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mHealth Medical Record to Contribute to NonCommunicable Diseases in Indonesia

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Abstract

NonCommunicable Diseases (NCDs) have been the public concern worldwide, both in developed and developing countries. The issues are not only about the number of mortality but also the economic implications caused by the diseases. This paper aims to exploit the mobile technology potential by developing an mHealth medical record to assist the prevention and controlling of diseases in Indonesia, particularly in the West Papua Province. Design Science Research (DSR) methodology in Information System (IS) is employed to guide these research activities. This solution enables the medical data to be deposited by a person directly and personally utilising the developed mHealth application installed in the smart phone. By the time that person needs a further health examination for the NCD symptoms, the deposited data allows a General Practitioner (GP) making decision relatively easier at the first place. Some issues have been identified: data integrity and reliability as well as the manual assessment by the GP. Therefore, further evaluations are sought.

Keywords: mHealth; NonCommunicable Diseases (NCDs); West Papua Province Indonesia; Design Science Research

1. Introduction

According to the recent report by World Health Organisation (WHO) "NonCommunicable Diseases Progress Monitor 2017" [1], NonCommunicable diseases affect not only the developed countries but also the developing

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countries (Lower and Middle-Income Countries/LMICs). This implies that the diseases are caused both by the lack of access to the health services and also because of the unhealthy lifestyle. Of all various deaths worldwide, 70% of them are caused by these diseases and its 80% is in the LMICs disproportionately [1]. Cardiovascular disease (Heart disease), Cancer, Respiratory (Airway) disease and Diabetes cause highest NCD death [2], thus monitoring preventable risk factors would be beneficial for preventive healthcare. Several factors have been identified as risk for having NCD which includes, high blood pressure, high glucose level, high lipid (cholesterol), physical inactivity, poor nutrition, high body weight (obesity), smoking and alcohol [3]. Testing, monitoring and recording preventable risk factors in medical record will assist in healthcare decision making thus developing mHealth medical record will be beneficial for prevention and control of disease in Indonesia.

Much has been done in attempt to prevent and control these diseases due to the adherent consequences. The efforts have also been worldwide recognised through the Sustainable Development Goals (SDGs) [4]. Of all, one of them that emerges and gains wide attention is by harnessing mobile health (mHealth) technology [5, 6, 7]. This is due to the advancement of that technology as the core of mHealth that transforms the health care to be more accessible, affordable and available [8]. In Indonesia, telecommunication infrastructure penetration, particularly the mobile technology, increases significantly [9]. This is followed by considerably increasing the smart phone adoption [10]. These, by far, have been the drivers to exploit these technologies to contribute to the health care deliveries to more citizens, particularly to those who underserved.

Drawing from the Design Science Research (DSR) methodology in Information system (IS) [11], this research, therefore, set out to contribute to the NCDs by developing a mobile application, mHealth medical record. This solution is aimed to help persons in the prevention and controlling activities by depositing the history of their NCD indicators directly and personally utilising their smart phones. Subsequently this allows the GP to easily assess these particular indicators for a better decision-making process of their NCD symptoms. Specifically, this research targets the rural citizens of West Papua Province who do not have access to the health care services in general practice. This particular setting is chosen as, (1) as in Indonesia generally, mobile phone subscribers in that province specifically grows considerably high [12]. The growth is more than double from 25% to 60% in the past 6 (six) years [13]; (2) according to the data of Informatics and Communication Ministry of Indonesia, of all the mobile phone subscribers in this province, 95% of them access the internet from their mobile phones. This implies that the access are from the smart phone [14]; (3) the most important reason in our view is that we have initiated a prospective communication with the head of health office of the West Papua Province to materialise this research. Our communication has come to an understanding that the research will benefit for both of the healthcare programs of the province and research per se. Therefore, a high collaboration is urgent. Particularly, a support for the administrative perspectives: permit, access to health resources such as clinics, hospital and pharmacies to be able to get feedback in the development and evaluation processes is clearly important to complete the research cycle.

This article proceeds as follows: The following section provides related works from the extant literature of the study. Section 3 discusses the proffered solution for the issue previously discussed. Section 4 presents the methodology employed in this research. Section 5 discusses the to-be-developed system architecture and this research is concluded by Section 6.

2. Related works

NCDs (also known as chronic diseases) has been a public health concern worldwide [2]. The NCDs are the type of long duration diseases and the result of a combination of genetic, physiological, environmental and behaviours factors. *"The four main types of noncommunicable diseases are cardiovascular diseases (like heart attacks and stroke), cancer, chronic respiratory diseases (such as chronic obstructed pulmonary disease and asthma) and diabetes*" [2]. These typical diseases are associated with the unhealthy diet: low fibre, high salt, sugar and fat diets, nicotine addicted and less physical activities [2]. In Indonesia alone as the focus of this research, the death percentage caused by these diseases is 73% of all or roughly 1.5 million populations [1]. Apart from the high number, these diseases also brings serious economic implications, for instance, undercutting productivity, physical deactivation which lead to unproductive economically [15].

As indicated earlier, among the promising ways to accelerate the health care delivery to the wider community is by harnessing mHealth technology. This technology, in fact, has been adopted globally in various themes of health cares,

ranging from health call centre, toll free emergency, treatment compliance, patient monitoring, surveillance to decision support system [6]. In Indonesia, as a matter of fact, investigating the efficacy of the mHealth has also been the concern since more than a decade ago [16, 17, 18]. These mHealth technologies have developed and adopted for various health cares. For instance, an mHealth developed to assist maternal and infant health care, particularly in the rural areas [19], to prevent the mother-to-child transmission of HIV/AIDs [20], to help a self-assessment health care monitoring [21]. These adoptions are driven by the significant increase in the smartphone and telecommunication infrastructure [22]. Thus, it is no surprise that the notion to adopt the mHealth in the prevention and controlling the NCDs also increases.

As described previously that although the mHealth technology in Indonesia has also been exploited for particular NCDs, however, mostly they shortfall in two ways (1) they do not inform how the validation is pursued. This is a challenging task yet crucial as most mHealth developments are far from the adoption as there is no evidence providing they are useful [23]; (2) there is lack of theoretical ground and are not supported by a rigour methodology [17]. This is urgent as it guides the research cycle for the contribution the research aims for and at the same time, hinders redevelop the known solution for the known problem [24]. In the context of this research, apart from the rationales as presented in the Section 1 Introduction as to why we opt for developing and evaluating the mHealth medical record for the eastern province in Indonesia, this province has also been subjected to a special autonomy status in Indonesia. The aim is to transform the health delivery, education, societies empowering to as wide communities as possible. Therefore, we envision to contribute to this by collaborating with the health province authority for the health issues. We also view that this research can be able to complete the strategic plan of the health authority in the West Papua Province 2017-2022 [25] particularly for prevention and controlling the NCDs.

3. Proffered solution

This research seeks to contribute the issue mentioned earlier by developing an mHealth medical record, that is a mobile (smart phone) based application that can assist to assess the related NCD indicators in subsequent to be used for a later examination of the symptoms of these particular diseases of that person. However, as there are variety of the defined risk factors of those particular diseases based on NCD Global Monitoring Framework of WHO [26], this initial research confines only to these six indicators: (1) harmful use of alcohol, (2) physical inactivity, (3) salt and sodium intake, (4) tobacco use, (5) raised blood pressure and (6) obesity. These factors are chosen as they contribute the most of the NCDs in Indonesia [27]. In other words, they are the common factors to be examined in a preliminary health condition of a person before aiming to see a GP.

In our context, the examination is regularly begun by a blood testing to measure the liver function tests, cholesterol, triglyceride, blood sugar level and body mass index. These indicators are measured through a person's blood examination, height and weight measurements. This can be done easily, relatively cheap and quickly of a person by visiting a clinic/pharmacy/hospital as mostly it provides such examination. The other indicators are obtained by asking the related closed-type questions to the person at the same time the blood is examined. For instance, social habits like drinking and tobacco related information are obtained asking the alcohol related questions recommended by the National Institute on Alcohol Abuse and Alcoholism, USA [28]. The results of the blood test and the answers from the person will all be deposited, directly and personally, by that person him/herself with the assistance of the health care officer in the clinic/pharmacy/hospital using the person's smart phone. This assisting employee has already been trained prior to this type of addition task. For a person without a smart phone, they are not subjected to the research.

4. Research methodology

This research adopts Design Science Research (DSR) methodology of Information System (IS) [11]. Unlike the behavioural science methodologies that attempts to explain and predict, based on the observational activities, the impact of IS adoption to individual, group or organisation [29], the DSR aims to create an IS artefact: model, method, construct and instantiation to be an innovative solution for a particular issue [30]. This methodology by default is seen as the most natural and appropriate one for this typical research. This is due to the aim of this research to develop a concrete solution, the mHealth application for medical record in Indonesia in the prevention and controlling endeavours for the NCDs, particularly in the context of West Papua Province. It is worth noting, nevertheless that

both paradigms are inseparable in IS research. Both seek to extend the boundaries of human and organisation capabilities [29, 31] .

4.1. Design science research

DSR as in Hevner [32], comprises two stages: "build" and "evaluate". As previously described, the developed mHealth is aimed to assist those with the NCD indications to be better assessed of their risk level by a doctor. To be able to achieve this, the first to be completed is the development process of the IS artefact, the mHealth for medical record. Once built, it should then be evaluated rigorously at the first place. The evaluation is conducted thoroughly to ensure the efficacy as well as the effectivity of the developed mHealth. Following the three-cycle view of DSR of Hevner [32], these "build" and "evaluate" stages are named the "*design cycle*" [32].

However, as the developed mHealth aims to contribute to the prevention and controlling the NCDs in a particular setting, understanding the organisation/environment context, the people, as well as the technical aspects surrounding the research stages is urgently required. These understandings should be acquired as early as possible subsequent to the building and evaluation phases. These processes are represented as "*relevance cycle*" following Hevner at al's three cycle view of DSR.

In addition, once the evaluation is completed, the next to be concerned is whether the solution offered to this particular problem can also be embraced to be able to apply at addressing other similar issues [33]. The concern of this is simply to avoid the "*reinventing the wheel*" activities. As such, the idea of generalising this particular solution needs to be formulated for a class of problem of this particular issue. The aim is "*to address not only the specific problem at hand but as an instance of more generic class of problems*" [33]. This view is heavily related to another broad consensus in the typical IS research that is not only solving the emerging problem but also generating a contribution to knowledge (a theoretical contribution) (Please see eq. [24] for a further elaboration. As in Hevner's three cycle view of DSR [32], this task is referred to as "*rigor cycle*".

4.2. Research stages

To ascertain the three-cycle view of DSR can be rigorously materialised, Hevner *et al*. [11] elaborate them into the seven research stages as described in Table 1.

Table 1. The artefact development based on the DSR framework [11].

Design research guidelines	Our artefact design
Relevance cycle: identifying problems and the artefact type	<u>*Stage 1: Design as an artefact*</u> This research aims to develop an mHealth medical record to support doctors in the decision making process regarding the NCDs' symptoms. <u>*Stage 2: Problem relevance*</u> On the one hand, the target population is seriously subjected by Sustainable Development Goals (SDGs). In addition, there is no such mobile solution (mHealth) developed for the NCDs in our context nor in the national level generally, given the concomitant risks socially and/or economically that might be caused by them. On the other hand, the adoption of mHealth technology has been increasing in Indonesia and successful for some particular diseases. As such, those lesson learnt have been the motivation of this research.
Design Cycle: developing and evaluation the artefact	<u>*Stage 3: Design evaluation*</u> The DSR evaluation is about measuring the efficacy and effectivity of the to-be-developed IS artefact, the mHealth medical record. The aim is to ascertain (1) whether the to-be-developed mHealth works as it aims for; and (2) whether it works in the specified conditions. <u>*Stage 5: Research rigor*</u> The mHealth is developed based on mobile application. As mention earlier, once built, the evaluation is the next to be proceed. Both development and evaluation are undertaken rigorously and conducted to both

Design research guidelines	Our artefact design
	developers and the end users alike. The aim is to acquire the feedbacks to improve the mHealth application.
	Stage 6: Design as a search process
	The DSR is an iterative research methodology by default. Therefore, the building and evaluation procedures will be kept active until they meet all the requirements previously itemised. That is the condition in which the developed artefact/prototype, the mHealth medical record, works as it aims for. Those iterative processes are guided by the constructive feedbacks from a previous condition.
Rigor cycle: research contribution and communicating of the developed artefact	*Stage 4: Research contribution*
	This research contributes in developing the mHealth medical record as a mean to support the decision-making process by doctors for those who are indicated the NCDs. In the end, the developed mHealth can be of help in the NCD prevention and control activities in the context of this research. In DSR, this typical contribution by [24] is an improvement: a new solution to the known problem. In addition, In the context of IS research in Indonesia, harnessing the DSR drawn in this paper is expected to contribute to enrich the relatively nascent IS research in Indonesia.
	Stage 7: Communication of research
	In this stage, this research will be presented to academics and professional, in particular to those who are interested and work in this domain. This is conducted verbally in workshops, conferences and/or journals. The presentation encompasses the initial development including the one presents in this paper. These presentations are also with the aim to expect feedback for the later improvement of the developed artefact.

5. The to-be-developed system architecture

The system architecture and the working components in this research are shown in Fig. 1. It consists of three main parts: (1) the device and platform types that can be used to deposit and retrieve the data of the NCDs; (2) a cloud-based back-end storage that is used to deposit the NCD data; (3) the decision making process based on the deposited data by the general practitioners/physicians. As can be seen from the Fig. 1, the to-be-developed mHealth can be accessed from mobile and web front-end.

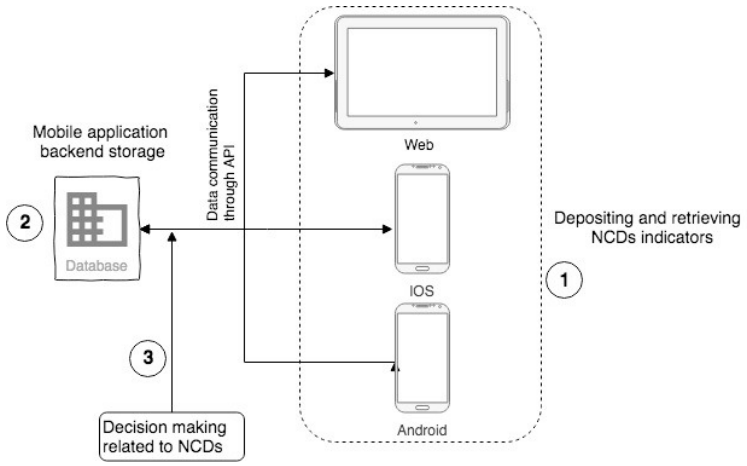

Fig. 1. Proffered system architecture of the mHealth medical record.

Initially, every time a person who visits clinics/hospitals/pathology to get the blood tested for the NC indicators will be encouraged to store the result of the examinations: for example, lipid profile such as cholesterol, triglyceride, liver function test, uric acid or even blood for malaria parasite using her/his mobile phone (smartphone) directly by her/his self. The officer/employee who conducts the blood test has been trained prior at using the developed

application. The aim to store the test result is that the log of the blood test result containing the NCD indicators can be managed to be later used to assess whether the person has the latent symptom of the disease.

As discussed previously that the developed mHealth medical record application is the artefact produced from the research. The aim is as a tool to deposit the various indicators of the NCD. Fig. 1 depicts the model of depositing activities of the NCD indicators. The tool can be accessed via mobile-based or web-based. Once the data is deposited, it can be accessed whenever there is an internet connection for the NCD related decision making by a GP. The architecture described in Fig. 1 is part of the environment supporting the developed artefact described based on the research methodology drawn in Table 1.

As indicated previously, one of the ways to monitor the NCDs indicator of a person is by overseeing the blood test. And in Indonesia case, although it is relatively easy and cheap to take a blood test for the NCD indicators, however almost in entire examinations the result printed/written down in a piece of paper will be easily abandoned and forgotten. This is because this activity is not a routine scheduled of person. Thus, by depositing this typical data once the blood is tested directly by a person her/him self through personal gadget, the history of health condition ever the NCD symptoms can be monitored at the first place.

In this research, as the real time synchronisation between the data of the frontend devices (web and mobile) and the back end as a service needs to be supported by the accordance technology. We use Google firebase for this purpose. This is because the event handler feature that can be able to manage the real time database is the requirement in this particular system architecture. In other words, anytime there is a change in the data, this can be easily synchronised to the storage through the Application Program Interface (API) provided by the backend service. Once a person needs to see a GP for a consultation or in a particular case, the data of the person can be easily retrieved utilising the smart phone. Subsequently, the decision by a GP can be relatively easier to be assessed.

5.1. Evaluation technique

The essence of the developed artefact evaluation is as mentioned as Stage 3: *Design Evaluation* in Subsection 4.2 Research Stages. Once developed, the mHealth medical record should be evaluated at the first place. However, not only "*why"* and "*when"* but also "*what"* and "*how*" the evaluation of the work product needs to be undertaken [24]. The aim is nothing but to provide feedback for further development and ensure that the research is rigorously conducted. In this research, we follow descriptive and observational evaluation procedures as in Hevner *et al.* [11] and employ Venable *et al*. [34] for the guidelines to be able to answer these types of empirical questions.

5.2. Setting, participant and data collection technique

To allow the research to materialise, an initial discussion with the head of health office of the West Papua Province has been developed. This initiative is a crucial part in the mHealth research as: (1) they are the entities by which the mHealth is developed for. In other words, the development and evaluation cycles of the developed mHealth need a formal collaboration with all the health resources accordingly in the provincial level. As such, engaging them and increasing their awareness as early as possible of this research is urgently required; (2) among the major issues of mHealth research adoption widely today is due to the lack of support from the health authorities [17, 35]. Therefore, our initiative to engage with the health authoritative since the beginning of the research is aimed to mitigate among the factors hindering the mHealth development and adoption. Moreover, securing the support from the authority at the provincial level is also with the aim to mediate this research and the participants in particular in the evaluation stage. The participants are those who will be the target of the research and use the application. Both qualitative and quantitative will be collected from these participants as part of descriptive and observational evaluations [11]. These participants are as described in Table 1.

Table 2. Participants and data collection technique.

Data Collection Technique	Participants	Outcome	Participant number
Discussion	Head of Provincial Health Office	To collaborate	1

Data Collection Technique	Participants	Outcome	Participant number
Persons' records	Randomly selected	Obtaining the NCD data as described in this research	<=50
Focus Group Discussion	Senior healthcare employees	To get feedback for the development and evaluation procedures	<=5
Interview	GPs	To get feedback for the development and evaluation procedures	2-3

6. Discussion and conclusion

Currently, the initial prototype has been developed based on the system prototype described in Figure 1. Once development is finalised, the evaluation activities will be proceeded. First step is the evaluation of the efficacy of the developed prototype followed by the its effectivity preceding testing it in the real environment. This stage is crucial to ensure that the mHealth is developed as aimed for. Our initial collaboration with the health authority provides the support of the environments the research is developed and evaluated, particularly in the real setting. In term of the potential contribution, it is worth noting that this particular DSR project has a potential one for the known problem. In Gregor and Hevner [24]'s term, this is known as an *improvement*: develop a new solution for known problem. We also note that this technology-driven solution produced from the research can be generalised to be used in the different province with the same characteristics or for other types of NCDs other than the ones described in this research. However, in this stage, there are issues we concern that need to be mitigated: (1) data integrity. As we described earlier that the developed mHealth is essentially a personalised mobile tool to assist a person in the NCD criteria to deposit all the information regarding the diseases' indicators. Once that person needs to see a GP for a further examination, the data history can be easily retrieved for a decision making process. The issue is that, on the one hand, in this stage our system trusts that the data submitted by a person to be stored is a correct or final one. But there might be a possibility of incomplete data or the misinterpretation in decision making by a GP if otherwise. In other words, the human error as the nature one of human being might hinder the correct decision made by a GP as the stored data is inaccurate.

On the other hand, if the developed system is readjusted to allow a person to edit the data previously stored, then this poses the issue of data reliability. If this is the case, the decision of the health condition regarding the NCDs of a person, again, will be misjudged. As we concern to the issue, however, in this stage, we opt for trust to a person in submitting the data as the data stored in the system will assist in his/her health care. Nevertheless, this will be our concern to improve the mHealth being developed; (2) device integrity. As a matter of fact, our initial testing of blood examination using different brand devices in the clinics/pathologies and hospital return different results. This will definitely be our concern particularly in the evaluation procedure as it might lead to another calculation issue of the health NCD assessment.; (3) As we described earlier that the decision making process in this stage is still manual. In other words, whether the indicators deposited by a person leading to a particular symptom of an NCD type is still manually assessed by a GP. We envision that this could be, at a certain degree, automatically validated by a system. We view that although the system cannot conclude the exact type of the NCD of a person based on the indicators stored using the mHealth, however, at least the application is able to inform an early NCD symptom that person might be suffered from at the first place. And to evaluate this preliminary conclusion by the system, a further examination should be sought by that person.

As we discussed in the previous sections that this is an early research stage aimed to contribute to the NCDs in Indonesia, particularly in the West Papua Province. Completing the development stage and conducting the ex ante and ex post evaluations [34] are among the concerns that need to be followed up of the research. In addition, to what extent the usefulness of the developed artefact to combat the NCDs in that particular setting is another future research that need to be discerned. However, collaborating with the stakeholders of the research will be the first step leading to these.

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