DEVELOPMENT OF
USABLE MOBILE APPLICATION AND
ITS EFFECTIVENESS IN HEALTH PROMOTION
AND EDUCATION ON COLORECTAL CANCER

by

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In the name of ALLAH, the most compassionate and the Most Merciful. Salutations be upon His Messenger Muhammad (peace be upon him), his family and his companions. With the help and success granted by ALLAH, I have finished and completed this dissertation on time. I would like to express my deepest gratitude and thank the following individuals who have contributed and supported me in so many ways in conducting this study:

TABLE OF CONTENTS

APPENDICES

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

LIST OF ABBREVIATIONS

Adj. OR   Adjusted Odds Ratio

AIC   Akaike's Information Criterion

ASR   Age-Standardised Rate

BIC   Bayesian Information Criterion

CRC   Clinical Research Centre

FDA   Food and Drug Administration

GIST   Gastrointestinal Stromal Tumours

HSB   Hospital Sultanah Bahiyah

IARC   International Agency for Research on Cancer

iFOBT   immunochemical Faecal Occult Blood

IPH   Institute for Public Health

JePEM   Jawatankuasa Etika Penyelidikan (Manusia)

KOSPEN   Komuniti Sihat Pembina Negara

MaHTAS   Malaysia Health Technology Assessment Section

MCMC   Malaysia Communication and Multimedia Commission

MOH   Ministry of Health

NHMS   National Health and Morbidity Survey

NCD   Non-Communicable Disease

NCPR-CC   National Cancer Patient Registry – Colorectal Cancer

NGT   Nominal Group Technique

OR   Odds Ratio

RM ANCOVA   Repeated Measure Analysis of Co Variance

ROC   Receiver Operating Characteristic

RR   Relative Risk

SKAMA   Skala Kebolehgunaan Aplikasi Mudah Alih

SD   Standard Deviation

SPSS IBM   Statistical Package for The Social Science

SUS   System Usability Scale

U.S.M   Universiti Sains Malaysia

WHO   World Health Organization

LIST OF SYMBOLS

>	More than
<	Less than
=	Equal to
≥	More than and equal to
≤	Less than and equal to
α	Alpha
β	Beta
%	Percentage
Δ	Precision / Delta
p	*p*-value

ABSTRAK

PEMBANGUNAN APLIKASI MUDAH ALIH BOLEH GUNA DAN KEBERKESANANNYA DALAM PROMOSI DAN PENDIDIKAN KESIHATAN TERHADAP KANSER KOLOREKTAL

Latar belakang: Kadar saringan kanser kolorektal masih rendah dan kurangnya pengetahuan serta kesedaran terhadap penyakit ini merupakan salah satu halangan kepada aktiviti saringan. Dengan kemajuan teknologi hari ini, masyarakat lebih memilih untuk mencari maklumat melalui media yang lebih interaktif seperti aplikasi mudah alih berbanding membaca bahan bercetak seperti risalah. Justeru, aplikasi mudah alih mampu menjadi salah satu kaedah pendidikan dan promosi kesihatan dalam meningkatkan pengetahuan dan sikap masyarakat mengenai kanser kolorektal serta meningkatkan penerimaan saringan dan pengesanan kanser kolorektal.

Objektif: Kajian ini dijalankan dengan 4 objektif iaitu untuk menentukan faktor-faktor yang berkaitan dengan kanser kolorektal di Malaysia, untuk menilai kebolehgunaan aplikasi mudah alih sebagai salah satu kaedah dalam promosi dan pendidikan kesihatan berkaitan kanser kolorektal, dan untuk membandingkan min skor peratusan pengetahuan dan min skor peratusan sikap tentang kanser kolorektal antara kumpulan intervensi dan kawalan dengan pertimbangan aspek masa sebelum dan selepas intervensi.

Metodologi: Kajian ini dijalankan dalam dua fasa. Fasa pertama adalah kajian kes-kawalan menggunakan data daripada *National Cancer Patient Registry - Colorectal Cancer* (NCPR-CC) dan Tinjauan Kesihatan dan Morbiditi Kebangsaan 2015 untuk mencapai objektif pertama. Analisis dilakukan menggunakan kaedah regresi logistik berganda. Dalam fasa kedua, satu aplikasi mudah alih yang dinamakan ColorApp

(Colorectal Cancer Application) telah dibangunkan. Kebolehgunaan serta keberkesanannya telah diuji dalam satu kajian kuasi eksperimen melibatkan 100 peserta dari lokaliti Komuniti Sihat Pembina Negara (KOSPEN) terpilih di daerah Kota Setar sebagai kumpulan intervensi, dan daerah Kuala Muda sebagai kumpulan kawalan. Analisis utama dilakukan berdasarkan kepada niat untuk merawat menggunakan ujian T satu sampel untuk objektif 2 dan Langkah Berulang Analisis Kovarians untuk objektif 3 dan 4.

Keputusan: Mereka yang berumur di antara 50 hingga 70 tahun mempunyai 10.56 kali lebih kemungkinan (95% CI: 8.66, 12.88) dan yang berumur melebihi 70 tahun mempunyai 39.79 kali lebih kemungkinan (95% CI: 31.86, 49.69) untuk mendapat kanser kolorektal berbanding dengan mereka berumur kurang daripada 50 tahun. Perkaitan signifikan juga didapati di kalangan etnik Cina (Adj. OR: 3.51; 95% CI: 3.01, 4.08), perokok (Adj. OR: 2.18; 95% CI: 1.88, 2.52) dan pesakit diabetes (Adj. OR: 1.32; 95% CI: 1.11, 1.56). Min (SD) skor kebolehgunaan ColorApp ialah 72.9(11.52) iaitu lebih tinggi daripada piawaian skor kebolehgunaan 68.0 menunjukkan ia merupakan aplikasi mudah alih yang boleh digunakan. Tiada perbezaan signifikan ditemui pada pengetahuan dan sikap antara kumpulan intervensi dan kawalan sebelum intervensi dijalankan. Kajian ini mendapati terdapat perbezaan signifikan antara min skor pengetahuan antara kumpulan intervensi dan kawalan [F $(1,95) = 19.81$; $p < 0.001$]. Walaubagaimanapun, tiada perbezaan nilai min skor sikap antara kumpulan intervensi dan kawalan [F$(1,95) = 0.36$, $p = 0.550$].

Kesimpulan: Aplikasi mudah alih adalah satu cara untuk promosi dan pendidikan kesihatan, terutamanya dalam pencegahan dan pengesanan awal kanser kolorektal.

KATA KUNCI

Kanser kolorektal, aplikasi mudah alih, kebolehgunaan, keberkesanan, pendidikan kesihatan, promosi kesihatan.

ABSTRACT

DEVELOPMENT OF USABLE MOBILE APPLICATION AND ITS EFFECTIVENESS IN HEALTH PROMOTION AND EDUCATION ON COLORECTAL CANCER

Background: Lack of knowledge and awareness on colorectal cancer is one of the barriers for screening participation. With the advancement of technology today, people's preference of information search has shifted from reading the printed material such as pamphlet to more interactive media such as mobile application. Therefore, a usable mobile application can be one of the methods in health promotion and education to improve the knowledge and attitude on colorectal cancer hence increase the screening and detection of colorectal cancer.

Objectives: The objectives were to determine the factors associated with colorectal cancer in Malaysia, to assess the usability of the mobile application as a method for health promotion and education on colorectal cancer, and to compare the mean percentage score of knowledge and mean percentage score of attitude on colorectal cancer between intervention and control group with consideration of time pre and post intervention.

Methodology: This study was conducted in two phases. Phase one was a case-control study using data from the National Cancer Patient Registry - Colorectal Cancer (NCPR-CC) and National Health and Morbidity Survey (NHMS) 2015 to achieve the first objective. The analysis was done using multiple logistic regression. In phase two, a mobile application named ColorApp (Colorectal Cancer Application) was developed. Its usability and effectiveness were tested in a quasi-experimental study involving 100 participants from selected Komuniti Sihat Pembina Negara (KOSPEN)

localities in Kota Setar district as the intervention group, and Kuala Muda district as the control group to achieve objective 2, 3 and 4. The analysis was conducted using One sample T-test for objective 2 and Repeated Measures Analysis of Covariances (RM ANCOVA) for objective 3 and 4.

Result: People at the age group between 50 to 70 years old have 10.56 times higher odds (95% CI: 8.66, 12.88) and people aged above 70 years old have 39.79 times higher odds to develop colorectal cancer (95% CI: 31.86, 49.69) compared to people less than 50 years old. A significant association also found among Chinese (Adj. OR: 3.51; 95% CI: 3.01, 4.08), smokers (Adj. OR: 2.18; 95% CI: 1.88, 2.52) and diabetic patient (Adj. OR:1.32; 95% CI: 1.11, 1.56). The ColorApp's mean (SD) usability score was 72.9(11.52) which is significantly higher than the standard usability score of 68.0 indicating a usable mobile application. There was no significant difference in baseline knowledge and attitude between intervention and control groups. There was overall significance difference of mean knowledge score between intervention and control group [F (1,95) = 19.81; $p < 0.001$]. However, there was no overall significance difference of mean attitude score between intervention and control group [F (1,95) = 0.36, $p = 0.550$].

Conclusion: A mobile application is a way forward for health promotion and education, particularly in the prevention and early detection of colorectal cancer.

KEYWORDS

Colorectal cancer, mobile application, usability, effectiveness, health education, health promotion.

CHAPTER 1

INTRODUCTION

1.1 Colorectal cancer

Colorectal cancer is cancer that is originated from colon and rectum (American Cancer Society, 2018). Colon and rectum form the lower part of the digestive system where the water is reabsorbed and left the stool inside. The stool will pass through the rectum before it leaves the body during defecation. Colon and rectal cancer are grouped together as colorectal cancer because they shared many features in common.

There are many types of colorectal cancer include adenocarcinoma, carcinoid tumours, gastrointestinal stromal tumours (GISTs), lymphomas, and sarcomas. Adenocarcinomas contribute to more than 95% of colorectal cancer (American Cancer Society, 2017). This cancer originated from the cells in the large intestine that produce mucus (Fleming *et al.*, 2012).

1.2 Cancer prevention

Colorectal cancer can be prevented if it is detected and treated early (Torre *et al.*, 2016). The 5 years survival rate is highly dependent on the stage at diagnosis (Haggar and Boushey, 2009). The 5 years survival rate range from 95% if detected at stage 1 to 8% if detected in stage IV. However, in Malaysia, 65% of colorectal cancer was detected at stage III and IV (Manan *et al.*, 2016).

Mass population screening is not yet available in Malaysia. Many cancer cases are diagnosed among symptomatic patients (Manan *et al.*, 2016). Screening for colorectal cancer was conducted as an opportunistic screening program using various

methods including immunological faecal occult blood test (iFOBT), flexible sigmoidoscopy and colonoscopy (Su *et al.*, 2013). iFOBT is available at health clinic whereas flexible sigmoidoscopy and colonoscopy are available at the tertiary hospital. Currently, screening for colorectal cancer was conducted at most health clinics using iFOBT. An individual with positive iFOBT will be referred to the nearest tertiary hospital for a colonoscopy. However, participation in the screening program is very low (Harmy *et al.*, 2012). Not to mention the compliance with colonoscopy among individuals with positive iFOBT only 68.1% (Abu Hassan *et al.*, 2016).

1.3 Public awareness on colorectal cancer

Studies had suggested that the low knowledge and poor attitude towards colorectal cancer screening are one of the contributing factors to the low screening participation in Malaysia (Harmy *et al.*, 2011; Koo *et al.*, 2012). These also lead to the detection of the disease only when symptoms affecting a person to seek help which most likely too late (Ristvedt *et al.*, 2005).

Risk factors for colorectal cancer include increased age, male sex, family history of colorectal cancer, smoking habit, diabetes mellitus, increased body mass index, unhealthy diet and sedentary lifestyle (ASCO, 2017). It is thus, very important for a person to be aware of their risk. Risk perception, on the other hand, has been shown to be influenced by knowledge regarding the disease especially when it is tailored to the local situation (Inouye, 2014). Therefore, a risk communication tool to impart knowledge and change to the attitude towards screening is highly needed to reverse the adverse outcome of colorectal cancer in Malaysia.

1.4 Smartphone technology application in health promotion and education

Smartphones are mobile devices with additional capabilities such as email, text messaging, video streaming, and wireless internet excess (Fukuoka *et al.*, 2011). Most of the mobile phones nowadays are smartphones as they provide more advanced functions as mentioned before. Smartphone ownership has increased tremendously since 2013 in emerging and developing countries (Poushter, 2016). Malaysia had an increment as high as 34% since 2013. The popularity of this mobile device dominates all range of age group from the young to elderly people (Park *et al.*, 2013). Sixty-five per cent of total Malaysia population and nearly half (46%) of the population aged more than 35 years old were reported to have a smartphone (Poushter, 2016).

U.S Food and Drug Administration has defined mobile application or "mobile app" as a software application that can be executed or run on a mobile platform, or a web-based software application that is tailored to a mobile platform but is executed on a server (FDA, 2015). It can be downloaded via Google Play Store for Android smartphone or App Store for iOS smartphone. Until February 2017, more than 2.7 million mobile application available in the Google Play Store and 2.2 million applications available in the Apple Store (Statista, 2017a). There are nearly 100,000 mobile applications for health (mHealth) in the Google Play Store and another 13,600 in the App Store. These were reported to be among the 10 most popular categories of mobile applications. mHealth is defined by the WHO as the medical and public health practice supported by mobile devices, such as mobile phones, patient monitoring devices, personal digital assistances and other wireless devices (Kay *et al.*, 2011). The FDA estimates that roughly 500 million people globally are already using personal healthcare 'apps' or mobile software applications in 2015 and this number will increase from year to year (FDA, 2018).

Despite huge increment in smartphone ownership and availability of mobile applications, little is known about the technology implementation in health promotion and education, especially in Malaysia. Studies in other countries have suggested that mobile applications are a potential intervention tool in improving health awareness and promoting behavioural changes (Fukuoka *et al.*, 2011; Vervloet *et al.*, 2011). Mobile applications provide a useful and low-cost strategy in disseminating information including the risk factors, preventive measures such as proper diet and nutrition and available screening methods for chronic diseases such as cancer to the general population and at-risk populations (Bert *et al.*, 2014). It can have variety features including visually engaging design, text, video and audio, content sharing via social media, progress tracking and usage with or without cellular coverage or internet access. Apart from that, the artificial intelligence or decision-making capability is the add-on values of a mobile application. Incorporation of a self-risk assessment application for colorectal cancer for example, can analyse the risk that the user had and suggest further action such as to undergo the screening test. This 2-way interaction between the user and the mobile application will enhance the delivery of health information.

Currently, most of the health materials are distributed as printed materials in the form of pamphlet or posters in the health clinic and during health campaigns. However, with the advancement of communication technology today, reading through pamphlet has become less popular. The Interim Review of Malaysian Citizens Reading 2014 reported that people nowadays prefer to read from their smartphone using a web browser or mobile app as compared to printed material (Yusop, 2017). To date, there is no specific mobile application had been developed to empower the public on

colorectal cancer in Malaysia particularly by increasing their knowledge on colorectal cancer and attitude toward the screening program.

1.5 Problem statement

Studies showed that the knowledge and awareness on colorectal cancer among Malaysian is still low (Hilmi *et al.*, 2010; Koo *et al.*, 2012; Suan *et al.*, 2015). It was also reported that lack of knowledge and low attitude on colorectal cancer is one of the barriers of screening participation (Harmy *et al.*, 2011; Su *et al.*, 2013; Norwati *et al.*, 2014). Detection of colorectal cancer when the patient is having the signs and symptoms usually indicates that the disease is already at late stage. This alarming situation is supported by a report showing that more than half of colorectal cancer cases that were detected in Malaysia presented at late stage (Manan *et al.*, 2016).

Currently, health promotion and education on colorectal cancer was given in the form of printed materials such as pamphlet and poster despite the increased preference of Malaysia to read from their smartphone (Yusop, 2017). If the information dissemination is diverting from the current trend of information search, the knowledge and awareness on colorectal cancer will remain low leading to low screening participation and increase the prevalence of colorectal cancer diagnosed at late stage.

1.6 Research justification

The knowledge and awareness on colorectal cancer are still low among Malaysian. These have led to low participation in the screening activities. Risk communication in which the content is based on factors identified from the local

situation, evidence-based, and practical may increase the perception of self-risk, leading to increment of the awareness and participation in the screening program. Nowadays, health promotion and education on colorectal cancer mostly done in the form of printed material such as pamphlet or poster. The rapid emergence of mobile technology and health applications should be fully utilized as a new tool for health promotion and education of the colorectal cancer screening in line with the change of the way people search for knowledge from reading printed material to using a more interactive mobile application. Therefore, this study is important in developing the mobile application to disseminate the information to the intended users. The mobile application must be usable by the intended users, acceptable, attractive, and informative that is tailored to the local setting and health literacy. It is expected to improve their knowledge and attitude leading to increase participation in colorectal cancer screening.

1.7 Research question

Phase one: What are the associated factors for colorectal cancer in Malaysia?

Phase two:

1. Does the mobile application is a usable tool in health promotion and education on colorectal cancer?

2. Can the mobile application increase the knowledge and attitude of the population at risk of colorectal cancer in Kedah?

1.8 Objectives

1. General objective:

To develop and assess a usable mobile application for health promotion and education on colorectal cancer.

2. Specific objectives:

    i.   To determine the factors associated with colorectal cancer in Malaysia.

    ii.   To assess the usability of the mobile application as a tool for health promotion and education on colorectal cancer.

    iii.   To compare the mean percentage score of knowledge on colorectal cancer between intervention and control group with consideration of time pre and post usage of the mobile application.

    iv.   To compare the mean percentage score of attitude towards colorectal cancer between intervention and control group with consideration of time pre and post usage of the mobile application.

1.9 Research hypothesis

1. There is a significant association between age group, sex, race, smoking habit, diabetes mellitus and colorectal cancer in the Malaysian population.

2. The mean usability score value is significantly higher than the standard usability value of 68.

3. There is a significantly higher mean percentage score of knowledge on colorectal cancer in the intervention group as compared to control group with consideration of time.

4. There is a significantly higher mean percentage score of attitude on colorectal cancer in the intervention group as compared to control group with consideration of time.

CHAPTER 2

LITERATURE REVIEW

2.1 Colorectal cancer epidemiology

Cancer incidence and mortality are rapidly growing worldwide. It was reported that there were 12 million new cases in 2008 with 7 million deaths from cancer (Boyle and Levin, 2008). The number has increased drastically in 2015 in which the Global Burden of Disease Study 2015 has estimated 17.5 million new cancer cases with more than 8.7 million deaths from cancer (Global Burden of Disease Cancer *et al.*, 2017). In fact, cancer is the second leading cause of death worldwide after cardiovascular diseases (GBD 2015 Mortality Causes of Death Collaborators, 2016).

Looking into colorectal cancer specifically, there were 1.7 million new cases in 2015 with 832 000 deaths globally (Global Burden of Disease Cancer *et al.*, 2017). It is the third most commonly diagnosed cancer. However, according to National Cancer Registry Report 2007-2011, colorectal cancer is the second most common cancer detected in Malaysia with 13,693 or 13.2% from total cancer cases registered (Manan *et al.*, 2016). The Age Standardized Rate (ASR) of colorectal in Malaysia was 14.6 per 100,000 population for male and 11.1 per 100,000 population for female. There is a wide disparity in the country-specific incidence, with the highest incidence being reported in Singapore (Age Standardized Rate (ASR) 33.7 per 100,000 persons versus 14.6 per 100,000 male population in Malaysia) (National Registry of Disease Office, 2015). However, trends for both the incidence and the mortality rates for Singapore have been stable and even declining since 2000. Other Southeast Asian countries, such as Indonesia, Thailand, Vietnam, and Myanmar, have comparatively lower incidence rates of colorectal cancer than Malaysia (Torre *et al.*, 2015).

9

Manan *et al.* (2016) also reported that colorectal cancer is the most common cancer among male and second among female with 7,646 cases (11.7%) and 6,047 cases (10.7%). The percentage of colorectal cancer detected at stage I and II was only 34.1% and 34.8% respectively for both male and female. More than half were diagnosed at late stage.

Several studies have been done in Malaysia to identify the location of the tumour site. It was reported that colorectal cancer is more commonly located at the rectum. A study involving 248 patients from University Malaya Medical Centre from 1999 to 2003 reported that 36% of tumour located at the rectum, followed by sigmoid (32%), and colon (32%) (Goh *et al.*, 2005). A study conducted in Hospital Tengku Ampuan Afzan, Pahang from 2001 to 2005 involving 119 patients has reported that 55% of colorectal cancer occur in rectum and rectosigmoid area, 26% occur at sigmoid, descending colon and transverse colon, and 19% occur at ascending colon and cecum (Azmi *et al.*, 2007). A more recent study conducted by Kaur *et al.* (2011) involving 148 patients from 3 hospitals in the northern part of Malaysia reported that 46% of colorectal cancer occurs at the rectum, 20% at sigmoid and the rest occur at the colon. Hassan *et al.* (2017) in the National Cancer Patient Registry – Colorectal Cancer Report for Northern Region of Malaysia 2008 - 2014 has reported that the most common tumour site was rectum 37.5% from 2213 registered colorectal cancer cases and 86.4% was a left-sided tumour.

Adenocarcinoma is the commonest histological features of colorectal cancer in which more the 95% cases reported with this type (Thrumurthy *et al.*, 2016). Other types of colorectal cancer include carcinoid tumour, sarcoma and lymphoma. Marzuki (2015) has reviewed the National Cancer Patient Registry – Colorectal Cancer (NCPR-CC) for Kedah state reported that 93.4% of patients were reported to have

adenocarcinoma. Hassan *et al.* (2017) also reported that the commonest histological features of colorectal cancer in Malaysia was adenocarcinoma with 91.2% from total registered cases and 86.6% were moderately differentiated.

2.2 Factors associated with colorectal cancer

According to American Society of Clinical Oncology, among factors that associated with colorectal cancer are age, gender, family history of colorectal cancer, a rare inherited condition such as familial adenomatous polyposis, inflammatory bowel disease, race, physical inactivity and obesity, nutrition and smoking (ASCO, 2016).

2.2.1 Age

The risk to get colorectal cancer is increasing with age. In Malaysia, more than 90% of colorectal cancer cases occur among people more than 40 years old whereby the incidence rate increases exponentially especially after the age of 50 years old (Lim *et al.*, 2008; Manan *et al.*, 2016). The age characteristics of colorectal cancer patients registered in the National Cancer registry showed an occurrence of 14.6% patients younger than 50 years, and 7% of cases were among patients younger than 40 years (Lim *et al.*, 2008). A similar trend was observed in the neighbouring country Singapore and other ASEAN countries for decades (Sung *et al.*, 2005; Pourhoseingholi *et al.*, 2015). A developed nation such as the US has shown the rising trend colorectal cancer incidence rates in younger age groups coincident with declining rates in older age groups whereby the proportion of cases diagnosed in individuals younger than age 50 increased from 6% in 1990 to 11% in 2013 (American Cancer Society, 2017). In fact, colorectal cancer is now one of the 10 most commonly diagnosed cancers among men and women aged 20 to 49 years globally (Haggar and Boushey, 2009).

2.2.2 Sex

Generally, the risk of getting colorectal cancer is greater in men than in women (CDC, 2016). American Cancer Society (2017) also reported that the incidence rates are substantially higher in men than in women. According to GLOBOCAN, a project of the International Agency for Research on Cancer (IARC), in 2012 there is wide geographical variation in incidence across the world and the geographical patterns (GLOBOCAN, 2012). However, the disparities between men and women are very similar.

In Malaysia, colorectal cancer affects more males with ASR 14.6 per 100,000) as compared to females (ASR 10.8 in 100,000 population) (Manan *et al.*, 2016). Study in Singapore also showed a similar trend (de Kok *et al.*, 2008). However, several studies have shown that the association between gender and colorectal cancer depend on the age, cancer site, and stage of colorectal cancer. As the age increase, the incidence was found to be higher among women which are explained by the hormonal protection (de Kok *et al.*, 2008). Women also tend to have late stage of colorectal cancer and the location are usually more distal (Koo and Leong, 2010; Clarke *et al.*, 2014). Although the mechanism causing these differences between men and women remains poorly understood, the differences in fat proportions between men and women and abdominal adiposity are thought to influence the risk (Johnson *et al.*, 2013).

2.2.3 Races

It has been reported that certain race groups in Asia, are more susceptible to colorectal cancer (Leung *et al.*, 2016). Manan *et al.* (2016) reported that for both sexes, Chinese are the most vulnerable to be diagnosed with colorectal cancer. The age-standardise rate (ASR) for male and female Chinese is 21.1 per 100,000 population and 17.1 per 100,000 population respectively as compared to male Malay and Indian

which are 11.3 and 10.3 respectively and female Malay and Indian which are 8.1 and 8.7 respectively. The similar trend also reported in Singapore that has a similar racial composition with Malaysia (Ling *et al.*, 2017). Even though Chinese has higher ASR for colorectal cancer, Marzuki (2015) in his study looking at late stage at diagnosis of colorectal cancer found that 53.2% of patient in Kedah, Malaysia were from Malay race.

2.2.4 Diabetes Mellitus

A meta-analysis has supported the evidence for a causal relationship between DM and colorectal cancer based on 24 observational studies of epidemiological data (Deng *et al.*, 2012). An individual with DM has a significant risk of getting colorectal cancer as compared to normal individual (pooled RR: 1.26; 95% CI: 1.20, 1.31). Deng *et al.* (2012) postulated that there is the reason why they observed an increment in the number of diabetic patients and colorectal cancer. The risk also even higher if the patient is on insulin treatment (RR: 1.24; 95% CI: 1.18, 1.35). Apart from sharing common risk factors such as obesity, unhealthy diet and physical inactivity, diabetes may directly influence the neoplastic mechanism such as hyperinsulinemia either endogenous due to insulin resistance or exogenous due to administered insulin, hyperglycaemia, or chronic inflammation (Giovannucci *et al.*, 2010).

2.2.5 Smoking

Smoking is a well-known risk for lung cancer, oral cancer, oesophageal cancer, colorectal cancer, and bladder (Cancer Research UK, 2016). Hoffmeister *et al.* (2014) showed that former regular smoking was found to have an increased risk of getting colorectal cancer with adjusted odds ratio 1.5 (95% CI: 1.28, 1.75). A meta-analysis of 36 studies encompassed diverse population in North America, Europe, and Asia had

reported that even though the association between smoking and colorectal cancer is controversial, majority of the study conducted after 1970 have supported the association (Liang *et al.*, 2009). This meta-analysis has shown that colorectal cancer was associated with the smoking habit (ever smoked), daily cigarette consumption, duration, pack-years, and age of initiation. Those who ever smoke have 1.25 to 1.40 higher risk of getting colorectal cancer than those who never smoke. Another meta-analysis also showed that the association is time and dose dependent. The results showed a significant relationship between smoking and colorectal cancer with 6 % greater risk for 5 pack-years (95% CI: 1.03, 1.08) and 26 % (95% CI: 1.17, 1.36) greater risk for 30 pack-years as compared to non-smokers.

2.2.6 Family history of colorectal cancer

Another important risk factor for colorectal cancer is having family member who suffered from the disease. A meta-analysis of 59 studies estimated a pool risk for colorectal cancer 2.24 (95% CI: 2.06, 2.43) if 1 affected first-degree relative, and increased to 3.97 (95% CI: 2.60, 6.06) if at least 2 relatives are affected (Butterworth *et al.*, 2006). Taylor *et al.* (2010) has conducted a study using Utah Population Database (UPDB) involving 10, 556 colorectal cancer patients that have ≥ 3 generation positive family history of colorectal cancer had reported that a person with first degree relative history has 2.05 higher risk of colorectal cancer (95% CI: 1.96, 2.14). If the person has second-degree relative and third-degree relative history will have 33% higher risk of colorectal cancer as compared to a person with first-degree relative history (95% CI: 1.13, 1.55). However, if the person has family history in all three generations, the risk increased to 3.28 times higher as compared to a person with first-degree relative history (95% CI: 2.44, 4.31). It is believed that the inherited cancer genes can be passed from a parent to a child. However, the increased risk is not well

understood in all cases since the other environmental factor such as food also may play a role (Cancer Research UK, 2018).

2.2.7 Other risk factors

Other factors that increase the risk of an individual to get colorectal cancer include inflammatory bowel disease, obesity, history of intestinal polyps, sedentary lifestyle, and unhealthy food intake (Johnson *et al.*, 2013). The meta-analyses by Johnson *et al.* (2013) also showed that previous history of inflammatory bowel disease confers almost 3 times higher risk of getting colorectal cancer with 95% CI range from 1.79 to 4.81. However, there was no prevalence data in Malaysia but a study conducted by Hilmi *et al.* (2015) has estimated that the incidence of the disease is low, with the incidence rate of 0.68 per 100000 population per year.

The similar meta-analysis also reported an increment of 10% (95% CI = 8%, 12%) risk of colorectal cancer with increment of 8 kg/m^2 BMI and 12% higher risk for low physical activity (RR: 1.12; 95%CI: 1.09, 1.14). Similar meta-analyses also showed that red meat intake of 5 servings/week have positive association with colorectal cancer (RR = 1.13 per 5 servings/week, 95% CI 1.09–1.16), consumption of vegetable that have significant inverse association to colorectal cancer (2 servings/day with RR: 0.94; 95% CI: 0.91, 0.98 vs 5 servings/day with RR: 0.86; 95% CI: 0.78, 0.94) and fruit consumption that also has protective risks of colorectal cancer as the fruit intake is more (1 serving/day with RR: 0.91; 95% CI: 0.85, 0.96 versus 2 servings/day with RR: 0.85; 95% CI: 0.78, 0.94 versus 3 servings/day with RR: 0.84; 95% CI: 0.75, 0.96) as compared to very little fruit consumption.

2.3 Colorectal cancer screening initiative

Colorectal cancer is highly preventable and easily treatable especially when detected early. Therefore, early detection through colorectal cancer screening is highly recommended to prevent the disease or ensure good prognosis and improved survival of the patient (Burt *et al.*, 2010). Moreover, early detection of colorectal cancer allows less invasive treatment, lower morbidity, mortality and treatment cost. The screening method ranges from a non-invasive faecal occult blood test to invasive imaging technique via colonoscopy (Schreuders *et al.*, 2015).

Asia Pacific Working Group on Colorectal Cancer and international experts have launched a consensus recommendation aiming to improve the control and prevention program, and to increase the awareness of the healthcare provider of the changes of colorectal cancer epidemiology and the screening test available (Sung *et al.*, 2008). According to this working group, screening for colorectal cancer should be the national health priority of all the Asian countries. Faecal occult blood test (FOBT), guaiac-based and immunochemical tests, flexible sigmoidoscopy, and colonoscopy are the recommended screening method depending on the country financial status. FOBT is recommended for resources-limited countries. Screening program in the US has significantly reduced the incidence of colorectal cancer up to 3.8% and successfully reduce the death of colorectal cancer up to 3.4% (CDC, 2016). Japan, Australia and Singapore have started their national program since 1992, 2006, and 2011 respectively (Hassan *et al.*, 2015).

In line with the recommendation mentioned above, Malaysia has endorsed the National Cancer Control Blue Print in 2008 that include colorectal cancer as one of the cancers of concern and suggest the initiation of the screening program (Tamin, 2013). Since 2014, the colorectal cancer screening program has implemented

gradually in government health clinics and selected hospitals (Hassan *et al.*, 2015). It aims to screen the pre-cancerous lesion and colorectal cancer as early as possible among healthy Malaysian age 50 years old to 70 years old. It was carried out as selective opportunistic screening method using immunochemical faecal occult blood test (iFOBT) to an individual that interested to participate. The information regarding the screening program was distributed to the public through the poster, banner and pamphlets (Tamin *et al.*, 2017).

Malaysia Health Technology Assessment Section (2017) or MaHTAS in Clinical Practise Guidelines (CPG) on Management of Colorectal Cancer has recommended iFOBT to be used in the screening of average-risk population and colonoscopy is a screening method for moderate to high-risk group. According to the CPG, the people aged above 50 years old without any family history of colorectal cancer are considered in the average-risk group. The people with family history of colorectal cancer either one or more first-degree relatives (FDR), one FDR and more than one second-degree relative, or more than three with 1 of them must be FDR is considered in the moderate-risk group. The high-risk group are those who have family history of colorectal cancer at age <50 years, familial adenomatous polyposis (FAP), hereditary non-polyposis, colorectal cancer (Lynch Syndrome), Peutz-Jegher Syndrome, Juvenile Polyposis, MUTYH-associated polyposis. Immunochemical faecal occult blood, (iFOBT) is recommended for screening of average-risk group (Malaysia Health Technology Assessment Section, 2017). MaHTAS in the health technology assessment report based on the literature review of many studies found that a screening programme using iFOBT can be effective for prevention of colorectal cancer and reduce mortality from 60.0% to 23.0%.

2.4 Colorectal cancer awareness and screening participation

The public knowledge and awareness regarding the rising incidence of colorectal cancer are low, leading to a low rate of screening uptake (Koo *et al.*, 2012). This study that comparing the countries in the Asia Pacific Region also found that Malaysian, Singapore, India and Brunei had significantly more negative response compared to Philippines and Japan, and lack of intention to undergo colorectal cancer screening. They suggested that low knowledge regarding colorectal cancer and attitude toward screening may explain the negative perception toward the screening program. The median score for knowledge on symptom, risk factor and screening test were very low in Malaysia whereby more than half of the respondent in the study could not recall any symptoms or risk factor. This might explain why the perceived need for screening among Malaysian as found in this study was also low. Another study by Hilmi *et al.* (2010) reported only 38% of those who are at high risk of getting colorectal cancer were willing to go for screening. This study showed that the intention to go for screening among people age 50 years old and above and from the Chinese population was also the lowest as compared to the younger age group and other races.

Many studies found that negative perception towards screening is among the barrier to colorectal cancer screening (Sung *et al.*, 2008; Harmy *et al.*, 2012; Yusoff *et al.*, 2012). The perception becomes more negative toward invasive screening method such as colonoscopy. The fear, painful procedure, feeling of embarrassment and lack of confident were among reported negative view. Accessibility also was reported as one of the barriers to colorectal cancer screening with regard to financial constraint, or time constraint (Sung *et al.*, 2008; Harmy *et al.*, 2012; Koo *et al.*, 2012; Yusoff *et al.*, 2012). The colorectal cancer screening in Malaysia is subsidised by the government, therefore, the patient does not need to pay however, they still have to pay the cost of

transportation to the health clinic. Many of the respondents also claimed that they are busy with their work and the test also take sometimes to do.

From all barriers that were studied, lack of knowledge or education is the most critical barrier that is reported in many studies (Sung *et al.*, 2005; Sung *et al.*, 2008; Harmy *et al.*, 2011; Harmy *et al.*, 2012; Koo *et al.*, 2012; Yusoff *et al.*, 2012; Wong *et al.*, 2013). Those studies found that poor knowledge of the general public on the risk factors, sign and symptoms, and screening test available that lead to low awareness. Apart from that, the background education level also plays an important role in determining health literacy, especially in the rural area. As compared to lung, breast and cervical cancer, the health promotion and education colorectal cancer by Ministry of Health Malaysia are still lacking despite increasing incidence from year to year (Harmy *et al.*, 2011). Therefore, the awareness program on colorectal cancer and extensive health promotion and education should be strengthened in Malaysia.

2.5 Factors associated with knowledge and attitude on cancer

Studies have shown that the knowledge and attitude on cancer especially colorectal cancer is significantly associated with sociodemographic characteristics such as age, gender, educational level, occupation, income and smoking habit (Sessa *et al.*, 2008; Wong *et al.*, 2013; Al-Thafar *et al.*, 2017; Ismail *et al.*, 2018).

A study conducted in China involving 10,078 participants in a screening program showed that male gender, higher age group, lower educational level, and lower-income, are associated with poor knowledge on colorectal cancer (Wong *et al.*, 2013). The findings were in line with another study among adult in Italy also found that younger age group, female, higher education level are associated with higher

knowledge and good attitude toward colorectal cancer (Sessa *et al.*, 2008). Another study conducted in the United Arab Emirates also found that female and higher education level are significantly associated with good knowledge on colorectal cancer (Al-Sharbatti *et al.*, 2017). A cross-sectional study was conducted among teaching staff in Saudi Arabia in 2017 found out that those with higher education will have higher awareness on colorectal cancer (Al-Thafar *et al.*, 2017). The study also found that there was no discrepancy between rural and urban population on colorectal cancer awareness. Mitiku and Tefera (2016) in their study in Northeast Ethiopia found that the level of education and economic status are associated with knowledge on cervical cancer. A study in Hong Kong by (Wong *et al.*, 2013) also found that smokers in the study had low awareness and knowledge on colorectal cancer. Other study conducted in Taiwan involving 7762 participants with mean age of 51 years old looking at the health literacy and participant's body mass index (BMI) found that there were significant different of BMI between participants in health literacy score group = 10 (23.8 (3.3) kg/m^2) versus ≤9 (25.3 (3.8) kg/m^2) with $p < 0.001$ and =11 (23.9 (3.4) kg/m^2) versus ≤9 (25.3 (3.8) kg/m^2) with $p = 0.008$ (Cheng *et al.*, 2018). These factors should be taken into consideration when we want to compare the level of knowledge and attitude between two group and control during analysis is important to ensure that the improvement of the knowledge post intervention due to the intervention only.

2.6 Methods in health information delivery

Face-to-face with health care provider remains the best method for communicating the general health information to the patient and public. A health talk, for example, is one of the commonest method used throughout the world (Prozesky, 2014). It is usually delivered in the local language. The main advantages of this

approach include a fairly large number of people that can be reached at the same time with relatively little preparation and the two-way communication that able to improve the audience understanding. Group discussion also can be conducted to deliver health information. It usually provides a better understanding of the participant as there will be more interaction between participant and health care provider. However, health care providers have very limited time to spend with the patient not to mention, the publics (Davidoff, 1997). Moreover, in this modern health care, people who really need the information may not come to the health talk (Prozesky, 2014). Therefore, other methods of health information delivery are needed to complement the constraints.

Many studies have been conducted to look into various methods of health information delivery in order to improve the knowledge and attitude of the public. Meade *et al.* (1994) have conducted a randomised control study in the US involving 1100 participant with mean age 60.6 years old looking into the different of the printed material in the form of booklet versus videotape (versus control) for improving the knowledge on colorectal cancer. They found that both interventions were able to enhance the knowledge of participant as compared to the control group and there was no difference between the two methods as far as the materials tailored with the target group.

Another study by Wilson *et al.* (2010) involving 450 middle-aged and older adults from Chicago, Illinois and Hartford US to compare delayed recall of information about managing asthma symptoms through avoiding triggers and properly using an inhaler using video and print material in the form of brochure or pamphlet. The result showed that participants who received either video or printed material have better recall of both asthma trigger and inhaler use information as compared to the control group. Further analysis also showed that participants who received both print

and video materials have better recall as compared to participants that received video only. This study concluded that short, simple intervention in both printed and video can effectively improve patient's understanding and recall of information about chronic health conditions.

Campbell *et al.* (2004) have conducted a study involving 238 middle-aged participants to compare between original modified inform consent form and modified inform consent form in the form of 'enhanced printed form', 'video' with voice narration and laptop computer-based where the participant can control over the advancement of review of each frame. The study found that, in general, the laptop computer-based and enhanced printed form that required the more active involvement of the participants was superior as compared to the other forms. Video per se was not effective in conveying information to the participants.

In the era of information technology, the methods of information delivery in health promotion and education have been shifted to the usage of internet-based. Marcus *et al.* (2007) have conducted a study to compare the usage of the internet and printed based physical activity interventions involving 249 participants found that there was a similar improvement of physical activity among participant from both groups. The study concluded that internet-based may be an opportunity to reach more sedentary adult in a more cost-effective way. A meta-analysis of 22 randomised controlled trials involving participants with a range of age from 8.3 years old to 63 years old found that there was a significant improvement of knowledge and attitude of the study participant as compared to control group (Portnoy *et al.*, 2008).

2.7 Mobile application versus website

Basically, there are two options when using an internet-based either web site or mobile application. There were several advantages of using the mobile application as compared to the website (Armour, 2017). The most prominent advantage of the mobile application is the ability to be used without internet connectivity. This enables the user to use it at any time and anywhere. A mobile application also allows more interaction with the user. This will facilitate user to engage more with the application's content rather than looking at the same image, and text in the website. On top of that, the mobile application can interface with the smartphone's features and hardware such as camera, phone call, email, social media, and instant updates. This will increase the interaction capabilities of the mobile application with the user.

It is postulated that the smartphone will be the only computer in two years (Bonninton, 2015). It is also reported that those in developing countries, a smartphone is the first computer and the only devices with internet connectivity. Cisco (2016) has reported two-third of all online activities will be taken place by mobile devices by the year 2020. Therefore, the mobile application should be the way forward as health promotion and education.

2.8 Smartphone usage in Malaysia

The smartphone revolution started to grow since 2002 with the introduction of the BlackBerry smartphone and took off in 2007 with Apple's revolutionary iPhone (Grush, 2012). There has been a rapid diffusion of smartphone technology in society. As the world today becoming more interconnected, smartphone usage remains as one of the important elements in our daily routine. Over the past few years, there has been

a steady rise in the percentage of people who own and use a smartphone. In 2017, there was 14.5 million smartphone user in Malaysia (Statista, 2017b). It is also estimated that in 2020, the number of mobile phone user in Malaysia will be more than 20 million. Malaysia Communication and Multimedia Commission (MCMC) reported that smartphone ownership in Malaysia is as high as 90.7% and 87.3% of them have access to the internet (MCMC, 2016). Texting and information search were the most common online activities followed by social networking and leisure.

According to MCMC, nearly 81.9% of Malaysian aged between 20 and 49 old years owned or used a smartphone. The ownership percentages of people in the higher age group are slightly lower. However, the percentage of user age 50 years old and above has increased from 11.8% in 2009 to 14.4% in 2014 (MCMC, 2015). With the increment of the population aged 50 and above, the number of smartphone user in the age group is increasing from year to year.

2.9 Mobile application for health promotion and education

With the increasing use of smartphone, the industries of mobile phone applications have faced high demand from the user (Bert *et al.*, 2014). These specific applications or more commonly called apps could be used for social interaction, education, entertainment, and personal health. Nowadays, there are more than 7000 documented cases of applications have been developed for health purposes (Kailas *et al.*, 2010).

Studies in other countries have suggested that mobile applications may have potential as an intervention for health awareness and behavioural changes (Fukuoka *et al.*, 2011; Vervloet *et al.*, 2011). By incorporating multiple functions of the smartphone