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# **Introduction and Background**

World health organization (WHO) has identified hypertension as one of the most important risk factors for morbidity and mortality worldwide (Kitt et al., 2019). Hypertension affects an estimated 1.28 billion persons aged 30 to 79 worldwide, out of which more than nine million people die each year (Huang et al., 2019; Poudel et al., 2020) and the majority (two-thirds) of burden is in low- and middle-income countries (LMICs) (Dhungana et al., 2021). Among the noncommunicable diseases (NCDs), Hypertension (HTN) is regarded as a major global health issue (Adebayo et al., 2013; Pyakurel et al., 2019). Because of unfavourable health shifts from a preponderance of dietary deficiencies and infectious illnesses to chronic diseases such as cardiovascular disease (CVD), south Asian communities have seen a major change in their health over the previous several decades (Laar et al., 2021; Pyakurel et al., 2019).

Previous studies have shown that most people with hypertension are unaware of their condition (hypertension awareness); fewer people are on treatment, and only a small percentage of those who are on treatment have their blood pressure under control (Chow, 2013; Tobe et al., 2016). As the age grows, people intend to live more sedentary life (Dhungana et al., 2021; Pyakurel et al., 2019). Due to the accessibility of facilities and goods in urban areas (Dokunmu et al., 2018), people are more likely to develop hypertension due to a lack of physical activities (Whelton, 2015; Volpi at al., 2021). Also, HTN in community remain unknown as people measure their blood pressure only when they are sick or during a routine health check-up at a health facility (Dhungana et al., 2021; Peterse & Hempler, 2017).

Routine follow-up by health personnel has shown significant improvement in health outcomes worldwide (Adler et al., 2019; Piette et al., 2015; Poudel et al, 2020). Mobile Health interventions can be beneficial in managing non-communicable diseases (NCDs) and improving patient adherence to medicines (Adler et al, 2019; Volpi et al., 2021). Thus, this document will introduce a mobile application solution named “community hypertension management” application, built into free version of CommcareHQ (web platform for commcare) platform to manage hypertension in the urban and semi-urban communities of Nepal. The commcare software provides platform for developing android-based mobile applications in low-resource environments. Further, this application would help community health volunteers (CHVs) or community health workers (CHWs) to conduct household screening to find people with hypertension and conduct follow-ups of patients who are identified with hypertension. Also, the web version can be used by the health administers and planners to monitor the program. To develop and test the application, project [timeline](https://swanseauniversity-my.sharepoint.com/:x:/g/personal/2127642_swansea_ac_uk/ESofUIgudpZHsovj6dGvIroB4OYbah1I_gjHBqzT6GkDTA?e=Z4sKPI) was constructed and followed accordingly. The link to the application and user credentials can be found [here](https://swanseauniversity-my.sharepoint.com/:w:/g/personal/2127642_swansea_ac_uk/EXmB3A9Z5tpKm5DfCyS1PkABu6Q7Qi0hXZequBHADZrGcg?e=Wxf9Y1).

# **Problem statement**

Hypertension, which was thought to be non-existent, is now rapidly becoming a major public health problem among the populations of developing countries since the early seventies (Addo et al., 2006; Koju et al., 2010; Pyakurel et al., 2019). In the Nepalese context, the prevalence of hypertension, which was less than six percent in 1981, has been found to become around thirty percent in 2010 (Koju et al., 2010). Pyakurel et al. (2019) mentioned that one in every four people in an urban area of Nepal has had hypertension. The early detection of people who are at risk of developing hypertension is crucial for its management and prevention (Dokunmu et al., 2018). Hypertension is a silent killer (Tyson & McElduff, 2003), and most people are diagnosed with hypertension during hospital admission (Koju et al., 2010).

Despite the awareness against NCDs in education curriculum, radio, television, and social media, the prevalence of hypertension is increasing (Pyakurel et al., 2019) because people seem to be ignoring the risk of hypertension until they are sick or identified as having hypertension (Volpi et al., 2021; Whelton, 2015). Although the awareness level and health service accessibility are increasing in the urban and sub-urban areas of Nepal (Pyakurel et al., 2019), the prevalence of hypertension is still peaking (Koju et al., 2010; Poudel et al., 2020). The increase in prevalence could be due to rapid changes in the dietary pattern and lack of physical activity brought on by urbanisation and modernisation (Addo et al., 2006).

The use of available data in managing hypertension is crucial (Laar et al., 2021). Currently, in the Nepalese health sector, proper data recording and use of data in implementing health interventions are still lacking (Basnet et al., 2021; Huang et al., 2019). For immediate action and data-based planning, a reliable source of data is necessary (Citrin et al., 2018; Volpi et al., 2021). In this regard, mobile health interventions are providing a significant contribution to advancing medication adherence in hypertension (Xiong et al., 2018).

# **Rationale for choosing the solution**

There is a high prevalence of hypertension among the age groups of 40 and above in the communities of Nepal (Pyakurel et al., 2019; Rawal et al., 2020). Sedentary lifestyle (Poudel et al., 2020), dietary pattern, smoking, and alcohol consumption are the major identified risk factor for hypertension in urban and semi-urban communities (Bhadoria et al., 2014; Pyakurel et al., 2019). Treatment adherence for controlling hypertension is important (Laar et al., 2021; Xiong et al., 2018), however, people are hesitant of going to a health facility because of the distance and lack of availability of the family member who can take their elderly to regular health check-up (Vaidya et al., 2012).

Patients of hypertension require frequent encouragement, counselling, and reminders regarding lifestyle-related management of hypertension, and monitoring of blood pressure to enhance medication adherence (Kitt et al., 2019; Tobe et al., 2016; Whelton, 2015). In this context, the CHVs or CHWs in Nepal, visits home to support counselling, provide first aid services and support regular government health programs (Bhardwaj et al., 2010; Vaidya et al., 2012). The CHVs submit their report monthly in a paper-based format (Basnet et al., 2021). This process seems to be broken as it does not process data for the reminder to do follow-up visits.

A significant number of low and middle-income countries (LMICs) have implemented mHealth interventions on hypertension, and evidence so far suggests that programs are viable and may enhance medication adherence and disease outcomes (Duffy et al., 2020; Piette et al., 2015). Because poor treatment adherence raises disease complications and is marked by a lack of understanding and acceptance of continued treatment (Volpi et al., 2021). Thus, by fighting therapeutic methods with appealing solutions, mobile health apps can optimise the process and facilitate access to health information (Kitt et al., 2019; Li et al., 2020). Thus, a mobile application solution was chosen to develop for managing hypertension in the urban and semi-urban communities of Nepal. The application would support screening as well to do follow up visits by health personnel.

# **First cycle of application development**

## **Identifying testers**

The application is designed to be used by community health volunteers (CHVs) or community health workers (CHWs). For testing the application, health informaticians, community health nurses (CHNs), CHWs, and a doctor were chosen. Because Basnet et al. (2021), mentioned that CHVs showed an important role in counselling and assessing risk factors of ischemic strokes such as body mass index (BMI), screening of blood pressure, and management of diabetes through home blood glucose monitoring. Also, Alder et al., (2019); Citrin et al., (2018); Rawal et al., (2020) showed that community health nurses (CHNs) or CHWs can be involved in a variety of non-communicable diseases (NCDs) specific initiatives such as NCD screening, provisional diagnoses, health education and counselling, basic medication, and referrals. The doctor was chosen to validate the parameters of blood pressure as there involved a range of algorithms to assist with diagnosis, decision-making, and prediction (Park et al., 2021). In this application testing, health informaticians were selected to test the overall functionality and development of the application.

## **First design attempt**

There are two levels of users who use the application, the web users, and the mobile application users (as shown in figure 1). The CHVs or CHWs will be using the online/offline version of the application to screen and follow up on patients with hypertension in the community whereas the health program managers will use the web version to manage forms and extract data/reports to support real time data based decision making as well as they also develop list of patients for next follow-up visit (figure 2).

The CHVs or CHWs will do a hypertension screening of all 40 years and above population in their catchment area. During the screening visits, CHVs or CHWs will identify the person in hypertension medication, as well as the susceptible new case of hypertension. The person who is already identified with hypertension will be checked for medical adherence and the susceptible new case will be referred to the nearest hospital for a check-up. The CHVs will do follow-up visits every three months (or as planning of local health authority) to check medical compliance and adherence to the hypertension treatment.

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| Figure 1: Design workflow of community hypertension management appl in commcare  (*Image source: 1.* [*https://www.commcarehq.org/a/community-blood-pressure/dashboard/project/*](https://www.commcarehq.org/a/community-blood-pressure/dashboard/project/)) |

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| Figure 2: Community hypertension management application workflow in the community  (*Image source can be found* [*here*](https://swanseauniversity-my.sharepoint.com/:w:/g/personal/2127642_swansea_ac_uk/EaYvC3jfe_lChL9yXytDb9kBg-hu4X9Il7ZcnOBPG0-ajg?e=mk4Ywb)) |

The registration and follow-up forms are designed, considering demographics, and questions related to the measurement of blood pressure, symptoms of hypertension, and medications were selected (Tyson & Elduff, 2003; Volpi at al., 2021; Piette et al., 2015).

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| **Registration form** | **Follow up form** |
| Consent to enrol in the program | Are you on medication? |
| Client’s full name | Medication start date |
| Age | Do you take medicine every day? |
| Sex | Do you allow to measure your BP |
| House number | BP measurement |
| Contact number | Ask for symptoms |
| Do you allow to measure your BP | Message for referrals |
| BP measurement | Referral required? |
| Counselling | Counselling |

After developing the form in commcareHQ, the application was released to test how it works. Latest released version of the application was downloaded in the developer’s mobile phone using QR code, auto-generated by the commcareHQ form builder. The project “community hypertension management” was created and edited several times and released to check the functionality of the application (Petersen & Hempler, 2017). After testing the functionality of the application, the testers were informed to download and test the application on their mobile devices. User guides for downloading and using the application were sent via email while sharing the tester request email ([Appendix 1](https://swanseauniversity-my.sharepoint.com/:w:/g/personal/2127642_swansea_ac_uk/EYDxMSPXumZFg9WRhd9pVYkBc9gu7TxoEdOSPOLWsFRW8w)).

## **User feedback**

User feedbacks were collected in the form of email. Here are some of the images of the feedback received during first round of the application testing.

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| Figure 3: First cycle user feedback from the user A |

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| Figure 4: First cycle user feedback from the user F |

Also, some common feedback received from testers were solved and implemented in the application. Tester D suggested that “house number may not be relevant as in most of the municipalities, there is no provision of providing house number. You can use the electricity bill number, or the household number provided by the water and sanitation authority”. Similarly, tester E focused the consent saying, “first question on consent may not be required”, which was important because there is not point for starting the form if the consent to enrolment could not be made initially. Testers also requested to put audio or video file to counsel, and to remove some of the icons from the application, however this could not be attended because the available Commcare platform do not support interface change in the free version. After receiving feedback from the testers, developer notified testers regarding the unattended feedback via email (Appendix 14).

## **Reflection**

During the first cycle of app development, the activities such as project initiation, planning, requirement collection, project layout, testing, deployment, and maintenance were used to accurately complete the design and growth of the android mobile application. These activities were organised into different categories, and time was allotted for each task based on the complexity and activities involved in each step. However, during the first cycle of testing, I ran into a few major roadblocks that kept me blocking from progressing and I had to come up with a rapid solution for them.

The first issue I encountered was by using the variable, household (HH) number in the registration form. The idea of putting HH numbers was taken from the source where the variable was relevant to obtain. However, in the context of Nepal, the unique house number is still not provided by the government. In this regard, I did not have thought it would be such a big issue. According to my app testers, a unique household number is important as it could be used to identify the distinct patient during follow-up visits. Later, I did some research on the household number in Nepal and found there is no provision for such numbers. However, some organizations, have created them for their interventional project (Citrin et al., 2018). Since it would take lots of time and cost to create and provide household numbers in the community, according to the tester’s suggestion, I rather used the electricity bill number as a household number because it is also a uniquely assigned number and is provided by the national electricity authority.

Using advanced MS excel functions as a code for algorithms was another problem, I faced during the first cycle of application development. Commcare uses MS excel functions as a code to build algorithms and automation in its forms. As I did not have training or knowledge of advanced MS excel functions before, I struggled to understand the available codes in commcare confluence (a web-based wiki). During application development, I went through the Comcare confluence, and MS excel tutorials on youtube to modify the forms and make them as informative as I can. However, the knowledge gained in MS excel functions for the application became useful to build the automated project timetable in MS excel, which I built previously in MS word.

Because of the focus I made only on the Commcare platform availability and accessibility, I underestimated the usability of the application. After sending request to test the application, one of the testers let me know that the Commcare does not work in IOS system. Since I already had sent the request template, I could not change the request template however, I have confirmed that the application could not work in the IOS system to the other testers through an email and requested them to use android devices only ([Appendix 3](https://swanseauniversity-my.sharepoint.com/:w:/g/personal/2127642_swansea_ac_uk/EbTG1rWM15pKusQAJuHBbGYBLMd6As13pJ6zHq1jsHagGw?e=pUfFjq)). By that time, I almost was in halfway to the project timeline and I could not afford to find another platform to work from the beginning. So, I opted to do thorough research from next time on what I work and do not harm anybody’s time due to my mistake.

## **Changes made**

Based on the user feedback (see [Appendix](https://swanseauniversity-my.sharepoint.com/:w:/g/personal/2127642_swansea_ac_uk/ESjVQ49-wCNNnPhP7zGaNvwBLETUQNxHxpe_v_eMcq-qSA)), the following changes have been made.

1. The first question regarding consent for enrolling people in the program is removed. Consent to enrol in the program can be taken verbally and the application can only be started when verbal consent is obtained.
2. The tags named “End of form” and “Press- Finish " to submit data” were removed. Instead, a message regarding counselling is placed at the end of the form.
3. To address the error in displaying the pre-hypertensive stage, the backend formula as the display condition is edited and the application is now able to show the pre-hypertensive stage.
4. The question, “do you allow to measure your BP” is changed to “Do you consent to measure your blood pressure?”.
5. The word “Person” is chosen instead of using the word “Client”.
6. Two options, Symptoms other than those mentioned above and No symptoms of HTN are added to the question “Ask patients if they are experiencing symptoms”.
7. To address the relevance of the context, the question regarding house number is changed to “House number (Customer number in electricity bill)”
8. Two questions regarding physical activity are added.

# **Second cycle of application development**

## **Second design attempt**

After the application is modified according to the feedback received from the first cycle of development, the updated version was published in CommcareHQ, and the same testers from the first cycle were notified again to test the application through an email message ([Appendix 15](https://swanseauniversity-my.sharepoint.com/:w:/g/personal/2127642_swansea_ac_uk/EbfECI5kp2RApnow-wWjoSUB2zTiVif9pi2_cNFckmB1Pg)).Changesidentified in the first cycle of development were deployed in the application and the following list of questions was identified to keep in an updated version of the application.

|  |  |
| --- | --- |
| **Registration form** | **Follow up form** |
| Consent to enrol in the program | Are you on medication for HTN? |
| Person’s full name is | Medication start date |
| Age | Do you take medicine every day? |
| Sex | Do you consent to measure your blood pressure? |
| Are you on hypertension medication? | BP measurement |
| House number/ Electricity bill number | Ask patient if they are experiencing symptoms like; |
| Contact number | Mention the other symptom |
| Do you consent to measure your blood pressure? | Do you perform exercise? |
| BP measurement | What do you do for your exercise? |
| Counselling | Referral required? |
|  | Mention the name of the referred health facility |
|  | Counselling |

## **Users feedback**

Most of the testers in the second round of testing seem to be satisfied with the changes made. However, some testers suggested some minor changes that would make a huge impact on the final version of the application. Here are some of the images of the feedback received during second round of the application testing.

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| Figure 5: Second cycle feedback from tester J |

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| Graphical user interface, text, application, email  Description automatically generated |
| Figure 6: Second cycle feedback from tester G |

It was important to work on the unique identifier in follow up form, as tester E mentioned “However, you can still work on creating a list containing at least one unique identified in follow-

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| Graphical user interface, application  Description automatically generated |
| Figure 7: Follow up patient list |

up form to select the unique client. This would help users to select a unique client when there is a chance of registering clients with the same name and age. As you know, some common names are used widely in the Nepalese Context.” Similarly, tester G also focused on the unique identifier,

“As in the conversation we discussed, I would still suggest putting some unique identifiers in the follow-up form to identify the particular patient.” The concern with the identifier in follow up form (as shown in figure 7) is the possibility of encountering with the same name of the person with same age. Tester D suggested to put referral place, where the person would be referred, and the tester J emphasized on the change in user interface. Both the testers put importance on user experience while using application.

## **Reflection**

In the second cycle of testing, I again tried to incorporate all the ideas suggested by the testers. I received few suggestions to improvise the application in this cycle. However, the changes identified were challenging to achieve.

Testers suggested changing the user interface. Regarding the user interface, I would not be able to modify the interface of the application because it is the default interface provided by the Commcare application developers. Since the commcare mobile application is used by the community-level health workers in most of the LMICs for health and care delivery. I used the interface, which is tested, simple, and would be useful in the same way because the application is designed to be used by CHVs or CHWs, who are working at the ground level of health service delivery and are not very technology friendly. Also, there are limitations in using free version of the application.

I felt challenged in making the patient list unique in follow-up form. In the first cycle of development, the patient’s name and age were kept identifying the particular patient to be followed up. However, according to the testers, just the patient’s name and age cannot be the unique variables to identify a particular patient. There may be the same name of patients with the same age, in the community. So, I tried to add a variable as a contact number in the case list (containing name and age) because each person has a unique ten digits contact/phone number otherwise, contact number of other family member could also be used. Since I used the free version of the application, I am not able to add one more variable to the case list. However, the process has let me know the importance of a unique identifier in selecting a particular patient during follow-up visit. Also, I would be able to add the case list when using the premium version of the application.

## **Changes made**

In the second cycle of application development, free text question regarding the place/ institution name was added to record the place of referral. However, the other changes suggested by the testers in this cycle could not be attended due to the free version of the Commcare application.

After the tester feedback and correction of the application forms, the application is perfectly in working condition and is ready to use. The testers were notified to update their application to see the final product version of the application (Appendix 26).

Mobile phone and web user guide can be found [here](https://swanseauniversity-my.sharepoint.com/:w:/g/personal/2127642_swansea_ac_uk/EZRRl1dygn5LhlfJBDxZgOgB01Eq2Mg_NfC6h0aWdQqZcQ?e=Mrv94o). Though the application only supports android devices, one can test mobile phone interface provided in web version (please follow user guide).

# **Conclusion**

Commcare mobile application introduced in this document is a free software, being used in LMICs to monitor and control health-related problems. So, the commcare platform was chosen, as an application to manage hypertension in the urban and semi-urban populations of Nepal. In few decades, there has been a significant rise in hypertension cases in the urban and semi-urban communities of Nepal. The application “community hypertension management” is supposed to be used by CHVs/CHWs, who will do the screening as well as follow-up of the people identified with hypertension.

During the application building process, most of the pieces of information related to the development were collected from the commcare official site. Since commcare supports Ms excel functions as a code to build algorithms in the forms, it was easy to understand and put mathematical calculations in the forms. Testers were asked for testing the application and provide feedback in two consecutive design cycles. Testers had shown a participatory interest in building and modifying the application, which helped to understand the local context as well as the standard procedures to follow in managing hypertension.

The application building process has also faced several constraints in both the cycles of development. The developer could not address all the tester’s suggestions because, most of the constraints were not fulfilled because of using the free versions application. However, the final product is still able to help CHVs/CHWs in the screening and follow-up of the people for hypertension in urban and semi-urban areas of Nepal. Also, the application is able to record real-time data for the health administrators and planners to use data in decision making.

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# [**Appendices**](https://swanseauniversity-my.sharepoint.com/:w:/g/personal/2127642_swansea_ac_uk/ESjVQ49-wCNNnPhP7zGaNvwBLETUQNxHxpe_v_eMcq-qSA?e=fJIrBe)