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A Self-Risk Assessment Tool for Stratifying Risk of COVID-19 through mHealth

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The COVID-19 pandemic has been spreading at an exponential pace. In Malaysia, the current pandemic infectivity rate is high with a reproduction number calculated at Rt 1.57, which is the highest in the ASEAN region. The rising incidence of the pandemic calls for an effective outbreak management system. Using a risk assessment questionnaire for COVID-19, we can identify those at high risk of infection early. Developing a questionnaire requires defining the dimensions of the construction, and execution should be carried out efficiently for ease of assessment. This paper presents a work carried out in Universiti Malaysia Sabah (UMS) on the creation of a risk assessment questionnaire aimed at classifying individuals at risk of COVID-19, and the method of implementation using a mobile health (mHealth) technology. The methodology used comprises two steps: (i) the development of the risk-assessment questionnaire and (ii) the implementation using the mHealth technology in the form of a web-based application, UMS-Shields. UMS Shield's self-risk assessment tools emphasise more on the epidemiologic conditions, and the risk-stratified management provides a list of actions that should be taken by the user. The tool hence allows better management of COVID-19 by the Crisis Preparedness and Response Centre of the university.

Key words: *COVID-19, self-risk assessment, mHealth, questionnaire development*

1. INTRODUCTION

The COVID-19 pandemic announced by the World Health Organisation (WHO) on 11th March 2020 has expanded into a global pandemic of exponential proportions. China, the country where the virus was originated from, had suffered a significant impact in an upsurge of positive and suspected cases (Wu et al., 2020a). Although COVID-19 is described to be less severe than SARS-CoV and MERS-CoV, the rapid onset of the illness and symptoms among people within close contact suggests the probability of the virus being highly contagious and pointing towards human-to-human transmission (Team, 2020). Globally, the total number of deaths has reached almost 1.2m (WHO, 2020). However, the case fatality rate varies between countries, and has been reported to be as low as 1.4% – 2.3% in China (Wu et al., 2020a; Wu et al., 2020b), 1.7% in the US (Omer et al., 2020) and to a staggering figure of 7.2% – 10.8% in Italy (Onder et al., 2020; Wu et al., 2020a).

Malaysia was among the earliest countries in South East Asia to be affected by this pandemic in March 2020 (Abdullah et al., 2020). Approximately one week after the pandemic was announced, the country has enacted a movement control order (MCO) in an attempt to flatten the epidemiological curves (Salim et al., 2020). This is especially prescient in the local Malaysian setting, as the disease has now moved beyond cluster transmission towards community transmission. For the state of Sabah in northern Borneo, an increasing figure of positive COVID-19 cases was seen in the east coast region with an upsurge figure from mid-September onwards. This was after observing a decline in the period of positive cases leading to the instigation of controlled MCO, known as conditional movement control order, an aggressive effort to curb the rapidly rising rate of positive COVID-19 cases (Povera, 2020). As of the latest news, Malaysia has reported a relatively high figure of infectivity rate based on the COVID-19 reproduction number with a calculated Rt of 1.57 compared to other neighbouring countries in the ASEAN (Times, 2020).

The rising incidence of this pandemic calls for an effective outbreak management system. One of the core components is disease surveillance that scrutinised the occurrence of disease(s) and health-related events continuously for prompt intervention in the effort to control the disease(s) (Isere et al., 2015). Disease surveillance utilises risk stratification or assessment tools to stratify individuals at risk, and several tools have been developed for COVID-19 (Chatterjee et al., 2020). Implementing such risk assessment tools for mass surveillance is only feasible and practical if it is constructed in the form of a questionnaire and delivered rapidly for ease of retrieval by the intended respondents and the analyser, in this case, public health agencies. Developing a questionnaire requires identification of the dimensions of the construct, in which several approaches have been suggested for this purpose including content analysis, review of research, critical incidents, direct observations, expert judgment, and instructions (Crocker et al., 2006).

The intention of developing a questionnaire for risk assessment in COVID-19 is to have the ability for detecting those at high risk of the infection for early screening and detection. Once developed, traditional methods of utilising pen and paper testing or telephone interviews would have been exhausting for healthcare professionals, if executed among thousands of individuals in a specific community. The field of healthcare is now moving towards the use of the disruptive technologies brought by the 4th Industry (IR4.0), such as the Internet of Things (IoT) (Kumar et al., 2020). Hence, applying IoT, in the form of a mobile health (mHealth) system, for implementing risk stratification on a massive number of respondents through risk assessment questionnaires, is seen as the most practical innovative approach especially in an era that emphasises strict minimal contact. Furthermore, this questionnaire serves as an empowering tool that would alert individuals on the risk status and the obligations to adhere to good self-care practice.

Therefore, this article described the work on developing a questionnaire for risk assessment aimed for stratifying individuals at risk of COVID-19, highlighted the obligatory management based on different levels of risk, and elucidated the implementation process through a web-based application. The presented risk assessment module is part of the ongoing work to develop a comprehensive mHealth system, which is increasingly being used worldwide (Marcolino et al., 2018), for outbreak surveillance among the mass population of Universiti Malaysia Sabah (UMS), a public university in the northern Borneo. The article briefly reviewed a few similar questionnaires from the local context and addressed some of the anticipated barriers for validation.

The remainder of this paper is organised as follows. Section 2 presents the methodology of the risk assessment tool questionnaire development. The results and discussions are described in Section 3 and 4. Section 5 concludes this paper.

2. METHODOLOGY

In this section, the methodology used to develop the self-risk assessment tool is described. Subsection 2.1 presents the site and population of the study. Subsection 2.2 describes the details of the development of the risk assessment tool. The implementation of the risk assessment tool is described in Subsection 2.3.

2.1 STUDY SITE AND POPULATION

UMS is a public-governed university established in 1994 with its main campus located in the heart of Sabah state, Kota Kinabalu and two more campuses are situated in Sandakan and Federal Territory of Labuan. The main campus has been labelled as one of the attraction places to visit in Sabah and considered as one of the most scenic eco-campus. Overall, the university has more than 18000 registered students (included both undergraduates and postgraduates)

with almost 2000 staff, inclusive of academic and non-academic. Accommodation in these three campuses house almost 6000 students and administrative data have reported an average of the daily entrance of non-UMS workers (such as construction employees, domestic labours and cafe workers) and visitors of almost 500 people. With this staggering figure and the increasing rate of COVID-19 outbreak in Sabah, an effective measure has to be implemented to allow only those at low risk of infection to enter the premise. Ethical approval was received from the Medical Ethics Committee of UMS, and collected data were treated with confidentiality.

2.2 DEVELOPING RISK ASSESSMENT TOOL QUESTIONNAIRE

Based on the guidelines (Tsang et al., 2017), constructing a validated questionnaire involves three major steps; preliminary considerations, development process and validation. This paper described in detail the first two steps; however, the outcomes from the final step are beyond the scope of this article. The process was initiated in May 2020, and the questionnaire was released fully by June 2020.

A. Preliminary considerations

In this current state where COVID-19 was still impacting the world globally, a validated risk stratification tool had yet to be established and adopted. In the local setting, there were only minimal risk stratification questionnaires established in the country. Three were concurrently developed and utilised during the time where the authors were developing the risk assessment tool described in this article. These questionnaires are: 1) Risk Assessment (RA) Form for COVID-19 Transmission by the Sabah State Health Department (JKNS, 2020), 2) COVID-19 Health Risk Assessment and Self Evaluation (CHaSe) System by Universiti Sultan Zainal Abidin (UniSZA) (UNISZA, 2020), and 3) MySejahtera by the government of Malaysia (Malaysia, 2020). Table 1 shows the main features and characteristics of each questionnaire.

Table 1: Features and characteristics of risk stratification questionnaires of RA, CHaSe and MySejahtera

Features	**Questionnaire**		
	RA	CHaSe	MySejahtera
Dimensionality of constructs	Risk factor – 2 items Symptoms – 1 item Epidemiological condition – 2 items	Risk factor – 4 items Symptoms – 7 item Epidemiological condition – 3 items	Risk factor – 4 items Symptoms – 7 item Epidemiological condition – 3 items
Format of questionnaire	Self-administered	Self-administered	Self-administered
Format of items	'Yes' or 'No' responses Positive response type Close-ended statements	'Yes' or 'No' responses Positive response type Close-ended statements	'Yes' or 'No' responses Positive response type Close-ended statements
Level of risk	High Low	High Moderate Low	High Low
Length of questionnaire	5	14	6
Mode of implementation	Manual (pen and paper) and online (web-based application)	Online (web-based application)	Online (web-based and mobile application)
Targeted respondents	For those coming to Sabah state (land, sea and air routes)	For those wishes to enter UniSZa	For any premises that requested the use of MySejahtera application

Generally, the construct dimension in each questionnaire is multidimensional and appears relatively similar covering risk factors, symptoms and epidemiologic conditions. However, both RA and MySejahtera placed each dimension separately. For instance, questions on having contact with a positive case of COVID-19 and history of being in a mass gathering were inquired in two different items, but CHaSe asked two epidemiological conditions in the same item. RA and MySejahtera placed related inquiries within the same item, e.g. symptoms like fever, cough, shortness of breath, sore throat, runny nose, loss of taste and smell are gathered in the same item, rather than separately like CHaSe. MySejahtera is applicable for any premises or places that have requested and granted QR code from the system. CHaSe is intended for every individual that wishes to enter UniSZA while RA is meant to be filled for those who are entering Sabah state, either through the land, water or air routes.

During the time of the questionnaire development, the validation of MySejahtera, RA and CHaSe has yet to be ascertained. Nevertheless, a risk assessment tool for stratifying those at risk of COVID-19 in UMS was urgently and strictly needed. Based on these comparisons, MySejahtera seemed to be the most comprehensive and readily available to be used. However, the data in this particular system is centrally controlled and not readily accessible for the team of Crisis Preparedness and Response Centre (CPRC) in the university to act upon, hindering the main objectives of COVID-19 surveillance within the UMS population. Therefore, a group of experts in the field of public health and healthcare technology was formed in early April 2020 for this purpose.

B. Development process

As iterated by Tsang, Royce and Terkawi, 2017, the process of developing a questionnaire entails addressing seven following issues (Tsang et al., 2017).

1. Identifying the dimensionality of the construct

Based on the preliminary considerations of the three analysed questionnaires, three main domains are covered in the dimension of construct: risk factor, respiratory symptoms, and epidemiologic conditions. The presence of risk factors, namely hypertension, diabetes, asthma and ischemic heart disease has been shown to be associated with a higher mortality rate compared to people without these non-communicable diseases (Zhou et al., 2020). Common reported respiratory symptoms for COVID-19 are fever, cough and shortness of breath (Wiersinga et al., 2020). The average time from exposure to symptom onset is five days, and 97.5% of those with symptoms displayed the clinical features within 11.5 days of exposure (Wiersinga et al., 2020).

A review from Taiwan highlighted several features on the epidemiologic conditions with an emphasise on the duration of 14 days prior to symptoms onset before proceeding with the diagnostic investigation: 1) travel history from or positive contact with individuals having fever or respiratory symptoms in the first-class epidemic area of COVID-19 (reported as Hubei, including Wuhan and Guangdong), 2) travel history from or living in other parts of mainland China, 3) positive contact with probable or confirmed COVID-19 cases, including health provider, under the same roof, or direct contact with affected mucus or body fluid (Wu et al., 2020c). In reference to the use of epidemiologic conditions as screening questions before diagnostic sampling, Taiwan CDC guideline instructed that the following individuals needed reporting to Taiwan CDC within 24 hours: the presence of any clinical condition and fulfil epidemiological condition 1 or 3, *OR* any two clinical conditions and epidemiologic condition 2 (Wu et al., 2020c).

The questionnaire developers also viewed established guidelines from the local perspective that includes the definition and standard operating procedure (SOP) for those identified as suspected, probable, confirmed and person under surveillance (KKM, 2020b).

2. Determining the format for the questionnaire to be administered

As the intended respondents would be in a mass number, a self-administered format would be the best solution although this questionnaire could be administered by any of the healthcare staff. There is a possibility that inaccurate information might be submitted; however, such inaccuracy would remain the same if the questionnaire is to be administered by any of the healthcare professionals.

3. Determining the item format

Considering the dimensions of constructs are to be determined in binary responses of 'Yes' or "no', each item is to be phrased as a closed-ended type. However, bearing in mind that the backgrounds of respondents are mixed, some of the responses have to be elucidated in a more elaborated but simplified manner, instead of a brief 'Yes'.

4. Developing item(s)

With the same consideration imparted for determining the item format, inscribing the item questions have to be simple, brief and written in plain languages for targeted respondents. As the university employs expatriate and received foreign students, the items are written in dual language: English and Malay languages, in which the latter is the native language of the country. Each item was constructed to be addressing one issue and the experts opted not to use the reverse scoring system to avoid confusion in the understanding of the item statement. Each item was given a specific score weightage, and the sum of the scores was then utilised for grouping the risk levels: low, moderate and high risk.

5. Determining the length of the questionnaire

Based on the construct of interest, the number of items to be included has to be grounded on the three domains ascertained: risk factor(s), clinical symptom(s), and epidemiological condition(s). Bearing in mind that the intended respondents include visitors and non-UMS workers entering the UMS premise, the questionnaire should not be lengthy but sufficient to address all required construct domains and completed within a brief period of time.

6. *Reviewing and revising the initial pool of items*

The items went through several cycles of reviews and revisions by a group of public health experts in the university's CPRC team before the final version of the risk assessment tool was released for pilot testing.

7. *Preliminary pilot testing*

The preliminary testing was conducted among a group of healthcare and non-healthcare professionals respondents to assess the practicality of filling up the questionnaire and to determine the difficulties of comprehending any of the items.

2.3 IMPLEMENTING MHEALTH FOR DELIVERING RISK ASSESSMENT QUESTIONNAIRE

The questionnaire is placed in a web-based application of an outbreak management system called UMS-Shields (UMS, 2020). UMS-Shields was designed as such so that the layout of the system is adaptive for desktop and mobile phone views, whereby the latter is the main focus as the tool should be easily accessible anywhere and at any time. The developed system was intended for surveillance, detection and monitoring of COVID-19 in UMS. In addition to the module for risk assessment questionnaire, UMS-Shields consists of four other modules to encompass the needs for monitoring high-risk individuals and massive screening of students. It is opened for the public as a means to monitor outside people entering the premises for recreational or non-recreational purposes.

As the COVID-19 outbreak is highly dynamic, particularly observing the rapid changes of the affected districts in the country and the number of active clusters present, relevant items in the questionnaire have to be continuously updated to ensure accurate responses. Hence, the areas and clusters are easily modified through real-time and the required information for these are available through COVID-19 website by the Ministry of Health (MOH), Malaysia (KKM, 2020a).

The system requires the user to allow location tracker using the global positioning system (GPS) module embedded in their mobile phone that would allow tracking the area where the responses were made. This would be useful for the risk assessment questionnaire so that the monitoring team of the CPRC could assess the accuracy of submitted responses and correctly determined the status of the red zones. A red zone is defined by the MOH as the district with more than 40 active cases at one point of time.

The innovative approach of the UMS-Shields system is developed as such that the output from the risk assessment questionnaire would yield an automatic e-letter for the respondents to download and display to the security personnel at the entrance of UMS. Each type of risk imposes a different mode of management incorporating permission to work/study in or entering UMS, the level of monitoring by CPRC team, and self-care advice for respondents. This system has inter-operability with the existing university's online system that permits detection of individuals' risk before permission to work/study in UMS is granted.

3. RESULTS

This section presents the results of the risk assessment tool questionnaire development. Subsection 3.1 presents the logical design of UMS-Shields. Subsection 3.2 describes the finalise questions for the risk assessment, while Subsection 3.3 presents the risk management as the outcome of the risk assessment questionnaire.

3.1 THE LOGICAL DESIGN OF UMS-SHIELDS FOR SELF-RISK ASSESSMENT

This section describes the processes involved in performing the self-risk assessment of the UMS-Shields, as depicted in Figure 1.

First, the user has to login to the system. The staff and students of UMS can log in to the system using the existing active directory. Others will need to register an account before they can log in to the system. Second, once the user has successfully logged in to the system, he/she need to choose the take self-risk assessment option. The user is required to answer eight questions; the details of the questions are described in Section 3.2. Third, once the user has submitted his/ her answers to the questionnaires, a risk status will be calculated and shown to the user. The system will then generate an electronic letter (e-letter) that shows the risk status of him/ her. The e-letter can be downloaded and will be used as a pass to enter UMS; all those who wish to enter UMS need to show this e-letter to the security officer at the entrance. The e-letter is also stored in the database and can be accessed at any time by the respective user when necessary.

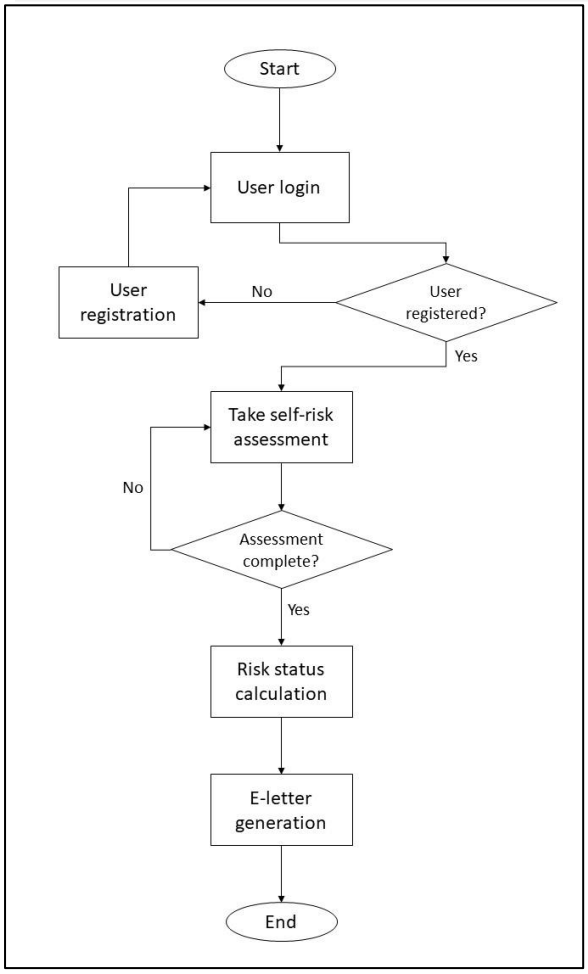


Figure 1: The flowchart of the UMS-Shields for self-risk assessment

3.1 QUESTIONNAIRE FOR SELF-RISK ASSESSMENT TOOL

Addressing step 1-6 in the questionnaire development process as iterated in Subsection 2.1, Table 2 displays the finalised 8-item questionnaire with corresponding scoring weightage. The questionnaire is to be self-administered and termed as Self-Risk Assessment Tool. It requires respondents to activate GPS in their mobile phone, laptop or any gadget used before filling in the questionnaire is permitted. Initially, there were only seven items in the question but based on the feedback from the respondents, the questionnaire failed to capture anyone having evidence of positive associations with COVID-19 clusters. Hence item 5 was included. The final score ranges from 0 to 13 and the stratification of risk is based on the final score attained, as shown in Table 3.

Table 2: 8-item questionnaire of Self-Risk Assessment Tool

Domain construct	Question	Answer	Score
Risk factor	1. Do you have any of these diseases? (Allow to click more than once)	Diabetes	0
		Hypertension	0
		Asthma	0
		Heart Disease	0
		None	0
Symptom	2. Are you having any of these now? (Allow to click more than once)	Fever	1
		Cough	1
		Shortness of breath	1
		Sore throat	1
		None	0
Epidemiological condition	3. Have you travelled outside Malaysia in the past 14 days?	Yes	2
		No	0
	4. Have you been to the following area in the past 14 days? (Area refers to red zones and updated continuously)	Living in or visited the area	1
		No	0
	5. Have you ever been to any places associated with any of the COVID19 clusters in the last 14 days (Clusters are updated continuously)	Yes	1
		No	0
	6. Do you have any contact with a positive OCVID-19 case (Definition explained after the questions)	Yes	2
		No	0
	7. Have you been to any mass gathering in the past 14 days?	Yes, I have attended a wedding/party/event involving more than 250 people	1
		No	0
	8. Are you a health care worker? (Only one answer is allowed)	Yes, I manage positive COVID19 cases	2
		Yes, I am a frontliner and do COVID-19 screening	1
		Yes, I am a healthcare worker but do not manage or screen COVID19	0
		No	0

Table 3: Classification of risk status based on the scoring system

Risk status	Total score
Low	0
Moderate	1
High	2 or more

Based on the outcomes from the preliminary pilot study conducted, item 4, 6 and 7 were modified. For item 4 that assesses the risk of exposure in red zones, the three initial responses were either 'Living in the area (score of 2)', 'Visited the area (score of 1)' and 'No (score of 0)'. However, as the university is located in Kota Kinabalu, separating the living and visited responses was deemed inappropriate, as it would create a high likelihood for false positives in the absence of other positive responses. The initial responses for item 6 were either 'Yes (score of 2)', 'Unsure (score of 1)' and 'No (score of 0)'. These responses yielded a high false-positive as respondents had the tendency to answer 'Unsure', but further data clarification captured inaccurate responses. The responses in item 7 were modified slightly based on the definition of the number of people in the mass gathering. At the time of writing, the latest definition by the MOH for the threshold of the minimum number of people in a mass gathering is 250 in contrast to the figure of 50 prior to August 2020.

Figure 2 shows an example of the implemented risk assessment tool of UMS-Shields. The tool is designed using paging questionnaire instead of scrolling. In paging design, the end-user sees only one question per page, which would minimise the need for scrolling that may increase the error rate in item or answer selection (Punchoojit et al., 2017). The chosen designed also allows the user to focus only at one question at a time, which would increase the accuracy of the submitted response (Peytchev et al., 2006), although higher breakoff rates (but not significantly higher) (Mavletova et al., 2014) may occur.

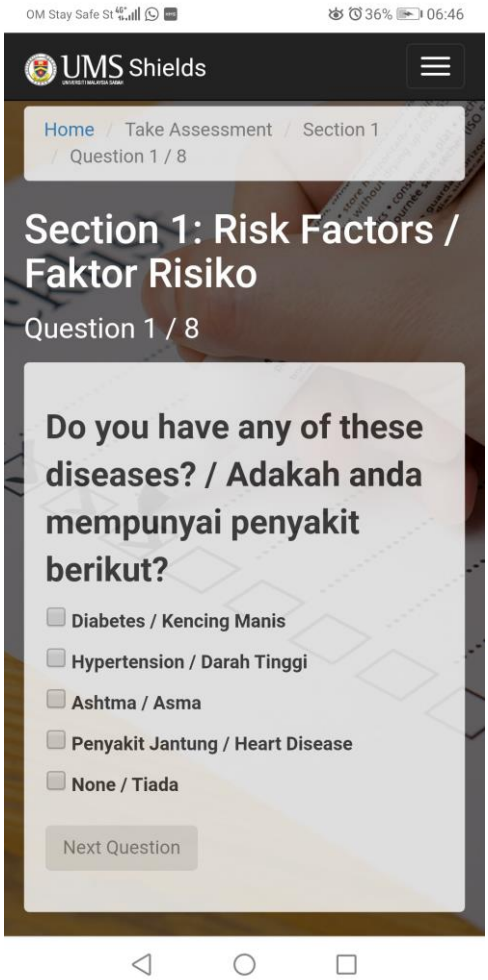


Figure 2: An example of the question in the risk assessment tool

3.2 RISK-STRATIFIED MANAGEMENT FROM SELF-RISK ASSESSMENT TOOL

Once the questionnaire is completely filled in and submitted, the score is automatically calculated and respondents would receive a notification of risk status with corresponding management measures. Table 4 shows the risk-stratified management plan with Figure 3 and 4 illustrating examples of the management advise and e-letter received through UMS-Shields.

Table 4: Risk-Stratified Management from Self-Risk Assessment Tool

Risk level	**Action to be taken**	
	Fitness status / Status to enter	**Action to be taken**
High	Not allowed to work or attend classes or enter UMS. Advised to stay put until a proper medical assessment is carried out.	1. Immediate medical attention: You are **required to see a doctor at PRW immediately or any nearby MOH COVID19 screening center for further clinical assessment**. Throat swab/ nasopharyngeal swab may be taken. 2. Preventive action: You **should wear a mask, practice good personal hygiene, and practice adequate physical distance** (at least one meter) from another person. 3. Isolate, quarantine, monitor symptoms: To protect others you **should stay away** from them. Quarantine may be imposed for at least 14 days. Monitor your symptoms and inform any health care provider if its get worse.
Moderate	Not allowed to work or attend classes or enter UMS until proper medical assessment is carried out	1. Clinical assessment: UMS health care provider will be calling you for further clinical assessment. You **may be asked to go to PRW (contact no: 019-8842400)** for throat swab/ nasopharyngeal swab. 2. Preventive action: You **should wear a mask, practice good personal hygiene, and practice adequate physical distance** (at least one meter) from another person. 3. Isolate, quarantine, monitor symptoms: To protect others you **should stay away** from them. Quarantine may be imposed for at least 14 days. Monitor your symptoms and inform any health care provider if its get worse. You are advised to do the self-risk assessment on daily basis.
Low	Allowed entry into UMS campus for approved activities in the campus	1. Preventive action: You **should practice good personal hygiene, and practice adequate physical distance** (at least one meter) from another person, and avoid unnecessary mass gathering. Wear mask when indicated. 2. Self-risk assessment: You are **encouraged to do the COVID-19 self-risk assessment** on regular basis

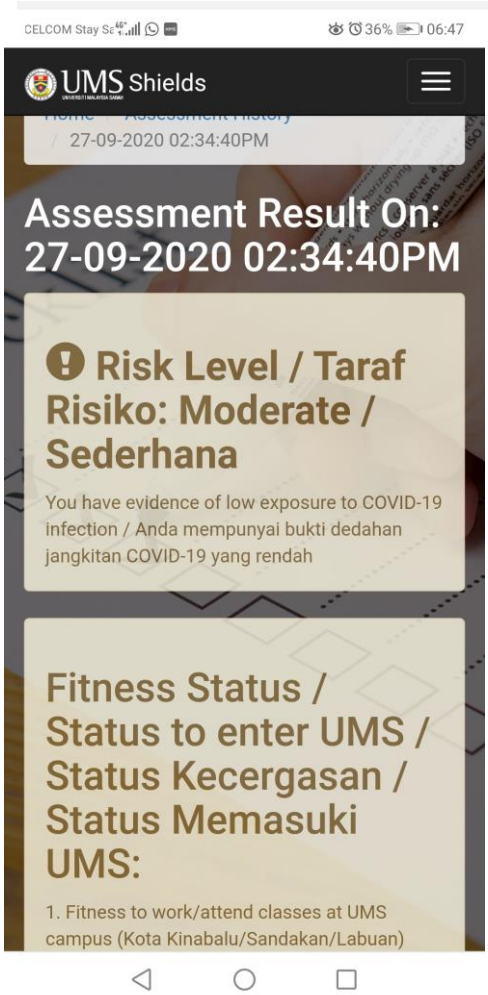
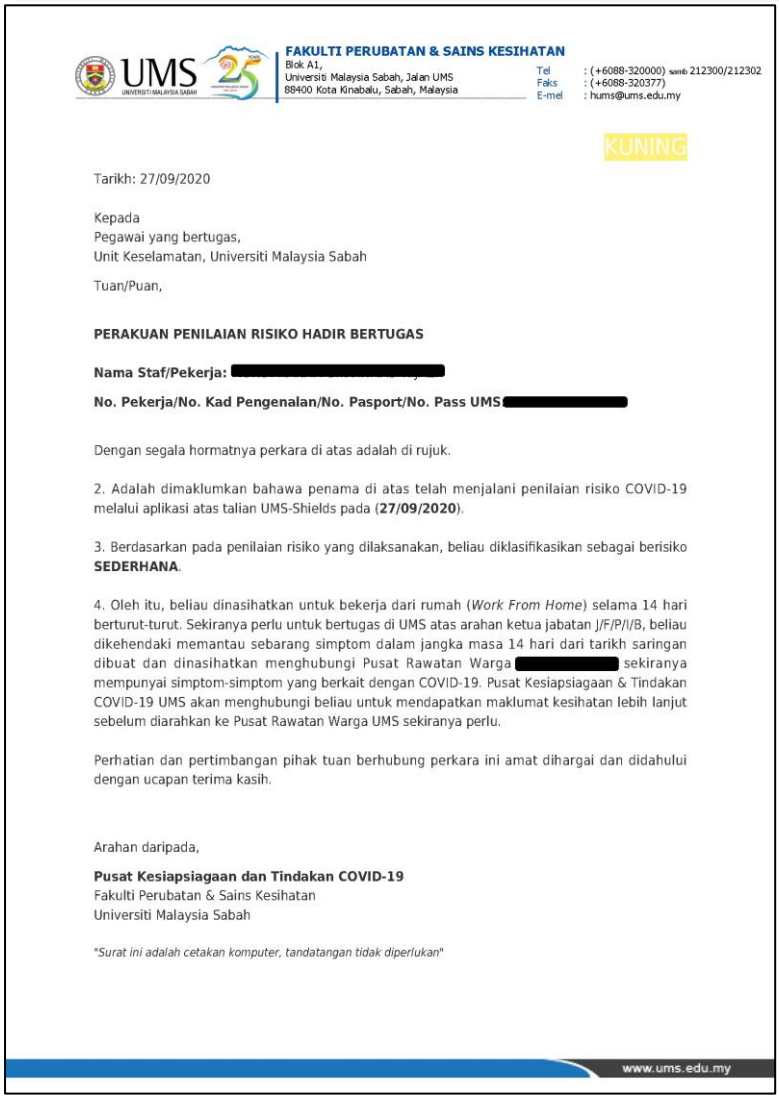


Figure 3: An example of the risk management advise page

From Figure 3, the risk status page is designed in such a way whereby the risk status of the user can be easily seen and navigated. The box and the font that display the risk status are colour-coded, whereby green represents the 'Low' risk status, while yellow and red represent the 'Moderate' and 'High' risk status respectively. The date and time when the self-risk assessment was taken are also shown. The similar colour code and the time the self-risk assessment was taken are also displayed in the e-letter, as depicted in Figure 4.



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KUNING

Tarikh: 27/09/2020

Kepada
Pegawai yang bertugas,
Unit Keselamatan, Universiti Malaysia Sabah

Tuan/Puan,

PERAKUAN PENILAIAN RISIKO HADIR BERTUGAS

Nama Staf/Pekerja: [redacted]

No. Pekerja/No. Kad Pengenalan/No. Pasport/No. Pass UMS [redacted]

Dengan segala hormatnya perkara di atas adalah di rujuk.

2. Adalah dimaklumkan bahawa penama di atas telah menjalani penilaian risiko COVID-19 melalui aplikasi atas talian UMS-Shields pada (**27/09/2020**).

3. Berdasarkan pada penilaian risiko yang dilaksanakan, beliau diklasifikasikan sebagai berisiko **SEDERHANA**.

4. Oleh itu, beliau dinasihatkan untuk bekerja dari rumah (*Work From Home*) selama 14 hari berturut-turut. Sekiranya perlu untuk bertugas di UMS atas arahan ketua jabatan J/F/P/I/B, beliau dikehendaki memantau sebarang simptom dalam jangka masa 14 hari dari tarikh saringan dibuat dan dinasihatkan menghubungi Pusat Rawatan Warga [redacted] sekiranya mempunyai simptom-simptom yang berkait dengan COVID-19. Pusat Kesiapsiagaan & Tindakan COVID-19 UMS akan menghubungi beliau untuk mendapatkan maklumat kesihatan lebih lanjut sebelum diarahkan ke Pusat Rawatan Warga UMS sekiranya perlu.

Perhatian dan pertimbangan pihak tuan berhubung perkara ini amat dihargai dan didahului dengan ucapan terima kasih.

Arahan daripada,

Pusat Kesiapsiagaan dan Tindakan COVID-19
Fakulti Perubatan & Sains Kesihatan
Universiti Malaysia Sabah

"Surat ini adalah cetakan komputer, tandatangan tidak diperlukan"

www.ums.edu.my

Figure 4: An example of the e-letter issued to the user

4. DISCUSSION

Risk assessment tools for COVID-19 have been developed since the emergence of the disease in late 2019 at both the global and local context to evaluate the potential risk of COVID-19 transmission in a targeted locality (Shaw et al., 2020). The risk assessment provides information needed to the health authority, for better preparedness and evidence-based responses which later help in elucidating the allocation of resources (Punchoojit et al., 2017). The incorporation of mHealth into the development of risk assessment tools further enhances the timely response to this pandemic which is in line with the nation's IR 4.0 vision (Vaishya et al., 2020). In addition, this tool can serve as one of the pathways for risk communication to the public to improve the population's resiliency against COVID-19 (DeWitt et al., 2020).

UMS has a strong Public Health background from the Faculty of Medicine and Health Sciences in terms of the availability of experts and the services or courses provided. The COVID-19 pandemic thus further underscores the need for the university's effort in controlling the spread of the disease, especially among the staffs, students or any person attending to the university. Together with the availability of healthcare technology aided by the Centre for Research and Innovation, UMS Shields was formed. The self-risk assessment tools incorporated in UMS Shield is intended to stratify the risk of contracting COVID-19 among the UMS population and provides the necessary management according to the risk level (high, moderate and low).

The development of UMS Shields' self-risk assessment tools for COVID-19 was based on the locally available tools such as the MySejahtera, RA and CHaSe. However, the practical usage of UMS Shields' self-risk assessment tools is far better compared to the previous tools as it was tailored to the need of the UMS population. Furthermore, the data were readily accessible and owned by the university itself. Thus, the internal management involving COVID-19 spread in UMS can be carried out smoothly and in a timely manner. The differences between risk assessment tools available outside the country and the proposed tool are mainly based on the sociodemographic data due to the dissimilarity in population health status as well as the level of healthcare technology available (Chatterjee et al., 2020).

As for the domain construct in the questionnaire, UMS Shield's self-risk assessment tools emphasised more on the epidemiologic conditions domain compared to MySejahtera, RA and CHaSe. This is to make sure the tools can precisely differentiate the person's risk based on the current fluctuations of the COVID-19 situation in local settings. The risk-stratified management based on the self-risk assessment tools clearly allocates the person's action to be taken either for clinical assessment, prevention plan, isolation, quarantine or for symptoms monitoring only. However, the healthcare jurisdiction is still under the authority of the Kota Kinabalu District Health Office and the decisions are simultaneously shared with mutual understanding.

The next step once the tool is implemented on a mass population is to further assess its reliability and validity. For this, the most appropriate measures to be considered are inter-rater reliability assessment and evaluation of sensitivity and specificity. As the tool clearly has three different construct domains (i.e. underlying risk factor, presence of respiratory symptoms, and epidemiological conditions) with zero marks indicating the desired low-risk status, the resultant internal consistency would be likely to be negative. Test-retest reliability would not be a suitable measure to use for reliability as the pandemic is highly dynamic leading to rapid change in individuals' circumstances as the risk (or the total score) would definitely differ between two short time intervals of two weeks. This duration is taken as it is currently accepted that the incubation period of the COVID-19 virus is within this duration. Hence, inter-rate reliability would be the best alternative measure as it can also ascertain the intended sensitivity and specificity outcomes. At the time of writing, the tool has been implemented on a massive

scale of more than 10000 respondents and the tool developers are gathering the data for analysing these two main parameters.

5. CONCLUSION

Developing risk assessment tools for a targeted population has much more benefit in terms of local planning and management. The tools must be suited to the needs of the particular institutions in order for the disease to be contained successfully. This paper presents the development of a risk assessment tool questionnaire for COVID-19 intended to manage the risk of COVID-19 spreading in UMS, one of the public university in Malaysia. The methodologies adopted to develop the questionnaire are described in detail, whereby the implementation and delivery of the questionnaire are using the mHealth technology. The tool has been used since June 2020 to allow the CPRC team of UMS to manage the COVID-19 risk amongst the university's community. Nonetheless, this risk assessment tools can be modified and used in the future for any kind of novel infectious diseases that have public health importance.

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