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BRIEF REPORT
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Assessing the feasibility of introducing an electronic health information system into Tuberculosis clinics and laboratories in Myanmar

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Abstract: Myanmar has launched an advanced tuberculosis examination policy, which involves specimen exchanges among clinics and referral laboratories. However, with the current paper-based operation, it is difficult to trace information accurately. Therefore, since April 2017, we introduced a pilot operation consisting of an electronic health information system (HIS) that uses QR codes for data sharing in the tuberculosis laboratory at seven facilities. This study aimed to assess the feasibility of introducing the electronic HIS into tuberculosis clinics and laboratories based on staff perception, workload and workflow, and data accuracy, and to clarify its advantages and disadvantages. The analysis was descriptive, and it involved a semi-structured interview for the staff, workflow observations to evaluate the workload and describe the change in workflow, and evaluation of the data accuracy by comparing the numbers yielded by the paper-based and HIS-based reports. The HIS was positively accepted as it improved work efficiency, while the operation still depended on paper-based reports. Parallel data registration using both paper-based and HIS-based reports increased the workload. Data discrepancies were found when comparing the paper-based and HIS-based reports, and these discrepancies were not directly attributed to the HIS introduction but individual factors. Crucial facilitating factors of the HIS were its operability and user-friendliness, because it does not require specific training. The additional workload translates into the need for additional human resources, and the parallel data registration remains a challenge. However, we consider that these challenges could be overcome as coverage of the HIS expands.

***Keywords*:** health information system, QR code, data sharing, tuberculosis, Myanmar

Introduction

Since the early 2000s, the increasing use of information and communication technologies (ICT) in health services in both developed and developing countries has resulted in the progressive development of eHealth. With this trend, many developing countries have attempted to introduce electronic health information systems (HIS) (*1*). In the era of Sustainable Development Goals, the need for introducing ICT for data management continues to grow (*2*).

Tuberculosis (TB) is one of the health priorities in Myanmar as this country appears in the three high burden country lists by the World Health Organization (WHO): TB, TB/HIV, and multi-drug resistant (MDR)-TB (*3*). The epidemic of MDR-TB has changed the control measures of TB as well as the diagnostic flow. Previously, for smear-positive cases, treatment was started at the nearest TB facility at which smear examination was available. Currently, all smear-positive cases should be screened for MDR-TB by GeneXpert® that is only available at selected sites. Patients diagnosed as MDR-TB by GeneXpert® should be monitored regularly by culture and drug sensitivity test (DST) and line probe assay (LPA) that are only available at National Reference Laboratories (*4,5*) (Figure S1, *https://www.globalhealthmedicine.com/site/supplementaldata.html?ID=8*). Therefore, there is frequent transfer of specimens with patient information during the diagnosis and treatment of TB. However, it is difficult to secure the traceability of specimens and patient information among clinics and laboratories by using the current paper-based operation. Thus, it was hypothesized that implementing a HIS to assist the National TB Program (NTP) of Myanmar could help improve TB patient data management, including traceability. Thus, the Myanmar Ministry of Health and Sports has launched the Strategic Action Plan for Strengthening Health Information 2017-2021 (*6*).

To contribute to the NTP, we developed the electronic TB laboratory HIS. The system is based on the use of a two-dimensional barcode (QR code) used to exchange and synchronize information, and an internet

connection is not required to operate the system. This system intends to reduce the workload of the staff who handle the patient data in clinics and laboratories while improving patient traceability. The registration of patient information is done using a touchscreen tablet device, which is aligned with the current paper-based format. At each visit, the information, such as name, sex, date of birth, and address, is inputted to the tablet, and patient information is outputted to the examination order sheet with a QR code. This examination order sheet is sent to a referral laboratory with the patient's specimens. At the laboratory, the QR code is scanned, and the patient's data and examination orders are registered into the system. The results of the laboratory tests are registered into the system, and the result sheet is printed out with the QR code, which goes back to the clinic. When the QR code is scanned at the clinic, the results of the laboratory tests are added automatically.

In April 2017, we introduced the HIS as a pilot operation at one National Reference Laboratory (NRL), two Regional Reference Clinics and Laboratories (RRCL), and two Township Clinics and Laboratories (TCL) in Yangon in cooperation with NTP. The pilot was also expanded to two additional TCLs in March 2018 (Table 1). This study aimed to assess the feasibility of introducing the electronic HIS into TB clinics and laboratories in Myanmar according to staff's perception, workload and workflow, and data accuracy. This study also aimed to clarify the advantages and disadvantages of HIS introduction.

Materials and Methods

The study was approved by the ethical committees of the National Center for Global Health and Medicine and School of Tropical Medicine and Global Health, Nagasaki University. The feasibility was assessed descriptively by semi-structured interviews, workflow observation, and the comparison of the reported patient number on the quarterly reports between the paper-based and the HIS-based.

Semi-structured interview

Semi-structured interviews were conducted on seven individuals between July 2017 and January 2018 as these were third and ninth months of the pilot system operation at the NRL, two RRCLs, and two TCLs. The number of interviewees was limited to seven since the assigned personnel in charge of HIS operation at each facility were two or one. The purpose of the interviews was to clarify the perception of the staff and identify achievements and challenges. We prepared an interview guide based on a review of relevant literature that included three categories: System operation, Challenges, and Expectations. We categorized the obtained qualitative data along with the three categories and summarized them.

Workflow observations

Workflow observations were conducted at one RRCL and four TCLs during July 2018. We identified and described the changes in workflows and evaluated the workload resulting from the paper-based and the HIS-based operations. We excluded the NRL as this operated differently from other facilities. Observations were described on who, where, when, and how the systems were used with the current paper-based operation using the prepared workflow-check sheet.

Evaluation for data accuracy

The data for the second and the third quarter at the four TCLs were collected during December 2018. The NRL and two RRCLs were excluded since they did not produce the quarterly reports. We referred to the registration book (TB-03 form) manually written by staff from individual outpatient-department (OPD) books and counted the numbers by type of patient and type of disease, in accordance with the classification used in the quarterly report. The counted numbers were regarded as the Accuracy test dataset, which was compared with the numbers on the HIS-produced quarterly reports and the manual quarterly reports (Figure 1).

Results and Discussion

Perception of the staff

Table 2 shows the summary of comments from semi-structured interviews. Overall, there were no specific

Table 1. System installation facilities

	Type of facility	Type of lab. exam. implemented*	Installation date
1	National reference laboratory (NRL)	Smear, GeneXpert, DST, LPA, Culture	April 2017
2	Regional reference clinic and lab. (RRCL-A)	Smear, GeneXpert	April 2017
3	Regional reference clinic and lab. (RRCL-B)	Smear, GeneXpert	April 2017
4	Township clinic and lab. (TCL-A)	Smear, GeneXpert	April 2017
5	Township clinic and lab. (TCL-B)	Smear	April 2017
6	Township clinic and lab. (TCL-C)	Smear	March 2018
7	Township clinic and lab. (TCL-D)	Smear, GeneXpert	March 2018

*Smear, smear microscopy; DST, drug sensitivity test; LPA, line prove assay.

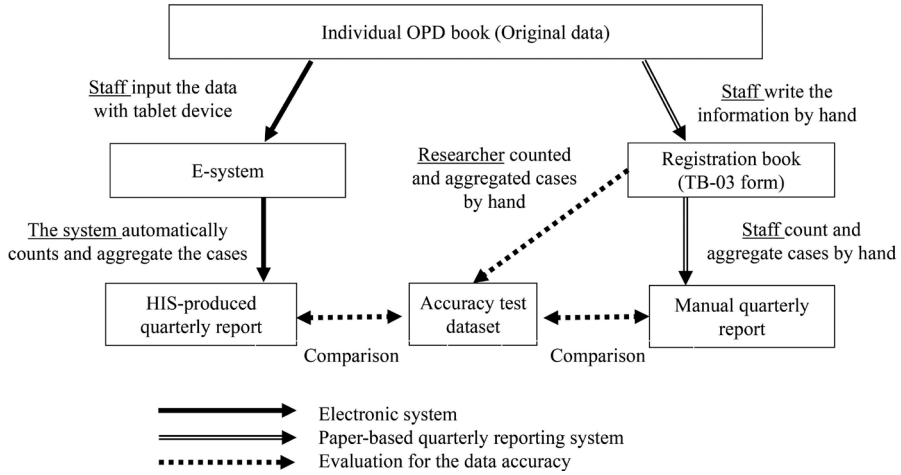

Figure 1. Method of the Evaluation for the data accuracy.

Table 2. Summary of comments from semi-structured interviews

Categories	Questions	Summary of comments
System operation	How long do you need operational support for system introduction?	Less than 1 month and the operation is not complicated.
	Do you still use an existing paper-based registration with the system operation?	Yes, system operation only is not permitted yet; the paper-based operation is more accurate in the workflow.
	Is the touch screen operation smooth and effective for data entry?	Easy to understand, but using the keyboard and mouse is preferable.
	Is patient search function easy and effective?	Easy, but need to add different ID numbers such as OPD, TB, and presumptive TB.
	Did QR code operation reduce the workload of data registration?	It reduces the time for data registration, but QR code sharing is limited still among facilities.
	When do you register patient info./ lab. test results into the system?	In the evening after registering on the paper book because of the high number of patients who visit at the same time and waiting for lab results.
		It is timely done in the workflow.
	Are there any changes to the workflow?	The system operation is extra work for now; need data entry into the system after paper registration.
	Has work efficiency improved by the system function?	Patient search is easy, but the function should be improved.
		QR code reduces the time for data exchange, but errors sometimes occur while scanning QR code
		The operation of the treatment card remains paper-based.
		The quarterly report still depends on the paper registration book.
	Is there any duplication of the patient registry?	Yes, when it's confusing to search for patients, they are registered as new cases.
		Data mis-entry occurs.
Challenges	What is the current problem with the system or work?	Parallel operation with paper-based is time-consuming.
		HR is needed for data entry.
		Patient search conditions should be improved.
		Errors occur during QR code reading and slow loading.
		During a blackout, the printer does not work.
Expectations	What kind of support do you expect?	Expansion of the system; QR code should be shared with other facilities so that the workload is further reduced.
		Provision of paper and printer toners.
		HR may be needed for the successful installation of other facilities.
		Adding other specific formats aligning with the paper operation.

differences of the perception between the NRL, two RRCLs, and two TCLs for introducing the HIS.

After the HIS introduction, the staff had a positive perception of the effectiveness of the QR code operation, although challenges remained. The paper operation was perceived as more accurate than the HIS. Additionally, both the paper-based and the HIS-based operations were being conducted simultaneously, which was time-consuming. The five respondents mentioned that patient registration in the HIS was done collectively at the end of the day because of the high number of patients, and doing both registrations simultaneously consumed time. Two respondents indicated that the HIS registration could be done in a timely manner within the regular workflow. None used the monthly reporting function on the HIS but still depended on the paper-based reporting. Additionally, a need for more human resources (HR) to enter data was reported. Advantages were noted by the five respondents: work efficiency was improved for patient searching and patient data and laboratory test results registration using the QR code. All respondents expected application of the HIS to help other facilities, because the workload could eventually be reduced by using the QR code. These findings indicate that the HIS operation was accepted with the expected operational efficiency, and users considered its expansion to other centers and widespread use of the QR code to be advantageous. Indeed, the QR code operation was successfully adopted without changing the main workflows and contributed to the instant data exchange (Table 3). Further, it can be expected that the operability of the system would further contribute to the positive perception of the staff as it does not require specific training. However, based on previous experiences, providing enough training is one of the essential elements for a successful introduction of an electronic HIS (*7-13*).

Impact on the workload and workflow

Data exchange between clinics and laboratories was implemented as intended using the QR code produced by the system at the OPD reception and laboratories to reduce the workload and improve work efficiency (Table 3). It was expected that parallel data registration with the paper-based and the HIS-based procedures at the OPD reception and laboratories is unavoidable during the introduction phase of the HIS as previously reported (*7,9,10,13-18*). Additionally, it was expected that the parallel data registration would help evaluate feasibility of the operation, as reported for the introduction of an electronic TB surveillance system (*9,19*). Considering the HR constraints tend to be the greatest challenge for the introduction of a HIS, the expansion of the QR code operation into other facilities would likely help reduce the workload for data registration. In TCLs, where the number of patients is relatively lower, HIS users were able to update the data without hiring data processing clerks. This indicates that the HIS does not necessarily require additional HR. We consider that any additional workload would be compensated by the benefit of having centralized patient information that was usually managed using different registration books, for example, TB patient, presumptive TB patient, laboratory examination, and OPD with different IDs. Because the treatment of TB patients is long term, the HIS will facilitate data transfers and exchanges using the patient identifier (QR code), which is crucial to monitor and trace the records effectively (*19*).

In terms of workflows, it was indicated that the HIS could be used simultaneously with the current paper-based operation without affecting the workflows. It was considered that the system interface aligned to the paper format helped the staff operate the HIS efficiently without training. Indeed, the operation of the laboratory-order sheets and the result sheets using the QR code produced by the systems have replaced the paper operation at the OPD receptions and the laboratories. Additionally, the system can work as an operational tool for handling case-based data for TB patients at the facility level. As the QR code contains all the necessary information for patients, it can be expected to improve the accuracy of data transfer as it has been previously reported for clinical paper-based and electronic sources (*20*).

The accuracy of data registration

Table 4 shows the reported numbers for the type of patient and type of disease for the second and the third quarters of 2018 at four TCLs (shown as TCL-A, B, C, and D). Each number in the HIS-based (HIS-produced quarterly report) and the Paper-based (manually quarterly report) were compared with the Accurate (Accuracy test dataset). The evaluation results indicated that accuracy most likely corresponded with personnel understanding but was not directly affected by the HIS introduction. In other words, there was no difference in the accuracy of data registration between HIS-based and Paper-based. It also indicated that the HIS was understandable and operable at each facility.

TCL-A, B, and C reported the number of patients completely accurately in the Paper-based, and we interpreted that the data registration into the HIS was nearly correct since the number of discrepancies found in the HIS-based was 1 to 3 due to incorrect data entry and automatic calculation by the system. Conversely, TCL-D incorrectly reported the number of patients with 25 to 63 discrepancies in both Paper-based and HIS-based, respectively. This was attributable to misinterpretations of patients' classification between Bacteriologically-confirmed cases and clinically diagnosed cases on the registration book (TB-03 form), which was based on the first result of the smear examination, positive or negative with symptoms. Accordingly, there is room for

Table 3. Findings from workflow observation

Site	Clinical work	Paper-based	HIS-based	Findings
Reception	· Registration	· OPD registration book · OPD card for each patient		
OPD/TB clinic	· Seen by doctor · Refer patients with TB symptoms to TB clinics · Order diagnostic test (sputum/Xp)	· Presumptive TB registration book (Note)	· Registration as presumptive TB · Printing out a Lab. request form with QR code	· Registration is not shifted to the HIS but parallelly operated with paper-based. · Lab. request form with QR code is functioned as intended. · The HIS is not operated directly at the doctor's consultation.
Laboratory	· Smear exam · Xpert for smear positive specimens (send the specimen to Xpert site for screening RR) · Culture for RR in Xpert	· Laboratory registration book	· Scanning QR code · Entering the Lab. results · Printing out a Lab. result form with QR code	· Registration is parallelly operated. · Data transfer by QR code is functioned.
TB clinic	· Register patients when diagnosed with drug-susceptive TB and start the treatment · Refer MDR patients to an MDR-TB clinic for treatment · Monitor treatment efficacy	· TB registration book (TB-03) · Treatment card (patient referral form)	· Scanning QR code · Registering as a TB case · Printing out a Lab. request form with QR code	· Registration is parallelly operated. · Data transfer by QR code is functioned. · Treatment card operation on the HIS is not implemented, but the paper-based is used.
Laboratory	· Smear exam (at least 3 times for 6-month treatment course)	· Laboratory registration book	· Scanning QR code · Entering the Lab. results · Printing out a Lab. result form with QR code	
TB clinic	· Evaluate treatment outcome · Reporting cases on a quarterly basis	· Quarterly report (TB-07, TB-08)		· The quarterly report is not produced by the HIS, but the paper-based is used as the main operation.

Table 4. Accuracy of the reported number of patients on the HIS-based and Paper-based quarterly reports

Site	Quarter	Method	Type of patient				Total	Type of disease*				Total	Cause of discrepancy
			New	Re-treatment				Pul., Bac. confirmed	Pul., Cli. diagnosed	Ex-Plu., Bac. confirmed	Ex-Plu., Cli., diagnosed		
				Relapse	Prev. treated	Unknown							
A	2Q	Accurate	104	18	1	0	123	60	43	0	20	123	Data mis-entry
		HIS-based	104	18	1	0	123	60	43	0	20	123	
		Paper-based	104	18	1	0	123	60	43	0	20	123	
	3Q	Accurate	96	13	0	0	109	49	51	0	9	109	
		HIS-based	97 (+1)	12 (-1)	0	0	109	49	51	0	9	109	
		Paper-based	96	13	0	0	109	49	51	0	9	109	
B	2Q	Accurate	74	14	1	0	89	39	40	0	10	89	Data mis-entry, misclassification by the HIS
		HIS-based	75 (+1)	13 (-1)	0 (-1)	1 (+1)	89	39	41 (+1)	0	9 (-1)	89	
		Paper-based	74	14	1	0	89	39	40	0	10	89	
	3Q	Accurate	102	13	4	0	119	55	46	0	18	119	
		HIS-based	100 (-2)	14 (+1)	2 (-2)	2 (+2)	118 (-1)	54 (-1)	49 (+3)	0	15 (-3)	118 (-1)	
		Paper-based	102	13	4	0	119	55	46	0	18	119	
C	2Q	Accurate	139	32	0	0	171	95	63	0	13	171	Data mis-entry, misclassification by the HIS
		HIS-based	139	32	0	0	171	95	62 (-1)	1 (+1)	13	171	
		Paper-based	139	32	0	0	171	95	63	0	13	171	
	3Q	Accurate	135	18	2	0	155	84	62	0	9	155	
		HIS-based	135	18	0 (-2)	2 (+2)	155	83 (-1)	63 (+1)	0	9	155	
		Paper-based	135	18	2	0	155	84	62	0	9	155	
D	2Q	Accurate	280	33	4	0	317	178	108	0	31	317	Misunderstanding of the classification criteria, data mis-entry, misclassification by the HIS
		HIS-based	280	33	4	0	317	148 (-30)	140 (+32)	2 (+2)	26 (-5)	316 (-1)	
		Paper-based	280	33	4	0	317	174 (-4)	133 (+25)	0	10 (-21)	317	
	3Q	Accurate	329	37	3	0	369	178	157	0	34	369	
		HIS-based	329	37	3	0	369	115 (-63)	216 (+59)	1 (+1)	33 (-1)	365 (-4)	
		Paper-based	329	37	3	0	369	173 (-5)	162 (+5)	0	34	369	

Each "+," "-" and the following number shows the discrepancy of the number compared with the Accurate. *Pul, pulmonary; Bac, bacteriologically; Cli, clinically; Ex-Pul, extrapulmonary.

improvement of accuracy as these discrepancies were easily corrected once we intervened and gave necessary instructions. Indeed, we corrected the registered data in the HIS with the personnel and an administrator at TCL-D with the discussion of the NTP's criteria of patient classification.

Improvements of timeliness and completeness of reporting in the quarterly report were also expected once the cause of discrepancy was identified and corrected since the HIS can produce a report within a few seconds, while the paper operation may take up to a few days to generate a report. Patient numbers between the paper-based and HIS are then compared. This is one of the indicators that the criteria are in use (*19,20*).

Advantages and disadvantages of the HIS introduction

In this study, an advantage of the HIS was its user-friendliness. Additionally, it allowed alignment with the current paper-based operation. Other benefits are that the HIS targets resource-limited situations, and specific training and additional HR are not needed, which makes this a feasible operation. While the parallel data registration increased the workload and possibly hindered the acceptance of the staff or administrators, we expect further effective operation including several aspects such as interoperability, patient traceability, and patient registry.

The interoperability of the QR code may be another advantage as the introduction of electronic HIS should be integrated for avoiding complexity among other HIS (*7,9,10,16-18,21*). In Myanmar, MDR-TB patient information is managed by OpenMRS, which is one of the HIS adopted by NTP and was installed at the NRL (*5*). We discussed this with a team from OpenMRS, adopting the system possible to share data using the QR code among both HIS. Understanding the context of the country and the region is crucial such as the national guideline and the operational flows at the facility level.

Improvement of patient traceability is also expected because of the QR code. In the current networking of TB patients, information and laboratory specimens were all moving in different directions; thus, it takes manual data registration using the different types of registration books at each facility. This situation makes tracing patients challenging, and it has sometimes caused missing patients. Therefore, the QR code starts a battery specimen, which would be a strong point in terms of patient traceability.

As the internet infrastructure is rapidly growing, the tools assessed herein may need to be updated for future utility in Myanmar. Considering these aspects, the system is designed to allow for internet-based data storage once the environment is secured in the future. We presume that data sharing using QR code is the first step for the digitalization of the HIS. Furthermore, it would contribute to establishment of a client registry with the integration of aggregated health information according to the national strategy in Myanmar (*6*).

Feasibility of the HIS introduction

In conclusion, this study showed that indeed it is feasible to introduce an electronic HIS intended to align with the current paper-based format and adopting QR code operation in TB clinics and laboratories in Myanmar. The user-friendliness, no need for specific training, or additional HR are the main advantages of the HIS introduction in a resource-limited situation. The additional workload of the parallel data registration may require additional HR and remains a challenge; however, it would be expected to overcome this challenge as the use of the HIS expands and there is interoperability with other HIS. The system operation is still in the pilot phase and not fully operational or widespread. Thus, we were unable to show improvement in operational outcomes such as the timeliness and completeness for reporting, interoperability with other HIS, and patient traceability. Further research and follow-up for the system expansion would make it possible to show more convincing outcomes to attract staff, administrators, and policymakers.

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