THE EFFECT OF A MOBILE-BASED EDUCATIONAL PROGRAM ON KNOWLEDGE OF STROKE PREVENTION, LIFESTYLE CHANGES AND HEALTH-RELATED QUALITY OF LIFE AMONG MIDDLE-AGED ADULTS AT RISK OF STROKE IN CHINA

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THE EFFECT OF A MOBILE-BASED EDUCATIONAL PROGRAM ON KNOWLEDGE OF STROKE PREVENTION, LIFESTYLE CHANGES AND HEALTH-RELATED QUALITY OF LIFE AMONG MIDDLE-AGED ADULTS AT RISK OF STROKE IN CHINA

ABSTRACT

Stroke is a significant global public health concern, ranking as the primary cause of both death and disability. Alarmingly, most stroke-related fatalities are concentrated in low- and middle-income nations. China currently bears the highest burden of stroke cases and associated mortality worldwide, accounting for nearly 30% of all stroke-related deaths. The purpose of this study is to develop and evaluate a mobile-based educational program on knowledge of stroke prevention, lifestyle changes, and health-related quality of life among middle-aged adults at risk of stroke in China. This study adopted an exploratory mixed-method design which includes 2 phases. Phase 1 was to design and develop the mobile-based educational program which included qualitative focus group discussions to assess the needs of participants at risk of stroke, evaluation by a panel of multidisciplinary experts, development, and usability test of the program. The outcomes of phase 1 indicated that the mobile-based educational program provides a simple platform that can be easily operated by a wide variety of users with a risk of stroke and the content is highly relevant to their physical condition and daily life. Phase 2 was a quasi-experimental study, employing a non-randomized concurrent controlled trial, to assess the impact of mean differences within and between the intervention and control groups on dietary intake, physical activity, knowledge related to stroke prevention, and health-related quality of life. Four instruments were used in this study including the Stroke Knowledge Questionnaire, the Simplified Food Frequency Questionnaire Chinese version (FFQ-25), the International Physical Activity

Questionnaire short form (IPAQ-SF), the abbreviated World Health Organization Quality of Life questionnaire (WHOQOL-BREF) Chinese version. The results of phase 2 showed that the mobile-based educational program had effectively increased the food intake among these middle-aged adults, followed by the difference of change in mean value between intervention and control groups in physical activity, and there was an increase in the post-stroke prevention knowledge scores, with the intervention group obtaining a higher score than the control group. This study has provided a promising mobile application intervention solution for middle-aged individuals at risk of stroke. This research has the potential to offer more effective tools for stroke prevention and management, improving the lifestyle of at-risk individuals, raising awareness of health issues, and reducing the risk of stroke.

Keywords: Primary stroke prevention, diet, physical activity, health-related quality of life, middle-aged adults.

KESAN PROGRAM PENDIDIKAN BERASASKAN MUDAH ALIH KE ATAS PENGETAHUAN PENCEGAHAN STROK, PERUBAHAN GAYA HIDUP DAN KUALITI HIDUP BERKAITAN KESIHATAN DI KALANGAN ORANG DEWASA SEDERHANA UMUR YANG BERISIKO MENDAPAT STROK DI CHINA

ABSTRAK

Stroke adalah kebimbangan kesihatan awam global yang signifikan, dianggap sebagai punca utama kematian dan kecacatan. Menghairankan, kebanyakan kematian berkaitan strok terumpu di negara berpendapatan rendah dan sederhana. China kini menanggung beban strok dan mortaliti berkaitan strok tertinggi di seluruh dunia, menyumbang hampir 30% daripada semua kematian berkaitan strok. Tujuan kajian ini adalah untuk membangunkan dan menilai program pendidikan berasaskan mudah alih mengenai pengetahuan pencegahan strok, perubahan gaya hidup, dan kualiti hidup berkaitan kesihatan di kalangan individu dewasa pertengahan berisiko strok di China. Kajian ini mengadopsi reka bentuk eksploratori campuran yang merangkumi 2 fasa. Fasa 1 adalah untuk mereka bentuk dan membangunkan program pendidikan berasaskan mudah alih yang merangkumi perbincangan kumpulan fokus kualitatif untuk menilai keperluan peserta yang berisiko strok, penilaian oleh panel pakar multidisiplin, pembangunan, dan ujian kebolehgunaan program. Hasil fasa 1 menunjukkan bahawa program pendidikan berasaskan mudah alih menyediakan platform mudah yang boleh dikendalikan oleh pelbagai pengguna dengan risiko strok, dan kandungannya sangat relevan dengan keadaan fizikal dan kehidupan harian mereka. Fasa 2 adalah kajian kuasi-eksperimental, menggunakan ujian terkawal serentak bukan rawak, untuk menilai impak perbezaan min dalam dan di antara kumpulan intervensi dan kawalan terhadap pengambilan makanan, aktiviti fizikal, pengetahuan berkaitan pencegahan strok, dan kualiti hidup berkaitan

kesihatan. Empat instrumen digunakan dalam kajian ini termasuk Kuestioner Pengetahuan Strok, Soal Selidik Frekuensi Makanan Ringkas Versi Bahasa Cina (FFQ-25), Soal Selidik Aktiviti Fizikal Antarabangsa versi pendek (IPAQ-SF), dan Soal Selidik Kualiti Hidup Pertubuhan Kesihatan Sedunia yang diringkaskan (WHOQOL-BREF) versi Bahasa Cina. Keputusan fasa 2 menunjukkan bahawa program pendidikan berasaskan mudah alih telah berjaya meningkatkan pengambilan makanan di kalangan individu dewasa pertengahan ini, diikuti oleh perbezaan perubahan nilai min antara kumpulan intervensi dan kawalan dalam aktiviti fizikal, dan terdapat peningkatan dalam skor pengetahuan pencegahan strok selepas strok, dengan kumpulan intervensi mendapat skor lebih tinggi daripada kumpulan kawalan. Kajian ini telah menyediakan penyelesaian intervensi aplikasi mudah alih yang menjanjikan untuk individu dewasa pertengahan berisiko strok. Kajian ini berpotensi untuk menawarkan alat yang lebih berkesan untuk pencegahan dan pengurusan strok, meningkatkan gaya hidup individu yang berisiko, meningkatkan kesedaran isu kesihatan, dan mengurangkan risiko strok.

Kata Kunci: Pencegahan utama stroke, diet, aktiviti fizikal, kualiti hidup berkaitan Kesihatan, orang dewasa pertengahan.

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LIST OF SYMBOLS AND ABBREVIATIONS

mHealth	:	Mobile health
HBM	:	Health belief model
PA	:	Physical activity
NCD		Non-communicable diseases
CVI		Content validation index
MMR	:	Mixed method research
FGDs	:	Focus group discussions
RCT	:	Randomized control trial
DALYs	:	Disability-adjusted life years
CSSPP	:	Chinese stroke screening and prevention project
CVD	:	Cardiovascular disease
QUAN	:	Quantitative
QUAL	:	Qualitative
SUS	:	System Usability Scale
FFQ25	:	Food frequency questionnaire
CHBMS	:	Champion health belief model scale
IPAQ	:	The short-form international physical activity questionnaire
WHOQOL	:	World Health Organization Quality-of-Life Scale

LIST OF APPENDICES

CHAPTER 1: INTRODUCTION

This chapter presented the context, issue statement, and importance of this study. This chapter provided explicit descriptions of the objectives, operational definitions, and research questions.

1.1 Introduction

Stroke is the primary cause of mortality and morbidity and has emerged as a significant public health concern globally, with almost 80% of fatalities happening in low- and middle-income nations (Feigin, 2007). China now holds the highest rates of stroke occurrence and death globally, contributing to around 30% of the global stroke-related fatalities. There are more than 8 million stroke patients with various degrees of hemiplegia, speech difficulties, and cognitive impairment in China, which brings a heavy economic burden.

Stroke can occur in individuals of various age groups and diverse backgrounds (Prust et al., 2024). Cardiovascular risk factors are commonly believed to have harmful impacts on brain function through obvious strokes. Nevertheless, it is more probable that the accumulation of brain lesions caused by cerebrovascular disease occurs without exhibiting noticeable symptoms over several years or even decades (Kissela et al., 2012). The precise onset of these risk variables and their impact remains poorly understood. Multiple studies have identified a pattern indicating a rise in the occurrence of strokes among individuals in younger age groups. This holds immense importance in the field of public health since strokes occurring in younger individuals have the potential to result in a higher level of disability throughout their lifespan. Furthermore, certain factors that contribute to this trend have been identified and can be modified. The increasing incidence of stroke in younger individuals may be attributed to the changing prevalence of risk factors (Amoah et al., 2024).

Certain risk factors make certain people more likely to have a stroke or die from one. These risk factors include both controllable and non-modifiable risk factors. People with various risk factors, such as hypertension, diabetes, dyslipidemia, obesity, and so on, are at a higher risk of stroke (Shigematsu et al., 2015). The majority of these populations have heard of stroke but lack awareness of its risk factors and knowledge(Abate et al., 2019) (Han et al., 2019) (Chukwuocha et al., 2018), which is one of the main contributing factors to the incidence of stroke. In addition, the population's participation in the management and prevention of dietary is also poor. Since maintaining a healthy diet is a complex lifelong regimen, patients must be motivated, knowledgeable, and compliant in order for the population to participate in self-management of their food. In halting the rising burden of stroke, there is a need to increase the awareness and good diet knowledge of stroke to prevent the incidence of stroke among people with risk of stroke and benefit the community at large.

There are many approaches to health education intervention, such as face-to-face communication, teaching with an educational manual, and using mobile health (mHealth) support (Ridwan et al., 2020), among them mhealth support is one of the most effective prevention strategies where chronic diseases are concerned. Recently, the World Health Organization (Organization, 2011) has defined mHealth as the "use of mobile and wireless technologies to support the achievement of health objectives.". The mhealth modality offers the possibility of delivering behavior change for health education and disease management in a scalable and cost-effective way. The main stroke preventive techniques now in use are insufficiently successful because they are not widely used. As of right now, there is no proof that using smartphone applications to target the various risk factors that contribute to the total risk of stroke can be effective.

1.2 Background

Stroke is a neurological condition defined by the obstruction of blood arteries (Kuriakose & Xiao, 2020). Brain clots obstruct blood flow, blocking arteries and rupturing blood vessels, which results in bleeding. When a stroke occurs, the arteries supplying the brain burst, causing brain cells to suddenly die from a shortage of oxygen. It encompasses both ischemic and hemorrhagic strokes, with ischemic strokes occurring more frequently than hemorrhagic ones (Wolfe, 2000) (accounting for 60% to 70% of the total number of strokes) and has five major characteristics: high morbidity, high disability, high mortality, high recurrence rate, and high economic burden. In 2018, 1853 tertiary care hospitals admitted 3010204 inpatients with stroke, according to data from the Hospital Quality Monitoring System. Of those, 447 609 (14.9%) had intracerebral hemorrhages (ICHs), 95810 (3.2%) had subarachnoid hemorrhages (SAHs), and 2466 785 (81.9%) had ischemic strokes (ISs).

According to the 2016 China Stroke Prevention and Control Report, 65.0% of stroke populations aged 40 to 64 years old accounted for 65.0%, and the average age of onset was more than 10 years earlier than in the United States, showing a younger trend. Stroke is a major cause of death among Chinese residents. China has the highest lifetime risk of stroke, at 39.3%, according to data from the Global Burden of Disease in 2016. This indicates that 118 million Chinese people will get a stroke by 2030 (Wu et al., 2019).

In China, there were notable regional differences in the prevalence of stroke, with the northern provinces having a higher prevalence than the southern provinces (Li et al., 2011). In the Chinese population aged 40 years and above, the age-standardized prevalence of hypertension, diabetes, dyslipidemia, atrial fibrillation, and obesity were, respectively, 35.24%, 9.55%, 58.72%, 1.57%, and 4.09% (Li et al., 2017). Middle-aged

adults, often at the height of their productivity, face increasing risks from lifestyle factors, genetic predispositions, and insufficient preventive measures. Despite advances in medical technology and healthcare services, effectively preventing strokes in this demographic remains a significant challenge. Implementing robust primary prevention strategies is crucial to addressing this escalating public health concern and enhancing the quality of life for those at risk. Stroke and related vascular risk factors continue to pose a significant public health issue in China, and effective primary prevention programmes targeted at reducing the burden of stroke and its risk factors are urgently required.

The Chinese government has put a great deal of effort into providing better stroke prevention services. Approved by the Ministry of Health, the Chinese Society of Geriatric Healthcare and Medical Research initiated the "Stroke Screening and Prevention and Control Project" in early 2009. The goals of this project are: Firstly, formulating China's screening specifications, intervention principles, and carotid endarterectomy surgical standards and related requirements as soon as possible; secondly, striving to establish at least one stroke screening and intervention center or base in each province, region, and city across the country within three years; thirdly, general screening of high-risk groups and promotion of ABCDE prevention and control strategies (A: antithrombotic therapy; B: blood pressure and weight control; C: lower cholesterol, quit smoking, Carrying out stents and carotid endarterectomy; D: control of diabetes, diet adjustment; E: health education, physical exercise, regular physical examination), which is also a secondary prevention strategy for stroke so that to strengthen the treatment and education of stroke patients, avoid recurrence and benefit the general public.

1.2.1 Stroke Risk Factors

Epidemiological research indicates that a stroke does not happen randomly and that there are risk factors that exist years before a stroke (Healey et al., 2005). These include non-modifiable and modifiable risk factors (An et al., 2017). Except for non-modifiable risk factors such as age, gender, race/ethnicity, and family history of stroke which cannot be changed, other modifiable risk factors with sufficient evidence can be prevented and controlled through healthy behaviors (Hill & Towfighi, 2017). Anyone can have a stroke at any age, but the chance of having a stroke increases if people have a certain risk factor.

Modifiable risk factors for the first stroke (Hadjiev et al., 2003) include hypertension, cardiac disease (particularly atrial fibrillation), diabetes, hyperlipidemia, cigarette smoking, alcohol abuse, physical inactivity, asymptomatic carotid stenosis, and transient ischemic attack. According to the Worldwide Burden of Disease Study, modifiable risk factors account for 90.5% of the worldwide burden of strokes (Feigin, Roth, et al., 2016).

In recent years, hypertension, diabetes, and hyperlipidemia have become common in the Chinese population. Those factors with the highest attributable risk appear to be the best targets for stroke prevention, and they can be avoided and managed by healthy behaviours. Therefore, the most effective way to reduce the burden of cerebrovascular disease is to strengthen the primary prevention before the first onset, that is carry out early intervention for the risk factors of cerebrovascular disease actively and strive to reduce the incidence of the population at risk of stroke.

1.2.2 Primary Stroke Prevention

The goal of primary stroke prevention is to keep patients who have stroke risk factors but have not yet experienced a stroke from ever having one. Among the strategies include medication, community interventions, education, and others.

The mainstays of stroke prevention are blood pressure management and the encouragement and upkeep of a healthy lifestyle. A healthy lifestyle consists of abstaining from smoking (and quitting for those who already smoke), abstaining from binge drinking, getting regular exercise, and maintaining a diet high in fruits and vegetables, low in trans fats, and low in sodium. Populations or people at high risk may be the focus of cardiovascular disease (CVD) prevention measures. Clinical recommendations propose a high-risk target strategy as the primary approach; nevertheless, it has been argued that the majority of CVD events occur in those with low to moderate absolute risk of CVD (Ray et al., 2014). As a result, the population-level benefit of high-risk prevention methods on stroke risk reduction may be limited. Which option is more cost-effective is still up for debate; a more successful plan might combine the two.

1.2.3 Nurses in Primary Stroke Prevention

The interconnection between nursing and primary stroke prevention in China is complex. Despite the well-established awareness of stroke risk factors and their susceptibility to lifestyle interventions, the integration of primary stroke prevention into healthcare services lacks consistency. Nurses, with their diverse skill sets as leaders, innovators, educators, and researchers, can play a central role in initiating and managing comprehensive primary stroke prevention services, contributing to the well-being of those at risk (Magwood et al., 2020).

In community settings, nurses actively engage in health education initiatives, fostering awareness about stroke risk factors and preventive measures. This involves educating the public on lifestyle adjustments, such as maintaining a healthy diet, regular physical activity, and avoiding tobacco and excessive alcohol consumption (Clare, 2017). Nurses also play a vital role in community-based health screenings, identifying individuals at risk for stroke by assessing factors like high blood pressure, diabetes, and atrial fibrillation. Their involvement extends to referring individuals for further evaluation and management. Within clinical environments, nurses advocate for stroke prevention by ensuring patients undergo appropriate screenings, vaccinations, and counseling. They provide continuous support and education to individuals with risk factors, aiding in their comprehension and adherence to prescribed preventive measures.

Nurses significantly contribute to stroke prevention through research on effective prevention strategies and advocacy for policies promoting a healthier environment. Their involvement may extend to initiatives focused on enhancing public health infrastructure and improving access to preventive healthcare services. Engaging and educating individuals at risk of stroke, along with the communities they serve, positions nurses as catalysts for change. Their experiences can inform practices across various services, fostering a holistic approach essential for reducing stroke incidence and enhancing overall population health. Community nurses, in their role as providers of primary prevention services, could act as case managers within larger multidisciplinary teams, offering valuable advice and treatment. Given the diverse population in China, nurses must approach stroke prevention with cultural sensitivity. Understanding cultural beliefs, practices, and healthcare barriers becomes integral to enhancing the effectiveness of prevention strategies (Kozub, 2010).

1.2.4 Mobile Applications for Health Education

Nowadays, mobile applications are playing an increasingly crucial role in health education (Ridwan et al., 2020), offering the possibility of delivering behavior change for health education and disease management in a scalable and cost-effective way. According to September 2021 mobile user statistics: the current global smartphone user base is 3.8 billion, representing 48.16% of the world's population. This figure represents a significant increase from 2016 when there were just 2.5 billion users, or 33.58% of the global population.

Health-related smartphone applications have great potential and have been recently used to provide self-care for various diseases (K. Liu et al., 2020). A variety of mobile health solutions can help physicians and patients enhance their quality of treatment and gain access to vital wellness resources (Piette et al., 2015), it is critical amid a rising shortage of healthcare workers and can deliver favourable results for both patients and healthcare providers. (Feigin, Norrving, et al., 2016).

WeChat, a popular social media and messaging app in China, has become an indispensable application in the daily lives of Chinese people, offering a wide range of features and services that meet the diverse needs of users (Sun et al., 2021). It has become an important tool for healthcare providers to deliver healthcare information, communicate with patients, and manage their health. WeChat offers a range of features that can be leveraged for mobile health, such as WeChat Official Accounts and WeChat Mini Programs, allowing for convenient and efficient delivery of healthcare services. With the increasing availability and popularity of mobile health services, WeChat is poised to become an even more important player in the field of mobile health. However, there is still much space for development to realize their full potential advantages. The increasing popularity of mobile health apps has made it imperative to enhance the

design processes to create user-friendly applications that yet have the desired impact on the user.

1.3 Problem Statement

The increase in the population at risk of stroke leading to a higher incidence of stroke with its associated co-morbidity and mortality, the current situation of unhealthy lifestyle with a specific focus on dietary and physical activity, and poor awareness of stroke prevention are discussed below.

1.3.1 The High Incidence of Stroke in China

Stroke risk factors put certain people at higher risk of stroke or death from stroke. However, the source of the continuous increase in the incidence and prevalence of stroke in China is based on many people with chronic diseases, especially those with cardiovascular diseases (Z. Li et al., 2019). At present, there is a large portion of high-risk populations: 266 million patients with hypertension, 97 million patients with diabetes (97 million), 250 million people with dyslipidemia, 350 million smokers, 7.7 million patients with atrial fibrillation, 23.9 million patients with a transient ischemic attack (TIA), about 240 million people who are overweight and obese. These figures lay down the hidden dangers for many people at high risk of stroke and it significantly increases the incidence of stroke (Yang et al., 2013). According to the World Health Organization, it is expected to have more than 30 million stroke patients in China by 2030 (Stevens et al., 2016). This shows that the situation of stroke prevention and control in China is grim. The key prevention and control of stroke should be "advanced", that is, move forward from treatment-oriented to prevention-oriented, and take action to reduce the risk of stroke.

1.3.2 The High Prevalence of Stroke-associated Co-disability and Mortality

Although in the past two to three decades, the clinical diagnosis and treatment of cerebrovascular disease have made great progress, most stroke patients will still have different degrees of sequelae, which affect the patients' work and daily activities. There are nearly 7 million surviving stroke patients in China, among which the disability rate is as high as 75% (Wang et al., 2020). About 4.5 million patients are incapacitated or unable to take care of themselves to varying degrees. A national survey of disabled persons showed that physical disabilities caused by cerebrovascular diseases (CVD) accounted for first place among all physical disabilities. In 2013, the mortality rate of cerebrovascular diseases among urban residents in China was 125.56 per 100,000, and the mortality rate of cerebrovascular diseases in rural areas was 150.17 per 100,000. The death rate of major diseases among urban and rural residents in China was still higher than that of central cerebrovascular diseases. The death rate of stroke in China is 4 to 5 times that of European and American countries (Healey et al., 2016). The World Health Organization has predicted the number of deaths from stroke in China, if the mortality rate remains unchanged, 2030, China will have nearly 4 million deaths due to stroke each year; If the mortality rate increases by 1%, by 2030, nearly 6 million people will die of stroke each year in China (Stockings et al., 2019).

Given the high burden of stroke, initiatives to prevent stroke are vital but the community residents generally lack knowledge of stroke prevention and treatment, and their beliefs and behavioral adherence to prevention and treatment are relatively low. It is necessary to strengthen the education and intervention of knowledge, belief, and behavior among such people.

1.3.3 The Current Situation of Unhealthy Lifestyle in China

An unhealthy lifestyle encompassing healthy eating and physical activity is one of the important risk factors that cause death and disease burden of cardiovascular and metabolic diseases in China. The growth in stroke risk in China over the past few decades has likely been caused by dietary changes brought about by rising income; this rise has accelerated in recent years (Tian et al., 2017). In 2017, about 2.63 million cardiovascular deaths in China were attributable to dietary factors, an increase of 38% compared to 2007; about 56 million DALYs were attributable to unreasonable diets of premature deaths or disability caused by cardiovascular diseases (Zerbo et al., 2021). The results of a total of four national nutrition surveys from 1982 to 2012 showed that the fat intake of Chinese residents gradually increased, and the intake of carbohydrates decreased; the number of people consuming food containing added sugars increased. Micronutrients such as calcium, iron, vitamin A, and vitamin D are deficient; dietary fiber intake is insufficient. Although sodium intake has a slow downward trend, it is still much higher than the World Health Organization (WHO) recommended daily sodium salt <5 g standard. A recent cohort study found that the proportion of people aged 30-79 in China who consume fresh fruits every day is lower (only 18%). Compared with those who do not eat fresh fruits, those who eat fresh fruits every day The risk of ischemic stroke is reduced by 25%, and the risk of hemorrhagic stroke is reduced by 36% (Du Toit et al., 2016). In China, meat and egg consumption has skyrocketed in recent years (Spence, 2018), whereas consumption of whole grains, vegetables, and fruit has decreased. This most likely explains a large portion of the rise in fasting cholesterol levels (Reddy, 2004) and coronary disease (Critchley & Capewell, 2003) in China at the same time.

There is a wealth of evidence backing the positive health outcomes associated with physical activity. These advantages include a lower risk of osteoporosis, hypertension,

high cholesterol, obesity, osteoarthritis, cardiovascular disease, stroke, and some malignancies as well as type 2 diabetes and overall mortality (Health & Services, 2002). Furthermore, engaging in physical activity is linked to enhanced psychological well-being, improved functional status, and reduced healthcare costs. (Colditz, 1999). In metropolitan Tianjin, China, a cross-sectional survey was carried out with a total of 2002 male and 1974 female participants, ages 15 to 69. During the survey, information was gathered on various factors involving physical activity during free time and when commuting, blood pressure, body mass index, and cigarette smoking (Hu et al., 2002). The findings indicate that both commuting, and leisure-time physical activities had positive associations with cardiovascular risk factors in this Chinese population. Nonetheless, it's important to emphasise that increased blood pressure was associated with physical activity lasting longer than 60 minutes. The prevalence of obesity, physical inactivity, and declining physical fitness are significant factors contributing to the increasing burden of chronic diseases in China. A research study conducted by Tian et al. (2016) examined these variables in Chinese adults over 14 years, from 2000 to 2014. The data used for this study were obtained from randomized national surveys. According to the study, the prevalence of central obesity, overweight, and obesity all rose considerably with age (all $p<0.0001$) and were more common in men than in women. Furthermore, the researchers observed a decline in all aspects of physical fitness among normal-weight adults over time (all $p<0.0001$), except for resting heart rate ($p=0.69$).

1.3.4 Poor Awareness of Stroke Prevention

The growth in stroke risk in China over the past few decades has likely been caused by changes in lifestyle brought about by rising income; this rise has accelerated in recent years (Tian et al., 2017) However, a large proportion of high-risk patients with chronic diseases have poor awareness of the risk factors of strokes(Han et al., 2019;

Luitse et al., 2012), they were not aware of the associated risk factors of stroke which are believed to be an outcome of diseases. At the same time, the dietary compliance of this population is also relatively poor due to various factors. There are still gaps in the knowledge-to-action pipeline when it comes to changing behaviour and adopting healthy lifestyles. To prevent and control stroke, patient education becomes a central component.

While there are known management options for primary stroke prevention in persons with cardiovascular disease, their use is underutilised, and current primary stroke preventive approaches are insufficient. Although the number of strokes worldwide is decreasing, the level seen as a result of the study indicates methods for boosting prevention. Avoidance measures are required since an ageing population is predicted to cause a large increase in the overall number of strokes in the coming years (Béjot et al., 2019). Both the individual and community levels. Behavioral interventions (Stuart-Shor et al., 2012) are cutting-edge tactics to enhance the management of cardiovascular disease risk factors. By complementing cost-effective individual healthcare interventions with population-wide stroke prevention strategies, mobile-based applications could make a substantial impact on the global stroke epidemic.

1.4 Research Questions

This study attempted to answer the following questions:

(a) What are the requirements or components necessary in developing a mobile-based educational program?

(b) What are the insights and views from experts on the mobile-based educational program?

(c) What is the usability of a mobile-based educational program among people at risk of stroke?

(d) Is there any significant difference in knowledge of stroke prevention, lifestyle changes, and health-related quality of life among participants in the intervention group and control group?

1.5 Objectives of the Study

1.5.1 General Objectives

To develop and evaluate a mobile-based educational program on knowledge of stroke prevention, lifestyle changes, and health-related quality of life among middle-aged adults at risk of stroke in China.

1.5.2 Specific Objectives

Phase 1:

(a) To develop materials for the mobile-based educational program.

(b) To get insights and views from experts on the mobile-based educational program.

(c) To evaluate the usability of the mobile-based educational programs among the intervention group.

Phase 2:

(d) To evaluate the effects of the mobile-based educational program on knowledge of stroke prevention, lifestyle changes, and health-related quality of life among middle-aged adults at risk of stroke in China.

1.6 Significance of the Study

Stroke, a behavior-related disease, poses a significant global health challenge. The escalating stroke burden highlights the limitations of current primary stroke prevention methods, necessitating the exploration of impactful new strategies. Traditional face-to-face dietary health education encounters challenges like inconvenient transportation, high personal visit costs, and conflicts with medical treatment schedules. Mobile

applications, on the other hand, offer distinct advantages in information dissemination, patient monitoring, timely reminders, consultations, and communication.

In contemporary China, dietary shifts associated with increased affluence have substantially heightened stroke risk in recent decades, with this trend intensifying in recent years. The WeChat app, unrestricted by time or location, offers time-saving convenience and can alleviate the medical burden on patients. It allows them to access dietary health guidance from the comfort of their homes, facilitating the development of healthy eating habits and enhancing self-management skills. Additionally, mobile health applications can play a role in supporting global public health and may introduce a novel approach to clinical health management.

As a contemporary tool for guiding high-risk individuals toward healthier lives, mobile applications can provide patients with scientifically sound dietary management information. They can encourage self-management and self-support among high-risk groups, assisting patients in controlling factors like blood pressure, blood sugar, and weight, potentially reducing the risk of future strokes. In doing so, they indirectly alleviate the economic burden of stroke on our nation.

This study's objective is to create and assess an education-centered mobile application tailored for Chinese individuals at risk of stroke. If mobile health interventions prove effective, this research has the potential to provide a robust strategy for addressing the pressing need for healthier dietary habits while concurrently reducing stroke risk. Consequently, this endeavor could significantly enhance stroke prevention and management, ultimately contributing to improved public health outcomes.

1.7 Operational Definition

The following definitions are provided to clarify a better understanding of the important study variables and terms in this study.

1.7.1 Mobile Health

Mobile Health, also known as mHealth. The World Health Organization (Organization, 2011) defines mHealth as "medical and public health practice supported by mobile devices, such as mobile phones, patient monitoring devices, personal digital assistants, and other wireless devices".

1.7.2 Mobile-based Educational Program

Applications for cell phones and tablet PCs that provide health-related services are known as health apps. Health apps are a component of the shift in healthcare towards mobile health (mHealth) programmes because they allow patients to get care both at home and on the go (Xu & Liu, 2015). A mobile phone educational-based program will offer educational-related health services for smartphones.

1.7.3 Primary Stroke Prevention

Primary prevention refers to the active early intervention and prevention of risk factors of cerebrovascular disease to reduce the occurrence of stroke (Bronner et al., 1995). The updated guidelines for the primary prevention of stroke offer the most up-to-date, thorough evidence-based advice for primary stroke prevention. These recommendations cover both well-known stroke risk factors like obesity, diabetes, atrial fibrillation, hypertension, and metabolic syndrome as well as less well-known ones like migraine, metabolic syndrome, alcohol use, obstructive sleep apnea, inflammation, and infection. They also include interventional methods like asymptomatic carotid stenosis and antithrombotic treatments.

1.7.4 Stroke Related Knowledge

Improved stroke prevention could result from a greater public awareness of stroke prevention (Boden-Albala & Quarles, 2013). Nutrition, a low-salt diet, physical activity, quitting smoking, abstaining from alcohol, medication adherence, blood pressure checks, stroke warning signs, stroke risk factors, and pre-hospital delay awareness are some of these knowledge areas.

1.7.5 Healthy Lifestyle

A healthy lifestyle (Organization, 1999) is a manner of living that reduces the likelihood of becoming seriously ill or dying prematurely. Not all diseases are preventable, but many deaths, notably from coronary heart disease and lung cancer, can be averted. Scientific research has found specific patterns of behaviour that lead to the development of non-communicable diseases (NCDs) and premature death. Health is more than just avoiding disease. It also refers to physical, mental, and social well-being.

1.7.6 Dietary Adherence

Adherence (Cramer et al., 2008) is also called patient compliance and treatment compliance. It describes how people behave when they follow their doctor's instructions and treat them as prescribed. It is customary to call the patient “cooperation”; otherwise, it is called non-compliance. Dietary adherence refers to the degree to which the patient's dietary behavior is consistent with the doctor's advice during the treatment of the disease.

1.7.7 Physical Activity

Physical activity (PA) is described as any physiological movement resulting from skeletal muscle contraction that requires energy expenditure (Organization, 2023). It encompasses exercise as well as other physical activities such as playing, working, active transportation, housework, and recreation.

1.7.8 Health-related Quality of Life

Health-related quality of life refers to an individual's satisfaction with the important parts of life affected by health. It pays more attention to reflecting the patient's point of view. It is an important measure for the study of chronic diseases, covering physical function activities, social interactions, daily living skills, Emotional state, physiological state, and many other aspects (Karimi & Brazier, 2016).

1.7.9 Middle-aged Adults

Middle age is the life stage that falls between young adulthood and the onset of old age. Defining middle age precisely lacks universal consensus, and its exact range is a subject of academic debate. However, it is commonly understood to encompass the age range from approximately 40–45 to around 60–65 (Wikipedia, 2023). Following the "Law of the People's Republic of China on the Protection of the Rights and Interests of the Elderly," individuals aged 60 and above are considered elderly. Therefore, for this study, middle-aged individuals are defined as those between 45 and 59 years old.

1.8 Summary

This chapter offers valuable background information crucial for the development of a mobile-based educational program targeting middle-aged adults at risk of stroke in China. Given the high incidence of stroke in China, coupled with the significant prevalence of stroke-related disabilities and mortality, the emphasis on stroke prevention takes precedence over treatment. The research problem is systematically addressed through a series of well-crafted research questions and objectives. These defined terms provide the researcher with a clear and structured approach to tackling the problem. The main goal of this research is to create and evaluate a mobile education programme for Chinese citizens who are at risk, with an emphasis on how it will affect participants in the intervention and control groups' understanding of stroke prevention,

changes in lifestyles, and health-related quality of life. Should mobile health interventions prove effective, this research has the potential to offer a robust strategy for promoting healthier dietary habits while concurrently reducing the risk of stroke. As a result, this endeavor holds the promise of substantial benefits in terms of stroke prevention and management, ultimately contributing to improved public health outcomes.

CHAPTER 2: LITERATURE REVIEW

2.1 Introduction

Detailed descriptions of the literature search strategies were provided in this chapter. It then discussed the contents of the literature review, these include mobile technology for risk assessment on stroke prevention, the relationship between primary stroke prevention and healthy lifestyle (including dietary and physical activity), effects of mobile-based behavior intervention on multifaceted lifestyle (containing dietary and physical activity), gaps in the literature. Following this, this chapter explained the study's conceptual framework.

2.2 Search Strategies and Literature Screening

The review process began with a search for relevant literature in electronic databases to which the University of Malaya subscribes as part of digital library services. CINAHL, Embase, Web of Science, CNKI, and PubMed were the main databases used for this review. The search phrases were combined with the Boolean operators 'AND' and 'OR' to narrow and broaden the results.

Three main concepts were searched: mobile applications, healthy lifestyle, and primary stroke prevention. The PICO format (P = population with cardiovascular risks, I = mobile application, C =control, O = outcomes) was used to formulate the research question.

The search strategies used were following keywords: (Stroke OR "Disease Prevention, Primary" OR "primary prevention" OR "primary stroke prevention" OR "risk factors") AND ("health promotion" OR "health behaviors" OR "behavior change" OR "healthy lifestyle" OR diet OR "healthy diet" OR exercise OR "physical activity") AND ("mobile applications" OR "Digital Technology" "Telemedicine" OR "digital technolog*" OR "electronic technolog*" OR "mobile technolog*" OR "digital health"

OR Smartphone OR “mobile phone” OR “mHealth” OR “mobile health” OR App OR apps OR “mobile app*” OR “smartphone app*” OR “text messaging”) AND (“Quality of life” OR “health-related quality of life” OR “HRQOL”). Titles of items searched and screened from the database were viewed, in the full-text articles.

Inclusion criteria: (a) English or Chinese articles published from the establishment of the database until now; (b) Research on first-level prevention-related Apps; (c) Articles limited to Chinese or English language.

Exclusion criteria: (a) Review and protocol studies; (b) Studies with titles or abstracts only, without full-text access; (c) Full-text available but significant data missing; (d) Non-APP health intervention methods.

2.3 The Relationship between Stroke Prevention and a Healthy Lifestyle

Maintaining a healthy lifestyle dramatically lowers the chance of stroke. The main components of a healthy lifestyle are abstaining from smoking, excessive alcohol use, being overweight, eating unhealthy food, and not exercising.

2.3.1 Primary Stroke Prevention and Healthy Diet

Diet plays an important influence in the development and prevention of cardiovascular disease, the leading cause of death worldwide (Hooper et al., 2001). Dietary hazards have emerged as the primary factor contributing to NCDs, representing 12.2% of disability-adjusted life years (DALYs) for men and 9.0% for women (Afshin et al., 2019).

Dietary patterns have been extensively employed to ascertain customary assortments of foods, which have been linked to the risk of stroke and mortality in populations from the United States and Europe. The lifestyle management or cardiovascular disease prevention guidelines in European and American countries recommend the (a)

Mediterranean diet (Mediterranean style dietary) or the dietary approaches to stop (b) hypertension (DASH) diet (Feng et al., 2018), which helps prevent or manage hypertension, Dyslipidemia helps control weight, blood sugar and prevent stroke. These dietary patterns encourage higher consumption of potassium and lower consumption of sodium, resulting in decreased blood pressure and a lowered risk of stroke (Kris-Etherton et al., 2009), it is suggested (Class I, Level of Evidence A) to consume diets that are rich in vegetables, fruits, nuts, low-fat dairy products, and low in saturated fat to decrease the likelihood of experiencing a stroke.

According to current nutrition and disease research findings, the Mediterranean diet promotes the consumption of more fresh vegetables and fruits (especially green vegetables), whole grains, and fish (particularly fish rich in omega-3 fatty acids); a limited intake of red meat; the use of low-fat or skim dairy products in place of high-fat dairy products; the consumption of olive oil, nuts, and other foods. Along with emphasizing vegetables, fruits, and whole grains, the Mediterranean diet also features a limited intake of dairy products, a high content of healthy oils (olive and canola), and a relatively low amount of animal flesh (Spence, 2018).

A Mediterranean diet has been shown in studies to lower the risk of heart disease, prevent vascular damage to the brain, lower the risk of stroke, and improve memory (Gardener et al., 2011; Lakkur & Judd, 2015). In a study of a population at high risk of cardiovascular disease in Spain (Estruch et al., 2018), the non-calorie Mediterranean diet plus nuts (walnuts, hazelnuts, and American almonds) diet intervention group reduced the risk of stroke by 28% compared with the control group. If you change to extra virgin olive oil reduces the risk of stroke by 31%. In the study of the British cohort population, it is confirmed that the risk of stroke is reduced by about 17% in those who strictly follow the Mediterranean diet, especially women (Paterson et al., 2018). The

“Mediterranean diet" is now also used to refer to a healthy, simple, light, and nutritious diet.

In addition to the Mediterranean diet, the DASH diet is also one of the best diet patterns for stroke prevention, which has also been proven to be effective in preventing stroke (Fung et al., 2008). The DASH diet was developed in 1997 as part of a massive American programme to prevent and treat hypertension (Blackburn, 1997). The DASH diet is a consumption pattern that is high in fruits, vegetables, whole grain foods, low-fat dairy, and low in red meat, saturated fat, sugar-sweetened beverages, and sodium. Blood pressure is one of the main risk factors for cardiovascular diseases, and this diet is known to significantly lower blood pressure. Specifically, the DASH diet encourages the consumption of a range of nutrients, focusing on consuming more magnesium, potassium, and calcium while consuming less cholesterol and saturated fat (Sacks et al., 2001).

It was shown that if you can reduce the quantity of fat (especially animal fats rich in saturated fatty acids) in your diet and consume enough fruits, vegetables, and low-fat (or skim) milk, you can maintain your plasma intake of potassium, magnesium, and calcium, low salt, less intake of sweets, sugary drinks, red meat can effectively lower blood pressure (Bai et al., 2017; Saneei et al., 2014).

Observational studies have shown that some nutrients in the diet are related to the risk of stroke (Bernstein et al., 2012; Hallgren et al., 2001). Using a 24-hour diet review method, a 19-year cohort follow-up of 14407 subjects aged 25 to 74 years found that the daily intake of 2.3 g (100 mmol) of dietary sodium in overweight people increased the risk of death from stroke by 89%, the risk of morbidity increased by 32%, and the effect of this dietary sodium intake on the risk of stroke morbidity and death is independent of the baseline systolic blood pressure level (Hooper et al., 1996).

According to estimates from the INTEREST (International Study of Salt and Blood Pressure) study, the average drop in blood pressure from age 25 to 55 would be 9.0 mmHg for systolic and 4.5 mmHg for diastolic pressure with a 100 mmol reduced daily sodium intake (Group, 1988). Japan has a greater stroke incidence than other countries, in part due to the country's higher salt intake and higher frequency of hypertension. Sodium consumption was progressively linked to death from ischemic stroke (hazard ratio 2.0, 95% confidence interval (CI) 1.4-2.9), stroke (hazard ratio 1.6, 95% CI 1.2-2.0), and cardiovascular disease (hazard ratio 1.4, 95% CI 1.2-1.7) in a sizable Japanese general population (Umesawa et al., 2008).

A meta-analysis of more than 240,000 people in 15 cohorts found that a daily potassium intake of 1.64 g (42 mmol/d) can reduce the risk of stroke by 21% (D'Elia et al., 2011). Compared with people who hardly eat fish, people who eat fish $\geqslant$5 times a week have a 31% lower risk of stroke (He et al., 2004). There is a significant negative correlation between the intake of fruits and vegetables and the risk of stroke. Compared with the low intake of fruits and vegetables, the risk of ischemic stroke in the highest intake group was reduced by 31%, people who consume less than 3 servings of fruits and vegetables per day have a much lower risk of ischemic stroke (Gao et al., 2021).

The "Dietary Guidelines for Chinese Residents" are developed based on country conditions and nutrition concepts. Its purpose is to inform individuals on how to eat a fair, balanced diet to maintain good health. The Pagoda of Balanced Diet for Chinese Residents (Wang et al., 2018) is designed according to Chinese Residents' Dietary Guidelines and the characteristics of Chinese residents' dietary structure (Lin et al., 2013). It converts the principle of a balanced diet into the weight of various foods and expresses it in the form of an intuitive pagoda (Ge, 2011), which is convenient for the masses to understand and implement in their daily lives. The Balanced Diet Pagoda is

structured into five tiers, each representing essential food groups recommended for daily consumption. The placement and size of each tier in the pagoda reflect the significance and proportion of various foods in a healthy diet. At the base, cereal foods form the foundation, with a daily recommended intake of 300-500 grams. The second tier consists of vegetables and fruits, advocating for daily consumption of 400-500 grams and 100-200 grams, respectively. The recommended daily consumption for the third tier, which includes fish, poultry, meat, and eggs, is 125–200 grammes (50 grammes for fish and prawns, 50–100 grammes for livestock and poultry meat, and 25–50 grammes for eggs). The fourth tier, which is made up of milk and legumes, emphasises consuming 100 grammes of dairy products and 50 grammes of beans and soy products per day. Finally, the fifth tier represents fats, with a recommended daily limit of no more than 25 grams (Ge et al., 2007).

2.3.2 Primary Stroke Prevention and Physical Activity

Exercise and other forms of physical activity are widely recognised as viable behavioural strategies for stroke prevention (Billinger et al., 2014). A review underscores the substantial preventive impact of physical activity and exercise in reducing the recurrence of strokes (Gordon et al., 2004). A substantial body of evidence reinforces the significance of physical activity as a vital element in primary stroke prevention strategies. Frequent exercise is widely recognised for its many health advantages, which include lowering the risk of hypertension (Chakravarthy et al., 2002), type 2 diabetes mellitus (Hamasaki, 2016), depression (Kim, 2022), and obesity (Fox & Hillsdon, 2007), and aiding in the management of these risk factors.

In the WHO's guidelines for physical activity, the maxim "more is better" is applied. It is recommended that adults, elderly persons, and those with chronic illnesses partake in 150–300 minutes a week of moderate–to–intense physical activity. Additionally, it is

recommended to perform muscle-strengthening activities at least twice per week and to limit sedentary time, especially when it comes to screen time (Bull et al., 2020). Exercise is an effective preventive measure against obesity for almost all individuals who are willing to engage in it. The CDC has discovered that primary prevention of overweight/obesity also decreases the likelihood of developing several other health conditions, such as stroke.

The ideal quantity of physical activity (PA) within a healthy lifestyle was determined to be at least 30 minutes per day of moderate or strenuous activity. This determination was made using a self-administered questionnaire that asked about the frequency of PA throughout the preceding year (Chiuve et al., 2008). Within the Sweden Mammography Cohort, which consists of 31,696 women, a healthy level of physical activity is defined as engaging in low and moderate-intensity activities, such as walking or cycling, for a minimum of 40 minutes per day. Additionally, it involves participating in at least 1 hour of structured exercise per week (Larsson et al., 2014). An extensive meta-analysis of 23 research revealed a significant correlation between engaging in moderate to high levels of physical exercise and a decreased likelihood of experiencing overall stroke, as well as ischemic and hemorrhagic stroke. Restricting the analysis to prospective cohort studies, it was shown that individuals who engaged in high or moderate levels of physical activity had a 25% or 17% reduced risk of stroke incidence or mortality, respectively, compared to those who were sedentary (Iaccarino et al., 2005).

The American Stroke Association noted that physical activity “reduces blood pressure, improves endothelial function, reduces insulin resistance, improves lipid metabolism, and may help reduce weight” (Howard & McDonnell, 2015). Some large-scale observational studies (Kesäniemi et al., 2010) have shown a dose-response risk

decrease for stroke with physical activity intensity and duration, or between fit and highly active individuals and unfit individuals.

Quantifying the influence of physical activity (PA) on the likelihood of experiencing a stroke is challenging due to the tendency for PA to frequently coexist with other favorable lifestyle factors, such as a nutritious diet, abstaining from smoking, and keeping a healthy body weight. PA is thought to decrease the risk of stroke by positively influencing these additional factors that contribute to stroke risk. When examining the 10 modifiable risk factors identified in international case-control research as responsible for 90% of the risk of stroke, physical activity (PA) has been shown to have a favorable impact on at least 3 of these factors: Hypertension, diabetes mellitus, and adiposity (O'donnell et al., 2010).

2.4 Effects of Mobile-based Behavior Intervention on Dietary

Diet has a crucial role in stroke prevention due to our frequent consumption of three meals every day. As stated in the Introduction, the subsequent dietary parameters have been associated with stroke prevention: lowering salt consumption, increasing consumption of fruits and vegetables, and reducing intake of saturated and overall fats.

The correlation between elevated blood pressure (BP) and sodium consumption is generally acknowledged. It has been seen that reducing dietary sodium over an extended period leads to a decrease in BP, irrespective of an individual's hypertension status, gender, ethnic background, or usage of medication to lower BP.

Non-communicable diseases (NCDs) stand out as leading contributors to global mortality, surpassing the cumulative impact of all other causes. Within this epidemiological context, a controlled parallel intervention study (Jarrar et al., 2022) conducted by Jarrar et al. in 2022 offers valuable insights into potential strategies for

NCD prevention. This study, executed with a randomized distribution of participants into three groups—Control, WhatsApp, and Electronic Brochures—spanned 6 weeks in 2020. Throughout the intervention, a systematic dissemination of educational materials occurred among participants in the WhatsApp and Electronic Brochures groups. The study's findings illuminated a noteworthy reduction in sodium levels for both intervention groups. Specifically, the WhatsApp group exhibited a substantial decrease of 278 mg ($p < 0.001$), while the Electronic Brochures group demonstrated a reduction of 169 mg ($p < 0.018$). In contrast, the Control group did not exhibit any statistically significant changes. Moreover, the intervention's culmination witnessed a significant reduction in the percentage of participants surpassing the World Health Organization (WHO) recommendations for sodium intake ($p = 0.004$). Notably, the WhatsApp group exhibited superior efficacy in reducing the percentage of participants surpassing the WHO recommendations when compared to the baseline, with a p-value of 0.023. This study goes beyond a mere reporting of findings and invites a critical examination of the efficacy of digital platforms, such as WhatsApp and Electronic Brochures, in achieving salt reduction goals within the broader context of NCD prevention.

The principal objective of the Salt Alternatives Study (SALTS) was to examine the effects on the estimated 24-hour urine sodium excretion in people with hypertension of an intervention lasting twelve weeks using a salt-reduction package. The sodium-reduction intervention package was randomly allocated to eligible participants in a 1:1 ratio. The control intervention, on the other hand, comprised general information about heart-healthy eating. Critically examining the trial findings, it becomes apparent that there is a notable absence of clear evidence supporting the effectiveness of the salt-reduction intervention package, incorporating a smartphone app and RSS. This lack of effectiveness is evident in its influence on estimated 24-hour sodium excretion and any assessed secondary outcomes in adults with high blood pressure. The trial encountered

challenges related to the implementation of trial technologies and was underpowered, partially owing to the COVID-19 pandemic's effects. This underpowering introduces the possibility that a genuine effect might have gone undetected, underscoring the limitations and potential biases inherent in the study's design and execution (Eyles et al., 2023).

A higher fruit and vegetable diet is associated with lower risks of stroke, cancer, heart disease, and overall mortality (Aune et al., 2017). There is a suggestion that the protective effects of consuming vegetables are more significant compared to fruits. Furthermore, these advantages are observed to increase with the amount consumed, following a dose-response relationship. The benefits are observed with a consumption of at least 7 or more servings per day (Joshipura et al., 1999). Numerous compelling studies have explored the effectiveness of mobile applications as a targeted tool for enhancing vegetable consumption, particularly within the context of overweight adults. One notable investigation involved the implementation of the Vegethon mobile app—a theory-based application that facilitated goal setting, self-monitoring, and feedback, incorporating "process motivators" such as fun, surprise, choice, control, social comparison, and competition. Through random assignment, participants were allocated to either the stand-alone Vegethon mobile app or a wait-listed control condition. Significantly higher vegetable consumption was observed among participants in the intervention group compared to the control condition after the 12-week pilot study. The Vegethon mobile app demonstrated both initial efficacy and user acceptability. These encouraging results imply that, even in the context of maintaining weight loss, a mobile app intervention may be able to successfully increase vegetable consumption among overweight individuals. Importantly, the observed increases in vegetable consumption hint at the possibility of influencing overall diet composition and contributing to weight loss. This underscores the need for further research to explore and substantiate the long-

term impact and broader implications of mobile app interventions in promoting dietary improvements among this population. (Mummah et al., 2016).

Elbert et al (2016) conducted a randomised controlled study to assess the effectiveness of a 6-month intervention delivered using a mobile phone app. The intervention included individualised health information, either in the form of text or audio, to encourage individuals to consume more fruits and vegetables. Upon installing the mobile phone app, participants were regularly exposed to personalised health information and feedback, either in the form of text or audio, every month for 6 months. Furthermore, participants in the control group alone completed the initial and final assessments. Our primary outcome measure in this study was the amount of fruits and vegetables self-reportedly consumed. at the 6-month follow-up, which was obtained from a community sample recruited online. An important result was observed regarding the impact of the condition on fruit intake (P=.049, partial $\eta 2$=0.04). Following exposure to auditory information, individuals with poor perceived health showed a significant increase in fruit consumption (P=.003, partial $\eta 2$=0.08). Furthermore, the impact of the condition on vegetable intake 6 months later was influenced by health literacy, with a significant effect (P<.001, partial $\eta 2$=.11). Recipients with high health literacy who were exposed to either the textual or aural intervention had a greater consumption of vegetables in contrast to those under the control setting.

2.5 Effects of Mobile-based Behavior Intervention on Physical Activity

Stroke prevention is deemed to be more efficacious than stroke treatment (Pandian et al., 2018). Physical activity is widely recognised as one of the most recommended techniques of prevention. In a medically underserved rural population with a high prevalence of metabolic syndrome (MS), the Diabetes and Technology for Increased Activity study set out to evaluate the effectiveness of a lifestyle intervention involving

self-monitoring of blood glucose (BG), blood pressure (BP), physical activity (PA), and weight in improving cardiovascular disease (CVD) risk factors. Physical activity is one of the preventative strategies that is most frequently mentioned. To evaluate the efficacy of a lifestyle intervention on CVD risk factors in a medically underserved rural population with a high incidence of metabolic syndrome (MS) by having participants self-monitor their blood pressure, weight, physical activity, and blood glucose. A total of twenty-four individuals, ranging in age from 30 to 71 years, successfully finished the 8-week intervention. Participants saw notable enhancements in the clinical indicators ($p = .046$) and self-measured diastolic blood pressure ($p = .001$), body mass index ($p = .002$), total cholesterol ($p = .009$), and daily step count. The daily physical activity (PA) levels rose, along with the participants' enthusiasm and readiness to adopt lifestyle modifications that influence health results. The study revealed that the participants' cardiovascular disease (CVD) risk profile was enhanced through self-monitoring of multiple sclerosis (MS) risk factors and increased physical activity (PA). The findings of this intervention, which lasted for 8 weeks, are promising. The utilisation of learning and technological advances as instruments in this lifestyle intervention validates the effectiveness of remote health monitoring (Stuckey et al., 2011).

Strong evidence indicates that increasing physical activity (PA) and cardiorespiratory fitness (CRF) lowers the risk of cardiovascular disease. Of the sixty-three healthy participants who signed up, eighteen assessed the Cardio-Fitness App's (CF-App) user interface, and forty-five participated in a two-week intervention. Thirty-three members of the latter group finished the intervention satisfactorily, demonstrating the effectiveness of a programme with scientific backing that aims to improve CRF and PA. A freely available, user-friendly smartphone app was used to implement the programme. The purpose of the study was to find out if this kind of strategy might indeed raise CRF. The results showed that an app-based intervention with a 10,000-step-per-day goal

improved CRF in a way that was comparable to a programme based on ACSM standards. This was seen regardless of whether supervised gym sessions or a mobile app were used to carry out the programme. Furthermore, HR-based training demonstrated an equivalent improvement in CRF compared to steps-based training, however with a greater number of heartbeats within the training zone for the same amount of steps per day as Step-based training (Rospo et al., 2016).

2.6 Effects of Mobile-based Behavior Intervention on Multifaceted Lifestyle

The exploration of information communication technologies for addressing obesity has gained substantial attention. A smartphone-delivered intervention stands out as a promising avenue, offering a convenient, potentially cost-effective, and widely accessible strategy for weight management. In the evaluation of the MMM app, the selection of an Android operating system reflects a deliberate choice to facilitate testing on contemporary and widely used mobile devices. This app incorporates a range of features, including goal setting, self-monitoring of dietary and physical activity behaviors, and the delivery of feedback through weekly text messages. In contrast, the website group interacted with an established commercially available weight management website provided by Weight Loss Resources, complemented using paper diaries. Despite the comparator groups implementing a self-monitoring intervention like the app, they employed different delivery methods. The trial's 6-month duration featured both intervention and comparator groups operating in a self-directed manner, without ongoing human input from the research team. In-person interactions were restricted to baseline recruitment and quick follow-ups at six weeks and six months, mostly for the administration of questionnaires and anthropometric measures. This pilot trial, focusing on an app for weight loss on smartphones, goes beyond reporting its findings to reveal insights into the intervention's acceptability and feasibility. Critically, adherence to both the intervention and the trial was notably higher in the smartphone group compared to

the comparator groups, indicating a potential preference for the mobile app. The app garnered favorable ratings in terms of satisfaction and acceptability, suggesting positive user experiences. However, a more nuanced critique might delve into potential limitations, such as the generalizability of findings and the impact of self-directed interventions on long-term behavior change. (Carter et al., 2013).

Safran Naimark and their colleagues assessed the effectiveness of a recently introduced web-based application designed to encourage healthy lifestyles and provide education on this topic for adults. They also conducted an examination to identify factors that predict success in adopting and maintaining a healthy lifestyle. Weight and waist circumference measurements, among other characteristics, were taken from participants at the start and end of a 14-week study. Online questionnaires were used to collect information on physical activity duration, food quality, and nutritional awareness. The outcomes showed that throughout the 14-week intervention, the recently created web-based programme had a favourable effect on several kinds of lifestyle markers. Although these results show promise for the app's ability to encourage healthy living, more thorough and prolonged research is required to reach more firm conclusions (Safran Naimark et al., 2015).

The mobile phone application, MyBehavior, has been intricately designed with the primary goal of processing tracked data related to physical activity and eating behaviors, delivering users personalized, practical, and convenient recommendations tailored to their surroundings and past behavior. This versatile application has multiple purposes, utilising both automated and manual recording to track a range of physical activities like walking, jogging, and gym visits. It also monitors user location and dietary intake. MyBehavior, to distinguish between frequent and infrequent behaviors, automatically analyzes logs of activities and food consumption. To provide customised

recommendations, the programme cleverly employs the multi-armed bandit (MAB), a common machine-learning decision-making technique. In order to help users reach their behavioural objectives, these recommendations encourage people to either stick with their current behaviours, refrain from doing specific things, or make little changes. In a randomized trial involving two groups, participants were randomly assigned to either receive personalized suggestions from MyBehavior (n=9) or non-personalized recommendations (n=8) created by professionals through a mobile phone app over 3 weeks. Daily activity levels and dietary intake were meticulously tracked through logged data, and at the study's conclusion, an in-person survey was conducted to gauge users' subjective intention to follow MyBehavior's suggestions. Qualitative data from daily diaries, interviews, and surveys indicated that users found MyBehavior's recommendations highly actionable, expressing their intention to follow them. While during the three-week trial, MyBehavior users showed a statistically significant increase in walking (P=.05) in comparison to the control group; however, there was no statistically significant difference in dietary choices, specifically choosing lower-calorie items (P=.15). In a post-study poll, consumers consistently judged MyBehavior's personalised ideas more favourably than the non-personalized advice given by professionals (P<.001). MyBehavior stands as a pioneering effort in the automatic development of personalised, context-aware, and actionable recommendations based on self-tracked information, encompassing both manual food logging and automated tracking of physical activity. The study not only highlights the application's effectiveness but also provides critical insights into the challenges of manual logging and usability concerns, laying a foundation for potential future directions. However, a more critical examination might delve into the generalizability of the findings, potential biases in user self-reporting, and the sustainability of behavioral changes beyond the study period (Rabbi et al., 2015).

To ascertain whether using a year-long, smartphone-based self-management program, either with or without phone health counseling by a diabetes specialist nurse for the first four months, could improve glycated haemoglobin A1c (HbA1c) level, self-management, and health-related quality of life compared with usual care, Holmen et al. (2014) conducted a 3-arm prospective randomised controlled trial with two intervention groups and one control group. Participants in the study were required to have type 2 diabetes and be at least eighteen years old, with an HbA1c level of ⩾7.1% (⩾54.1 mmol/mol). A software for self-management on mobile devices called The Few Touch Application (FTA) was supplied to both intervention groups. The FTA included a blood glucose-measuring device with wireless data transfer that was automatic, a nutrition guide, a physical activity tracker, and a personal goal management system. All these features were recorded and managed through the use of a diabetic diary app on a smartphone. After a year, follow-up information was provided for 120 individuals (79%). After a year, the HbA1c level dropped in each group but did not change between them. After correcting for age, gender, and education, the FTA-HC group's mean change in heiQ domain skills and technique learning was considerably higher (P=.04). After a year, there was no difference between the groups' other secondary outcomes. 39% of the FTA group and 34% of the FTA-HC group, respectively, were heavy users of the app. The app was used more by those over 63 than by those under that age (OR 2.7; 95% CI 1.02-7.12; P=.045).

2.7 Mobile Technology for Risk Assessment on Stroke Prevention

New primary preventive measures with greater effect sizes are required, as the increasing worldwide stroke burden strongly shows that the present primary prevention strategies are not effective enough (Rahmawati et al., 2020). According to recent research, the worldwide burden of stroke and CVD may be reduced by bridging the gap between population-wide and high-risk preventative initiatives and enabling people to

use increasingly ubiquitous mobile devices to reduce their risk of stroke or CVD. An app-based primary prevention strategy carries almost no cost, and there are no unfavourable stakeholders that could sway the person's decision to lower their risk of contracting a disease. On the other hand, there are some expenses linked to the execution of primary preventive measures that apply to the entire community, and there are substantial expenditures involved in screening the population before implementing high-risk prevention techniques (Feigin & Norrving, 2014).

These inadequacies in primary stroke prevention were addressed with the creation of the Stroke Riskometer App as a unique, validated, and evidence-based tool that targets the several risk factors linked to the total risk of stroke (Parmar et al., 2015). The Auckland University of Technology in Auckland, New Zealand is the developer and owner of it. The verified Stroke Riskometer app is an illustration of this tactic; it has been approved by numerous national stroke organisations, such as the National Russian Organisation for the Fight Against Stroke, the Australian Stroke Foundation, and the China Stroke Association, in addition to major international organisations.

A new approach called 'mass-elevated risk stroke/cardiovascular disease prevention' is being advocated as an addition to the current absolute risk stroke/cardiovascular disease prevention approach, based on the developed Stroke Riskometer app. This novel approach has two key aspects. First of all, by utilizing cutting-edge mobile technologies, people can determine their precise risk of having a stroke within the next five to ten years and contrast it with the risk of people their age and gender who do not have any risk factors. Secondly, it incorporates personalized self-management strategies to actively involve the individual in stroke/cardiovascular disease prevention, tailored to their specific risk profile. This innovative strategy opens the possibility of creating similar preventative approaches for other non-communicable

diseases for which there are solid predictive models and guidelines for prevention. Implementing such strategies could significantly alleviate the global burden of non-communicable diseases. People are encouraged to lower their risk of stroke by using the app, which not only gives them knowledge of their absolute risk but also their relative risk of getting one within the next five to ten years. The app indicates a noticeably increased relative risk of stroke, which may be enough to encourage individuals who do not currently have cardiovascular disease to lower their risk, as 78% of adults without CVD have at least two modifiable CVD risk factors, such as blood pressure, cholesterol levels, glucose, body mass index, tobacco use, exercise, or diet. With translations into the most widely spoken languages in the world (covering over 90% of the global population), the smartphone application has a chance to save millions of lives by helping users reduce their risk of stroke and other serious non-communicable diseases (NCDs) like diabetes mellitus, ischemic heart disease, and dementia that have similar risk factors to stroke. It has been proposed that reducing the risk of cancer and other chronic diseases will also result in better CVD health through improved control of CVD risk factors. A motivated population-wide approach like this could turn the tide in primary prevention of CVD and stroke as well as other NCDs globally. We think that the app's efficacy in preventing stroke and other significant NCDs that have similar risk factors to stroke would be comparable to the mass method.

The Stroke Riskometer app is currently undergoing a global pilot in a randomized controlled trial with more than 300 collaborators in over 100 countries. Rita Krishnamurthi et al. conducted a 2-arm prospective, parallel, open-label pilot randomized controlled experiment to demonstrate the concept (Krishnamurthi et al., 2019). A research assistant who was blind to the group allocation administered the tests over the phone or in person at baseline, three, and six months. The results demonstrated that the Stroke Riskometer App is practical for stroke prevention in a high-income

nation with a diverse ethnic population, based on a fully randomised controlled experiment. The Stroke Riskometer app will enable tailored primary prevention of stroke and related health conditions thanks to recent developments in telecommunications and mobile technologies. This could potentially reach a sizable portion of the Chinese population and lessen the country's NCD burden. By using this app, users in the Chinese population may be able to lower their risk of stroke and significantly lower the country's stroke burden (Feigin et al., 2015).

The Mobile-Stroke Risk Scale and Life Style Guidance is another straightforward, free, and freely available progressive web application that can be loaded on a smartphone or viewed through a website (MSRSguide). It gives people access to media that provides general information on strokes as well as details about the symptoms and signs of the condition, early at-home stroke treatment, post-stroke rehabilitation, and health programmes offered by the public health centres or hospitals closest to their homes (Dharma & Parellangi, 2020). M-SRSguide is a useful tool for encouraging a healthy lifestyle. This study finds that at-risk individuals' risk factors for stroke are reduced and their adoption of healthy lifestyles is promoted by using the M-SRSguide application and handbook for self-assessment of stroke risk as well as basic information about strokes. However, compared to using the handbook among those who are at risk, using the M-SRSguide is more effective in promoting healthy behaviours and lowering stroke risk factors.

These apps have the potential to be useful instruments for self-care and as educational resources for stroke-risk individuals. The use of mobile applications for primary stroke prevention will get more and more attention as people's awareness of mobile health grows.

2.8 Evaluation of the Assessment Tools

People with chronic diseases are often required to make changes in their diets and lifestyle. When it comes to preventing chronic diseases, one of the most practical and economical preventive methods is teaching healthy lifestyles. They are also evidence-based, reasonably priced therapy approaches for the management of numerous chronic illnesses. Changes in nutritional consumption and constructive physical activity, as well as lifestyle education or counseling treatments, are responsible for the good results.

The effectiveness of mobile interventions using a fully automated mobile healthy lifestyle application on lifestyle change outcomes, which included dietary behaviors such as nutrition scores and dietary compliance, active physical activity, and health-related outcomes such as body mass index (BMI), clinical metabolic parameters and health-related quality of life, and for knowledge of stroke prevention (Fakih El Khoury et al., 2019). The researcher of this study applied dietary compliance, physical activity, health-related quality of life, and knowledge of stroke prevention to evaluate the mobile-based educational program.

2.8.1 Assessment Tools Related to Dietary Adherence

Dietary adherence refers to the degree to which the patient's dietary behavior (Turrell, 1997) is consistent with the doctor's advice during the treatment of the disease. It is well known that a patient's health and wellness can be seriously jeopardised by noncompliance and that following dietary recommendations is essential to both avoiding and treating chronic illnesses.

A meta-analysis of cohort studies has demonstrated a notable reduction in cardiovascular disease (CVD) risk within the general population associated with higher adherence to a healthy diet, with a combined risk ratio of 0.78 (95% confidence interval: 0.75 to 0.81) (Schwingshackl et al., 2018). Despite the growing recognition that non-

adherence to dietary recommendations acts as a barrier to translating new nutritional knowledge into practical use, prior knowledge syntheses have offered limited actionable guidance to decision-makers and knowledge users for the development of effective interventions aimed at improving adherence to dietary advice (Arvaniti & Panagiotakos, 2008).

While more objective measures of dietary adherence do exist, they are often underutilized. For example, 24-hour urine salt excretion can be used to evaluate diet adherence to low sodium (Chung 2008), but there is currently no universally accepted gold standard for precisely determining dietary intake. Self-reporting energy intake is a common practice in nutrition-related research and has been shown to underestimate actual intake when compared to more objective measures such as resting energy expenditure assessed through indirect calorimetry (Mossavar-Rahmani et al., 2013). Underreporting of energy intake is more frequently observed in specific demographic groups, such as women versus men (Johnson et al., 1994), older individuals versus younger ones (Howarth et al., 2005), and obese individuals versus those with normal weight (Pikholz et al., 2004). Even though self-report measures are frequently subject to several biases, like dependence on memories, reporting errors regarding food composition and size of portions, everyday food choice variations, and social desirability, they are still an easy, practical, and affordable approach. Commonly employed dietary survey methods include dietary recall and food frequency questionnaires.

The 24-hour dietary recall method involves collecting precise information about an individual's food intake from the previous day or within the hour before the survey. This information is then summarized and used to estimate the average food and nutrient intake for a group of people (Pikholz et al., 2004). Currently, it is the most widely

employed dietary survey method in research. Its applicability spans various age groups, from preschool children to the elderly, and numerous research reports demonstrate its reliability and validity. Compared to the food frequency questionnaire method, this approach offers higher accuracy and imposes fewer restrictions on the research subjects. Many food frequency questionnaires are evaluated for reliability and validity with multiple 24-hour dietary recall methods serving as the reference standard (Casey et al., 1999). However, the limitation of this method lies in its focus on a specific time, typically the hour before the survey. While it provides precise quantitative data reflecting recent dietary intake, a single survey may not suffice to capture the habitual dietary patterns of the research subjects. Hence, it is common practice to conduct multiple dietary recalls with participants to obtain a more accurate representation of their usual intake. To ensure a reliable estimate of dietary intake, it is essential to conduct dietary reviews over an adequate number of days.

Food frequency questionnaires can be divided into qualitative, quantitative, or semi-quantitative types (Cade et al., 2002). Qualitative food frequency questionnaires usually only get the number of times each food is eaten in a specific period, without collecting data on the size of food share or food intake; quantitative food frequency questionnaires require subjects to provide the weight of the food eaten; The semi-quantitative food frequency questionnaire needs to collect data on the food intake per unit time (such as monthly, weekly, daily, etc.) from the research subjects, and generally provide the research subjects with the size of the standard or average food share during the survey (Sampson, 1985). Compared with other dietary survey methods, the food frequency questionnaire method focuses more on the measurement of long-term exposure, so that rough, total, and general information can be obtained over a long period, rather than the measurement of the intake of certain meals on certain days, because for any person, it is easier to describe the frequency of foods they usually

consume than to describe a specific food they have consumed at a certain time in the past. The food frequency questionnaire method has been widely used and promoted in research. Although the food frequency questionnaire method can obtain the usual dietary intake, the operation is simple, the burden on the subjects is light, and the response rate is high, but due to the influence of recall bias, its accuracy in estimating food intake is lower than dietary intake. Diary method and hourly meal review method.

In conclusion, it's important to recognize that each dietary survey method comes with its own set of advantages and limitations, and there's no one-size-fits-all approach that can fulfill the requirements of every research study. To address the limitations of a single method, researchers often opt to combine two or more methods, as suggested by Willett (Willett, 1994). In selecting the most suitable dietary assessment methods for a specific study, factors such as the research objectives, the characteristics of the study population, the precision needed in dietary measurements, available funding, and the duration of the study should all be considered. In the context of this study, and given the constraints related to time, human resources, materials, and financial resources, the food frequency questionnaire method was employed to conduct dietary surveys.

2.8.2 Assessment Tools Related to Physical Activity

The physical activity questionnaire stands out as the most prevalent and practical method for appraising physical activity within the realm of epidemiological research. Its core methodology centers on recollection to gauge an individual's physical activity. With a rich array of options, there are up to 30 mainstream physical activity questionnaires, incorporating diverse formats such as diaries, journals, interviews, and quantitative retrospectives. These surveys are characterized by their cost-effectiveness, ease of administration, and favorable reception among survey participants, rendering them a pragmatic choice. These questionnaires typically span various facets of daily

physical activity, encompassing areas like transportation-related activities, occupational exertions, household chores, leisure pursuits, and sporting endeavors.

Noteworthy among internationally recognized physical activity questionnaires are the Global Physical Activity Questionnaire (GPAQ), the Total Energy Expenditure Questionnaire (TEEQ), and the International Physical Activity Questionnaire (IPAQ), to name a few. Among these, the IPAQ questionnaire reigns supreme in terms of prevalence across diverse studies (Lee et al., 2011).

The international standard for assessing physical activity was initiated in Geneva in 1998 and subsequently subjected to thorough reliability and validity assessments conducted across 12 countries involving 14 research sites in the year 2000. The conclusive findings indicate that these metrics exhibit sound measurement characteristics, making them applicable in various contexts and languages. They are well-suited for conducting nationwide prevalence studies on physical activity participation. Further refinements and adaptations took place in 2001 through the involvement of various organizations, including the World Health Organization and the U.S. Centers for Disease Control and Prevention. The IPAQ questionnaire comes in several variants, encompassing long forms, short forms, self-administered versions, and interview-based forms. The long form delves into five principal categories of physical activity, comprising occupational tasks, household responsibilities, commuting activities, recreational pursuits, and sedentary behavior, featuring a total of 27 questions. Meanwhile, the short form primarily focuses on assessing sedentary time, walking, moderate-intensity physical activity, and vigorous physical activity. The long form finds its niche in comprehensive research regarding daily physical activity assessment, while the short form is predominantly employed for ongoing physical activity monitoring.

In 2003, a comprehensive reliability and validity evaluation of IPAQ long and short forms was conducted by Craig, CL (2003) and other researchers, encompassing a population aged 18-65 across 12 countries and 14 research centers, encompassing both male and female participants. The findings revealed that the IPAQ questionnaire exhibited a noteworthy test-retest reliability coefficient of 0.8 and a criterion validity coefficient of 0.3, underscoring its robust reliability and applicability across different nations and population groups. Consequently, the IPAQ questionnaire emerges as an internationally adaptable tool.

2.8.3 Assessment Tools Related to Health-related Quality of Life

The origin of the concept of quality of life (QOL) can be traced back to the time of Aristotle (Cella, 1994). The concept of quality of life was formally proposed by the American economist JK Calbraith in the 1950s. The current definition of quality of life is not uniform. The World Health Organization (WHO) defines quality of life as different cultures and Individuals in the value system experience the state of life-related to their life goals, expectations, standards, and things they care about (Férnandez-Ballesteros, 1998). Quality of life is a multifaceted topic that reflects the health status of the population from specific aspects such as physical function, psychological function, and social function. With the continuous development of society, people's health concepts continue to change, and the focus on the quality of life is more refined, from ordinary the masses are gradually paying attention to various marginal groups, such as caregivers of a certain disease.

With the transformation of the biomedical model, extensive explorations on the quality of life have been carried out in the field of medical research, forming a category of quality of life with disciplinary characteristics, that is, life quality related to health. According to the World Health Organization, it is an individual's assessment and

demand for their health status in different cultures and value systems, or the degree of subjective recognition that arises when they meet expectations. It is a comprehensive evaluation index for the quality of life. Different researchers have different cognitions and understandings of HRQOL (Herdman et al., 1998). The evaluation of HRQOL should include four aspects: physical condition, physiological function, mental state, and subjective feelings.

There are many ways to assess the quality of life of patients, the most important of which is scale measurement. The current quality of life assessment scales used for diseases are mainly divided into two categories according to the scope of the population to which they are applied: One is a scale used to measure the quality of life of a specific disease. The other type is a universal scale suitable for general individuals or the general population, the scale mainly includes Nottingham Health Profile (NHP), the 36-item Short-Form Health Survey Questionnaire, (SF-36), Sickness Impact Profile, (SIP), Euro QOL five dimensions (EQ-5D), World Health Organization Quality of Life-BREF Scale (WHOQOL-BREF), etc.

The WHOQOL-BREF, a concise 26-item version of the WHOQOL-100 assessment, underwent psychometric analysis using cross-sectional data gathered from a survey of adults across 23 countries (Skevington et al., 2004). The sample included individuals from both healthy and ill populations, drawn from the public, hospitals, rehabilitation centers, and primary care facilities, encompassing patients with physical and mental health issues, and covering a range of important socio-demographic variables. Participants completed the WHOQOL-BREF self-assessment, along with inquiries related to socio-demographics and health status. Analysis of internal consistency, item-total correlations, discriminant validity, and construct validity through confirmatory factor analysis revealed that the WHOQOL-BREF exhibits strong to

excellent psychometric properties in terms of reliability and performed well in initial assessments of validity. These findings collectively affirm that the WHOQOL-BREF is a robust, cross-culturally valid instrument for assessing quality of life. It effectively captures four distinct domains: physical, psychological, social, and environmental aspects.

2.8.4 Assessment Tools Related to Knowledge of Stroke Prevention

Increased knowledge of stroke prevention in the population may lead to improved prevention of stroke (Boden-Albala & Quarles, 2013). A healthy lifestyle, nutrition, a low-salt diet, quitting smoking, abstaining from alcohol abuse, medication adherence, blood pressure checks, stroke warning signs, stroke risk factors, and pre-hospital delay awareness are some of these knowledge domains.

The stroke-knowledge questionnaire was an outcome measure used to evaluate patients' understanding of stroke risk factors based on differences in the questionnaire's change score between pre-and post-intervention. At present, most of the stroke prevention knowledge questionnaires are designed by researchers themselves, and there is a lack of recognized questionnaires. In this study, a stroke prevention knowledge questionnaire designed and formulated by Chinese scholar Wan Lihong (2010) will be used to evaluate the prevention knowledge level of people at high risk of stroke. Stroke knowledge questionnaire (SKQ) is a stroke prevention knowledge questionnaire designed by Wan Lihong based on domestic and foreign literature, including daily life, exercise, diet, medication, regular monitoring, stroke risk factors, and stroke precursors. Stroke treatment 8 items, a total of 36 items, with "know, don't know" as an alternative, a correct answer is 1 point, a wrong answer is 0 points, using a percentile system, standard score = the sum of the scores of each item composing a certain item ÷The total project score × 100, the higher the standard score, the higher the patient's stroke health

knowledge level. The original questionnaire is evaluated by experts and has a good surface validity and content validity of 0.89.

2.9 Gaps in the Literature

Mobile technology such as smartphones offers a potential solution for measuring a healthy lifestyle. The existing literature on mobile applications for stroke prevention highlights their potential in managing risk factors, promoting physical activity, improving dietary habits, and facilitating weight loss. However, a critical gap is observed in the predominant focus on risk screening, with limited emphasis on providing comprehensive educational guidance for cultivating a healthy lifestyle, especially regarding stroke prevention.

While many countries, including China, have established dietary guidelines, the overall dietary patterns worldwide have not exhibited significant improvement over the past decades (Wang et al., 2016). The current health education strategies are deemed insufficient, necessitating a shift in focus towards enhancing knowledge and fostering lifestyle changes. Moreover, the absence of tailored, culturally appropriate guidance for specific diseases, such as stroke, remains a notable gap. Chinese residents' dietary habits exhibit unique characteristics, and the integration of proven dietary patterns preventing stroke with these habits is crucial for effectively improving the dietary choices of the high-risk population in China.

In the evolving landscape of mobile health applications, the reviewed literature predominantly addresses obesity (Mahli et al., 2019; Wang et al., 2017)and diabetes (Karduck & Chapman-Novakofski, 2018), neglecting the specificities of stroke prevention. The evaluated diet applications often lack personalized guidance for stroke-related nutritional needs, hindering their effectiveness in improving the awareness and behavior change of high-risk patients regarding diet and physical activity. Despite

incorporating basic principles of energy balance, these applications exhibit limited nutritional functionality. Therefore, there is a compelling need to bridge this gap by developing mobile health apps that provide cutting-edge technical features, thorough individualized guidance, and an evidence-based nutritional understanding of stroke.

Moreover, the literature underscores the importance of culturally appropriate and tailored health messages to enhance knowledge and awareness of health behaviors, such as healthy eating and physical activity. Smartphone apps are recognized as potential low-cost interventions for improving diet and nutrition and addressing obesity in the general population. However, the existing gap emphasizes the necessity for applications that not only meet users' preferences for quick and easy administration but also provide personalized, evidence-based guidance, particularly in the context of stroke prevention. Closing this gap will be instrumental in advancing the effectiveness of mobile applications in promoting healthy lifestyles and preventing stroke.

2.10 Conceptual Framework of the Study

The conceptual framework is the structure that holds or supports a research study's theory. The conceptual framework introduces and describes the idea that explains why the research problem being investigated exists. This research introduced the Health Belief Model (HBM).

2.10.1 The Health Belief Model

Social scientists at the U.S. Public Health Service created the Health Belief Model in the early 1950s (Hochbaum et al.) to help them understand why people didn't use screening tests for early disease diagnosis or disease prevention techniques (Rosenstock, 1974). Later, HBM was applied to track compliance with treatment and patient reactions to symptoms. A person's view of their risk of illness or disease, as well as their

assessment of the effectiveness of recommended health behaviors, can predict their likelihood of adopting those behaviors, according to the Health Belief Model (HBM).

The cornerstone of the HBM is a psychological and behavioural theory, which holds that there are two aspects of health-related behaviour: (1) the wish to prevent sickness, or on the other hand, to recover if one is already unwell; and (2) the belief that taking a specific activity will either treat or prevent disease. Ultimately, the way someone makes choices often depends on how they perceive the benefits and drawbacks of adopting healthy behaviors. There are six structures in the HBM. Perceived susceptibility, perceived severity, perceived hurdles, and perceived barriers were the initial four constructs that were created as the foundation of the HBM. The latter two, signals to action and self-efficacy, were added as the research on the HBM developed.

The health belief model consists of three parts: individual health beliefs, cues to action, and modifying factors. Under the prompting factors, the individual's behavior motivation is finally stimulated, and the individual adopts healthy behaviors (Champion & Skinner, 2008). They can choose from numerous sources of information to shape these beliefs, and, ultimately, their behaviors. The components of the Health Belief Model as shown below.

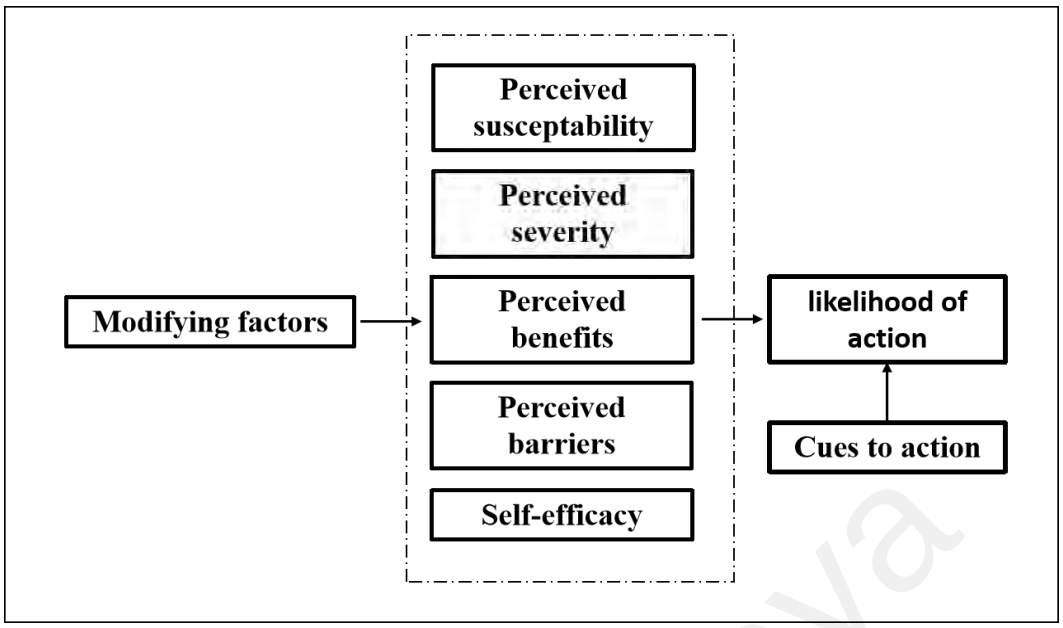

Figure 2.1: The components of the health belief model

2.10.2 Conceptual Framework

Theoretically, this program is based upon the HBM that attempts to explain and predict health-related behaviors and has since been widely used in health promotion, disease prevention, and behavior change interventions, making it one of the most widely utilized models in understanding health-related actions. Within this model, key factors influencing health behaviors include an individual's perceived susceptibility to sickness or disease, their perception of potential consequences, recognition of the positive outcomes of acting, awareness of barriers to action, exposure to factors that motivate action, and their confidence in their ability to succeed.

In this study, in the context of behavioral constraints (including internal knowledge reserves, etc.), perceive the susceptibility and severity of a stroke, and then perceive the benefits of preventive behavior and the obstacles that occur in preventive behavior. Next, the individual has a correct evaluation and judgment of his behavioral ability and believes that the participants have the confidence and will to overcome difficulties. Under the promotion factors of preventive measures (mobile-based educational

application program), it can stimulate the motivation of behavior change, and adopt healthy behaviors that can promote lifestyle changes.

When conducted intervention for the risk population of stroke, we must first comprehensively consider the demographic, social psychology, and other relevant influencing factors of the risk population of stroke in China. Through the learning of stroke prevention knowledge and diet-related health knowledge, participants were encouraged to realize their susceptibility and severity of a stroke, and then the participants perceive the threat of disease. By studying knowledge related to diet and health before adopting dietary behaviors, we can understand the benefits of a healthy lifestyle, including its impact on preventing strokes and diseases. Additionally, this allows us to fully comprehend the obstacles and difficulties encountered during the implementation process. Next, make correct judgments on their ability to perform behaviors, and believe that they can achieve the desired result of preventing stroke. Through the change of dietary behavior, it is judged whether the diet-related mobile application education intervention has a promoting effect on the individual's healthy dietary behavior and whether it can improve the health-related quality of life. Figure 2.2 shows the conceptual framework of the study based on the health belief model.

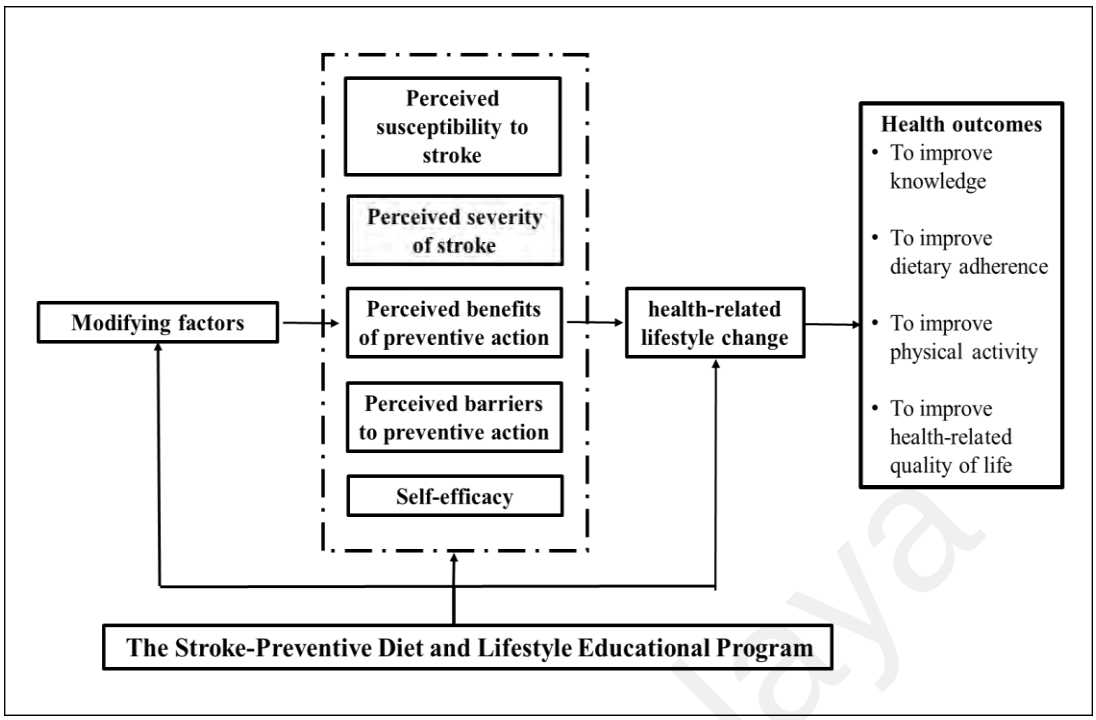

Figure 2.2: Conceptual framework of the study

2.11 Summary

The literature review comprehensively explores facets related to stroke prevention and the influence of mobile-based behavior interventions on lifestyle factors. In the section concerning search strategies and literature screening, the methodologies employed to identify and select relevant studies are outlined, ensuring a thorough coverage of the existing literature. The relationship between stroke prevention and a healthy lifestyle is scrutinized, emphasizing the pivotal role of lifestyle choices in mitigating stroke risk. Subsequently, the review delves into the effects of mobile-based behavior interventions on dietary habits, highlighting the potential of mobile technology to shape and enhance dietary choices. In the examination of the impact on physical activity, the literature review explores studies assessing how mobile-based interventions contribute to promoting and sustaining physical activity, a critical aspect of a healthy lifestyle. Moreover, the review addresses the effects of multifaceted lifestyle factors, recognizing the interconnected nature of various elements in stroke prevention. The

section on mobile technology for risk assessment in stroke prevention underscores the role of mobile tools in evaluating and managing stroke risk factors, providing a comprehensive overview of the current landscape. Additionally, an analysis of the assessment tools utilized in relevant studies is presented, offering insights into the methodologies employed for data collection and measurement. By identifying gaps in the literature, the review pinpoints areas necessitating further research, thereby contributing to the ongoing discourse on stroke prevention through mobile interventions. Finally, the conceptual framework of the study is outlined, providing a theoretical foundation for the research and guiding the exploration of the interplay between mobile-based behavior interventions and stroke prevention within a holistic lifestyle context. Overall, the literature review provides a solid basis for comprehending the state of knowledge today, identifying research gaps, and framing subsequent investigations within a conceptual framework.

CHAPTER 3: METHODOLOGY

3.1 Introduction

This chapter introduced the research methodology used in this study. The research design of mixed-method research was discussed first. Secondly, the research phases were discussed carefully. Thirdly, an explanation of the research setting was provided for this study. And then, the population sampling and sampling size in the study were highlighted. Following that, the research instruments employed to collect data and for the pilot study were discussed. After that, a data collection plan to summarize both the quantitative and qualitative data was explained. Ethical considerations to conduct this study were explained finally.

3.2 Research Design

The design allowed researchers to focus on research methods that were suitable for the subject matter and set up their studies for success. To achieve the study's aim, an exploratory mixed-method study design was employed.

3.2.1 The Mixed-method Research Design of this Study

A research process known as "mixed methods research" entails gathering, examining, and combining quantitative and qualitative data. According to different standards, mixed-method research can be classified in different ways. Tashakkori and Teddlie (2021) discovered in the literature study over forty different classification techniques. After a 15-year analysis of the literature on mixed approaches, 12 classifications were compiled. Approaches encompassing fields like assessment, medical research, and educational research. The various varieties and classification schemes mirror the evolving features of hybrid research methodologies. While scholars from various fields have differing concerns with hybrid method design, there are some commonalities in the categories they establish. Plano, Creswell, Clark, and others (2011)

proposed four types of mixed methods design, namely the triangulation design, the embedded design, the explanatory design, and the exploratory design.

Exploratory design is a two-step process, often known as exploratory sequential design. This design intends those qualitative methods can help expand and deepen quantitative methods (Greene et al., 1989). When there is a lack of ready-made questionnaires, variables, or conceptual frameworks, exploratory design can be used. Since the design starts from qualitative research, it is most suitable for exploring certain social phenomena (Clark & Creswell, 2004). The focus is on gaining insights and familiarity, especially during the preliminary stages of research. Since the design begins with a qualitative approach, it is particularly suitable for exploring specific social phenomena. The exploratory design includes two main models: the "tool development model" and the "category development model." Both methodologies begin with qualitative research and conclude with quantitative research. Figure 3.1 provides the flow chart of the embedded design of MMR applied in this study.

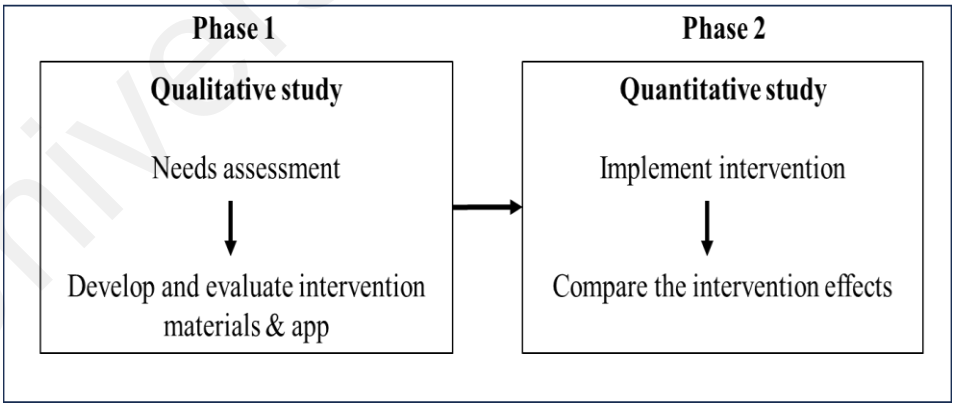

Figure 3.1: The exploratory mixed-method design of this study

3.2.2 The Qualitative Design Using Semi-Structured Interview

The collection methods of qualitative research mainly include interviews and observation. A semi-structured interview (Kallio et al., 2016) is one of the most used

interview collection methods in a qualitative design. Interviewers in a semi-structured interview usually have a framework of topics to explore and are widely used for qualitative research, mainly including in-depth interviews and focus group interviews. The qualitative data were analysed using a framework technique, followed by a thematic analysis of the patients. Before the intervention, a qualitative design involving semi-structured focus group discussions was employed to explore and understand the diet-related needs and the level of stroke prevention. Focus group discussions were used as a method of qualitative research, where a group was interviewed through inquiries and discussions to gather its views and evaluations on a particular product, service, concept, advertisement, or design (Moretti et al., 2011). Focus group discussions were generally utilized to collect preliminary data and provide a foundation for subsequent research using other research methods in the future. They were particularly suitable when confirmation of the analysis was sought from a wide variety of participants' profiles, serving as an effective means to exchange perspectives and conversation disagreements among participants. These dynamics wouldn't be captured in a face-to-face interview. Such interviews could collect data from multiple persons on the same subject and were a fantastic approach to learn about complex behaviours. Given their short implementation time and great flexibility, focus group discussions could be applied to exploring various problems.

Through the qualitative data collection, an assessment of the content of healthy lifestyle practices and the needs was figured out. More insights were likely collected, which were useful for a later quantitative phase. This qualitative part provided information to develop the diet educational material. Thus, to understand and explore the diet-related needs and the level of stroke prevention of the qualitative part, focus group discussions were an appropriate study.

3.2.3 The Quantitative Design Using Quasi-Experimental Study

Through the intervention, a quasi-experimental study with a non-equivalent control group before and after the control study (also known as a non-randomized concurrent controlled trial) was conducted. The quantitative data collection examined the effect of mobile-based educational programs on knowledge of stroke prevention, lifestyle changes, and health-related quality of life.

According to whether intervention factors are applied to the research subjects, clinical research is divided into two categories: experimental research and observational research. The gold standard of clinical trials is randomized Controlled Trials (RCT), which has the advantages of strict bias control (randomization, control, etc.), transparent management, etc., which makes the research highly authentic, but it also has difficulty in the control group. Some restrictions such as the management of large or super-large samples and the difficulty of experimental operation make it unrealistic to apply RCT to the evaluation of the effect of many public health interventions, and sometimes it does not meet the ethical requirements.

In educational studies, it can be challenging to implement "blinding" techniques to conceal from learners the group to which they have been assigned. The absence of blinding may lead to participants reacting differently upon realizing they are under study or assigned to a specific group, as pointed out by Sullivan (2011). Moreover, in training programs, trainees often interact extensively, which can result in contamination effects – for instance, trainees sharing their learning experiences. This sharing compromises the randomization process further. In cases where active interventions deemed crucial for learning cannot be withheld, researchers may consider utilizing crossover designs. However, it's important to note that crossover designs may also introduce the risk of learning contamination between groups.

Appropriate application of non-randomized control trials (non-RCT) can make up for these shortcomings of RCT and achieve the same research purpose. The non-randomized concurrent controlled trial is also a prospective study. The experimental group and the control group are studied at the same time, but the grouping is not randomized, but according to the wishes of the investigator or the patient. It is often used to compare the effects of different clinical interventions. Its design mode and result analysis are like cohort studies. However, due to human factors in the grouping of research subjects, subjects in different groups are often in different baseline states before the experiment. In the research process, it is also difficult to blindly evaluate the test results, causing many biases.

In this study, the analysis to determine differences between control and intervention group results was provided, and the differences between pretest and post-test results were explored for the study. The quantitative data collection examined the effect of the mobile-based educational program on lifestyle changes, health-related quality of life, and knowledge of stroke prevention. Therefore, to answer the research questions of the quantitative part, a quasi-experimental study was deemed appropriate.

3.3 The Research Phases

There were two research phases conducted in this study. In this study, the researcher chose the exploratory mixed-method design to address the research question. Figure 3.2 shows the flow chart of the research phases.

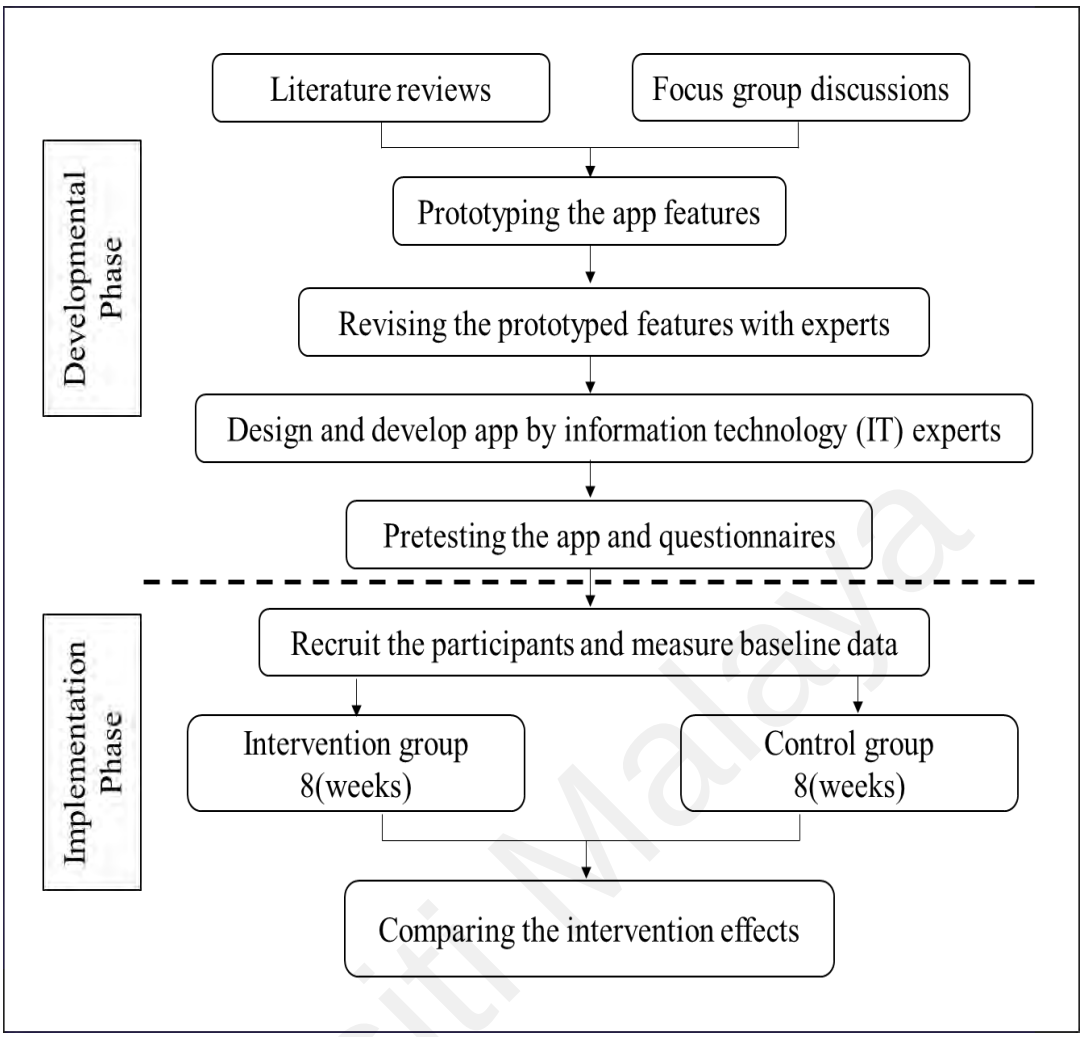

Figure 3.2: The flow chart of the research phases

3.3.1 Phase 1: Development and Usability Evaluation of the Mobile-Based Educational Program

The developmental phase consists of 3 stages as follows:

Stage 1: Initially, qualitative focus group discussions were employed to engage individuals at risk of stroke for this study. The interviews primarily centered on participants' suggestions regarding the functionality, content, interface design, and security aspects of the app. Through qualitative analysis, the study explored the needs and expectations of the stroke-risk population for a healthy lifestyle intervention app to offer insights and guidance for the design and development of customized apps tailored to the requirements of the at-risk population. Drawing upon the outcomes of the

qualitative assessment regarding health app requirements for the stroke-risk population, and informed by a comprehensive literature review, the research was further guided by the theoretical and conceptual underpinnings of the Health Belief Model. This culminated in the creation of the preliminary iteration of the mobile phone stroke prevention educational-based app.

Stage 2: Subsequently, the written design and technical feasibility of the program underwent evaluation by a panel of multidisciplinary experts. This panel included dietitians, specialist nurses, and technical professionals. Their insights were pivotal in refining and ultimately solidifying the written design of the program. The semi-structured interviews were audio recorded and transcribed verbatim. The data were assessed using structured qualitative content analysis (Kuckartz, 2012). The following 6 topics were discussed: (1) the advantages and disadvantages of the main module content, and do they need improvement or adjustment, (2) the suggestion to enhance the effectiveness of the intervention and dietary compliance among the target population, (3) the suggestions for improving the app's contents to enhance the educational intervention, (4) the recommendations and content improvements can be made for specific dietary guidance for chronic diseases to ensure better understanding and compliance among the intervention group, (5) the suggestions for the content and format of module four (real-time updates), and (6) feasibility.

After that, a content validation index (CVI) was carried out. The most extensively documented method for ensuring content validity in instrument development is CVI, which may be calculated using the Scale-level-CVI (S-CVI) and the Item-CVI (I-CVI). The I-CVI is calculated by dividing the total number of experts by the number of experts who rate each item as "very relevant." The values are as follows: if the value is less than 0.70, the item is discarded; if the value is between 0.70 and 0.79, the item

needs modifications; and if the value is greater than 0.79, the item is relevant. Expert Inclusion Criteria: (a) Experts in fields such as clinical medicine, clinical nursing, nursing education, etc.; (b) bachelor's degree or higher, and at least junior-level professional title; (c) Over 5 years of relevant work experience in the field; (d) Familiarity with specialized care for home-based stroke patients; (e) Willingness to participate in this research.

Stage 3: The third stage involved the development and usability evaluation of the program prototype. A software development team was established, comprising four members, including two senior software engineers (responsible for App module design, development, and operational maintenance), one professional graphic designer (in charge of page design), and a researcher. The researcher was responsible for formulating the App development plan, proposing App system requirements, and maintaining real-time communication with team members.

Following the completion of development, we recruited users to utilize the mobile program for 2 weeks. Subsequently, quantitative data were collected through the System Usability Scale (SUS) to assess the usability of the educational mobile program. Additionally, the opinions of end-users to gauge their satisfaction with the program through semi-structured qualitative interviews to ensure comprehensive testing of the usability of the program so that is to gain a deep understanding of the application's usability in practice, explore user experience, analyse strengths and weaknesses, and provide valuable insights and recommendations for the development of mobile health management applications.

3.3.2 Phase 2: Intervention Study

To compare the effectiveness of lifestyle behaviors, health-related quality of life, and knowledge of stroke prevention at baseline and prospective follow-up among

participants receiving usual care and intervention care. This implementation phase was conducted as a quantitative study respectively starting from post-intervention data collection administered to both the intervention and control groups. The intervention group received mobile-based educational intervention for 8 weeks. The control group received routine community follow-up for 8 weeks. Data were collected in the following time points: pre-intervention, and 8 weeks post-intervention. The evaluation tools included the Food Frequency Questionnaire Chinese version (FFQ25), the Chinese short version of the International Physical Activity Questionnaire, the World Health Organization Quality of Life (WHOQOL), and the Stroke Knowledge Questionnaire (SKQ).

Table 3.1: The mapping of the objectives to methodology

Specific objectives	Study phase and stage	Study design & methods	Chapter
(a) To develop materials for a mobile-based educational program on self-management of dietary practices.	Phase 1-Stage1	FGDs	Chapter 4
(b) To get the insights and views from experts.	Phase 1-Stage2	Expert consultation	Chapter 4
(c) To assess the usability of mobile-based educational program.	Phase 1-Stage3	Usability test	Chapter 4
(d) To evaluate the effects of the mobile-based educational program on knowledge of stroke prevention, lifestyle changes, and health-related quality of life among middle-aged adults at risk of stroke in China.	Phase 2-Stage4	Intervention study	Chapter 4

3.4 Research Setting

Henan Province, nestled in the heart of China, occupies a pivotal role within the northern region of the country. Its distinctive geographical placement has given rise to a diverse culinary culture, enriched by the influence of its neighboring regions. Renowned as a culinary epicenter in northern China. As the capital of Henan province, Zhengzhou not only has a sizable local population but also attracts a significant number of rural migrant workers; such a distribution of the population is more conducive to the comprehensiveness of our research.

In the community of Zhong yuan District, Zhengzhou City, the researcher will strictly select according to the inclusion and exclusion criteria and screen out people at risk of stroke who agreed to participate in the study. The ZhongYuan district is in Zhengzhou City, Henan Province, China. As of June 2019, Zhengzhou has 6 districts, namely: Huiji District, Shangjie District, Jinshui District, Guancheng District, Erqi District, and Zhongyuan District. Zhongyuan District is one of the central districts of Zhengzhou City, Henan Province. It is in the west of Zhengzhou's downtown area. It is the seat of the Zhengzhou Municipal Party Committee and Government and the political and cultural center of Zhengzhou. There are 14 street offices in the district, covering an area of 193 square kilometers. The permanent population is 1.048 million, and the urbanization rate is 90.96%.

3.5 Population and Sampling

The sample population included middle-aged adults at risk of stroke 45 to 59 years old from community residents from the Henan Province, China. The selection criteria for participants were: (1) the presence of one or more “modifiable” stroke risk factors including hypertension, diabetes, cardiovascular disease, dyslipidemia, atrial fibrillation, as well as being overweight or obese, physical inactivity, smoking, and excess alcohol

consumption, (2) owned smartphones running either iOS or Android that they had been using for at least three months; Persons who did not complete the usability test and were incapable of understanding the meaning of the study, were excluded. All participants received and signed written informed consent before participation.

3.5.1 Qualitative Sampling Method

Purposive sampling, or non-probability sampling, is frequently employed in qualitative research; that is, the research object that can supply the most information for the research problem is chosen under the study goal. Since the goal of qualitative research is to gain a more comprehensive and in-depth explanatory understanding of the study objects, there are typically not many research objects, therefore using probability sampling techniques is both impractical and impracticable.

A purposive sampling method was utilized to choose research middle-aged participants (45-59) in Henan Province who were at risk of stroke. As the capital of Henan province, Zhengzhou not only has a sizable local population but also attracts a significant number of rural migrant workers; such a distribution of the population is more conducive to the comprehensiveness of our research.

For qualitative interviews on usability testing, between February and April 2022, middle-aged adults from communities covering urban and rural districts located in Zhengzhou City, Henan Province, were purposively sampled. We recruited through a combination of community collaboration, social media, and networking. The inclusion criteria were taken as the research objects. The selection criteria for participants were: (1) the presence of one or more “modifiable” stroke risk factors including hypertension, diabetes, cardiovascular disease, dyslipidemia, atrial fibrillation, as well as being overweight or obese, physical inactivity, smoking, and excess alcohol consumption, (2) no previous stroke, (3) agreed to participate by signing a consent form. Persons who had

medical illnesses, serious complications, or co-morbidities rendering them unable to cooperate with investigators were excluded.

3.5.2 Quantitative Sampling Method

Because in non-probability sampling, all elements have different chances of being selected. In this study, the quantitative research was conducted using convenience sampling, where participants were assigned to receive either usual care or intervention care. Convenience sampling can help researchers directly reach these individuals, ensuring the feasibility of the study. It allows researchers to select participants from existing or easily accessible groups. Assessments were completed at baseline and after 8 weeks. With informed consent obtained, communities in Zhengzhou city were selected as the research subjects. Participants from different communities were allocated between the two groups to avoid contamination.

3.6 Sample Size

Determining the sample size is the operation of selecting the observation values or the number of repeated samples to be included in the statistical sample. The sample size is an important feature of any empirical research, in which the purpose is to draw general inferences based on the sample. In actuality, the sample size that is employed in the study is typically chosen to provide it with the necessary statistical power and depends on the cost, time, or convenience of data collection.

3.6.1 Qualitative Sample Size

Focus group discussions involve conducting interviews with a group of people to gather a range of data. The minimum number of people for a focus group interview is 3 to 4, the ideal size of a focus group for most noncommercial topics is five to eight participants, around the size of a dynamic seminar session, plus a facilitator and a note-taker (Carlsen & Glenton, 2011). In the data analysis stage, the researcher must find

different voices, clarify, and further explore the differences of each point of view. Too many participants will make it difficult for researchers to transcribe and analyze the content of the meeting. Larger focus group interviews can result in some participants taking centre stage while others are hardly acknowledged (Guest et al., 2017). Thus, for this focus group study, 4-8 cases for the narrative inquiry will be included for discussion of the result and the interview will be conducted until data saturation is achieved.

Studies have found that 98% of usability issues could be identified through feedback from 10 users (Faulkner, 2003). Based on this, A total of 23 persons (23 individuals for the quantitative data collection and 15 participants to join the qualitative interview after using the application for 2 weeks) participated in the usability testing to ensure comprehensive testing of the usability of the program. The recruiting was stopped once data saturation was reached.

3.6.2 Quantitative Sample Size

The sample size was calculated by the researcher using G-Power (version 3.1). Based on a two-sided alpha threshold of 0.05, the research was designed to have an 80% power to distinguish the intervention group from the control group. Both the intervention and control groups were assigned in a 1:1 ratio, with a 20% dropout rate taken into account in each case. Therefore, the minimum number of participants needed for this study was 128.

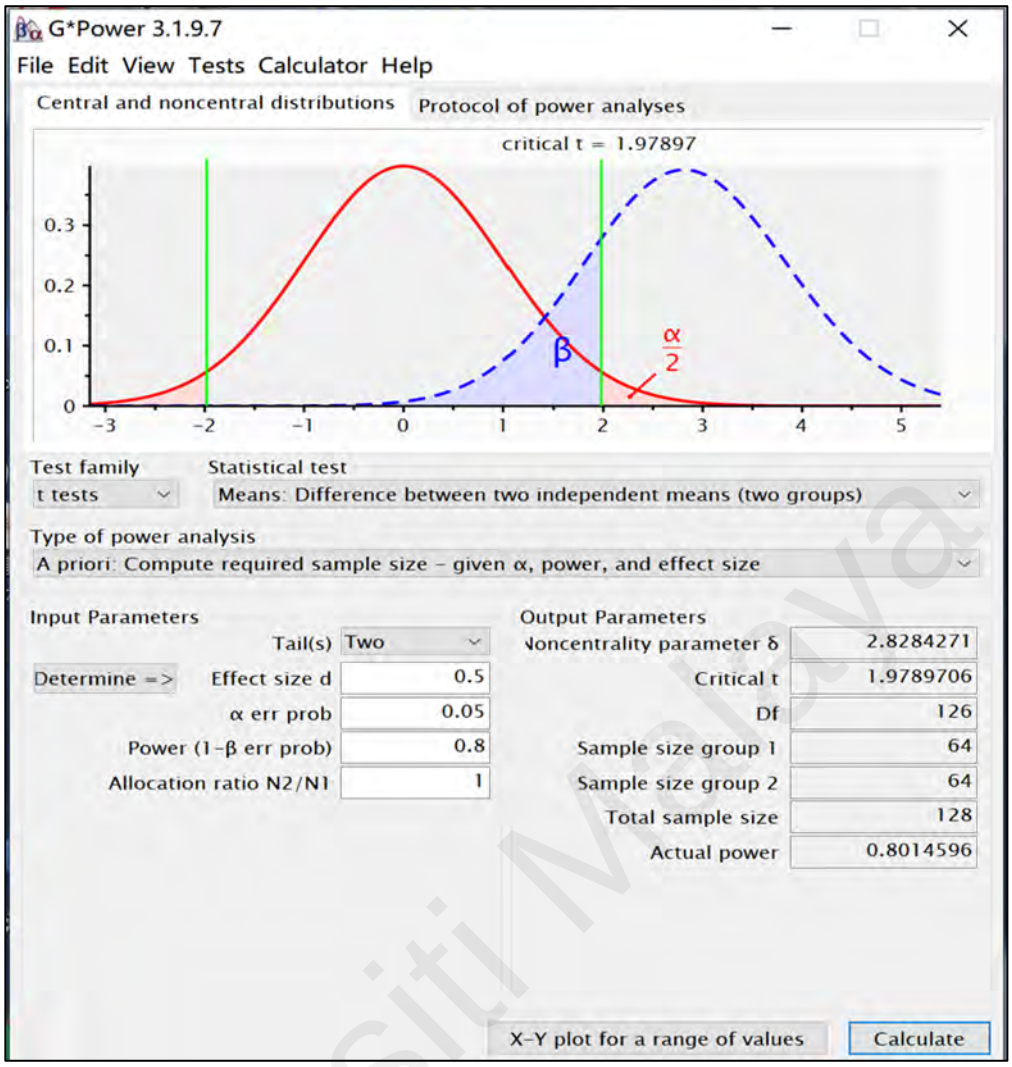

Figure 3.3: The calculation of sample size using G*Power

3.7 Research Instruments

Four questionnaires and one scale were used in this study to collect data, which included the Stroke Knowledge Questionnaire, the Simplified Food Frequency Questionnaire Chinese version (FFQ-25), the International Physical Activity Questionnaire short form (IPAQ-SF), the abbreviated World Health Organization Quality of Life questionnaire (WHOQOL-BREF) Chinese version, and the System Usability Scale (SUS). A self-developed demographic data acquisition form was used to collect the information of participants as well.

3.7.1 Focus Group Discussions

The study employed a descriptive qualitative design with Focus Group Discussions (FGDs) (Thorne et al., 1997). FGDs are a type of qualitative research technique where a group is questioned and interviewed to find out what they think about a certain product, service, idea, advertisement, or design. Its characteristics include (1) Collecting data from different people on the same issue is an excellent way to collect information on complex behaviors. It is typically used to gather early data and serve as a foundation for later research using different research techniques. (2) Short implementation time and great flexibility. (3) It has high surface validity. (4) The discussion situation is difficult to control. Some individuals control the conversation and try to impose their views on other members, which is prone to group pressure and convergence. Therefore, focus group investigations rely heavily on the facilitator's skills. (5) In the discussion, people do not conduct discussions completely and naturally, nor do they consciously think about research issues.

3.7.2 System Usability Scale

The System Usability Scale (SUS) is a straightforward ten-item Likert scale designed to provide a comprehensive perspective on subjective assessments of usability. Developed by John Brooke (John, 1996) at Digital Equipment Corporation in the UK in 1986, the SUS serves as a valuable tool in the usability engineering of electronic office systems. To calculate the SUS score, users are required to rank each of the ten template questions on a scale of 1 to 5 based on their level of agreement. For odd-numbered questions, 1 is subtracted from the score, and for even-numbered questions, the score is subtracted from 5. The resulting scores are then aggregated and multiplied by 2.5 to derive the final SUS score. Data were summarized in both categorical and numerical forms, with mean and standard deviation (SD) presented for numerical data.

3.7.3 Demographic Characteristics

Self-compiled, comprising the following information about people at risk of stroke: age, gender, level of education, couple status, work, living style, monthly family income, mode of payment for medical bills, stroke risk factors, etc.

3.7.4 The Stroke Knowledge Questionnaire

The stroke knowledge questionnaire (SKQ) is used to measure health knowledge about stroke prevention, which was designed by Wan Lihong (2010) and others based on the literature. The questionnaire includes 36 items and 8 dimensions. The 8 dimensions are daily life (8 items), exercise (4 items), diet (4 items), stroke risk factors (5 items), and medication (5 items). Items), blood pressure monitoring (2 items), stroke signs (6 items), stroke treatment (2 items), each item has two options: “know” and “don't know”, “know” Counts 1 point, “Don't know” Counts as 0 points. The higher the score, the higher the knowledge level of the high-risk group. Chinese scholar Dong Xiaofang used this scale to measure the knowledge level of people at high risk of stroke. The original questionnaire is evaluated by experts and has a good surface validity and content validity of 0.89.

3.7.5 The Chinese Short Version of the Food Frequency Questionnaire

The scale was designed by Willett, W. C in 1985 (Willett et al., 1985). The FFQ had a total of 85 items divided into 8 food groups that included the staples of the adult Sri Lankan diet, along with 12 color photos that indicated serving sizes. In terms of calorie, carbohydrate, protein, fat, and dietary fiber intake, there were substantial positive correlations ($p < 0.05$) between the two techniques when the FFQ was verified against 7-day weighed-intake dietary records.

Chinese scholar Gao (2011) evaluated the reliability and validity of the simplified food frequency questionnaire (FFQ25). The 25 food items on the FFQ25 are a non-

quantitative, paper-based, brief food frequency questionnaire that emphasizes fruit, vegetables, high-fat and high-sugar foods, meat, meat products, and fish. For use in population surveys, the tool measured the quality of diets. The design of FFQ25 mainly refers to previous studies on dietary patterns abroad and domestic semi-quantitative food frequency questionnaires, as well as the foods and food categories found in previous studies that are related to chronic diseases of the middle-aged and elderly people, and a total of 25 food categories are included. Gao Jian applied the scale to middle-aged and elderly people after verification, and the results showed good reliability and validity. In this study, a revised version will be used.

FFQ25 investigates the dietary intake over the past year of the study subjects, encompassing 25 types of foods, with intake frequencies ranging from "never consumed" to "more than 3 times a day," weighted as 0.00, 0.03, 0.07, 0.22, 0.50, 0.79, 1.00, 2.00, 3.00, respectively. Portion sizes, ranging from "less than 1 Liang" to "5 Liang or more," carry weights of 0.50, 0.75, 1.00, 1.50, 2.00; specialized foods like eggs, beverages, beer, etc., are expressed in specific units such as pieces, bottles, etc. Following validation, FFQ25 demonstrates high test-retest reliability and good validity. Utilizing FFQ25 to collect dietary information, the food intake patterns of the study population are analyzed. This data is then compared against the Recommended Nutrient Intakes (RNI) outlined in the "Chinese Residents' Balanced Dietary Guidelines (2022)" to assess their dietary nutritional status.

3.7.6 The Chinese Short Version of the International Physical Activity Questionnaire

The International Physical Activity Questionnaire short form was used to measure changes in physical activity (IPAQ) (Craig et al., 2003). The IPAQ-SF was scored using established methods and data were reported as a continuous measure in metabolic

equivalent of task (MET)-minutes per week. The IPAQ short form comprises a total of 7 questions, with 6 of them focusing on an individual's physical activity. It retains the same question structure as the long form but narrows its focus to activity intensity. The short form simplifies the assessment by inquiring about the frequency and cumulative daily time for various intensity activities, particularly emphasizing walking, moderate-intensity, and high-intensity activities. Nevertheless, respondents are still required to consider the four categories of physical activities mentioned earlier. In the IPAQ short form, MET values are assigned as follows: 3.3 for walking, 4.0 for moderate-intensity activities, and 8.0 for high-intensity activities.

Concerning data cleaning and outlier removal procedures, initially, the cumulative daily time for each activity must be converted into minutes. Any missing frequency or time data are excluded from the analysis. It is assumed that individuals sleep for a minimum of 8 hours per day. If an individual reports a total daily time spent on physical activities of all three intensities exceeding 960 minutes (16 hours), that individual is excluded from the analysis. It is also assumed that physical activities need to last at least 10 minutes to yield health benefits. If the daily cumulative time for any intensity of physical activity reported by an individual is less than 10 minutes, both the time and the corresponding weekly frequency are coded as "0".

Regarding the data truncation approach, in the short form, if the daily time for a specific intensity of physical activity surpasses 3 hours, it is adjusted to 180 minutes. This principle permits a maximum of 21 hours (1260 minutes) of reported physical activity per week for each intensity. This strategy effectively prevents the erroneous classification of individuals into the "high" activity group.

For the IPAQ short form, an individual's weekly level of physical activity for a specific intensity is calculated as follows: MET value associated with that physical

activity × weekly frequency (times per week) × daily time (minutes per day). The sum of the three intensity levels represents the individual's overall physical activity level.

3.7.7 The World Health Organization Quality of Life-Brief Version

The WHOQOL-BREF, a derivative of the WHOQOL-100 (De Vries & Van Heck, 1997), maintains the comprehensiveness of the original instrument (Group, 1998). The WHOQOL-BREF consists of 26 items, categorized into four domains: physical, psychological, social relationships, and environmental. Among these items, Q1 and Q2 are independent questions, and their combined score (Q1+Q2) serves as an overall indicator of life quality assessment. Each item on the scale employs a 1 to 5 rating, with scores ranging from 1 to 5. Notably, three items (3, 4, 26) employ a reverse scoring structure, where levels 1 to 5 correspond to scores of 5 to 1. Two subjective items were not included in the total score. The score calculation formula for each domain is: PHYS = 4 × ［(6 - Q3) + (6 - Q4) +Q10 + Q15 + Q16 + Q17 + Q18］/7, PSYCH = 4 × ［Q5 + Q6 + Q7 + Q11 +Q19 + (6 - Q26) ］/6, SOCIL = 4 × (Q20 + Q21 + Q22) /3, ENVIR = 4 × (Q8 + Q9 + Q12 + Q13 + Q14 +Q23 + Q24 + Q25) /8. A higher total score signifies a higher quality of life. Importantly, this scale demonstrates strong reliability and validity. The Cronbach's α was 0.912.

3.8 Data collection

Collecting data refers to obtaining data and information from research objects, which is a very important link in the scientific research process. This chapter introduced the data collection of phases 1 and phase 2.

3.8.1 Phase 1

A qualitative interpretive descriptive (Thorne et al., 1997) study was conducted using semi-structured FGDs. This design is well-suited for addressing complex experiential issues and can produce valuable insights, making it a viable methodological option for

medical education research. Interviews were conducted with middle-aged individuals at risk for stroke from both rural and urban areas. Thematic analysis (Clarke & Braun, 2017) was subsequently performed to uncover their genuine perceptions and health needs within the context of disease prevention and management. The audio recorded were facilitated by two research assistants: one of the researchers led the interviews and the other took field notes while observing changes in their expressions, tone, and body language. The interview location was chosen to be either a community meeting room or a place convenient for the interviewees. Before proceeding with the interviews, the purpose, content, and confidentiality principles of the interviews were fully explained, and the interviewees were asked for their consent and signed an informed consent form. During the interviews, the researchers used the interview outline as a guide and asked targeted questions to avoid deviating from the main topics and affecting the interviewees' experiences and feelings. If there were any uncertainties, they were promptly clarified.

An interview script for the FGDs was drafted to meet the study aim with its content derived from reviews of the literature and preliminary interviews with three research subjects. Following that, the interview guide was evaluated and revised by two nursing experts with qualitative research experience. Table 3.2 shows the protocol of the interview session.

Table 3.2: The protocol of the interview session

No.	Questions	Probes
1	What is your current health status?	Chronic diseases
2	Tell us a little about your understanding of and experience with stroke.	causes of onset risk factors precursors of stroke

Table 3.2, continued

		What preventive measures are in place?
3	Please talk specifically about the relationship between your healthy lifestyle and disease prevention	
4	Do you know and use health-related mobile apps and describe your experience using them?	If applicable: ● Regarding what topics? ● What are your thoughts and feelings about such applications? ● What aspects particularly attract you and encourage continued usage? ● What aspects do you dislike, leading to your reluctance to further use?
5	What is your perspective on using applications to intervene in the healthy lifestyle of high-risk populations?	How do you perceive the functionality of an app in helping you set healthy dietary and exercise goals?
6	What content and functional guidance do you hope health-related apps should include?	Considering your current dietary structure, what dietary guidance do you hope to receive? What fundamental aspects of design would make you more interested in using it?
7	What designs and functionalities in a mobile app would make you dislike it?	What are your opinions on the layout and design? Are there any aspects you dislike or find peculiar?
8	Are there any other important features that we didn't talk about that could help them to become healthier?	

Homogenous focus group discussions (FGDs) of four to seven participants per group were formed to collect qualitative data (O. Nyumba et al., 2018). Saturation is a commonly employed criterion for determining sample sizes in qualitative research. In this study, while four focus groups were adequate for achieving code saturation and identifying a spectrum of new issues, it became apparent that a larger number of groups were required to achieve meaning saturation and gain a comprehensive understanding of these issues (Hennink et al., 2019). Each interview would take approximately 60-90 minutes. Recruitment and interviews continued until no new or significant information was obtained, indicating data saturation had been achieved.

To assess the usability of the educational-based program, participants were provided with a brief introduction to the program's purpose and functionality. All participants used their smartphones to access the program independently. Throughout the two weeks, participants had the option to contact the researcher directly via phone for any inquiries or concerns they had. At the end of the two weeks, participants were instructed to independently complete the SUS, which served as a quantitative measure of the program's usability. Following two weeks of using the program, we also conducted user interviews to collect data related to participants' experiences in using mobile applications. Inductive thematic analysis with semi-structured interviews was conducted. An interviewer and a note-taker from the research team conducted the sessions. The interview outline is included in Table 3.3.

Table 3.3: The interview outline

Questions:	**Probes**
How do you overall feel about using this mobile program?	● What are your thoughts on obtaining information through WeChat? ● What beneficial experiences has this mini-program provided to you?

Table 3.3, continued

	• Do you find this application easy to use?
How do you feel about the combination of the mini-program and the official account?	• What content within the mini-program encourages you to continue using it? • What are your thoughts on the real-time updates provided by the official account? • Which features do you find most convenient to use?
Any thoughts on the layout and distribution?	
What are your thoughts on the content of the articles?	• Content distribution • Images • Colors • Text
What additional information would you like this program to provide? What specific information are you more interested in?	• Diet • Physical activity • Disease
Are there any shortcomings of this program? How would you suggest improving them?	
Would you be willing to continue using this program to assist with your dietary self-management? What is your reason?	

3.8.2 Phase 2

The participants were introduced to the purpose, methods, and precautions of the study. These participants will be invited to the WeChat group for group interaction. Data was collected in two stages. Phase 1 included the Stroke Knowledge Questionnaire, FFQ-25, IPAQ-SF, and WHOQOL-BREF Chinese version. We also assessed the self-

developed sociodemographic acquisition form. Phase 2 incorporated the Stroke Knowledge Questionnaire, FFQ-25, IPAQ-SF, and WHOQOL-BREF (Chinese version), each subject to repeated assessments throughout the study's duration.

Baseline: Data collection for Phase 1 took place over one month, from March 1, 2023, to April 2, 2023. Researchers initially contacted participants using numbers provided by the community office to arrange data collection times. Depending on the participants' preferences, data was collected either at their homes or at other community venues. Assessors met participants at the agreed-upon time and location, establishing a rapport to ensure optimal cooperation. They introduced themselves, emphasizing their qualifications, before beginning the data collection process. Participants received a thorough explanation of the study's goals, methods, and time commitment. They were also reminded that participation was entirely voluntary and that they could withdraw at any time. Written consent was obtained before data collection, and participants were assured of the study's confidentiality. The researchers provided participants with the Stroke Knowledge Questionnaire, FFQ-25, IPAQ-SF, WHOQOL-BREF (Chinese version), and a self-developed sociodemographic information form. Each scale and questionnaire were completed by the participants independently, and the evaluation instruments were collected upon completion. To ensure fairness and accuracy for participants with lower reading proficiency, the researchers read the items aloud and objectively recorded their responses.

Follow-up: Using the same methodology used at baseline, participants in the intervention group were required to complete the IPAQ-SF, WHOQOL-BREF (Chinese version), FFQ-25, and Stroke Knowledge Questionnaire at the end of the intervention. The steps and timing in the control group were identical to those in the intervention groups at the same time.

Before beginning data collection, we provided a brief introduction to the program's functionality to familiarize participants with its operations. Participants were given the flexibility to independently access the program using their smartphones. Throughout the eight weeks, they had the option to contact the researcher directly by phone with any questions or concerns. The content of the application integrates the Health Belief Model (HBM), the Chinese Guidelines for the Prevention and Treatment of Stroke, and the Dietary Guidelines for Residents (2022). The HBM is used to explain and predict individual health behaviors, as well as to design and implement health behavior interventions and educational programs. This approach contributes to the creation of a more comprehensive, scientifically sound, and practical health application, enabling users to better adopt a healthy lifestyle. The content of a culturally adapted stroke prevention educational program is shown in Table 3.4.

Table 3.4: The content of a culturally adapted stroke prevention educational program

Concept	Educational modules	Contents
Perceived severity	Risk Management	Educate users to assess their health risks through risk self-assessment, explain the risk factors of diseases to users, allow users to evaluate their vulnerability in terms of health, and further motivate them to take action.
Perceived susceptibility	Chronic disease management	Show users the potential risks and negative impacts of chronic diseases on health, such as obesity, heart disease, diabetes, etc., to enhance users' awareness of these issues.
Perceived benefit	Diet and physical activity	Introduce to users the benefits of healthy eating and exercise to help users understand the positive impacts of improving dietary habits and enhancing physical activity.

Table 3.4, continued

Emphasize the correlation between diet/exercise and health.	Diet and physical activity	Explain the close relationship between diet and health, including the benefits of a healthy diet on the body. Strengthen users' understanding of the relationship between diet and health by providing scientific research and case studies.
Perceived barriers	The integration of Official Accounts and Mini Programs	Identify the obstacles users may face in improving their lifestyle and provide coping strategies and solutions

The WeChat mini program included 4 modules. For Module 1, Risk management-- Risk self-assessment, Hazard identification, Stroke prevention, Chronic disease knowledge, Dietary health; for Module 2, Diet-- Dietary guidelines, Food pyramid, Three meals a day, Diet for chronic diseases, Dietary tips, My recipe; Module 3, Physical activity-- Goals, Core recommendations, Sports knowledge corner, Exercise basics; and Module 4-- the rapid identification of stroke symptoms. The main content of the intervention is shown in Table 3.5

Table 3.5: The main content of the intervention

Train sessions	Objectives	Contents
Week 1	Risk management: Educating users to assess their health risks through risk self-assessment, explaining the risk factors of diseases to users, allowing users to evaluate their vulnerability in terms of health, and further motivating them to act.	What is a stroke? Who is at high risk of stroke? The status and impact of stroke in the country. What are the causes of stroke? Criteria for assessing the risk of a "stroke." Early recognition of stroke.
Week 2	Showing the potential risks and negative impacts of chronic diseases on health, such as obesity, heart disease, diabetes, etc., to enhance users' awareness of these issues.	Understanding the definition and causes of common chronic diseases (hypertension, obesity, heart disease, diabetes, hyperlipidemia) Recognizing the dangers of chronic diseases Exploring the connections between various chronic diseases and stroke.
Week 3	Introducing the benefits of healthy eating and exercise to help users understand the positive impacts of improving dietary habits and enhancing physical activity.	The Relationship Between Dietary Patterns and Health Diet and Health Why is the Eastern healthful diet more suitable for you? Is your dietary structure balanced?

Table 3.5, continued

Week 3	Introducing the benefits of healthy eating and exercise to help users understand the positive impacts of improving dietary habits and enhancing physical activity.	Core Exercise Recommendations (Aerobic Exercise, Resistance Exercise, and Flexibility Exercise) Benefits of Exercise
Week 4	Facilitating skill development activities and offering support to boost self-efficacy, thereby increasing the chances of successful behavior changes.	Balanced diet/Dietary Pyramid Following the dietary pattern of the Chinese people - Eastern Healthy Dietary Pattern Dietary core recommendation: Dietary plate Correct understanding of food classification
Week 5	Introducing the benefits of healthy eating and exercise to help users understand the positive impacts of improving dietary habits and enhancing physical activity.	Recommendations for Three Meals a Day
Week 6	Facilitating skill development activities and offering support to boost self-efficacy, thereby increasing the chances of successful behavior changes.	Common dishes Diet for chronic diseases
Week 7	Aiding in identifying and reducing barriers to action by leveraging the WeChat platform	Dietary tips for food variety and proper combinations
Week 8	Aiding in identifying and reducing barriers to action by leveraging the WeChat platform	Exercise methods and techniques suitable for middle-aged individuals

The entire intervention process lasted for 8 weeks, a duration determined by referencing other intervention studies and considering the feasibility of our project. The strategies for improving adherence to the study included the following: (1) The intervention group received health education information through WeChat every 2 days in the afternoon. The impact of WeChat push frequency on information distribution had been demonstrated by a prior study (Ji & Cai, 2016). To prevent encouraging participants to engage in undesirable behavior, consideration was given to the timing and frequency of interventions when using the WeChat platform to educate people about edible oils. As a result, to help participants better accept the intervention and improve its effectiveness, we provided it every two days; (2) Each reading displayed the number of readers, and if readership was low, we provided a reminder in the WeChat group. Sometimes, if the information in the WeChat Official Account was not seen promptly, sharing it within the WeChat group through the publication of Official Account articles allowed everyone to easily access the content; (3) We encouraged participants to check in on their learning progress in the WeChat group after completing their weekly assignments. Control group participants continued their standard lifestyle. The results were interpreted and analyzed to identify associations and commonalities among categories, revealing the characteristics, patterns, and trends of the research subject.

3.9 Data analysis

This part described qualitative and quantitative data analysis as follows.

3.9.1 Phase 1

The researcher transcribed the data within 24 hours after the interview and then imported the data into the NVivo project for management and analysis. Based on the research objectives and questions, the researcher categorised and labeled the information in the text according to predetermined coding rules. The coding results were integrated and summarised to establish a comprehensive coding system. The researcher counted and analysed the codes within each category, determining the frequency and proportion of occurrence for each category. The counting and statistical results were interpreted and analysed to identify associations and commonalities among categories, revealing the characteristics, patterns, and trends of the research subject.

In qualitative research, the coding of interview data is a crucial analytical process. It is recommended to have at least two independent coders to code and analyze the data to enhance the credibility and reliability of the study. Independent coders can also perform quality control by comparing and discussing coding results to identify and rectify errors and inconsistencies promptly, thereby improving the reliability and trustworthiness of the research data.

Methodological rigor is established through various factors, including credibility, dependability, confirmability, and transferability (Tobin & Begley, 2004). To ensure the credibility of our data sources, we implemented several strategies. Firstly, we

engaged in prolonged engagement with participants, allowing us to build trust and gain in-depth insights. Additionally, we conducted member checks, seeking feedback and validation from participants to enhance the accuracy and authenticity of our findings. Our commitment to rigor extended to the thorough review of audio recordings, transcriptions, and field notes to maintain data accuracy.

Dependability was a key focus, and we employed a rigorous auditing process to achieve this. We meticulously maintained audit trails by consistently recording reflexive memos and utilizing codebooks throughout every stage of the research process (Golafshani, 2003). This systematic approach enabled us to track and mitigate potential biases or assumptions, ensuring the reliability of our findings.

To bolster confirmability, we engaged researchers in the analysis process. Two members of the research team independently participated in a multi-phase approach, which included initial coding, theme development, review, and definition (Drisko, 1997). This dual-checking process aimed to verify the accuracy and appropriateness of our interpretations. Any discrepancies were thoroughly discussed and resolved through consensus, further enhancing the confirmability of our results.

Lastly, in pursuit of transferability, we provided detailed demographics and descriptions of our study context. By offering this information, we enable readers to assess the applicability of our findings to different settings or populations. This

approach ensures that our research can be considered and adapted in various contexts, increasing its relevance and utility (Slevin & Sines, 1999).

After all data gathering was finished, the analysis was done for qualitative interviews related to usability tests. Using NVivo 12 Plus software, the audio-recorded interviews were transcribed word for word and subjected to thematic analysis. Initially, two researchers read over the transcripts and field notes several times to become acquainted with the material. Using the study objective as a guide, they separately coded every word, sentence, and paragraph in the transcript. The relationships found between and within the codes were used to interpret the larger themes that resulted from the merging of the codes. A third researcher independently confirmed the analysis. After discussing the findings in meetings, the two researchers agreed on any differences in coding. All of the topics and categories that were identified were carefully examined and thoroughly debated by the study team.

3.9.2 Phase 2

Use SPSS27.0 statistical analysis software for data entry, sorting, and statistical analysis. $P<0.05$ indicates that the difference is statistically significant. The statistical methods are as follows:

Using descriptive epidemiological analysis methods, calculate rates, means, etc. For normally distributed data, describe central tendency and dispersion trends using the mean and standard deviation, while for skewed data, describe central tendency

using the median. The descriptive analysis such as frequency and percentage were used to describe gender, age, marital status, residential location, living arrangements, educational level, average income per month, and risk factors for both the intervention and control groups to describe categorical variables. Using the chi-square test, we analyzed gender, age, marital status, residential location, living arrangements, educational level, average income per month, and risk factors to ascertain whether the intervention and control groups differed significantly from one another. $P > 0.05$ indicates comparability at baseline.

Two-sample t-tests are utilised for regularly distributed data for comparing differences between two groups, and non-parametric Mann-Whitney U rank sum tests are used for non-normally distributed data. For within-group comparisons at different time points, a paired t-test is applied for data that follows a normal distribution, while a non-parametric Wilcoxon signed-rank test is used for non-normally distributed data. For the statistical analysis, we first did a baseline comparison between the intervention group and the control group. Using the paired t-test or non-parametric Wilcoxon signed-rank test, the patients' stroke prevention knowledge, dietary adherence, physical activity, and HRQOL in both groups were compared before and after the intervention. The non-parametric Mann-Whitney U rank sum test or the independent sample t-test was used to determine the differences between the two groups' knowledge of stroke prevention, dietary adherence, physical activity, and HRQOL. Table 3.7 presents the coding of variables in the statistic stage.

Table 3.6: Objective, variable, and analyzing method

Objective	Variable	Analyzing method
To compare the comparability at the baseline	Sociodemographic data	Tests of homogeneity Descriptive statistics (Frequency, Proportion)
To determine the mean difference of dietary intake between and within the intervention and control groups	FFQ25	Mann-Whitney U test Paired Samples Wilcoxon Signed Rank Test
To determine the mean difference of physical activity between and within the Control Group and Intervention Groups	IPAQ-SF	Mann-Whitney U test Paired Samples Wilcoxon Signed Rank Test
To determine the mean difference in stroke prevention knowledge between and within the intervention and control groups	SKQ	Independent T-test Paired Sample T-test
To determine the mean difference in health-related quality of life between and within the intervention and control groups	WHOQOL-BREF	Independent T-test Paired Sample T-test

Table 3.7: Coding of variables in the statistics

Variable	Coding
Gender	1=man, 2=woman
Age	1=＜50, 2=50-55, 3=＞55
Marital status	1=divorced or widowed, 2=married
Residential location	1=rural, 2=urban
Educational background	1= Junior high and below, 2= High schools and above
Risk factors	1=one, 2=two, 3=≥3

3.10 Pilot study

Pilot studies are small-scale, exploratory investigations designed to determine whether essential elements of the primary study would be possible. A pilot study investigates if a particular idea can be implemented, whether it should be pursued further, and if so, how. For example, they may be used to predict and improve upon various aspects of the study design. Using a sample size of 10 to 20% of your full-scale survey sample size, or at least 30 to 50 respondents, is a frequent practice (Hertzog, 2008). Researchers can lower errors and risks in the primary trial by identifying and resolving concerns from the pilot study. As a result, the main study's findings have increased validity and reliability.

The pilot study was conducted in communities in Zhengzhou city. Convenience sampling was used to facilitate easy sample collection. A total of 30 middle-aged adults at risk of stroke completed the Stroke Knowledge Questionnaire, FFQ-25, IPAQ-SF, WHOQOL-BREF, and sociodemographic data collection forms in person at the community locations. The purpose of this pretesting was to assess the instruments' reliability and to gauge the time required for their completion. The pretest results for each instrument revealed Cronbach alpha values within the acceptable range, as discussed in the Research Instrument subsection. On average, students took approximately 15 to 20 minutes to complete each instrument, and there were no concerns concerning comprehension and administration of the scale were reported.

3.11 Ethical Considerations

This study, bearing the registration number XYLL-20210321, obtained ethical approval from the Ethics Committee of Xinxiang Medical University. Our research meticulously conforms to both international and national ethical guidelines for biomedical research, with a strong commitment to upholding values like respecting human dignity, preserving individual privacy, securing informed consent, and recognizing the right to independent decision-making.

Before collecting data, we ensured that participants received in-depth information about the study's objectives, content, significance, and the assurance of confidentiality. Informed consent was diligently obtained from all participants before data collection.

This study rigorously adhered to fundamental ethical principles, including the Voluntary Principle, the Principle of Non-Harm, and the Confidentiality Principle. Patients willingly provided informed consent and retained the right to withdraw from the study at any time. All patient information was treated with utmost confidentiality, and all study data was exclusively accessible to authorized research personnel. Under no circumstances would any patient information be disclosed without the patient's explicit consent. Furthermore, any specialized procedures involved in the research were conducted by trained professionals.

3.12 Summary

Chapter 3 used the exploratory design of MMR to conduct this study. There were two research phases conducted in this study which include the developmental phase and implementation phase. The developmental phase consisted of 3 stages and the implementation phase focused on the intervention study to determine knowledge of stroke prevention, healthy dietary adherence, physical activity, and health-related quality of life at baseline and prospective follow-up 8 weeks among participants in the intervention group and control group. This design intended those qualitative methods can help expand and deepen quantitative methods. A quantitative study was conducted as a quasi-experimental study in which participants receive usual care or intervention care to evaluate the intervention effects.

CHAPTER 4: RESULTS

4.1 Introduction

In this chapter, a needs assessment was carried out with semi-structured focus group discussions to develop materials for the mobile-based educational program on self-management of healthy lifestyles. After that, the initial draft of the program's design was presented. To assess its viability, we engaged a panel of multidisciplinary experts who provided valuable feedback and suggestions for refinement in preparation for prototype development. The chapter also provided a detailed account of the expert evaluation methodology and the outcomes. This chapter introduced the evaluation of the usability of the mobile-based educational program. Detailed results of the intervention in this study were also discussed in this chapter.

4.2 Results of the Development Phase

The results of the development phase encompassed various components, including focus group discussions, expert consultations, application design, and usability evaluation.

4.2.1 Result of Focus Group Discussions

A total of 25 individuals at risk of stroke were selected for interviews in this study and no people dropped out. Among them, there were 17 males and 8 females. The participants were categorized into different age groups: 24% were aged 45-50, 16%

were aged 51-55, and 60% were aged 56-59. General information about the study participants can be found in Table 4.1.

Table 4.1: Participants' characteristics

Characteristic	N	%
Gender		
Female	8	32
Male	17	68
Age (years)		
45-50	6	24
51-55	4	16
56-59	15	60
Living arrangements		
With a partner (no children)	2	8
With a partner and children	18	72
Alone	3	12
With family	2	8
Education		
Junior high school and below	7	28
High school	4	16
Junior college or college	13	52
Bachelor's degree and above	1	4
Employment		
Working	18	72
Retired	1	4
Unemployed	6	24
Risk factors		
One	6	24
Two	13	52
Multiple	6	24

Overall, participants showed strong agreement and support for learning through mobile phone-based interventions. This study revealed four themes that describe the participants' perception of the mobile-based educational program and the need for mHealth interventions for primary prevention: Individual Differences among Users, Diversity of Needs, Simplification for Accessibility, and Enhancing Credibility.

Themes and sub-themes explaining participants' needs towards the mobile-based educational program can be found in Table 4.2.

Table 4.2: Themes and sub-themes

Themes	Sub-themes
Individual Differences among Users	Population characteristics Disease-specific targeting Regional classification
Diversity of Needs	Early detection and warning of diseases Prevalent chronic disease knowledge Healthy lifestyle Social support and incentives
Simplification for Accessibility	Suitable presentation for the age group Simplification Convenient search function
Enhancing Credibility	Scientific and authoritative Non-commercialization

4.2.1.1 Theme 1: Individual Differences among Users

The features of individual differences among users needed to be considered which includes population characteristics, disease-specific targeting, and regional classification.

(a) Population characteristics

Within the middle-aged group aged 45-59, there is a 15-year age span, and participants exhibit varying degrees of emphasis on disease prevention and physical condition. Younger middle-aged individuals tend to have a greater awareness and emphasis on prevention, while older participants, who may already show signs of certain illnesses, focus more on disease management and maintaining health.

"For those who are already suffering from an illness, they want to know how to eat healthier; for those who are not ill, they want to know how to prevent diseases. If we provide these contents based on their needs, why wouldn't they be interested? For example, if someone has high blood pressure and comes across relevant dietary information that shows how proper nutrition can improve hypertension and high blood sugar, wouldn't they be interested? The more health problems one has, the more interesting they would be." (FGD6: participant 3)

"It also depends on individual physical conditions. If you look around now, like those people exercising in the park, 80% of them are those with health issues, and only 20% are healthy. That means people only pay attention to their health when they encounter problems." (FGD5: participant 4)

(b) Disease-specific targeting

In the population at risk of stroke, there are varying degrees of existing health issues, such as hypertension, high blood sugar, or obesity. Participants expressed

strong interest and willingness to learn about their specific health conditions. However, they showed less interest in health topics unrelated to their health concerns. Therefore, it is important to categorize and manage commonly occurring chronic disease knowledge in a way that allows them to access targeted educational content.

"For example, as a diabetes patient, I want to know what I should pay attention to in my diet, or what I can do to lower my blood sugar. I would be interested in content that can improve my condition. But if it introduces other unrelated cases, I wouldn't want to read it." (FGD2: participant 3)

"I don't read content that is not related to my health. For instance, if I don't have high blood pressure, I won't look at that kind of content." (FGD3: participant 1)

(c) Regional classification

Participants indicated that there are certain regional differences in lifestyle. For example, people in coastal areas consume more fish and seafood, while those in northern regions prefer staple foods like noodles and bread. Completely adopting one-size-fits-all approaches can be challenging, and improvements should be tailored to the specific conditions of different regions.

"We should classify the content based on different regions. Recipes for the northern region should be suitable for the north, and recipes for the southern region should be suitable for the south. Also, there's the issue of cooking ingredients.

Although food is widely available now, there are still differences in eating habits and the food situation in different places." (FGD5: participant 1)

4.2.1.2 Theme 2: Diversity of Needs

Diversity of needs for the mobile phone educational-based program includes early detection and warning of diseases, prevalent chronic disease knowledge, healthy lifestyle, social support, and incentives,

(a) Early detection and warning of diseases

Although participants' levels of disease awareness vary, they all show a strong interest in early detection and warning of diseases. They believe it is essential and hope that through learning, they can become more aware of their health status and improve their disease prevention consciousness.

"I find the content related to disease prevention useful. If there is such content available, it would be great, and I would pay more attention to it." (FGD3: participant 1)

(b) Prevalent chronic disease knowledge

During the interviews with the participants, their concern for diseases and their health conditions was evident. Most of them have started paying attention to health issues due to the emergence of various chronic health problems with age. They

express a desire to learn more about medical health knowledge, especially related to diseases.

"I want to know about common diseases that people of our age group may experience and knowledge about diseases that are likely to occur in the future." (FGD1: participant 2)

"I would like to learn about the prevalent diseases like heart and brain conditions using my mobile phone. Also, I'm interested in learning about blood pressure, blood lipids, and how to pay attention to my diet in daily life." (FGD6: participant 4)

"If you want me to consider, I would be interested in learning about health knowledge for middle-aged and elderly people. I want to know how to transform a person from being vulnerable to diseases to becoming healthy." (FGD6: participant 1)

(c) Healthy lifestyle

A good lifestyle has an undeniable impact on health. Many participants acknowledged the importance of a healthy lifestyle and the significance of dietary and exercise habits. Therefore, they hope that health education content will include knowledge about nutrition, physical activity, and other aspects to promote health.

"Knowledge about diet, walking, drinking, smoking, and other related aspects is crucial. The more you understand, the more helpful it is for your body. I enjoy

watching TV programs that discuss diabetes, hypertension, and other health topics. They are frequently broadcast." (FGD6: participant 1)

"I now need assistance in this area, and I am already making efforts myself. In my mind, dietary supplementation is deeply ingrained. I know that dietary supplementation is better than taking medicines, so I try to eliminate health issues through diet. I hope to control my health on one hand and, on the other hand, learn about health measures through various channels like the internet and television." (FGD5: participant 2)

"Also, rational suggestions, such as how to exercise and better methods for introducing physical activity, are important." (FGD2: participant 1)

(d) Social support and incentives

During the interviews, participants also discussed their views on the content and functionalities of mobile apps they commonly use. They expressed a need for social support and reminder features.

"It would be great to have reminders. For example, what I need to do today, if I forget, my family can remind me. Like reminding you when it's time to take medicine, right?" (FGD4: participant 3)

"Reminders can motivate you and help you gradually change your bad habits. This way, good habits can be established over time." (FGD4: participant 5)

In addition, they recognized the importance of motivational measures, considering them essential factors for enhancing health compliance.

"Another thing is related to walking in WeChat. I often pay attention to the number of steps I walk, especially when I walk a lot. Now, what I care about is the ranking of steps taken while walking. This way, I can understand my step count." (FGD5: participant 2)

4.2.1.3 Theme 3: Simplification for Accessibility

There are a few points in the design of the mobile phone program so that to simplification for accessibility by the participants. It includes a suitable presentation for the age group, simplification, and a convenient search function.

(a) Suitable presentation for the age group

As individuals age, the physical functions of the middle-aged population change and gradually approach aging. Visual impairment becomes a barrier to reading content on mobile phones. Prolonged reading of a single piece of content becomes challenging for them. Therefore, they express an interest in alternative formats such as short videos and voice broadcasts.

"Sometimes, short videos are the best. They have lively content with visuals and sound, and they don't strain the eyes." (FGD3: participant 1)

"But as I get older, my eyesight becomes weaker, so I don't like reading as much. I prefer listening, especially at night when I wear a steam eye mask and listen to articles." (FGD2: participant 3)

"With my poor eyesight, I can't see some of the words on the phone clearly. Listening helps me understand the content better. My eyesight isn't very good." (FGD4: participant 3)

(b) Simplification

Regarding content, participants advocate for simplification and prefer the use of fewer words and shorter texts. Lengthy and elaborate explanations lead to a loss of interest in learning. Almost all participants express a preference for a combination of text and visuals, as well as short videos, as these formats present the required information with fewer words.

"I like video recommendations. If they are presented from a professional perspective, the content can become very long. I prefer the content to be simplified, with as few words as possible. If it's always lengthy and elaborate, I lose interest." (FGD1: participant 1)

"There should be a combination of images and text; these are essential. The quantity doesn't matter if the essence is captured, and the information can be understood easily. Nowadays, in image news, a single image corresponds to just a

sentence or two. It should be straightforward to understand the meaning; it doesn't need to be complicated." (FGD6: participant 3)

(c) Convenient search function

When using their phones, they hope that the interface's search function is user-friendly. This way, they can quickly find the content they are looking for. A cumbersome search process increases the difficulty of usage.

"All aspects of search should be simple, for example, if blood pressure is high, I search for 'blood pressure,' and immediately health-related diet information should pop up." (FGD5: participant 2)

"For example, the design of the cover should not be overly complex. Information about which vegetables diabetics should eat should be readily visible when the app is opened. If it's a long and elaborate explanation, it becomes confusing." (FGD5: participant 4)

4.2.1.4 Theme 4: Enhancing Credibility

The scientific authoritative, and non-commercialization of the content should be considered to enhance the credibility of the educational-based mobile phone program.

(a) Scientific and authoritative

Participants show great concern about the scientific and authoritative nature of mobile health education content. They believe that health education content must be based on scientific evidence and be trustworthy to maintain user motivation. They are reluctant to view content with low credibility and place more trust in information released by authoritative experts and research institutions.

"Currently, this app is necessary, but it must be based on scientific principles and feasibility. Additionally, there must be authority and credibility. To be more specific, the content must be associated with authoritative figures or institutions, such as research institutions or professional universities. There are too many people talking about health in the media now, and we cannot allow it to become overly common. I have seen many instances where what they say is unscientific and deviates from the truth based on their knowledge level." (FGD1: participant 3)

(b) Non-commercialization

Participants strongly oppose educational forms that are mixed with commercial elements. They believe that if an app involves commercialization and requires them to purchase products, they will immediately abandon its use and question the content.

"On television, many health lectures are promoting drugs. Some claim to be from traditional Chinese medicine or famous doctors, but in the end, they are just promoting drugs. For this app, at any time, it should not have commercial elements. If

it appears to have commercial intent, I will immediately question its reliability." (FGD5: participant 2)

4.2.2 Design the First Draft of the Program

Through an extensive literature review aimed at elucidating the content and requisites of health management for individuals at risk of stroke, and a market survey aimed at gaining insights and innovating upon existing diet, physical activity, or healthy lifestyle management mini-programs and apps available in the market, we proceeded to craft the initial draft of the program.

The content of this application combines the Chinese Dietary Guidelines for Residents (2022) (CN, 2022), China National Guidelines for the Prevention and Treatment of Stroke (L. Liu et al., 2020), and HBM. The Chinese Dietary Guidelines for Residents is an important guide for guiding the Chinese people's diet, providing basic principles and methods for dietary intake, including content related to moderate diversity, balanced nutrition, and food safety. Designing the content of the application program in conjunction with the Chinese Dietary Guidelines for Residents can help users better understand the key points and nutritional requirements of a healthy diet, as well as how to select, match, and cook food, thus achieving the goal of a healthy diet. Combining the Chinese Dietary Guidelines for Residents with the Health Belief Model can lead to the design of a more comprehensive, scientific, and practical health application, helping users to better practice a healthy lifestyle.

This program, titled 'The Stroke-Preventive Diet and Lifestyle Educational Program' features four primary indicators (disease prevention, chronic disease management, dietary recommendations, and real-time updates) and twelve secondary indicators as described below:

(a) Disease prevention:

The content specifically covers certain health issues, including stroke risk assessment and the relationship between chronic diseases and stroke, so that users can perceive whether they face health threats and understand the consequences of the health issue to emphasize its severity. Provide suitable exercise plans according to the "eating and exercise combined for a healthy weight" mentioned in the Chinese Resident Dietary Guidelines, list specific steps for healthy exercise behaviors, and provide solutions to help users overcome barriers to adopting healthy behaviors.

(b) Chronic Disease Management:

Knowledge includes diabetes, hypertension, heart disease, dyslipidemia, and obesity.

(c) Diet:

Introduce the current dietary situation, the content of balanced dietary guidelines, and the benefits of a healthy diet to make users aware of the benefits of a healthy lifestyle. Provide recommended dietary plans and recipe examples from the Chinese Resident Dietary Guidelines, and list specific steps for healthy eating behaviors.

Considering personal factors of the Chinese middle-aged stroke high-risk population, such as age, gender, and socioeconomic status, as well as cultural and environmental factors that may affect health-related behaviors, provide solutions to help users overcome barriers to adopting healthy behaviors, such as how to develop a healthy eating plan and how to choose healthier foods. Additionally, the application may include other features such as recipe and nutrition value sharing.

(d) Real-time Updates:

Take advantage of the WeChat public account's strengths to update the latest information in real time, including seasonal recipes, common recipes, disease prevention knowledge, reminders, and health interactions. For example, how to alleviate and prevent diseases. The design of the functional modules and module content is illustrated in Figure 4.1 and detailed in Table 4.3.

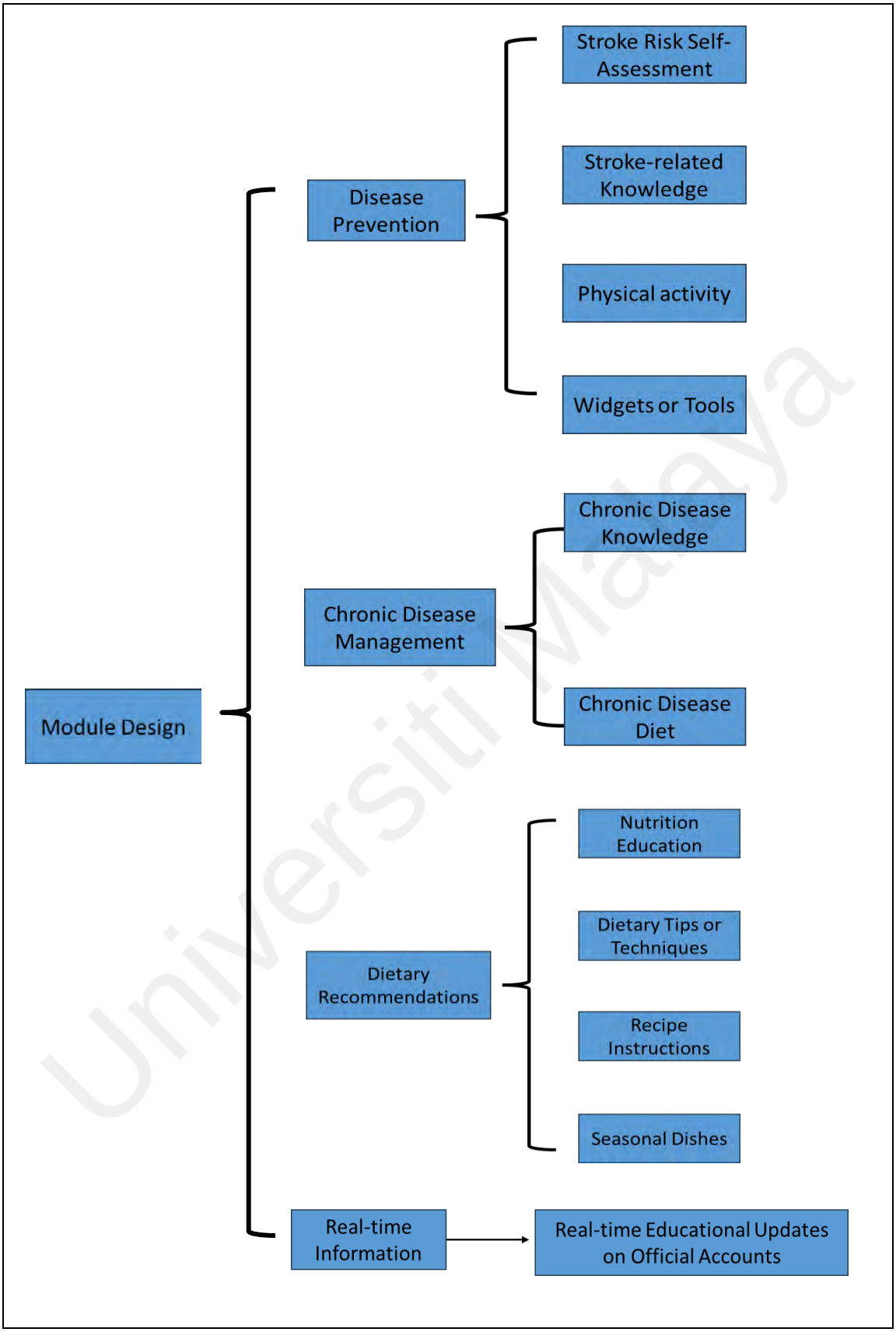

Figure 4.1: Design of Functional Modules

Table 4.3: Module Content

Modules	First-level indicator	Second-level indicator
Disease Prevention	Risk assessment	Outcomes： ● low risk ● medium risk ● high risk
	Stroke prevention	Understanding stroke
		Risk factors for stroke: ● Uncontrollable risk factors ● Controllable risk factors
		Clinical manifestations of stroke
		Early Recognition and First Aid of Stroke
	Physical activity	Relationship between physical activity and health
		Common knowledge about physical fitness and health
	Widgets or tools	Measuring Body Mass Index
		Goal setting
		Logging and track
		"FAST" stroke recognition
Chronic Disease Management	Popularization of chronic diseases	Knowledge including diabetes, hypertension, heart disease, dyslipidemia, and obesity) ● Causes of various chronic diseases ● clinical manifestations ● Complications and hazards ● prevention and treatment
	Chronic disease diet	Diet recommendations for diabetes, high blood pressure, heart disease, obesity, etc.

Table 4.3, continued

Chronic Disease Management	Chronic disease diet	Recommendation for low-salt diet Recommendation for a low-sugar diet Recommendation for a low-fat diet
Dietary Recommendations	Nutrition education	Mediterranean diet
		DASH diet
		Chinese Dietary Guidelines
		Knowledge of balanced nutrition
		Introduction to the Chinese Food Collection "Three Meals a Day"
	Dietary tips or techniques	
	Recipe instructions	A simple daily healthy diet Recommendations suitable for Chinese middle-aged and elderly people and in line with local characteristics
	Seasonal dishes	Recommend some seasonal dishes
Real-time Updates	Real-time Educational Updates on Official Accounts	Primary Content Updates Include: Latest Dietary Evidence Balanced Diet Recipes Seasonal Dish Recommendations Exercise-related Information
	Reminders	Design Goals for Timely Prompts According to Requirements (Eating Fruit, Drinking Water, Exercising)

4.2.3 Expert Consultation Results

"An inquiry of information from one or more individuals" is the definition of expert consultation. We refer to expert consultation if the parties are knowledgeable about the subject matter of the information requested (Gustafsson & Ollila, 2003). There exist multiple methods for consulting experts, each with pros and cons that vary based on the circumstances. The two most common techniques of consulting are in-person interviews and questionnaires. Using mockups, the concept was presented before the interviews began.

The outcomes of the expert consultations encompass expert feedback obtained through expert interviews. The specialists were specifically chosen to ensure that, given their many areas of expertise, they would generate a variety of suggestions. It is a consensus in the field that for content validation, a minimum of two experts is acceptable. Nevertheless, most recommendations advocate for a minimum of six experts. Considering these recommendations (5–8) and the author's expertise, the ideal number of experts for content validation should range from a minimum of six to a maximum of ten (Yusoff, 2019). Our interdisciplinary panel was composed of three nursing education experts, one clinical medicine physician, four clinical nursing experts, and two nutritionists to enhance the exchange of ideas. Table 4.4 shows the essential expert information.

Table 4.4: The essential expert information

NO.	Qualification	Level	Area	Duration
1	PHD	Prof	Nursing	26
2	PHD	Associate prof	Nursing	23
3	PHD	Senior lecturer	Nursing	16
4	Master	Associate Chief of Nursing	Neurology	24
5	Master	Associate Chief of Nursing	Neurology	12
6	PHD	Associate chief physician	Clinical medicine	16
7	Master	Associate professor of nursing	Clinical care	18
8	Master	Nurse-in-charge	Clinical care	17
9	PHD	Chief physician	Nutrition	22
10	PHD	Chief physician	Nutrition	26

Building on overall approval, the experts provided valuable insights and recommendations regarding the content of the app modules, app features, feasibility, and user adherence. These insights were subjected to discussions within the research team and subsequently integrated into the project.

Table 4.5: Summary of Expert Opinions

	Expert suggestions	**Prototyping**
Module	Most of the content in this module focuses on stroke and stroke prevention knowledge in the context of disease prevention. It is recommended to change the module name to 'Stroke Prevention	Change the module "Disease Prevention" to "Stroke Prevention."
	Placing the exercise module within the stroke prevention module may affect the effectiveness of exercise intervention. It is recommended to list it separately.	List relevant knowledge about exercise separately

Table 4.5, continued

	Preventing stroke is particularly important, and it is crucial to make the research subjects aware of the early warning signs as a key aspect of prevention.	Consider placing 'Early Identification' prominently so that everyone can quickly recognize it.
Content	How can we make the intervention content more understandable for participants? Only through understanding can they make judgments and act.	The content design should be straightforward to understand, avoiding the use of excessive technical jargon.
	The principles are quite simple, but after explaining them, the patient still doesn't know anything.	Consider adding visuals, audio, and video content appropriately.
	It's essential to understand the specific areas of interest for everyone.	Thoroughly integrating the content of qualitative interviews conducted in the early stages with the research population to gain in-depth insights and understanding of the research population's concerns and preferences.
	Different populations require tailored dietary plans based on their physiological characteristics.	For example, in the case of obese patients, with three meals a day, each meal should consist of roughly one-third of the total intake. The dietary plan should prioritize vegetables, with an emphasis on dark-colored vegetables comprising half of the meal, while carbohydrates can be more flexible.
	The content needs to be authentic, reliable, and evidence-based	According to the disease prevention and control guidelines, provide categorized and relevant introductions.

Table 4.5, continued

Feasibility	The concept of a diabetes diet is very comprehensive, with knowledge of overall quantity control and combinations, but lacking specifics on how to implement it.	A weekly meal plan must be presented in a very specific manner. Patients receive educational content in the form of everyday explanations, handouts, and food estimations, which enable them to better understand.
	Although an Eastern healthy diet is preferable, it might be challenging for individuals in the Northern regions to adhere to. Therefore, a recommendation would be to consume fish or seafood at least twice a week.	Tailoring intervention content to local habits and customs of the study population to make it easier to achieve the intervention goals.
Adherence	How to improve patient dietary and physical activity compliance? How to make it more purposeful and increase participant engagement?	Tailor the plan to align with their existing lifestyle habits. Provide options for free choice, similar to food exchange options. Offer professional, regular follow-up. Conduct risk self-assessment, which is crucial for increasing motivation and purpose. Introduce topics of interest to individuals with chronic conditions, such as providing an overview and explanation of chronic diseases, to make them more attentive to their health. Emphasize the risks by detailing the severity of the consequences of the disease, ideally with visual representations.

Validation of content by professionals is a crucial step in the development of educational materials (Gustafsson & Ollila, 2003). Content validity, also known as "theoretical analysis" (Morgado et al., 2017), refers to the "adequacy with which a measure assesses the domain of interest". The content validation process was carried out through face-to-face interactions. It involved an independent review utilizing a content validation form adapted from an instrument originally proposed by Silveira de Castro et al (Silveira de Castro et al., 2007). The evaluation of this module focused on three primary aspects: its objectives, content, and overall usefulness.

Table 4.6: Content validity index among experts

Criteria	Item Description	Relevant (Rating 3 or 4)	Not relevant (Rating 1 or 2)	CVI	Interpretation
Module objectives	1. The objectives are clearly stated	10	0	1	Appropriate
	2. The objectives are well-planned, formulated, and organized	9	1	0.9	Appropriate
	3. The objectives are relevant to the topics	10	0	1	Appropriate
	4. The objectives consider the target population's needs.	10	0	1	Appropriate
Module content	1. The content is directly relevant to the defined objectives	10	0	1	Appropriate
	2. The content is clear and easy to understand.	10	0	1	Appropriate
	3. The topic is fully discussed.	10	0	1	Appropriate
	4. The proposed content in every section follows a logical sequence.	10	0	1	Appropriate
	5. The content of the module is appropriate to the level of knowledge of the target population.	10	0	1	Appropriate
	6. The topics in every section portray key aspects that need to be reinforced.	9	1	0.9	Appropriate
	7. The time allocated to the individuals to complete the module was sufficient and appropriate	10	0	1	Appropriate
Module usefulness	1. The module can be implemented perfectly.	9	1	0.9	Appropriate
	2. The module is socially and culturally appropriate for the proposed target population.	10	0	1	Appropriate
	3. Overall, the information in the module can be used as a guide for healthcare professionals to conduct an educational intervention.	10	0	1	Appropriate
				S-CVI/AVE	0.98

I-CVI, Item content validity index, S-CVI/Ave, content validity index by scale, average

Rating:1= totally disagree, 2= partially agree, 3 = agree, 4 = totally agree

4.2.4 Prototyping and Development of the App

The mobile-based educational application has taken advantage of the WeChat Official Account's strengths to update the latest information in real time, including disease prevention knowledge, reminders, health interactions, and more. Use of the app begins with the login interface and once the users have logged in, they visualize the home interface, which includes several tabs (e.g., risk management, diet, exercise, and identification).

The tab of 'Risk' specifically covers certain health issues, including stroke risk assessment and the relationship between chronic diseases and stroke, so that users can perceive whether they face health threats and understand the consequences of the health issue to emphasize its severity. The interface educates users to assess their health risks through risk self-assessment, explaining the risk factors of diseases to users, allowing users to evaluate their vulnerability in terms of health, and further motivating them to act.

The interface 'diet' introduces the current dietary situation, the content of balanced dietary guidelines, and the benefits of a healthy diet to make users aware of the benefits of a healthy lifestyle. It provides recommended dietary plans and recipe examples from the Chinese Resident Dietary Guidelines and lists specific steps for healthy eating behaviours. The interface considers personal factors such as age, gender, and socioeconomic status, as well as cultural and environmental factors that may affect health-related behaviours, and provides solutions to help users at high risk of a stroke overcome barriers to a healthy lifestyle. These include how to develop a healthy eating plan and how to choose healthier foods. Additionally, the application may include other features such as recipe and nutrition value sharing.

The interface about ‘exercise’ provides suitable exercise plans in line with the guidelines of "eating and exercise combined for a healthy weight" mentioned in the Chinese Resident Dietary Guidelines. This lists specific steps for healthy exercise behaviours and provides solutions to help users overcome barriers to adopting them.

The last tab of ‘identification’ is about how to quickly recognise stroke symptoms.

Before commencing the development process, the research team engaged in multiple discussions with the software development team. In these deliberations, the researchers initially introduced the background, objectives, and significance of the study. Subsequently, they delineated their envisioned content and desired features for the app. The technical team provided feedback regarding the feasibility of the proposed functionalities, confirming their ability to complete them within the agreed-upon timeframe and methodology. In instances where full implementation was unattainable, alternative suggestions were put forth. Upon the conclusion of the requirements discussion, a comprehensive list of the system's functionalities was compiled. This list specified the included features, sub-features, column attributes, column formats, column content, and other relevant details, which were documented in tables or textual formats. With the support of the software development team, five modules were constructed: risk assessment, diet, physical activity, identification, and real-time updates area.

Establishing a software development team consisting of 4 members, including two senior software engineers (responsible for app module design, development, and ongoing maintenance), 1 professional graphic designer (responsible for page design), and a researcher. The software development team, after optimizing the initial draft of the app content based on preliminary research and expert consultations, proceeded to design the application. They also modified and wrote the frontend and backend code for the application and completed the development of the mobile app.

The researcher was responsible for formulating the app development plan and proposing system requirements for the app. They maintained real-time communication with team members. The software development professionals were in charge of software design and development.

4.2.5 Result of the Usability Test

Usability testing is a type of user research that evaluates the user's experience when interacting with a website or app (Maramba et al., 2019). It assists your product teams and designers in determining how user-friendly and intuitive your products are. Usability testing involves asking actual users to complete a set of usability activities on your product (instead of developers or designers), which helps you find issues with your product that you might have overlooked otherwise. The outcomes, rate of success, and routes followed to finish the activities are then examined to find possible problems and areas that could use improvement. Developing a product that aids users in achieving their goals and has a pleasant user experience is the aim of usability testing.

The usability evaluation study for the mobile-based educational program included both quantitative and qualitative data, allowing investigators to make inferences based on the advantages of both forms of data and to thoroughly investigate complicated phenomena in order to generate more valuable research. The quantitative collaboration by using SUS and the semi-structured qualitative interviews with end-users to test the satisfaction of the educational mobile program.

Overall, the study was conducted from December 2022 to February 2023, involving a total of 23 participants who completed the SUS. Among them, 15 participants also participated in qualitative interviews. There were no dropouts among the participants during the study period. The demographic characteristics of the participants are presented in Table 4.7.

Table 4.7: Demographic information of individuals

Characteristics	N	%
Age range (years) n(%)		
45-50	4	17.4
51-55	9	39.1
56-59	10	43.5
Gender, n(%)		
Males	11	47.8
Females	12	52.2
Work, n(%)		
Full-time work	12	52.2
Part-time work	6	26.1
Retired	5	21.7
Education, n(%)		
Junior high school and below	4	17.4
High school	7	30.4
Junior college or college	8	34.8
Bachelor's degree and above	4	17.4
Marital status, n(%)		
Single	4	17.4
Married/Cohabiting	19	82.6
Residence, n(%)		
Rural area	6	26.1
Urban area	17	73.9

4.2.5.1 Quantitative evaluation (questionnaire)

For the usability test, the data were entered and evaluated using SPSS Statistics Version 27. The data were summarized as categorical data, as well as mean and SD for numerical data. To calculate the SUS score, users would first rank each of the 10 template questions on a scale of 1 to 5 based on their level of agreement. For odd-numbered questions, 1 is subtracted from the score, and for even-numbered questions,

the score is subtracted from 5. The resulting scores are added up and multiplied by 2.5 to obtain the final SUS score. In this study, all 23 participants completed the quantitative evaluation. Fig.7 refers to the detailed results. The mean SUS score of 23 users was 81.5(SD 7.49), with a minimum score of 72.5 and a maximum score of 95, indicating the good usability of the application used in this study. The details of the quantitative evaluation are shown in Table 4.8.

Table 4.8: The result of the SUS

NO.	SUS questions	Strongly disagree	Disagree	No opinion	Agree	Strongly agree	Score Mean (SD)
1	I think that I would like to use this system frequently.				16 (69.6)	7 (30.4)	3.30 (0.470)
2	I found the system unnecessarily complex.	7 (30.4)	14 (60.9)	2 (8.7)			3.22 (0.600)
3	I thought the system was easy to use.			1 (4.3)	15 (65.2)	7 (30.4)	3.26 (0.541)
4	I think that I would need the support of a technical person to be able to use this system.	5 (21.7)	17 (73.9)	1 (4.3)			3.17 (0.491)
5	I found the various functions in this system were well integrated.				18 (78.3)	5 (21.7)	3.22 (0.422)
6	I thought there was too much inconsistency in this system.	6 (26.1)	17 (73.9)				3.26 (0.449)
7	I would imagine that most people would learn to use this system very quickly.			1 (4.3)	13 (56.5)	9 (39.1)	3.35 (0.573)
8	I found the system very cumbersome to use.	11 (47.8)	10 (43.5)	2 (8.7)			3.39 (0.656)
9	I felt very confident using the system.			1 (4.3)	17 (73.9)	5 (21.7)	3.17 (0.491)
10	I needed to learn a lot of things before I could get going with this system.	8 (34.8)	13 (56.5)	2 (8.7)			3.26 (0.619)
	The mean SUS scoring (summation of item scores)						81.5 (7.49)

4.2.5.2 Qualitative interview

Two themes in the semi-structured interviews revealed qualitative results: program characteristics, and user needs. Table 4.9 displays the demographic attributes of the participants involved in the qualitative interviews.

Table 4.9: Demographic information of individuals involved in the qualitative interviews (N=15)

NO.	Gender	Age	Education level	Residence	Marital status
1	Female	55	Junior college or college	Urban area	Single
2	Male	50	Junior college or college	Urban area	Married
3	Female	48	Junior college or college	Urban area	Single
4	Female	59	Junior high school	Urban area	Married
5	Female	57	Junior high school	Urban area	Married
6	Male	57	High school	Rural area	Married
7	Male	59	Junior college or college	Rural area	Married
8	Male	45	Bachelor's degree	Urban area	Married
9	Male	48	Junior college or college	Rural area	Married
10	Male	58	Junior college or college	Rural area	Married
11	Female	53	Junior college or college	Urban area	Married
12	Female	59	High school	Urban area	Married
13	Male	58	High school	Urban area	Married
14	Male	53	Junior college or college	Urban area	Married
15	Female	50	Junior college or college	Urban area	Married

(a) ***Theme 1： Program characteristics***

The theme is about the experiences and perspectives on using WeChat Mini Programs and Official Accounts, as well as their integration.

Subtheme: Comprehensive

According to the participants, the content of the resource covers a wide range of topics, such as risk management, diet, exercise, and self-improvement, which makes it a comprehensive learning resource.

Overall, the impression is that the content is very comprehensive, written in an easy-to-understand manner, and particularly suitable for the daily lives of middle-aged people. It is of certain reference value for daily life.（User 5）

Subtheme: Relevant

Most participants appreciated the Mini Program and believed that learning from it was very helpful for them. They reported gaining a preliminary understanding of the disease, including knowledge about stroke prevention, healthy eating habits, appropriate dietary choices, and the importance of regular exercise in maintaining a healthy lifestyle.

After reading this, you'll have a better understanding of what to keep in mind. Sometimes, we overlook our eating habits, but with the help of this program, we should start paying attention. If neglected, our well-being can lead to harmful diseases. I believe it is helpful for me. (User 1)

Subtheme: Prevention-oriented

Participants pointed out that the current era is characterised by a high incidence rate of disease. In this context, the concept of "prevention" holds greater appeal compared to previous approaches focused on education alone. People are increasingly recognising the significance of prevention and are consciously prioritising disease awareness.

Just like middle-aged and elderly people nowadays, it's time to pay attention to prevention. The term "prevention" really strikes a chord with everyone. Before

retirement, I used to indulge in unhealthy eating and excessive drinking due to work reasons. After retiring, I realised that what I used to consume was unhealthy, with lots of meat, heavy salt, and alcohol. Now, I've started to focus on health preservation. That's why I will use it. (User 12)

Constantly updated, updated disease prevention. I think in terms of prevention, stroke prevention, if he knows that his physical condition will cause a stroke, then he will focus on prevention. Diet does not also include prevention, what can be prevented, can prevent stroke. (User 5)

Subtheme: Easy to operate

Using WeChat in their daily lives is effortless for many people. Additionally, many users actively follow Official Accounts that cater to their interests and regularly check their messages. They highly appreciate the convenience of using WeChat as an application to acquire knowledge and find it extremely convenient.

As we have been using apps like WeChat for many years, operating them has become second nature. When clicking on a Mini Program or Official Account within WeChat, the content is straightforward to navigate. Users can easily open the sections they're interested in and access the content they want, making it very convenient. (User 11)

Subtheme: Real-time update

Regarding Official Account, most participants approve of its real-time updating feature, believing that it enables them to constantly learn new knowledge through frequent updates.

Once you follow the Official Account, it will continuously deliver real-time updates to your subscription feed. I find this automated push feature quite convenient. (User 2)

Subtheme: Seamless integration

Most participants indicated that the combination of the Mini Program and Official Account can achieve a synergistic effect greater than the sum of their parts. It can be combined with the Official Account to promote the better use of the Mini Program.

The combination of the two is quite effective and mutually beneficial. In the Mini Program, the content is more comprehensive. With so much information, I can't remember everything. When I need to review, I can simply use the Mini Program for studying. On the other hand, the Official Account provides timely reminders, and I can see real-time updates, which is more convenient. (User 7)

(b) ***Theme 2：User needs***

The theme revolves around the suggestions and ideas provided by the interviewees regarding the shortcomings of the program after use.

Subtheme: Emphasis on recipes and local seasonal vegetables

The public is more concerned about food safety, and now they prefer to eat healthy, seasonal food. They believe that it is better to follow nature and think that out-of-season vegetables are not healthy. In terms of diet, they hope to learn how to eat and how to achieve a reasonable mix.

I feel that I want to learn about some local vegetables commonly available. I believe it's better to eat seasonal produce. (User 10)

I feel that due to the development of technology, we can now eat anything, including out-of-season fruits and vegetables, but I think it is still better to eat seasonal food. Out-of-season vegetables and fruits are not good. (User 1)

Subtheme: Focus on individual needs

Individuals have diverse requirements, especially those at risk of stroke. To ensure the effectiveness of educational efforts, it is crucial to customise our approach based on their specific concerns and needs. Many participants emphasised that their primary focus lies in addressing their specific health issues. Other aspects or topics are of minimal interest to them as they prefer to concentrate solely on their immediate health priorities.

I hope there can be more targeted content, for example, if I have blood lipid issues, I will search for information related to blood lipids. (User 14）

Regarding exercise, I feel it is related to age. For example, people over 80 cannot walk too far, and some people cannot do certain types of exercise, such as heart disease patients who cannot do intense exercise. (User 2)

Subtheme: Healthy interaction through WeChat Groups

To achieve optimal results, WeChat's chat interface, WeChat Groups, can be fully utilised. While Official Accounts have a certain degree of reminder and message update functions, real-time messages posted may sometimes be easily overshadowed by other Official Accounts. It is recommended to establish WeChat Groups among the targeted population for intervention and forward the content links from Official Accounts to the WeChat Groups.

Sometimes, the daily posts on the Official Account can get easily overshadowed by messages from other subscription feeds. If you don't check them promptly, you may miss out on important updates.（User 6）

Subtheme: Reduction of texts

Most of the participants complained that their eyes felt uncomfortable after prolonged use of their mobile phones. Due to their age and physical condition, reading text-based content was sometimes strenuous for them. They preferred forms of content such as voice broadcasts, short videos, and cartoon images, which allowed them to receive information more directly.

I prefer content with videos, as it's easier on the eyes. If you are young, reading text might be fine, but as you age, watching videos is more convenient. (User 4)

It is also best to use visual aids such as cartoons, animations, or simplified instructions to reduce the number of textual descriptions and make it easier to understand. Adding small illustrations can make it easy to comprehend the information presented. (User 11)

4.2.5.3 Refine the App

During usage, the participants gave positive evaluations of the application, the participants have shown a great deal of interest in the content of this mini-program and expressed a strong willingness to continue using and learning from it. They felt that the content is highly relevant to their physical condition and daily life and the layout design is reasonable, making it easy to find the information you want to view. But there were also some issues identified. The limitations and solutions of the application are summarized below in Table 4.10.

Table 4.10: User evaluation and solutions description

Modes	User evaluation and problem description	
	Weakness	**Solutions**
WeChat official account	Some participants mentioned that when reopened the program, they were unsure where to find the public account. It was difficult to locate it again.	It would be helpful to send regular reminders to prompt users on how to access it.
	When the page content was re-opened, the participant was not initially aware that the video on the page could be played.	This reminds us that in the content creation of the public account, we can add symbols and text annotations to ensure everyone is aware of the interactive elements.
	The demand for content related to daily life is evident. Some of the participants expressed that adding some daily cases can help participants understand and recognize disease knowledge and expand their knowledge base through easy-to-understand examples.	The content should be easy to understand and avoid excessive use of medical jargon.
WeChat mini program	The pictures on the page are too small and cannot be enlarged. The image clarity needs to be adjusted.	Engage in effective communication with technical personnel to address and resolve the identified issue.
	Adding some refined exercise knowledge, such as suitable exercise methods for middle-aged individuals and how middle-aged individuals with chronic diseases should exercise.	Refine the content related to physical activity to better align with the needs.

4.3 Results of the Intervention Phase

Out of 169 participants who were assessed for potential eligibility to be included in this study, 25 individuals were eliminated due to their lack of interest and failure to meet the inclusion requirements. We assigned 144 participants with stroke to the intervention and control groups (n =72 in each). After the process of 8 weeks of follow-

up sessions, 14 losses to follow-up because they were uncontactable and discontinued intervention. All test procedures were completed by 130 participants, 64 of whom were in the intervention group and 66 in the control group. The flow of the data collection process for phase two is shown in Figure 4.2.

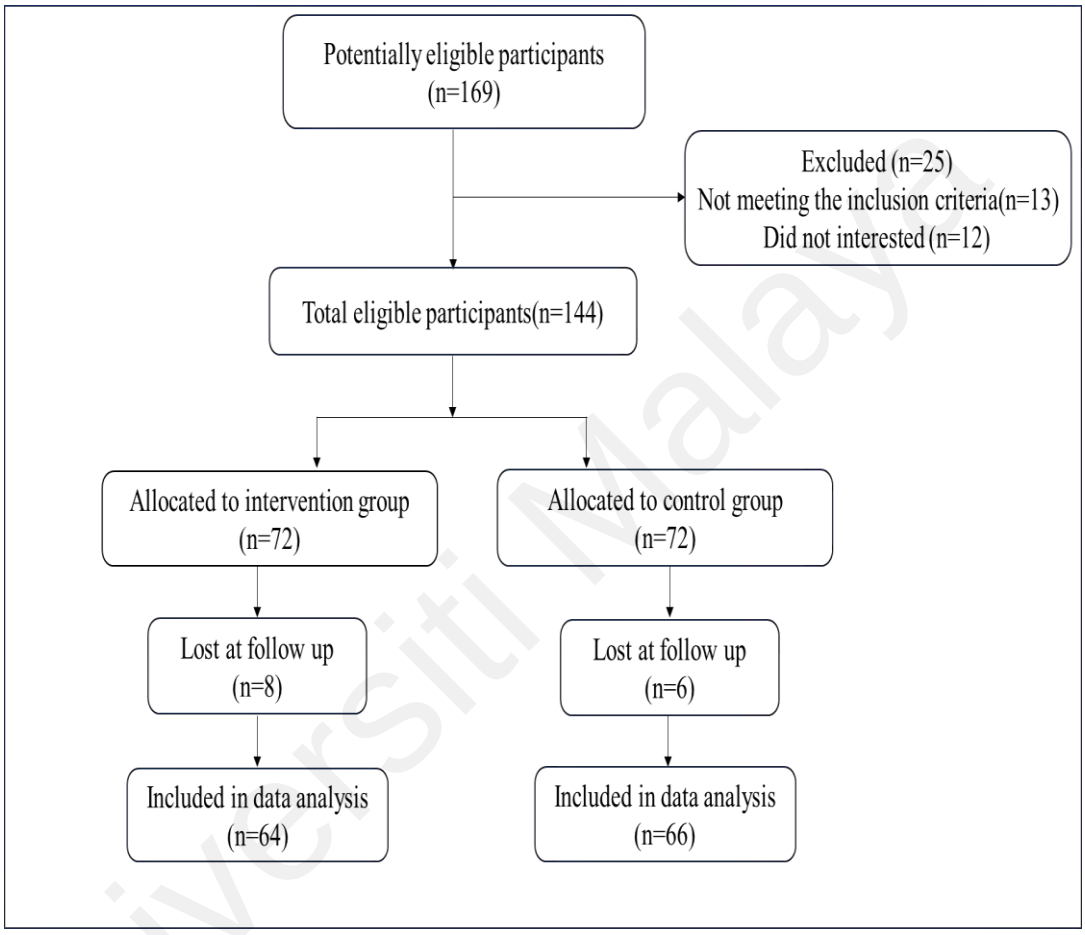

Figure 4.2: The Flow Chart

4.3.1 Distribution of data

To test the normality of data distribution can be performed by using graphical and statistical methods. Histogram, stem and leaf plot, boxplot, P-P plot and Q-Q plot were used to visually check for data normality, while several statistical tests such as Kolmogorov Smirnov (K-S) test, Lilliefors corrected K-S test, Shapiro-Wilk (S-W) test was also employed, but the K-S test is often used to check normality among them and it is usually used for when the number of participants is more than 50 (Yap & Sim, 2011).

To test data distribution, using skewness and kurtosis to assess normality could be considered, as there is no current gold standard method. For normally distributed data, a t-test is employed, while for non-normally distributed data, a non-parametric test is utilized.

The normality of the dataset for the FFQ-25, IPAQ-SF, SKQ, and WHOQOL-BREF scores was evaluated using the Kolmogorov Smirnov test, Histogram, and Q-Q plot to decide on the inferential statistics either using parametric or non-parametric tests. In this study, the data from the responses of the SKQ and WHOQOL-BREF at the pretest and posttest measurement met the assumption of normally distributed data. Hence, the parametric test which is the t-test was used to determine whether there is a significant difference between and within the mean values of the SKQ and WHOQOL-BREF scores measured educational intervention. However, the data from the responses of the FFQ and IPAQ-SF at the pretest and posttest measurement cannot meet the assumption of normally distributed data, Hence, the non-parametric test was used to determine whether there is a significant difference between and within the mean values of the FFQ and IPAQ-SF scores measured educational intervention.

4.3.2 Demographic Characteristics

For categorical variables like gender, age, marital status, residential location, educational level, and risk factors, the Chi-square test was employed for comparison. The study comprised 130 participants, encompassing both the intervention and control groups, with ages ranging from 45 to 59 years. More than half of the male participants in the intervention group, 34 (53.10%) and 40 (60.60%) in the control group compared to females 30 (46.90%) and 26 (39.40%) respectively. There was a higher number of participants who were married 119 (91.5%) and living with a family member 116 (89.20%). Nearly one in two among them living in rural in the intervention group, 41

(64.15%) and 44 (66.7%) in the control group. Participants who were in Junior high and below education level were slightly higher in the intervention group 36 (56.30%) and 34 (51.50%) in the control group compared to high school and above 28 (43.80%) and 32 (48.50%). Seventy-eight (60%) participants had average income per month ⩾3000 compared to 52 (40%) with average income per month ⩽ 3000. Participants undiagnosed 1, 2, 3, or more risk factors accounted for 60 (46.20%),44 (33.8%), and 26 (20.00%), respectively.

To assess the homogeneity in demographic variables between the intervention and control groups at the pretest, the Chi-Square test was conducted. As presented in Table 4.11, the results indicated that there were no significant differences in demographic variables between the intervention and control groups at the pretest, as evidenced by a p-value exceeding .05. Therefore, it can be concluded that the intervention and control groups exhibited homogeneity.

Table 4.11: The demographic characteristics of participants (N=130)

Variables	**Total**	**Treatment (n=66)** n (%)	**Control (n=64)** n (%)	$\chi 2$	***P***
Gender				0.742	0.389
men	74 (56.90)	34 (53.10)	40 (60.60)		
women	56 (43.10)	30(46.90)	26 (39.40)		
Age				1.514	0.469
＜50	53 (40.80)	24 (37.50)	29 (43.90)		
50-55	31 (23.80)	14 (21.90)	17 (25.80)		
＞55	46 (35.40)	26 (40.60)	20 (30.30)		
Marital status				0.796	0.372
divorced or widowed	11(8.5)	4 (6.30)	7 (10.60)		
married	119 (91.5)	60 (93.80)	59 (89.40)		
Residential location				0.097	0.755
rural	85(65.4)	41 (64.1)	44 (66.7)		
urban	45 (34.6)	23 (35.9)	22 (33.3)		
Living arrangements				0.004	0.951

Table 4.1, continued

living with family	116 (89.20)	57 (89.10)	59 (89.40)		
alone	14 (10.80)	7 (10.90)	7 (10.60)		
Education level				0.239	0.588
Junior high and below	70 (53.80)	36 (56.30)	34 (51.50)		
High school and above	60 (46.20)	28 (43.80)	32 (48.50)		
Average income per month				0.251	0.616
＜3000	52 (40)	27 (42.2)	25 (37.9)		
≥3000	78 (60)	37 (57.8)	41 (62.1)		
Risk factors				0.487	0.784
1	60 (46.20)	30 (46.9)	30 (45.5)		
2	44 (33.8)	20 (31.3)	24 (36.4)		
≥3	26 (20.00)	14 (21.9)	12 (18.2)		

X2=Chi-square test

* Significant at 0.05 level (2 tailed)

4.3.3 Objective 1: To Determine the Difference in Dietary Intake between and within the Intervention and Control Groups.

For the current study, we practiced two groups' assessments. Using the Chinese Dietary Guidelines as a reference, analysed food intake quantities and conducted a comparative analysis. Due to the non-normal distribution of dietary intake data, the Mann-Whitney U test was conducted to determine the changes between the intervention and control groups. Table 4.12 presents the baseline difference of dietary intake for the 4 domains between groups. There are no statistically significant changes that were found between groups.

Table 4.12: The baseline difference in dietary intake changes between groups

Domains	Intervention M (P_{25}, P_{75})	Control M (P_{25}, P_{75})	Z	P
Whole grains	144.25(110, 256.5)	151(113.5, 206)	-0.403	0.687
Vegetables	73.5(47, 150)	72(44, 122)	-0.803	0.422
Fruit	33(14, 75)	33(20,84)	-0.456	0.649
Aquatic products	6.5(3, 14.38)	7.75(2.63, 18.38)	-0.009	0.993

Apart from the comparison between the groups, we wanted to observe any significant change in food intake within two groups at baseline and 8 weeks. Due to the non-normal distribution of dietary intake data, the Paired Samples Wilcoxon Signed Rank Test analysis was conducted to determine the changes within the intervention and control group. As shown in Table 4.13, except for aquatic products (6.5(3, 12.5) vs 6.5(3, 14.38)), the whole grains (144.25(110, 256.5) vs 204.5(146, 277), P= 0.011), the fruit ((33(14, 75) vs 75(22, 118.5), P=0.016) and vegetable scores (73.5(47, 150) vs 129(81.25, 194.75), P= 0.010) were all higher than those in the pretest, but the differences were nonsignificant in control groups.

Table 4.13: The total and each score of dietary intakes (pre- and post-) for both the intervention and control groups

Domains	Baseline M (P_{25}, P_{75})	8 weeks follow up M (P_{25}, P_{75})	Z	P
Whole grains				
Intervention	144.25(110, 256.5)	204.5(146, 277)	-2.555	0.011
Control	151(113.5, 206)	151.5(113.5, 206)	-1.461	0.144
Vegetables				
Intervention	73.5(47, 150)	129(81.25, 194.75)	-2.585	0.010
Control	72(44, 122)	72(48.5, 122)	-1.342	0.180
Fruit				
Intervention	33(14, 75)	75(22, 118.5)	-2.416	0.016
Control	33(20,84)	50(22, 100)	-1.133	0.257
Aquatic products				
Intervention	6.5(3, 14.38)	6.5(3, 12.5)	-0.708	0.479
Control	7.75(2.63, 18.38)	7.75(3, 18.38)	-0.108	0.914

To determine the follow-up difference of changes between the intervention and control group in dietary intake, we conducted a non-parametric Mann-Whitney U rank sum test. At the 8-week program, there is no significant difference in the aquatic products (P = 0.282) and fruit (P=0.309) between the two groups. However, the dietary intake per week in the intervention group improved significantly compared to the control group and was significantly greater for whole grains (P＜0.001), and vegetables (P＜0.001) follow-up 8 weeks. Table 4.14 shows the follow-up difference of change between intervention and control groups in dietary intake. This indicates that the mobile-based educational program had effectively increased the whole grains and vegetable intake among these middle-aged adults.

Table 4.14: The follow-up difference in dietary intake changes between groups

Domains	Intervention M (P_{25}, P_{75})	Control M (P_{25}, P_{75})	Z	P
Whole grains	204.5(146, 277)	151.5(113.5, 206)	-3.351	＜0.001
Vegetables	129(81.25, 194.75)	72(48.5, 122)	-3.934	＜0.001

Table 4.14, continued

Fruit	75(22, 118.5)	50(22, 100)	-1.018	0.309
Aquatic products	6.5(3, 12.5)	7.75(3, 18.38)	-1.075	0.282

4.3.4 Objective 2: To Determine the Difference in Physical Activity between and within the Intervention and Control Groups

The IPAQ was scored using recognised methods, and the results were presented as a continuous measure in metabolic equivalent of task (MET)-minutes each week. To determine the difference in physical activity between the control and intervention groups, the Mann-Whitney U test and Wilcoxon Signed Rank Test were used due to the non-normal distribution.

The baseline result of the analysis of physical activity MET-minutes per week of middle-aged participants between the two groups using the Mann-Whitney U test. According to the result of the analysis, there is no significant difference in the total physical activity (P=0.958) and each physical activity including vigorous (P=0.203), moderate (P=0.973), and walking (P=0.081) at baseline between the two groups.

Table 4.15: The baseline difference in physical activity changes between groups

Domains	Intervention M (P_{25}, P_{75})	Control M (P_{25}, P_{75})	Z	P
Vigorous physical activity	0(0, 240)	0(0, 1380)	-1.273	0.203
Moderate physical activity	260(0, 1140)	320(10,720)	-0.034	0.973
Walking physical activity	990(594, 1650)	693(346.5, 1386)	-1.744	0.081
Total physical activity	1848(955, 3225)	1885.5(1077.8, 3149.3)	-0.053	0.958

The result of the analysis within each group using the Paired Samples Wilcoxon Signed Rank Test showed that the total physical activity MET-minutes per week of middle-aged participants from the intervention group had been significantly enhanced (P=0.003). Meanwhile, in the control group, participants' total physical activity MET-minutes per week did not change significantly after 8 weeks (P=0.074). Table 4.16

shows the mean total and each score of physical activity (pre- and post-) for both the intervention and control groups.

Table 4.16: The total and each score of physical activity (pre- and post-) for both the intervention and control groups

Domains	Baseline M (P_{25}, P_{75})	8 weeks follow up M (P_{25}, P_{75})	Z	P
Vigorous physical activity				
Intervention	0(0, 240)	0(0, 2400)	-1.630	0.103
Control	0(0, 1380)	0(0, 1920)	-0.662	0.508
Moderate physical activity				
Intervention	260(0, 1140)	640(90, 3420)	-2.518	0.012
Control	320(10, 720)	450(80, 1440)	-1.709	0.087
Walking physical activity				
Intervention	990(594, 1650)	2079(937.5, 2772)	-3.077	0.002
Control	693(346.5, 1386)	891(470.25, 1386)	-0.858	0.391
Total physical activity				
Intervention	1848(955, 3225)	3508(2030.5,7428.75)	-2.933	0.003
Control	1885.5(1077.8, 3149.3)	2959(1106.13, 4347)	-1.785	0.074

The follow-up results of the analysis of physical activity MET-minutes per week of middle-aged participants between the two groups using the non-parametric Mann-Whitney U rank sum test. At the 8-week program, there is no significant difference in vigorous physical activity (P =0.761) and moderate physical activity (P=0.156) between the two groups. However, the MET-minutes per week that the intervention group improved significantly compared to the control group for walking (P=0.002), and total physical activity (P=0.035) follow-up 8 weeks. Table 4.17 shows the follow-up difference of change between intervention and control groups in physical activity.

Table 4.17: The follow-up difference in physical activity changes between groups

Domains	Intervention M (P_{25}, P_{75})	Control M (P_{25}, P_{75})	Z	P
Vigorous physical activity	0(0, 2400)	0(0, 1920)	-0.305	0.761
Moderate physical activity	640(90, 3420)	450(80, 1440)	-1.417	0.156
Walking physical activity	2079(937.5, 2772)	891(470.25, 1386)	-3.166	0.002
Total physical activity	3508(2030.5, 7428.75)	2959(1106.13, 4347)	-2.103	0.035

4.3.5 Objective 3: To Determine the Mean Difference in Stroke Prevention Knowledge between and within the Intervention and Control groups.

Stroke Knowledge Questionnaire (SKQ) used 36 items to evaluate general stroke prevention knowledge. The baseline result of the analysis of stroke prevention knowledge of middle-aged participants between the two groups using the independent t-test measurement. According to the result of the analysis, no significant differences between the intervention and control groups were discovered for stroke knowledge (P= 0.753) before the intervention.

Table 4.18: The baseline difference in the change of mean values between groups in stroke prevention knowledge

Domains	Intervention Mean±(SD)	Control Mean±(SD)	T	P
Daily routines	6.89±1.39	6.73±1.27	0.699	0.486
Exercise	3.42±0.85	3.5±0.73	-0.563	0.574
Diet	3.63±0.79	3.58±0.82	0.348	0.728
Risk factors	3.73±1.01	3.68±1.15	0.276	0.783
Medication	3.44±1.18	3.68±1.15	-1.194	0.235
Blood pressure monitoring	1.56±0.5	1.58±0.5	-0.151	0.88
Early signs of stroke	4.2±1.49	4.35±1.44	-0.565	0.573
Management	1.55±0.59	1.55±0.64	0.013	0.989
Total score	28.42±3.82	28.64±3.93	-0.315	0.753

The result of the analysis within each group using the Paired t-test measurement showed that the total knowledge score of middle-aged participants from the intervention group had been significantly enhanced between the pre-test (mean=28.42, SD=3.82) and post-test (mean=31.48, SD=2.09). Meanwhile, in the control group, participants' total knowledge score did not change significantly between the pre-test and post-test (mean=28.64, SD=3.93 and mean=28.67, SD=3.9). Table 4.19 shows the mean total of knowledge (pre- and post-) for both the intervention and control groups.

Table 4.19: The mean total scores of stroke prevention knowledge (pre- and post-) for both the intervention and control groups

Domains	Baseline Mean±(SD)	Follow up Mean±(SD)	T	P
Total score				
Intervention	28.42±3.82	31.48±2.09	-8.860	< 0.001
Control	28.64±3.93	28.67±3.9	-1.425	0.159

The follow-up results of the analysis of stroke prevention knowledge of middle-aged participants between the two groups using the independent t-test measurement. During the 8-week program, the knowledge score of the intervention group improved significantly compared to the control group for the total knowledge score ($P<0.001$) follow-up 8 weeks. There was an increase in the post-stroke prevention knowledge scores, with the intervention group obtaining a higher score than the control group. Table 4.20 presents the difference of change in the mean value of stroke prevention knowledge between groups.

Table 4.20: The follow-up difference in the change of mean value between groups in stroke prevention knowledge

Domains	Intervention Mean±(SD)	Control Mean±(SD)	P
Total score			
Baseline	28.42±3.82	28.64±3.93	＜0.001
Follow up	31.48±2.09	28.67±3.9	

4.3.6 Objective 4: To Determine the Mean Difference in Health-related Quality of Life between and within the Intervention and Control groups

For assessing quality of life, this study utilized the WHOQOL-BREF assessment tool, comprising 24 items categorized into four domains: physical, psychological, social, and environmental. Additionally, two general items related to health conditions were independently analyzed.

An independent t-test was conducted to determine significant differences between the intervention and control groups for health-related quality of life due to the normal distribution. We computed the analysis to determine the mean difference in health-related quality of life between the intervention and control groups at baseline, the result of analysis within each group using the independent t-test measurements. According to the result of the analysis, no significant differences between the intervention and control groups were discovered for stroke knowledge (P= 0.852) before the intervention. Table 4.21 presents the baseline difference between the changes in mean values between both groups.

Table 4.21: The baseline difference in the change of mean values between groups in WHOQOL-BREF

Domains	Intervention Mean±(SD)	Control Mean±(SD)	T	P
Physical health	14.29±1.51	14.16±1.91	-0.459	0.647
Psychological health	14.16±1.59	14.04±1.66	-0.406	0.685
Social relationships	14.1±1.68	14.4±2.11	0.896	0.372
Environment	13.93±1.42	14.08±1.91	0.494	0.622
Total	56.48±4.75	56.68±6.89	0.188	0.852

A paired t-test was used to determine the difference in the quality of life pre-and post-test for both the control and intervention groups. To determine the mean difference in health-related quality of life within the intervention and control groups of WHOQOL-

BREF, the result of analysis within each group using the Paired t-test measurements. In the intervention groups, the total scored from 56.48 during the pre-test to 59.09 at the post-test, the physical health domain scored from 14.29 during the pre-test to 15.07 at the post-test, the psychological domain scored from 14.16 during the pre-test to 15.07 at the post-test, the social relationships domain scored from 14.1 during the pre-test to 14.65 at the post-test, and the environment domain scored from 13.93 during the pre-test to 14.31 at the post-test. There were significant differences in the mean quality of life scores for the total score (P=0.005), physical health (P=0.007), and psychological health domains (P=0.003) except for social relationships, and environmental health. In the control group, there were no significant increases in the mean quality of life scores in all domains. Table 4.22 presents the change in the total and four domains of WHOQOL-BREF (pre- and post-) within the group.

Table 4.22 The change in the total score and four domains of WHOQOL-BREF (pre- and post-) within groups

Domains	Baseline Mean±(SD)	Follow up Mean±(SD)	T	P
Physical health				
Intervention	14.29±1.51	15.07±1.72	-2.782	0.007
Control	14.16±1.91	14.71±1.97	-1.425	0.132
Psychological health				
Intervention	14.16±1.59	15.07±1.78	-3.132	0.003
Control	14.04±1.66	14.47±1.74	-1.35	0.172
Social relationships				
Intervention	14.1±1.68	14.65±1.57	-1.766	0.082
Control	14.4±2.11	14.46±1.99	-1.759	0.083
Environment				
Intervention	13.93±1.42	14.31±1.69	-1.39	0.169
Control	14.08±1.91	14.05±1.9	1.654	0.103
Total				
Intervention	56.48±4.75	59.09±5.26	-2.906	0.005
Control	56.68±6.89	57.69±4.7	-1.673	0.116

We computed the analysis to determine the mean difference in health-related quality of life between the intervention and control groups at follow-up, the result of analysis

within each group using the independent t-test. According to the analysis results, the total score P=0.112. The physical health domain scored P=0.268, the psychological domain scored P=0.055, the social relationships domain scored P=0.566, and the environment domain scored P=0.414. There is no significant difference between the follow-up in the physical health scores, psychological health, social relationships scores, and the environmental health scores of this questionnaire.

Table 4.23: The follow-up difference in the change of mean values between groups in WHOQOL-BREF

Domains	Intervention Mean±(SD)	Control Mean±(SD)	T	P
Physical health	15.07±1.72	14.71±1.97	2.825	0.268
Psychological health	15.07±1.78	14.47±1.74	3.338	0.055
Social relationships	14.65±1.57	14.46±1.99	0.576	0.566
Environment	14.31±1.69	14.05±1.9	0.82	0.414
Total	59.09±5.26	57.69±4.7	2.256	0.112

4.4 Summary

Chapter 4 provided valuable insights into the perceptions and needs of middle-aged individuals at risk of stroke, which can inform the development and improvement of the app. This chapter was also founded upon a qualitative needs assessment of the research population conducted in the preceding phase, as well as a comprehensive literature review. It also encompassed the creation of an initial draft for the APP modules, with the Health Belief Model theory serving as the guiding framework. After expert interviews, the preliminary platform framework and content draft were subjected to thorough deliberation, leading to revisions based on expert feedback, ultimately culminating in the finalization of the platform's content and functionality.

The usability of this chapter demonstrated that the education-based mobile program provided a simple platform that can be easily operated by a wide variety of users with a

risk of stroke. Study findings also provided insight into participants' preferences for mobile applications that can inform future research and development projects. Once we have further refined the project, we can conduct intervention experiments to validate its positive impact on individuals at risk of stroke and to verify its feasibility.

This chapter also focused on describing the quasi-experimental part of this study, outlining its methods, and presenting its results. Descriptive statistics were provided for demographic data, dietary intake, physical activity, stroke prevention knowledge score, and health-related quality of life among middle-aged participants at risk of stroke in both the intervention and control groups. T-tests and non-parametric tests were employed for the analysis.

CHAPTER 5: DISCUSSION

5.1 Introduction

This chapter discussed the main findings of this study and compares them with the previous studies. It began with the discussion of qualitative findings including the description of requirements for middle-aged adults at risk of stroke. Then, the usability evaluation of the mobile-based educational program was discussed. It also explained the effectiveness of the mobile-based educational program.

5.2 Requirements for Middle-aged Adults at Risk of Stroke

The primary goal of this qualitative study was to create a mobile app tailored to the needs of middle-aged individuals at risk of stroke, to aid in stroke prevention and management. Qualitative analysis provided valuable insights into user needs and expectations, serving as a guiding framework for app development and enhancement.

In terms of user awareness regarding stroke risk in middle age, our research revealed that most middle-aged individuals have a relatively low level of awareness regarding stroke (Nicol & Thrift, 2005). Their attention tends to focus on health issues that arise in later stages of life, often neglecting the risks associated with middle age. Consequently, the app's design must prioritize the education of users about the significance of middle-aged stroke risk, effectively increasing their awareness of this critical health concern. Furthermore, our research identified variations in app needs and usage patterns among distinct user groups. These discrepancies stem from differences in health conditions and personal preferences, emphasizing the importance of tailoring app features and services to meet the specific requirements of diverse user groups (Schnall et al., 2016).

Qualitative analysis revealed a diverse range of needs among individuals at risk of middle-aged stroke. Some users seek information related to healthy eating and exercise through the app to mitigate their stroke risk, while others prioritize monitoring

physiological indicators such as blood pressure and blood sugar, necessitating effective data management. Additionally, certain users are particularly concerned about early warning signs of stroke and require guidance on emergency measures. Consequently, in the app's feature design, it is imperative to integrate these disparate needs and offer personalized services.

Users have high expectations for app interface design and user experience. They anticipate a user-friendly interface with clear, engaging information presentation to enhance user engagement and retention (Wei et al., 2020). During app development, it is crucial to accord priority to user interface design to ensure a positive overall user experience. To foster increased user engagement and ongoing app utilization, it may be beneficial to incorporate elements such as reward mechanisms and social interaction. These incentives can encourage users to sustain a healthy lifestyle and continue using the app over time.

Users place a premium on the privacy of their health data (Dogruel et al., 2017). They express a strong aversion to health apps with commercial motives and exhibit skepticism toward profit-oriented software. In the app's development, it is paramount to guarantee the security of user data through stringent data encryption and privacy protection measures. Moreover, it is essential to transparently communicate the purpose and scope of data usage to users and obtain explicit consent. Qualitative analysis also unveiled some users' desire for the app to be integrated with medical institutions or professional doctors to receive specialized advice and guidance. This underscores users' expectations regarding the authority and credibility of the data, as they seek comprehensive and authoritative health recommendations.

We found that users have a relatively low level of awareness about stroke, indicating a need for enhanced health education. User demands are diverse, highlighting the

importance of providing personalized services. User experience and interface design are crucial aspects to consider. Data privacy and security must be thoroughly ensured. Additionally, establishing connections with healthcare institutions and enhancing user engagement are also noteworthy areas. We hope that the results of this study will offer beneficial guidance for the development of stroke prevention and management apps for middle-aged individuals. This, in turn, can better cater to users' needs, promote healthier lifestyles among middle-aged individuals, and reduce the risk of stroke.

5.3 Usability Evaluation of the Mobile-Based Educational Program

This usability test was also founded upon a qualitative needs assessment of the research population conducted in the preceding phase, as well as a comprehensive literature review. It also encompasses the creation of an initial draft for the APP modules, with the Health Belief Model theory serving as the guiding framework. After expert interviews, the preliminary platform framework and content draft were subjected to thorough deliberation, leading to revisions based on expert feedback, ultimately culminating in the finalization of the platform's content and functionality. We designed the Stroke-Preventive Diet and Lifestyle Educational Program which is based on the WeChat ecosystem. This app displays 4 tabs that deliver information on and assess risk management, diet, exercise, and identification, and offers personalized recommendations and health interventions to encourage behavioral change for stroke prevention.

During the usability testing, the participants demonstrated high levels of cooperation and persisted in using the application until completion without any instances of dropouts. In this study, the quantitative questionnaire analysis results indicated that participants generally acknowledged the good usability of and their satisfaction with the mobile application. The findings demonstrate a positive reception towards the mobile

app and a willingness to recommend it to others. The results of the qualitative part are from users who see it as a tool for promoting and enhancing their lifestyles. The reasonable classification system of the application makes the information more organized, improving the efficiency of browsing and searching for information, resulting in positive feedback from users with valuable experiences.

The study's usability test indicated that the mobile-based instructional programme provides a basic platform that can be easily used by a wide range of people at risk of stroke. The study's findings also reveal participants' preferences for mobile applications, which can help inform future research and development projects. Once we have further refined the project, we can conduct intervention experiments to validate its positive impact on individuals at risk of stroke and to verify its feasibility.

The evaluation outcomes have provided valuable insights into the perceptions and needs of middle-aged individuals at risk of stroke, which can inform the development and improvement of the app. We found that users have a relatively low level of awareness about stroke, indicating a need for enhanced health education. User demands are diverse, highlighting the importance of providing personalized services. User experience and interface design are crucial aspects to consider. Data privacy and security must be thoroughly ensured. Additionally, establishing connections with healthcare institutions and enhancing user engagement are also noteworthy areas. We hope that the results of this study will offer beneficial guidance for the development of stroke prevention and management apps for middle-aged individuals. This, in turn, can better cater to users' needs, promote healthier lifestyles among middle-aged individuals, and reduce the risk of stroke.

Currently, WeChat has a very high usage rate in China (Hou et al., 2022). In recent years, there have been some studies on the use of WeChat for mobile education

interventions (X. Li et al., 2019; Song et al., 2021). In the era of mobile technology, where information abounds, there still exists a shortage of dependable and tailored avenues for mobile-based learning. What is needed is a dedicated platform that can enable effective learning for all. The respondents in this study expressed that a learning app of this nature resonated with them, as it not only served to increase their health awareness but also provided guidance on adopting healthier eating and exercise habits as preventive measures. The introduction of such a channel via WeChat has been met with widespread acceptance, notably improving the accessibility of learning for users.

From the perspective of Mini Program operators, the program's success hinges on effectively harnessing its social features to attract users and enhance user retention (Dwivedi et al., 2021). Different marketing strategies wield varying impacts on the diffusion process. Notably, social media marketing plays a pivotal role, especially during the initial stages of diffusion. The magnitude of advertising and interactive marketing directly influences the program's reach within a specific timeframe. More robust advertising and interactive marketing endeavors lead to swifter dissemination and a shorter timeline to reach a broader audience. Consequently, implementing appropriate marketing activities, such as bolstering advertising through increased promotion via public accounts, and integrating interactive marketing initiatives like incentive programs, can significantly amplify the diffusion of Mini Programs. The benefit of the Official Account lies in its real-time updates, allowing users to access the latest information directly on WeChat (Shen et al., 2019). The capabilities and offerings of WeChat Official Accounts continue to evolve, becoming increasingly sophisticated and robust. By incorporating additional features and services within WeChat Mini Programs, users can become more reliant on both the Official Account and Mini Program, thereby enhancing user engagement.

During the two-week trial conducted in this study, it became evident that while Official Accounts offer robust functionality and facilitate comprehensive user engagement, which is advantageous for information dissemination and promotional purposes, they may not fully cater to complex interaction scenarios and can be overshadowed by other subscription accounts. In various intervention studies centered around WeChat Official Accounts, the typical practice involves conducting large-scale tests (He et al., 2017), and interventions often extend over a relatively lengthy period due to the time required for effective information dissemination and promotion to take effect. Therefore, to optimize the short-term effectiveness of WeChat Official Accounts, it may be beneficial to leverage WeChat's communication features, such as WeChat Groups, to achieve this objective.

5.4 The Effectiveness of the Mobile-Based Educational Program

The findings of this study suggest that the mobile-based educational program effectively contributed to increased whole grains and vegetable intake among middle-aged adults. Notably, there were significant improvements in whole grain (P= 0.011), fruit (P=0.016), and vegetable scores (P= 0.010) compared to pretest levels. This positive impact on dietary habits aligns with existing literature highlighting the utility of mobile health (mHealth) interventions in enhancing dietary adherence.

Several studies have disclosed the positive impact of mobile-based intervention on dietary intake. Various studies, such as the work in Indonesia (Dharma & Parellangi, 2020), have consistently reported the effectiveness of mHealth in promoting a healthy lifestyle and reducing stroke risk factors among at-risk individuals. Their investigation into healthy lifestyle behavior assessment items within the intervention group demonstrated notable improvements in areas such as healthy diets, activity patterns, and stress control ($P < 0.01$) following the use of the M-SRSguide.

Furthermore, in America, Sarah Mummah and colleagues in 2017 conducted a study focusing on the impact of a mobile app on enhancing vegetable consumption among overweight adults engaged in weight loss maintenance (Mummah et al., 2017). The primary outcome, measured eight weeks post-randomization, assessed daily servings of vegetables using an adapted Harvard food frequency questionnaire (FFQ). Secondary outcomes included daily vegetable servings measured by 24-hour dietary recalls, administered five weeks post-randomization. The results indicated a significant increase in daily vegetable consumption in the intervention group compared to the control group for both measures (adjusted mean difference: 2.0 servings; 95% CI: 0.1, 3.8, p=0.04 for FFQ; and 1.0 serving; 95% CI: 0.2, 1.9; p=0.02 for 24-hour recalls). Moreover, baseline vegetable consumption emerged as a significant moderator of intervention effects (p=0.002), suggesting that the positive effects were more pronounced among individuals with higher baseline consumption. These findings collectively underscore the efficacy of mobile apps in influencing dietary behaviors, particularly in increasing vegetable intake.

As the current study demonstrated the Paired Samples Wilcoxon Signed Rank Test analysis within the intervention group revealed a significant enhancement in the total physical activity MET-minutes per week for middle-aged participants (P=0.003). Subsequent follow-up analysis, comparing physical activity MET-minutes per week between the intervention and control groups using the non-parametric Mann-Whitney U rank sum test at the 8-week mark, showed no significant difference in vigorous physical activity (P = 0.761) and moderate physical activity (P=0.156). However, the intervention group demonstrated a significant improvement compared to the control group in MET-minutes per week for walking (P=.002) and total physical activity (P=.0035) at the 8-week follow-up.

Following the current study's findings, the mobile app intervention significantly enhanced the physical activity MET-minutes per week. In support of this, studies conducted by Stephanie R Partridge (2015) designed and evaluated the efficacy of a mHealth prevention program, TXT2BFiT, targeting young adults at elevated risk of obesity and unhealthy lifestyle choices. The intervention group had a weight loss of 2.2 kg (95% CI 0.8-3.6) after 12 weeks, in comparison to the control group (P=.005). In addition, individuals in the intervention group exhibited a significant rise in vegetable consumption (P=.009), a decrease in the consumption of sugary soft beverages (P=.002), and a reduction in the consumption of energy-dense takeaway meals (P=.001) compared to the control group. Furthermore, in comparison to the control group, the intervention group demonstrated a significant increase in overall physical activity by 252.5 MET-minutes (95% CI 1.2-503.8, P=.05) and an increase in the frequency of physical activity by 1.3 days (95% CI 0.5-2.2, P=.003).

Similarly, researchers D. P. Gill and D. P. Gill (2019) conducted a study involving one hundred eighteen participants in Southwestern Ontario, Canada. Randomized into either the intervention group (HealtheSteps™ program, n = 59) or a wait-list control group (n = 59), participants in the HealtheSteps™ program experienced a significant increase in step counts (between-group [95% confidence interval]: 3132 [1969 to 4294], $p < 0.001$), a reduction in sitting time, and an improvement in overall healthful eating compared to the control group after 6 months. These studies collectively highlight the substantial impact of mobile app interventions in promoting physical activity among diverse populations, emphasizing their potential to foster healthier lifestyle behaviors.

According to the results of the current study, the analysis within the group revealed a significant enhancement in the total knowledge score among middle-aged participants in the intervention group, showcasing a noteworthy progression from the pre-test

(mean=28.42, SD=3.82) to the post-test (mean=31.48, SD=2.09). This signifies a substantial increase in stroke prevention knowledge following the mobile-based educational program.

The observed improvement aligns with findings from previous Randomized Controlled Trials (RCTs), where interventions employing mobile healthcare apps demonstrated significant enhancements in health-related knowledge. For instance, in a study conducted by Kang et al. (2019), 76 stroke patients were randomly and equally assigned to intervention and control groups, highlighting the effectiveness of mobile interventions in improving knowledge levels related to health outcomes. These results underscore the potential of mobile apps as impactful tools in enhancing health-related knowledge, particularly in the context of stroke prevention.

Meanwhile, within the intervention groups, the results of the analysis unveiled significant differences in the mean quality of life scores, particularly in the physical health (P=0.007) and psychological health domains (P=0.003). However, no statistically significant differences were observed in the social relationships and environmental health domains. The finding of the aforementioned is supported by the findings of previous studies. Drawing on related research, Kang et al. (2019) conducted a study involving the random and equal allocation of 76 stroke patients into intervention and control groups. While the EQ-5D VAS score (62.30 ± 18.77 vs. 59.67 ± 20.17, P=0.45) and EQ-5D index (0.62 ± 0.29 vs. 0.55 ± 0.29, P=0.11) showed increases in the intervention group as compared to the pretest, these differences were not statistically significant.

In a cluster-randomized controlled trial by Yan et al. (2021), the SINEMA intervention aimed to assess its effectiveness in enhancing stroke management in rural China. The trial, involving 1,299 stroke patients in Hebei Province, demonstrated the

intervention's significant association with improvements in 6 out of 7 secondary outcomes. These improvements encompassed health-related quality of life ($p = 0.008$), and physical activity level ($p < 0.001$). In conclusion, the findings suggest that a primary care-based mobile health intervention, integrating both provider-centered and patient-facing technology, can effectively reduce blood pressure and enhance stroke secondary prevention in resource-limited rural settings in China. It has been proposed that integrating mHealth with health counseling could serve as a valuable strategy for improving health-related quality of life.

While our findings align with the majority of studies, a study (Holmen et al., 2014) carried out in the region of Norway found no discernible effect of mobile-based intervention on health-related quality of life. This study, part of a 1-year follow-up in a 3-arm prospective randomized controlled trial with two intervention groups and one control group, failed to identify a significant impact of mobile-based interventions on health-related quality of life. There were no significant differences seen in either the unadjusted or adjusted analyses across all eight subscales and the two summary component scores of the SF-36. Furthermore, in the German research study A Mobile-Based Intervention to Boost Self-esteem in Students with Depressive Symptoms (Bruhns et al., 2021), which explores internet- and mobile-based interventions as promising alternatives to address the treatment gap, the results of the paired-sample t-test indicated no significant increase in quality of life (WHOQOL-BREF). Using baseline ratings as covariates, the ANCOVA showed that none of the samples' quality of life significantly improved with time. The quality of life was not significantly improved by using the self-help smartphone app, contrary to expectations (WHOQOL-BREF).

The WHOQOL-BREF, defining quality of life as an individual's perception of their life situation, utilized a single global item for assessment. It is plausible that improvements may only become evident after a more extended period, possibly revealed in follow-up examinations. Given the assessment's reliance on a single global item, it's conceivable that improvements could have been found on specific subscales of the WHOQOL-BREF, such as psychological quality of life and social relationships.

It is essential to acknowledge the inherent limitations in our current understanding and application of mobile apps for the population at risk of stroke. To address these, there is a need for a more profound exploration and enhancement of mobile app functionalities. This involves a continued refinement and optimization of existing apps to deliver a more personalized, practical, and user-friendly experience. Incorporating smarter risk assessments, precision in health data monitoring, engaging user interfaces, and fostering increased interactivity and social elements are crucial aspects to stimulate and sustain active user participation.

Furthermore, future research endeavors should shift their focus toward unraveling the long-term effects and sustainability of mobile app interventions. The current landscape lacks comprehensive insights into the enduring impact of app interventions on the lifestyle and health status of individuals at risk of stroke over extended periods. Consequently, there is a pressing need for more extensive, long-term follow-up studies that span several years or even longer. These studies will play a pivotal role in affirming the lasting effectiveness of app interventions, providing valuable insights to refine intervention strategies, and ensuring that users can consistently maintain a healthy lifestyle in the long run.

5.5 Summary

This chapter engages in a comprehensive discussion of the study findings. Our examination revealed that users exhibit a relatively low level of awareness regarding stroke, underscoring the imperative for heightened health education initiatives. The diverse demands articulated by users underscore the critical importance of delivering personalized services. The usability test conducted in this study unveiled that the mobile-based educational program serves as a user-friendly platform, easily navigable by a broad spectrum of individuals at risk of stroke. Additionally, the study findings offer valuable insights into participants' preferences for mobile applications, which can significantly inform future research and development projects. Moreover, the findings of this study posit that the mobile-based educational program made a substantial and effective contribution to dietary intake, physical activity, knowledge of stroke prevention, and health-related quality of life among middle-aged adults. In conclusion, it is imperative to acknowledge the inherent limitations in our current understanding and application of mobile apps for the population at risk of stroke within the discussion of these findings.

CHAPTER 6: CONCLUSIONS

6.1 Introduction

The Stroke-Preventive Diet and Lifestyle Educational Program has the potential to provide valuable stroke prevention knowledge and encourage lifestyle changes among individuals at risk of stroke. This chapter outlined the strengths and limitations of the present study, provided recommendations for enhancing future research in this area, and concluded with a summary of key findings.

6.2 Strengths of the Study

The main strength of this study lies in targeting the specific age group of middle-aged individuals, development, and evaluation of the Culturally Adapted Stroke Prevention Educational Program. Moreover, this application combines the various features of WeChat Mini Programs and Official Accounts.

6.2.1 Targeting the Specific Age Group of Middle-aged Individuals

Stroke is common in elderly people, but it also affects a large number of people under 65. Teenagers and young adults between the ages of 15 and 49 account for about one in seven strokes. Experts believe that because more young individuals are obese, have high blood pressure, or have diabetes, younger people are suffering from strokes. The stage of a person's life after early adulthood but before old age begins is known as middle age. Academic controversy surrounds the precise range, but generally speaking, the word refers to the age range of roughly 40–45 to roughly 60–65. People gradually deteriorate physically, cognitively, and socially during this stage of life.

6.2.2 Culturally Adapted Stroke Prevention Educational Program

Recognizing the diverse cultural landscape in different regions, nurses can contribute to the development of culturally sensitive mobile health interventions. This involves tailoring content and strategies to address the specific needs and preferences of diverse

populations, thereby amplifying the overall effectiveness of stroke prevention efforts. An unhealthy diet is one of the important risk factors that cause death and disease burden of cardiovascular and metabolic diseases in China. The growth in stroke risk in China over the past few decades has likely been caused by dietary changes brought about by rising income; this rise has accelerated in recent years.

Chinese people have seen a dramatic shift in their dietary habits over the last 20 years, moving from a traditional Chinese diet to one based more on the Western diet. During this time, they have consumed more red meat, eggs, and oils and fewer fruits and vegetables. We have discovered that the predominant eating habits of the Chinese populace encompass both customary and contemporary patterns that mirror China's recent shift in nutritional practices. These patterns have been linked to abnormal glucose tolerance and obesity.

The lowest incidence of stroke was linked to the traditional diet of the southern Chinese people, which is marked by high consumption of rice and vegetables and minimal consumption of animal products. The traditional northern Chinese diet, which is marked by high intakes of salted vegetables, potatoes, and refined cereal items, was linked to an increased risk of stroke when compared to the typical southern diet. We discovered that a traditional diet in the south was linked to a low prevalence of stroke, while a traditional diet in the north was linked to a higher risk of stroke. There was no correlation with the traditional cardiovascular risk factors. It has been revealed that the southern regions of China have a lower stroke prevalence than the northern portions.

Many mobile apps targeting stroke prevention primarily focus on risk screening, often with limited emphasis on providing educational guidance for adopting a healthy lifestyle. Moreover, there is a notable absence of comprehensive, personalized dietary guidance for specific health conditions. Additionally, tailored intervention programs

aligned with the dietary habits of the Chinese population and culture are lacking. As internet access and mobile phone ownership continue to grow in China, and with the rising popularity of the WeChat platform, a culturally adapted mobile educational program could effectively enhance stroke awareness among middle-aged adults, who are increasingly susceptible to this condition.

6.2.3 Combines the Different Functionalities of WeChat Mini Programs and Official Accounts

Our program strategically combined WeChat Mini Programs and Official Accounts to bolster stroke prevention efforts, drawing upon established theories, disease knowledge, and evidence about diet and exercise.

A WeChat Official Account serves as a publicly accessible profile that enables individuals or entities to share content, gather followers, and promote their offerings. This platform facilitates communication, allowing account holders to engage with their audience. As one of the earliest features of WeChat, public accounts have garnered a substantial user base and considerable user engagement. Articles from Official Accounts can be easily shared on WeChat Moments or through article push notifications, thereby attracting more user attention and traffic. Official Accounts also enjoy prominent visibility on WeChat, making them easily discoverable and followable for users. They offer advantages in terms of content dissemination, ease of operation and maintenance, enhanced interactivity, and a stable user base.

The WeChat Mini Program, on the other hand, is a lightweight application seamlessly integrated into the WeChat platform, requiring no installation, downloads, or uninstallations. Mini Programs offer a user-friendly interface with a low entry barrier, extensive audience reach, robust social interaction, and versatile application scenarios. They provide a native application experience, enabling richer and more intricate

interactive experiences. Mini Programs are designed to address the limitations of Official Accounts in terms of interactive applications.

Both WeChat Mini Programs and Official Accounts function within the WeChat ecosystem. Official Accounts can promote Mini Programs through articles or custom menus, ensuring convenient access for users. Additionally, they can establish a Mini Program entrance in the menu bar for easy accessibility. These two components complement each other across various scenarios, collectively enhancing the overall user experience.

6.3 Limitations of the Study

It's important to acknowledge that this study comes with certain limitations. The first limitation in our study design pertains to the ineffective calculation of completion time in evaluating user usage patterns. Accurately measuring the time for each task transition was challenging. Furthermore, as the WeChat Mini Program developed in this study is based on the personal version rather than the enterprise version, we couldn't gather comprehensive data through the background during the two-week usage period. Nevertheless, qualitative interviews complemented the usability testing, providing insights into users' real feelings and experiences during usage, thereby comprehensively evaluating all aspects of the application. The subsequent qualitative interviews offered valuable in-depth insights, enriching our results to some extent.

Additionally, effective dietary education and disease prevention demand a substantial knowledge base for the ongoing maintenance of the educational program. Team collaboration is crucial for regularly updating and enhancing content, ultimately adopting a more expert approach to primary stroke prevention.

Furthermore, the extensive workload during the initial phases of app development and design, along with practical challenges in community recruitment, demanded a significant investment of time and effort. In this randomized controlled intervention study, data collection was limited to baseline and the 2-month post-intervention period, without effective data collection for a more extended post-intervention period.

6.4 Recommendations for Future Research

Recommendations for nursing practices in mobile health and nursing collaborations are explained further in this section.

6.4.1 Nursing Practices in Mobile Health

Mobile-based stroke primary prevention stands as a promising frontier for future research, with nurses poised to play a pivotal role in advancing this field. Nurses can actively contribute to the development and implementation of mobile applications aimed at educating individuals on stroke risk factors and preventive measures. These applications have the potential to deliver tailored interventions, providing users with personalized recommendations for lifestyle modifications, medication adherence, and regular health screenings.

Leveraging technological progress, nurses can explore the utilization of mobile devices for remotely monitoring individuals at risk of stroke. This may involve tracking vital metrics such as blood pressure and heart rate. Additionally, telehealth consultations conducted through mobile platforms empower nurses to deliver real-time guidance and support, thereby augmenting the overall accessibility of healthcare services. Mobile-based platforms offer nurses opportunities to deliver behavioral interventions and motivational support. Through features like messaging, notifications, and interactivity, nurses can actively encourage individuals to adopt and sustain healthy behaviors, thereby enhancing adherence to preventive strategies.

Active involvement in collecting and analyzing data generated by mobile applications empowers nurses to gain valuable insights into user engagement, intervention effectiveness, and patterns of behavior change. Nurses with expertise in data analysis can significantly contribute to comprehending the impact of mobile-based interventions on stroke prevention outcomes. Nurses can explore strategies for seamlessly integrating mobile-based stroke prevention initiatives with electronic health records. This integration facilitates effective communication between patients and healthcare providers, ensuring that pertinent health information is readily accessible to the entire healthcare team. Advocacy by nurses for the accessibility and inclusivity of mobile-based interventions is paramount. This entails addressing factors such as language barriers, literacy levels, and technological literacy to ensure that the benefits of mobile health are accessible to a diverse and broad audience.

In terms of future research, it is imperative to delve deeper into the application of mobile apps in populations at risk of stroke. Continual refinement and optimization of existing apps should be pursued to provide more personalized, practical, and user-friendly features. This includes implementing smarter risk assessments, more precise health data monitoring, engaging user interfaces, and increased interactivity and social elements to stimulate active user participation.

Additionally, future studies can focus on the long-term effects and sustainability of mobile app interventions. Long-term follow-up studies are needed to understand the enduring impact of app interventions on the lifestyle and health status of individuals at risk of stroke over several years. This will help confirm the lasting effectiveness of app interventions and further enhance intervention strategies to ensure that users can maintain a healthy lifestyle in the long run.

6.4.2 Nursing Collaborations

Additionally, future research can explore more factors related to mobile app interventions, such as user concerns about privacy and data security. It can also investigate how to establish closer collaborations with healthcare institutions and professional healthcare providers to offer more authoritative health advice. These factors will contribute to further refining the design and functionality of mobile apps to meet user needs and expectations. Achieving comprehensive stroke prevention requires seamless interdisciplinary collaboration. Nurses closely collaborate with physicians, dietitians, physical therapists, and other healthcare professionals to develop integrated care plans tailored to the unique needs of each patient. In conclusion, nurses have a significant role to play in shaping the future of mobile-based stroke primary prevention research. Their expertise in patient education, behavioral interventions, data analysis, and cultural sensitivity positions them as key contributors to the development and implementation of effective mobile health strategies for stroke prevention.

6.5 Summary

This study focused on middle-aged individuals at risk of stroke in China and underwent a mixed research stage, including preliminary qualitative needs assessment, expert consultations, usability testing, and finally, the intervention experiment. Through qualitative demand interviews, we gained in-depth insights into the needs and expectations of this specific group at risk of stroke. These insights served as a robust guide for subsequent intervention procedures, ensuring that our mobile application could meet the actual needs of users, including personalized health information, risk assessment, and health monitoring. Expert consultations played a crucial role in ensuring the scientific validity and feasibility of our intervention strategies. Expert opinions and recommendations helped us better design intervention content tailored to the needs of middle-aged individuals at risk of stroke, ultimately enhancing the

effectiveness of the intervention. During the usability testing phase, we identified and addressed potential issues and bottlenecks in the mobile application through user feedback and test results. This ensured the usability of the application, improved the user experience, and increased user engagement and retention. The final intervention experiment was a pivotal component of this study, enabling us to assess the effectiveness and feasibility of the mobile application in promoting lifestyle changes among middle-aged individuals at risk of stroke. Data collection and analysis during this phase provided crucial results, helping us evaluate the intervention's efficacy.

In summary, this study conducted across multiple research stages, has provided a promising mobile application intervention solution for middle-aged individuals at risk of stroke. This research has the potential to offer more effective tools for stroke prevention and management, improving the lifestyle of at-risk individuals, raising awareness of health issues, and reducing the risk of stroke. Future work will continue to drive advancements in this field. mobile apps hold tremendous potential in lifestyle interventions for individuals at risk of stroke.

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