detection and management, whereby events such as the nationwide outbreaks of circulating vaccine-derived poliovirus and coronavirus disease 2019 (COVID-19) were able to be monitored via the system.

Quality

The Asian Development Bank’s independent review of the electronic national health information system found that the system’s data storage and automation of summary reports have likely reduced error in data collection across hundreds of sites (Matheson D, et al., Asian Development Bank, Port Moresby, unpublished data, 2016). In addition, data quality improvements only achievable at the point of electronic data entry would have strengthened the system’s data quality over the old national health information system. For example, the use of mandatory fields, mirrored fields, drop-down lists and rules on data formats in the data registers helps to optimize the internal validity of the data. Staff engagement with the system is enabling data-driven process improvement cycles. For example, tuberculosis staff in provincial health authorities are using mapping tools to identify individual tuberculosis patients who may require further care and are providing feedback to clinic staff on how to improve the timeliness and quality of tuberculosis data if anomalies across the data are identified.

Case-based registers

We believe that an important element of the electronic information system’s success is balancing the burden of data entry with end-user benefits (such as automated reporting) in the context of the potential public health benefits of improved data capture. The large amount of complete and timely patient register data may be seen as a proxy for system acceptability by users and provides insights into how additional register data might be adopted (for example, to create an immunization register).

Inpatient data entered into the system are automatically coded to the International statistical classification of diseases and related health problems, 10th revision (ICD-10) codes, with less than 1% of entries left to be coded by staff with higher levels of training. ICD-10 codes not available in the country’s shortlist can be remotely added without needing a version update to the mobile application. From 1 January 2015 to 31 December 2020, the electronic information system assisted health workers to report 706,261 inpatient discharges, ICD-coded and geolocated to village level.

The electronic system has revitalized platforms for civil registration systems which had previously stalled. By the end of 2020, 4881 births had been geolocated and registered and 44,188 ICD-10-coded inpatient deaths were geolocated to village level. The future
integration of biometric data into the digital birth register and other case-based data sets should improve the efficiency of public health programmes by increasing the accuracy of the data (for example, knowing an individual requires which dose of a COVID-19 vaccine). The policy and practice implications of achieving a functioning civil registration system are important. National population estimates with local modifications are available in the electronic system, as is the potential for users to select alternate populations (for example, to produce population estimates for small areas) through the electronic national health information system in the future.

Malaria test and treatment records were previously only available in paper registers in health facilities (non-geolocated) or entered into a global donor-supported separate database then sent to the donor partner’s headquarters and not reported to the national system. The electronic information system has enabled the malaria programme to integrate these national data back into the national system so that users can analyse malaria records for all types of programme management needs; automatically run statistical algorithms over the data to identify outbreaks; detect shifts in non-malaria febrile illness; and provide the data required for malaria risk or incidence maps down to subdistrict level. By the end of 2020, 1,313,431 individual malaria patient test and treatment records, geo-coded to village level, had been reported (system described elsewhere). The electronic information system has also received 92,294 national HIV surveillance testing reports, 2,241 treatment reports and 1953 risk-factor summaries over 2015–2020. However, national authorities, World Health Organization (WHO) and partners requested that the HIV programme data management remain unchanged and run separately outside the new system. In districts with extremely high HIV test-positivity but with easy access to health facilities, triangulation with monthly stock-out data (test kits, treatment) highlighted gaps in the policies and practices associated with the current model of support.

We have created a tuberculosis patient information management system within the electronic information system, currently being used in selected priority provinces of the country’s national tuberculosis emergency plan. The electronic system has replaced a poorly performing paper register and report-filing on spreadsheets, with detailed quarterly reports on drug-sensitive tuberculosis patients now being automated. The new system supports clinicians with the capture and ongoing management of geolocated tuberculosis patient information; automatically shifts patients between the intensive and continuation phase of therapy; automates patient progress summary reports and medical notes; provides clinicians with the drug, dose and number of pills to provide until the next appointment; sets dosage limits; and reports adverse events. Health authority users are provided with an ever-expanding suite of maps, reports and dashboards that help them improve the performance of the tuberculosis programme. Since 2019, 12,495 presumptive tuberculosis patients, 7,527 drug-susceptible patients geolocated to household level and 29 drug-resistant patients were registered for care and public health management in the National Capital district alone.

The tuberculosis management system will also help to link patients with community support by generating automated geolocated job lists. The job lists will orient the actions of the hundreds of geolocated community health workers and treatment supporters who are paid to follow up on tuberculosis patients and their contacts. The new system also creates synergies for future patient registers to integrate the follow-up required of community workers (such as for children missing immunizations) with existing geolocated community tuberculosis job lists, to provide more comprehensive health system coverage. These are practical steps towards UHC: automated reporting in the tuberculosis patient information management system saves 2–3 days (for drug-sensitive tuberculosis) and 3–4 days (for drug-resistant tuberculosis) of clinician time per report. The system gives real-time guidance for managing individual tuberculosis patients (including maximal drug dosages) in a setting of limited training and frequent changes in complex clinical guidelines. The new system also gives support with patient scheduling linked to the amounts of tuberculosis medication to be provided; automated patient progress summaries; and reduced data entry by linking and mirroring data entry fields across registers.

Further benefits for clinicians include automatically updating clinical and public health directories; two-way communication at no cost to staff; and improving the quality of data entry. Automated, real-time ICD coding removes the 3–4-year delay to using inpatient data. These improvements mean that the inpatient data set can now feed into outbreak detection processes using the disease outbreak dashboard to more quickly support clinicians when events are identified and to create automated monthly feedback bulletins. Future automated tools for clinicians and their communities could include mobile phone message reminders for immunizations and other appointments (with mobile numbers stored for potential communication during outreach and campaigns), and the linkage of digital personal identification systems to patient registers. National health authorities should now consider the integration of data on human resources, finances, drug supplies and other key data to broaden the scope of health system analyses and further increase efficiency.

Benefits to clinicians
The electronic information system gives clinicians an incentive to enter timely, quality data, because they themselves benefit, in contrast to the previous system where clinicians knew their data may never be used by the health authorities. For example, the automation of more accurate monthly summary reports saves 2–3 days of clinician time in 473 facilities every month and avoids repeated data entry within provincial and national authorities (Matheson D, et al., Asian Development Bank, Port Moresby, unpublished data, 2016). The system is important. National population estimates with local modifications are available in the electronic system, as is the potential for users to select alternate populations (for example, to produce population estimates for small areas) through the electronic national health information system in the future.

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time transmission of existing data sets is
providing new and enhanced utility to
the data. Challenges and opportunities
to improve UHC are visualized through
mapping service delivery and disease
data down to the level of health facility,
village and household.

Factors in this success were focusing
on building tools to benefit clinicians in
primary care; leveraging the public–private partnership with a locally experi-
cenced implementing partner; harnessing
mobile technologies that operate in 2G
phone networks; and obtaining rich
geographic information systems data
sets. While the electronic information
system platform has been a key part of
the transformation, the public–private partnership with a company with proven
record of accomplishment for innovation
and political navigation in Papua New
Guinea has also been important. Despite the many achievements, ensur-
ing that health authority staff take full
advantage of the new system remains
an important challenge.

Towards UHC
Better information about the quantity,
distribution and growth of populations
is crucial to sustainable development
globally.6 The importance of integrating
these data into service delivery and
performance measurement is clearly
outlined in the investments of Gavi6 and
the Bill & Melinda Gates Foundation,7
particularly for hard-to-reach urban
slum populations. According to the
WHO Director-General, “all roads lead
to universal health coverage – the top
priority at WHO”.8 However, without
knowing where facilities are located and
if they are open or closed (Fig. 3; avail-
able at: http://www.who.int/bulletin/
volumes/99/s/5-20-267823), where
the population resides and the villages
where services reach and do not reach, a
country will not be on the road to UHC.

Visualizing the geographical distri-
bution of disease and service delivery
performance using real-time health in-
formation system data alongside where
the population actually resides can en-
able planners and decision-makers to
better allocate resources. For example,
the new information system in Papua
New Guinea makes it possible to better
understand UHC issues such as zero-
dose communities (children who never
received a first dose of a diphtheria-
tetanus–pertussis-containing vaccine).

Future geographic information innova-
tions within the system may include:
recommendations to health workers
on which communities should be tar-
ged for outreach services; capture of
data down to the level of health facility;
and automating the individual tasking
of community workers to follow up on
patients lost to interventions. Given
the problematic nature of census data
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based on geographic information sys-
tems and household composition data
could be used to generate small-area
population estimates.10 These local data
have the potential to further improve
efficiencies in health service delivery.

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Malaysia

Ejercicio de la información sobre los servicios de salud utilizando los datos de las antenas múltiples y los sistemas de información geo-gráfica, en Papúa Nueva Guinea.

En el marco de la transición hacia la cubierta universal de la salud, el país ha logrado avances significativos en la eficiencia de su sistema de salud, particularmente en áreas urbanas y periurbanas. Sin embargo, sin información adecuada sobre la ubicación y disponibilidad de los servicios de salud, es difícil para los planes y decisiones tomadores asignar recursos de manera efectiva.

En Papúa Nueva Guinea, se ha implantado un nuevo sistema de información que permite visualizar la distribución de las enfermedades y el rendimiento del servicio en tiempo real, lo que facilita la asignación de recursos de manera más eficiente. A pesar de los logros conseguidos, la implementación de la transición hacia la cubierta universal de la salud en Papúa Nueva Guinea sigue enfrentando desafíos, destacándose la necesidad de fortalecer la participación de los profesionales de la salud y la alineación efectiva de los recursos de los donantes para optimizar el impacto de todos los programas.

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巴布亚新几内亚：利用移动和地理信息技术改造卫生信息系统

巴布亚新几内亚正在提高其卫生系统的效率，以克服在2020年全球疫情导致经济增长加速下滑的情况下，巴布亚新几内亚所面临的挑战。利用移动和地理信息技术改造卫生信息系统，将移动技术与包含全国每个家庭、村庄和公共卫生保健设施的数据结合起来，不仅提供了更好的质量和服务分析，而且提高了效率。例如，巴布亚新几内亚国家卫生信息系统基于地理信息系统和家庭组成数据，可以根据人口估计生成小区域数据，从而为更有效的健康服务提供可能。

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竞争利益：没有声明。
Transformación del sistema de información sanitaria mediante tecnologías de información móvil y geográfica, Papúa Nueva Guinea

En el contexto de un crecimiento económico en declive, agravado ahora por la pandemia de la enfermedad por coronavirus, Papúa Nueva Guinea está aumentando la eficiencia de sus sistemas sanitarios para superar las dificultades para alcanzar los objetivos globales de salud y desarrollo. Antes de 2015, el sistema nacional de información sanitaria estaba fragmentado, carecía de fondos suficientes, su utilidad era limitada y las autoridades sanitarias accedían a él con poca frecuencia. Construimos un sistema electrónico que integraba tecnologías móviles y conjuntos de datos del sistema de información geográfica de cada casa, pueblo y centro de salud del país. Entre 2015 y 2016 pusimos a prueba el sistema en 184 establecimientos de salud en la región de la Nueva Guinea. De 2015 a 2016, los tabletas móviles del sistema se implementaron en 473 centros de salud, y el uso de los dispositivos móviles se extendió a todo el país durante los seis últimos años. Como resultado, se ha mejorado la calidad, la accesibilidad, la flexibilidad, la aceptabilidad y la eficacia de la información en todos los niveles de servicios de salud.

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13 provincias, mientras que la plataforma en línea estaba disponible en
las autoridades sanitarias de las 22 provincias, incluidos los servicios de
salud de las iglesias. Se han integrado los silos de datos fracturados de los
programas sanitarios heredados y se ha establecido una plataforma para
los sistemas de registro civil. Exponemos cómo las tecnologías móviles y
los sistemas de información geográfica han transformado los sistemas de
información sanitaria en Papúa Nueva Guinea en los últimos seis años,
aumentando la puntualidad, la exhaustividad, la calidad, la accesibilidad,
la flexibilidad, la aceptabilidad y la utilidad de los datos sanitarios
nacionales. Para lograr esta transformación, destacamos la importancia
de tener en cuenta los beneficios de las herramientas móviles y de
utilizar conjuntos de datos ricos en sistemas de información geográfica
para los trabajadores sanitarios de la atención primaria, además de las
necesidades de las autoridades sanitarias públicas.

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Fig. 3. Example screenshot showing functional status of health facilities in the electronic national health information system, Papua New Guinea

CHP: community health post; HC: health centre; SC: sub-centre.

Note: The map is a screenshot of the user interface, displaying the location of health centres and aid posts. Aid posts are the first level of primary care and serve a population of 10,000 people. Papua New Guinea Remote Sensing Centre owns these maps and has provided a free licence to the National Department of Health for their use. These are the maps endorsed by the National Department of Health (Government of Papua New Guinea) for integration into the electronic national health information system. The geographic features of the map were derived from GeoSAR imagery. The locations of health centres were obtained by staff visiting these locations with hand-held global positioning system units.