The Effectiveness of Mobile Health Application on Dietary Behaviors in Patients with Coronary Artery Disease: A Systematic Review and Meta-Analysis

Usama Singhasem

A Thesis Submitted in Partial Fulfillment of the Requirements for the Degree of

Master of Nursing Science in Adult and Gerontological

Nursing (International Program)

Prince of Songkla University

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Author	Miss Usama Singhasem
Major Program	Adult and Gerontological Nursing (International Program)

Major Advisor

……
(Asst. Prof. Dr. Charuwan Kritpracha)

Co-advisor

……
(Asst. Prof. Dr. Jindarat Chaiard)

Examining Committee:

……..….Chairperson
(Assoc. Prof. Dr. Patraporn Bhatarasakoon)

…… Committee
(Asst.Prof.Dr. Charuwan Kritpracha)

…… Committee
(Asst.Prof. Dr. Jindarat Chaiard)

…… Committee
(Asst. Prof. Dr. Jintana Damkliang)

The Graduate School, Prince of Songkla University, has approved this thesis as partial fulfillment of the requirements for the Master of Nursing Science Degree in Adult and Gerontological Nursing (International Program)

……
(Asst. Prof. Dr. Thakerng Wongsirichot)
Acting Dean of Graduate School

This is to certify that the work here submitted is the result of the candidate's own investigations. Due acknowledgement has been made of any assistance received.

……. Signature
(Asst. Prof. Dr. Charuwan Kritpracha)
Major Advisor

……. Signature
(Asst. Prof. Dr. Jindarat Chaiard)
Co-advisor

……. Signature
(Miss Usama Singhasem)
Candidate

I hereby certify that this work has not been accepted in substance for any degree, and is not being currently submitted in candidature for any degree.

……. Signature
(Miss Usama Singhasem)
Candidate

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ABSTARCT

This systematic review aims to evaluate the effectiveness of mobile health application on dietary behaviors in patients with coronary artery disease. The randomized control trial and quasi-experimental studies, which investigated the effectiveness of mHealth application on dietary behaviors in patients with CAD, were selected for searching review materials in this study. Published and unpublished studies in Thai and English from 2012 to 2022 are included in this review. Eligible studies were critically appraised by two reviewers using the JBI critical appraisal instruments (Joanna Briggs Institute [JBI], 2017). Where possible, studies were pooled using meta-analysis. Where statistical pooling was not possible, the findings were presented in narrative form. The degree of certainty of the evidence on clinical outcomes was assessed using the GRADE approach. Systematic review registration number was CRD42022320586.

The search identified 934 potential studies, only 20 studies met the inclusion criteria and finally 7 studies passed the criteria for critical appraisal assessment. Six studies could be analyzed by meta-analysis and one study for narrative summary. The result found that the mHealth application improved dietary behavior in patients with CAD, SMD 0.30, 95% CI 0.09 to 0.51, (p=.006) and found that there was a statistical significance between one to three months, SMD 0.30, 95% CI -0.01 to 0.53, (p=.059). The certainty of evidence for each outcome ranged from very low to moderate level.

This systematic review suggested that mHealth application is one option for improving dietary behaviors in patients with CAD for the first three months. The limitation of this review is that the reviewer focused on only experimental studies (RCT and quasi-experimental studies). Further primary research may fill this gap or further review should clarify effectiveness of mHealth application on dietary behaviors in patients with CAD by looking at a larger number of studies.

ชื่อวิทยานิพนธ์ ประสิทธิผลของสมาร์ทโฟนแอปพลิเคชันต่อพฤติกรรมการบริโภคอาหารในผู้ป่วยโรคหลอดเลือดหัวใจ : การทบทวนวรรณกรรมอย่างเป็นระบบและการวิเคราะห์อภิมาน

ผู้เขียน นางสาวอุษมา สิงหเสม

สาขาวิชา การพยาบาลผู้ใหญ่และผู้สูงอายุ (นานาชาติ)

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บทคัดย่อ

การทบทวนอย่างเป็นระบบนี้มีวัตถุประสงค์เพื่อประเมินประสิทธิผลของสมาร์ทโฟนแอปพลิเคชันต่อพฤติกรรมการบริโภคอาหารในผู้ป่วยโรคหลอดเลือดหัวใจ การทบทวนวรรณกรรมอย่างเป็นระบบครั้งนี้ได้คัดลือกการวิจัยการทดลองแบบสุ่ม (randomized controlled trial) และวิจัยกึ่งทดลอง (quasi-experimental research) ที่ทดสอบผลของการใช้สมาร์ทโฟนแอปพลิเคชันต่อพฤติกรรมการบริโภคอาหารในผู้ป่วยโรคหลอดเลือดสมอง การศึกษาที่เผยแพร่และไม่ได้เผยแพร่ในภาษาไทยและภาษาอังกฤษตั้งแต่ปี 2555 ถึง 2565 รวมอยู่ในการทบทวนนี้ การศึกษาที่ผ่านเกณฑ์การคัดเข้า (inclusion criteria) ได้รับการประเมินคุณภาพของการศึกษา (quality assessment) โดยผู้ตรวจสอบสองคนโดยใช้เครื่องมือการประเมินของ JBI (Joanna Briggs Institute [JBI], 2017) หากผลลัพธ์ของข้อมูลสามารถวิเคราะห์อภิมาน (meta-analysis) ได้ข้อมูลจะถูกรวบรวมเพื่อการวิเคราะห์อภิมาน (meta-analysis) ในกรณีที่ไม่สามารถวิเคราะห์ได้ ผลการวิเคราะห์จะถูกนำเสนอในรูปแบบบรรยาย (narrative synthesis) ผู้วิจัยใช้ระบบ GRADE ประเมินระดับคุณภาพของหลักฐานทางวิชาการ (certainty of evidence) หมายเลขทะเบียนโปรโตคอลของการทบทวนวรรณกรรมอย่างเป็นระบบครั้งนี้คือ CRD42022320586

ผลการศึกษาพบว่ามีการศึกษาที่เกี่ยวข้องทั้งหมด 934 เรื่อง มีเพียง 20 เรื่องเท่านั้นที่เข้าเกณฑ์การคัดเลือก และมีเพียง 7 เรื่องที่ผ่านเกณฑ์การคัดเข้า (inclusion criteria) และผ่านเกณฑ์การประเมินคุณภาพของการศึกษา (quality assessment) การศึกษา 6 เรื่องสามารถวิเคราะห์ได้โดยการวิเคราะห์อภิมาน (meta-analysis) และ 1 การศึกษาสำหรับการสรุปเชิงบรรยาย (narrative synthesis)

ผลการวิจัยพบว่าสมาร์ทโฟนแอปพลิเคชันสามารถปรับปรุงพฤติกรรมการบริโภคอาหารในผู้ป่วยโรคหลอดเลือดหัวใจมีความแตกต่างระหว่างกลุ่มทดลองและกลุ่มควบคุมอย่างมีนัยสำคัญทางสถิติ SMD 0.30, 95% CI 0.09 ถึง 0.51, (p=.006) ผู้วิจัยได้ทำการวิเคราะห์กลุ่มย่อยพบว่าพฤติกรรมการบริโภคอาหารในช่วง 3 เดือนแรกมีความแตกต่างอย่างมีนัยสำคัญทางสถิติระหว่างกลุ่มทดลองและกลุ่มควบคุม SMD 0.30, 95% CI -0.01 ถึง 0.53, (p=.059) ระดับคุณภาพของหลักฐานทางวิชาการ (certainty of evidence) ในแต่ละผลลัพธ์มีตั้งแต่ระดับต่ำไปจนถึงระดับ

ปานกลาง การทบทวนอย่างเป็นระบบนี้ชี้ให้เห็นว่าสมาร์ทโฟนแอปพลิเคชันเป็นทางเลือกหนึ่งสำหรับการปรับปรุงพฤติกรรมการบริโภคอาหารในผู้ป่วยโรคหลอดเลือดหัวใจในช่วงสามเดือนแรก ข้อจำกัดของการทบทวนครั้งนี้ คือ ผู้ทบทวนเน้นเฉพาะการศึกษาเชิงทดลองแบบสุ่มและการศึกษากึ่งทดลอง การวิจัยปฐมภูมิ (primary research) ในอนาคตอาจศึกษารูปแบบการศึกษาวิจัยแบบอื่นเพิ่มเติมเพื่อเพิ่มจำนวนการศึกษาที่คัดเข้าเพื่อเพิ่มระดับคุณภาพของหลักฐานต่อไป

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Usama Singhasem

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CHAPTER 1
Introduction

This chapter details the study's background and significance of the problem, objectives, research questions, definition of terms, its scope as well as significance.

Background of the Study

Coronary Artery Disease (CAD) is the leading cause of death worldwide, responsible for 16% of the world's total deaths. CAD is one of the most common causes of mortality and morbidity in both developed and developing countries (Sekhri et al., 2014). Central and Eastern European countries are sustaining the highest prevalence (Khan et al., 2020). In Asia and Australasia the CAD prevalence rate was 1,440 per 100,000 population for 2017 (Khan et al., 2020). CAD is also the top of the leading causes of death in Thailand, responsible for 35% of the population, accounting for 24.5 million Thai people; the mortality rate of coronary heart disease per 100,000 persons was 26.9, 27.8, 29.9, 32.3, 31.8, respectively from 2013 to 2017 (Ministry of Public Health (MOPH), 2018). CAD is the most common type of cardiovascular disease (CVD) (WHO, 2020) and is a multifactorial disease affected by age, gender, hereditary, and behavioral risk factors (Ram & Trivedi, 2012). Various behavioral risk factors like smoking, physical inactivity, unhealthy diet, and alcohol consumption are known to be the vital risk factors for CAD (Ram & Trivedi, 2012). Although diet is not the sole factor of coronary artery disease, diet is a daily necessity which plays a vital role in people's lives (Better Health Channel, 2021) indicating that "you are what you eat" (Banerjee, 2015). In addition, the American College of Cardiology (ACC) and AHA

2019 revealed that consuming high amounts of saturated fats or trans-fat, cholesterol, sodium, processed meats, refined carbohydrates (white bread, pasta, and white rice), and sweetened beverages can lead to overweight and obesity, high blood cholesterol, high blood pressure, atherosclerosis, and plaque buildup in the heart's arteries (Arnett et al., 2019). Although appropriate dietary patterns or guideline have been created and shared widely, the compliance among the patients to change the dietary behaviors in accordance with these recommendations is low (Eckardt et al., 2021). Mobile health applications have been identified as the popular method in dietary management for patients with CAD (European Society of Cardiology (ESC), 2017).

The American Health Association (AHA) published a scientific bulletin in 2015 calling for more research to assess the viability and efficacy of mobile health applications in the prevention of cardiovascular disease (CVD) (Bernal-Jiménez et al., 2021). Similarly, the European Society of Cardiology (ESC) reported that mobile health applications play a vital role in achieving its mission of reducing the burden of cardiovascular disease and allowing people to live longer, healthier lives (European Society of Cardiology (ESC, 2017). These data suggest that mobile health apps have become a part of daily life and it's a useful tool for health and lifestyle management and can be integrated into communication between healthcare professionals and patients.

Previous studies found that mobile health applications enhancing dietary behaviors have components of training sessions by providing information, and self-monitoring by taking a picture of their food (Choi et al., 2019) or using a checklist for recording their behaviors, motivating patients by automatic message reminders about healthy habits, and support by communication with the dietitian or nurse (Bernal-

Jiménez et al., 2021; Choi et al., 2019; Chow et al., 2015; 2018). These related outcomes of diet were studied, including dietary behaviors, fasting lipid parameters (total cholesterol, high-density-lipoprotein cholesterol (HDL) cholesterol, low density-lipoprotein cholesterol (LDL), and triglycerides), HbA1c, high-sensitivity CRP, weight, height, body mass index (BMI) and blood pressure (Bernal-Jiménez et al., 2021; Choi et al., 2019; Chow et al., 2015; 2018).

Nurses are the key persons to promote dietary behaviors. Educating patients with CAD about diet is an important role of nurses. In addition, nurses' roles also include assessment, nursing care plan with patients, and evaluation (Lupan, 2019). For this reason, a mobile health application is vital for nurse to educate and follow CAD patients because technology-based treatment has resulted in increased survival of patients with CAD in recent decades (Yu et al., 2018).

The initial search from Prospero, the Cochrane Database of Systematic Reviews, JBI Database of Systematic Reviews for systematic review on the mobile health application among patients with CAD indicated that there were four reviews and the outcomes of the reviews were adherence of cardiac rehabilitation, exercise capacity, medication adherence, smoking cessation, mental health, and quality of life (Douma & Habibovic, 2021; Meehan et al., 2019; Widmer et al., 2017; Xu et al., 2019). No studies were found that are related to the outcome of dietary behaviors. Recently, primary studies on mobile health application have been conducted which measure diet behaviors (Choi et al., 2019; Krackhardt et al., 2022; Manzoor et al., 2021; Michelsen et al., 2022; Tang et al., 2018; Varnfield et al., 2014; Widmer et al., 2017). Our study focused on diet behaviors as outcome and the research studies which were published in Thai were included. The method used was following the JBI guideline which has nine essential

steps including 1) formulate review question; 2) define inclusion and exclusion criteria; 3) locate studies; 4) select studies; 5) assess study quality; 6) extract data; 7) analysis data; 8) present results; and 9) interpret findings and recommendations to guide nursing practice based on the Joanna Briggs Institute manual (Aromataris, 2014).

Objective of the Study

The purpose of this study is to evaluate the effectiveness of mobile health applications versus standard of care on dietary behaviors in patients with coronary artery disease.

Review Question

Are mobile health applications effective compared with standard of care for improving dietary behaviors among patients with CAD?

Conceptual framework

This systematic review is to assess the effectiveness of mobile health application versus standard of care on dietary behaviors in patients with CAD, based on a systematic review process proposed by the Joanna Briggs Institute (Aromataris, 2014), consisting of nine steps: 1) formulate review question; 2) define inclusion and exclusion criteria; 3) locate studies; 4) select studies; 5) assess study quality; 6) extract data; 7) analysis data; 8) present results; and 9) interpret findings and recommendations to guide nursing practice by specifying the qualifications of the research on mobile health application on dietary behaviors in patients with CAD. The randomized control trial or quasi-experimental study method was selected for conducting the review search in this study. Published and unpublished studies in English and Thai languages are included in the review for the period from 2012 to 2022.

CHAPTER 2

Review of Related Literature

The review of literature in this chapter is organized into four major parts. The first part is an overview of CAD. The second part covers the mobile health application for patients with CAD. The third part is the dietary behavior of patients with CAD. The fourth part concerns the factors related to dietary behaviors for patients with CAD. Finally, the method for conducting a systematic review is introduced. The literature can be outlined as follows:

1. Overview of Coronary Artery Disease
    - 1.1 Pathophysiology of Coronary Artery Disease
    - 1.2 Etiology of Coronary Artery Disease
    - 1.3 Epidemiology of Coronary Artery Disease
    - 1.4 Treatment of Coronary Artery Disease
2. Dietary Behavior of Patients with CAD
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4. Systematic Review
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Overview of Coronary Heart Disease

Coronary artery disease (CAD) is the leading cause of death worldwide and causes a variety of health problems. This section will be addressing topics that include pathophysiology, etiology, epidemiology, and treatments.

Pathophysiology of Coronary Artery Disease

CAD occurs when the blood flow that brings oxygen to the heart muscle is severely reduced or stopped (American Heart Association [AHA], 2020) and is the most common type of heart disease occurring worldwide. It is sometimes called coronary heart disease or ischemic heart disease (Centers for Disease Control and Prevention [CDC], 2021). This happens because coronary arteries that supply the heart with blood can slowly become thicker and harder from a buildup of fat, cholesterol, calcium, and other substances, called plaque. This slow process is known as atherosclerosis. If the plaque breaks open and a blood clot forms that blocks the blood flow, a CAD occurs. It also called myocardial infarction or heart attack (AHA, 2020b; CDC, 2021)

Etiology of Coronary Heart Disease

Comprehensive research has identified factors that increase a person's risk of developing coronary heart disease. Risk factors fall into three main categories (AHA, 2016; CDC, 2019) as follows:

Major Risk Factors. A factor that cannot be avoided and cannot be changed. The more of these risk factors the patients have, the greater chance of developing coronary artery disease, since people who have these factors cannot do

anything about them, for example: increasing age, male gender, and heredity including race (AHA, 2016; CDC, 2019).

Modifiable Risk Factors. A factor that can be controlled. For example, smoking, high blood cholesterol, high blood pressure, physical inactivity, obesity and being overweight, and diabetes (AHA, 2016)

Contributing Risk Factors. These factors are related to increased risk of CAD, but their significance and prevalence have not yet been determined such as stress, alcohol, and diet (American Heart Association (AHA), 2016).

Epidemiology of Coronary Artery Disease

Currently, CAD is the world's biggest killer, responsible for 16% of the world's total deaths. Since 2000, the largest increase in deaths has been for this disease, rising by more than 2 million to 8.9 million deaths in 2019 (World Health Organization [WHO], 2020). CAD affects approximately 126 million individuals (1,655 per 100,000), which is about 1.72% of the world's population. Men were more affected than women and the incidence usually begins in the fourth decade and increases with age (Khan et al., 2020). The worldwide prevalence of CAD is increasing. The current prevalence rate of 1,655 per 100,000 population is expected to exceed 1,845 by 2030. Eastern European countries still have the highest prevalence today. The age standard rate, which removes the effects of population change over time, has declined in many regions. (Khan et al., 2020).

CAD is also at the top of the leading causes of death in Thailand, responsible for 35% of the population, accounting for 24.5 million Thai people, as the mortality rate of coronary heart disease per 100,000 persons was 26.9, 27.8, 29.9, 32.3, 31.8,

respectively for the period from 2013 to 2017 (Ministry of Public Health (MOPH), 2018).

Treatment of Coronary Artery Disease

The common treatment of patients with CAD aims to reduce symptoms and improve prognosis with appropriate medications and interventions, and to control risk factors including lifestyle behaviors.

Lifestyle Changes. It is a method making a commitment to following healthy lifestyle changes that can go a long way toward promoting healthier arteries including smoking cessation, healthy diet, physical activity, healthy weight, medication adherence, and reduction of stress (Knuuti et al., 2020).

Pharmacological Management. The aims of pharmacological management of patients with CAD are to reduce angina symptoms and exercise induced ischemia, and to prevent cardiovascular events. Patients with CAD, that have stents placed in their coronary arteries, or undergo coronary artery bypass graft surgery (CABG) are treated with two types of antiplatelet agents at the same time to prevent blood clotting. This is called dual antiplatelet therapy (DAPT). Aspirin is a common drug used in the antiplatelet drugs. In addition to aspirin, there are also effective antiplatelet drugs used in the acute coronary syndrome in Thailand, including P2Y12 inhibitors. AHA recommended clopidogrel is greater than ticagrelor and prasugrel. Both new drugs were found to reduce the incidence of death or the recurrence of myocardial infarction to a greater extent than clopidogrel, so these are recommended before using clopidogrel. Patients should receive dual antiplatelet therapy (DAPT) - P2Y12 inhibitors with aspirin for at least twelve months if no contraindications occur.

HMG-CoA reductase inhibitors such as simvastatin and atorvastatin are usually used to lower LDL ("bad") cholesterol for patients with CAD (AHA, 2020a).

Reperfusion Therapy. It is the management guideline for patients with acute coronary syndrome including primary percutaneous coronary intervention (PCI) and pharmacoinvasive strategy. Primary PCI strategy is the management guideline for cardiac catheterization. Primary PCI is the preferred reperfusion strategy in patients with STEMI within twelve hours of symptom onset, provided it can be performed expeditiously. However, there are also limitations especially in countries where primary PCI is not available. If the time to refer the patient to primary PCI (time from diagnosis of STEMI to wire crossing) is less than 120 minutes, the patient should be referred for primary PCI; if it is more than 120 minutes, it should be treated by thrombolytic drugs. However, the diagnosis and treatment must be done as quickly as possible (The Heart Association of Thailand under the Royal Patronage of H.M. the King, 2020). If the reperfusion strategy is fibrinolysis, the goal is to inject the bolus of fibrinolytics within ten minutes from STEMI diagnosis (Ibañez et al., 2018).

Fibrinolytic therapy is an important reperfusion strategy in an environment where primary PCI is not readily available and prevented 30 premature deaths per 1,000 patients treated within six hours of symptom onset. The greatest benefit was seen in patients at highest risk, including the elderly, and when treated less than two hours after onset of symptoms. Fibrinolytic therapy is recommended within 12 hours of symptom onset if primary PCI is not achieved within 120 minutes of diagnosis of STEMI and there are no contraindications (Ibañez et al., 2018).

To sum up, CAD is the most common type of heart disease worldwide. CAD occurs when the coronary artery is narrowed because of the accumulation of a buildup of fat, cholesterol, and other substances, called plaque. This process is called "Atheriosclelosis". If the plaque ruptures, the blood clot will obstruct the blood flow. Then, the blood flow cannot deliver oxygen to supply the heart muscle and lead to a non-functioning of the heart muscle area, often referred to as a heart attack, myocardial infarction, coronary artery disease, and coronary heart disease. The etiology of CAD was divided into three main groups including: 1) major risk factors which cannot be avoid and cannot be changed; 2) modifiable risk factors, a factor that can be controlled; and 3) contributing risk factors, this factor may increase risk of CAD. The treatment of patients with CAD aims to reduce symptoms and improve prognosis through appropriate medications and interventions, and to control risk factors including lifestyle behaviors, which can be summarized into three main groups including lifestyle changes, phamacological management, and reperfusion therapy.

Dietary Behaviors of Patients with Coronary Artery Disease

Definition of dietary behaviors

Dietary behaviors are the patterns of an individual's food and beverage consumption habits, indicated by food choices, meal frequency, and portion size (IGI Global, 2022).

Dietary behaviors are the food eaten in each meal which can be recorded using a tool from which the food, and the amount consumed are selected. This may be recorded daily, at least once a week, per meal, or per week. (Bernal-Jiménez et al., 2021; Choi et al.,2019).

Recommendations for improving dietary behaviors

The Mediterranean diet is characterized by nuts, olive oil, vegetables, legumes, fish, white meat and wine, and the Prevención con Dieta Mediterránea (PREDIMED) study showed that major adverse cardiovascular events were reduced by 30% for patients at high risk of atherosclerosis disease when they were given a Mediterranean diet rich in olive oil and nut consumption. (Choi et al., 2019).

The current guidelines showing the dietary recommendations to reduce risk of atherosclerotic cardiovascular disease (ASCVD) are composed of emphasizing intake of vegetables, fruits, legumes, nuts, whole grains, and fish, replacement of saturated fat with dietary monounsaturated and polyunsaturated fats, a decrease of amounts of cholesterol and sodium, a decline in the intake of processed meats, refined carbohydrates, and sweetened beverages, Importantly, the intake of trans fats should be avoided to reduce ASCVD risk (Arnett et al., 2019).

Good dietary behavior is accomplished by regular consumption of fruits and vegetables, whole grains and legumes, reducing consumption of sugar-sweetened beverages, sodium, low-fat foods and low-carbohydrate foods (Nurpratama et al., 2021). Food high in fiber--this includes legumes, grains, fish, dietary control and a proper diet--will have the effect of reducing cholesterol levels. LDL cholesterol, blood pressure, and blood sugar levels ((Turk-Adawi & Grace, 2015)), as well as less chances of developing coronary heart disease.

Component of dietary behaviors

The dietary behavior component of the mobile application includes the foods eaten at each meal (breakfast, lunch, tea and dinner) and this is recorded using a drop-down list which selects the food and amount consumed (a portion, half portion or quarter portion) should be recorded daily or at least once a week. (Bernal-Jiménez et al., 2021). For example, results show the total consumption of vegetables, fruits, fried foods, snack foods, sugar, dairy products, meat (Manzoor et al., 2021), fat, fiber, sodium, and alcohol (Varnfield et al.,2014).

From the literature, dietary behaviors were measured by the checklist of the amount of food serving and type of Mediterranean diet which was consumed daily. For example, at least two servings of veggies, at least three servings of fruit, or avoiding butter and cream. A Mediterranean diet includes olive oil, nuts, legumes, vegetables, fish, white meat, and wine. There were weekly challenges to encourage dietary modification; this was done by taking pictures of their food, document meals and amounts consumed, ask questions to the RD, increasing daily servings of vegetables, or decreasing of consumption of red meat.

Measurement of dietary behaviors

Many studies focusing on mobile health application on dietary behavior in patients with CAD measured the dietary behaviors by using questionnaires e.g., a self-reported composite health behavior score (Dale et al., 2015), an adherence to the Mediterranean diet and average intake of each food group questionnaire (Bernal-Jiménez et al., 2021), Mediterranean Diet Score (MDS) (Choi B et al., 2018), healthy

eating assessment questionnaire (HEQ) (Manzoor et al., 2021), or the Healthy diet index as evaluated within SEPHIA (Gonzalez et al., 2019) .

The healthy eating assessment questionnaire (HEQ) measured the summation of intake of fruits, vegetables, meat, sugar, snacks , milk products, and fried foods as reported by the participants. Healthy eating assessment comprises ten items and scoring values range from 10 to 50; categories are fair (20-29), good (30-39), and excellent (40-50) (Manzoor et al., 2021). In the 14-point MDS quantitative score of adherence to the Mediterranean diet. 'High compliance' with the Mediterranean diet was defined as MDS ≥9 (Choi et al., 2019). Michelsen et al. (2022) evaluated dietary behavior by using a 4-item questionnaire modified from the national for managing unhealthy lifestyles in the general population. The questions aim to measure the amount of vegetables, fruit, fish and sweets consumed. Each question has 4 possible answers, on a scale of 0 to 3, and then the scores were added for each question. Dietary Habits Questionnaire (DHQ) scores were calculated by the summation of intake of fat, fiber, sodium, and alcohol (Varnfield et al., 2014), which is similar to Widmer et al.'s (2017) Diet scores that were calculated by summation of daily servings of fruits, vetgetables, whole grains, and lean proteins with points taken away for daily serving of saturated fats and sweets.

In conclusion, Dietary behaviors are the patterns of an individual's food and beverage consumption habits, indicated by food choices, meal frequency, and portion size. It is the leading cause of mortality and disability-adjusted life years lost, greater than smoking, obesity, physical inactivity, high cholesterol, hypertension, or diabetes. Consuming carbohydrates, high in fat and sodium including processed food, canned food, fast food, bakery items, regular consumption of sweetened beverages can lead to

high blood pressure, diabetes, hyperlipidemia, and obesity, which were associated with an increase in major adverse cardiovascular events for patients with CAD. While a Mediterranean diet (e.g., olive oil, nuts, vegetables, legumes, fish, white meat, and wine) and a proper diet, will have the effect of reducing cardiovascular morbidity and mortality, dietary behavior in patients with CAD considers the component that includes meals, type of food, and amounts consumed that was measured by using questionnaires which is the summation of intake of healthy and unhealthy food.

Mobile health application for dietary behaviors

Many studies have been conducted to identify the effective strategies for enhancing the knowledge and self-care compliance on dietary bahaviors of patients with CAD (Bhattacharjya et al., 2019; Choi et al., 2019; Yudi et al., 2016) . The current number of smartphone users in the world today is 6.378 billion, and this means 80.63% of the world's population owns a mobile health app (Turner, 2018). Various educational multimedia materials have been developed, such as a program using image-based inputs for monitoring dietary behaviors of patients with CAD (Choi et al., 2019) and an Interactive Web Application for self-monitoring about eatting habits of CAD patients (Bernal-Jiménez et al., 2021). Although computer-based support can help CAD patients and their families make decisions about proper dietary choices, such support cannot help them in places without computers.

An education program using mobile healths and tablets has recently been used for discharging education program for CAD patients with the increasing use of smartphone. Thailand has a number of mobile health ownership of 98.9% of the total Thai population (Muangtum, 2021); the use of smartphone and the internet go hand in

hand. In recent years, internet penetration in Thailand had gradually and steadily increased and was predicted to rise even further in the next years (Statista, 2021). The key feature that distinguishes smartphones from existing mobile phones is that the operating system installed in the smartphone makes it possible to install and remove a wide variety of applications (apps). et al., 2014). The number of medical or health apps registered in the Apple App Store or in the Android Google Play Store has increased recently. The American Health Association (AHA) revealed a scientific statement in 2015 called for more research to assess the viability and efficacy of mobile health applications in the prevention of cardiovascular disease (CVD) (Bernal-Jiménez et al., 2021). In the same way, the European Society of Cardiology (ESC) reported that eHealth is vital to achieving its mission of reducing the burden of cardiovascular disease and allowing people to live longer, healthier lives (European Society of Cardiology (ESC), 2017).

Mobile health applications have been gaining power in the field of preventive cardiology recently, especially in the field of dietary behaviors, as several trials have already reported good results with digital cardiology (Dendale & Jessa Ziekenhuis, 2021). Mobile health technology is an advancement of old telemedicine and messaging technologies. It has the potential to revolutionize the landscape of secondary prevention as it can provide a platform for patient-centered programs with the ability to integrate education, real-time feedback, motivation, reminders and support. It is also a food monitoring tool, exercise, medication, and cardiovascular risk factor parameters. Finally and most importantly, a mobile health-based program can be started immediately, used from anywhere, anytime and for extended periods of time (Yudi et al., 2016).

Previous studies found that mobile health applications enhancing dietary behaviors have components of training session by providing information, self-monitoring by taking a picture of their food (Choi et al., 2019) or using a checklist for recording their behaviors, motivating patients by automatic message reminders about healthy habits, and support by communication with the dietitian or nurse (Bernal-Jiménez et al., 2021; Choi et al., 2019; Chow et al., 2015; 2018).

In conclusion, mobile health applications have recently started to play an important role in the field of preventive cardiology. Especially in dietary behaviors, with an AHA and ESC approved mobile health application in the prevention of cardiovascular disease. One component of the application is composed of a training session by providing information, self-monitoring by taking a picture of their food or using a checklist for recording their behaviors, motivating patient by automatic message reminders about healthy habits, and support by communication with the dietitian or nurse.

Systematic review

Concept and principle of systematic review

A systematic review is a summary of the medical literature that uses a clear and repeatable method to systematically search, evaluate critically, and synthesize on specific issues. It synthesizes the results of several related primary studies using strategies that minimize biases and random error. For this purpose, systematic reviews may or may not include a statistical synthesis known as a meta-analysis. It depends on whether the studies are sufficiently similar. Then, combining the results is meaningful (Gopalakrishnan & Ganeshkumar, 2013).

A systematic review is a type of literature review that collects and critically analyzes a lot of research studies or papers. It is a secondary research for figuring out answers or solutions (Kummatid, 2016).

The systematic review is importantly an analysis of the available literature and an assessment of effectiveness or practice which is complex steps (Martin, 2017).

Systematic review aims to provide an extensive, neutral synthesis of relevant studies in a single document using accurate and clear methods to summarize and synthesize existing knowledge for answering review questions (Aromataris, 2020).

Systematic review attempts to collect evidence that met pre-specified eligibility criteria to address a specific research question and to reduce bias by using systematic and apparent approach documented in advance with the protocol (Chandler et al., 2022).

There were two systems of systematic review, namely those of the Cochrane library and of the Joanna Briggs Institute (JBI) (Kummatid, 2016). The Cochrane Methodology Reviews attempts to answer questions about various aspects of the methodology for systematic reviews, randomized study and other assessments of health and social care. They provide the evidence base for these assessment methods. It also provides a description of other relevant issues, e.g., to show the scale of problems researchers faced in systematic reviews or making decisions about health and social care. The Cochrane Methodology Reviews use a variety of evidence, including: experimental studies, such as randomized studies (for example, to compare different strategies to increase survey response rates); comparative observational studies (e.g., to examine the relationship between the use of reporting guidelines and the quality of

research reports); and descriptive observational studies (e.g., presenting the proportion of study presented at the conference to be published in full) (Higgins et al., 2022).

As part of the process of preparing and maintaining Cochrane systematic reviews on the effects of healthcare interventions, all authors should consult the handbook for guidance on the methods used in Cochrane systematic reviews. The Handbook contains instructions on the standard methods that apply to every review (planning review, searching, screening, selecting, collecting data, assessing the risk of bias, analyzing statistical data, GRADE and interpreting results) (Higgins et al., 2022).

The Joanna Briggs Institute (JBI) systematic reviews aims to provide a comprehensive and unbiased synthesis of a large number of relevant studies in a single document using a rigorous and transparent methodology. The systematic review aims to synthesize and summarize existing knowledge. It attempts to reveal "all" of the evidence relevant to the question. Given the explosion of knowledge and access to diverse sources of knowledge over the past decade. It is almost impossible for an individual physician or clinical team to keep up with knowledge in a given field. This issue prompted systematic reviews (also known as research syntheses), conducted by skilled review groups, established to extract international evidence and synthesize the results of this search into evidence to inform guidelines and policies. They follow a structured research process that requires a rigorous method to ensure that the results are reliable and meaningful to the end user. The quality of a systematic review depends on the extent to which the methods are used to reduce the risk of error and bias during the review process. Such a rigorous methodology distinguishes systematic reviews from existing literature reviews. For this reason, clear and thorough reporting of the

methodology used in the synthesis is essential and a feature of a systematic review well run system as a scientific organization, systematic reviews will influence health care decisions and should be conducted with the same rigor expected from all research (Aromataris, 2020).

JBI currently has formal recommendations for the following types of reviews: systematic reviews of experiences or meaningfulness, effectiveness, statements and opinions/policies, prevalence and incidence, costs of intervention, process or procedure, etiology and risk, mixed methods, diagnostic test accuracy, umbrella review, and scoping review. The following steps are generally accepted in systematically examining any type of evidence. These include the following: formulation of review questions, defining of inclusion and exclusion criteria, locating study through searching, study selection for inclusion, assessing the quality of studies, extracting data, analyzing and synthesizing relevant studies, presenting and interpreting results, and possibly including the process of establishing certainty of the evidence (via systems such as GRADE) (Aromataris, 2020).

Steps in doing systematic review

This systematic review followed the Joanna Briggs Institute (JBI) Reviewers Manual for the effectiveness in quantitative studies (Aromataris, 2020). The process of conducting systematic reviews of effectiveness included nine steps, namely: 1) formulate review question; 2) define inclusion and exclusion criteria; 3) locate studies (searching); 4) select studies; 5) critical appraisal; 6) data extraction; 7) data synthesis; 8) present results; and 9) interpret/ establish confidence in results. These will be described in the following section below.

1. Formulate Review Question. It provides clear and precise clarification of review questions. Reviewers typically use the PICO mnemonic (population, intervention, comparator and outcome) to generate clear and meaningful review questions about quantitative evidence on effectiveness of the intervention (Aromataris, 2020).

Population. The most important characterestics including demographic factors of the population (e.g., age, gender, ethnicity), socioeconomic factors (e.g., education, occupation), the setting (e.g., hospital, community etc.).

Intervention. The primary intervention of interest (experimental group)

Comparator. The control group such as passive (placebo, no treatment, standard care, or a waiting list control), active (variation of the intervention, a drug, or kind of therapy). To be considered are: dosage/intensity, mode of delivery, and frequency/duration/timing of delivery.

Outcomes. Identify the primary outcome/s in order to reach a clinically relevant conclusion. Outcomes should be stated neutrally, covering benefits and disadvancetages. The researcher should consider how the type and duration of outcome measurements affect on outcome measurement.

2. Define Inclusion and Exclusion Criteria. This determines which research articles will be selected. It follows the same PICO framework used to develop the question and allows the reader to understand the focus of the review. Inclusion criteria should specify explicit, unambiguous, and reasonable conditions. Inclusion criteria for a review are not intended to be considered separately; in this regard it should be clear

and not repeat information relevant to other aspects of the PICO. The components of inclusion criteria should be composed of: 1) participants/population characteristics; 2) intervention, interest, exposure or phenomenon under investigation; 3) comparators; 4) outcomes; 5) context; 6) condition; and 7) types of studies to be included (Aromataris, 2020).

3. Locate Studies. A key characteristic of systematic review is a comprehensive search. The attempt to locate all published and unpublished evidence relevant to a review question is divided into three steps as follows (Aromataris, 2014):

Phase one (initial search): Initial search of Pubmed, CINAHL followed by analysis of text words in the title and abstract and index terms used.

Phase two (second search): Apply identified keywords and index terms across all published and unpublished databases/sources.

Phase three (third search): Review reference lists of all studies retrieved for critical appraisal.

4. Select Studies. In a systematic review study, selection (both at title/abstract screening and full text screening) should be performed by two or more reviewers, independently. Any disagreements are solved by consensus or by the decision of a third reviewer The software used for managing search results should be specified (e.g., Covidence, Endnote, Zotero) (Aromataris, 2020).

The results of the search and the study inclusion process will be reported in full in the final systematic review and presented in a Preferred Reporting Items for Systematic Reviews and Meta-analyses (PRISMA) flow diagram (Page et al., 2021). Currently, JBI SUMARI allows for study screening at both the Title/Abstract level

(e.g., screening of records) and at full text level (e.g., screening of reports) (Aromataris, 2020). Other software may be used for Title/Abstract Screening (Endnote, Excel, Covidence) (Aromataris, 2020).

5. Critical appraisal. The goal of critical appraisal (assessment of bias risk) is an assessment of the methodological quality of a study and determining the extent to which the study excludes or reduces the possibility of bias in its design, conduct and analysis (Aromataris, 2020).

According to the JBI manual (2021), two reviewers should perform independent critical appraisal of retrieved studies using the standardized critical appraisal checklists developed by JBI. The protocol should state that any conflicts must be addressed and solved by consensus or by the decision of a third reviewer. In experimental studies (randomized experimental studies and quasi-experimental studies), the most significant biases are: selection bias, performance bias, detection bias, attrition bias, and reporting bias. In observational studies the most significant biases are: information bias, selection bias, and confounding.

6. Data extraction. Data extraction is the process of sourcing and recording relevant results and details from the primary studies included in the systematic review. Standardized data extraction tools facilitate the extraction of data of the same type from all pooled studies, and necessary for the JBI systematic reviews. Data extraction occurs in two phases (Aromataris, 2020):

Phase 1 consists of the study characteristics such as citation, study design and method, setting/context, population characteristics, intervention / comparator / condition / exposure / tests, outcomes.

Phase 2 consists of results data such as measures of effect. The meaning of the measure of effect could be the size of a relationship between two factors, the direction of this effect, and if this effect is beneficial or harmful. The important measures of effect included Relative Risk (RR), Risk Difference (RD), Odds Ratio (OR), Weighted Mean Difference (WMD), and Standardized Mean Difference (SMD).

7. Data synthesis. A systematic review of effectiveness. There are two synthesis types: statistical synthesis (meta-analysis) and narrative synthesis (Aromataris & Munn, 2020). Meta-analysis can be performed if results are obtained from two or more independent studies addressing the same review question (Card, 2012 and Khan et al., 2012, as cited in Aromataris & Munn, 2020). If the meta-analysis is not appropriate, the researcher should use the narrative synthesis (Aromataris & Munn, 2020). Relative risk (RR) or odds ratio (OR) is recommended to be the effect size for dichotomous data, and weighted mean difference (WMD) or standardized mean difference (SMD) and is recommended for the effect sizes of continuous data. The homogeneity of review results will be considered by statistical chi-square or the percentage of I square statistic (I^2). The fixed effects model should be considered if there is homogeneity of statistical homogeneity. In contrast, the random effects model will be considered for statistical heterogeneity. However, it has been suggested by statisticians that the fixed effects model is the suitable model whenever the number of studies is small (less than five studies) (Cooper & Hedges, 1994, and Murad et al., 2015, p. 511 as cited in Aromataris & Munn, 2020).

8. Present Results. Reviewers should report the assessment of methodological quality including narrative summary of the overall methodological

quality of the included studies, by means of a table showing the appraisal results, appraisal tools included in the appendices or references.

Reviewers should report review results and in finalizing the report. The review results, including a detailed description of the results of the review, and the specific review question can be used to structure the results section, if findings can be reported under the outcomes or if findings can be reported by study design. In general, findings are discussed textually and supported with forest plots, tables, and figures as appropriate (Aromataris & Munn, 2020;).

Discussion should briefly summarize and discuss the main findings (including strength of the evidence for each outcome), situate their findings in the broader literature, address limitations of the review (including limitations of the included studies), establish a line of argument based on the findings (is it in line with current knowledge?), and outline the application of the findings to stakeholders.

The conclusion should mention about a summary of the major findings of the review, issues related to the quality of the research within the area of interest, other issues of relevance, recommendations for practice and research, including recommendations for the future, and potential limitations of the systematic review (Aromataris, 2020).

Recommendations for practice based on the review findings may be included but this may not always be possible. Recommendations are expected to be included for research based on the review findings, identified gaps or areas of weakness in the literature (Aromataris, 2020).

9. Interpret/ Establish Confidence in Results. JBI applies the GRADE approach to create a summary of Findings tables in reviews on the effectiveness of

interventions. GRADE Working Group developed a system to help interpret the results and establish certainty in a body of evidence. Evidence ranking can be different for each outcome. The use of the GRADE approach is currently endorsed by JBI and JBI reviewers must use it regardless of the synthesis approach employed, meta-analysis or narrative synthesis following the guidance in the GRADE handbook (Schünemann et al., 2013).

In the context of a systematic review, the ratings of the quality of evidence reflect the extent of our confidence that the estimates of the effect are correct. In the context of making recommendations, the quality ratings reflect the extent of our confidence that the estimates of an effect are adequate to support a particular decision or recommendation (Schünemann et al., 2013).

The certainty in the evidence varies from high to moderate, low, and very low. RCTs start with high quality rating; observational studies as low quality rating. The certainty can be downgraded 1 or 2 points for each area of concern, with a maximum downgrade of 3 points overall (Schünemann et al., 2013).

Determinants of certainty have five domains that can lower certainty including methodological limitations in detailed design and execution (risk of criteria bias), inconsistency (or heterogeneity), indirectness (PICO and applicability), imprecision (number of events and confidence intervals), publication bias. Three factors can increase certainty including large magnitude of effect, plausible residual bias or confounding, and dose-response gradient (Schünemann et al. 2013).

In conclusion, a systematic review is a summary of the literature review of primary research that uses explicit and reproducible methods to systematically search, critically appraise, and synthesize on a specific issue by using strategies that reduce

biases and random errors. Systematic reviews may or may not include a meta-analysis, depending on whether the studies are similar enough so that combining their results is meaningful. This review, following the JBI guideline for systematic review (Aromataris, 2020), included nine steps, namely: 1) formulate review question; 2) define inclusion and exclusion criteria; 3) locate studies (searching); 4) select studies; 5) critical appraisal; 6) data extraction; 7) data synthesis; 8) present results; and 9) interpret/ establish confidence in results.

Summary of Literature Review

To summarize the literature review, CAD is the leading cause of death worldwide and causes a variety of health problems. There are many causes of CAD, which dietary behavior being one major cause of CAD. The treatment of patients with CAD can be summarizeg into three main groups including lifestyle changes, phamacological management, and reperfusion therapy. Modification of dietary behavior is one domain in lifestyle changes and refers to the patterns of an individual's food and beverage consumption habits, indicated by food choices, meal frequency, and portion size. Currently, guidelines show the dietary recommendations to reduce risk of atherosclerosis such as DASH diet and Mediteranean diet. The dietary behavior in patients with CAD was measured by using questionnaires revealing the summation of intake of healthy and unhealthy diet. Currently, mobile health applications have recently also been gaining power in the field of preventive cardiology, especially in the field of dietary behaviors, and several trials have already reported good results with digital cardiology.

A systematic review is a summary of the literature review of primary research that uses explicit and reproducible methods to systematically search, critically appraise, and synthesize on a specific issue by using strategies that reduce biases and random errors. This review followed the JBI guideline for systematic review (Aromataris, 2020) that aims to review all available studies on mobile health application on dietary behaviors in patients with CAD which has nine essential steps including 1) Formulate review question; 2) Define inclusion and exclusion criteria; 3) Locate studies; 4) Select studies; 5) Assess study quality; 6) Extract data; 7) Analysis data; 8) Present results; and 9) Interpret findings and recommendations to guide nursing practice by grading system.

CHAPTER 3

Research Methodology

This chapter presents the research methodology following the manual of the systematic reviews of effectiveness in quantitative studies from the Joanna Briggs Institute (JBI) (Aromataris, 2020). The topics of this chapter are presented as follows: research design, population and sample, instrumentation, quality control in systematic review, data collection, and data analysis.

Research Design

A systematic review and meta-analysis were used to investigate the effectiveness of mobile health application on dietary behaviors in patients with CAD. This review followed the JBI guidelines for systematic reviews. This protocol has been registered with PROSPERO (CRD42022320586). This review followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines (Page et al., 2021) which is available in Appendix A.

Population and Sample

Population

The population in this systematic review consisted of studies that investigated about the mobile health application on dietary behaviors in patients with CAD.

Sample

Sample in this systematic review refers to the studies about the mobile health application on dietary behaviors in patients with CAD which were selected on the basis of inclusion and exclusion criteria as follows:

Population. This review considered the studies that focused on patients aged 18 years or older diagnosed with CAD. There will be no restrictions regarding participants' setting, as participants may be admitted to an in-patient unit or out-patient unit or long-term care at home. The patients who were diagnosed with CAD and cognitive impairment or a psychiatric disease will be excluded.

Intervention. The intervention was a mobile health application used for improving dietary behaviors. A mobile health application may be used of any duration, frequency, and intensity designed to improve dietary behaviors. For this review, interventions included mobile health application that use mobile healths, tablets, and computer or software installed on mobile electronic devices which can deliver health services and information using the internet and related technologies, such as self-monitoring by taking a picture of their food or putting a check mark in a checklist for recording their behaviors, motivating patient by automatic message reminders about healthy habits, and supporting patients. The interventions that include only telephone follow-up or text messaging (SMS message) were excluded.

Comparator. Standard of care was the common practice of care services regarding dietary behaviors for patients with CAD which are provided by nurses or cardiologist such as educating patient about lifestyle modification and following up patients without mobile health education.

Outcomes. The primary outcome of this review was a list of dietary behaviors. This outcome was measured by a questionnaire such as diet scores that were calculated by the summation of intake of fat, fiber, sodium, alcohol, daily servings of fruits, vegetables, whole grains, lean proteins, sweets, seafood beans, white meat, nuts, olive oil, red meat and sausage, butter and cream, soda, and juices.

This study investigated secondary outcomes as well, including changes in body mass index (BMI), LDL-cholesterol level, total cholesterol, and blood pressure. These outcomes were measured by the standard laboratory test for CAD patients.

Research Design. Experimental studies were included (RCT and Quasi-experimental design study) comparing mobile health application to the standard of care that evaluate a primary outcome of change in dietary behaviors. Therefore, any descriptive study designs were excluded.

Year of Publication. The published and unpublished studies in English or Thai from the year 2012 to 2022 will be included.

Instrumentation

There were three types of instrumentation used in this research which are the inclusion criteria form, the critical appraisal form and the data extraction form. The details are as follows:

1. The inclusion criteria form is a tool developed by the researcher following the PICO criteria according to the inclusion criteria. It is available in appendix E.

2. The critical appraisal form is a tool used to assess the research methodology of the research selected for systematic review. The researcher used the JBI critical appraisal checklists for randomized controlled (13 items) and nonrandomized trials (9 items) (Joanna Briggs Institute, 2017). Both of these are available in Appendices F and G.

3. The data extraction form is a tool used to record data from selected studies for systematic review. The researchers used the JBI data extraction form for review for systematic reviews and research syntheses developed by the Joanna Briggs Institute

(Joanna Briggs Institute, 2020). It covers details regarding the study, the participants, settings, the interventions, the comparators, the outcome measures, study design, statistical analysis, and results.

Quality Control in Systematic Review

Quality control in this systematic review consists of the quality control of reviewer, the quality control of instrument, and the quality control of data collection, which are detailed as follows:

Quality control of reviewer

The researcher has undergone a practical training on systematic literature review (Comprehensive Systematic Review Training Program) organized by The Thailand Centre for Evidence Based Health Care: A JBI Center of Excellence (TCEBH: JBI EC) supported by the Faculty of Nursing, Chiang Mai University on June 7-9, 2021. The major advisor received a certificate for the comprehensive systematic review training conducted by TCEBH. The co-advisor is certified by JBI as a comprehensive systematic review trainer.

Quality control of instrument

The inclusion form was a research screening form that was developed based on PICO principles, so there is no need to check the quality of the tool. The quality of the critical appraisal form and the data extraction form, which is a standard tool, created and developed by The Joanna Briggs Institute is guaranteed. It does not need to be checked in terms of the quality of the instrument.

Quality control of data collection

Researchers and the main advisor tried out the inclusion criteria form, the critical appraisal form, and the data extraction form with three quasi-experimental studies and three randomized control trials and compared the results of the records to find the consistency of the records. It was found that the researchers and main advisors had the same opinion. Then the researcher and main advisor independently assessed the studies in three steps from selected studies including screening research, critical appraisal assessment, and data extraction and comparing the research result. It was found that the researcher and the main advisor again had the same opinion.

Research Ethics in Systematic review

In this review, reviewers used the exemption ethic according to the consideration from the ethical committee of faculty of nursing, Prince of Songkla University.

Data Collection

1. Formulate review question

Guiding question were “Are mobile health applications effective compared with standard of care for improving dietary behaviors in patients with CAD?” This was created based on the PICO format: population (P), intervention (I), comparison (C), outcome (O), study design (S) as presented in Table 1.

Table 1

PICO Focused Review Question

P: Patient/ Population/ Problem	CAD patients
I: Intervention or Issue of interest	Mobile health application
C: Comparison/ Context	Routine care/ no mobile health intervention
O: Outcome of interest	Primary outcomes: 1) Dietary behaviors Secondary outcomes: 1) BMI 2) LDL-cholesterol level 3) Total cholesterol 4) Blood pressure
S: Study design	Randomized control trial, Quasi experimental study design

2. Define inclusion and exclusion criteria

The inclusion and exclusion criteria were mentioned above in the part on population and sample.

3. Locate studies

The databases to be searched included Pubmed, MEDLINE, CINAHL Complete, Cochrane Library, ProQuest, Clinical key nursing, Thaijo, ScienceDirect, Scopus, Embase, Oxford Academic, Springer, BMJ Journals, and Wiley online library. Sources of unpublished studies/ gray literature to be searched included Cochrane central register of controlled trials, OVID, Google scholar, Thailist (a Thai literature for

theses), and ProQuest Dissertations and Theses. The search strategy was conducted, and three phases of searching were used as following:

Phase one: initial search of PubMed followed by analysis of text words in the title and abstract and index terms used.

Phase two: Apply identified keywords and index terms across all published and unpublished databases/sources.

Phase three: Review reference lists of all studies retrieved for critical appraisal.

The full list of search strategies and keywords for searching are available in Appendices C and D. Studies published in English and Thai language since 2012 - 2022 were included.

4. Select studies

Following the comprehensive literature search, all identified studies were screened for title and abstract against inclusion criteria with PICO principle by using Zetero and the duplicate studies were removed. The full text was screened by the researcher and major advisor for assessment against the inclusion criteria for the review. Potentially relevant studies were retrieved in full and their citation details imported into the JBI System for the Unified Management, Assessment and Review of Information (JBI SUMARI) (JBI, Adelaide, Australia) (Munn et al., 2019). Reasons for exclusion of papers at full text that do not meet the inclusion criteria were recorded and reported in the systematic review. No disagreement was observed between the reviewers in the selection process. The results of the search and the study inclusion process were reported in full in the final systematic review and presented in a Preferred Reporting

Items for Systematic Reviews and Meta-analyses (PRISMA) flow diagram as Appendix B.

5. Assess study quality

Risk of bias was assessed independently between the two reviewers using the JBI critical tools in JBI SUMARI. The tools that were used in this review are the JBI critical appraisal checklists for randomized controlled (13 items) and nonrandomized trials (9 items) (Joanna Briggs Institute, 2017). Both of these are available in Appendices F and G.

There was a difference in an independently given answer between reviewers, but after the first and second reviewer discussed it and finally came to a consensus, it was not sent to a third reviewer anymore. Reviewers agreed that reviewers should determine the criteria for inclusion when the total number of "yes" answers was more than 7 of 9 for quasi-experimental studies and more than 8 of 13 in RCTs.

6. Extract data

Data were extracted from studies included in the review by the researcher and major advisor using JBI SUMARI which followed JBI Data Extraction Form for Review for Systematic Reviews and Research Syntheses, available in Appendix H (Joanna Briggs Institute, 2020). Data was extracted consisting of the study characteristics and results data.

Data Analysis

1. Characteristics of included studies used narrative synthesis.

2. The effectiveness of mobile health application on dietary behaviors in patients with CAD and other secondary outcomes used narrative synthesis and meta-analysis. Data from included trials were pooled in a statistical meta- analysis model using JBI SUMARI software. The primary outcome, dietary behaviors were continuous data, and statistical analyses were used fix effects model because the number of studies was less than five studies and there was no methodological heterogeneity. Similarly, the secondary outcomes including systolic blood pressure, BMI, LDL-cholesterol, and total cholesterol also used fixed effect model. Additionally, the reviewer did the sub-group analysis for dietary behaviors outcome by dividing them into two groups including one to three months and six to twelve months because the outcome measurement was different among included studies. Statistical heterogeneity was assessed in the meta-analysis using I^2 and x^2 statistics, The I^2 index interpreted as the percentage of the total variability in a set of effect sizes due to true heterogeneity lies between 0% to 100%. A value of 0% indicates no observed heterogeneity, and larger values show increasing heterogeneity. One proposed suggestion was to consider levels of low, moderate, and high heterogeneity for I2 values of 25%, 50%, and 75% (Higgins et al 2003). Additionally, heterogeneity was considered substantial if I^2 was >50% and p value <0.10 in the x^2 test. Sensitivity was considered in this review for examining the impact of decisions made during the review process. Funnel plot for analyzing publication bias was not performed because the number of studies included was less than ten studies (Aromataris, 2020).

CHAPTER 4

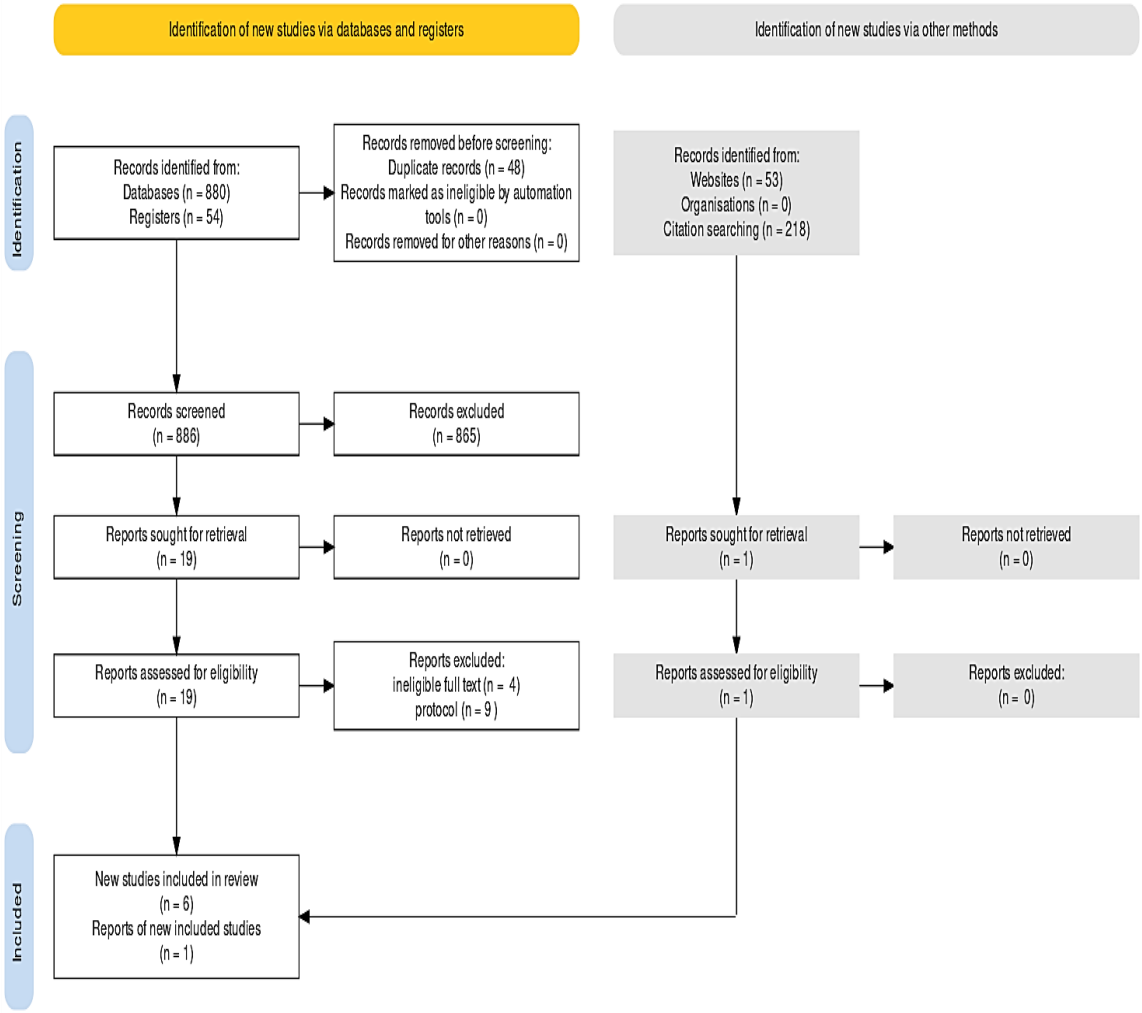
RESULTS AND DISCUSSION

Result of the Study

This study is a systematic review on the effectiveness of a mobile health application on dietary behaviors in patients with CAD. This review included studies that focused on mobile health application intervention to promote dietary behaviors in patients with CAD which were quasi experimental studies and randomized control trials (RCT) in Thai and English language that were published or were unpublished studies for the period from 2012 to 2022. The search identified 934 potential studies, with 886 studies remaining after duplicates were removed. After a review of the title and abstract, 19 studies were identified for potential inclusion in the review. The reference lists from full text screening were 218 studies, 217 were excluded as they did not meet the inclusion criteria after screening the abstracts. The 19 full-text studies were retrieved, but 13 studies were excluded after examination of the full text against the inclusion criteria because four studies were unable to assess full text and eight studies were the protocol studies, therefore reviewer could not assess the outcomes. Six studies and one report were included in this review and passed the critical appraisal assessment as shown in tables 3 and 4. The PRISMA flow diagram details the results of the search (Figure 1). However, for one study that had unclear statistics, the reviewer contacted the corresponding author but received no response from them. Therefore, one study used a narrative summary and other six studies were used for meta-analysis.

Figure 1

PRISMA flow diagram



All seven studies were assessed in terms of quality, whereas risk of bias will be assessed independently between the two reviewers using the JBI critical tools in JBI SUMARI. Six studies used JBI critical appraisal checklists for randomized controlled studies (13 items) and one study used non-randomized trials (9 items) (Joanna Briggs Institute, 2017). The reviewers arrived at a mutual agreement that the scores for RCT quality assessment must pass 8 from 13 scores, for quasi-experimental study, it must pass 6 out of 9 scores. All seven studies passed the quality assessment criteria. These are available in Appendices F and G.

Table 2

Critical Appraisal Results (randomized controlled trials)

citation	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	Q13	scores
Choi et. al., 2019	Y	U	Y	Y	U	N	Y	Y	Y	Y	Y	Y	Y	10/13
Krackhardt et.al., 2022	Y	U	Y	U	U	U	Y	Y	Y	Y	Y	Y	Y	9/13
Manzoor et. Al. 2021	Y	Y	Y	U	U	U	Y	Y	Y	Y	Y	Y	Y	10/13
Ögmundsdóttir et.al., 2022	Y	Y	Y	N	N	Y	Y	Y	Y	Y	Y	Y	Y	11/13
Varnfield et.al., 2014	Y	Y	Y	N	N	N	Y	Y	Y	Y	Y	Y	Y	10/13
Widmer et.al., 2017	Y	Y	Y	U	Y	Y	Y	Y	Y	Y	Y	Y	Y	12/13
%	100	67	100	17	17	33	100	100	100	100	100	100	100	

Note. Y=yes, N= no, U= unclear

Q1 = Was true randomization used for assignment of participants to treatment groups?

Q2 = Was allocation to treatment groups concealed?

Q3 = Were treatment groups similar at the baseline?

Q4 = Were participants blind to treatment assignment?

Q5 = Were those delivering treatment blind to treatment assignment?

Q6 = Were outcomes assessors blind to treatment assignment?

Q7 = Were treatment groups treated identically other than the intervention of interest?

Q8 = Was follow-up complete and if not, were differences between groups in terms of their follow-up adequately described and analyzed?

Q9 = Were participants analyzed in the groups to which they were randomized?

Q10 = Were outcomes measured in the same way for treatment groups?

Q11 = Were outcomes measured in a reliable way?

Q12 = Was appropriate statistical analysis used?

Q13 = Was the trial design appropriate, and were any deviations from the standard RCT design (individual randomization, parallel groups) accounted for in the conduct and analysis of the trial?

Table 3

Critical Appraisal Results (quasi-experimental study)

citation	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	scores
Tang et.al., 2018	Y	Y	Y	Y	Y	Y	Y	Y	Y	9/9
%	100	100	100	100	100	100	100	100	100	

Note. Y=yes, N= no, U= unclear

Q1 = Is it clear in the study what is the ‘cause’ and what is the ‘effect’?

Q2 = Were the participants included in any comparisons similar?

Q3 = Were the participants included in any comparisons receiving similar treatment/care, other than the exposure or intervention of interest?

Q4 = Was there a control group?

Q5= Were there multiple measurements of the outcome both pre and post the intervention/exposure?

Q6 = Was follow-up complete and if not, were differences between groups in terms of their follow-up adequately described and analyzed?

Q7 = Were the outcomes of participants included in any comparisons measured in the same way?

Q8 = Were outcomes measured in a reliable way?

Q9 =Was appropriate statistical analysis used?

Reviewers presented the characteristics and assessment of methodological quality of seven studies that passed the quality assessment as follows:

Characteristics of Included Studies

Among the trial studies included in the review, six were RCTs, and one study was a quasi-experimental study design. Two studies were conducted in the USA (Choi et al., 2019; Widmer et al., 2017), and the other five studies were from Pakistan (Manzoor et al., 2021), Sweden (Michelsen et al., 2022), Malaysia (Tang et al., 2018), Germany (Krackhardt et al., 2022), and Australia (Varnfield et al., 2014). The participants in all the studies were diagnosed with coronary artery disease. The number of participants in the studies ranged from 80 to 672. The distribution of male and female participants in the trials showed male predominance. The mean age of participants in the trials ranged from 52.67 to 63.6. The duration of intervention for most cases was 4-24 weeks, 2 trials were 48-56weeks, as shown in Table 3.

Table 4

Characteristics of Included Studies (N=7)

General Characteristic Research	Number (n)	Percent (%)
Research Methodology		
RCT	6	85.71
Quasi-experimental	1	14.29
Country		
USA	2	28.57
Germany	1	14.29
Malaysia	1	14.29
Pakistan	1	14.29
Sweden	1	14.29
Australia	1	14.29
Participant characteristics		
Mean Age		
52-60 years old	6	85.71
More than 60 years old	1	14.29
Gender		
Male predominance	7	100
Female predominance	0	0
Disease		

General Characteristic Research	Number (n)	Percent (%)
Coronary Artery Disease	7	100
Participants		
Small sample size (n≤150)	5	71.43
Large sample size (n>150)	2	28.57
Duration of intervention and outcome measurement		
4 weeks	1	14.29
6 weeks	1	14.29
12 weeks	1	14.29
24 weeks	2	28.57
48 weeks	1	14.29
56 weeks	1	14.29
Components in Mobile Application		
Monitoring dietary behaviors, monitoring clinical assessments, taking picture of food by patients, and face-to-face counseling mentors	1	14.29
Monitoring dietary behaviors, monitoring clinical assessments, educational material messages, and individualized feedback	4	57.13
Motivational messages, and individualized counselling	1	14.29
WhatsApp (Group discussion chat), and educational material messages	1	14.29

Methodological Quality

Assessment of methodological quality was carried out by two independent reviewers for the six studies. This review included randomized and quasi-experimental study designs. There were six randomized studies and one quasi-experimental study included in this review. The results of the critical appraisal are shown in table 1. The first and second authors determined that seven of all studies met the criteria of methodological quality and were appropriate for analysis. Regarding randomized controlled trial, six studies used randomization. The methodologies for randomization were computer-based randomization (Manzoor et al., 2021; Varnfield et al., 2014; Widmer et al., 2017), opaque sealed envelope (Michelsen et al., 2022), whereas others did not mention what particular methodology of randomization they used (Choi et al., 2019; Krackhardt et al., 2022).

For RCT, reviewers discussed the methodological quality of blinding the participants (Q4), treatment deliverers (Q5) and accessors (Q6). Blinding of the participants was mentioned in one study (Choi et al., 2019) and blinding of deliverers of intervention was also mentioned in only one study (Widmer et al., 2017). Likewise, blinding of outcome accessors was mentioned in only one study (Widmer et al., 2017). All articles measured the outcomes in a reliable way and used an appropriate trial design.

For one quasi-experimental study, it is clear that the intervention was on mobile health application and that outcome showed adherence to a healthy style. There was a clear control and intervention group. The measurement can be used for measuring all outcomes. However, there were results for overall adherence to healthy lifestyle, but

it did not have the result of each dimension such as dietary behaviors. Therefore, this study was summarized in narrative form.

To summarize, all seven articles were included because the total number of "yes" answers was more than 6 out of 9 and 8 out of 13 in quasi-experimental studies and RCT. The review results are presented as tables 4 and 5.

Review Findings

There were six studies that can be used for meta-analysis and one study for which narrative synthesis was used. One study (Tang et al., 2018) did not report the dietary behavior outcome; therefore, we contacted the author of the research by email but received no response. We excluded this study from the meta-analysis but reported it in narrative summary. The review findings are presented as follows:

Dietary Behaviors

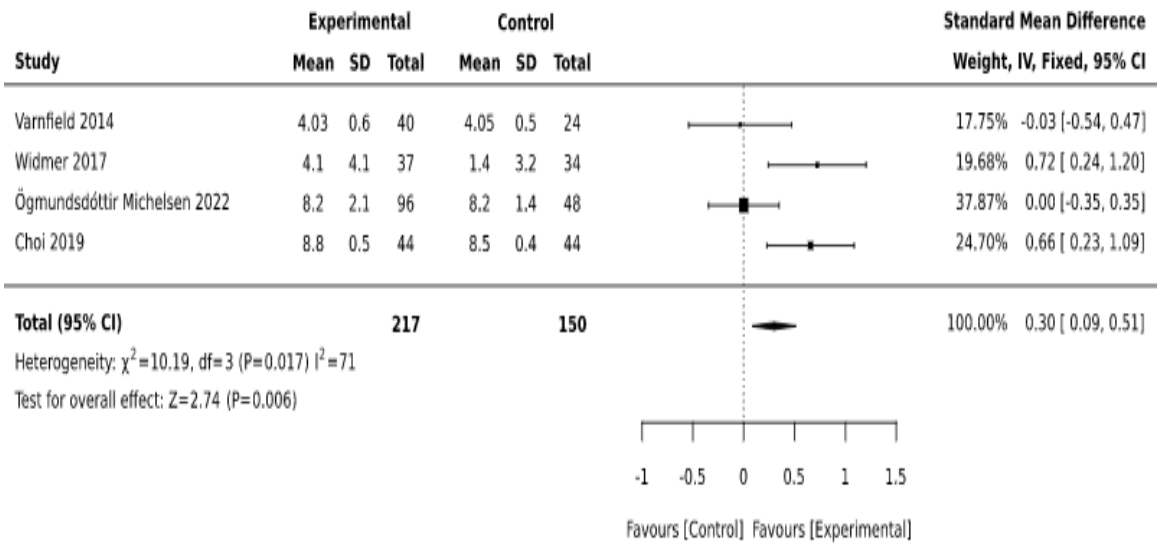
The studies were about mobile health application for promoting dietary behavior in patients with CAD. Four studies could be analyzed by meta-analysis (Choi et al., 2019; Michelsen et al., 2020; Varnfield et al., 2014; Widmer et al., 2017); there were 367 participants, which were divided into an intervention group (217 participants) and a control group (150 participants). The pool result showed a significant difference between these two groups, SMD 0.30, 95% CI 0.09 to 0.51, (p=.006). Moreover, there was a high heterogeneity (I^2= 71, p >0.01) (figure 2).

For three studies (Krackhardt et al., 2022; Manzoor S et al., 2021; Tang et al., 2018) that could not be analyzed by meta-analysis because these studies had a difference in terms of dietary behavior outcome measurement, (Krackhardt et al., 2022), measured healthy eating scores were divided into three groups: fair, good, and exellent

(Manzoor et al., 2021). Another one (Tang et al., 2018) did not show any numeric data of dietary behavior outcome. The result showed that mobile health application increased adherence to proper diet by the increase in HEQ scores at 12 and 24 weeks follow-up (Manzoor S et al., 2021) and agreed or partially agreed to a healthy diet showing a significant increase from 85.7% to 91.9% in 48 weeks (Krackhardt et al., 2022). In addition, Tang et al. (2018) revealed that the intervention group used WhatsApp as an information sharing tool and that this had a significant development of adherence to healthy lifestyles (included dietary behavior) from a mean of 42.89 to 63.55 (p=0)(Tang et al., 2018).

Figure 2

The effectiveness of mobile health application on dietary behavior outcome in patients with CAD



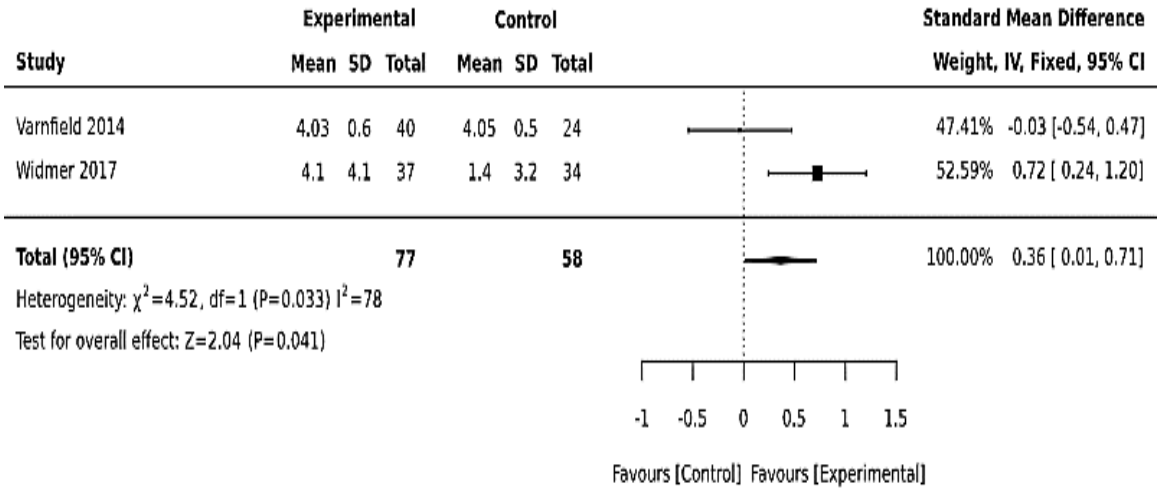
Dietary Behaviors at 1-3 months

Some studies about using a mobile health application for promoting dietary behavior had measured the outcome between one to three months including the study of Varnfield et al. (2014) and Widmer etal. (2017). From the meta-analysis, there were

135 participants, which were divided into an intervention group (77 participants) and a control group (58 participants). The pool result showed a significant difference between these two groups, SMD 0.36, 95% CI 0.01 to 0.71, p=.041. However, there was a high heterogeneity (I^2= 78, p >0.01) (figure 3).

Figure 3

The effectiveness of mobile health application for improving dietary behaviors at 1-3 months in patients with CAD.

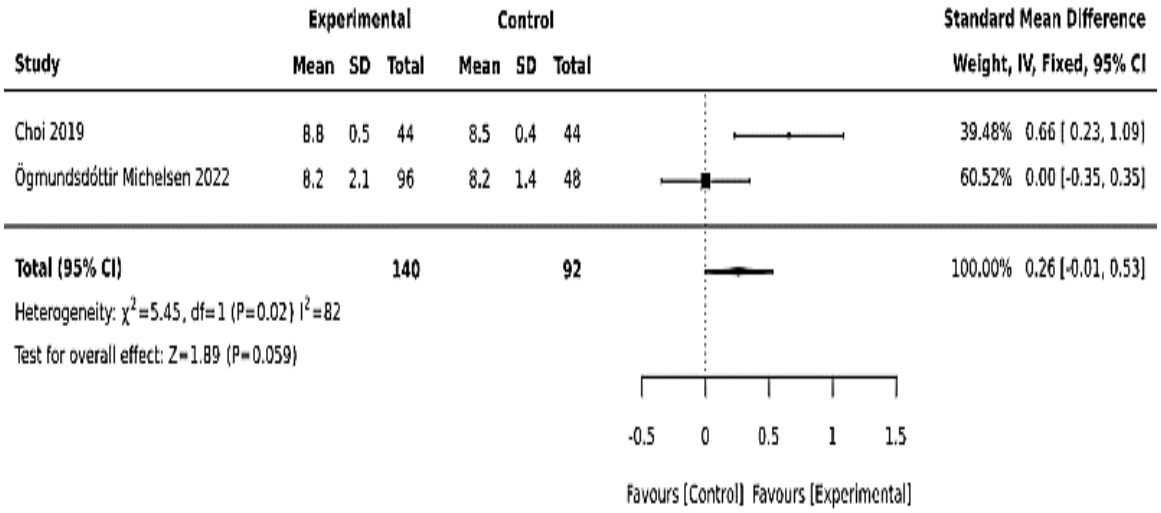


Dietary Behaviors at 6-12 months

Some studies about using a mobile health application for promoting dietary behavior had measured the outcome between six to twelve months including the study of Choi et al. (2019) and Michelsen et al. (2022). From the meta-analysis, there were 232 participants, which were divided into an intervention group (140 participants) and a control group (92 participants). The pool result showed no significant difference between these two groups, SMD 0.26, 95% CI -0.01 to 0.53, p=.059. However, there was a high heterogeneity (I^2= 82, p >0.01) (figure 4).

Figure 4

The effectiveness of a mobile health application for improving dietary behaviors at 6-12 months in patients with CAD.



Systolic blood pressure (SBP)

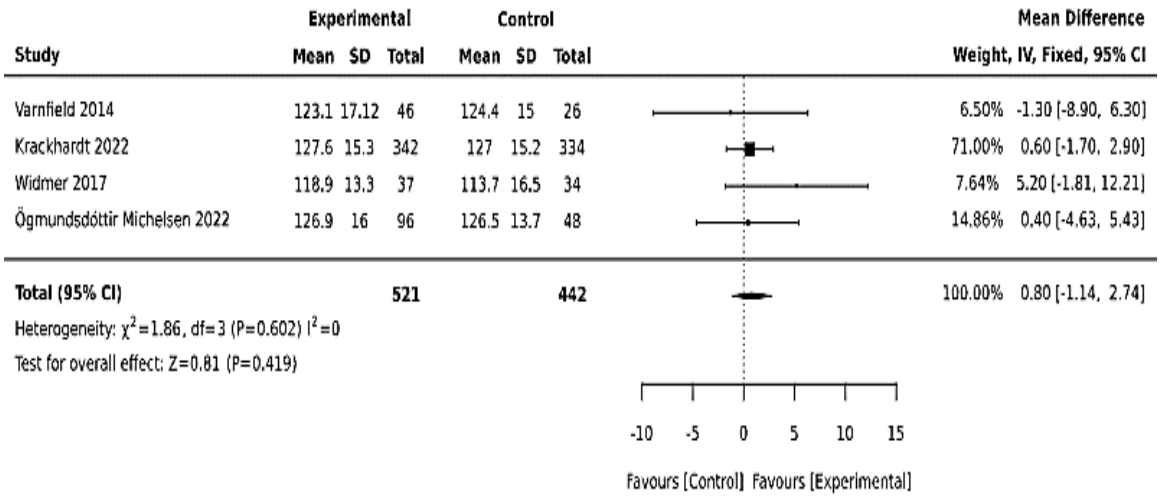
For the studies about using a mobile health application for controlling SBP in patients with CAD, five studies can be analyzed by meta-analysis (Choi et al., 2018; Krackhardt et al., 2022; Michelsen et al., 2020; Varnfield et al., 2014; Widmer et al., 2017). There were 963 participants, which were divided into an intervention group (521 participants) and a control group (442 participants). The pooled result showed no significant difference between these two groups, WMD 0.80 (95% CI -1.14 to 2.74) (p = .419) (figure 5).

For two studies that could not use meta-analysis (Krackhardt et al., 2022; Manzoor S et al., 2021) because these were using different outcome measurement, the result showed that there were no significant differences in systolic blood pressure level between groups but it was in the normal range in both group (Krackhardt et al., 2022) and blood pressure checking had a non-significant difference between two group at 12

and 24 weeks follow-up; Also, the intervention group was checking BP more often than the control group (Manzoor et al., 2021).

Figure 5

The effectiveness of mobile health application for improving SBP in patients with CAD.



Diastolic Blood Pressure (DBP)

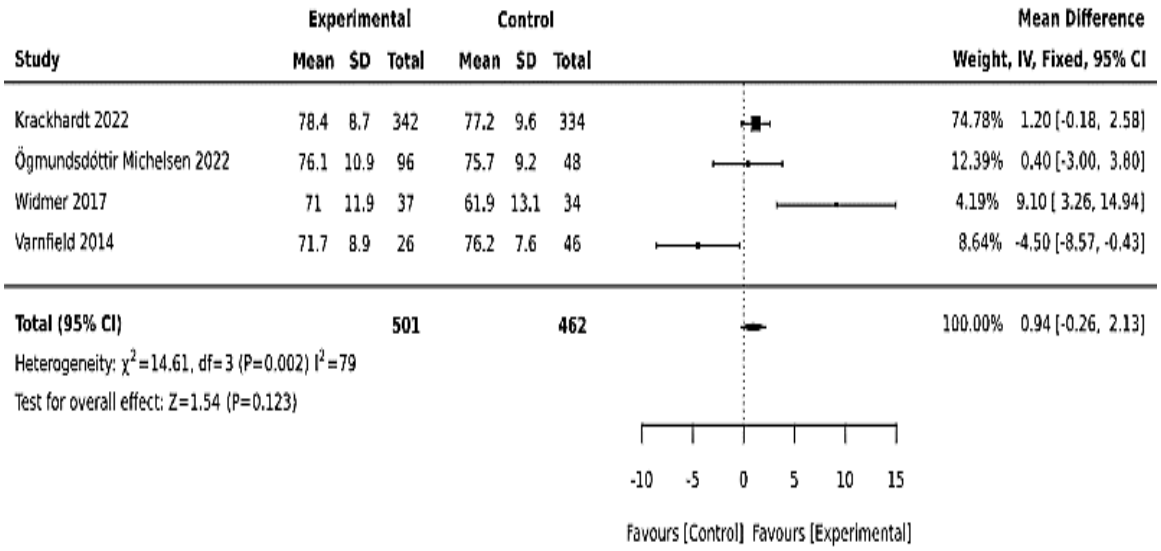
Among the studies about using a mobile health application for improving DBP in patients with CAD, four studies can be analyzed by meta-analysis (Choi B et al., 2018; Krackhardt et al., 2022; Michelsen et al., 2020; Varnfield et al., 2014; Widmer et al., 2017). There were 963 participants, which were divided into an intervention group (501 participants) and a control group (462 participants). The pooled result presented no significant difference between two groups, WMD 0.94 (95% CI -0.26 to 2.13) (p = 0.123) (figure 6).

For two studies that could not use meta-analysis (Krackhardt et al., 2022; Manzoor S et al., 2021) because these were using different outcome measurement, the result showed that there were no significant differences in diastolic blood pressure level between groups but it was in the normal range in both groups (Krackhardt et al., 2022)

and blood pressure checking had a non-significant difference between two groups at 12 and 24 weeks follow-up; the intervention group was checking BP more than the control group (Manzoor S et al., 2021).

Figure 6

The effectiveness of mobile health application for improving DBP in patients with CAD.



Body Mass Index (BMI)

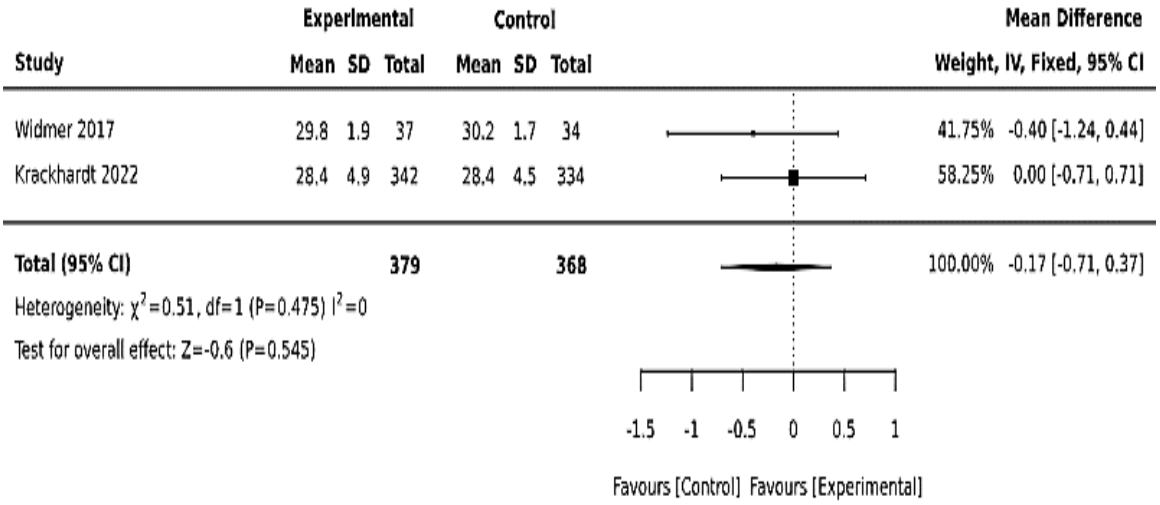
Among the studies about using a mobile health application for improving BMI in patients with CAD, two studies could be analyzed by meta-analysis (Krackhardt et al., 2022; Widmer et al., 2017) There were 747 participants, which were divided into an intervention group (379 participants) and a control group (368 participants). The pool result showed no significant difference between these two groups, WMD -0.17 (95% CI -0.71 to 0.37) (p = .545) (figure 7).

For two studies that could not use meta-analysis (Krackhardt et al., 2022; Manzoor S et al., 2021) because these were using different outcome measurement, The result showed that there were no significant differences in BMI level between visits (Krackhardt et al., 2022) and BMI checking had a non-significant difference between

two group at 12 and 24 weeks follow-up; the intervention group was checking BMI more than control group (Manzoor S et al., 2021).

Figure 7

The effectiveness of mobile health application for improving BMI in patients with CAD



LDL-cholesterol level

For the studies about using a mobile health application for decreasing LDL-cholesterol in patients with CAD, three studies could be analyzed by meta-analysis (Michelsen et al., 2020; Varnfield et al., 2014; Widmer et al., 2017). There were 287 participants, who were divided into an intervention group (179 participants) and a control group (108 participants). The pool result showed no significant difference between these two groups, SMD 0.14 (95% CI -0.10 to 0.38) (p=.25) (figure 8).

Total Cholesterol level

For the studies about using a mobile health application for reducing total cholesterol in patients with CAD, three studies could be analyzed by meta-analysis. There were 259 participants, who were divided into an intervention group (146 participants) and a control group (113 participants). The pool result showed no

significant difference between two groups, SMD 0.14 (95% CI -0.11 to 0.40) (p=.268) (figure 9).

Figure 8

The effectiveness of mobile health application for decreasing LDL-cholesterol in patients with CAD

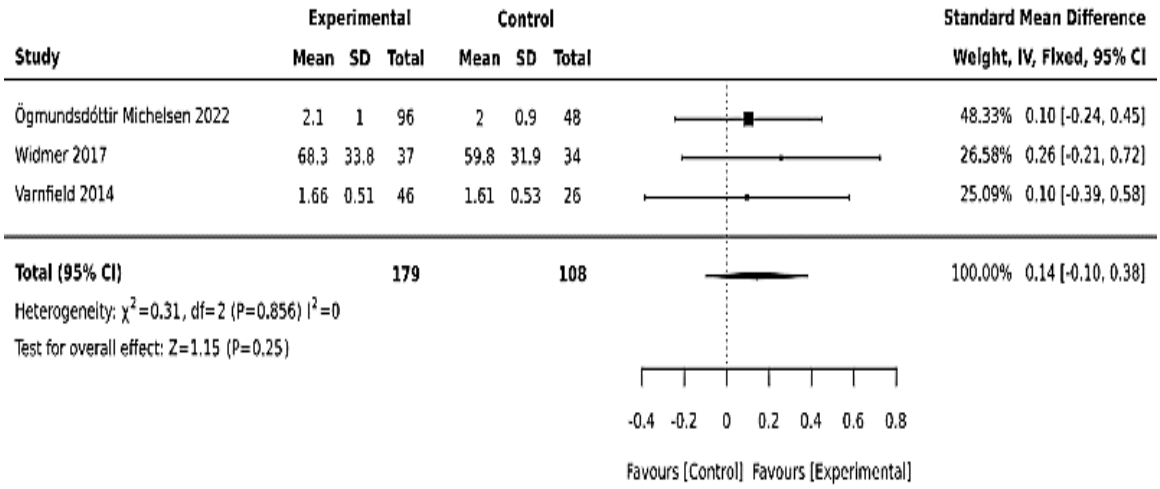
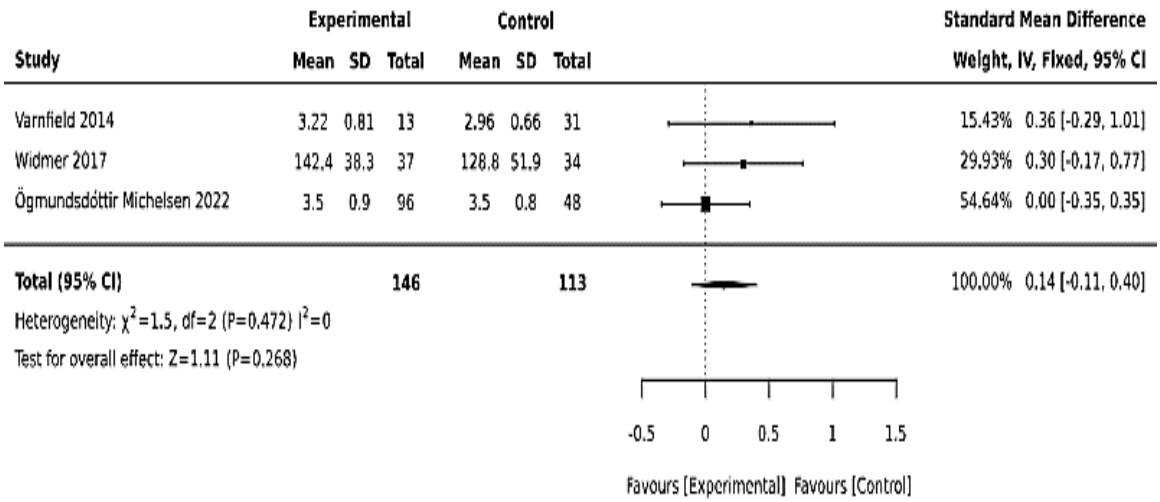


Figure 9

The effectiveness of mobile health application for decreasing total cholesterol in patients with CAD



For outcome of BMI, LDL-cholesterol and total cholesterol, the reviewer excluded the study of Choi et al. (2019) because it was the reason of heterogeneity.

GRADE 'Summary of Findings' table

Reviewers followed JBI which applied the GRADEpro software (McMaster University and Evidence Prime, 2022) approach to create summary of findings tables in reviews on the effectiveness of interventions as shown in figures 10:

Figure 10

Summary of findings tables in reviews on the effectiveness of mobile health application

Mobile health application on dietary behaviors compared to standard of care in patients with coronary artery disease

Patient or population: patients with coronary artery disease
Setting:
Intervention: mobile health application on dietary behaviors
Comparison: standard of care

Outcomes	№ of participants (studies) Follow-up	Certainty of the evidence (GRADE)	Relative effect (95% CI)	Anticipated absolute effects	
				Risk with standard of care	Risk difference with mobile health application on dietary behaviors
Dietary behaviors assessed with: Self-reported questionnaire follow-up: range 1 months to 14 months	367 (4 RCTs)	⨁⨁◯◯ Low[a,b,c]	-	-	SMD **0.3 SD more** (0.09 more to 0.51 more)
dietary behavior between 1-3 months assessed with: self-reported questionnaire	135 (2 RCTs)	⨁⨁◯◯ Low[a,b,c]	-	-	SMD **0.36 SD more** (0.01 more to 0.71 more)
dietary behaviors more than 3 months assessed with: self-reported questionnaire	232 (2 RCTs)	⨁⨁◯◯ Low[a,b,c]	-	-	SMD **0.26 SD more** (0.01 fewer to 0.53 more)
Systolic Blood Pressure (SBP) assessed with: clinical assessment follow-up: range 1 months to 14 months	963 (4 RCTs)	⨁⨁◯◯ Low[a,b,d]	-		WMD **0.8 more** (1.14 fewer to 2.74 more)
Diastolic Blood Pressure (DBP) assessed with: clinical assessment follow-up: range 1 months to 14 months	963 (4 RCTs)	⨁◯◯◯ Very low[a,b,d]	-		WMD **0.94 more** (0.26 fewer to 2.13 more)
Body Mass Index (BMI) assessed with: clinical assessment follow-up: range 3 months to 12 months	747 (2 RCTs)	⨁⨁⨁◯ Moderate[a,c,d]	-		WMD **0.17 fewer** (0.71 fewer to 0.37 more)
LDL-cholesterol assessed with: standard laboratory test follow-up: range 1 months to 14 months	287 (3 RCTs)	⨁⨁⨁◯ Moderate[a,c,d]	-	-	SMD **0.14 SD more** (0.1 fewer to 0.38 more)
Total Cholesterol assessed with: standard laboratory test follow-up: range 1 months to 14 months	259 (3 RCTs)	⨁⨁⨁◯ Moderate[a,c,d]	-	-	SMD **0.14 SD more** (0.11 fewer to 0.4 more)

***The risk in the intervention group** (and its 95% confidence interval) is based on the assumed risk in the comparison group and the **relative effect** of the intervention (and its 95% CI).

CI: confidence interval; **SMD:** standardised mean difference **WMD**: weighted mean difference

GRADE Working Group grades of evidence
High certainty: we are very confident that the true effect lies close to that of the estimate of the effect.
Moderate certainty: we are moderately confident in the effect estimate: the true effect is likely to be close to the estimate of the effect, but there is a possibility that it is substantially different.
Low certainty: our confidence in the effect estimate is limited: the true effect may be substantially different from the estimate of the effect.
Very low certainty: we have very little confidence in the effect estimate: the true effect is likely to be substantially different from the estimate of effect.

Explanations

a. concerning the risk of bias on blinding
b. concerning heterogeneity of included studies
c. small number of study
d. the outcomes were surrogate outcome.

Discussion

A total of seven studies were selected for systematic review, including six randomized controlled trial (RCT) studies and one of quasi-experimental study design. The majority of studies was conducted in Europe with four studies. All studies involved patients with CAD and were published in 2014-2022. There were five studies that used a small sample ($n \leq 150$) and it was found that the majority of the studies were conducted for a duration of 24 weeks. All studies passed the criteria for assessment regarding their quality in order to conduct a systematic review. There were six studies that could be used for meta-analysis and another was used for narrative summary. In this study it was found that the intervention was done by mobile health application, and that the details in the application were composed of monitoring dietary behaviors, monitoring clinical assessment, educational material messages, face-to-face counseling mentors, individualized feedback, motivational messages, preinstalled audio and video files, taking picture of food by patients, and group discussion chat. Afterwards, these were compared with the standard of care for patients with CAD.

The results showed that the mobile health application on dietary behavior in patients with CAD had a significant difference between mobile health application and the standard of care group. However, there was a high heterogeneity; this may be because there were differences of duration of outcome measurement. Then the reviewer did the subgroup-analysis of dietary behaviors between one to three months and six to twelve months. It was found that dietary behaviors between one to three months had a significant difference from standard of care group. However, it still showed a high heterogeneity which may be because they were the summation of diet scores from

different types of food; for example, Varnfield et al. (2014) measured diet scores calculated by the summation of intake of fat, fiber, sodium, and alcohol, whereas Widmer et al. (2017) measured diet scores calculated by summation of daily servings of fruits, vetgetables, whole grains, and lean proteins with points taken away for daily serving of saturated fats and sweets. Meanwhile, dietary behaviors between six to twelve months had a non-significant difference between the two group. Consequently, using a mobile health application within the first three months assures more enhancing patients' adherence to healthy diet in patients with CAD than six to twelve months. It may be that this is so because by then they were familiar with the application, and for this reason, the patient's attention was less in the latter, which was consistent with the study of Michelsen et al. (2022) when it presented that the healthy diet score improved significantly at two weeks in the intervention group. Additionally, the study of Widmer et al. (2017) showed diet scores increasing significantly at three months in the intervention group. From this review, it can be summarized that using a mobile health application was able to improve dietary behaviors between one to three months. Therefore, it is one option for patients with CAD for improving dietary behaviors; however, this result was summarized from few studies. The level of certainty of evidence varied between very low and moderate level because there were concerns regarding the risk of bias on blinding, concerning heterogeneity of included studies, the outcomes were surrogate outcome (i.e., BP, BMI, LDL and total cholesterol), and some studies had a small number of events. On the basis of current evidence, further research using larger studies may increase the certainty of the evidence.

CHAPTER 5

CONCLUSION AND RECOMMENDATIONS

This chapter illustrates the conclusion of the study based on the review results. The results, limitation, implications for practice, and implication for research are also presented.

Conclusion

This review is a systematic review of effectiveness of a mobile health application in dietary behaviors in patients with CAD which selected quasi experimental studies and randomized control trials (RCT) in Thai and English language that have been published or were found as unpublished studies since 2012-2022, based on a systematic review process proposed by the Joanna Briggs Institute (Aromataris, 2014) which consists of 9 steps: 1) formulate review question; 2) define inclusion and exclusion criteria; 3) locate studies; 4) select studies; 5) assess study quality; 6) extract data; 7) analysis data; 8) present results; and 9) interpret findings and recommendations to guide nursing practice.

From the selection of 19 full-text studies, seven related studies were found that met the selection criteria according to the research quality assessment, which were six randomized controlled trials (RCTs) and one quasi-experimental study. These six studies were analyzed by meta-analysis using weighted mean difference (WMD) and standard mean difference (SMD) and used random effects model and fix effects model. One study that could not be meta-analyzed was summarized in narrative summary. Reviewers summarized results, and recommendation as follows:

Results

The review results found that a mobile health application improved dietary behavior in patients with CAD, SMD 0.30, 95% CI 0.09 to 0.51, (p=.006) and found that there was a statistical significance between one to three months, SMD 0.30, 95% CI -0.01 to 0.53, (p=.059). This systematic review suggested that mobile health application is one option for improving dietary behaviors in patients with CAD between one to three months. The limitation of this review is that the reviewer focused on only experimental studies (RCT and quasi-experimental studies), therefore, it may affect the certainty of the evidence.

Implications for Practice

The recommendations in this review are based on the findings of a small number of studies, the limitations of which have been clearly outlined. This review recommended that using a mobile health application is one option for improving dietary behaviors in patients with CAD between one to three months.

Implications for Further Research

The certainty of evidence for each outcome in this review was ranging from very low to moderate level because there were concerns regarding the risk of bias on blinding and concerning heterogeneity of included studies. Moreover, the outcomes were surrogate outcome (i.e., BP, BMI, LDL and total cholesterol), and some studies had a small number of events. Further primary research may fulfill this gap or further review should clarify effectiveness of mobile health application on dietary behaviors in patients with CAD by using larger studies thus increasing the certainty of the evidence such as including the descriptive studies or collecting more studies due to the emergence of new features in the application that may occur in the future.

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Administration and Time Schedule

Activity/Process	Year 2022											
	1	2	3	4	5	6	7	8	9	10	11	12
-Thesis proposal defense		↔										
-Searching												
-Select study		↔	↔									
-Assess study quality				↔								
-Extract data				↔								
-Analyze data				↔	↔							
-Present Result					↔							
-Interpret findings and recommendations						↔	↔					
-Sending thesis defense request form								↔	↔	↔		
-Thesis defense										↔		
-Submit											↔	↔

Budget

Items	**Total**
1. Expense	
1.1 analysis of samples	2,000
1.2 Transportation for data/sample collection	2,000
2. Material	
2.1 Office items/Photocopy	2,000
Total	**6,000**

Appendices

Appendix A: PRISMA 2020 checklist

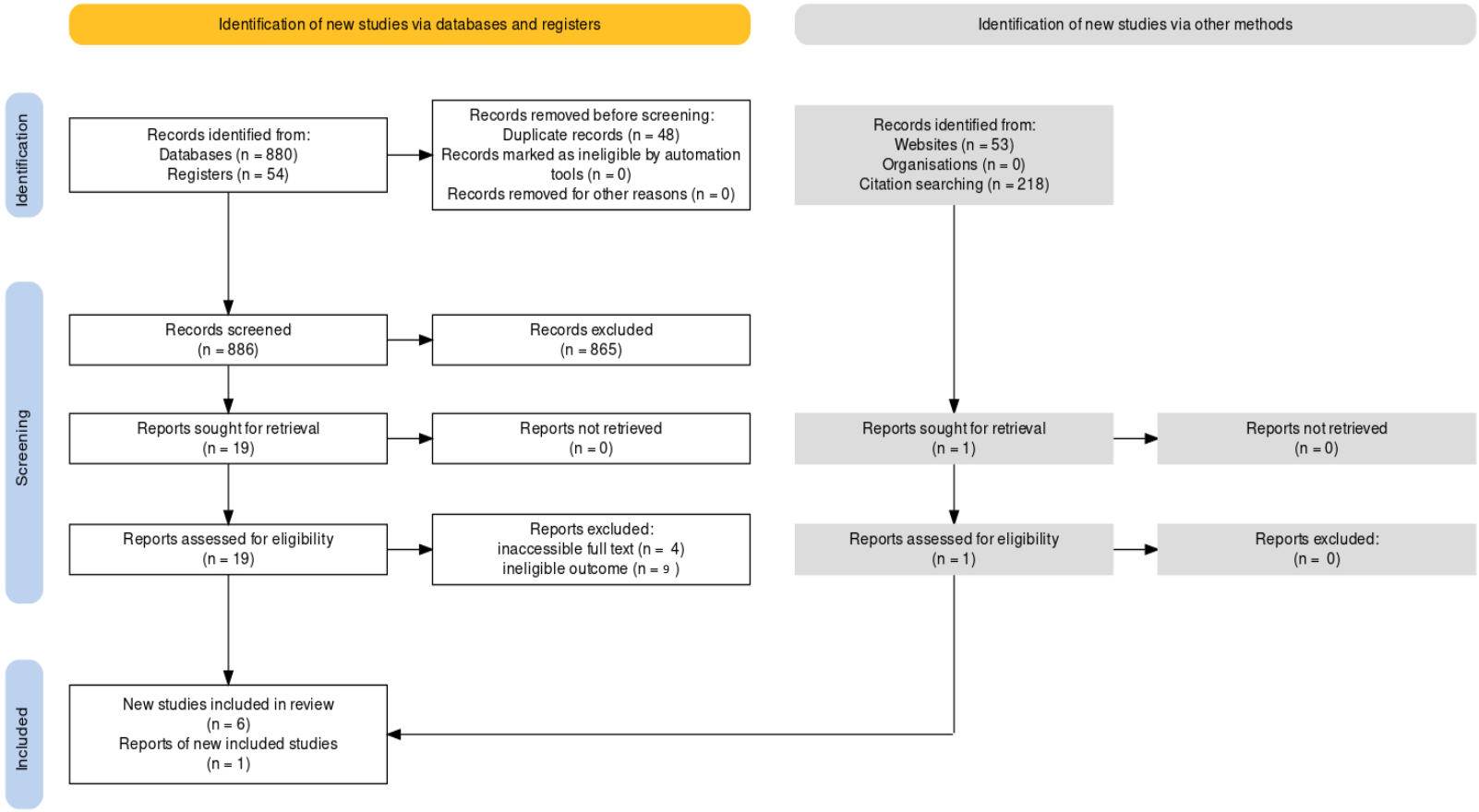
Section and Topic	Item #	Checklist item
TITLE		
Title	1	Identify the report as a systematic review.
ABSTRACT		
Abstract	2	See the PRISMA 2020 for Abstracts checklist.
INTRODUCTION		
Rationale	3	Describe the rationale for the review in the context of existing knowledge.
Objectives	4	Provide an explicit statement of the objective(s) or question(s) the review addresses.
METHODS		
Eligibility criteria	5	Specify the inclusion and exclusion criteria for the review and how studies were grouped for the syntheses.
Information sources	6	Specify all databases, registers, websites, organisations, reference lists and other sources searched or consulted to identify studies. Specify the date when each source was last searched or consulted.
Search strategy	7	Present the full search strategies for all databases, registers and websites, including any filters and limits used.
Selection process	8	Specify the methods used to decide whether a study met the inclusion criteria of the review, including how many reviewers screened each record and each report retrieved, whether they worked independently, and if applicable, details of automation tools used in the process.
Data collection process	9	Specify the methods used to collect data from reports, including how many reviewers collected data from each report, whether they worked independently, any processes for obtaining or confirming data from study investigators, and if applicable, details of automation tools used in the process.
Data items	10a	List and define all outcomes for which data were sought. Specify whether all results that were compatible with each outcome domain in each study were sought (e.g., for all measures, time points, analyses), and if not, the

Section and Topic	Item #	Checklist item
		methods used to decide which results to collect.
	10b	List and define all other variables for which data were sought (e.g., participant and intervention characteristics, funding sources). Describe any assumptions made about any missing or unclear information.
Study risk of bias assessment	11	Specify the methods used to assess risk of bias in the included studies, including details of the tool(s) used, how many reviewers assessed each study and whether they worked independently, and if applicable, details of automation tools used in the process.
Effect measures	12	Specify for each outcome the effect measure(s) (e.g., risk ratio, mean difference) used in the synthesis or presentation of results.
Synthesis methods	13a	Describe the processes used to decide which studies were eligible for each synthesis (e.g., tabulating the study intervention characteristics and comparing against the planned groups for each synthesis (item #5)).
	13b	Describe any methods required to prepare the data for presentation or synthesis, such as handling of missing summary statistics, or data conversions.
	13c	Describe any methods used to tabulate or visually display results of individual studies and syntheses.
	13d	Describe any methods used to synthesize results and provide a rationale for the choice(s). If meta-analysis was performed, describe the model(s), method(s) to identify the presence and extent of statistical heterogeneity, and software package(s) used.
	13e	Describe any methods used to explore possible causes of heterogeneity among study results (e.g., subgroup analysis, meta-regression).
	13f	Describe any sensitivity analyses conducted to assess robustness of the synthesized results.
Reporting bias assessment	14	Describe any methods used to assess risk of bias due to missing results in a synthesis (arising from reporting biases).
Certainty assessment	15	Describe any methods used to assess certainty (or confidence) in the body of evidence for an outcome.

Section and Topic	Item #	Checklist item
RESULTS		
Study selection	16a	Describe the results of the search and selection process, from the number of records identified in the search to the number of studies included in the review, ideally using a flow diagram.
	16b	Cite studies that might appear to meet the inclusion criteria, but which were excluded, and explain why they were excluded.
Study characteristics	17	Cite each included study and present its characteristics.
Risk of bias in studies	18	Present assessments of risk of bias for each included study.
Results of individual studies	19	For all outcomes, present, for each study: (a) summary statistics for each group (where appropriate) and (b) an effect estimate and its precision (e.g. confidence/credible interval), ideally using structured tables or plots.
Results of syntheses	20a	For each synthesis, briefly summarise the characteristics and risk of bias among contributing studies.
	20b	Present results of all statistical syntheses conducted. If meta-analysis was done, present for each the summary estimate and its precision (e.g., confidence/credible interval) and measures of statistical heterogeneity. If comparing groups, describe the direction of the effect.
	20c	Present results of all investigations of possible causes of heterogeneity among study results.
	20d	Present results of all sensitivity analyses conducted to assess the robustness of the synthesized results.
Reporting biases	21	Present assessments of risk of bias due to missing results (arising from reporting biases) for each synthesis assessed.
Certainty of evidence	22	Present assessments of certainty (or confidence) in the body of evidence for each outcome assessed.
DISCUSSION		

Section and Topic	Item #	Checklist item
Discussion	23a	Provide a general interpretation of the results in the context of other evidence.
	23b	Discuss any limitations of the evidence included in the review.
	23c	Discuss any limitations of the review processes used.
	23d	Discuss implications of the results for practice, policy, and future research.
OTHER INFORMATION		
Registration and protocol	24a	Provide registration information for the review, including register name and registration number, or state that the review was not registered.
	24b	Indicate where the review protocol can be accessed, or state that a protocol was not prepared.
	24c	Describe and explain any amendments to information provided at registration or in the protocol.
Support	25	Describe sources of financial or non-financial support for the review, and the role of the funders or sponsors in the review.
Competing interests	26	Declare any competing interests of review authors.
Availability of data, code and other materials	27	Report which of the following are publicly available and where they can be found: template data collection forms; data extracted from included studies; data used for all analyses; analytic code; any other materials used in the review.

Appendix B: Prisma flow diagram



Source: Page, et al. (2021). The PRISMA 2020 statement: An updated guideline for reporting systematic reviews. *PLoS Medicine*, *18*(3), e1003583.

Appendix C: Keywords Used for Searching Materials

Keyword	MesH terms
Coronary Artery Disease	• Coronary Disease • Coronary Diseases • Disease, Coronary • Diseases, Coronary • Coronary Heart Disease • Coronary Heart Diseases • Disease, Coronary Heart • Diseases, Coronary Heart • Heart Disease, Coronary • Heart Diseases, Coronary
Mobile health application	• Application, Mobile • Applications, Mobile • Mobile Application • Mobile Apps • App, Mobile • Apps, Mobile • Mobile App • Portable Software Apps • App, Portable Software • Portable Software App • Software App, Portable • Portable Software Applications • Application, Portable Software • Portable Software Application • Software Application, Portable • Mobile health Apps • App, Mobile health • Apps, Mobile health • Mobile health App • Portable Electronic Apps • App, Portable Electronic • Electronic App, Portable • Portable Electronic App • Portable Electronic Applications • Application, Portable Electronic • Electronic Application, Portable • Portable Electronic Application

Keyword	MesH terms
Dietary behavior	• Diet, Mediterranean • Diets, Mediterranean • Mediterranean Diets • Diet Therapies • Therapy, Diet • Diet Therapy, Restrictive • Restrictive Diet Therapies • Therapy, Restrictive Diet • Restrictive Diet Therapy • Restriction Diet Therapies • Diet Therapies, Restriction • Diet Therapy, Restriction • Therapy, Restriction Diet • Restriction Diet Therapy • Dietary Restriction • Dietary Restrictions • Restriction, Dietary • Dietary Modification • Dietary Modifications • Modification, Dietary • Diet Modification • Diet Modifications • Modification, Diet

Appendix D: Search Strategies

Searching Concept

1. Mobile health application
2. Diet
3. Coronary artery disease

	Concept1	Concept2	Concept3
Keyword	Mobile health application	Diet	Coronary artery disease
Synonyms/ thesaurus	mHealth,eHealth, smartphone application, Mobile Application, Mobile Apps, Portable Software Apps, Electronic Application	Food, food consumption, eating, eating habit, eating behavior, nutrition, Mediterenean, diet therapy, dietary modification, dietary behavior, dietary intake, restrictive diet therapy	Myocardial infarction, heart attack, coronary heart disease, chronic coronary syndrome, atherosclerosis, left main disease, ischemic heart disease
Truncation symbol	App*, smartphone app*, mobile apps*	Diet*, nutri*, eating habit*, dietary habit*,	
Wildcard symbols		Dietary behavi?r, eating behavi?r, food consumption behavi?r	
Boolean operators	AND OR NOT		
Field code	[TW]/[TI]/[AB]		

Searching in published databases

Data-base	Search	**Results**
Pubmed	(("mobile health application"[All Fields] OR "mobile app*"[All Fields] OR "smartphone application*"[All Fields] OR "smartphone app*"[All Fields] OR "app"[All Fields] OR "application*"[All Fields]) AND ("diet*"[All Fields] OR "nutrition*"[All Fields] OR ("eating"[MeSH Terms] OR "eating"[All Fields]) OR "eating habit*"[All Fields] OR ("food"[MeSH Terms] OR "food"[All Fields]) OR "dietary modification*"[All Fields] OR "dietary intake"[All Fields] OR ("mediterranean"[All Fields] OR "mediterraneans"[All Fields])) AND ("coronary artery disease"[All Fields] OR "coronary heart disease"[All Fields] OR "myocardial infarction"[All Fields] OR "heart attack"[All Fields] OR "ischemic heart disease"[All Fields] OR "chronic coronary syndrome"[All Fields] OR "atherosclerosis"[All Fields] OR "left main disease"[All Fields])) AND ((y_10[Filter]) AND (clinicaltrial[Filter] OR randomizedcontrolledtrial[Filter]))	**19**
MEDLINE with Full Text	(("mobile health application" OR "mobile app*" OR "smartphone application*" OR "smartphone app*" OR app* OR application*)) AND ((diet* OR nutrition* OR eating OR "eating habit*" OR food OR "dietary behavi?r" OR "dietary modification*" OR "food consumption behavi?r" OR mediterranean)) AND (("coronary artery disease" OR "coronary heart disease" OR "myocardial infarction" OR "heart attack" OR "ischemic heart disease" OR "chronic coronary syndrome" OR "atherosclerosis" OR "left main disease")) Limiters - Full Text; Published Date: 20120101-20211231; Randomized Controlled Trials; Controlled Clinical Trials Expanders - Apply equivalent subjects Search modes - Boolean/Phrase	**1,207**
	AB (("mobile health application" OR "mobile app*" OR "smartphone application*" OR "smartphone app*" OR app* OR application*)) AND ((diet* OR nutrition* OR eating	**658**

Data-base	Search	**Results**
	OR "eating habit*" OR food OR "dietary behavi?r" OR "dietary modification*" OR "food consumption behavi?r" OR mediterranean)) AND (("coronary artery disease" OR "coronary heart disease" OR "myocardial infarction" OR "heart attack" OR "ischemic heart disease" OR "chronic coronary syndrome" OR "atherosclerosis" OR "left main disease")) Show Less Limiters - Full Text; Published Date: 20120101-20211231 Expanders - Apply equivalent subjects Search modes - Boolean/Phrase	
	TI (("mobile health application" OR "mobile app*" OR "smartphone application*" OR "smartphone app*" OR app* OR application*)) AND ((diet* OR nutrition* OR eating OR "eating habit*" OR food OR "dietary behavi?r" OR "dietary modification*" OR "food consumption behavi?r" OR mediterranean)) AND (("coronary artery disease" OR "coronary heart disease" OR "myocardial infarction" OR "heart attack" OR "ischemic heart disease" OR "chronic coronary syndrome" OR "atherosclerosis" OR "left main disease")) Show Less Limiters - Published Date: 20120101-20211231 Expanders - Apply equivalent subjects Search modes - Boolean/Phrase	**18**
CINAHL Complete	(("mobile health application" OR "mobile app*" OR "smartphone application*" OR "smartphone app*" OR app* OR application*)) AND ((diet* OR nutrition* OR eating OR "eating habit*" OR food OR "dietary behavi?r" OR "dietary modification*" OR "food consumption behavi?r" OR mediterranean)) AND (("coronary artery disease" OR "coronary heart disease" OR "myocardial infarction" OR "heart attack" OR "ischemic heart disease" OR "chronic	**347**

Data-base	Search	**Results**
	coronary syndrome" OR "atherosclerosis" OR "left main disease")) Limiters - Full Text; Published Date: 20120101-20211231; Randomized Controlled Trials; Controlled Clinical Trials Expanders - Apply equivalent subjects Search modes - Boolean/Phrase	
	AB (("mobile health application" OR "mobile app*" OR "smartphone application*" OR "smartphone app*" OR app* OR application*)) AND ((diet* OR nutrition* OR eating OR "eating habit*" OR food OR "dietary behavi?r" OR "dietary modification*" OR "food consumption behavi?r" OR mediterranean)) AND (("coronary artery disease" OR "coronary heart disease" OR "myocardial infarction" OR "heart attack" OR "ischemic heart disease" OR "chronic coronary syndrome" OR "atherosclerosis" OR "left main disease")) Limiters - Full Text; Published Date: 20120101-20211231 Expanders - Apply equivalent subjects Search modes - Boolean/Phrase	**238**
	AB (mhealth OR mobile health OR m-health OR mobile app OR mobile application OR smartphone application OR app*) AND AB (diet OR food OR eat) AND AB ("coronary artery disease" OR "coronary heart disease" OR "myocardial infarction")	**88**
Cochrane central register of	AB (("mobile health application" OR "mobile app*" OR "smartphone application*" OR "smartphone app*" OR app* OR application*)) AND ((diet* OR nutrition* OR eating OR "eating habit*" OR food OR "dietary behavi?r" OR "dietary modification*" OR "food consumption behavi?r"	**49**

Data-base	Search	**Results**
controlled trials	OR mediterranean)) AND (("coronary artery disease" OR "coronary heart disease" OR "myocardial infarction" OR "heart attack" OR "ischemic heart disease" OR "chronic coronary syndrome" OR "atherosclerosis" OR "left main disease")) Limiters - Full Text; Published Date: 20120101-20211231 Expanders - Apply equivalent subjects Search modes - Boolean/Phrase	
	TI (("mobile health application" OR "mobile app*" OR "smartphone application*" OR "smartphone app*" OR app* OR application*)) AND ((diet* OR nutrition* OR eating OR "eating habit*" OR food OR "dietary behavi?r" OR "dietary modification*" OR "food consumption behavi?r" OR mediterranean)) AND (("coronary artery disease" OR "coronary heart disease" OR "myocardial infarction" OR "heart attack" OR "ischemic heart disease" OR "chronic coronary syndrome" OR "atherosclerosis" OR "left main disease")) Limiters - Published Date: 20120101-20211231 Expanders - Apply equivalent subjects Search modes - Boolean/Phrase	**10**
Proquest	("mobile health application" OR ("mobile app" OR "mobile application" OR "mobile applications" OR "mobile apps") OR ("smartphone application" OR "smartphone applications") OR ("smartphone app" OR "smartphone application" OR "smartphone applications" OR "smartphone apps") OR app* OR application*)) AND ((diet* OR nutrition* OR eating OR ("eating habit" OR "eating habits") OR food OR "dietary behavi?r" OR ("dietary modification" OR "dietary modifications") OR "food consumption behavi?r" OR mediterranean)) AND (("coronary artery disease" OR "coronary heart disease" OR	**4,852,325**

Data-base	Search	**Results**
	"myocardial infarction" OR "heart attack" OR "ischemic heart disease" OR "chronic coronary syndrome" OR "atherosclerosis" OR "left main disease") Limit 2012-2022	
	("mobile health application" OR "mobile app*" OR "smartphone application*" OR "smartphone app*" OR app* OR application*) AND (diet* OR nutrition* OR eating OR "eating habit*" OR food OR "dietary behavi?r" OR "dietary modification*" OR "food consumption behavi?r" OR mediterranean) AND ("coronary artery disease" OR "coronary heart disease" OR "myocardial infarction" OR "heart attack" OR "ischemic heart disease" OR "chronic coronary syndrome" OR "atherosclerosis" OR "left main disease") NOT ("systematic review" OR protocol) AND (randomized OR effect) Limit 2012-2022	**51,450**
	("mobile health application" OR "mobile app*" OR "smartphone application*" OR "smartphone app*" OR app* OR application*) AND (diet* OR nutrition* OR eating OR "eating habit*" OR food OR "dietary behavi?r" OR "dietary modification*" OR "food consumption behavi?r" OR mediterranean) AND ("coronary artery disease" OR "coronary heart disease" OR "myocardial infarction" OR "heart attack" OR "ischemic heart disease" OR "chronic coronary syndrome" OR "atherosclerosis" OR "left main disease") NOT ("systematic review" OR protocol) AND (randomized OR effect) Limit: 2012-2022, cardiovascular	**11,218**
	ti(("mobile health application" OR "mobile app*" OR "smartphone application*" OR "smartphone app*" OR app* OR application*)) AND ab((diet* OR nutrition* OR eating	**17**

Data-base	Search	**Results**
	OR "eating habit*" OR food OR "dietary behavi?r" OR "dietary modification*" OR "food consumption behavi?r" OR mediterranean)) AND ti(("coronary artery disease" OR "coronary heart disease" OR "myocardial infarction" OR "heart attack" OR "ischemic heart disease" OR "chronic coronary syndrome" OR "atherosclerosis" OR "left main disease")) NOT ti("systematic review" OR protocol) AND ti(randomized OR effect) Limit: 2012-2022, cardiovascular	
	ab(("mobile health application" OR "mobile app*" OR "smartphone application*" OR "smartphone app*" OR app* OR application*)) AND ab((diet* OR nutrition* OR eating OR "eating habit*" OR food OR "dietary behavi?r" OR "dietary modification*" OR "food consumption behavi?r" OR mediterranean)) AND ab(("coronary artery disease" OR "coronary heart disease" OR "myocardial infarction" OR "heart attack" OR "ischemic heart disease" OR "chronic coronary syndrome" OR "atherosclerosis" OR "left main disease")) AND ti((randomized OR randomised OR quasi)) NOT ti((systematic review) OR protocol)	**19**
Clinicalkey nursing	(mHealth OR app OR mobile) AND (diet OR food) AND (coronary artery disease OR coronary heart disease OR myocardial infarction)	**7**
Thaijo	แอพพลิเคชั่น อาหาร	**29**
	แอพพลิเคชั่น หัวใจ	**7**
Sciencedirect	(“mobile health application” OR “smartphone application”) AND (“coronary artery disease” OR “coronary heart disease” OR “myocardial infarction”) AND (diet OR food OR eat) AND randomized controlled trial Limit: 2012-2022, Nursing and Health Professions	**28**
	(“mHealth” OR “smartphone application”) AND (“coronary artery disease” OR “coronary heart disease” OR	**69**

Data-base	Search	**Results**
	“myocardial infarction”) AND (diet OR food) AND (“randomized controlled trial” OR quasi) NOT “systematic review”	
Scopus	(mhealth OR "mobile health application" OR app) AND (diet* OR eat OR food) AND ("coronary artery disease" OR "coronary heart disease" OR "myocardial infarction")	**29**
Embase	(mhealth OR 'mobile health application' OR app) AND (diet* OR eat OR food) AND ('coronary artery disease' OR 'coronary heart disease' OR 'myocardial infarction') AND ('randomized controlled trial' OR 'quasi experimental study') AND [2012-2022]/py	**20**
Oxford Academic	(mhealth OR "mobile health application" OR app) AND (diet* OR eat OR food) AND ("coronary artery disease" OR "coronary heart disease" OR "myocardial infarction") AND (randomized OR quasi)	**0**
Springer	'(mhealth OR "mobile health application" OR app) AND (diet* OR eat OR food) AND ("coronary artery disease" OR "coronary heart disease" OR "myocardial infarction") AND (randomized OR quasi)' **within Cardiology and Article and 2012 - 2022**	**118**
BMJ Journals	**"(mhealth OR "mobile health application" OR app) AND (diet* OR eat OR food) AND ("coronary artery disease" OR "coronary heart" and published between "01 Jan, 2012 and 06 Jun, 2022"**	**0**
Wiley online libraly	**(mHealth+OR+"mobile+health+application"+OR+"smartphone+application"+OR+app)" anywhere and "(diet* OR food OR eat*)" anywhere and "("coronary**	**96**

Data-base	Search	**Results**
	artery disease" OR "coronary heart disease" OR "myocardial infarction")" anywhere and "(randomized OR quasi)" anywhere	

Searching in unpublished databases

Sources	**Search**	**Results**
Thailist (included all articles/ proceeding/e-book/rare book/archive/research report/thesis/article)	**แอพพลิเคชั่น อาหาร**	**0**
	แอพพลิเคชั่น	**708**
	กล้ามเนื้อหัวใจขาดเลือด	**80**
OVID	((mobile health application or mHealth or app) and (diet* or food or eat) and ("coronary artery disease" or "coronary heart disease" or "myocardial infarction")).mp. [mp=title, abstract, full text, caption text]	**286**

Searching in grey literature

Sources	Search	**Results**
Google scholar	(("mobile health application" OR "mobile app*" OR "smartphone application*" OR "smartphone app*" OR app* OR application*) AND (diet* OR nutrition* OR eating OR "eating habit*" OR food OR "dietary behavi?r" OR "dietary modification*" OR "food consumption behavi?r" OR mediterranean) AND (clinicaltrial[Filter] OR randomizedcontrolledtrial[Filter])) AND (("coronary artery disease" OR "coronary heart disease" OR "myocardial infarction" OR "heart attack" OR "ischemic heart disease" OR "chronic coronary syndrome" OR "atherosclerosis" OR "left main disease")	**19,700**
	"mobile health application" OR "smartphone application" OR "coronary artery disease" OR "coronary heart disease" OR "myocardial infarction" OR "diet*" OR "food" OR "eat*" "randomized controlled trial" -systematic -and -protocol	**53**

Mesh Term Searching

Syntax	**MesH terms**	**Results**
#1	• **Coronary Disease** • **Coronary Diseases** • **Disease, Coronary** • **Diseases, Coronary** • **Coronary Heart Disease** • **Coronary Heart Diseases** • **Disease, Coronary Heart** • **Diseases, Coronary Heart** • **Heart Disease, Coronary** • **Heart Diseases, Coronary**	3,400

Syntax	MesH terms	Results
	Search: "Coronary Artery Disease"[Mesh] **Filters:** Clinical Trial, Randomized Controlled Trial, from 2012 - 2022 **Sort by:** Most Recent	
#2	• Application, Mobile • Applications, Mobile • Mobile Application • Mobile Apps • App, Mobile • Apps, Mobile • Mobile App • Portable Software Apps • App, Portable Software • Portable Software App • Software App, Portable • Portable Software Applications • Application, Portable Software • Portable Software Application • Software Application, Portable • Mobile health Apps • App, Mobile health • Apps, Mobile health • Mobile health App • Portable Electronic Apps • App, Portable Electronic • Electronic App, Portable • Portable Electronic App • Portable Electronic Applications • Application, Portable Electronic • Electronic Application, Portable • Portable Electronic Application Search: **"Mobile Applications"[Mesh]** Filters: **Clinical Trial, Randomized Controlled Trial** Sort by: **Most Recent**	1,204
#3	• Diet, Mediterranean • Diets, Mediterranean • Mediterranean Diets • Diet Therapies • Therapy, Diet	550

Syntax	MesH terms	Results
	• Diet Therapy, Restrictive • Restrictive Diet Therapies • Therapy, Restrictive Diet • Restrictive Diet Therapy • Restriction Diet Therapies • Diet Therapies, Restriction • Diet Therapy, Restriction • Therapy, Restriction Diet • Restriction Diet Therapy • Dietary Restriction • Dietary Restrictions • Restriction, Dietary • Dietary Modification • Dietary Modifications • Modification, Dietary • Diet Modification • Diet Modifications • Modification, Diet Search: "Diet, Mediterranean"[Mesh] Filters: Clinical Trial, Randomized Controlled Trial, from 2012 - 2022 Sort by: Most Recent	
#1 AND #2 AND #3	(("Mobile Applications"[Mesh] AND (clinicaltrial[Filter] OR randomizedcontrolledtrial[Filter])) AND ("Diet, Mediterranean"[Mesh] AND ((clinicaltrial[Filter] OR randomizedcontrolledtrial[Filter]) AND (2012:2022[pdat])))) AND ("Coronary Artery Disease"[Mesh] AND ((clinicaltrial[Filter] OR randomizedcontrolledtrial[Filter]) AND (2012:2022[pdat])))	0

Appendix E: Inclusion Criteria Form

Inclusion criteria

1. ***Population***:

Adult patients (18 years or older) who were diagnosed with CHD.

☐ yes ☐ no

2. **Intervention:**

Mobile health application used for improving dietary behaviors. Intervention included mobile health application that uses smartphone, tablets, and computer or software installed on electronic devices which can deliver health services and information using the internet and related technologies, such as self-monitoring by taking a picture of their food or checking mark in a checklist for recording their behaviors, motivating patient by automatic message reminders about healthy habits, and supporting patients. The interventions that include only telephone follow-up or text messaging (SMS message) will be excluded.

☐ yes ☐ no

3. **Comparator:**

Routine care/ no mobile health intervention.

☐ yes ☐ no

4. **Outcomes:**

Primary outcome: dietary behaviors.

☐ yes ☐ no

The secondary outcomes: BMI or LDL-cholesterol level or total cholesterol or blood pressure.

☐ yes ☐ no

5. **Types of studies:**

Any experimental study design: randomized controlled trials, quasi-experimental.

☐ yes ☐ no

6. **Year of publication:**

The published and unpublished studies from the year 2011 to 2021.

☐ yes ☐ no

7. **Language:**

Thai or English

☐ yes ☐ no

Include in the review ☐ yes ☐ no

Appendix F: JBI Critical Appraisal Checklist for Randomized control trial

JBI Critical Appraisal Checklist for Randomized Controlled Trials

Reviewer_____Date_____

Author _____Year_____Record Number_____

		Yes	No	Unclear	NA
1.	Was true randomization used for assignment of participants to treatment groups?	☐	☐	☐	☐
2.	Was allocation to treatment groups concealed?	☐	☐	☐	☐
3.	Were treatment groups similar at the baseline?	☐	☐	☐	☐
4.	Were participants blind to treatment assignment?	☐	☐	☐	☐
5.	Were those delivering treatment blind to treatment assignment?	☐	☐	☐	☐
6.	Were outcomes assessors blind to treatment assignment?	☐	☐	☐	☐
7.	Were treatment groups treated identically other than the intervention of interest?	☐	☐	☐	☐
8.	Was follow up complete and if not, were differences between groups in terms of their follow up adequately described and analyzed?	☐	☐	☐	☐
9.	Were participants analyzed in the groups to which they were randomized?	☐	☐	☐	☐
10.	Were outcomes measured in the same way for treatment groups?	☐	☐	☐	☐
11.	Were outcomes measured in a reliable way?	☐	☐	☐	☐
12.	Was appropriate statistical analysis used?	☐	☐	☐	☐
13.	Was the trial design appropriate, and any deviations from the standard RCT design (individual randomization, parallel groups) accounted for in the conduct and analysis of the trial?	☐	☐	☐	☐

Overall appraisal: Include ☐ Exclude ☐ Seek further info ☐

Comments (Including reason for exclusion)

_____

_____

_____

Appendix G: JBI Critical Appraisal Checklist for Quasi-Experimental Studies

JBI Critical Appraisal Checklist for Quasi-Experimental Studies (non-randomized experimental studies)

Reviewer_____Date_____.

Author _____Year_____Record Number_____.

	Yes	No	Unclear	Not applicable
1. Is it clear in the study what is the 'cause' and what is the 'effect' (i.e. there is no confusion about which variable comes first)?	☐	☐	☐	☐
2. Were the participants included in any comparisons similar?	☐	☐	☐	☐
3. Were the participants included in any comparisons receiving similar treatment/care, other than the exposure or intervention of interest?	☐	☐	☐	☐
4. Was there a control group?	☐	☐	☐	☐
5. Were there multiple measurements of the outcome both pre and post the intervention/exposure?	☐	☐	☐	☐
6. Was follow up complete and if not, were differences between groups in terms of their follow up adequately described and analyzed?	☐	☐	☐	☐
7. Were the outcomes of participants included in any comparisons measured in the same way?	☐	☐	☐	☐
8. Were outcomes measured in a reliable way?	☐	☐	☐	☐
9. Was appropriate statistical analysis used?	☐	☐	☐	☐

Overall appraisal: Include ☐ Exclude ☐ Seek further info ☐

Comments (Including reason for exclusion)

_____

_____

_____

Appendix H: JBI Data Extraction Form

Data Extraction Form

Title: .....

Author: .....

Study method: .....

Country: .....

Setting: .....

Participant characteristics: .....

Groups description and sample: .....

Clinical outcome measure

Outcome description	Scale/measure

Study results

(a) Dichotomous data

Outcome	Intervention group (number/total number)	Control group (number/total number)

(b) Continuous data

Outcome	Intervention group (number/total number)	Control group (number/total number)

Authors' conclusions: .....

.....

.....

Comments: .....

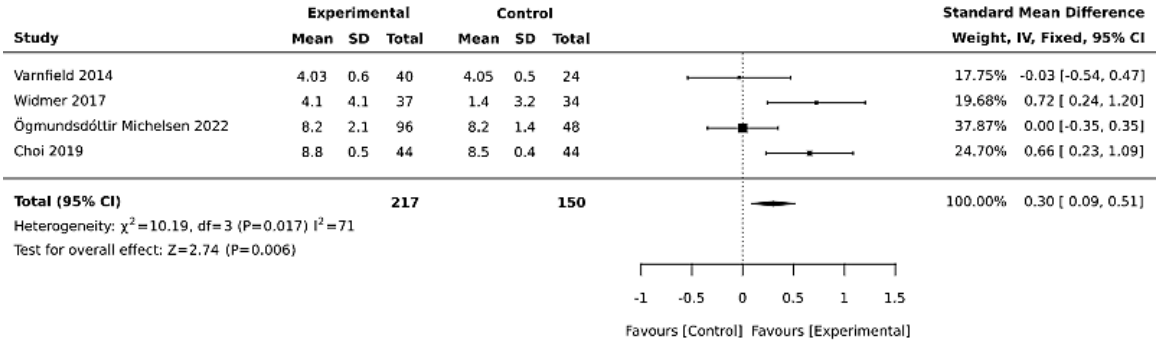
.....

.....

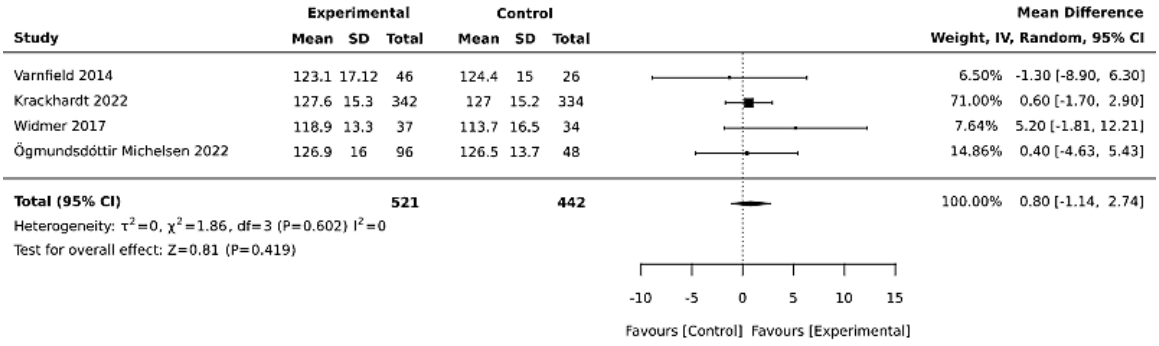
Appendix I : Sensitivity Analysis

Dietary behavior

Fixed model



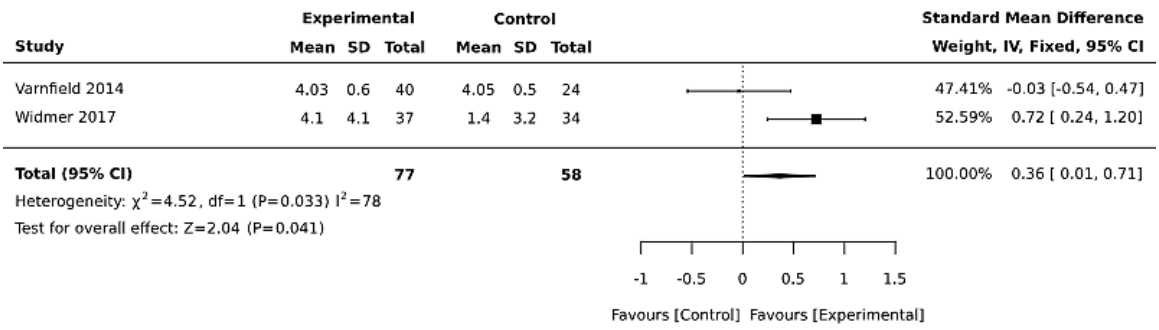
Random model



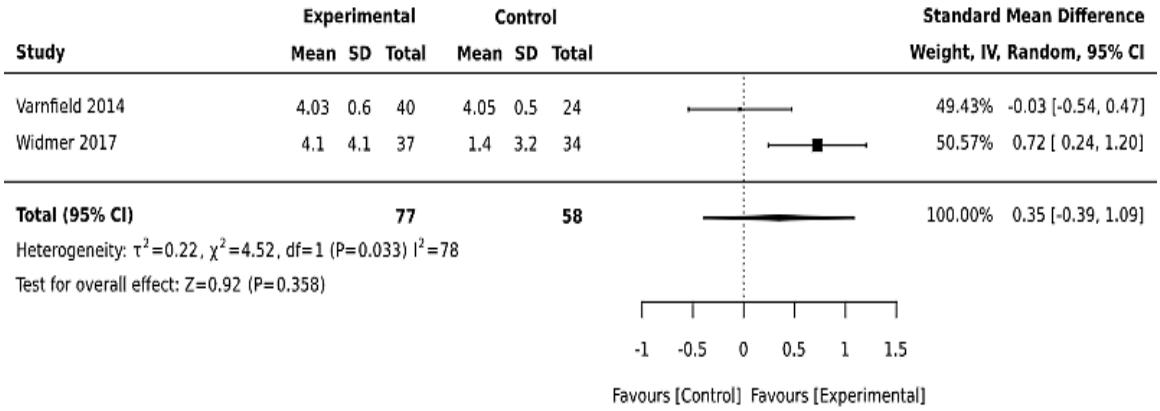
Subgroup- analysis

1. Dietary behaviors 1-3 months

Fixed model

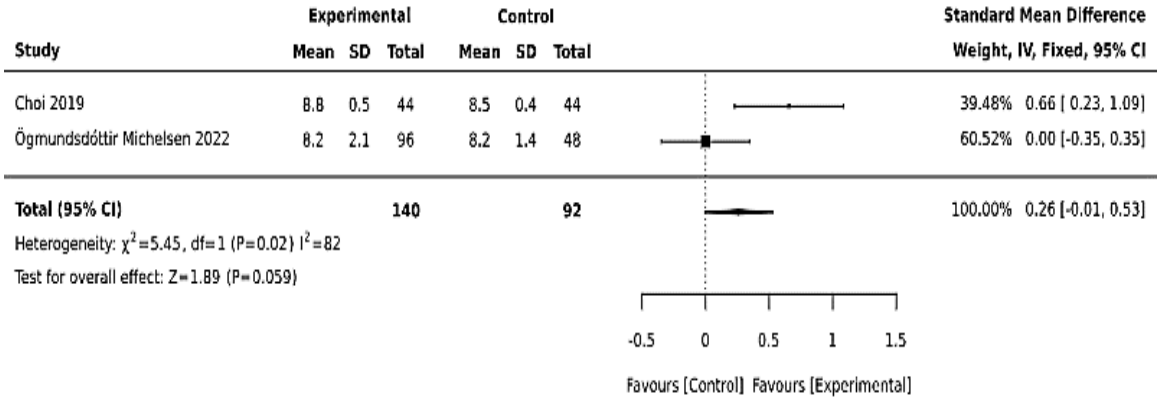


Random model

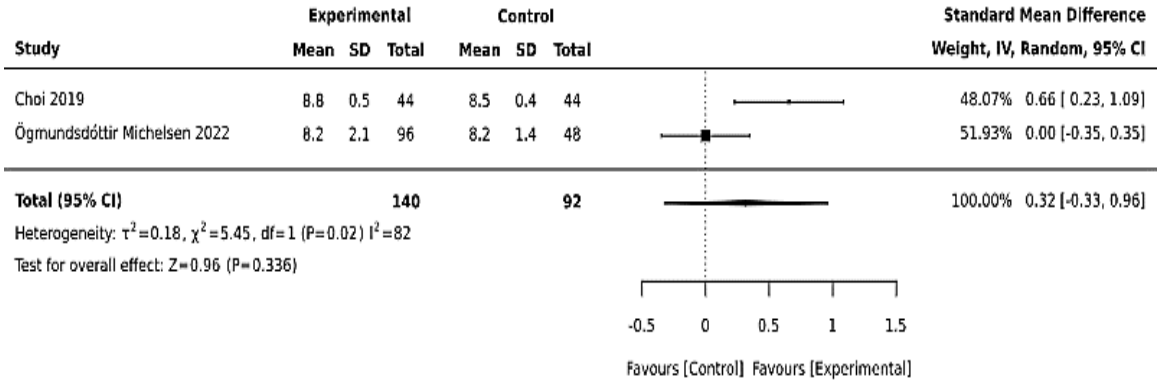


2. Dietary behaviors 6-12 months

Fixed model

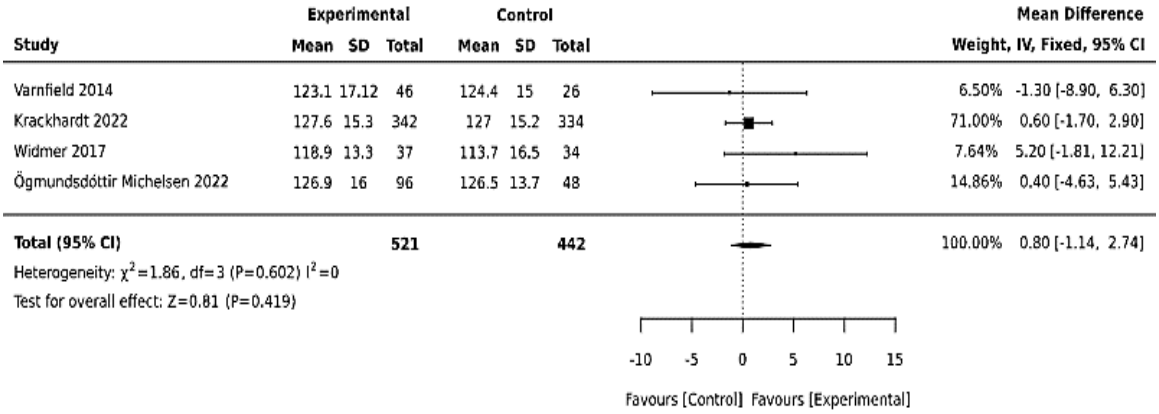


Random model

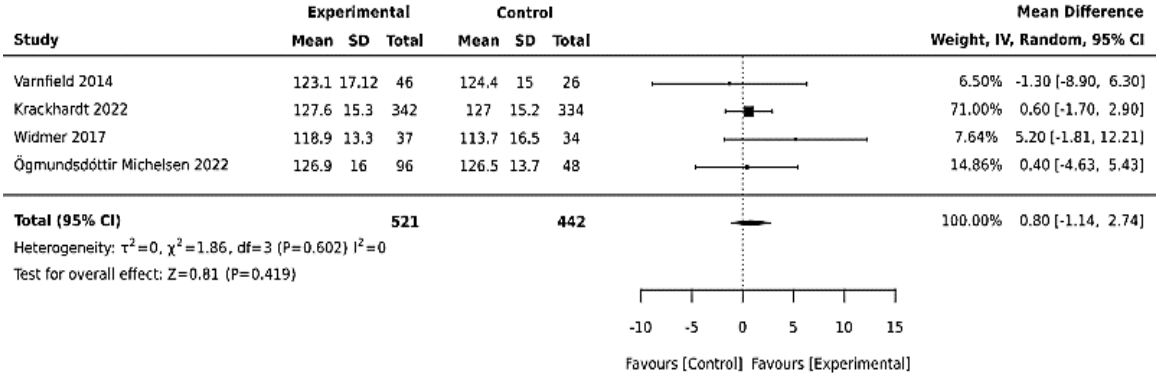


Systolic Blood Pressure

Fixed model

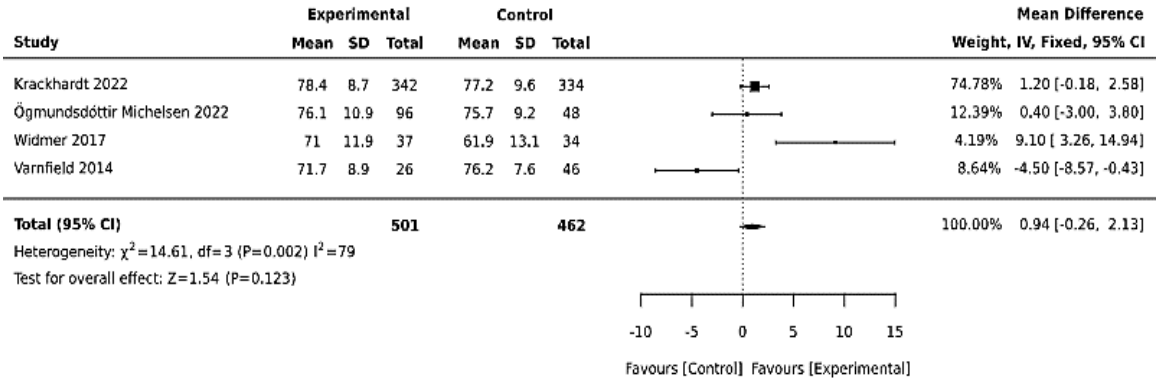


Random model

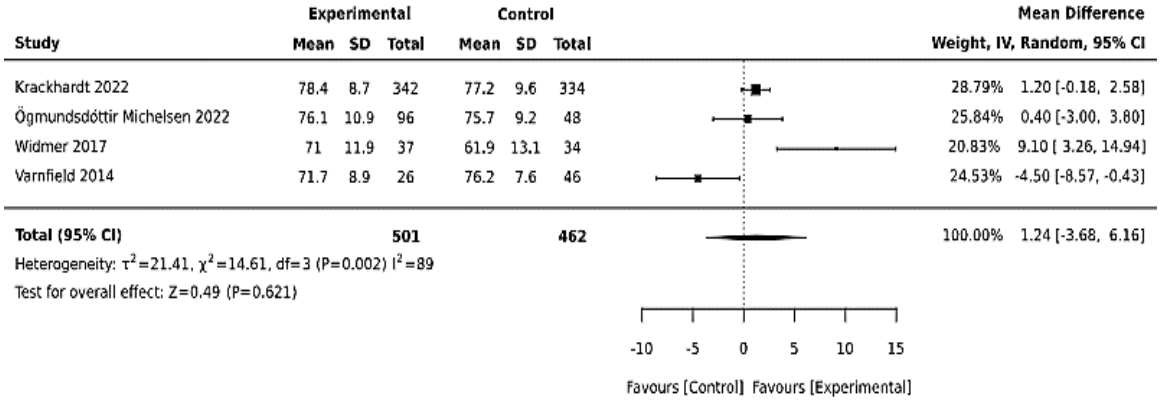


Diastolic Blood pressure

Fixed model

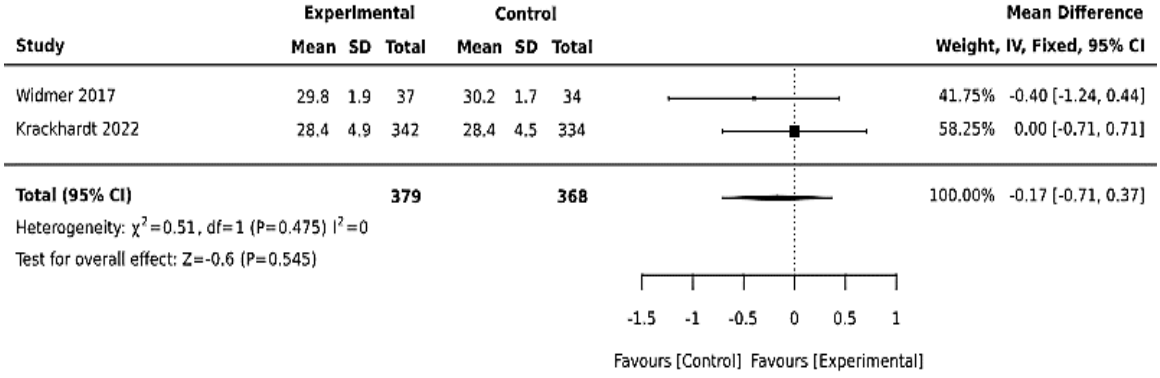


Random model

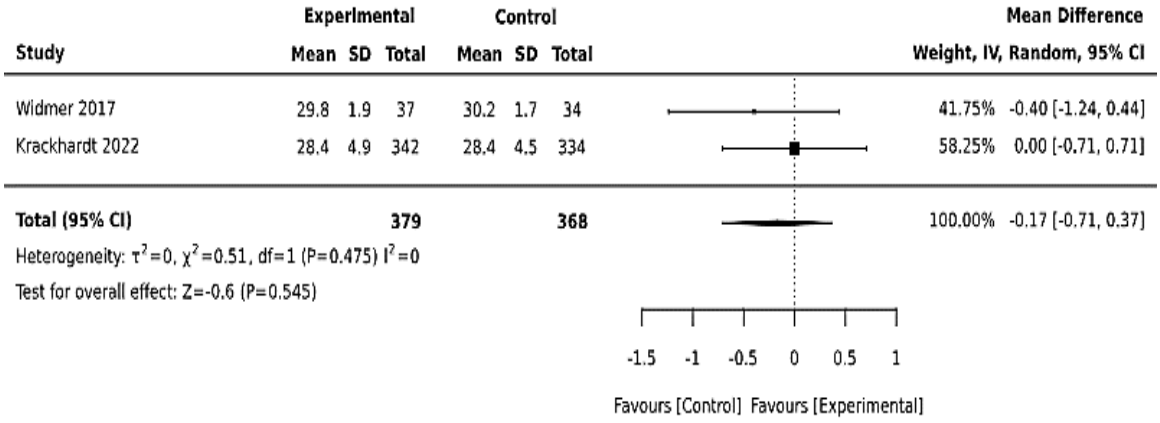


BMI

Fixed model

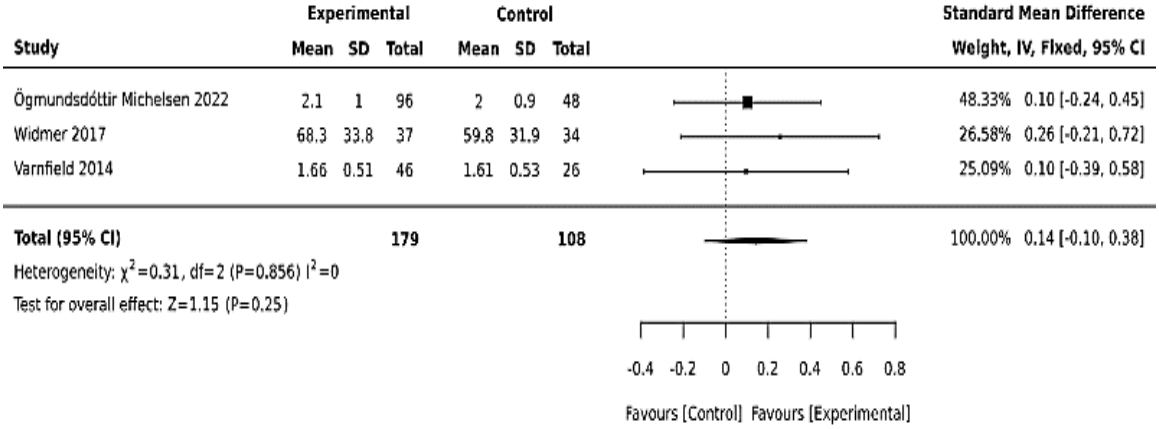


Random model

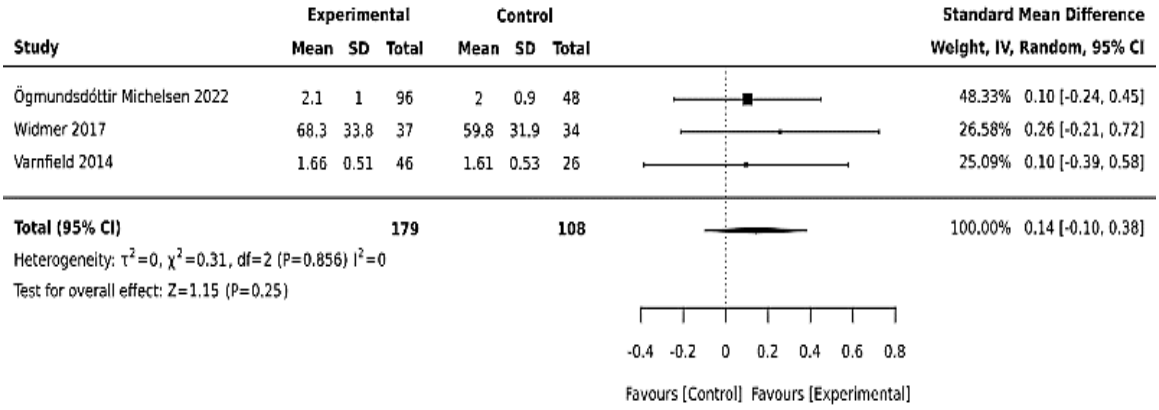


LDL- cholesterol level

Fixed model

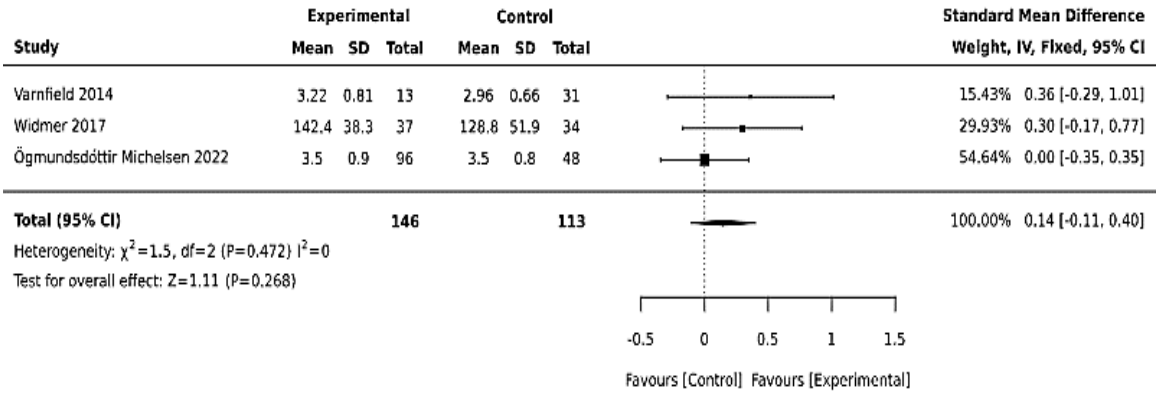


Random model

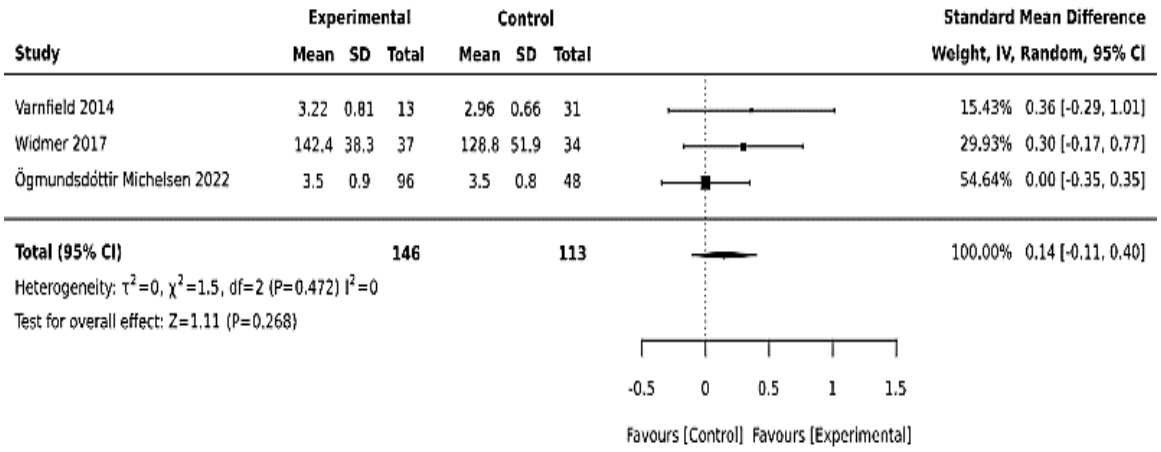


Total cholesterol level

Fixed model



Random model



Appendix J: Extract Data Table

Extract data table

Citation/ title	Country	Design /Time	Mean age/ gender	Participants	Intervention	Control	Tools	Result	Conclusion
Choi et. Al. 2019 **Image-Based Mobile System for Dietary Management in an American Cardiology Population: Pilot Randomized Controlled Trial to Assess the Efficacy of Dietary Coaching Delivered via a Smartphone App Versus Traditional Counseling**	USA	RCT/ 6 months	SOC:56.6 (1.7) EXP: 57.2(1.8) Male S:32(65.3) E:29(56.9)	N=100 Int = 51 Con =49	a custom smartphone app that reinforced the Mediterranean diet (n=51) The app included weekly challenges to encourage dietary modification, and either the RD or the patient could initiate contact through the app. Participants were encouraged to use the app to take pictures of their food, document meals and amounts	Participants in the control group received 2 additional sessions of in-person dietary counseling with the registered dietitian—30 min at 1 month and 30 min at 3 months (n=49)	Mediterranean Diet Score (MDS) The MDS, the 14-point quantitative score of adherence to the Mediterranean diet Baseline height, weight, blood pressure (BP), and laboratory biomarkers were collected. At 1, 3, and 6 months (Standard laboratory blood test)	There were no significant differences between EXP and SOC with regard to BP, lipid parameters, hemoglobin A1c, or C-reactive protein (CRP). Participants in EXP achieved a significantly greater weight loss on average of 3.3 pounds versus 3.1 pounds for participants in SOC, P=.04. Adherence to the Mediterranean diet increased significantly over time for both groups (P<.001), but there was no significant difference	Both traditional SOC counseling and smartphone-based counseling were effective in getting participants to adhere to a Mediterranean diet, and these dietary changes persisted even after counseling had ended. However, neither method was more effective than the other. This pilot study demonstrates that patients can change to and maintain a Mediterranean diet with either traditional or smartphone app-based nutrition counseling.

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					consumed, ask questions to the RD, document exercise, and monitor their BP and track it in the log if another provider recommended that it be recorded. The challenges were for patients to challenge themselves (i.e., they did not compete against other participants). Examples of challenges included increasing daily servings of vegetables or exercising daily. Additional face-to-face counseling was not offered by the RD. The allotted time that			between groups (P=.69). Similarly, there was no significant difference in diet satisfaction between EXP and SOC, although diet satisfaction increased significantly over time for both groups. The proportion of participants with high Mediterranean diet compliance (defined as the MDS ≥9) increased significantly over time (P<.001)—from 18.4% to 57.1% for SOC and 27.5% to 64.7% for EXP; however, there was no significant difference	

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					was not used in the first 3 months could be used after 3 months, but no counseling was provided after 6 months. If the participants used all of their allotted time, they could continue to initiate contact with their RD through traditional means (e.g., by telephone).			between the groups.	
Krackhardt et al., 2022 **Results from the "Me & My Heart" (eMocial) Study: a Randomized Evaluation of a New Smartphone-Based Support Tool**	Germany	RCT 12 months	Con:56 Int: 56.6 Male 86.5 83%	Patients N = 676 Con: = 334 Int: = 342	Patients in the active group active group (with support tool app for medication intake reminders and motivational messages) used the support tool app to enter	a control group (without support tool app), and observed for 48 weeks	Lifestyle Change Questionnaire (LSQ) It comprises questions on adherence to a healthy diet, a patient-reported outcome (PRO) about a healthy diet behavior	There were no significant differences in blood pressure and BMI between visits. General improvements in SF-36 and LSQ scores were	The patient support tool app was associated with significant improvements in patient-reported treatment adherence compared with a data collection app alone in patients prescribed ticagrelor for ACS.

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to Increase Therapy Adherence of Patients with Acute Coronary Syndrome					baseline information and additional data on an ongoing basis and received individualized feedback including optional daily reminders for medication intake and motivational and informative messages every few days (Supplementary Table 1). Qualitative information on cardiovascular risks in relation to lifestyle choices was displayed graphically throughout the study. Patients in both study groups received self-reporting		(Dichotomous data) assessed every 4 weeks Standard laboratory blood test	observed for both groups. Agreed or partially agreed to a healthy diet Con1 = 266 Int2 n = 124 n Con1 = 240 n Con2= 101 Int1=85.7 % Con1=89.2 % Int2=91.9 % Con2=82.2 % Visit 1: p* = 0.243 Visit 2: p* = 0.027	

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					questionnaires via their apps every 4 weeks to evaluate stud y endpoints.				
Varnfield et al., 2014 **Smartphone-based home care model improved use of cardiac rehabilitation in post-myocardial infarction patients: results from a randomized controlled trial**	Australia	RCT 1.5 month	Mean age con: 55.7±10.4 int: 55.5±9.6 years Male Con: 82% Int: 85%	N=120 Con: n=60 Int: n=60 For DHQ Con: n=24 Int =40	The Care Assessment Platform Cardiac Rehabilitation (CAP-CR) program was developed according to national guidelines to address all components of a comprehensive CR program. The CAP-CR platform used a smartphone for health and exercise monitoring, and delivery of motivational and educational materials to participants via text messages	a traditional, center-based program (TCR) in post-MI patients. The TCR program comprised of two supervised exercise and 1 h educational sessions on a weekly basis for 6 weeks at one of four Health Service District community centers. Participants started education sessions once enrolled to CR and twice-weekly exercise sessions commenced once center appointments became available.	Dietary Habits Questionnaire (DHQ) were calculated by the summation of intake of Fat Fiber Sodium Alcohol Clinical assessments (BP,BMI) and pathology testing. Pathology testing included a lipid profile. Baseline, 6 weeks, 6 months	Con: Int: Mean diff Fat 0.29* 0.15* Fiber 0.26* 0.31* Sodium 0.27* 0.32* Alcohol 0.17 0.33 *พบว่ากลุ่มที่ใช้ CAP-CR มีพฤติกรรมการรับประทาน fat น้อยลง และรับประทานผักมากขึ้น แต่ก็ทานโซเดียมเพิ่มขึ้นด้วย ในภาพรวมคือไม่ต่างกันระหว่างกลุ่มที่ใช้	This smartphone-based home care CR program improved post-MI CR uptake, adherence and completion. The home-based CR program was as effective in improving physiological and psychological health outcomes as traditional CR. CAP-CR is a viable option towards optimizing use of CR services

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					and preinstalled audio and video files (including understanding cardiovascular disease (CVD), symptoms and management). The platform included a web portal with participant data for mentors to provide weekly consultations.	Participants followed an individualized, supervised, circuit-based exercise program of light to moderate intensity according to Borg's scale. The program included cardiovascular and strengthening routines involving, for example, treadmill, rower, resistance bands, weights, squats and modified push-ups		smartphone กับ กลุ่ม traditional ควบคุมความดันโลหิตได้อยู่ในช่วงปกติทั้งสองกลุ่ม กลุ่มทดลองลด นน.ได้แตกต่างกันไม่เยอะ ลดไขมันได้ทั้งสองกลุ่มแตกต่างกันไม่เยอะ	
Manzoor et al., 2021 **Effectiveness of Mobile Health Augmented**	Pakistan	RCT 6 months	52.67(8.47) Males N=126 78.80%	N=160 Con:int n=80:80	the intervention group received the MCard intervention, a medically monitored cardiac rehabilitation	(no intervention) (standard post-ACS care	Healthy eating assessment questionnaire (HEQ)	Diet counselling increased adherence to proper diet, as shown by the increase in HEQ scores at 12 and	The MCard positively impacts the post-ACS participants' behaviors in terms of physical activity, healthy eating, and salt restriction. MCard evidenced as a

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Cardiac Rehabilitation on Behavioral Outcomes among Post-acute Coronary Syndrome Patients: A Randomized Controlled Trial					program. During the hospital stay, the first phase of the MCard included individualized counselling. The second phase included diurnal mobile texting of standardized messages about healthy lifestyle changes, using a specially created app.		Dietary assessment scores were calculated by using HEQ. Diet scores were calculated by the summation of intake of fruits, vegetables, fried foods, snacks, sugar, milk products, and meat as reported by the participants. HEQ comprises ten items and scoring ranges from values of 10-50; categories are fair (20-29), good (30-39), and excellent (40-50). (Dichotomous data) Data	24 weeks follow-up. Subjective assessment of healthy diet preference also showed marked improvement.	feasible intervention in terms of having lasting behavior modification among this vulnerable patient population

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							were collected at baseline 12 weeks follow-up and at 24 weeks follow-up.		
Ögmundsdóttir Michelsen et al., 2022 **Effect of a Lifestyle-Focused Web-Based Application on Risk Factor Management in Patients Who Have Had a Myocardial Infarction: Randomized Controlled Trial**	Sweden	RCT 14 months	Con: 60(8.9) Int:61.1 (8.6) Male Con: 73% Int: 84%	N=150 Con 49 Int 101 Diet Con96 Int 48	received access to the application for 25 weeks where information about lifestyle (e.g., diet and physical activity), risk factors (e.g., weight and blood pressure [BP]), and symptoms could be registered. The software provided feedback and lifestyle advice.	Participants in both arms of the study were offered participation in a comprehensive cardiac rehabilitation program at each center	Diet was evaluated using a 4-item questionnaire adapted from the national guidelines for the management of unhealthy lifestyle in the general population. The questions aim to quantify the amount of vegetables, fruit, fish, and sweets consumed. Each question had 4 possible answers, giving 0 to 3 points. The scores for each question were subsequently	A healthy diet index score improved significantly more between baseline and the 2-week follow-up in the intervention group (+2.3 vs +1.4 points; P=.05), mostly owing to an increase in the consumption of fish and fruit	Complementing cardiac rehabilitation with a web-based application improved BP and dietary habits during the first months after myocardial infarction. Although the study group was small, these positive trends support further development of eHealth in cardiac rehabilitation.

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							added, forming the healthy diet index (0-12 points)		
Widmer et al., 2017 **Digital health intervention during cardiac rehabilitation: A randomized control trial**	USA	RCT 3 months	Con: 63.6±10.9 Int: 62.5±10.7 Male Con: 85% Int: 78%	N=80 Con:37 Int: 34	Intervention group was educated on the use of online and smartphone-based CR program within 1 week following enrollment, and entered their metrics (included BMI, BP, diet habits, lipid) DHI reporting of dietary and exercise habits throughout CR as well as educational information toward patients' healthy lifestyles. Instructing the patients on the program use in a	Standard of CR	Diet scores were calculated by summation of daily servings of fruits, vegetables, whole grains, and lean proteins with points taken away for daily serving of saturated fats and sweets.	Our data show an augmented significantly reduction in risk factors including weight loss, BMI, Total cholesterol, LDL shown a non-significant reduction at 3 months Diet scores presented significant increase at 3 months (p=.03)	DHI significantly improves weight loss and might offer a method to reduce CV-related ED visits plus rehospitalization in patients after ACS undergoing CR. The study suggests a role for DHI as an adjunct to CR to improve secondary prevention of CV disease.

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					30-minute session during the first week of CR. Patients were prescribed a standard phase II CR program for 36 session around 12 weeks. Patients could contact the study team or obtain technical support through the online program and inquiries were usually answered within 24 hours.				
Tang et al., 2018 **The effect of mobile messaging apps on cardiac patient knowledge of coronary artery disease risk factors and adherence to a healthy lifestyle**	Malaysia	Quasi-experimental 1 month	59.93 ± 12.39 male 64.9%	N= 104 Con: 47 Int: 47	As for the intervention group, mobile technology intervention was introduced in addition to standard of care. The function of WhatsApp as an information-sharing tool was	For the control group, no information regarding knowledge of CAD risk factors and healthy lifestyle was given to them. Those participants in the control group	Part B consisted of a 29-item questionnaire with nine domains: obesity, cholesterol level, blood glucose level, exercise, stress,	The results of analysis in Table 4 show that for patients' adherence to a healthy lifestyle, the pretest and posttest mean scores for the intervention group were 42.89 and 63.55, which	This study concluded that WhatsApp was an effective health intervention in increasing coronary artery disease patient's knowledge and subsequently

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					explained. They were advised not to share personal information with the group to avoid privacy issues. Throughout the study, the information was shared daily with the group. The participants were encouraged to actively engage in the discussion. Throughout the period, the researcher uploaded information regarding anatomy and physiology of the heart, pathophysiology of CAD, signs and symptoms of CAD, and CAD risk factors, as well as	would receive only the standard of care provided by the hospital.	smoking, diet, heredity and blood pressure. Items 1–18 were intended to test general knowledge of CAD risk factors, while items 19–29 estimated participants' adherence to a healthy lifestyle.	means that there was an increase of 20.66. For the control group, however, the mean scores for the pretest and posttest were 39.66 and 39.68, with a small difference of 0.02 after a 1-month follow-up.	increasing their adherence to healthy lifestyles.

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					knowledge of CAD prevention. All information was taken from the American Heart Association (2017), the Texas Heart Institute (2015) and Clinical Practice Guidelines (2011) from Malaysia. After 1 month, the WhatsApp group was dismissed.				

VITAE

Name Miss Usama Singhasem
Student ID 6310430042
Educational Attainment

Degree	Name of Institution	Year of Graduation
Bachelor in Nursing and Midwifery	Faculty of Nursing, Prince of Songkla University	2019

Scholarship Awards during Enrolment

Scholarship for graduate study supporting from graduate school 2022

Work – Position and Address

Work position: Registered Nurse (Clinical Preceptor), Department of Adult and Elderly Nursing,

Address: Faculty of Nursing, Boromarajonani College of Nursing, Trang, Muang Trang district, Trang province, Thailand, 92000

Email: usama@bcnt.ac.th

List of Publication and Proceeding

Singhasem, P., Tiparat, W. & Singhasem, U. (2021). Geriatric Nursing Competencies among Nursing Students of Boromarajonani College of Nursing, Trang. Thai Journal of Public Health and Health Sciences (TJPHS), 4(2), 33-49.

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