RESEARCH PAPER

Integrated Healthcare Management System (An Urban and Rural Alliance of Healthcare Ecosystem)

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ABSTRACT
It is evident that a widening communication gap between patients and their doctors has grown in recent years. Patient satisfaction with health-care communication has dropped by 7%, Patients' urge for phone calls has decreased by 14%, text messages from their doctor are preferred by 79 percent of patients and 73 percent of patients desire the ability to text their doctors. Much work needs to be done to strengthen our health-care system, which is still severely fragmented, resulting in health disparities between the rich and the poor in both urban and rural areas. The researchers together with the industry partner MVSoftech envisions a fully integrated alliance of healthcare ecosystems that is accessible for both urban and barrio settings to enable growth and progress in all sectors and to integrate healthcare ecosystems by effectively lowering barriers to efficient and quality life (regardless of financial accessibility). Information Technology as a function of finance tends to be a lot of output with big investments, the researchers converted it to a business model subscriber-based operation aspects wherein Level 1 deals with enabling internal infrastructure, devices, access point, distribution, server, and fire walls. Level 2 deals with software ecosystem, document management system, electronic medical record, hospital information system, accounting, hospital management system. Level 3 augmenting ICT management, IT Services System Support, Level 4 optimized insurance. Bulacan State University together with our partner industry MVSoftech achieved to improved workflow, system integration and efficient healthcare delivery services that are made more convenient and accessible in urban and rural areas

Keywords: web portal, web systems, health information systems, healthcare, laboratory results.
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INTRODUCTION

The components of Universal Health Care revealed our weaknesses in terms of facilities, referral systems, and primary health care. When you consider how patients' communication preferences have changed during COVID, it's evident that a widening communication gap between patients and their doctors has grown in recent years. Patient satisfaction with health-care communication has dropped by 7%, Patients' urge for phone calls has decreased by 14%, Text messages from their doctor are preferred by 79 percent of patients and 73 percent of patients desire the ability to text their doctors. Much work needs to be done to strengthen our health-care system, which is still severely fragmented, resulting in health disparities between the rich and the poor in both urban and rural areas.

The reality is, patients in Geographically Isolated and Disadvantaged Areas (GIDA) such as CALABARZON (Region IV-A) and MIMAROPA (Region IV-B) urban and rural areas were not equipped with better facilities, and medical information systems as evidenced by the implementation of RxBox a multi-component program (biomedical device, electronic medical record system and telemedicine training) designed to provide better access to life-saving health care services in isolated and disadvantaged communities nationwide. It is observed that patients ' medical records were not referred to a district or private hospitals due to lack of connectivity.

Hospitals in Metro Manila are known for providing quick, accessible, and convenient medical services, and delivering timely and accurate results. Patients from urban and rural areas also wanted to experience the same healthcare services similar in the Metro and take pride in their competent primary care physicians and specialists, highly trained and licensed nurses, medical technologists, radiologists, state-of-the-art medical equipment, and comprehensive laboratory and diagnostic examinations services.

Equidistant in the northern and southern parts of Luzon is the province of Bulacan. The researchers have conducted virtual interviews from in-patient/out-patient point of view

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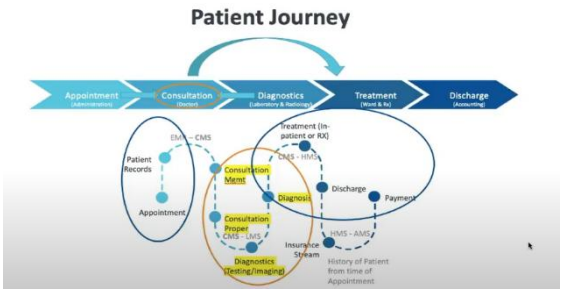
and have gathered the following pain points: (1) scheduling a walk-in appointment is difficult in situations where the clinic is accommodating only several patients. (2) Delay in the distribution of laboratory results and patients are asked to return for the results. (3) Different laboratory results are individually collected. The researchers have also conducted a virtual interview in several private and public clinic/hospitals in Bulacan and according to Administrator, Head Nurses, Doctors, Pharmacist, Medical Technician: (1) there should be a checklist in the system for the Standard Operating Procedures of Doctors so that during patient interview it would be easy for Doctors to just place a check mark; (2) medical prescription should be made printable and also medical certificate; (3) for consultation Doctors are not comfortable encoding the diagnosis, interaction with patient is very important, whenever Doctors are typing they are looking at the screen and not with patient; (4) a centralized record of patient would be easy especially for Doctors to co-manage patient; (5) for appointment scheduling when a patient experience covid symptoms patient will be refer automatically to hospitals treating infectious diseases; (6) for visiting doctors (affiliated to different hospitals) having a centralized record is really very helpful; (7) having a dashboard displayed on TV displaying a preview of line-up of patients simultaneous in different cubicles in the hospitals is very much appreciated; (8) for healthcare insurance / Phil Health there should be an easy way especially for Doctors in filling-out all the forms. The problem with patient history is that Doctors have seen the patient only once because most patients came from rural health centers (primary care) and there is no record forwarded to hospitals coming from health centers.

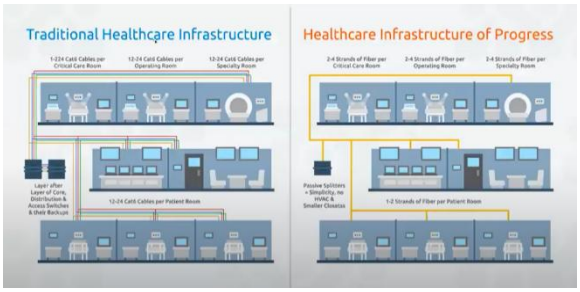
Fig. 1. Patient Journey.



MATERIALS AND METHODS

The researchers together with the industry partner MVSoftech an ICT operation that handles fiber optics all the way up to connectivity under MYFI Vital MINDS keyhole transformation services. Vital MINDS is a company that specializes in digital transformation and delivery that ease the burden of operations in order for healthcare providers to focus more on their true mandate, which is to heal and to care for communities. Among the partners of MVSoftech (end-to-end network infrastructure provider) were Ulap (innovative managed service provider), PayMaya (largest digital financial services provider in the country), Silicon Valley (renowned Silicon Valley cyber security company), MYFI (specialized critical internet provider). Bulacan State University and MVSoftech envisions a fully integrated globally aligned alliance of ecosystems that is accessible for both urban and barrio settings to enable growth and progress in all sectors and its mission to integrate ecosystems by effectively lowering barriers to efficient and quality life (regardless of financial accessibility). The project team is working with current and proven methodologies and technology to enable growth and innovation in the progress towards a sustainable, holistic and adaptable community. Together the project team provides an in-depth journey from end to end, in-depth assessment to connectivity, to patient care dealing with the medical records as well as digitization, digital transformation as well as technology side and consistent support.

Fig. 2. Traditional Healthcare Infrastructure and Healthcare Infrastructure of Progress



Dealing with a lot of traditional healthcare infrastructure the researchers together with MVSoftech will then convert it into a healthcare infrastructure that is more streamlined. From the hardware level from CAT 6 to Fiber. With the aim of focusing on reducing CAPEX, and OPEX. Converting CAPEX to OPEX deals with information technology as a function of finance that tends to be a lot of output with big investments, converted it to a business model into subscriber-based operation aspect wherein Level 1 deals with enabling internal infrastructure, devices, access point, distribution, server, and fire walls. Level 2 deals with software ecosystem, document management system, electronic medical record, hospital information system, accounting, hospital management system. Level 3 augmenting ICT management, IT Services System Support, Level 4 optimized insurance. The project team provides Security - secured hosted transactions and data, Connectivity - faster, more robust connectivity, Enabled Management - improved workflow and system integration for management and efficient service delivery - healthcare delivery services are made more convenient and accessible.

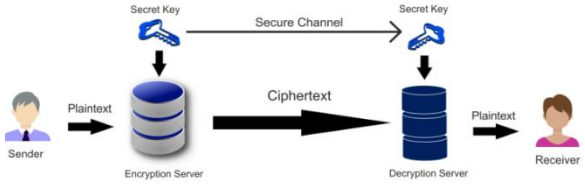


Fig. 3. Encryption and Decryption

AES encryption has become the industry standard for data security. AES comes in 128-bit, 192-bit, and 256-bit implementations, with AES 256 being the most secure. It is a key cipher with symmetric keys. This means that the same secret key is used for encryption and decryption, and the sender and recipient of the data both need a copy of the key. Asymmetric key systems, on the other hand, employ a separate key for each of the two processes. External file transfers benefit from asymmetric keys, whilst internal encryption benefits from symmetric keys. To ensure the security of the database, the researchers applied the AES 256 Encryption Algorithm. The Algorithm helps the researchers to encrypt the data upon saving on the database, protecting the data stored on the database from attacks of data phishers. AES 256 is one of the most secure encryption systems due to its superior technology and open nature. Researchers are continually looking into AES to see if there are any flaws.

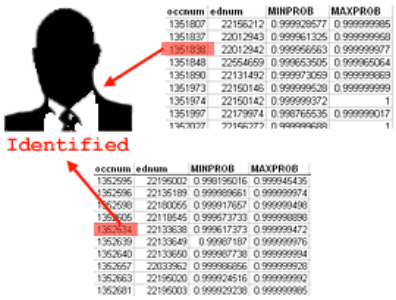


Fig. 4. Probabilistic Data Matching

This is largely due to the fact that exchanging data on the same patient remains a barrier for hospitals and doctors' offices. Patients and their doctors are unable to make proper judgments because of the inability to link patient records across multiple health systems and format the data in a way that can be easily communicated. Patients frequently see a variety of health care professionals, including primary care physicians, medical specialists, and inpatient and outpatient hospital treatment. Clinicians conduct physical examinations and order laboratory testing in each of these locations, recording their findings in an electronic health record. Hospitals and health care providers should be able to get relevant data from their own copies of patients' records as well as access information housed in other providers' electronic health records to treat patients more effectively and efficiently. Unfortunately, they are unable to do so currently. This roadblock, known as inadequate interoperability, results in duplication services, patient care errors, avoidable hospitalizations, treatment delays, and lost provider time, all of which drive up health-care costs. Many healthcare delivery systems have implemented probabilistic matching algorithms that offer a more accurate, dynamic, and robust matching strategy as healthcare delivery systems face increasing data volumes with numerous matching attributes. Probabilistic matching relies on a combination of widely available data, such as name, birth date, and social security number, zip code and address rather than an exact match on a name or a unique identifier. By considering a database's specific, unique properties, probabilistic matching can increase the rate and quality of matched entries. The more fields it compares, the better it will be able to distinguish between true and false matches. Probabilistic matching will be implemented in this study for better sensitivity or overall accuracy. The researchers also included data analytics management dashboards that will provide local government and its stakeholders crucial information to help manage the province's health programs. Information such but not limited to the following may be available, Consultations per health facility per period and Top illnesses reported per period. Generate periodic Consumption Reports to monitor how the province expends its medicines and supplies in fulfillment of the Universal Health Care, Monitor and audit inventory movement and stock levels in RHUs, for better inventory control and Monitor Healthcare Personnel deployment and attendance, to ensure that personnel are deployed to areas that need their services more.

The researchers together with MVSoftech focus on the development of the Integrated Healthcare Management System wherein the researchers gathered the pain points and shared ideas with the partner industry and collaborated to develop a good and functional system.

Meet and Plan. The researchers conducted a preliminary investigation through a virtual interview in several clinics and hospitals in Bulacan. As the researchers gathered all the pain points, the researchers also formulated the solutions for each pain point.

In the planning phase, the researchers document the project plan. The actual project Management Plan contains, among others, the work breakdown structure that identifies the hierarchical set of phases, activities and tasks to be undertaken, change management plan, and risk management plan.

Design. In this stage the information gathered in the previous stage allows the researchers to write about the elements of the system. The input and output record during the design was prepared, forms were laid out, and file specifications were written. Major aspect of the design phase includes structuring the kind of interface to be used for the system. The design phase extracts the ideas of the researchers and collaborates ideas with MVSoftech to develop a good and functional integrated healthcare management system.

During this phase, the formulated output of the developed project can now be visualized through the use of diagrams such as Visual table of contents (VTOC), Data flow diagram (DFD), Entity relationship diagram (ERD), and System Flowchart.

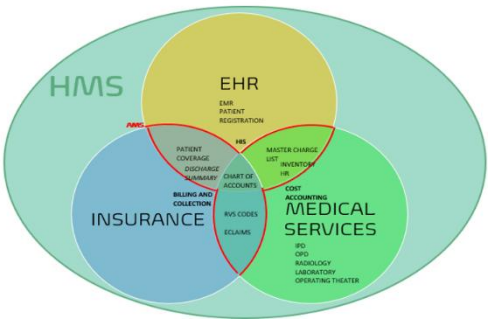


Fig. 5. Hospital Management System Framework

Develop. After the finalization of the required elements in the design phase, the researchers in collaboration with the partner industry will maximize the technology and develop each module. such as the Registration Module; Budget Module, Purchasing and Inventory Module; Accounting Department Module; Head Nurses and Doctor Module; Biomedical/equipment maintenance (preventive maintenance) Module; and lastly In-patient and out-patient portal module.

In this phase, the researchers and partner industry deliver all the features of the develop system. The researchers verify and validate all user requirements and identify if there are modifications to be done before the implementation of the develop system.

Code and Test. Finally, the researchers together with the partner industry will secure all patient's records using the Encryption Algorithm upon migrating the patient records from the clinic/hospital to the systems database. The researchers use AES encryption as the industry standard for data security. To ensure the security of the database, the researchers applied the AES 256 Encryption Algorithm. Then, the migration of patient records from the clinic/hospital to the systems database will be executed. The user acceptance testing shall also be done in this phase.

In order to determine the satisfaction of all the target users of the developed system, system evaluation will be conducted. The system evaluation serves as the basis for the researchers to meet the client requirements and to determine the quality of the developed system. Testing participants should include all the representatives from different clinics and hospitals.

To assess the acceptability of the developed system, the researchers will utilize the standard software evaluation criteria by the International Organization for Standardization (ISO) and by the International Electrotechnical Commission (IEC) 25010 (ISO 25000, n.d.) comprises of eight quality characteristics, namely: (1) Functional Suitability, (2) Performance Efficiency, (3) Compatibility, (4) Usability, (5) Reliability, (6) Security, (7) Maintainability, and (8) Portability.

Release, Track, and Monitor. Tracking of changes starts with the request for the change, tracks the approval status and ends when the change is added to the project. This continuous monitoring provides the project team insight into the health of the project and identifies any areas requiring additional attention.

Feedback. The feedback process consists of those processes required to track and initiate the corresponding changes. The purpose of this stage was to review the functionality of the system and determine their impact most especially project risk, scope, cost, and schedule and to assess each change request.

This section presents the significant findings of the study based on the results of the order of the general and specific objectives. The presentation includes the discussion of the statistical results obtained and the level of significance in the context of the study and discuss the representation of data and the statistical treatment and the output analysis conducted and the interrelated connections and significance between and among data in the context of the study. Likewise, this will deliberate the possible improvements to be made as well as future direction of the study.

Data Migration from the Healthcare Clinic/Hospital Database to the Web Portal database

The availability of the patient record is upon the data migration from the existing MSSQL database to the web portal's MySQL database. The researchers used the SymmetricDS, open-source software for database replication that can replicate data asynchronously. Configuring the SymmetricDS requires disabling of Windows firewall, modifying SQL file of symmetric, adding of a new port on the firewall, running the SQL's services from Windows services, and executing a command-on-command prompt. When the correct process was done, the data migration from the MSSQL database to the MySQL database was made possible.

Securing Patient's Data Upon Data Migration

To ensure the security of the database, the researchers applied an Encryption Algorithm. It helps the researchers to encrypt the data upon saving on the MySQL database, protecting the data stored on the database to different attacks of data phishers.

Design and Development of the System

The researchers focused on designing a database using an entity-relationship diagram, that serves as the storage of the patient's account, department of a clinic, administrator, and medical exam file. The diagram was created to determine and correctly identify the processes and the flow of the system to be developed, and how the data in the system will be managed.

User Interface

The appointment scheduling feature allows patients to schedule an appointment on the clinic online, without the difficulty of visiting the clinic for a schedule. With this feature, patients may identify if there are already scheduled appointments on a specific date, allowing them to choose dates with a schedule for a doctor's appointment. Laboratory results are uploaded by designated employees of the clinic/hospitals. Upon uploading, patients were notified about the availability of their results. The upload transaction when the user selects one of the patient records

on the table. The user can choose a file to upload to serve as a laboratory test results for a specific patient. The laboratory results availability is round the clock 24/7. The patient may access the medical record anywhere, anytime. The module where the patient could view the uploaded results. Patients shall log in to their accounts to view the results. Patients also have the option of saving and downloading their laboratory results.

RESULT AND DISCUSSION

System Evaluation Using ISO/IEC 25010

The ISO/IEC 25010 is an International Standard that provides quality models for systems and software quality requirements and evaluation. A standard definition of functional suitability, performance efficiency, compatibility, usability, reliability, maintainability, and portability are provided in the quality in use model of ISO/IEC 25010. The respondents of the study involved four experts from IT industry and from the academe. IT industry experts were consisting of web developers and in the academe composed of master's degree holder from IT courses. From the hospital/clinic, the evaluator comprises of three administrator and 11 employees from the clinic/hospitals. The system was evaluated using a five-point Likert Scale interpreted as follows: Excellent (5), Very Good (4), Good (3), Fair (2) and Poor (1).

TABLE I. OVERALL RESPONDENTS' EVALUATION SUMMARY

Criterion	Mean	Descriptive Rating
Functional Suitability	4.60	Excellent
Performance Efficiency	4.42	Very Good
Compatibility	4.40	Very Good
Usability	4.57	Excellent
Reliability	4.57	Excellent
Maintainability	4.71	Excellent
Portability	4.57	Excellent
Total Mean	**4.55**	**Excellent**

The data reveals in Table 1 that the system was rated "Excellent" in terms of Functional Suitability (4.60); Performance Efficiency (4.42); Compatibility (4.40); Usability (4.57); Reliability (4.57); Maintainability (4.71); and Portability (4.57), as a whole the obtained mean value of (4.55) indicates that the system was "Excellent" and was recommended for all intended users.

CONCLUSION

Bulacan State University Together With Our Partner Industry Mvsoftech Achieved To Improved Workflow, System Integration And Efficient Healthcare Delivery Services That Are Made More Convenient And Accessible In Urban And Rural Areas. The Researchers Together With The Industry Partner Mvsoftech Envisions A Fully Integrated Alliance Of Healthcare Ecosystems That Is Accessible For Both Urban And Barrio Settings To Enable Growth And Progress In All Sectors And To Integrate Healthcare Ecosystems By Effectively Lowering Barriers To Efficient And Quality Life (Regardless Of Financial Accessibility). Level 1 Deals With Enabling Internal Infrastructure, Devices, Access Point, Distribution, Server, And Fire Walls. Level 2 Deals With Software Ecosystem, Document Management System, Electronic Medical Record, Hospital Information System, Accounting, Hospital Management System. Level 3 Augmenting Ict Management, It Services System Support. Level 4 Optimized Insurance. The Target Beneficiaries Of The System Were Level 2, Level 3 And Level 4 Hospitals. Then, First- And Second-Class Municipality As Well As Third To Sixth Class Cities. With A Lot Of Competitors, The Researchers Were Able To Bundle The Services Into One, So That Provisions Were Made For Hospital Information Systems And Documentaries Systems And Single Point Contact For All Aspects. Focusing On Reducing Capex, Dealing Around 30% Difference And 35% For Opex The Systems Tend To Lower Cost With Back-End Support, Process Consultancy Service There Is No Competition There.

Managing Data Systems In An Offline Or Occasionally Connected Environment Can Be Challenging. In Remote Locations, It May Not Be Practical For It Staff To Service The Site Regularly. Therefore, A Carefully Planned Service Schedule Should Be Implemented With Advanced Notice To Ensure Site Staff Are Prepared. A "Lights-Out" Management (Lom) System Can Be Considered To Allow For Remote Administration And Monitoring, And Software Updates Can Be Downloaded On Removable Media To Install During These Visits To Keep Systems Up To Date. Secure Off-Site Backup May Be Difficult For Remote Locations. If Removable Media Is Used For Daily Or Weekly Backups, Ensure It Is Encrypted To Mitigate The Risk Of Data Leaks Through Loss Or Theft.

In Environments With Offline Or Occasionally Connected Remote Systems, Data Can Be Backed Up To Encrypted, Removable Media, Such As A Removable Hard Drive Or Usb Flash Drive And Sent To A Central Site For Integration Or Analysis—A Process Known As "Sneakernet". This Ensures That Data Is Periodically Backed Up And Stored Off-Site And Made Available For Reporting At A Central Level.

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REFERENCE

[1] ADB. 2018. Digital Health Impact Framework User Manual, ADB Sustainable Development Working Paper Series No. 57, November. www.adb.org/sites/default/files/publication/465611/sdwp-057-digital-health-impactframework-manual.pdf

[2] ADB. 2018. Guidance for Investing in Digital Health, May. www.adb.org/publications/guidance-investingdigital-health.

[3] ADB. 2018. Unique Health Identifier Assessment Tool Kit. May. https://www.adb.org/documents/unique-healthidentifier-assessment-toolkit.

[4] Amin, I. M., Husseinl, S. S., & Isa, W. A. (2011). Assessing User Satisfaction of using Hospital Information System (HIS) in Malaysia. IPEDR vol.5 (2011). Singapore: IACSIT Press, Singapore.

[5] De Alba, E. M., Gelindon, L. C., Lucero, J., & Marasigan, K. C. (2012). The effectiveness of hospital information system bizbox on the healthcare delivery system as perceived by selected staff nurses of De La Salle University Medical Center. Bachelor of Science in Nursing.

[6] HOMIS Revolutionizing Healthcare Delivery https://bghmc.doh.gov.ph/homis-revolutionizing-health-care-delivery/ (accessed September 10, 2021)

[7] ComLogic Solution, https://comlogikph.com/solutions/hims (accessed September 10, 2021)

[8] Healthcare Information and Management Systems Society, Inc. (HIMSS). n.d. Interoperability in Healthcare. www.himss.org/resources/interoperability-healthcare.

[9] HealthIT.gov. n.d. What is a patient portal? www.healthit. gov/faq/what-patient-portal.

[10] Irizarry, T., DeVito Dabbs, A., & Curran, C. R. 2015. Patient Portals and Patient Engagement: A State of the Science Review. Journal of Medical Internet Research. 17(6). e148. https://doi.org/10.2196/jmir.4255.

[11] ISO/IEC 25010 https://iso25000.com/index.php/en/iso-25000-standards/iso-25010 (accessed September 11, 2021

[12] Khoja, S., et.al. 2007. e-Health Readiness Assessment Tools for Healthcare Institutions in Developing Countries. Telemedicine Journal and e-Health. September.

[13] Kiberu, V., Mars, M., Scott, R., 2019. Development of an evidence-based e-health readiness assessment framework for Uganda. Health Information Management Journal. April.

[14] Kitskoo 2019. e-Government Assessment & Recommendation for The Cook Islands, April.

[15] Kitskoo. 2019. Government of the Cook Islands eGovernment Assessment & Recommendation presentation,

[17] Marcelo, A., Medeiros, D., Ramesh, K., Roth, S., and Wyatt, P. 2018. Transforming Health Systems Through Good Digital Health Governance. ADB. February. https://www.adb. org/sites/default/files/publication/401976/sdwp-051-transforming-health-systems.pdf.

[18] Jarocki, T. 2013. PMI Project Management versus Change Management: Similarities, Overlaps and Differences, Journal of Change Management Community of Practice, ProjectManagement.com. Webinar. June www.projectmanagement.com/videos/286316/ProjectManagement-vs-Change-Management.

[19] Loria, K. n.d. 3 Ways to Make Healthcare More Innovative, Managed Health Executive. www.managedhealthcareexecutive.com/view/3-waysmake-healthcare-more-innovative.

[20] Nieves, R. 2018. '3 tips on managing change in a hospital's digital transformation'. Elsevier Connect, February. https://www.elsevier.com/connect/3-tips-on-managingchange-in-a-hospitals-digital-transformation.

[21] Nolte, E. 2018. How do we ensure that innovation in health service delivery and organization is implemented, sustained and spread? Policy Brief, Health systems for prosperity and solidarity, WHO. www.euro.who.int/__data/assets/pdf_ file/0004/380731/pb-tallinn-03-eng.pdf

[22] World Health Organization. 2015. MAPS Toolkit mHealth Assessment and Planning for Scale. https://apps.who.int/iris/ bitstream/handle/10665/185238/9789241509510_eng. pdf?sequence=1.

[23] World Health Organization. 2017. Health information systems in the Pacific—at a glance 2016. Regional Office for the Western Pacific. Manila, Philippines. https://apps. who.int/iris/rest/bitstreams/1147902/retrieve.

[24] World Health Organization. 2017. Data Quality Review, Modules 1–3. World Health Organization Health Innovation Group. World Health Organization. www.who.int/lifecourse/about/who-health-innovation-group/en/. World Health Organization. 2020. Digital implementation Investment Guide (DIIG): Integrating Digital Interventions into health programmes. https://www.who.int/publications/i/ item/9789240010567.

[25] World Health Organization Global Strategy on Digital Health 2020-2025 https://cdn.who.int/media/docs/default-source/documents/gs4dhdaa2a9f352b0445bafbc79ca799dce4d.pdf?sfvrsn=f112ede5_75 (accessed September 11, 2021)