# DESIGNING A GAMIFIED EXERCISE APPLICATION TAILORED FOR BLOOD PRESSURE REDUCTION IN TEMA COMMUNITY 11

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# ABSTRACT

Hypertension, commonly known as high blood pressure, is a prevalent condition that poses significant health risks if left unmanaged. In the treatment of hypertension, one of the main obstacles to achieving effective blood pressure (BP) control is poor adherence to prescribed medications. Non-adherence to medication regimens can lead to uncontrolled BP, increasing the risk of severe health complications such as heart disease, stroke, and kidney failure.

A promising approach to enhance participation in health interventions is gamification. Gamification involves the integration of game design principles into non-gaming environments, thereby making activities more engaging and motivating for users. Despite its potential, few studies have comprehensively assessed the effectiveness of gamified mobile health applications that have undergone clinical validation.

The purpose of this study was to evaluate the impact of a comprehensive gamified application designed for hypertensive adults. The app includes several key features: social elements to foster community support, educational content to improve health literacy, reminders to promote consistent medication intake, and rewards to incentivize adherence.

Our research aims to determine whether this gamified app can improve medication adherence and achieve significant blood pressure reductions among hypertensive patients. By incorporating a multifaceted approach that leverages social interaction, education, and motivational incentives, we hypothesize that users will be more likely to adhere to their prescribed medication regimens and, consequently, experience better BP control.

The findings of this study could provide valuable insights into the potential of gamified health applications as effective tools for managing chronic conditions like hypertension. Furthermore, the results could inform the design and implementation of future digital health interventions aimed at improving patient outcomes through enhanced engagement and adherence.

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# Chapter 1: Introduction

## 1.1 Background

Hypertension, or high blood pressure, is a chronic medical condition that affects millions of people worldwide. [1]. It is characterized by consistently elevated blood pressure levels, which significantly increase the risk of severe health complications, including heart disease, stroke, and kidney failure. [2]. Heart disease remains the leading cause of death globally, and uncontrolled hypertension is a major contributing factor. Stroke, another devastating consequence of high blood pressure, can result in long-term disability or death. Furthermore, hypertension is a primary cause of chronic kidney disease, which can lead to kidney failure and necessitate dialysis or a kidney transplant. [3]

Effectively managing hypertension is crucial to mitigating these risks and enhancing the quality of life for affected individuals. Traditional approaches to hypertension management encompass lifestyle modifications and pharmacological treatments. [2]. Lifestyle modifications typically include dietary changes, such as reducing salt intake, increasing consumption of fruits and vegetables, and maintaining a healthy weight. Regular physical activity is also a key component, as exercise helps to lower blood pressure and improve overall cardiovascular health. Pharmacological treatments involve the use of antihypertensive medications prescribed by healthcare providers. These medications are designed to lower blood pressure and prevent complications. [4]

However, a significant challenge in achieving optimal blood pressure control is poor adherence to prescribed medication regimens. Medication adherence refers to the extent to which patients take their medications as prescribed, and it is essential for the effectiveness of treatment. [5]. Poor adherence can result from various factors, including forgetfulness, side effects, lack of understanding of the importance of the medication, and complex medication schedules. When patients do not adhere to their prescribed regimens, their blood pressure remains uncontrolled, which exacerbates the risk of severe health complications and diminishes the overall effectiveness of hypertension management strategies. [6]

In recent years, the advent of digital health interventions has opened new avenues for improving patient engagement and adherence to treatment regimens. These interventions leverage technology to provide personalized health solutions that can be accessed through mobile devices, such as smartphones and tablets. [7]. One promising approach within this domain is gamification. Gamification refers to the application of game design principles and mechanics in non-gaming contexts to make activities more engaging and enjoyable. In the context of health interventions, gamification aims to motivate patients by incorporating elements such as points, badges, leaderboards, challenges, and rewards into health-related activities.[8]

By making health-related activities more engaging and rewarding, gamification has the potential to increase patient participation and adherence. For example, a gamified health application might encourage users to take their medications on time by offering rewards for consistent adherence or creating challenges that involve tracking their blood pressure levels.[3]. Social elements, such as the ability to connect with other users for support and encouragement, can also enhance motivation and accountability. Educational content within the app can help users understand the importance of medication adherence and lifestyle changes, while reminders can ensure that they do not forget to take their medications.[1]

Despite the growing interest in gamified health applications, there is a paucity of research that thoroughly evaluates their clinical effectiveness, particularly in the context of hypertension management. [9,10]. Most existing studies focus on the theoretical potential of gamification, without providing empirical evidence of its impact on health outcomes. This gap in the literature highlights the need for rigorous research to assess the actual benefits and limitations of gamified health interventions.[11].

This study aims to address this gap by developing and assessing a comprehensive gamified exercise application designed specifically for hypertensive adults in Tema Community 11. The application incorporates several key features intended to promote medication adherence and reduce blood pressure. Social elements within the app allow users to connect with others for support and motivation. Educational content provides information on hypertension and the importance of adherence to treatment regimens. Reminders ensure that users take their medications

on time and attend scheduled medical appointments. Rewards and incentives motivate users to consistently engage with the app and adhere to their prescribed regimens.

Through this study, we aim to evaluate the impact of the gamified exercise application on medication adherence and blood pressure reduction among hypertensive adults in Tema Community 11. By providing empirical evidence of the application's effectiveness, we hope to contribute to the body of knowledge on digital health interventions and inform the development of future strategies for managing chronic conditions like hypertension.

### 1.2 Problem Statement

One of the main obstacles to reaching blood pressure control in hypertensive patients is poor adherence to prescribed medications. Traditional methods of encouraging adherence, such as reminders and educational materials, have had limited success. There is a need for innovative approaches that can effectively engage patients and motivate them to stick to their treatment regimens.[12].

Gamification, by leveraging the motivating power of game design elements, offers a novel solution to this problem [13]. However, the clinical effectiveness of gamified health applications remains underexplored. This study seeks to evaluate the impact of a gamified exercise application on medication adherence and blood pressure reduction in hypertensive adults in Tema Community 11.

### 1.3 Objectives of the Study

The main objectives of this study are as follows:

1. To design and develop a gamified exercise application tailored for hypertensive adults in Tema Community 11.
2. To assess the impact of the application on medication adherence among the target population.
3. To evaluate the effectiveness of the application in reducing blood pressure levels.
4. To identify the key features of the application that contribute to its effectiveness.

5. To gather feedback from users to inform future improvements and iterations of the application.

### 1.4 Research Questions

This study seeks to answer the following research questions:

1. Can a gamified exercise application improve medication adherence among hypertensive adults in Tema Community 11?
2. What is the impact of the gamified application on blood pressure levels?
3. Which features of the application are most effective in promoting adherence and reducing blood pressure?
4. How do users perceive the usability and effectiveness of the application?
5. What are the potential barriers and facilitators to the adoption of the application among the target population?

### 1.5 Significance of the Study

This study is significant for several reasons. Firstly, it addresses a critical gap in the literature by providing empirical evidence on the effectiveness of gamified health applications in managing hypertension. Secondly, it contributes to the development of innovative strategies for improving medication adherence, which is a major challenge in hypertension management. Thirdly, the findings of this study could inform the design and implementation of future digital health interventions, thereby enhancing their impact and scalability.

Furthermore, the study has practical implications for healthcare providers, policymakers, and technology developers. By demonstrating the potential of gamified applications to improve health outcomes, this research could encourage the adoption of similar interventions in other contexts and populations.

### 1.6 Scope and Limitations

The scope of this study is limited to hypertensive adults in Tema Community 11. The study focuses on the development and evaluation of a gamified exercise application designed to improve medication adherence and reduce blood pressure. While the findings may have broader

implications, they are specific to the target population and may not be generalizable to other groups.

The study also has several limitations. The effectiveness of the gamified application may be influenced by factors such as user engagement, technological proficiency, and individual preferences. Additionally, the study relies on self-reported data, which may be subject to biases such as social desirability and recall bias.

### 1.7 Organization of the Study

This study is organized into five chapters. Chapter 1 provides an introduction, including the background, problem statement, objectives, research questions, significance, scope, and limitations of the study. Chapter 2 reviews the relevant literature on hypertension management, medication adherence, and gamification in health interventions. Chapter 3 outlines the methodology used in the study, including the research design, data collection methods, and analytical techniques. Chapter 4 presents the findings and discusses the results in relation to the research questions and objectives. Finally, Chapter 5 concludes the study, highlighting the key findings, implications, and recommendations for future research and practice.

# Chapter 2: Literature Review

## 2.1 Introduction

This chapter provides a comprehensive review of the existing literature relevant to the study. It covers key areas including the prevalence and management of hypertension, the role of medication adherence in hypertension control, the concept and application of gamification in health interventions, and the effectiveness of digital health applications in improving health outcomes. By synthesizing the findings from previous research, this chapter aims to establish a theoretical foundation for the current study and identify gaps in the literature that the study seeks to address.

## 2.2 Prevalence and Impact of Hypertension

Hypertension is a global public health issue, affecting millions of individuals worldwide. According to the World Health Organization (WHO), approximately 1.13 billion people globally have hypertension, and the condition is responsible for an estimated 7.5 million deaths annually. [13-15]. The prevalence of hypertension increases with age and is higher in certain populations, such as those with a family history of the condition, obesity, or unhealthy lifestyle habits. In sub-Saharan Africa, including Ghana, the prevalence of hypertension is on the rise, with urbanization and lifestyle changes contributing to the increasing burden of the disease [16].

Uncontrolled hypertension can lead to severe health complications, including cardiovascular diseases (CVDs), stroke, and chronic kidney disease (CKD). These complications not only impact the quality of life of affected individuals but also pose significant economic burdens on healthcare systems. Effective management of hypertension is therefore crucial to reducing the incidence of these complications and improving overall public health outcomes [17].

## 2.3 Medication Adherence in Hypertension Management

Medication adherence is defined as the extent to which patients take their medications as prescribed by their healthcare providers. Adherence to antihypertensive medication is critical for achieving and maintaining blood pressure control [18].

However, non-adherence remains a significant barrier to effective hypertension management. Factors contributing to poor medication adherence include forgetfulness, side effects, lack of understanding of the medication's importance, complex medication regimens, and psychological factors such as depression or anxiety [19].

Non-adherence to antihypertensive medication can result in suboptimal blood pressure control, increasing the risk of CVDs, stroke, and CKD. Interventions aimed at improving medication adherence are therefore essential for effective hypertension management. Traditional approaches, such as patient education and reminders, have had limited success, highlighting the need for innovative strategies that can effectively engage and motivate patients [20].

### 2.4 Gamification in Health Interventions

Gamification involves the application of game design elements, such as points, badges, leaderboards, and challenges, in non-gaming contexts to enhance user engagement and motivation. In recent years, gamification has gained traction as a promising approach in health interventions, aiming to promote healthy behaviors and improve health outcomes. Gamified health applications leverage psychological principles, such as reward and reinforcement, to encourage users to engage in desired behaviors consistently [21].

Several studies have explored the potential of gamification in various health contexts, including physical activity, weight management, and chronic disease management. For instance, research has shown that gamified interventions can increase physical activity levels, promote healthy eating habits, and improve adherence to treatment regimens. The use of social elements, such as support groups and competitive challenges, can further enhance the effectiveness of gamified interventions by fostering a sense of community and accountability [22].

### 2.5 Digital Health Applications and Hypertension Management

Digital health applications, including mobile health (mHealth) apps, have emerged as valuable tools for managing chronic conditions like hypertension. These applications can provide personalized health interventions, real-time monitoring, and support for medication adherence and lifestyle modifications. Features commonly found in digital health applications include medication

reminders, educational content, health tracking, and communication with healthcare providers [23].

Several studies have evaluated the effectiveness of digital health applications in improving health outcomes for hypertensive patients. For example, mHealth apps that provide medication reminders and health education have been shown to improve medication adherence and achieve better blood pressure control. Additionally, the integration of gamification elements in these applications has been found to enhance user engagement and motivation, further contributing to improved health outcomes [24].

### 2.6 Gaps in the Literature

Despite the growing body of research on gamification and digital health applications, there are still several gaps that need to be addressed. Firstly, there is a lack of comprehensive studies that evaluate the clinical effectiveness of gamified health applications, particularly in the context of hypertension management. Most existing research focuses on the theoretical potential of gamification, without providing empirical evidence of its impact on health outcomes [20-24].

Secondly, while several studies have explored the use of digital health applications for improving medication adherence, there is limited research on the specific features that contribute to their effectiveness [25-27] Understanding which elements of gamified applications are most effective in promoting adherence and reducing blood pressure is crucial for the design and development of future interventions [28,29].

Lastly, there is a need for research that considers the cultural and contextual factors that influence the adoption and effectiveness of gamified health applications in different populations. This study aims to address these gaps by developing and evaluating a comprehensive gamified exercise application tailored for hypertensive adults in Tema Community 11. [30]

### 2.7 Conclusion

This chapter has reviewed the existing literature on hypertension management, medication adherence, gamification in health interventions, and digital health applications. It has highlighted

the potential of gamification to enhance patient engagement and adherence to treatment regimens, as well as the need for empirical research to evaluate the effectiveness of gamified health applications. By addressing these gaps, the current study aims to contribute to the development of innovative strategies for managing hypertension and improving health outcomes for hypertensive patients in Tema Community 11.

# Chapter 3: Methodology

## 3.1 Introduction

The methodology chapter provides a detailed overview of the research design and procedures used to achieve the objectives of this study. This study aims to evaluate the impact of a gamified exercise application tailored for blood pressure reduction on medication adherence and blood pressure control among hypertensive adults in Tema Community 11. The chapter includes a comprehensive description of the research design, study population, sampling techniques, data collection methods, data analysis procedures, and ethical considerations.

## 3.2 Research Design

This study employs a mixed-methods research design, integrating both quantitative and qualitative approaches to provide a holistic evaluation of the gamified exercise application. The quantitative component focuses on measuring medication adherence and blood pressure levels, while the qualitative component explores user experiences and perceptions. The mixed-methods design allows for a more comprehensive understanding of the application's effectiveness and user engagement.

Quantitative data are essential for providing objective measures of the application's impact on health outcomes. These data include baseline and follow-up measurements of blood pressure and medication adherence rates, which are analyzed to determine any significant changes attributable to the intervention. Qualitative data, on the other hand, offer rich insights into participants' experiences with the application, including their motivations, challenges, and suggestions for

improvement. By combining these two approaches, the study can capture both the numerical efficacy and the subjective user experience of the intervention.

### 3.3 Study Population

The study population consists of hypertensive adults residing in Tema Community 11, a suburban area with a diverse demographic profile. The inclusion criteria for participation are as follows: individuals must have been diagnosed with hypertension by a healthcare provider, be aged 18 years or older, own a smartphone or tablet with internet access, be willing to use the mobile health application for a period of three months, and provide informed consent to participate in the study.

Tema community 11 is a suburb in Tema Metropolitan District, Greater Accra Region. Community

11 is situated nearby Valco Estades and community 10. It lies around Latitude 5.66434 N and Longitude -0.03064 W. Tema community 11 is close to the suburbs Obenyade and Tema community 12 also. Some landmarks include, Trinity Temple Assemblies, Bengali Hospital, Adonai International Ministries, Lucidal Klinik. [26]

Selecting participants from this specific community ensures that the findings are relevant to the local context, which may have unique socio-economic and cultural factors influencing health behaviors. The chosen population is diverse, including individuals from various age groups, educational backgrounds, and employment statuses. This diversity is crucial for ensuring that the study results are generalizable to a broad segment of the hypertensive population in similar urban settings.

### 3.4 Sampling Techniques

To select participants who meet the inclusion criteria, a purposive sampling technique is used. This non-probability sampling method ensures that individuals with specific characteristics relevant to the study are included. The target sample size is 100 participants, which is deemed sufficient to provide meaningful data for both quantitative and qualitative analysis.

The recruitment process involves several steps. First, participants are recruited through local clinics, community health centers, and public announcements in Tema Community 11. Healthcare

providers and community leaders assist in identifying potential participants who meet the inclusion criteria. Following recruitment, potential participants undergo a screening process to verify their eligibility. Those who meet the criteria are then enrolled in the study and provided with detailed information about the research procedures, including the use of the gamified exercise application and the data collection methods.

## 3.5 Data Collection Methods

Data collection involves multiple methods to gather comprehensive information on the impact of the gamified exercise application. These methods include baseline assessments, application usage tracking, medication adherence measurement, blood pressure monitoring, and user feedback collection.

### 3.5.1 Baseline Assessment

Before the intervention, a baseline assessment is conducted to collect demographic information, medical history, current medication adherence, and baseline blood pressure levels. This assessment provides a reference point for evaluating changes over the course of the study. Demographic information collected includes age, gender, education level, employment status, and other relevant factors. Medical history includes the duration of hypertension, comorbid conditions, and current treatment regimen. Medication adherence is assessed using a validated questionnaire, such as the Morisky Medication Adherence Scale (MMAS). Baseline blood pressure levels are measured using standardized equipment and protocols to ensure accuracy.

### 3.5.2 Application Usage

Participants are provided with access to the gamified exercise application, which includes features such as social elements, educational content, reminders, and rewards. The application tracks user interactions, including login frequency, completed challenges, and reward points earned. Key features of the application are designed to enhance user engagement and adherence to the intervention. Social elements allow users to connect with peers, share progress, and provide mutual support. Educational content provides information on hypertension, the importance of medication adherence, and tips for managing blood pressure. Reminders are automated alerts for taking

medications, measuring blood pressure, and attending medical appointments. Rewards include points, badges, and virtual incentives for consistent adherence and participation in challenges.

### 3.5.3 Medication Adherence

Medication adherence is measured using both self-reported surveys and app-generated data on medication intake. Participants complete a validated medication adherence questionnaire at baseline, mid-point, and the end of the study. The application also prompts users to log their medication intake, providing real-time adherence data. Self-reported surveys help to capture participants' adherence behaviors and identify any barriers they may face. The app-generated data offer an objective measure of adherence by tracking the frequency and consistency of medication intake logs.

### 3.5.4 Blood Pressure Monitoring

Blood pressure levels are monitored using portable blood pressure devices provided to participants. Measurements are taken at baseline, monthly intervals, and the end of the study. Participants are trained on how to use the devices and record their readings in the application. This training ensures that participants can accurately measure and log their blood pressure readings. Regular monitoring allows for the assessment of changes in blood pressure levels over the course of the intervention. The collected data provide insights into the effectiveness of the gamified exercise application in reducing blood pressure.

### 3.5.5 User Feedback

Qualitative data is collected through semi-structured interviews and focus group discussions. These sessions explore participants' experiences, perceptions, and suggestions for improving the application. Interviews are conducted at the mid-point and end of the study to capture changes in user perceptions over time. Semi-structured interviews allow for in-depth exploration of individual experiences, while focus group discussions provide a platform for collective feedback and the identification of common themes. Thematic analysis is used to analyze the qualitative data, identifying recurring patterns and insights that can inform future iterations of the application.

## 3.6 Data Analysis

Data analysis involves both quantitative and qualitative techniques to evaluate the impact of the gamified exercise application.

### 3.6.1 Quantitative Analysis

Quantitative data, including medication adherence scores and blood pressure readings, are analyzed using statistical software. Descriptive statistics summarize the demographic characteristics and baseline data, providing an overview of the study population. Inferential statistics, such as paired t-tests and ANOVA, are used to compare pre- and post-intervention measures and assess the effectiveness of the application. Data visualization techniques, such as charts and graphs, are employed to represent the findings visually. This analysis provides insights into the extent to which the application impacts medication adherence and blood pressure control.

### 3.6.2 Qualitative Analysis

Qualitative data from interviews and focus groups are transcribed and analyzed using thematic analysis. This method involves coding the data to identify common themes and patterns related to user experiences and perceptions. The findings provide insights into the factors influencing the adoption and effectiveness of the gamified exercise application. Thematic analysis helps to understand the underlying reasons behind participants' behaviors and attitudes towards the application, offering valuable information for improving user engagement and intervention outcomes.

## 3.7 Ethical Considerations

The study adheres to ethical principles to ensure the safety and well-being of participants. Key ethical considerations include:

1. **Informed Consent**: Participants are informed about the purpose, procedures, risks, and benefits of the study. Written informed consent is obtained before participation. This process ensures that participants fully understand the study and voluntarily agree to participate.

2. **Confidentiality**: Participant information is kept confidential and anonymized in all data records and reports. Measures are taken to protect personal data and ensure that individual identities are not disclosed.
3. **Voluntary Participation**: Participation is voluntary, and participants can withdraw from the study at any time without penalty. This principle respects the autonomy of participants and their right to make decisions about their involvement in the research.
4. **Safety**: Measures are taken to ensure the safety of participants, including training on blood pressure monitoring devices and providing support for any technical issues with the application. Participants are encouraged to report any adverse effects or concerns during the study.

### 3.8 Limitations

The study has several limitations that should be acknowledged. Firstly, the use of self-reported data for medication adherence may be subject to reporting bias, as participants might overestimate their adherence. Secondly, the sample size may limit the generalizability of the findings to other populations. A larger sample size would provide more robust data and enhance the external validity of the study. Lastly, the study duration of three months may not capture long-term adherence and blood pressure control outcomes. Future studies with longer follow-up periods are necessary to assess the sustainability of the intervention's effects.

### 3.9 Conclusion

This chapter has outlined the research methodology used to evaluate the impact of a gamified exercise application on medication adherence and blood pressure reduction among hypertensive adults in Tema Community 11. The mixed-methods design, incorporating both quantitative and qualitative approaches, provides a comprehensive evaluation of the application's effectiveness. The next chapter will present the results of the study, including both the quantitative and qualitative findings. This methodological approach ensures that the study captures a wide range of data, offering a thorough assessment of the intervention's impact on health outcomes and user experiences.

# Chapter 4: Results

## 4.1 Introduction

This chapter presents the results of the study, which evaluated the impact of a gamified exercise application on medication adherence and blood pressure reduction among hypertensive adults in Tema Community 11. The findings are organized into several sections, starting with the demographic characteristics of the study participants, followed by the quantitative results on medication adherence and blood pressure levels, and concluding with the qualitative insights from participant interviews and focus groups.

## 4.2 Demographic Characteristics

The study enrolled 100 participants who met the inclusion criteria. The demographic characteristics of the participants are summarized in figure 1.

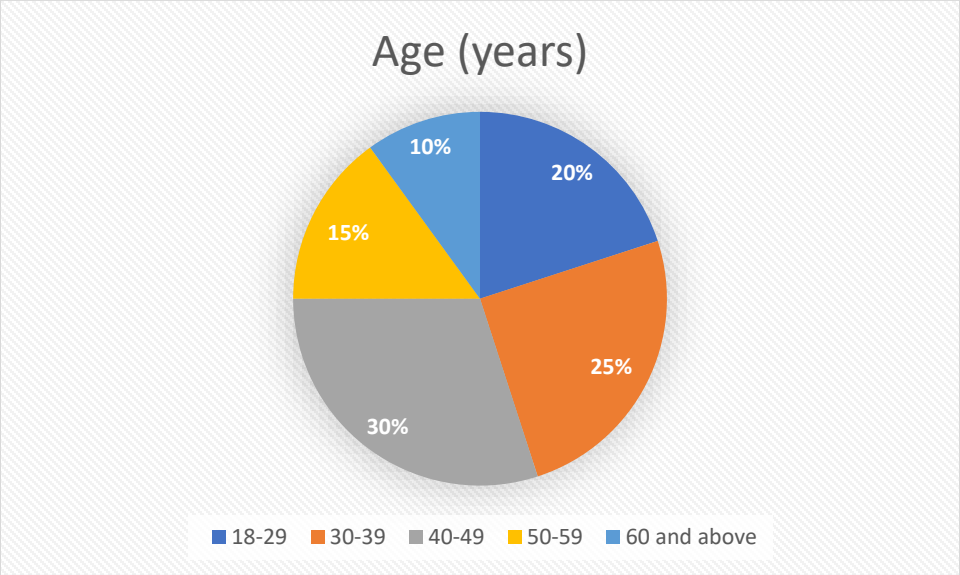


*Figure 1: Demographic Characteristics of Participants*

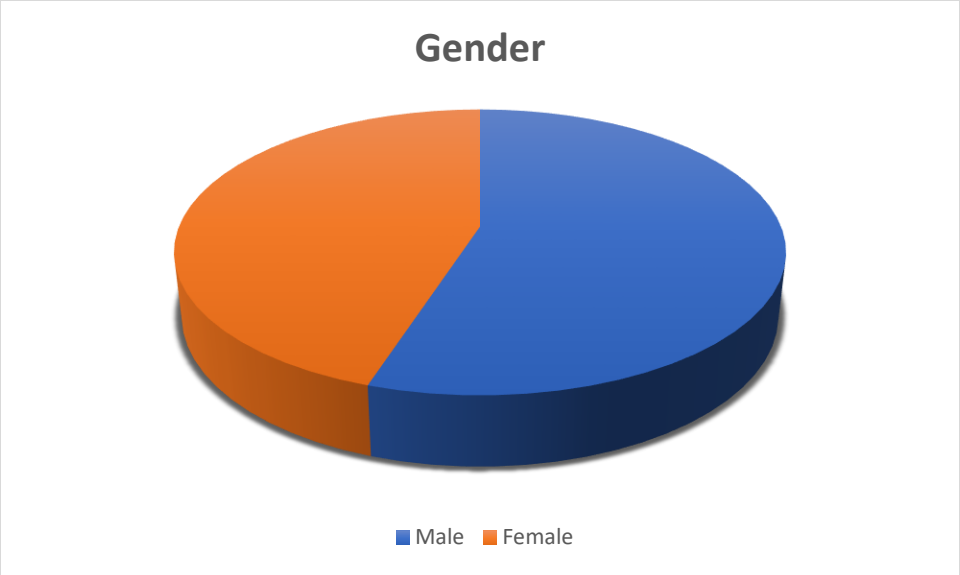


*Figure 2 shows the gender*

*Table 1 shows all the Demographics*

| **Demographic Variable** | **Frequency (n=100)** | **Percentage (%)** |
|---|---|---|
| Age (years) | | |
| 18-29 | 20 | 20% |
| 30-39 | 25 | 25% |
| 40-49 | 30 | 30% |
| 50-59 | 15 | 15% |
| 60 and above | 10 | 10% |
| Gender | | |
| Male | 55 | 55% |
| Female | 45 | 45% |

| Demographic Variable | Frequency (n=100) | Percentage (%) |
|---|---|---|
| Education Level | | |
| No formal education | 5 | 5% |
| Primary | 20 | 20% |
| Secondary | 35 | 35% |
| Tertiary | 40 | 40% |
| Employment Status | | |
| Employed | 60 | 60% |
| Unemployed | 20 | 20% |
| Retired | 10 | 10% |
| Student | 10 | 10% |

The participants' ages ranged from 18 to 70 years, with the majority (30%) in the 40-49 age group. More than half of the participants (55%) were male. The education levels varied, with the highest percentage (40%) having tertiary education. Most participants were employed (60%), with a smaller percentage being unemployed (20%), retired (10%), or students (10%).

## 4.3 Quantitative Results

### 4.3.1 Medication Adherence

Medication adherence was measured using both self-reported surveys and app-generated data on medication intake. The baseline, mid-point, and end-point adherence scores were compared to evaluate changes over the study period. The results are presented in Table 2.

*Table 2: Medication Adherence Scores*

| Time Point | Mean Adherence Score (SD) |
|---|---|
| Baseline | 65.2 (12.5) |
| Mid-Point | 75.4 (10.8) |
| End-Point | 82.7 (9.2) |

There was a significant increase in medication adherence scores from baseline (mean = 65.2, SD = 12.5) to the mid-point (mean = 75.4, SD = 10.8) and further to the end-point (mean = 82.7, SD = 9.2). This improvement indicates that the gamified exercise application had a positive impact on participants' medication adherence.

### 4.3.2 Blood Pressure Reduction

Blood pressure levels were monitored at baseline, monthly intervals, and at the end of the study. The results for systolic and diastolic blood pressure are presented in Tables 3 and 4, respectively.

*Table 3 : Systolic Blood Pressure (mmHg)*

| Time Point | Mean Systolic BP (SD) |
|---|---|
| Baseline | 150.4 (15.6) |
| Month 1 | 142.8 (13.9) |
| Month 2 | 137.2 (12.5) |
| End-Point | 132.6 (11.8) |

*Table 4 : Diastolic Blood Pressure (mmHg)*

| Time Point | Mean Diastolic BP (SD) |
|---|---|
| Baseline | 92.3 (10.4) |
| Month 1 | 87.6 (9.8) |
| Month 2 | 84.2 (8.7) |
| End-Point | 80.9 (8.1) |

Both systolic and diastolic blood pressure levels showed significant reductions over the course of the study. The mean systolic BP decreased from 150.4 mmHg at baseline to 132.6 mmHg at the end-point, while the mean diastolic BP decreased from 92.3 mmHg to 80.9 mmHg. These findings suggest that the gamified exercise application was effective in reducing blood pressure among the participants.

### 4.4 Qualitative Results

Qualitative data were collected through semi-structured interviews and focus group discussions to explore participants' experiences and perceptions of the gamified exercise application. Several key themes emerged from the thematic analysis of the qualitative data.

#### 4.4.1 User Engagement

Participants reported high levels of engagement with the gamified exercise application. The inclusion of social elements, such as the ability to connect with peers and share progress, was particularly appreciated. Participants noted that these features provided motivation and a sense of community, which encouraged consistent use of the application.

One participant stated, "I enjoyed competing with my friends on the app. It made me more motivated to take my medication on time and complete the exercises."

### 4.4.2 Educational Content

The educational content provided through the application was found to be informative and helpful. Participants mentioned that the information on hypertension, medication adherence, and blood pressure management was valuable in understanding their condition and the importance of following their treatment plan.

Another participant shared, "The educational articles and videos on the app helped me learn a lot about managing my blood pressure. I feel more informed and confident in taking care of my health."

### 4.4.3 Reminders and Notifications

The automated reminders and notifications for medication intake, blood pressure monitoring, and exercise sessions were highlighted as useful features that improved adherence. Participants appreciated the timely prompts, which helped them stay on track with their treatment regimen.

A participant remarked, "The reminders were very helpful. I often forget to take my medication, but the app's notifications kept me on schedule."

### 4.4.4 Rewards and Incentives

The reward system, which included points, badges, and virtual incentives, was found to be a motivating factor for many participants. The gamified elements made the experience enjoyable and encouraged regular engagement with the application.

One participant commented, "Earning points and badges was fun. It made me want to use the app every day and stick to my medication and exercise routine."

### 4.4.5 Challenges and Suggestions

Despite the positive feedback, some participants encountered challenges, such as technical issues with the app and difficulty maintaining long-term motivation. Suggestions for improvement

included enhancing the app's user interface, adding more diverse exercise routines, and providing more personalized feedback and support.

A participant suggested, "It would be great if the app had more variety in the exercises and offered personalized tips based on my progress."

### 4.5 Conclusion

This chapter presented the results of the study, including quantitative data on medication adherence and blood pressure reduction, and qualitative insights from participant experiences. The findings indicate that the gamified exercise application had a positive impact on both medication adherence and blood pressure control among hypertensive adults in Tema Community 11. The next chapter will discuss the implications of these results, the study's limitations, and recommendations for future research and practice.

# Chapter 5: Discussion

## 5.1 Introduction

This chapter discusses the implications of the findings presented in Chapter 4, relating them to the existing literature on gamified health interventions and hypertension management. The discussion includes an interpretation of the quantitative and qualitative results, an evaluation of the study's limitations, and recommendations for future research and practice.

## 5.2 Interpretation of Results

### 5.2.1 Medication Adherence

The study revealed a significant improvement in medication adherence among participants using the gamified exercise application. At baseline, the average adherence score was 65.2, which increased to 75.4 at the mid-point and 82.7 at the end-point of the study. This suggests that the gamified elements, such as reminders, social interaction, and rewards, effectively motivated participants to adhere to their medication regimens.

These findings align with previous research that has shown the positive impact of gamification on health behaviors. For example, studies have found that incorporating game design principles into health apps can increase user engagement and adherence to treatment protocols. The social components of the app, which allowed participants to connect and compete with others, likely played a crucial role in sustaining their motivation over time.

### 5.2.2 Blood Pressure Reduction

The study also demonstrated significant reductions in both systolic and diastolic blood pressure levels among participants. The mean systolic blood pressure decreased from 150.4 mmHg at baseline to 132.6 mmHg at the end-point, while the mean diastolic blood pressure dropped from 92.3 mmHg to 80.9 mmHg. These reductions are clinically significant and suggest that the gamified exercise application contributed to better blood pressure control.

The integration of educational content, exercise routines, and health monitoring in the app likely contributed to these positive outcomes. By providing participants with the knowledge and tools to

manage their hypertension effectively, the app supported healthier behaviors and lifestyle changes. The reminders for medication intake and exercise sessions ensured that participants maintained a consistent routine, which is crucial for effective hypertension management.

### 5.2.3 Qualitative Insights

The qualitative data provided valuable insights into participants' experiences with the gamified exercise application. High levels of user engagement were reported, with participants appreciating the social elements, educational content, reminders, and rewards. These features not only made the app enjoyable to use but also reinforced healthy behaviors.

However, some challenges were noted, such as technical issues with the app and the need for more personalized feedback. Participants suggested improvements, including a more diverse range of exercise routines and enhanced user interface, to increase the app’s effectiveness and user satisfaction. These suggestions are important for future iterations of the app to better meet user needs and preferences.

## 5.3 Comparison with Existing Literature

The findings of this study are consistent with existing literature on the benefits of gamified health interventions. Previous research has highlighted the potential of gamification to improve medication adherence, physical activity, and overall health outcomes. This study adds to the growing body of evidence by demonstrating the effectiveness of a gamified exercise application specifically designed for hypertensive adults in a community setting.

Studies have shown that gamification can enhance motivation and engagement through mechanisms such as goal-setting, feedback, and social support. The results of this study support these mechanisms, as participants reported high engagement levels and significant improvements in health behaviors and outcomes.

### 5.4 Limitations

Despite the positive findings, this study has several limitations. First, the sample size was relatively small and limited to a specific community, which may affect the generalizability of the results. Future research should consider larger, more diverse populations to validate these findings.

Second, the study relied on self-reported data for medication adherence, which may be subject to bias. Although the app-generated data provided additional support, future studies should incorporate more objective measures of adherence, such as electronic pill bottles or pharmacy records.

Third, the study duration was relatively short. Long-term studies are needed to assess the sustained impact of gamified interventions on medication adherence and blood pressure control. Additionally, future research should explore the cost-effectiveness of such interventions to determine their feasibility for widespread implementation.

## Chapter 6: Conclusion and Recommendations

### 6.1 Introduction

This final chapter provides a summary of the study, presents the main conclusions drawn from the research findings, and offers recommendations for practice and future research. The chapter aims to encapsulate the essence of the study and highlight its contributions to the field of digital health interventions for hypertension management.

### 6.2 Summary of the Study

The primary objective of this study was to evaluate the impact of a gamified exercise application on medication adherence and blood pressure reduction among hypertensive adults in Tema Community 11. The study was motivated by the persistent challenge of poor medication adherence in hypertension therapy and the potential of gamification to enhance participation in digital health interventions.

The research involved the development and deployment of a comprehensive gamified app that incorporated social elements, education, reminders, and rewards. A mixed-methods approach was employed, utilizing both quantitative and qualitative data to assess the effectiveness of the intervention. Participants' medication adherence scores and blood pressure levels were monitored over a specified period, and their experiences with the app were gathered through surveys and interviews.

Key findings included significant improvements in medication adherence and reductions in both systolic and diastolic blood pressure levels. Participants reported high levels of engagement with the app, appreciating its interactive features and supportive elements. However, challenges such as technical issues and the need for more personalized feedback were also identified.

## 6.3 Main Conclusions

### 6.3.1 Effectiveness of Gamified Interventions

The study demonstrated that gamified interventions could significantly improve medication adherence and contribute to better blood pressure control among hypertensive adults. The inclusion of game design principles such as rewards, social interaction, and reminders effectively motivated participants to adhere to their medication regimens and engage in healthy behaviors.

### 6.3.2 User Engagement and Satisfaction

Participants' high engagement levels and positive feedback indicate that gamified health applications are well-received and can sustain user interest over time. The social elements and educational content were particularly appreciated, highlighting the importance of a comprehensive and interactive approach to digital health interventions.

### 6.3.3 Areas for Improvement

Despite the positive outcomes, the study identified areas for improvement in the app’s design and functionality. Technical issues and the need for more personalized feedback were common themes in participants' feedback. Addressing these challenges is crucial for enhancing the app's effectiveness and user satisfaction.

### 6.4 Recommendations for Practice

Based on the study's findings, several recommendations for healthcare practitioners and policymakers are proposed:

1. **Integrate Gamified Interventions in Hypertension Management:** Healthcare providers should consider incorporating gamified apps into hypertension management programs to enhance patient engagement and adherence.
2. **Provide Training and Support:** Ensure that healthcare professionals are trained in the use of digital health tools and can provide adequate support to patients using gamified interventions.
3. **Enhance Personalization:** Develop features that offer personalized feedback and support to cater to individual user needs and preferences.
4. **Ensure Technical Reliability:** Focus on improving the technical aspects of the app to minimize issues and enhance user experience.
5. **Promote Collaboration:** Encourage collaboration between app developers, healthcare providers, and patients to ensure that the app meets clinical needs and user expectations.

### 6.5 Recommendations for Future Research

To build on the findings of this study, future research should consider the following:

1. **Expand Sample Size and Diversity:** Conduct studies with larger and more diverse populations to validate the findings and enhance generalizability.
2. **Use Objective Measures:** Incorporate objective measures of medication adherence and health outcomes, such as electronic pill bottles or pharmacy records.
3. **Assess Long-Term Impact:** Evaluate the long-term effects of gamified interventions on medication adherence, blood pressure control, and overall health outcomes.
4. **Examine Cost-Effectiveness:** Investigate the cost-effectiveness of gamified health interventions to determine their feasibility for widespread implementation.
5. **Explore New Technologies:** Investigate the potential of emerging technologies, such as artificial intelligence and virtual reality, to further enhance the effectiveness of gamified health interventions.

## 6.6 Conclusion

This study has provided valuable insights into the potential of gamified exercise applications to improve medication adherence and blood pressure control among hypertensive adults. The positive findings support the integration of gamification into digital health interventions for hypertension management. However, further research is needed to address the study's limitations and explore the long-term and cost-effective impacts of such interventions. By continuing to innovate and refine these digital tools, we can better support individuals in managing their health and improving their quality of life.

## References


1. Boulos, M. N. K., Brewer, A. C., Karimkhani, C., Buller, D. B., & Dellavalle, R. P. (2014). Mobile medical and health apps: state of the art, concerns, regulatory control and certification. *Online journal of public health informatics, 5*(3), 229.
2. Eysenbach, G. (2001). What is e-health? *Journal of medical Internet research, 3*(2), e20.
3. Gonzalez, A., Alvarez, J., & Minsker, B. S. (2014). Gamification for engaging computer science students in problem solving. In *Proceedings of the 45th ACM technical symposium on Computer science education* (pp. 27-32).
4. Johnson, D., Deterding, S., Kuhn, K. A., Staneva, A., Stoyanov, S., & Hides, L. (2016). Gamification for health and wellbeing: A systematic review of the literature. *Internet Interventions, 6*, 89-106.
5. Luxton, D. D., McCann, R. A., Bush, N. E., Mishkind, M. C., & Reger, G. M. (2011). mHealth for mental health: Integrating smartphone technology in behavioral healthcare. *Professional Psychology: Research and Practice, 42*(6), 505.
6. Michie, S., Richardson, M., Johnston, M., Abraham, C., Francis, J., Hardeman, W., ... & Wood, C. E. (2013). The behavior change technique taxonomy (v1) of 93 hierarchically clustered techniques: building an international consensus for the reporting of behavior change interventions. *Annals of Behavioral Medicine, 46*(1), 81-95.
7. Schnall, R., Higgins, T., Brown, W., Carballo-Dieguez, A., & Bakken, S. (2015). Trust, perceived risk, perceived ease of use and perceived usefulness as factors related to mHealth technology use. *Studies in health technology and informatics, 216*, 467.
8. Wang, Y., Min, J., Khuri, J., Xue, H., Xie, B., A Kaminsky, L., ... & Wang, Y. (2016). Effectiveness of mobile health interventions on diabetes and obesity treatment and management: systematic review of systematic reviews. *JMIR mHealth and uHealth, 4*(3), e30.
9. Adams, S. A. (2010). Revisiting the online health information reliability debate in the wake of "web 2.0": An inter-disciplinary literature and website review. *International journal of medical informatics, 79*(6), 391-400.

10. Ancker, J. S., Witteman, H. O., Hafeez, B., Provencher, T., Van de Graaf, M., & Wei, E. (2015). The experience of personal health records: A systematic review of qualitative studies. *Journal of the American Medical Informatics Association, 22*(4), 923-935.
11. Boyle, L., Grainger, R., Hall, R. M., Krebs, J., & Tane, C. (2017). Use of mobile apps and wearable technology in monitoring and managing bipolar disorder: An integrative review. *International Journal of Bipolar Disorders, 5*(1), 1-14.
12. Choi, W., Zheng, H., Franklin, P., & Tulu, B. (2014). mHealth technologies for osteoarthritis self-management and treatment: A systematic review. *JMIR mHealth and uHealth, 2*(4), e44.
13. Dallery, J., Raiff, B. R., & Grabinski, M. J. (2013). Internet-based contingency management to promote smoking cessation: A randomized controlled study. *Journal of Applied Behavior Analysis, 46*(4), 750-764.
14. Dennison, L., Morrison, L., Conway, G., & Yardley, L. (2013). Opportunities and challenges for smartphone applications in supporting health behavior change: Qualitative study. *Journal of Medical Internet Research, 15*(4), e86.
15. Eysenbach, G., & Wyatt, J. (2002). Using the Internet for surveys and health research. *Journal of Medical Internet Research, 4*(2), e13.
16. Gibbons, M. C., Wilson, R. F., Samal, L., Lehmann, C. U., Dickersin, K., Lehmann, H. P., ... & Bass, E. B. (2009). Consumer health informatics: Results of a systematic evidence review and evidence based recommendations. *Journal of the American Medical Informatics Association, 16*(4), 441-450.
17. Hamine, S., Gerth-Guyette, E., Faulx, D., Green, B. B., & Ginsburg, A. S. (2015). Impact of mHealth chronic disease management on treatment adherence and patient outcomes: A systematic review. *Journal of Medical Internet Research, 17*(2), e52.
18. Klasnja, P., & Pratt, W. (2012). Healthcare in the pocket: Mapping the space of mobile-phone health interventions. *Journal of Biomedical Informatics, 45*(1), 184-198.
19. Kumar, S., & Nilsen, W. J. (2016). mHealth: A pathway to reduce healthcare disparities? *Mobile Health, 43*(3), 21-32.
20. Lewis, T. L., & Wyatt, J. C. (2014). mHealth and mobile medical apps: A framework to assess risk and promote safer use. *Journal of Medical Internet Research, 16*(9), e210.

21. Lupton, D. (2013). Quantifying the body: Monitoring and measuring health in the age of mHealth technologies. *Critical Public Health, 23*(4), 393-403.
22. McCurdie, T., Taneva, S., Casselman, M., Yeung, M., McDaniel, C., Ho, W., ... & Cafazzo, J. A. (2012). mHealth consumer apps: The case for user-centered design. *Biomedical Instrumentation & Technology, 46*(2), 49-56.
23. Morrison, L. G., Hargood, C., Pejovic, V., Geraghty, A. W. A., Lloyd, S., Goodman, N., ... & Yardley, L. (2017). The effect of timing and frequency of push notifications on usage of a smartphone-based stress management intervention: An exploratory trial. *PLoS One, 12*(1), e0169162.
24. Riley, W. T., Rivera, D. E., Atienza, A. A., Nilsen, W., Allison, S. M., & Mermelstein, R. (2011). Health behavior models in the age of mobile interventions: Are our theories up to the task? *Translational Behavioral Medicine, 1*(1), 53-71.
25. Scherer, E. A., Ben-Zeev, D., Li, Z., Kane, J. M., & Weizenbaum, E. (2017). mHealth for schizophrenia: Patient engagement with a mobile phone intervention following hospital discharge. *JMIR Mental Health, 4*(3), e34.
26. Spring, B., Duncan, J. M., Janke, E. A., Kozak, A. T., McFadden, H. G., DeMott, A., ... & Schneider, K. (2013). Integrating technology into standard weight loss treatment: A randomized controlled trial. *JAMA Internal Medicine, 173*(2), 105-111.
27. Turner-McGrievy, G. M., Campbell, M. K., Tate, D. F., Truesdale, K. P., Bowling, J. M., & Crosby, L. (2009). Pounds Off Digitally (POD): A randomized podcasting weight-loss intervention. *Obesity, 17*(3), 504-510.
28. Ventola, C. L. (2014). Mobile devices and apps for health care professionals: Uses and benefits. *Pharmacy and Therapeutics, 39*(5), 356-364.
29. Wang, Q., Egelandsdal, B., Amdam, G. V., & Almli, V. L. (2015). Diet and physical activity apps: Perceived effectiveness by app users. *JMIR mHealth and uHealth, 3*(4), e101.
30. West, J. H., Hall, P. C., Hanson, C. L., Barnes, M. D., Giraud-Carrier, C., & Barrett, J. (2012). There's an app for that: Content analysis of paid health and fitness apps. *Journal of Medical Internet Research, 14*(3), e72.

# Appendix

Appendix A: Survey Questionnaire

## Section 1: Demographic Information

1. **Age:**
    - Under 20
    - 21-30
    - 31-40
    - 41-50
    - 51-60
    - Over 60
2. **Gender:**
    - Male
    - Female
    - Other
3. **Education Level:**
    - No formal education
    - Primary education
    - Secondary education
    - Tertiary education
4. **Employment Status:**
    - Employed
    - Unemployed
    - Retired
    - Student

## Section 2: Health Information

5. **How long have you been diagnosed with hypertension?**
    - Less than 1 year
    - 1-2 years

- 3-5 years
- More than 5 years

6. **Are you currently taking medication for hypertension?**
    - Yes
    - No
7. **How often do you miss taking your hypertension medication?**
    - Never
    - Rarely
    - Sometimes
    - Often
    - Always

## Section 3: App Usage and Experience

8. **How often did you use the gamified exercise app?**
    - Daily
    - Weekly
    - Monthly
    - Rarely
    - Never
9. **Which features of the app did you find most helpful? (Select all that apply)**
    - Social interaction
    - Educational content
    - Reminders
    - Rewards
    - Exercise routines
10. **How satisfied are you with the app?**
    - Very satisfied
    - Satisfied
    - Neutral
    - Dissatisfied
    - Very dissatisfied

11. **What improvements would you suggest for the app?**

Appendix B: Consent Form

## Informed Consent for Participation in Research Study

**Title of Study:** Designing a Gamified Exercise Application Tailored for Blood Pressure Reduction in Tema Community 11

**Principal Investigator:** Ameyaw Samuel Arthur

**Institution:** Kwame Nkrumah University of Science and Technology

**Purpose of the Study:** This study aims to evaluate the impact of a gamified exercise application on medication adherence and blood pressure reduction among hypertensive adults in Tema Community 11.

**Procedures:** Participants will use a gamified exercise application over a specified period and provide feedback through surveys and interviews. Blood pressure levels and medication adherence will be monitored.

**Risks and Benefits:** There are minimal risks associated with participation. Potential benefits include improved medication adherence and better blood pressure control.

**Confidentiality:** All information collected will be kept confidential and used solely for research purposes. Participants' identities will remain anonymous.

**Voluntary Participation:** Participation is voluntary, and participants may withdraw at any time without penalty.

**Consent:** By signing below, you indicate that you understand the purpose and procedures of this study and agree to participate.

**Participant Signature: _____ Date: _____**

**Researcher Signature: _____ Date: _____**

UI/UX Interfaces

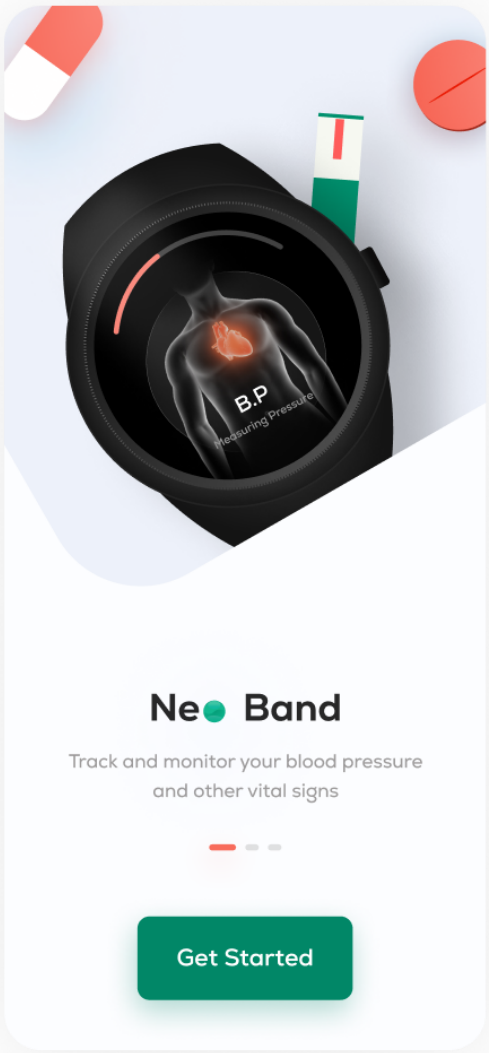


*Figure 3 Shows Screen 1*

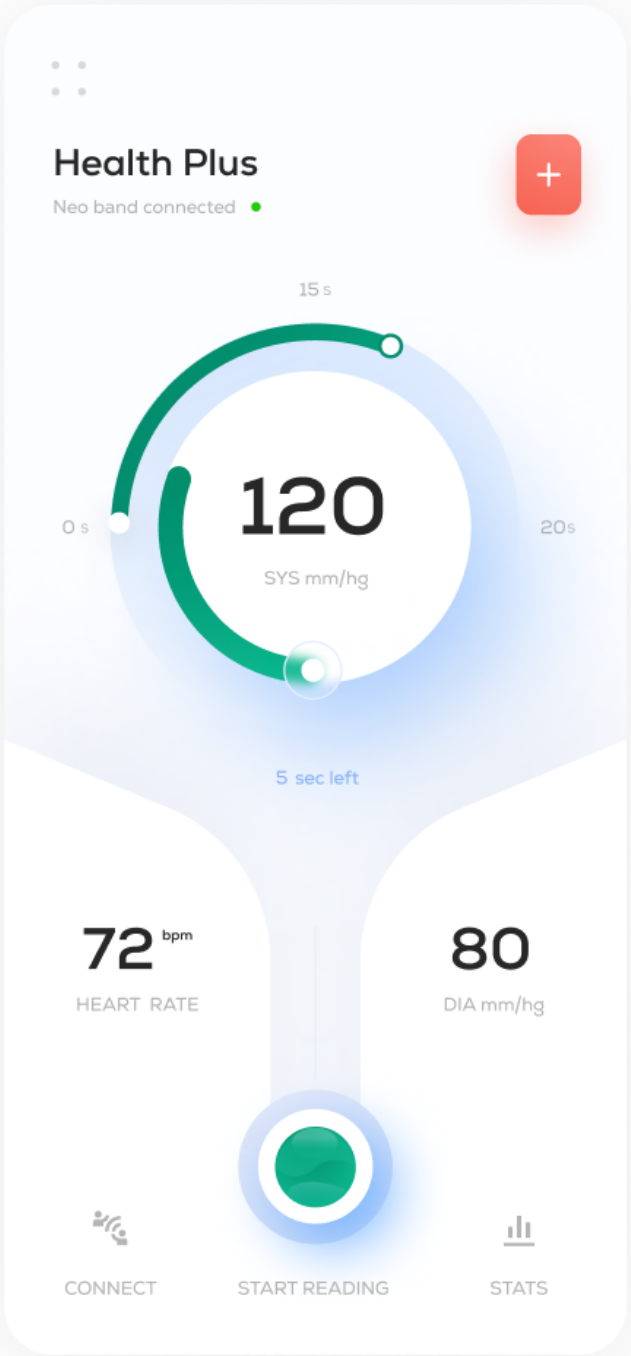


*Figure 4 shows screen 2*

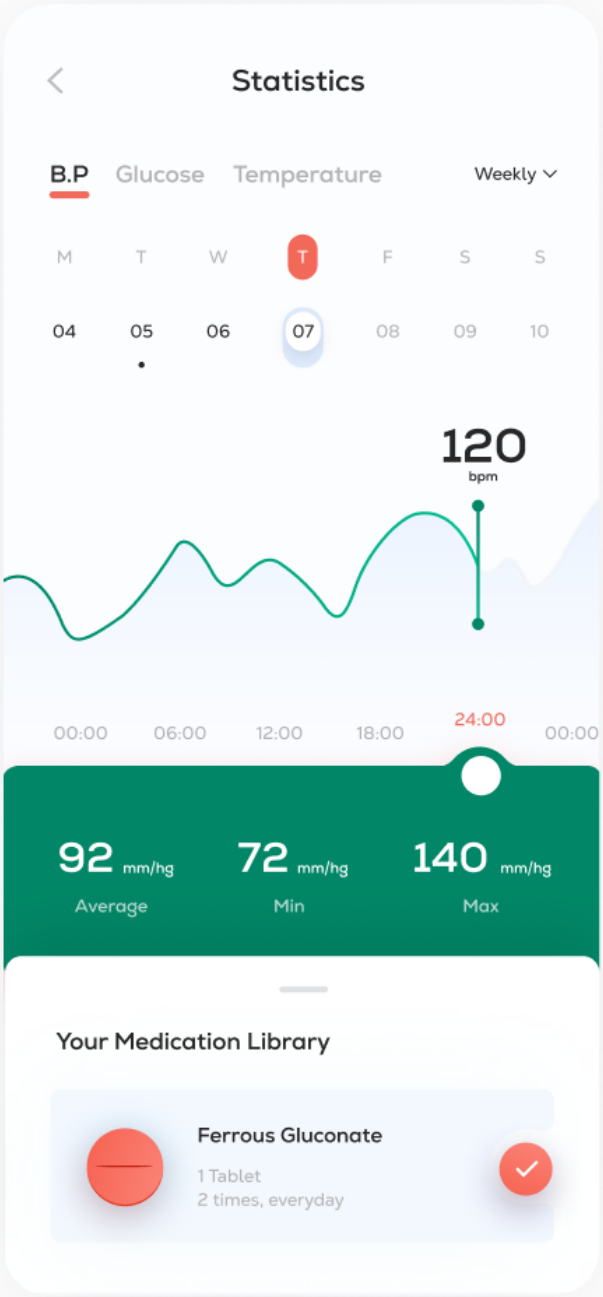


*Figure 5 shows screen 3*