Evaluations of the 45-49 year old health check program in Australian general practice

Si Si
MBBS

Thesis submitted in fulfillment of the requirements for the degree of
Doctor of Philosophy
November 2014

Discipline of General Practice

School of Population Health

Faculty of Health Sciences

The University of Adelaide

Australia

Table of Contents

Thesis abstract

Background: A health check refers to the practice of comprehensive medical assessments to detect and manage risk factors and early chronic disease. Debate about the value of health checks has lasted for decades. A systematic review reported that general health checks in middle-aged populations did not reduce total mortality. Nevertheless, new government funded health check programs have recently been introduced in several developed countries. In 2006, Medicare Australia funded a 45-49 year old health check in Australian general practice for all people at risk of developing chronic disease. However, this program has not been fully evaluated. To date, research has taken the perspective of health care providers, investigating their perceptions about the feasibility and challenges in performing a heath check. No study has yet investigated important questions arising from the perspective of patients or the government. Such research would provide a better understanding of which patients participate and why, and also the potential benefits and costs of this health check program.

Objectives: To investigate the effectiveness of general practice-based health checks; to understand patients' perceptions about general health checks and the psychological determinants of their attendance at a GP invited health check; to compare the demographic characteristics, past health service use including preventive health care of attendees and non-attendees at the 45-49 year old health check; to examine the long-term health effects of this health check program and to quantify its economic impact on the health care system.

Methods: A systematic review and meta-analysis was performed to determine the effectiveness of general practice-based health checks, using both surrogate and final outcome indicators.

A prospective cohort study was conducted in two general practices in the Adelaide metropolitan area. Patients who were eligible for the 45-49 year old health check program were identified from the two practices. A structured questionnaire was developed and sent to all eligible participants. Questions about demographic characteristics, self-reported medical history and perceptions about general health checks were included. After the return of study questionnaires, an invitation letter was sent to all participants, whether they had returned the questionnaire or not. Attendance at the health check in the following 6 months was recorded. Then, relevant medical records of all study participants from one year prior to the invitation were extracted from the electronic medical record system in each practice. Extracted data included gender, age, residential postcode; the number of general practice visits, pre-existing prescriptions and the uptake of preventive health care.

Finally, a Markov chain model was constructed to simulate the health check effects on a hypothetical cohort of 10,000 ‘healthy’ Australians aged 45-49 years. The risk profiles of a baseline cohort were generated using data from the 2011 Australian National Health Survey. Intervention effects were simulated using data on risk factor changes after the health check (results from the systematic review). The Life-Years and Quality Adjusted Life Years (QALYs) gained over the cohort’s remaining lifetime after a health check was estimated. The maximum acceptable costs for this health check program, including the initial consultation

and subsequent interventions, was calculated using a cost-effectiveness threshold of $50,000 per QALY.

Results: The systematic review of general practice-based health checks demonstrated significant, albeit small improvement in most investigated surrogate outcomes (i.e. total cholesterol, systolic and diastolic blood pressure and body mass index) after the intervention, especially among high risk patients. No significant improvement in surrogate outcomes was observed in non-practice based health check studies. No difference in total mortality was found in either practice-based or non-practice based studies. However, most general practice-based studies were not originally designed or powered to evaluate mortality changes.

The cohort study recruited 515 eligible participants from two participating general practices. 293 of the 515 (56.9%) participants returned the study questionnaire and altogether 117 (22.7%) attended the health check within 6 months. In the questionnaire study, respondents who indicated a strong attendance intention ($p<0.01$), and self-reported no pre-existing biomedical risk factors ($p<0.01$) and less recent uptake of preventive health care ($p<0.01$) were significantly more likely to attend a health check. In the medical record analysis, no significant differences in age, gender or socio-economic status were observed between health check attendees and non-attendees. However, the questionnaire respondents were almost 3 times as likely to attend as non-respondents (31% vs 12%) and the characteristics that were associated with attendance were different in questionnaire respondents and non-respondents. Among the respondents, those with more pre-existing prescriptions and recent uptake of preventive health care were slightly less likely to attend. Conversely, among non-respondents, individuals with two or more types of pre-existing prescriptions were significantly more likely to attend than those without (p=0.03).

The modelling study demonstrated that the 45-49 year old health check program would lead to 8.6 and 2.6 QALYs gained among 1,000 male and female attendees respectively in a lifelong projection (50 years). The threshold costs for the health check to be considered cost-effective were $465 for a male and $140 for a female patient using a threshold of $50,000 per QALY.

Conclusions: For health checks to be most effective, they should be undertaken in general practice as opposed to other settings (e.g. community or workplace). Tailored invitations could be employed to selectively invite patients who would most benefit from a health check (patients who are less proactive). Finally, the 45-49 year health check program is unlikely to be cost-effective among females in the current Australian context. Given these results, health policy changes such as delaying the health check by 5-10 years, introducing pre-screening procedures or targeting vulnerable patient groups should be considered to improve the effectiveness and cost-effectiveness of this health check program.

Declaration

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Signed..

Si Si

Date ....

List of publications contributing to this thesis

1. Si S, Moss JR, Sullivan TR, Newton SS, Stocks NP. Effectiveness of general practice-based health checks: a systematic review and meta-analysis. BJGP. 2014;64(618):e47-e53.
2. Si S, Moss JR, Giles LC, Stocks NP. Factors influencing attendance at the 45-49 year old health check: a questionnaire survey.
3. Si S, Moss JR, Giles LC, Stocks NP. Determinants of attendance at a 45-49 year old health check in Australian general practice: An observational cohort study.
4. Si S, Stocks NP, Moss JR, Karnon J. Effectiveness and cost estimates for the 45-49 year old health check in Australian general practice: a modelling study. Submitted to Applied Health Economics and Health Policy; Submitted in Jul 2014.

List of conference presentations during candidature

- Si S, Moss J, Stocks N. *An evaluation of the 45-49 year health assessment in Australian general practices: determinants of attendance, subsequent medical service use and costs.* Postgraduate Health Research Conference 2012; 2012 Sep; Adelaide

- Si S, Moss J, Stocks N. *The effectiveness of general practice-based health checks: a systematic review and meta-analysis*. North America Primary Health Care Group (NAPHCG) Annual Meeting 2013; 2013 Nov; Ottawa

- Si S, Moss J, Stocks N. *Characterizing attendees at the 45-49 year health check in two family practices in Adelaide.* North America Primary Health Care Group (NAPHCG) Annual Meeting 2013; 2013 Nov; Ottawa

- Si S, Stocks N, Moss J, Karnon J. *Effectiveness and cost estimates for the 45-49 year old health check in Australian general practice: a modelling study.* 2014Primary Health Care Research Conference; 2014 Jul; Canberra

Acknowledgements

My PhD journey has been a bitter sweet and life changing experience. Looking back at the fleeting four years, I realize that I have been the lucky one surrounded by intelligent, knowledgeable, loving and caring superiors and peers. It is hard to imagine what it would turn out without your guidance and support. At the end of the journey, I would love to extend my sincere gratitude to everyone who have contributed to this thesis and changed my life.

To my principal supervisors Prof Nigel Stocks, thank you for taking me on at my difficult time and guiding me into the area of primary health care research. Thank you for being an encouraging and supporting mentor and supervisor over the years. You have always been an exemplary for me, not only as a successful scholar/GP, but also as a humble, polite and positive individual.

To my co-supervisor A/Prof John Moss, thank you for having me in the first place. If not for you, I would never have had the opportunity to be here. I genuinely appreciate your support, advice and encouragement every step of the way. Your ‘green pen’ will be missed.

To Prof Jonathan Karnon, whose vision, wisdom and generous assistance helped me complete what I thought ‘mission impossible’.

To Thomas Sullivan and Dr. Lynne Giles, thank you for your constructive advice and support to get me through the aching process of data analysis and interpretation.

Special thank you to all general practice staff, especially Ms. Ruth Pavy and Ms. Nicole Smith, whose cooperation made my research possible.

To all my colleagues and fellow PhD students, who made me realize that I was never alone in this journey to the ivory tower. Heartfelt thanks go to the members of my thesis writing group, who have patiently reviewed a number of my immature manuscripts and generously offered me constructive feedback.

To all my friends who have always been there to share my happiness and grief, thank you for making me stronger and a better person.

Finally, but most importantly, my gratitude goes to my family, especially my parents and uncle, for their unconditional love, patience and dedication. I am fortunate and very proud of being a part of my family.

Abbreviations

ABB	Affective Behavioural Belief
ABHI	Australian Better Health Initiative
ABS	Australian Bureau of Statistics
AIHW	Australian Institute of Health and Welfare
ANHS	Australian National Health Survey
AR-DRG	Australian Refined Diagnosis-Related Group
BB	Behavioural Belief
BEACH	Bettering the Evaluation and Care of Health
BI	Behavioural Intention
BMI	Body Mass Index
CB	Control Belief
CCA	Cost-consequence Analysis
CDM	Chronic Disease Management
CEA	Cost-effectiveness Analysis
CHD	Coronary Heart Disease
CMR health check	Cardio-Metabolic Risk health check
COAG	Council of Australian Governments
CVA	Cerebral Vascular Abnormality
CVD	Cardiovascular Disease
DBP	Diastolic Blood Pressure
DM	Diabetes Mellitus
DOB	Date of Birth
DoH	Department of Health
EPC	Enhanced Primary Care
FRE	Framingham Risk Equations
GP	General Practitioner
HDL	High-Density Lipoprotein
IBB	Instrumental Behavioural Belief
LDL	Low-Density Lipoprotein
MBS	Medicare Benefits Schedule
MCS	Monte-Carlo Simulation
MI	Myocardial Infarction
NB	Normative Belief
NHCDC	National Hospital Cost Data Collection
NHMD	National Hospital Morbidity Database
NHMS	National Health Measurement Survey
NHS health check	National Health Service health check
OR	Odds Ratio
PBC	Perceived Behavioural Control
PHC	Preventive Health Care
PHE	Periodic Health Examination

QALY	Quality Adjusted Life Year
QoL	Quality of Life
RACGP	Royal Australian College of General Practitioners
RCT	Randomized Controlled Trial
RR	Relative Risk
SA	Stable Angina
SBP	Systolic Blood Pressure
SD	Standard Deviation
SES	Socio-economic Status
SMR	Standard Mortality Rate
SN	Subjective Norm
TC	Total Cholesterol
TIA	Transient Ischemia Attack
TPB	Theory of Planned Behaviour
UA	Unstable Angina
WHO	World Health Organization

List of tables

List of figures

List of appendices

CHAPTER 1: Introduction

1.1 Introduction to the 45-49 year old health check in Australia

A health check refers to the practice of a comprehensive health assessment including medical history, physical examination and pathology tests to detect and manage risk factors and early onset of preventable diseases that may be acute or chronic in nature. The content of a health check is determined by the health status of the target population (e.g. the susceptibility to certain diseases). Therefore, screening for chronic disease, risk factors and cancers is usually emphasized in a middle-aged population. This thesis is about middle-aged general practice-based health checks, more specifically, the 45-49 year old health check program in Australian general practice.

The 45-49 year old health check is an Australian government (Medicare Australia) funded program for 45-49 year old population who are at risk of developing chronic disease.[1] A comprehensive check-up and guideline-based follow-up interventions are applied to prevent or delay the onset of chronic disease. According to advice from Medicare Australia, the health check content should include: a comprehensive personal and family history recording; physical examinations and risk factor investigations; an overall health assessment; and health advice or intervention.[1] Lifestyle counselling using the '5A' approach (Ask, Assess, Advice, Assist and Arrange) is also recommended.[2] The health check is undertaken by general practitioners who may have assistance from a practice nurse. All Australians aged 45-49 years with at least one of the following chronic disease risk factors are eligible:

- A family history of a chronic disease;
- Lifestyle risk factors (e.g. smoking, poor nutrition, physical inactivity or excessive alcohol use);
- Biomedical risk factors (e.g. high blood pressure, high cholesterol, impaired glucose metabolism or excess weight).

General practitioners are encouraged to either systematically, using mailed invitations, or opportunistically, during a routine medical consultation, invite patients to a health check. However, since the introduction of this program in 2006, it has not been comprehensively evaluated. Only a few studies have been undertaken with an emphasis on identifying the practical challenges in performing a health check from the perspective of health care providers (general practitioners and practice nurses).[3]

1.2 Thesis objectives

There has been no assessment of the 45-49 year old health check program in Australia to examine: the determinants of patient's attendance or the effectiveness and economic impact of the program on the health care system. To bridge this gap in knowledge the objectives of this thesis are:

- To investigate the effectiveness of general practice-based health checks;
- To understand patients' perceptions about general health checks and the psychological determinants of attendance at a GP invited health check;
- To compare the demographic characteristics and past health service use (including preventive health care) of attendees and non-attendees at the 45-49 year old health check;

- To examine the long-term health effects of the 45-49 year old health check and to quantify its economic impact on the health care system.

1.3 Research questions and hypotheses

The research questions and study hypotheses were:

- Do general practice-based health checks improve patients' health outcomes (either surrogate or final outcomes)? Are general practice-based health checks more effective than non-practice-based health checks? It was hypothesised that general health checks performed in conjunction with patients' routine health care are more effective in improving patients' risk profiles and reducing long-term morbidity and mortality than those performed in other settings.
- What are patients' perceptions about attending a general practice-based health check and how would these affect their intended and actual attendance at a practice-initiated health check? According to the Theory of Planned Behaviour, people's attitudes, perceived social pressure and barriers are predictors of their behavioural intention as well as their behaviour.
- What are the differences between attendees and non-attendees to a general practice-based health check in terms of their demographic characteristics and health service use in the past 12 months? It has been argued that health check attendees are likely to be socio-economically advanced and proactive about preventive health care.

- Is the 45-49 year old health check cost-effective from the perspective of Australian health care system? The effectiveness and cost-effectiveness of this health check program has not been assessed.

1.4 Overview of thesis structure and content

This thesis consists of four related studies as summarized in Table 1.

Table 1: Thesis structure

Chapter	***Research Question (Aim)***	***Contents***
Chapter 1	Introduction	General introduction to the thesis
Chapter 2	Literature review	Literature review of the development and research related to health checks
Chapter 3	The effectiveness of general practice-based health checks	A systematic review of general practice-based health checks studies
Chapter 4	Cohort study design and methodology	Descriptions of the cohort study design
Chapter 5	Patients' perceptions about a general health check and the psychological determinants of attendance	A cross-sectional questionnaire survey with prospective follow-up
Chapter 6	Demographic characteristics and health service use of attendees and non-attendees at a 45-49 year old health check	A medical record analysis study
Chapter 7	The long-term health effects of the 45-49 year old health check and its economic impact on the health care system	An economic modelling study
Chapter 8	General discussion and conclusion	

CHAPTER 2: Literature review

2.1 The scope of health check

Conceptually health checks are used to reduce the population incidence of preventable disease. Generally speaking, the content of a health checks is determined by nature of a disease or risk factor; prevalence of the disease; and effectiveness of the preventive measures. Therefore, health check procedures usually vary between target populations.

In Australia for example, four government-funded health check programs are available to different age groups in general practice.[4] They are:

1) A healthy kids check for children aged 3-5 years;
2) A health assessment for people aged 75 years and older
3) A type 2 diabetes risk evaluation for high risk people aged 40-49 years
4) A health assessment for people aged 45-49 years

Besides these general practice-based health checks, there are others provided in community clinics or ancillary health providers as well. The content and procedures of health check programs vary considerably and reflect the prevalence of health conditions and medical needs in their target populations. In the main, evidence-based screening is performed in line with recommendations from the Guidelines for Preventive Activities in General Practice (the Red Book) developed by the Royal Australian College of General Practitioners (RACGP).[2]

More specifically, the healthy kids check is an assessment of a child's physical health, general well-being and development, with the aim of facilitating early medical intervention.[5] It is usually delivered in conjunction with the four year old immunization schedule.[5] Assessments of height and weight, eyesight, hearing, oral health, toileting, allergies and immunization status are recommended for kids in this age group by the Red Book.[2]

Given the increasing burden and the natural history of chronic disease, the majority of health check programs worldwide are for middle-aged and elderly populations. Correspondingly, in Australia, aside from the healthy kids check, other health check programs target the middle-aged and elderly.

An annual health assessment program for the 75+ years was initiated as an important component of the Enhanced Primary Care (EPC) plan in 1999.[6] According to the descriptions of the 75+ health assessment program from Australia Department of Health (DoH)[7], the following preventive assessments or tests are recommended: blood pressure; pulse rate and rhythm; continence status; immunization; physical, psychological and social functioning.

The 40-49 years diabetes assessment program was initiated as part of the Council of Australian Governments (COAG) national reform agenda in 2007. As a disease specific health assessment program, the procedures are clearly defined, including the use of Australian Type 2 Diabetes Risk Assessment Tool (AUSDRISK) for overall risk evaluation, an assessment of other related risk factors and lifestyle counselling.[8]

Finally, the 45-49 year old health check program was launched in late 2006.[9] Comprehensive risk factor assessment and lifestyle counselling should be included in this program. More detailed information is outlined in the following discussion (see section 2.8.3).

As mentioned in the introduction chapter, this thesis is about the 45-49 year old health check (a middle-aged health check program) in Australian general practice. Therefore, the literature review concentrates on chronic disease and related preventive health care.

2.2 Chapter outline

This literature review provides background information about chronic disease and preventive health care; outlines the conceptual development of health checks from a historical perspective; summarizes important research on health checks and its influence on the delivery of services; reviews the controversies associated with health checks; describes current health check programs; and summarizes the existing evidence for the 45-49 year old health check program in Australia.

2.3 Background information

2.3.1 Global burden of chronic disease

Chronic disease (e.g. cardiovascular disease, diabetes mellitus and cancer) is the leading cause of morbidity and mortality worldwide and is projected to increase substantially in the next two decades.[10] According to a World Health Organization (WHO) estimate, 35 million people died from chronic disease in 2005, accounting for 60% of all deaths. Among them, cardiovascular disease (CVD) alone accounted for 30% of all deaths; cancers, chronic respiratory disease and diabetes accounted for another 20%.[11] Almost one quarter of chronic disease incidence occurred in people aged under 60 years.[11] The rising demand for medical resources has imposed an unprecedented burden on health care systems worldwide.[11]

2.3.2 Natural history of chronic disease

The causal links between demographic characteristics, socio-economic status, health behaviours and biomedical risk factors with chronic disease are well established.[12] Epidemiological evidence has demonstrated that healthy lifestyles (e.g. sufficient physical activity, balanced nutrition, moderate alcohol consumption and abstinence from smoking) and controlled biomedical risk factors (e.g. blood pressure, serum lipids, blood glucose and body mass index) are associated with lower incidence of cardiovascular morbidity and mortality.[13-15] According to the WHO, 80% of premature heart disease, stroke and diabetes and 40% cancers are preventable via early detection and management of risk factors.[11]

2.4 Preventive health care (PHC)

Preventive health care is an important component of primary health care. It encompasses the practice of individualized, evidence-based screening and health assessment of a target population.[2, 16] Quality primary health care requires a holistic understanding of health and continuity of health service (primary, secondary and tertiary prevention).[17] Correspondingly, preventive health care should adopt an integrated approach, focusing on multiple risk factors (both lifestyle and biomedical) and should be part of routine health care, especially when dealing with chronic conditions in the middle-aged and the elderly populations.[18] Preventive health care should also be systematic and ongoing at a population level.[2] Relevant guidelines and recommendations have been developed to improve the routine practice of preventive health care and the quality of government funded health check programs in Australia,[2] the UK,[19] and the US[20] respectively.

2.5 The conceptual development of health checks

The concept of a 'health check' has been referred to under different names in different eras, including Periodic Health Examinations (PHE), multiphasic screening, health screening and health assessment. The concept has evolved alongside the development of evidence-based medicine. Departing from their beginning as an exhaustive list of bio-physical measurements for all participants, health checks today stress not only guideline-based preventive health care, but also the continuity of health care.

2.5.1 A brief history of health checks and their purposes

The conceptual roots of health checks can be traced back to as early as 1861, at which time they were described as PHE. A British physician Horace Dobell proposed PHE for apparently healthy persons to identify 'pre-existent physiological states' of 'low health'.[21] A few decades later, an American physician George Gould endorsed the practice of comprehensive PHE for the purpose of collecting extensive medical data to inform the course of disease.[22]

The involvement of life insurance and corporate industry in the late-1800s and early-1900s, to a large extent, propelled the development of PHE. Some early evidence suggested reduced mortality among examined persons compared to the expected mortality, which was later translated to cost savings for private industry and insurance companies.[23-25] The potential for profit further drove PHE to be exhaustively comprehensive. At the time, the aim of PHE was to identify conditions which were considered to be economic hazards to corporate industry, rather than to improve patients' health outcomes or quality of life.[24]

By the mid-20th century, with the introduction of pre-paid health care plans, PHE in the name of multiphasic screening became exceedingly popular in local medical centres.[26] From the perspective of health care providers, the more comprehensive PHE were, the more likely that patients' medical needs would be determined and medical resources efficiently assigned.[27] However, the increasing demand for, and practice of, multiphasic screening raised concerns from academic scholars. They started to question the value of PHE in terms of its impact on health outcomes.[28] Thereafter, the emphasis of PHE started to shift from identifying the 'economically hazardous' health conditions to improving patients' health outcomes (morbidity and mortality).[28, 29] Two large randomized controlled trials were conducted in the 1960s to evaluate the health impact of exhaustive screening.[30, 31] Neither found significant improvements in either morbidity or mortality. Therefore, both studies concluded that multiphasic screening was of limited value.[30, 31]

By the 1970s, the lack of empirical evidence and calls for screening to be evidence-based triggered another round of comprehensive evaluations of multiphasic screening. Three reviews of existing clinical evidence on screening were conducted by health scientists from three organizations.[32-34] The clinical recommendations from these reviews further transformed health screening from exhaustive examinations to case-finding, which advocated general assessments tailored to the need of a target population.[35] Later in the 1970s, the WHO coordinated a CVD risk screening trial among blue collar workers in workplace clinics across five European countries.[36] Reflective of the changes in concept, this trial adopted a less exhaustive screening protocol but incorporated certain follow-up interventions. The trial reported small improvement in risk factors after a health check.[36]

Later in the 1980-1990s, as the growing demand for combining screening with routine health care and calls for continuity of health care, more screening was performed in general practice. The term ‘health check’ has been widely used since then. At the time, a number of clinical trials were conducted in European countries to evaluate the effectiveness of general practice-based health checks, emphasizing their effect on risk factor control and management. Significant surrogate outcome benefits were reported in these trials.[37-39]

2.6 Important trials of health checks

Since the 1960s, a number of Randomized Controlled Trials (RCTs) were conducted to evaluate the effectiveness of health checks. The results of these trials informed the conceptual development of health checks over the decades. These studies reflect three development phases: multiphasic screening in the 1960s, the multifactorial trial in the 1970s; and health checks in the 1990s. In the 1960s, the multiphasic screening trials focused solely on performing pathology tests; few addressed subsequent interventions for identified risk factors and most used mortality, morbidity and subsequent health service use as primary outcomes. In the 1970s, studies started to address subsequent management of screening detected risk factors. From the 1990s onwards, the focus of health checks shifted from screening to screening and intervention. These changes reflected the development of pharmacological and behavioural interventions and improvements in knowledge gained from trials.

2.6.1 Multiphasic screening trials in the 1960s

Multiphasic screening is a combination of screening for multiple diseases and assessment of risk factors. In the early 1960s when it became widely accepted, people began to request multiphasic screening from local health care centres. At this stage, the focus of health screening was to predict morbidity and mortality rather than to control and manage risk factors. Furthermore, as it was treated as a separate clinical consultation at the time, very few patients with screening detected risk factors were referred to their regular health care provider for further intervention or treatment.

Two large randomized controlled trials were conducted in the 1960s to assess the clinical effectiveness of multiphasic screening: the Kaiser Permanente [31] and the South-East London screening studies.[30] The Kaiser Permanente study was an American study (California) conducted in 1965. Patients aged 35-54 years who were members of the Kaiser Permanente health plan (a plan for people in employment) were recruited. Participants in the intervention group (5138 patients) were urged to attend annual multiphasic screenings in community health centres for 16 years, while voluntary attendance was encouraged in the control group (5536 patients). A wide spectrum of pathology screening tests were implemented.[31]

The South-East London study was a general practice-based multiphasic screening study in 1967. Patients aged 40-64 years registered with a general practice were recruited and randomized into screening and control groups, with each group having more than 3,000 participants. Only participants in the intervention group were invited to the initial screening. Five years later, a screening was offered to participants in both groups. Altogether, this study followed participants for up to eight years.[30]

Reflecting the purpose of screening at the time, these trials adopted morbidity (self-reported disability, chronic disease), health service use (GP consultation and hospitalization) and total or disease specific mortality as study outcomes. Neither reported changes in lifestyle or biomedical risk factors. Unsurprisingly in retrospect, both trials failed to prove that screening led to significant reductions in morbidity or mortality and both concluded that multiphasic screening was of limited effectiveness.[30, 31]

2.6.2 The Multifactorial trial in the 1970s

Coordinated by the WHO, the multifactorial trial of coronary heart disease prevention was a cluster randomized controlled trial, conducted in five European countries: Belgium, Italy, Poland, Spain, and the UK. This study was undertaken in the workplace and targeted male blue-collar workers.[36] Altogether, around 30,000 participants were recruited in the intervention and control factories respectively. Baseline screening was offered to all participants in the intervention factories and a 10% random sample from the control factories. The trial followed participants for 5-6 years.[36]

Unlike studies from the 1960s, the screening procedures of the multifactorial trial were less exhaustive, and the trial protocol clearly outlined follow-up interventions for participants identified at high risk. Morbidity, mortality and surrogate outcomes (blood pressure, total cholesterol and smoking) were used to assess benefits of the intervention.[36] These changes marked a shift towards risk factor management in health screening programs. The trial demonstrated small but statistically significant improvements in risk factor control after a health check.[40] However, no differences were reported in either total or CVD related mortality.[41]

2.6.3 Health checks in the 1990s

Disputes about the effectiveness of health screening continued in the 1990s. Along with the development of evidence-based medicine and increased knowledge about the causal link between surrogate and final health outcomes, it was suggested that health screening should be tailored to the needs of a patient and that continuity of health care (management of lifestyle and biomedical risk factors) should be stressed.[35] It was further argued that health screening should be performed in conjunction with routine health care in general practice, not only because people regularly visit GPs, but also because GPs are medical generalists, who are familiar with a patient's physical and mental health and are able to deliver comprehensive and ongoing health services. Moreover, it was thought that the positive rapport between GP and patient could facilitate the implementation of such screening and intervention programs.[42]

These conceptual changes led to the initiation of government funded regular health checks for the general population under the British general practice contract in 1990. The policy aroused academic and economic controversy. Two general practice-based health checks RCTs were conducted in the UK at the time: the OXCHECK study and the British Family Heart (BFH) study.[37, 38] The OXCHECK recruited patients aged 35-64 years in participating practices. The study participants were randomized into intervention (2,760 patients) and control groups (2,783 patients). The initial health check was offered to participants in the intervention group at years 1, 2 & 3 respectively. All participants were invited to an exit health check at year four.[37] The BFH adopted a family intervention strategy by randomizing the 40-59 year old male patients in practices into intervention (2,373 patients) and control group (2,342 patients) and invited their partners along with them to participate. Participants in the intervention group were invited to an initial health check. One year later, all study participants and their partners were invited to an exit health check.[38]

In these trials, the health checks only included limited routine measurements (e.g. blood pressure, total cholesterol, height and weight) and assessments of lifestyle factors (e.g. smoking and nutrition). Surrogate outcomes were used as primary outcome measures instead of morbidity and mortality. Both the OXCHECK and BFH studies reported improved control of risk factors after the health checks, which was equivalent to a 12-13% reduction in CHD events in the long-term.[37, 38] At about the same time, a smaller health check RCT was conducted in Denmark.[39] This study randomly recruited patients aged 30 to 50 years from family practices in a single district. Study participants were then randomized into intervention (1,006 patients) and control (501 patients) groups. The intervention constituted two sub-groups: screening only (502 patients) and screening with annual health discussions (504 patients) sub-groups. It was concluded that, even though no differences were observed between the two intervention sub-groups, at the end of 5-years follow-up, the proportion of patients at elevated or high risk of CVD (CVD Risk Score (CRS)*>10 points)[1] halved in the intervention group (as a

[1] CRS is calculated based on individual's pre-existing risk factors including gender, family history of premature CVD, smoking status, BMI, diastolic blood pressure and serum cholesterol level. Individuals were categorized into low-risk (0-5 points); moderate risk (6-9 points); elevated risk (10-15 points) and high risk (>15 points)

whole) compared to that in the control group.[39] Mortality was reported as secondary outcomes in two of the three studies and no difference was found in either.[37, 43] However, none of these trials were designed or powered to detect a difference in either morbidity or mortality. Even though these RCTs demonstrated improved risk profiles and decreased CVD risk after health checks, critics argued that the benefits, especially the improvement in blood pressure could be attributed to patients' accommodation to the measurement, which were not clinically relevant.[37, 38]

2.7 Debates about general health checks in the 21st century

The controversy about general health checks have continued in the 21st century. The debate has centred on the effectiveness of general health checks, the potential harmful physical or psychological effects on participants, the settings, and also their cost-effectiveness.

2.7.1 Effectiveness of health checks

Krogsbøll and colleagues published a Cochrane review of general health checks in 2012. It concluded that such programs failed to improve total and disease-specific mortality; and there was no strong evidence suggesting they would reduce either morbidity or subsequent health service use.[44] Sixteen eligible trials were identified in this review and nine were included in the meta-analysis. The 16 included trials were published from the 1960s to the 2000s and conducted in different settings including general practice (5/16), community health centres (10/16) and the workplace (1/16).[44]

Despite the historical development in concept, the changing emphasis and application of health checks/screening, the authors did not perform subgroup analysis to differentiate study settings.[44] More importantly, the authors dismissed the use of surrogate outcomes as indicators of health check effectiveness. They argued that surrogate outcomes have unreliable effects on morbidity and mortality and that using them might conceal other harmful effects of health checks. The authors further questioned the sustainability of surrogate outcome change after intervention.[44] It is true that there are disadvantages with surrogate outcomes, especially when they are used as sole indicators in clinical trials.[45] However, considering the well-established correlations between surrogate outcomes (e.g. blood pressure, total cholesterol, etc.) and chronic disease,[4] the wide use of surrogate outcomes in routine medical practice, and also the conceptual development of health checks,[46] the measurement of surrogate outcomes could have a place in gauging the effectiveness of a health check and the following management of risk factors.

Another systematic review by Boulware and colleagues investigated the value of Periodic Health Examinations (PHE) in improving the provision of guideline-based preventive health care.[47] Twenty-one controlled trials comparing PHE versus usual care were included in this review. A qualitative synthesis of study results demonstrated increasing uptake of recommended screening in the PHE group. The review also reported beneficial psychological effects of PHE on participants. Mixed results were found concerning the clinical (surrogate and final) and economic impact of PHE.[47]

2.7.2 Adverse outcomes of health checks

The most commonly discussed adverse outcome of health checks is a negative psychological effect. It has been pointed out that patients who are not adequately prepared for risk labelling may suffer from short-term psychological distress.[48, 49] Some scholars have also argued that receiving an invitation for a health check could cause anxiety among some patients.[50] However, further studies found no short-term harmful psychological effects among patients being labelled as 'high risk' in a health check,[51-54] nor did the detection of early disease affect patients' quality of life in the long-term.[55-57] In addition, any negative influences could potentially be minimized if the screening and follow-up interventions were carried out by a regular health care provider.[58, 59]

No study has investigated the impact of false positive or false negative results on participants. Nevertheless, the health check procedures are guideline-oriented. For test-positive patients, confirmatory tests should be undertaken before diagnosis; while for test negative patients, appropriately timed regular re-checks can be scheduled. Therefore, the effects of false test results should be minimized. Moreover, general health checks differ somewhat from other targeted screening programs (e.g. cancer screening) because, in comparison: 1) the majority of tests in a health check are routinely available and familiar to participants; 2) the procedures are usually less invasive and 3) arguably, the results are usually less threatening to patients. However, it is possible that some GPs would use a health check program to perform screening tests that are not recommended by clinical guidelines (e.g. the prostate-specific antigen tests), especially for patients who are not frequent users of preventive health care. The possibility of over diagnosis under these circumstances should be considered as an adverse effect of a health check program. No studies have investigated the possibility and impact of over diagnosis in general health check programs.

2.7.3 Health checks in general practice

Historically, general health checks have been offered variously in the workplace, community health centre, pharmacy and general practice (family practice). Ever since the effectiveness of multiphasic screening was questioned,[35] there has been arguments about incorporating screening into routine medical practice to improve the continuity of health care.[60] As the main providers of health services for people in the community, general practice (or its equivalent) is better placed to provide health checks because a patient's overall health status is well known.[2] Additionally, a long-term clinical relationship is important in influencing patients' health perceptions and encouraging treatment compliance.[61] Lastly, general practitioners and practice nurses acknowledge their responsibility to provide preventive health care and agree that general practice is an ideal place for health checks.[3, 62]

2.7.3.1 The role of the practice nurse in the health check

Practice Nurses (PN) have emerged as important providers of health services including health assessment, lifestyle interventions and chronic disease management.[63-65] Evidence has demonstrated that PNs are capable of providing high quality preventive health care.[66] In addition, patients are generally confident about the clinical decisions and recommendations made by PNs,[67] with the majority of them satisfied with their experiences.[63, 67]

Current health check programs generally allow PNs to take an important role in organizing or conducting assessment in general practice. Their contribution ranges across patient identification, risk measurement, overall risk evaluation, counselling, patient education and follow-up arrangement.[68] For instance, the health check program in the Netherlands is entirely managed and conducted by PNs, with GPs only involved in the treatment of diagnosed or high risk patients.[62]

2.7.4 Economic considerations

The substantial professional resource burden and financial costs of health checks are important concerns.[69] However, it has also been argued that an all-in-one health check could potentially be cost saving, considering the increasing practice of preventive health care in routine medical practice.[70] Therefore, cost-effectiveness analysis has been widely applied in the evaluation of health check programs and also in informing policy making.

Three modelling studies have investigated the cost-effectiveness of regular (5-yearly) health checks in middle-aged populations in six European countries and Australia.[71-73] All of them simulated changes in population incidence of CVD and diabetes and concluded that regular health checks followed by guideline-oriented interventions for population aged 40 to 75 years are likely to be cost-effective in their respective settings (see 2.9.3 for detailed descriptions).

2.7.5 Other objectives of health checks

In the modern context, general health checks are not only part of preventive health care at an individual level, but also embody public health significance including improving quality of preventive health care; tackling health inequalities; and promoting health knowledge (e.g. healthy lifestyles).[74, 75]

2.7.5.1 Bridging gaps in preventive health care

Guidelines for preventive health care recommend regular assessment of chronic disease risk factors (e.g. blood pressure, serum lipids and blood glucose) for all middle-aged individuals regardless of their risk profiles.[2, 76] There are considerable gaps in the provision of guideline-based preventive health care worldwide, especially for the purpose of primary prevention.[77-81] Thus, health checks for the general population may potentially improve the quality of preventive health care, especially among high risk patients.

In Australia, gaps between guideline-based and routine practice of preventive health care have been identified in both the assessment and management of risk factors in general practice. The Bettering the Evaluation and Care of Health (BEACH) study in 2006, found that the recording of blood pressure and low-density lipoprotein (LDL) cholesterol was missing for 13% and 53% (respectively) of all patients who should have been tested. Among patients for whom the calculation of absolute CVD risk was recommended, 26% had at least one risk factor missing from their records.[78] Besides the documented provision of preventive tests, there were also gaps in prescriptions and treatment target attainment.[78] Taking LDL as an example, not only was a prescription indicated for 41% of patients who had not been medicated; among those who had been prescribed, 38% did not achieve target LDL levels.[78] Moreover, GPs had general misconceptions about patients' CVD conditions and overall risk.[82] Furthermore, considerable gaps existed in routine assessment and management of lifestyle risk factors in Australian general practice.[83] Nevertheless it can be expected that structured and well-organized health check programs would potentially improve both the accessibility[47] and the quality of preventive health care in a target population.[74, 75]

2.7.5.2 *Combating health inequalities*

Health inequalities refer to 'differences in health status or in the distribution of health determinants between different populations'. When the differences are avoidable or unfair, they lead to inequities.[84] Health inequalities are associated with gender, ethnicity, age (the elderly), socio-economic status and mental health status.[85] The causes of health inequalities include social determinants of health (including education, income, occupation and SES) and access to quality health care.[85]

Disappointingly, the improved clinical management of health conditions over the last few decades may have exacerbated the extent of health inequalities.[86] According to a report from the Australian Institute of Health and Welfare (AIHW) in 2006, significant health inequalities in morbidity, lifestyle, risk factors and health service use were observed between the least and the most socio-economically advantaged groups.[87] Similarly, in England it is estimated that in the past 10 years, health inequalities between social classes have increased by 4% and 11% among males and females respectively,[85] which is possibly associated with the observation that higher social class groups tend to respond better to health promotion programs than do lower social class groups.[85]

Tackling health inequalities is a complex task involving collaboration between different sectors and departments. Primary health care providers are at the frontline of this endeavour.[85] Making quality preventive health care (e.g. standard health checks and subsequent intervention programs) both financially and geographically accessible to patients in need (low SES or vulnerable populations) would contribute to bridging the gap. In fact, one of the objectives of a recently initiated health check program in England was to reduce health inequalities.[70]

2.7.5.3 *Promoting healthy lifestyles*

Unhealthy lifestyles including physical inactivity, smoking, poor nutrition and excessive alcohol consumption contribute to chronic disease. As an important component of preventive health care, lifestyle counselling has been recommended and incorporated as part of routine medical practice.[2]

As primary health care providers, GPs or PNs are accessible to the general population, and thus could potentially extend individualized lifestyle counselling to the majority of people in the community. However, there exist practical difficulties in systematically providing such services to everyone, due to limited resources. Organizational supports including improved infrastructure, training, guidelines and funding are required to facilitate such practice.[65] Therefore, government funded health check programs, by providing remuneration or other incentives, are likely to be a starting point to address these practical challenges.

2.8 Concurrent health check policies

Despite the ongoing controversy about health checks in middle-aged populations, during the past 5 years, programs have been initiated in several countries (England, the Netherlands and Australia). The aims, target populations and protocols may differ, but generally, all programs target a middle-aged 'well' population with no prior diagnosis of cardio-metabolic disease. Different reimbursement rates have been assigned to these health check programs, reflecting the complexity of the assessments and the involvement of various health professionals.

2.8.1 England

The National Health Service (NHS) health check program in England was initiated in 2010. It provides five yearly check-ups for 40-74 year old 'well adults'. The clinical objective of this health check program is to lower the population risk of heart disease, stroke, diabetes, kidney disease and some forms of dementia.[88] The other implied purposes of this program include: improving guideline-based quality health care and reducing health inequalities. According to the newly updated program guideline (April 2013), patients with existing chronic disease; already taking statins; or those who have already been fully checked and estimated to have high absolute risk of CVD (20%+) in the following 10 years are not eligible for further health checks.[70] The standard procedures include: mailed invitations, systematic screening, CVD risk factor measurement, absolute risk assessment, risk communication and lifestyle counselling.[88] Standard interventions and referral pathways are recommended for high risk patients. The health checks can be offered in general practice or local pharmacies.

2.8.2 The Netherlands

In the Netherlands, the cardio-metabolic risk (CMR) prevention consultation guideline was finalized in 2011. According to this protocol, all people aged 45-70 years without a diagnosis of cardio-metabolic disease and not on medication for high blood pressure or lipid abnormality are eligible for a CMR health check.[62]

A stepwise patient screening procedure is outlined in the guideline. A pre-screening questionnaire is used to identify relatively high risk individuals in the community, who are later invited to a CMR health check in general practice. In the first practice consultation, medical history, pathology tests and an overall assessment of CVD risk are performed by a PN. A second practice consultation is indicated if an individual is deemed at high risk of CVD in the initial assessment. The second practice consultation is also conducted by a PN, at which confirmatory tests are performed. Then the diagnosed patients are referred to their GP for further management.[62]

2.8.3 Australia

The 45-49 year old health check program was introduced to Australian general practice by Medicare Australia in 2006.[9] Eligible patients are of 45-49 years old and are at risk of developing chronic disease with at least one identifiable risk factor including lifestyle or biomedical risk factors or family history of a chronic disease.[1] As distinct from other health check programs, instead of excluding those with pre-existing biomedical risk factors (high blood pressure, high cholesterol or impaired glucose metabolism), an individual's eligibility is left to the discretion of a GP. For instance, patients who have a chronic disease (e.g. diabetes, asthma or rheumatoid arthritis) are eligible for a government funded chronic disease management plan which allows referral to allied health professionals and can involve review visits. To complete a 45-49 year old health check, a comprehensive personal and family history examination; risk factor measurement; an overall health assessment; and health advice or intervention should be incorporated in the initial consultation.[1] Lifestyle counselling is also recommended.[2] The health check can be operated by GPs or, under supervision, by PNs. However, Medicare does not provide specific details of follow-up procedures (e.g. the numbers of associated GP encounters or subsequent intervention plans). General practices are encouraged to either systematically, using mailed invitations, or opportunistically, during a routine consultation, invite patients to attend.

2.9 Health check research

Research about health checks in middle-aged populations has generally examined three aspects: attendance at health checks; the effects of health checks; and the economic impact of health check programs.

2.9.1 Attendance at health checks

There are concerns about unselectively inviting people to a health check.[69] It is argued that screening relatively low risk individuals could increase the chance of false positives.[69] However, given the increasing prevalence of risk factors (e.g. physical inactivity, poor nutrition and high BMI) and gaps in the provision and quality of preventive health care,[77-81] it is possible that a number of these unlabelled patients may have never had a comprehensive check-up. A health check program could potentially bridge this gap. As indicated in a pilot study in England, of all participants eligible for the NHS health check, 10-22% had a high CVD risk (10 year CVD risk >=20%).[89] Through the NHS health checks, a large number of unidentified high risk patients would be picked up.

Most health check programs today target populations, usually based on age, who are at risk of developing chronic disease. Others recruit high risk participants using pre-screening procedures. Studies have been undertaken to investigate the health check attendance rate in different settings; to compare patient recruitment strategies; and to examine the determinants of patients' attendance at health checks using demographic, health status and psychological indicators, as discussed below.

2.9.1.1 *Invitation strategies*

There are two different classes of patient invitation strategies: [1] positive invitations using a systematic mail-out or alternatively an opportunistic approach during routine consultations; or [2] passive invitations using posters or leaflets in general practice. A pilot study of the CMR health check program in the Netherlands demonstrated that patients were more responsive to positive invitations with a personal letter (33% response rate) than to passive invitations by posters or leaflets (1% response rate).[90] Of the positive invitation strategies, a systematic invitation was more effective by reaching nearly twice as many patients as opportunistic invitations in one study.[91] Pragmatically a combined invitation strategy (both systematic and opportunistic invitation) could be used in general practice.

In recent years, to encourage attendance, other positive invitation strategies have been trialled. For instance, the uses of monetary incentives and individualized pre-consultation preventive health care reminders have been studied in Australian general practice.[92, 93] The methods used have proven practical and the use of preventive health care reminder was well accepted by both patients and practice staff in a pilot study.[93] Further research is required to investigate their effects on improving attendance at health checks in general practice.

2.9.1.2 *Determinants of health check attendance*

Attendance at a general practice-based health check varied between 20-50% in recent studies.[68, 90, 92, 94, 95] Even so, the usefulness of health checks is widely accepted and highly regarded by patients regardless of their attendance. Research showed that not only did 71-81% of attendees regard the experience as helpful and satisfactory, but around 80% of non-attendees agreed that health checks should not be confined to those with symptoms.[96-99] On the other hand, a major concern about health checks is the 'worried well' effect,[100] which refers to the belief that health check attendees are more likely to be healthier and more socio-economically advantaged than non-attendees. A variety of factors have been shown to be associated with attendance at health checks including an individual's demographic characteristics, health status and psychological determinants – as discussed below.

2.9.1.2.1 Demographic characteristics

A review of literature yielded mixed results regarding the demographic determinants of health check attendance. Compared to most contemporary studies (within 5 years), earlier studies were more likely to demonstrate significant demographic disparities (including age, gender, marital status and SES) between attendees and non-attendees. Generally, the elderly, females, married and high SES individuals were more likely to attend compared to others.[101-106] Nowadays, with improved understanding and increasing accessibility to preventive health care, demographic differences have been less pronounced in more recent studies. A pilot study of the CMR health check in the Netherlands did not find any significant differences in age, gender, marital status, education and ethnic background.[90] A cohort study in the UK (a pilot study of the NHS health check) only found a lower attendance rate in the younger population (aged 35-54 years).[94] In Australia, national statistics seemed to suggest higher attendance at the 45-49 year old health check in lower SES groups.[107]

2.9.1.2.2 Health status

Two studies in the UK and the Netherlands investigated correlations between patients' health conditions and their health check attendance. These studies reported increased attendance amongst patients with pre-existing biomedical risk factors (e.g. hypertension) or a family history of chronic disease.[90, 94] However, those with either self-reported or recorded lifestyle risk factors (e.g. smoking, physical inactivity, excessive alcohol consumption, and overweight or obesity) were less likely to attend.[90, 94] No study has examined the correlation between patients' attendance at a health check and their past health service use including recent uptake of preventive health care.

2.9.1.2.3 Psychological determinants

Evidence indicates that patients today tend to be health conscious and rational when making decisions about health behaviours. A qualitative study of patients who had refused a health check found that the majority were fully aware of the potential benefits and limitations of health screening; they stressed their own responsibility to maintain good health and stated that they would actively pursue health care if they regarded it as necessary.[108]

To better understand patients' decisions and to promote health check attendance, a variety of Social Cognitive Models (e.g. the Health Belief Model, the Health Utilization Model and the Theory of Planned Behaviour) have been applied to analyse health-related decision making.[109-114] Generally, the following aspects have been found to be of relevance: 1) perceived necessity of performing a health behaviour; 2) perceived benefits/harm of doing it; 3) perceived social pressure to do it; and 4) perceived barriers to performing the behaviour.

In the context of health checks, the most common reasons for refusal include: disinterest, perceived lack of necessity, already been checked; fear of positive results; time pressure on keeping an appointment and other practical reasons.[106, 115, 116] Specifically, for patients to attend a health check, they have to first acknowledge the necessity of having one (e.g. to overcome disinterest, perceived lack of necessity), which is influenced by their perceptions about their own health status and their recent uptake of preventive health care (e.g. already being checked). Furthermore, patients' knowledge and emotional perceptions (e.g. fear of adverse results) about health check procedures and outcomes influence their decisions about attendance. In other words, if patients' positive perceptions outweigh the negative ones, they are more likely to have positive attitudes and eventually attend a health check. Furthermore, perceived barriers are also important factors to consider (e.g. time pressure on keeping an appointment, cost and other practical reasons). To improve attendance requires an understanding of such influencing factors in the target population and implementing interventions to reinforce facilitating factors while reducing the inhibiting ones.

2.9.2 Effects of health checks

A considerable proportion of attendees are either diagnosed or treated after a health check. One of the pilot NHS health check studies in England reported that new treatments were initiated in 29.8% of all eligible patients after a health check.[95] Two pilot studies of the CMR health check reported that, after the initial questionnaire assessment, 64% and 75% respondents (respectively) were considered at higher risk and thus invited to a further practice consultation.[68, 90] Although the practice attendance rates varied in the two studies (36% vs 72%), both of them found that, among patients who attended the practice consultation, more than 20% were diagnosed with at least one condition that required further medical attention (e.g. hypertension, hypercholesterolemia or diabetes).[68, 90]

Surrogate outcomes (e.g. blood pressure, serum lipids, smoking status etc.) and assessment of absolute CVD risks were widely used as outcome indicators in recent health check studies. A few cohort studies reported improvements in relevant risk factors leading to an approximate 10% decrease in absolute CVD risks among attendees.[117, 118] However the effects of a health check on lifestyle modification remains uncertain. Although one study reported improved patients' readiness to change their lifestyle after a health check,[119] most studies concluded limited effectiveness of lifestyle interventions in general practice. The Health Improvement and Prevention Study (HIPS study) in Australian general practice reported that, except for an increase in self-reported physical activity, no significant changes in either behavioural or biomedical outcomes were observed one year after practice-based lifestyle counselling.[120] Similarly, a RCT in the Netherlands did not demonstrate any beneficial effects of practice-based lifestyle interventions either.[121, 122] These evidence inevitably casts doubt on the effectiveness of general health checks. Clearly, more effective lifestyle intervention approaches, for instance the '5A' approach,[2] need to be implemented and trialled in general practice.

2.9.3 Economic evaluations of health check programs

Prior to the launch of the NHS health check in England, an economic model was constructed at the request of the Department of Health (DoH) to simulate the potential effectiveness and cost-effectiveness of the program.[71] After extensive scenario analyses of different target populations and health check procedures,[71] the model concluded that regular (5 yearly) health checks to the 40-75 year population with no pre-existing chronic disease tend to be the most cost-effective scenario.[71, 72] It concluded that, if an overall 75% uptake rate was achieved, this program would prevent at least 9,500 incident cases of heart attacks and strokes and 4,000 of type 2 diabetes a year, at a cost of £2,480 per QALY (approximately equivalent to $4500 AUD per QALY) in a lifelong projection.[71]

Two other modelling studies of the NHS health check compared the effectiveness of different recruitment strategies.[123, 124] Both studies concluded that the effectiveness of health checks would be improved if more selective recruitment strategies targeting high risk patients were adopted.[123, 124] At a general practice level, a stepwise screening approach using routine medical records and risk scores was recommended.[123] At a population level, targeting deprived communities or people with a family history of premature CVD could be more cost-effective.[124]

Since the publication of the economic evaluation of NHS health checks in England, models have been constructed to evaluate the cost-effectiveness of similar health check programs in other counties, including Australia.[72, 73] The Australian study concluded that, if the same screening and intervention protocols as the NHS health checks were applied in the local context, the program would be cost-effective (at a cost of $14,000 AUD per QALY) in a five-year projection.[73]

Another modelling study by Schuetz and colleagues simulated the cost-effectiveness of health checks in six European countries (Denmark, France, Germany, Poland, Italy and the UK).[72] By adopting screening and intervention procedures similar to the NHS health check, the author concluded that, in a 30-year projection, the program was likely to be cost-effective or cost saving in all simulated countries.[72]

Methodologically, all studies obtained representative individual level data either from general practice or a national survey. Guideline-oriented intervention programs were applied to individual patients with screening detected high risks. The effectiveness of health check programs were estimated by simulating the screening and intervention procedures, including detection rates, intervention rates, compliance rates and the effectiveness of intervention strategies (e.g. smoking cessation; medications of anti-hypertensive, statins and lifestyle interventions). However, the applicability of the model was limited to health check programs with well-organized and subsidized intervention strategies following the initial assessment. The 45-49 year old health check is a one-off visit in Australian general practice. No follow-up intervention protocols or funding have been specified by the Australian DoH in contrast to the NHS health checks. Therefore, this model and its results may not be applicable to the 45-49 year old health check program. Till now, the effectiveness and cost-effectiveness of the 45-49 year old health check program remains unevaluated.

2.10 Australian context

2.10.1 Burden of chronic disease in Australia

Chronic disease in Australia has accounted for more than two thirds of the burden of all disease in recent years.[125] CVD alone accounted for a third of all deaths in 2007.[125] In the 2011 Australian National Health Survey (ANHS), more than 16% of adult respondents self-reported suffering at least one circulatory system disease and 4% were diagnosed with Type 2 Diabetes Mellitus (T2DM).[126] CVD and DM were also the most common reasons for health service use (i.e. GP consultation, hospitalization and medication).[125]

2.10.1.1 *Prevalence of risk factors*

The increasing prevalence of lifestyle and biomedical risk factors is probably the underlying cause for the rising chronic disease burden in Australia. According to the 2011 ANHS, 18.0% of Australian adults were current smokers; 62.8% were overweight or obese; 67.5% were sedentary or physical inactive; and 19.5% consumed an excessive amount of alcohol that would lead to long-term harmful effects.[126] The 2011 National Health Measurement Survey (NHMS) reported the prevalence of high blood pressure and elevated total cholesterol and LDL to be 21.5%, 32.8% and 33.2% respectively in adults.[127] According to the estimates by Australian Institute of Health and Welfare (AIHW), 94% male and 89% female Australians aged between 45-54 years have at least one risk factor (lifestyle or biomedical) for cardio-metabolic diseases.[128]

2.10.2 The 45-49 year old health check

In 2006, the Council of Australian Governments (COAG) launched the Australian Better Health Initiative (ABHI). This initiative, for the first time, explicitly stressed the importance of primary prevention in the context of general practice. Later that year, the 45-49 years ‘well person’ health check program was introduced in Australian general practice.[9] Detailed procedures of this health check program were described earlier in this chapter under sub-heading 2.8.3. Since the initiation of this program in 2006, it has not been comprehensively evaluated. Limited studies have been undertaken with an emphasis on the practical challenges in performing a health check from the perspective of health care providers (GPs and PNs).[3]

45-49 years is considered a critical age band for preventive health care. According to the 2011 ANHS, the population prevalence of preventable chronic diseases or conditions (including type 2 diabetes, cardiovascular disease, hypertension and kidney disease) increases dramatically from the 35-44 year age group (with prevalence rates of 1.7%, 1.6%, 14.9% and 0.6% respectively) to the 45-54 year old age group (with prevalence rates of 4.2%, 3.9%, 25.6% and 1.1% respectively).[126] However, when compared to older population groups, 45-50 year olds were less conscious about preventive health care or regular check-ups. A cross-sectional study demonstrated that only 39%, 38% and 66% of middle-aged Australians (41-50 years) regularly monitored their cholesterol, blood glucose and blood pressure levels respectively, significantly lower than those aged above 50 years.[129] Additionally, only 8% of 41-50 year olds consulted a GP for a disease prevention plan compared to 21%, 25% and 30% among those aged 51-60, 61-70 and 71-80 years respectively.[129] On the other hand, the majority (94%) of 41-50 year olds reported positive attitudes towards health and preventive health care and 87% of them were willing to attend an annual health assessment.[129] Furthermore, as an important component of the ABHI, the 45-49 year old health check not only aims to facilitate early detection of chronic disease risk factors, but also to promote and support lifestyle change. Among 45-54 year old Australians, 22.9% were current smokers (21.2% were daily smokers); only 6.1% consumed adequate fruit and vegetables as recommended by the Australian dietary guidelines; and approximately 23.1% and 31.9% of 45-54 year olds were inactive or insufficiently active during any given week and 74.1% of the 45-49 year olds were overweight (39.1%) or obese (32.0%).[126] Lifestyle interventions therefore need to be emphasized in this population.

Even though advice for the 45-49 year old health check from the Australian DoH emphasizes the assessment of biomedical and lifestyle risk factors for CVD and behavioural interventions,[1] other screening is encouraged.[2] According to the Red Book,[2] opportunistic screening for depression is recommended in general practice for Australian adults aged 18 years and above; opportunistic skin examination is recommended for high risk individuals aged 40 years and above; and a biannual pap test is to be performed for all sexually active females aged 18 years and above. Therefore in general practice, brief evaluations of depression and screening for cancer are often, but not universally incorporated into the 45-49 year health check.

2.10.2.1.1 Policy changes

At the time when the 45-49 year health check was introduced in 2006, Medicare Australia did not provide detailed descriptions on either the eligibility criteria or the health check procedures. Thus the processes were not fully understood by GPs.[3] The length and depth (quality) of the health check varied between providers. Generally speaking, 1-3 consultations were undertaken to complete the health check, depending on patient's SES and GP's availability.[3]

Later, in 2010, Medicare revoked the single reimbursement rate for this health check program and adopted a more flexible reimbursement mechanism by taking into account the length of the initial consultation. In the amended scheme, a health assessment lasting less than 30 minutes was reimbursed at $58.20 AUD (MBS item 701); a 30-45 minutes consultation at $135.20 AUD (MBS item 703); a 45-60 minutes consultation at $186.55 AUD (MBS item 705); and a more than 60 minutes consultation at $263.55 AUD (MBS item 707).[1] Furthermore, detailed program templates were developed and recommended by the Australian DoH (Appendix 1). The involvement of PNs was described and encouraged.[1] These changes not only clarified the priorities and emphasis of this health check program, but also simplified its procedures. More importantly, the flexible reimbursement rates seem to address the 'worried well' effect. For patients at low risk or those who had already had relevant preventive tests, only a short consultation is necessary, while for patients who have not been checked, a longer consultation would be required.

2.10.2.1.2 GPs' attitude towards the 45-49 year old health check

GPs' attitudes towards preventive health care, to a large extent, influence the provision and quality of a health check. A qualitative study of 13 GPs in Sydney reported that, although most GPs acknowledged their obligations to provide preventive health care, the majority of them did not regard this as their priority, especially when dealing with behavioural risk factors.[3] They believed that, even though health professionals are responsible for providing lifestyle information and counselling, the choice of behavioural change and further help seeking should be left to patients.[3] Furthermore, GPs were generally concerned about the potential yields from the 45-49 year old health check and the effectiveness of lifestyle interventions.[3] Other commonly expressed concerns about this health check were the extensive workload implications and the amount of reimbursement.[3] However, the amended time-dependent reimbursement rates, the availability of procedure templates, together with the involvement of PNs in the process may, to some extent, relieve these concerns.

Although it is well-recognized that continuity is essential in preventive health care, a responsive and effective chain of health services, especially for lifestyle interventions, has yet to be established in most states in Australia.[65, 83] One of the most prominent issues identified for the 45-49 year old health check was GPs' reluctance to refer patients to allied health professionals or community organizations.[65] The following reasons have been suggested: [1] At-risk patients who have not developed chronic disease do not qualify for any subsidized health referral programs, therefore, referrals would impose financial burdens on patients; [2] Only loose connections exist between general practice and other health care services; [3] Many GPs are not convinced about the effectiveness of referral options or believe that they could provide the same services; and [4] GPs worry that referral suggestions would annoy patients.[3]

2.10.2.1.3 Uptake rates

Since the initiation of the 45-49 year old health check in 2006, its annual uptake has decreased. National rates have dropped from 7.2% in 2007/08 to 4.4% in 2009/10. No gender disparities have been observed.[130] In South Australia (SA), the uptake rates have been consistently lower than the national average, at 5.9% and 3.3% in 2007/08 and 2009/10 respectively.[107] Contrary to the 'inverse care law',[131] in South Australia, people from the lowest SES quintile (4.0% attendance rate in 2009-10) areas were 54% more likely to attend this health check compared to those from the highest SES quintile (2.6% attendance rate in 2009-10).[107] Although no research has been undertaken to determine why this occurred, it may be that general practices located in relatively low SES areas were more actively promoting this health check to their patients.

2.11 Research rationale

Although Krogsbøll's review found no health benefits (morbidity and mortality) after general health checks in middle-aged population,[44] the results should be interpreted with caution. Given the discussion about the unique role of general practice in preventive health care, it is expected that the effectiveness of general practice-based health checks could be different from those conducted in other settings. Additionally, surrogate outcomes should be used as indicators in the assessment of health check effects. Therefore, a review assessing the effectiveness of general practice-based health checks, using both surrogate and final outcome indicators would help inform the health check debate.

There is a gap in knowledge about the performance, effectiveness and economic impact of the 45-49 year old health check program in Australian general practice. No evidence has been generated regarding the determinants of patients' attendance, including their demographic characteristics, past health service use and psychological determinants. To bridge the knowledge gap, a cohort study using a questionnaire survey and medical record analysis would provide necessary evidence to improve attendance and justify continuation of the program.

Although the screening for cancer and depression is recommended among high risk participants, the 45-49 year old health check program is primarily a general assessment of CVD risks and relevant risk factors. Considering the possible variation in the performance of ‘recommended’ screening and the relatively low prevalence of cancer in this population, the investigation could be focused on CVD outcomes. An economic model simulating the potential health benefits (CVD morbidity and mortality) and the threshold costs for the 45-49 year old health check program would inform the cost-effectiveness of this program in the Australian context.

The findings of this thesis should generate more evidence about the performance of the 45-49 year old health check and potentially inform further studies and policy change.

CHAPTER 3: The effectiveness of general practice-based health checks: a systematic review and meta-analysis

3.1 Preface

This chapter presents a systematic review and meta-analysis of literature regarding general practice-based health checks. This paper has been published by the British Journal of General Practice.[132] It presents an evaluation of the effectiveness of general practice-based health checks using both surrogate outcomes (risk factor changes) and final outcomes (mortality) as indicators. The article also compares the results of studies conducted in different settings (general practice-based and non-practice based).

The surrogate outcome changes reported in this study were used as input data for the modelling study presented in Chapter 7. Most importantly, by establishing the effectiveness of general practice-based health checks, it justifies the continuation of health check programs in Australian general practice.

3.2 Statement of Authorship

Si S, Moss JR, Sullivan TR, Newton SS, Stocks NP. Effectiveness of general practice-based health checks: a systematic review and meta-analysis. BJGP. 2014;64(618):e47-e53.

By signing below, the authors declare that they give consent for this paper to be presented by Si Si towards examination for the Doctor of Philosophy.

Si Si (Candidate)

Developed the review protocol; undertook the literature search; screened titles and abstracts and made decisions about trial inclusion; extracted data; analyzed data and drafted the manuscript.

Nigel Stocks

John Moss

Reviewed the included studies; confirmed the inclusion and contributed to the manuscript revision.

Signed: Date: …2/9/2014…

Thomas Sullivan

Reviewed the analysis and contributed to the manuscript revision.

Skye Newton

Reviewed the analysis and contributed to the manuscript revision.

Si, S., Moss, J.R., Sullivan, T.R., Newton, S.S. & Stocks, N.P. (2014) Effectiveness of general practice-based health checks: a systematic review and meta-analysis.
British Journal of General Practice, v. 64(618), pp. e47-e53

NOTE:
This publication is included on pages 46-65 in the print copy of the thesis held in the University of Adelaide Library.

It is also available online to authorised users at:

http://doi.org/10.3399/bjgp14x676456

CHAPTER 4: Cohort study design and methodology

4.1 Preface

My systematic review (Chapter 3) demonstrated that general practice-based health checks were effective in managing surrogate outcomes, especially among high risk patients. To improve the performance of health checks, it is important to motivate attendance among patients who have the most to gain from a health check. The purpose of such programs should be identifying undiagnosed high risk patients and initiating follow-up interventions.

To promote health check attendance in a target population, the first step is to understand patients' perceptions about a general health check; and then to identify both the facilitating factors and barriers to their attendance. I conducted a questionnaire survey to answer these questions. A quantitative method was chosen because no study had been conducted in Australia investigating determinants of patients' attendance at health checks. The results of such a questionnaire study could inform further qualitative research. Also, it is equally important to investigate whether a universal invitation leads to attendance by those who need preventive health care the most or merely by the 'worried well'. I then compared the demographic characteristics and past health service use of attendees and non-attendees at a health check in general practice. The results of these studies will inform effective patient recruitment strategies in general practice.

4.2 Aims

The aims of this cohort study include:

- To understand patients' perceptions about general health checks and the psychological determinants of attendance at a GP invited health check;

- To compare the demographic characteristics and past health service use (including preventive health care) of attendees and non-attendees at the 45-49 year old health check.

4.3 Outline

This section comprises two related studies: a questionnaire survey and a medical record analysis. The collected data were analysed against participants' subsequent attendance at a free general practice-initiated health check. The questionnaire collected information about self-reported demographic characteristics, medical history and perceptions about general health checks. Medical records of all participants including their demographic characteristics and health service use in the previous 12 months were extracted from the electronic medical record system in each practice. The two studies were approved by the Human Research Ethics Committee of the University of Adelaide (Appendix 15).

4.4 Selection of study sites

Study participants were recruited from general practices affiliated with the University of Adelaide. Only general practices that kept electronic medical records and had not systematically invited patients to the 45-49 year olds health check were eligible. Among the seven affiliated practices, two were eligible and chosen to represent general practices in the Adelaide metropolitan area. Practice 1, located in a beachside suburb of Adelaide surrounded by a lower socioeconomic area, had two regular GPs and four practice staff. Practice 2, located in a busy outer suburb of Adelaide, had 13 regular GPs (6 Full Time Equivalent GPs) and three practice nurses.

4.5 Study process

The study adopted a prospective cohort design. Eligible participants were identified from the two participating general practices. All participants were given a unique identifier by practice staff at enrolment. A questionnaire package was sent to all. Participants were instructed to fill and return the questionnaire to the principal researcher (SS). All questionnaires were de-identified using the unique identifier assigned to individual participants. Following the return of the study questionnaire, a health check invitation was sent to all from the two general practices. Attendance information was collected six months following the initial mailing of invitations. The medical records of all participants from one year prior to the invitation were extracted regardless of their response to the study questionnaire and their subsequent attendance at a health check. Individual medical records were also coded with their unique identifiers.

4.5.1 Development of the study questionnaire

A structured questionnaire was developed, in which three sections were included (Appendix 8). Section 1- Demographic characteristics; Section 2 – Medical history; and Section 3 –Perceptions about general health checks, relevant questions were developed based on the Theory of Planned Behaviour (TPB).

4.5.1.1 Section 1: demographic characteristics

Standard socio-demographic items of sex, age, residential postcode, marital status, ancestry, language, working status, and education were included in the questionnaire. All items were validated and used in Australia wide surveys. [151, 152]

4.5.1.2 Section 2: Medical history

Patients' self-reported lifestyle and biomedical risk factors were assessed using established or adapted questions.

- **Lifestyle risk factors**

All lifestyle questions had been validated and recommended in the Guidelines for Preventive Activities in General Practice (the Red Book)[2] for routine medical practice use.

  - **Physical Activity (PA)**

A two-item PA assessment tool was used in this questionnaire. The two items assessed the weekly frequency of having no less than 30 minutes moderate and 20 minutes of vigorous PA respectively. Descriptions about the PA intensity were provided with each question. Based on the responses to the two questions, respondents were categorized into either having sufficient or insufficient PA with regard to the WHO PA recommendations.[153]

  - **Smoking status**

Respondents were asked to report their smoking status as either current smoker; daily smoker; ex-smoker or never smoker.

  - **Nutrition**

The portions of daily consumption of vegetables and fruit were assessed in two separate questions. Descriptions of a single portion of fruit and vegetables were provided alongside the questions. Responses were quantified into either having sufficient or insufficient consumption of fruit or vegetables with reference to the Australian national dietary guidelines.[154]

- **Alcohol consumption**

The three-item Alcohol Use Disorder Identification Test- Consumption (AUDIT-C) questionnaire was used to quantify respondents' alcohol consumption.[2] Descriptions and illustrations of standard drinks were attached with the questionnaire. High risk alcohol consumption (both in short- or long-term) were defined in line with the latest Australian national alcohol consumption guideline.[155]

- **Biomedical risk factors**

Questions about pre-existing biomedical risk factors, recent uptake of preventive health care and family medical history were included. Standard questions on weight and height were included for the calculation of Body Mass Index (BMI). Respondents were further asked if they have been told by a GP about having the following risk factors: high blood pressure, high cholesterol, high blood glucose levels or any other. Then respondents were asked to report if they had had any of the following test(s): blood pressure, serum lipids, blood glucose or any cancer screening in the past 12 months. Also, a question about family history of chronic disease was included. Respondents were instructed to choose from a list of chronic conditions that are common in Australia. Finally, two questions about their awareness of the 45-49 year old health check program and their self-reported prior attendance were included.

4.5.1.3 Section 3: Perceptions about general health checks

A number of Social Cognitive Models have been applied to predict the uptake of preventive health care including health checks.[111, 114] Among them, the Theory of Planned Behaviour (TPB) has several advantages: [1] it possesses relatively stable theoretical constructs and consistent associations;[156] [2] it includes belief-based measures, which are informative for policy makers in designing and evaluating intervention strategies;[156] and [3] systematic reviews of TPB studies have demonstrated reasonable correlations between TPB variables and health behaviours.[157-159] Therefore, TPB was adopted as a theoretical framework in the investigation of patients' perceptions about general health checks.

Questions in this section were framed based on the TPB.[160] According to the TPB, behavioural intention (BI), attitude (ATT), subjective norm (SN) and perceived behavioural control (PBC), to a large extent, explain an individual's behaviour or behaviour change. Then, ATT, SN and PBC were further deconstructed into the expectations of behavioural outcomes (behavioural beliefs, BB), the perceptions of the opinion of important others (normative beliefs, NB) and the perceived control factors (control beliefs, CB).[156] In this questionnaire, BI, BB, NB and CB were measured. All TPB items were rated on a 7-point likert scale anchored from 'strongly disagree' to 'strongly agree' or from 'highly unlikely' to 'highly likely'.[161]

A key purpose of the TPB is to offer an explanation about the perception-behaviour relationship. BI is the linkage in between.[160] Two standard BI questions were used in the study questionnaire: 'I intend to attend a health check if my GP invited me' and 'if my GP invited me I would be very likely to attend a health check'.[161] The mean score of the two items was used to represent attendance intention.

Attitude is regarded as the core of the TPB, as it has been proven to be the best predictor of intention.[156] BBs are respondents' perceptions about outcomes of the behaviour and their feelings towards it. Since it is impossible to capture all BBs in a close-ended questionnaire, only the salient ones that were widely used in the literature were included.[162] Several aspects have been repeatedly used in studies of health screening, such as reassurance about health, concerns about abnormal results, feeling embarrassed about the procedure, physical discomfort, early detection or diagnosis, early treatment, safety or side effects of screening tests, and the perceived efficacy of the screening.[91, 115, 163, 164] Considering the objectives and procedures of the 45-49 year old health check program, nine BB items were retained in this questionnaire.

SN represents the perceptions of social pressure for an individual to undertake a certain behaviour. The opinions of important others (NBs), to a certain extent, determine SN. Important others may vary according to the nature of the behaviours. In the context of health check, the opinions or suggestions of family members, a GP and friends were considered most relevant to an individual. Therefore, three NBs items were included in the questionnaire.

PBC or CBs are the beliefs or barriers that hinder individuals from undertaking a certain behaviour. They can be either objective or subjective in nature. A literature review suggested that time constrains, schedule arrangement, screening preparation, lack of symptoms, transportation, costs or insurance coverage, and a lack of motivation were the commonly mentioned barriers to health check attendance.[91, 115, 164] In this questionnaire, six CBs items were included.

4.5.2 Piloting and finalizing the questionnaire

To assess the face and content validity of the questionnaire, it was firstly reviewed by a panel of GPs and colleagues. Then, a pilot study was conducted, in which 11 middle-aged patients completed a pilot questionnaire. Revisions to the questionnaire were made based on the feedback obtained.

The pilot study was conducted in the waiting room of a third general practice in Adelaide. Middle-aged patients (mainly within the age range of 45-49 years) who came to the practice for a routine medical consultation were approached by a practice nurse and inquired if they were willing to complete a pilot questionnaire. The practice nurse was instructed to briefly explain the purpose of the study to patients and to clarify that participation was completely voluntary and would not affect the quality of medical service they received from the practice. If consent was granted, the patient was instructed to fill out the pilot questionnaire and write down their feedback on an attached feedback sheet (Appendix 9). Both the pilot questionnaire and feedback form were collected and later faxed to the principal researcher (SS). Over a month, 11 patients completed the pilot questionnaire and feedback form. Minor refinements were made to the questionnaire based on their feedback, including adding instructions to each segment of the questionnaire; clarifying the expression of a few questions; and re-ordering a few questions in the TPB section. Hard copies of the finalized questionnaire were used in the formal study (Appendix 8). The formal questionnaire was approved by all researchers and the Human Research Ethics Committee of the University of Adelaide (Appendix 15).

4.5.3 Selection of study participants

Patients from the two participating general practices who met the following selection criteria were recruited as participants in this study.

4.5.3.1 Inclusion criteria

Patients aged 45-49 years at the time of study, who were regular patients of the relevant practice, were eligible. We defined regular patients as those who had visited the practice at least once in the past 24 months. According to Medicare Australia, patients with at least one identifiable chronic disease risk factor (lifestyle or biomedical risk factors or family history) were eligible to participate. Given the high prevalence of risk factors in the Australian community, virtually everyone in the 45-49 year old age group would be eligible.

4.5.3.2 Exclusion criteria

Patients who were deemed to have left the practice by the practice manager were excluded. Patients who had been diagnosed with a chronic disease (e.g. cardiovascular disease, diabetes) or had had this health check prior to the study were also excluded. Other exclusions were made for practical reasons such as incorrect mailing address. The study flowchart is presented in Figure 14.

By reviewing Medicare item number claims (chronic disease management items) and the prescription records (e.g. anti-diabetic medications), patients with pre-existing chronic disease were excluded. Since no unique Medicare Benefits Schedule (MBS) item number has been available for this program since 2010 (shared MBS item numbers were used by several health check programs), it was impossible to identify patients who had had this health check prior to the study from the practice records. Therefore, we were only able to identify and exclude patients who self-reported having had this health check. Considering that both participating practices had not systematically invited patients to this health check, the number was not expected to be large.

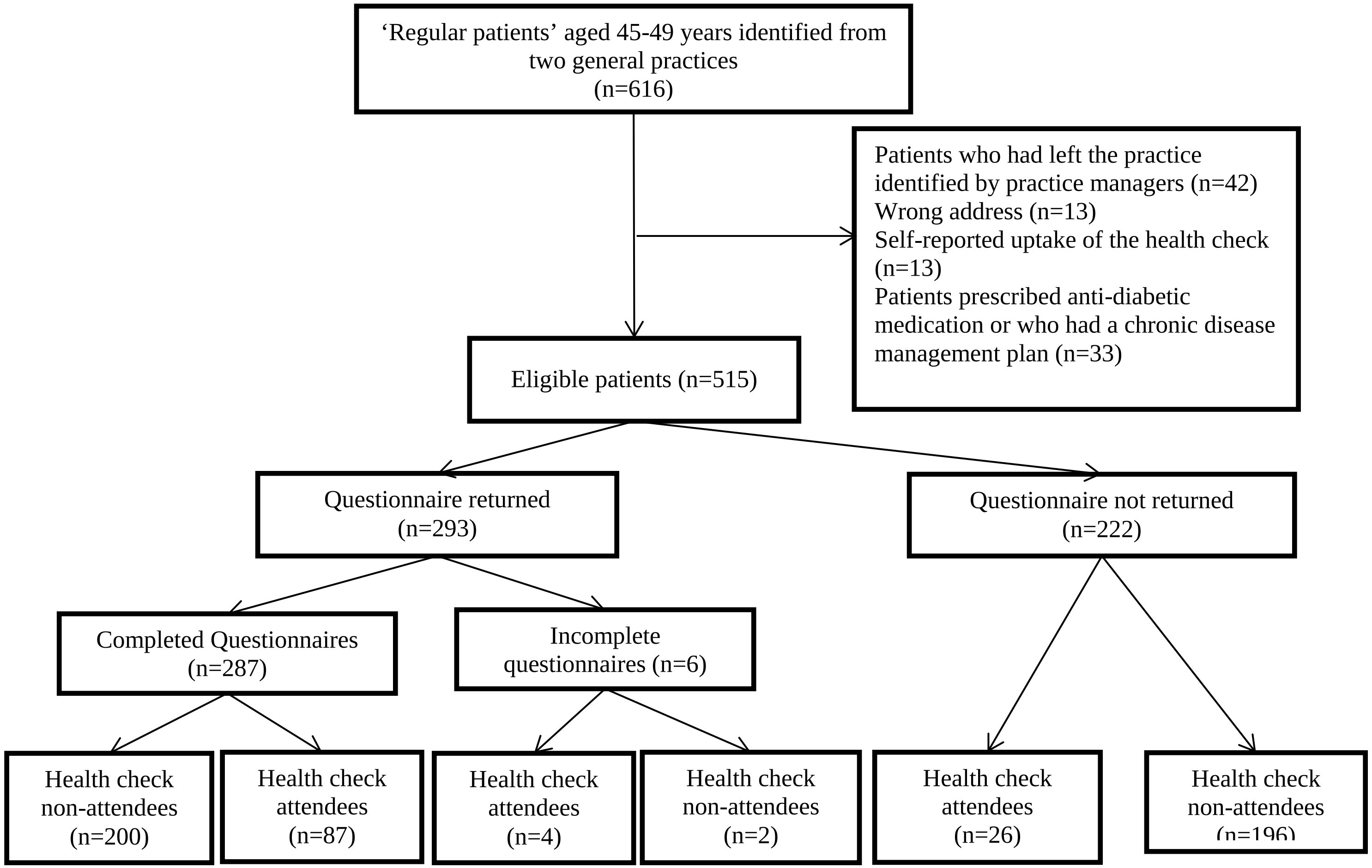

Figure 14: Study flowchart (cohort study)

4.5.4 Study procedures

In March 2012 (13-22/03/2012) study questionnaires inserted into standard A4 envelopes with the logos of the general practice and the University of Adelaide were sent to all study participants. Enclosed with the questionnaire (Appendix 8), was an information sheet detailing the objectives of the study, the importance of participation and an assurance about confidentiality (Appendix 10), an endorsement statement from the general practice (Appendix 11) and a pre-paid reply envelope addressed to the principal researcher (SS). Participants were instructed to complete and return the questionnaire. It was made clear that participation was completely voluntary and would not affect the quality of medical care they received from practice. To encourage questionnaire response, participants were informed about a random prize draw in the information sheet. Shopping vouchers to the value of $150, $100 and $50 were available to three respondents from each of two practices. Two weeks later, a reminder (Appendix 12) together with a replacement questionnaire was sent to all non-respondents at the time. Questionnaire collection was closed by the end of April 2012. The random prize draw was performed by the principal researcher (SS). The winners were randomly selected from a list of respondents using Excel 2010 at the date when questionnaire collection was censored (approximately 8 weeks after the initial mailing). The winners of the prize draw were contacted by their general practice and advised that their names would be posted in the practice if consent was granted. The shopping vouchers were then mailed to the winners.

Later at the beginning of May 2012, a health check invitation from each general practice (Appendix 13) was sent to all study participants regardless of their response to the study questionnaire. Approximately three months later (in August 2012), an invitation reminder (Appendix 14) was sent to all non-attendees at the time. In the meantime, patients' attendance at the health check was recorded by practice nurses. Data collection was completed in October 2012 (24/10/2012). Later in early 2013, relevant medical records of all participants were extracted. The study timeline is outlined in Figure 15.

4.6 Ethics

Ethics approvals for both studies were obtained from the Human Research Ethics Committee of the University of Adelaide (H-181-2011 and H-310-2011; see Appendix 15). The researchers were entirely blinded to participants' identifying information by the use of uniquely generated identifiers by the practice staff at enrolment. In addition, in the information sheet, all participants were informed that study participation was completely voluntary and that returning the questionnaire constituted consent to participate. They were also informed about an opt-out option. If they did not want to be involved in the study, by informing the practice, they would be excluded from the study.

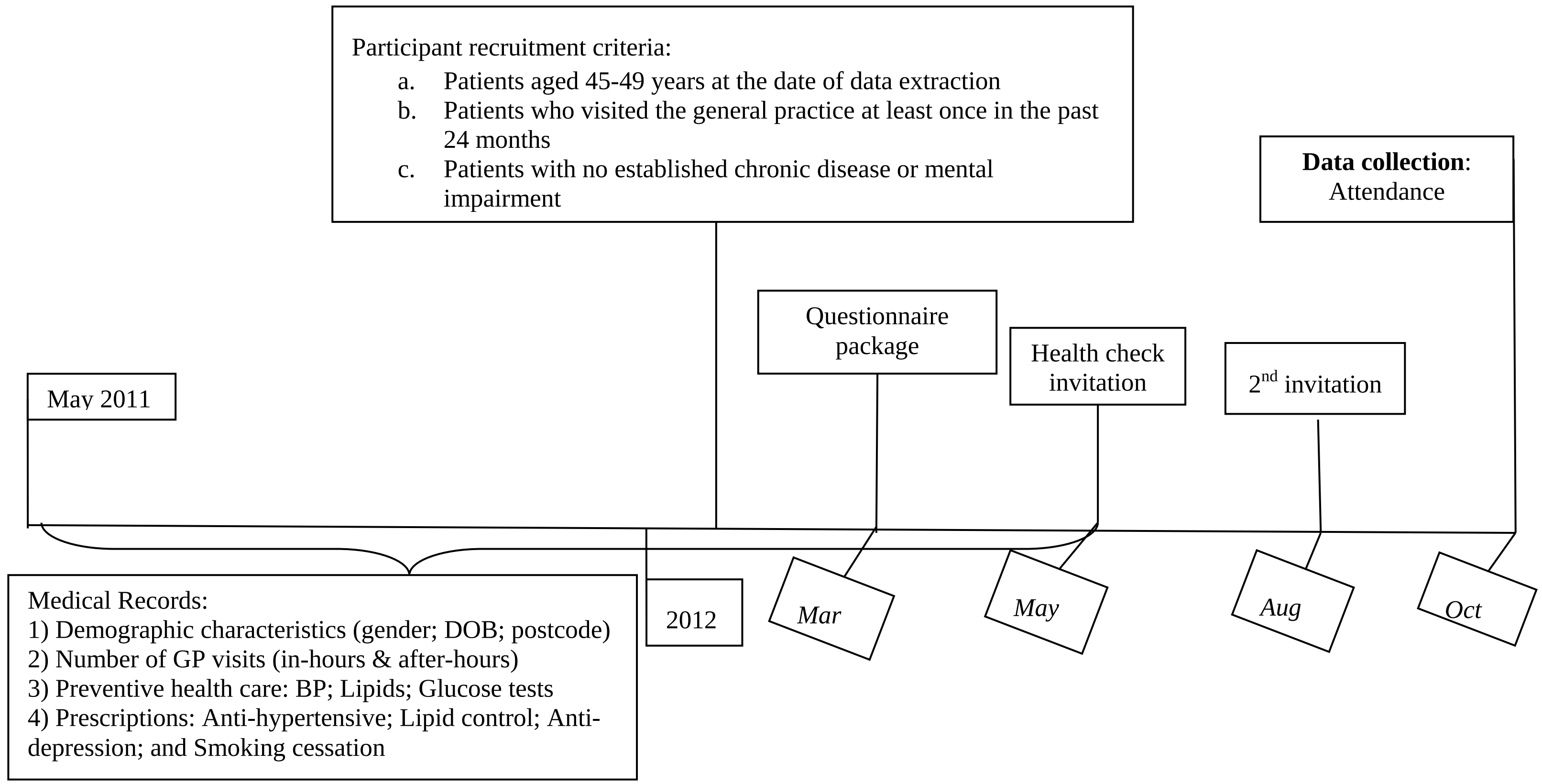

Figure 15: Study timeline (cohort study)

4.7 Data management

All returned questionnaires were stored in a secured cabinet at the University of Adelaide. Data collection and management was performed by SS (the PhD candidate). Data from each returned questionnaire were entered into an electronic database using Microsoft Excel 2007. Data extracted from practice electronic medical records were imported into Microsoft Access 2007. The datasets were saved on a personal, ID-protected university server site owned and operated by the University of Adelaide. The databases were later converted to STATA data files for analysis. Single-entry was performed for each of the data items entered into the database. Random verification was performed on 10% of entered data by SS.

4.8 Data analysis

Data analysis was performed with STATA version 12. Descriptive statistics were used to summarize information from the questionnaire and medical records using frequencies, measures of central tendency (mean, median), and measures of dispersion (standard deviation, skewness). Most of the variables were categorical.

For inferential data analysis, variables were cross-tabulated with comparable groups. Student's t test, Chi square/Fisher's exact test and ANOVA were used to test the differences between/among groups ($p<0.05$). Univariable and multivariable logistic regressions were undertaken to identify the determinants of attendance intention and attendance at the 45-49 year old health check. The strengths of associations were reported using adjusted Odds Ratios. I also examined the differences between questionnaire respondents and non-respondents in the medical record analysis.

CHAPTER 5: Factors influencing attendance at the 45-49 year health check: a questionnaire survey

5.1 Preface

This chapter presents the results of the analysis of the psychological determinants of a patient's intended and their actual attendance at a health check at their regular general practice. This paper will be submitted to a national or international journal.

The paper describes patients' self-reported demographic characteristics, lifestyle risk factors, medical histories and also their perceptions about general health checks (developed based on the Theory of Planned Behaviour). All these variables were introduced as predictors in the analysis of patients' self-reported attendance intention and their subsequent attendance at a health check in general practice.

5.2 Statement of Authorship

The following manuscript will be submitted to a national or international journal:

Si S, Moss JR, Giles LC, Stocks NP. Factors influencing attendance at the 45-49 year health check: a questionnaire survey.

By signing below, the authors declare that they give consent for this paper to be presented by Si Si towards examination for the Doctor of Philosophy.

Si Si (Candidate)

Developed the study questionnaire; performed the data collection and input; analyzed and interpreted data; drafted the manuscript and submitted to the journal.

John Moss

Assisted with the design of the study, reviewed the drafts of the manuscript and provided feedback.

Lynne Giles

Reviewed the analysis and contributed to the manuscript revision.

Nigel Stocks

Assisted with the design of the study, established the cooperation with the general practices; reviewed the drafts of the manuscript; provided comments and feedback; and acted as the corresponding author for this manuscript.

Signed: Date: 2/9/2014

5.3 Abstract

Background: The 45-49 year old health check funded by the Australian government aims to detect and manage early onset chronic disease and risk factors. Understanding patients' perceptions about general health checks is an important step in improving attendance. **Aim:** To characterize psychological factors influencing patients' intended and actual attendance at a health check. **Methods:** A questionnaire survey was conducted in two general practices in Adelaide, South Australia. It included questions about demographic characteristics, health status information and patients' perceptions about general health checks based on the Theory of Planned Behaviour (TPB). Subsequently all patients were invited to a health check at their general practice. **Results:** 515 eligible participants were identified. 287 (55.7%) completed and returned the questionnaire and 87 (30.3%) of them attended the health check within 6 months. Strong attendance intention, an absence of self-reported pre-existing risk factors and less recent uptake of preventive health care tests were predictors of attendance; altogether explained 17.1% of the variance. Perceived barriers did not directly influence attendance. The majority of respondents demonstrated strong attendance intention. Age, smoking status, alcohol consumption and TPB constructs (attitude, subjective norm and perceived control) altogether explained 47.5% of the variance in intention. **Conclusions:** Patients' attendance is associated with their knowledge about pre-existing risk factors, recent preventive health care use and attendance intention. General practices may be able to facilitate attendance by providing tailored medical information to patients. Highlighting the benefits of health checks and a recommendation from GP may strengthen attendance intention.

Key words: Preventive health care; Health check; Attendance; General practice; Questionnaires; Theory of Planned Behaviour

5.4 Introduction

To prevent early onset of chronic disease and encourage preventive health care in general practice, Australian government initiated a general practice-based health check program for 45-49 year olds in 2006. The program encourages a comprehensive check-up and lifestyle counselling for all people who have at least one risk factor for chronic disease.[1] It is funded by Medicare (Australia's universal health insurance scheme) via a series of time-based health assessment items, with some GPs charging a co-payment. The national uptake of this program have been decreased from 7.2% in 2007/08 to 4.4% in 2009/10.[165] No study has been conducted to investigate the determinants of patients' attendance at this health check. This study aims to develop understanding of patients' perceptions about general health checks, so that interventions can be developed, refined and implemented to improve attendance.

5.4.1 Theoretical frameworks

A number of Social Cognitive Models have been applied to predict the uptake of preventive health care including health checks.[111, 114] Among them, the Theory of Planned Behaviour (TPB) has several advantages: [1] it possessed relatively stable theoretical constructs and consistent associations;[156] [2] it include belief-based measures, which are informative for policy makers in designing and evaluating intervention strategies;[156] and [3] systematic reviews of TPB studies have demonstrated reasonable correlations between TPB variables and health behaviours.[157-159]

TPB describes behavioural intention (BI) as the direct antecedent of behaviours, and the direct determinants of BI include attitudes, perceived social pressure (Subjective Norm) and perceived barriers (Perceived Behavioural Control). The model further specifies the antecedents of the three determinants as Behavioural Beliefs (BB; anticipated outcomes of the behaviour), Normative Beliefs (NB; perceptions about how others want one to behave) and Control Beliefs (CB; potential barriers when performing the behaviour).

One of the most common criticisms of TPB is that it tends to undervalue the influence of emotional aspects of attitude by imposing measurements of the rational aspects.[156] The assessment of both rational (instrumental BB) and emotional aspects (affective BB) of attitude should be included. Then, additional variables have also been recommended to improve the predictive values of TPB depending on the study purpose and the nature of the target behaviour.[159, 166] In health service research, demographic characteristics and baseline health conditions are commonly used to predict the uptake of preventive health care.[101, 102, 167-170]

The aim of this study was to characterise factors influencing patients’ intended and actual attendance at a general practice-based health check, by adapting the Theory of Planned Behaviour.

5.5 Methods

5.5.1 Study design and settings

A cross-sectional postal questionnaire survey with prospective follow-up was conducted in two general practices affiliated with the University of Adelaide were recruited. Both practices used electronic medical records and had not systematically invited patients to the 45-49 year old health check. The practice populations were similar in composition to the general population in metropolitan Adelaide.

5.5.2 Sample selection

Eligible patients were aged 45-49 years at the date of participant recruitment (22/02/2012) and had visited the practice at least once in the previous 24 months. Patients were excluded if they had left the practice (as deemed by the practice managers); or the mail was returned due to incorrect address; or had had a 45-49 year old health check prior to the study; or had been diagnosed with diabetes or cardiovascular disease, either having been prescribed with diabetic medication or having had a chronic disease management plan. Patients with high blood pressure or abnormal serum lipids were eligible for a health check and were therefore eligible for this study. Altogether, 515 eligible patients were identified (Figure 16).

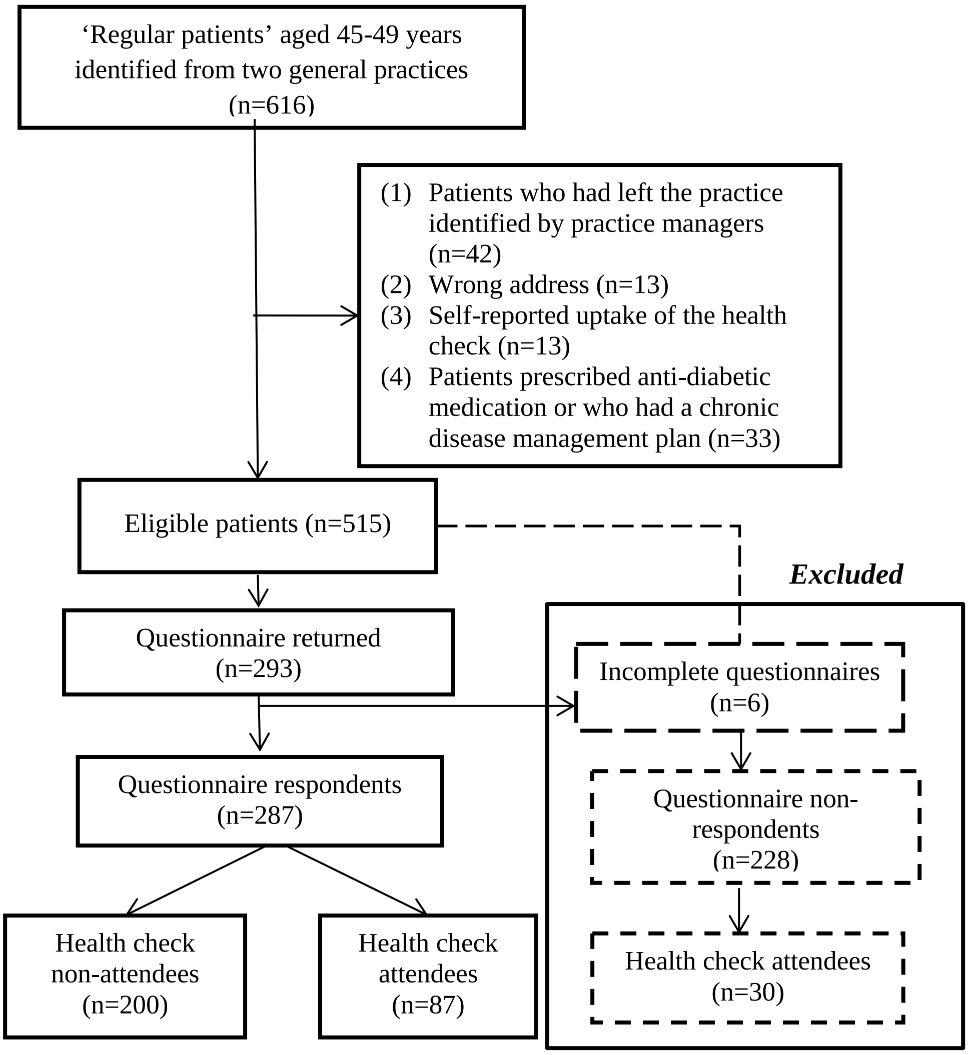

Figure 16: Identification of study participants (questionnaire survey)

5.5.3 Study procedures

The study questionnaire was sent to all 515 eligible study participants. A reminder letter and a replacement questionnaire were sent to non-respondents four weeks later. Then, all participants were invited to a health check by their general practice. A record of attendance was collected six months after the invitation.

5.5.4 Measures

The purpose-developed questionnaire included three sections: demographic characteristics (section A), medical history (section B) and TPB questions (section C). A short description of the health check was provided before section C.

5.5.4.1 Section A: Demographic characteristics

Age, sex, marital status, employment status, and highest education level were assessed in the questionnaire. Patients' socio-economic status (SES) was inferred from their residential postcode using the 2011 Index of Relative Socioeconomic Advantage and Disadvantage (IRSD) deciles,[171] and were categorized into low (deciles 1-4), medium (5-8) and high (9-10) SES groups.

5.5.4.2 Section B: Medical history

Questions about lifestyle (smoking status, vegetable and fruit consumption, alcohol consumption and physical activity) and biomedical risk factors (height, weight and pre-existing chronic conditions) were included. All questions had been validated in the Australian National Health Survey,[172] or recommended by the Royal Australian College of General Practitioners for collection in routine medical practice.[2]

Respondents were grouped into never; ex-; or current smoker. Consumption of fruit and vegetables was categorized as sufficient (≥2 fruit and ≥5 vegetable serves daily) or insufficient.[154] Based on the self-reported frequency and the average amount of alcohol consumption, respondents were classified as high (exceeded guideline recommendations) or low risk (did not exceed guideline recommendations) consumers according to the latest Australian national alcohol consumption guideline, in which no more than 4 standard drinks on a single occasion were recommended to reduce short-term risk of alcohol-related injuries; and no more than 2 standard drinks per day on a weekly basis (less than 14 standard drinks per week) were recommended to reduce long-term alcohol-related health risks.[155] Respondents were also asked to quantify the amount of moderate and vigorous intensity physical activities undertaken per week respectively. No less than 150 minutes of moderate-intensity or alternatively 75 minutes of vigorous-intensity physical activity in a week is recommend by the World Health Organization.[153]

Body Mass Index (BMI=weight (kg)/height^2(m^2)) was calculated using self-reported height and weight; with 25 and 30 kg/m^2 being the cut-off points for overweight and obese respectively. Respondents were also asked to report any pre-existing risk factors (e.g. high blood pressure, high total cholesterol; impaired glucose tolerance or other) and whether they had had relevant preventive health care in the past 12 months.

5.5.4.3 Section C: Cognitive factors

The TPB items were developed after a comprehensive literature review and discussion with a panel of GPs and colleagues. All items were rated on seven-point Likert scales ranging from 'strongly disagree' to 'strongly agree' or from 'very unlikely' to 'very likely'. Before the formal study, the questionnaire was piloted on 11 middle-aged volunteer patients; revisions were made based on their feedback. Intention was assessed using two items: '*I intend to have a health check if my GP invites me*'; and '*If my GP invited me, I would be very likely to attend a health check*'. Mean scores were used as outcome indicators. Behavioural Beliefs, Normative Beliefs and Control Beliefs were measured using 9, 3 and 6 items respectively (Table 6).

Table 6: Factor analysis and internal consistency tests of beliefs items

Instrumental Behavioural Beliefs (IBB) (29.9% variance explained / Cronbach's alpha=0.84)
• Detect unknown medical conditions • Receive lifestyle recommendation from GP • Receive health reassurance • Change lifestyle in the future • Better understand health status
Affective Behavioural Beliefs (ABB) (7.2% variance explained / Cronbach's alpha=0.64)
• Feel in control over life • Feel disappointed if miss a health check
Normative Beliefs (NB) (8.4% variance explained / Cronbach's alpha=0.81)
• My GP would want me to have a health check • My family would want me to have a health check • My friends would want me to have a health check
Control Beliefs (CB) (18.9% variance explained / Cronbach's alpha=0.85)
• No health problem or symptom • Already had all the check-ups that I need • Already taken good care of myself • Rearrange daily schedule • Convenient appointment with my GP • Arrange transport
Excluded items
• Attending a health check would be the right thing to do • Attending a health check could make me feel anxious

5.5.5 Statistical analysis

Exploratory factor analysis (using Principal Component and direct oblique rotation) on belief-based items was performed. Items were eliminated if the Measure of Sampling Adequacy (MSA) coefficients were <0.6 or if items had strong loadings >0.4 on multiple factors. Cronbach's alpha coefficients were obtained for the factors yielded. Factor scores were derived using a linear combination of the items loading on the factor of interest.[173]

Initially, analysis of intention using linear regression had been used as recommended in the TPB.[156] However, the distribution of intention scores was negatively skewed to the rating scales and not normally distributed. Transformations did not remedy this. An ordinal logistic regression model was then fitted with cut-off set at 5.5 and 6.5, but did not converge due to insufficient observations within strata. Finally, binary logistic regression was applied with intention dichotomized at the median (6.5).

Univariable logistic regressions were fitted to examine the determinants of intention and attendance (separately) at the health check. All variables with a P-value less than 0.25 in the univariable regression model were sequentially introduced by blocks (i.e. demographic, medical history and TPB blocks) into a multivariable regression model (hierarchical regression).[174] The multivariable model was then simplified using backward variable elimination with the least significant predictive variables eliminated one at a time using p= 0.05 (from the corresponding Likelihood ratio test) as criterion. A goodness of fit test was carried out for the final model. Cragg & Uhler's R^2 was used to determine the amount of variance explained by predictor variables. Since only two practices were involved in this study, it was not possible to perform multi-level analysis to adjust for a clustering effect. Instead, general practice was used as one of the predicting variables. All analyses were performed using STATA version 12.

5.6 Results

Overall, 293 of the 515 patients returned the questionnaire and 287 completed all three sections of the questionnaire. Only completed questionnaires were included in the analysis, representing a response rate of 55.7% (287/515). The overall health check attendance rate was 22.7% (117/515). In this study, we consider participants who returned a partial questionnaire as non-respondents. Comparisons between questionnaire respondents and non-respondents showed that females were more likely to respond to the questionnaire compared to males (p=0.02), and respondents were almost three times as likely to subsequently attend the health check as non-respondents (30.3% vs 13.2%). No differences were found between respondents and non-respondents in age and SES.

5.6.1 Characteristics of respondents

Respondents' mean age was 47.1 years and 61% were female. A majority of respondents were in a marital or de facto relationship (74%). More than half (57%) were employed full time and a similar proportion (57%) had undertaken some training after high school or were tertiary educated. The respondents were under-represented by low SES groups (23% of IRSD deciles 1-4).

Among the 287 questionnaire respondents, 23% were current smokers. Around 19% exceeded the short-term alcohol consumption recommendation while 21% exceeded the long-term recommendation. Only 36% consumed sufficient fruit, 4% sufficient vegetables, and 38% met the physical activity recommendations. BMI was calculated for 278 respondents, with 68% being overweight or obese. 63% of respondents reported never being told by a doctor about having elevated blood pressure, total cholesterol or blood glucose. 21% self-reported that they had not had any preventive health care tests (e.g. blood pressure, serum cholesterol, blood glucose and cancer screening) or did not remember having one in the past 12 months.

Factor analysis of belief-based TPB items yielded four meaningful factors which were labelled 'instrumental behavioural beliefs (IBB)', 'affective behavioural beliefs (ABB)', 'normative beliefs (NB)' and 'control beliefs (CB)' respectively. The results of the factor analysis and Cronbach's alpha coefficients are presented in Table 6.

5.6.2 Predicting attendance intention

The two BI items demonstrated satisfactory internal consistency (Cronbach's alpha=0.83). The distribution of the attendance intention scores was negatively skewed with a median of 6.5 at which the intention scores were dichotomized. Respondents were labelled as having strong (intention score ≥6.5) and less strong intention (intention score ≤6). Respondents who demonstrated strong intention were significantly more likely to attend the health check (P=0.01).

Results of univariable logistic regressions on intention are summarized in Table 7. Variables with P<0.25 (in bold) were sequentially introduced into a hierarchical multivariable logistic regression (Table 8). Three demographic variables explained 4.2% of the variance (Cragg & Uhler's R^2) in BI (Model 1). Medical history variables explained another 8.3% of the variance in Model 2, while the introduction of TPB variables in Model 3 accounted for another 38.2% of the variance.

A final multivariable model was derived by variable elimination from Model 3, as described in the method. Age, smoking status, alcohol consumption (short-term risks), IBB, ABB, NB and CB were retained, explaining 47.5% of the variance in attendance intention. Statistical tests indicated adequate model fit (Pearson Chi^2 (278) =284.5, P=0.38).

Table 7: Univariable logistic regression on intention and attendance

Variables	***Descriptive analysis (a)***	***Univariable logistic regression***			
	All respondents	**Attendance intention**		**Attendance**	
	N (%)	**OR (95%CI)**	**P value**	**OR (95%CI)**	**P value**
Demographic characteristics					
Age (Mean (SD))	47.1 (1.41)	1.16 (0.98, 1.36)	**0.09**	1.11 (0.92, 1.32)	0.27
Gender					
• Female	176 (61.3)	1.00	**0.20**	1.00	0.72
• Male	111 (38.7)	0.73 (0.46, 1.18)		1.09 (0.66, 1.84)	
IRSD					
• Deciles 1-4	65 (22.7)	1.00	0.85	1.00	0.99
• Deciles 5-8	141 (49.1)	1.17 (0.65, 2.11)		0.99 (0.52, 1.87)	
• Deciles 9-10	81 (28.2)	1.06 (0.55, 2.03)		0.95 (0.46, 1.93)	
Marital status					
• Married/ de facto	213 (74.2)	1.00	0.56	1.00	0.31
• Single/divorced/widowed	74 (25.8)	0.85 (0.50, 1.45)		0.74 (0.41, 1.34)	
Employment status					
• Full time	164 (57.1)	1.00	**0.02**	1.00	**0.05**
• Part time/not working	123 (42.9)	1.73 (1.08, 2.78)		1.67 (1.01, 2.78)	
Education					
• High school and below	123 (42.6)	1.00	0.46	1.00	**0.12**
• Above high school	166 (57.4)	0.84 (0.52, 1.34)		0.67 (0.40, 1.11)	
General practice			0.75		0.25
• 1	76 (26.5)	1.00		1.00	
• 2	211 (73.5)	1.09(0.64, 1.84)		0.72 (0.41, 1.26)	

Table 7 (continues): Univariable logistic regression on intention and attendance

Variables	*Descriptive analysis (a)* All respondents N (%)	*Univariable logistic regression* Attendance intention OR (95%CI)	P value	Attendance OR (95%CI)	P value
Medical history					
Smoking status					
• Non-smoker	221 (77.0)	1.00	**0.10**	1.00	**0.22**
• Current smoker	66 (23.0)	1.61 (0.92, 2.82)		1.43 (0.80, 2.56)	
Alcohol (short-term risks)					
• Low risk	232 (80.8)	1.00	**0.19**	1.00	0.67
• High risk	55 (19.2)	0.67 (0.37, 1.22)		1.15 (0.61, 2.16)	
Alcohol (long-term risks)					
• Low risk	228 (79.4)	1.00	0.48	1.00	0.97
• High risk	59 (20.6)	0.81 (0.46, 1.44)		1.01 (0.54, 1.88)	
Fruit consumption					
• Insufficient	184 (64.1)	1.00	**0.03**	1.00	0.63
• Sufficient	103 (35.9)	0.58 (0.36, 0.95)		0.88 (0.52, 1.48)	
Vegetable consumption					
• Insufficient	274 (95.5)	1.00	0.46	1.00	0.52
• Sufficient	13 (4.5)	0.65 (0.21, 2.05)		0.68 (0.22, 2.15)	
Physical activity					
• Insufficient	178 (62.0)	1.00	0.31	1.00	**0.12**
• Sufficient	109 (38.0)	1.28 (0.83,2.14)		0.66 (0.40,1.11)	
BMI					
• Normal	90 (32.4)	1.00	0.74	1.00	0.55
• Overweight/obese	188 (67.6)	1.09 (0.66,1.80)		0.85 (0.49,1.45)	
Biomedical risk factors					
• No/don't know	183 (63.8)	1.00	**0.02**	1.00	**<0.01**
• At least 1 risk factor	104 (36.2)	1.57 (1.08, 2.27)		0.45 (0.28, 0.73)	
Preventive health care tests					
• No/ don't know	59 (20.6)	1.00	**0.04**	1.00	**<0.01**
• 1-2 tests	107 (37.3)	0.73 (0.38, 1.38)		0.42 (0.22, 0.82)	
• 3-4 tests	121 (42.2)	1.42 (0.76, 2.66)		0.30 (0.15, 0.58)	

Self-report data; CI: confidence interval

5.6.3 Predicting health check attendance

Univariable regressions on attendance yielded 2 demographic and 4 medical history variables with p<0.25 (Table 7). These variables together with intention and CB were sequentially introduced into a hierarchical logistic regression (Table 8). Demographic characteristics (employment status and education) explained 2.8% of the variance in attendance (Model 1). Medical history variables explained a further 10.6% of this variance (Model 2). When the TPB variables were added, Model 3 explained a total of 20.9% variance in attendance.

After variable elimination, only three variables remained in the final model: intention, pre-existing biomedical risk factors and recent preventive health care use and these accounted for 17.1% of the variance in attendance. Model fit was again adequate (Pearson Chi^2 (42) =42.8, P=0.44). Significant pathways predicting BI and attendance are summarized in Figure 17.

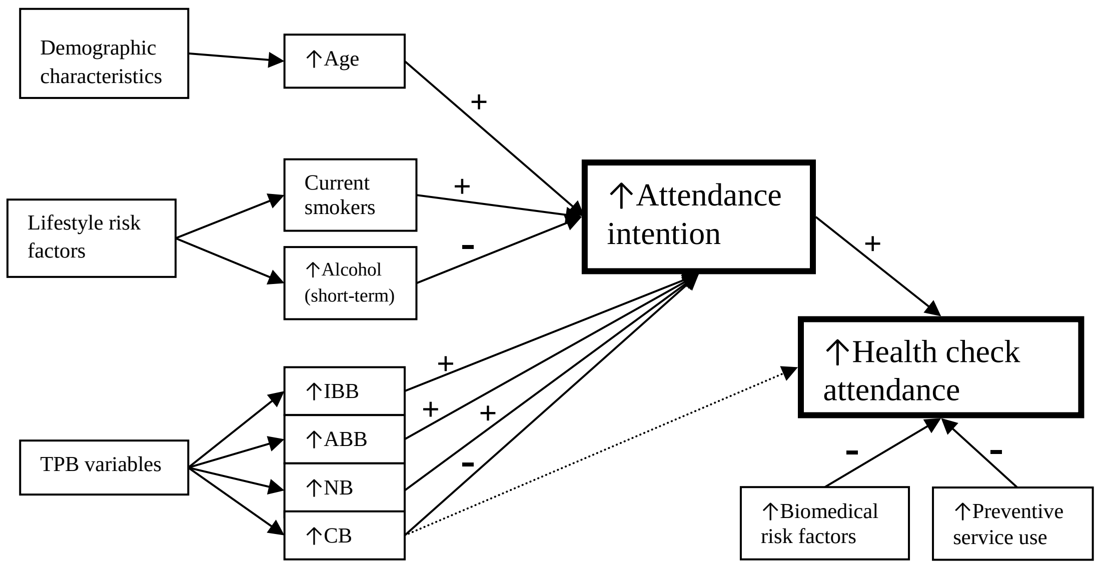

Figure 17: Significant pathways predicting intention and attendance

Table 8: Hierarchical multivariable logistic regression on intention and attendance

	Attendance intention								
Variables	**Model 1 (*R^2=0.042)**		**Model 2 (*R^2=0.125)**		**Model 3 (*R^2=0.507)**			**Final Model (*R^2=0.475)**	
	OR (95% CI)	**P**	**OR (95%CI)**	**P**	**OR (95% CI)**	**P**	***R^2**	**OR (95% CI)**	**P**
Age	1.18 (1.00, 1.40)	0.05	1.16 (0.97, 1.38)	0.10	1.29 (1.03, 1.61)	0.03	0.042	1.28 (1.03, 1.58)	0.02
Gender									
• Female	1.00	0.82	1.00	0.93	1.00	0.43			
• Male	0.94 (0.55, 1.61)		0.97 (0.54, 1.75)		1.34 (0.65, 2.80)				
Employment status									
• Full time	1.00	0.03	1.00	0.04	1.00	0.09			
• Part time/not working	1.78 (1.05, 3.04)		1.80 (1.03, 3.14)		1.86 (0.91, 3.80)				
Smoking status							0.083		
• Non-smoker			1.00	0.02	1.00	0.03		1.00	0.05
• Current smoker			2.04 (1.11, 3.78)		2.31 (1.06, 5.04)			2.16 (1.01, 4.62)	
Alcohol (short-term risks)									
• Low risk			1.00	0.15	1.00	0.02		1.00	0.03
• High risk			0.61 (0.31, 1.20)		0.38 (0.16, 0.88)			0.40 (0.18, 0.90)	
Fruit consumption									
• Insufficient			1.00	0.02	1.00	0.09			
• Sufficient			0.55 (0.32, 0.92)		0.57 (0.29, 1.09)				
Biomedical risk factors									
• No/don't know			1.00	0.07	1.00	0.14			
• At least 1 risk factor			1.49 (0.88, 2.52)		1.64 (0.85, 3.17)				
Preventive health care tests									
• No/ don't know			1.00	0.14	1.00	0.34			
• 1-2 tests			0.76 (0.38, 1.50)		0.57 (0.24, 1.33)				
• 3-4 tests			1.46 (0.74, 2.89)		0.86 (0.37, 2.00)				
Instrumental behavioural beliefs					2.05 (1.38, 3.05)	<0.001	0.382	2.12 (1.46, 3.09)	<0.01
Affective behavioural beliefs					2.95 (2.02, 4.30)	<0.001		2.79 (1.94, 4.02)	<0.01
Normative beliefs					1.52 (1.07, 2.16)	0.02		1.48 (1.06, 2.06)	0.02
Control beliefs					0.69 (0.50, 0.96)	0.03		0.66 (0.48, 0.90)	<0.01

Table 8 (continues): Hierarchical multivariable logistic regression on intention and attendance

Variables	*Attendance at health check*								
	Model 1 (*R^2=0.028)		**Model 2 (R^2=0.134)**		**Model 3 (R^2=0.209)**			**Final model (*R^2=0.171)**	
	OR (95% CI)	**P**	**OR (95%CI)**	**P**	**OR (95% CI)**	**P**	***R^2**	**OR (95% CI)**	**P**
Employment status							0.028		
• Full time	1.00	0.07	1.00	0.05	1.00	0.08			
• Part time/not working	1.62 (0.97, 2.70)		1.71 (0.99, 2.94)		1.66 (0.94, 2.92)				
Education									
• High school (year 12)	1.00	0.17	1.00	0.43	1.00	0.40			
• Above high school	0.70 (0.42, 1.17)		0.80 (0.46, 1.40)		0.78 (0.44, 1.39)				
Smoking status							0.106		
• Non-smoker			1.00	0.35	1.00	0.38			
• Current smoker			1.35 (0.72, 2.54)		1.35 (0.69, 2.63)				
Physical activity									
• Sufficient			1.00	0.10	1.00	0.09			
• Insufficient			0.63 (0.36, 1.09)		0.61 (0.34, 1.08)				
Biomedical risk factors									
• No/don't know			1.00	<0.01	1.00	<0.01		1.00	<0.01
• At least 1 risk factor			0.43 (0.23, 0.78)		0.39 (0.21, 0.73)			0.39 (0.21, 0.73)	
Preventive tests									
• No/ don't know			1.00	0.04	1.00	<0.01		1.00	<0.01
• 1-2 tests			0.52 (0.26, 1.03)		0.42 (0.20, 0.88)			0.40 (0.20, 0.82)	
• 3-4 tests			0.41 (0.20, 0.83)		0.30 (0.14, 0.65)			0.26 (0.13, 0.54)	
Intention					1.78 (1.31, 2.41)	<0.001	0.075	1.74 (1.30, 2.33)	<0.01
Control beliefs					0.99 (0.74, 1.32)	0.95			

** Cragg & Uhler's R2/ Nagelkerke R2: variance explained by the model; CI: confidence interval*

5.7 Discussion

Our study demonstrated that health check attendance was associated with the absence of self-reported recent uptake of preventive health care, fewer known pre-existing risk factors and strong attendance intention. CB did not emerge as direct predictor of attendance as proposed in the TPB. As a one-off behaviour, attending a health check at a regular general practice seemed less subject to the influence of perceived barriers compared to participating in long-term behavioural modification programs. Importantly, respondents appeared to make conscious decisions about attendance. They are less likely to attend a health check if they have had recent preventive health care tests or have been aware of pre-existing risk factors.

The negatively skewed intention scores suggest that the idea of a general practice-based health check is highly acceptable.[158] Strong intention is associated with age, smoking status, alcohol consumption (short-term risks) and all TPB variables. Even within the narrow age band, older respondents indicated a stronger intention. It is possible that younger respondents might be less motivated at this stage because they still have several years to attend. Current smokers were more likely to demonstrate a strong intention which perhaps reflects community knowledge of smoking risks. However, respondents with high risk alcohol consumption (short-term risk) were less likely to report strong intention. Unlike smokers, high risk drinkers may not have been aware that their level of alcohol consumption was hazardous, indicating a need for better community education and individual advice. The results also demonstrated that more positive perceptions about BBs and NBs and fewer concerns about the influence of CBs were associated with strong intention. Therefore, to strengthen intention, patients should be informed about all potential benefits of a health check including risk factor identification, lifestyle counselling and better health communication. Moreover, recommendations from GP, family or friends (NBs) would enhance attendance intention.

In our analysis of actual attendance, intention and CB accounted for 7.7% of the variance in attendance, which is comparable to other studies using TPB to predict attendance at health screening.[175-177] There are several reasons for this result. First, the questions on intention did not specify a time frame for the behaviour, and since the health check is available for all patients within the 45-49 years age band, some may want to wait a few years. Second, the applicability of TPB in predicting attendance at a one-off health check might be questioned. TPB has been claimed to represent a cognitive process that applies to novel situations or decisions that would have a considerable influence and usually require long-term compliance or repetitive applications.[156] Compared to these behaviours, attending a one-off health check requires less effort. Therefore the decision-making process could be simpler. Third, the performance of one-off behaviours is highly subject to the influence of a variety of idiosyncratic factors which may be hard to capture.[156, 159] Fourth, the stability of intention was subject to the influence of time and other events (e.g. the receipt of the invitation).[159, 176] A systematic review of TPB studies further suggested that the prospective and prolonged temporal distance between the measurements of BI and behaviour tended to undermine the predictive value of BI.[159] In our study, there was a six-week gap between the assessment of intention and patients' receipt of the health check invitation, and up to another six months before attendance for some patients. It is possible that a patient's attendance intention and other cognitive factors may have changed over time.

The mailed survey achieved a 55.7% response rate, with females being more likely to respond. This result is consistent with previous findings in relevant studies.[178] The overall health check attendance rate was 22.5%, which is comparable to similar studies in Australia that report rates ranging from 15.9% to 27.4%,[92, 119] but considerably lower than the average 44% reported in UK studies.[94, 95] The self-reported prevalence of biomedical and lifestyle risk factors was generally high, suggesting scope for preventive screening and interventions in the two general practices. However, the high self-reported recent uptake of preventive health care suggested that the recruitment of patients could be more selective and any subsequent interventions should be strengthened.

5.7.1 Limitations

The major limitations of this study include its reliance on self-report data and the limited information about non-respondents. Also, despite our best efforts, we managed to obtain a 55.7% response rate, which is lower than the average of 68% in mailed surveys published in medical journals.[179] In addition, due to the time and resource constrains, we managed to recruit only two eligible general practices. Therefore, in the analysis we were unable to perform adjustment for clustering effects. However, the univariable regressions on both intention and attendance did not suggest significant variance in the two general practices. Furthermore, the respondents were over-represented by female and higher SES group participants compared to the general 45-49 year old Australian population. However, this may not have affected the results, because neither gender nor SES emerged as direct predictors of either intention or attendance in the subsequent analyses. Moreover, a few studies investigating the potential bias introduced by survey non-response concluded that, although differences between respondents and non-respondents may influence the estimation of health status, such differences did not bias the examination of associations between demographic characteristics and health indicators.[180]

5.7.2 Implications

Our study showed that study patients' attendance at a health check is associated with their health status (pre-existing risk factors), recent uptake of preventive health care and their attendance intention. General practices could potentially facilitate patients' decision making by providing tailored medical information to individuals using the practice medical records. In addition, attendance could potentially be improved by measures that would strengthen attendance intention, including promoting benefits of health checks, health check/screening recommendation from health professionals, and removing barriers to attendance.

CHAPTER 6: Determinants of attendance at a 45-49 year old health check in Australian general practice: An observational cohort study

6.1 Preface

This chapter presents the results of the analysis of patients' medical records with regard to their attendance at a general practice-based health check program. This paper will be submitted a national or international journal.

The paper describes all study participants' basic demographic characteristics (gender, age and socio-economic status), past health service use (number of practice visits and pre-existing prescriptions) and recent uptake of preventive health care. The comparisons of health check attendees versus non-attendees and respondents versus non-respondents to a pre-visit questionnaire further allowed the identification of patients 'in need' and informed tailored invitation strategies.

6.2 Statement of Authorship

The following manuscript will be submitted to a national or international journal:

Si S, Moss JR, Giles LC, Stocks NP. Determinants of attendance at a 45-49 year old health check in Australian general practice: An observational cohort study.

By signing below, the authors declare that they give consent for this paper to be presented by Si Si towards examination for the Doctor of Philosophy.

Si Si (Candidate)

Developed the study questionnaire; performed the data collection and input; analyzed and interpreted data; drafted the manuscript and submitted to the journal.

John Moss

Assisted with the design of the study, reviewed the drafts of the manuscript and provided feedback

Lynne Giles

Reviewed the analysis and contributed to the manuscript revision.

Nigel Stocks

Assisted with the design of the study, established cooperation with the general practices; reviewed the drafts of the manuscript; provided comments and feedback; and acted as the corresponding author to this manuscript.

6.3 Abstract

Background: The 45-49 year health check is funded by the Australian government and aims to detect and manage early onset chronic disease and risk factors. General practitioners are encouraged to systematically invite patients to this health check. **Aim:** To investigate whether past health service use, patient's demographic characteristics or response to a pre-visit questionnaire predict attendance at a health check. **Method:** An observational cohort study was conducted in two general practices in Adelaide, South Australia. After receiving a health questionnaire, patients were invited to a free health check at their general practice. Six months later, their attendance together with relevant medical records one year prior to the invitation was extracted from the electronic medical record system in each practice. **Results:** 515 eligible participants were recruited, 117 of them attended a health check (23%). No significant differences in age, gender or socio-economic status were observed between attendees and non-attendees. Questionnaire respondents were almost 3 times as likely to attend as non-respondents (31% vs 12%). Among questionnaire respondents, those with more pre-existing prescriptions and recent preventive health care were slightly less likely to attend. Conversely, among non-respondents, those with two or more types of pre-existing prescriptions were significantly more likely to attend than those without (p=0.03). **Conclusion:** Overall no differences were found between attendees and non-attendees. However, the characteristics associated with attendance were different depending on patient's respond to a pre-visit health questionnaire. There appears to be scope to selectively invite patients who would most benefit from a health check. Such methods should be trialled in future studies.

6.4 Introduction

Despite the ongoing debate about the effectiveness of health checks,[44, 132] new, government funded, middle-aged health check programs have been introduced in developed countries in recent years.[1, 70] A few European studies have investigated the characteristics of health check attendees. The results demonstrated inconsistent associations between health check attendance and demographic characteristics (i.e. gender, age, ethnicity, education, marital status and socio-economic status)[62, 94, 95, 181] or pre-existing medical conditions.[94] No studies have investigated the relationship between health check attendance and past health service use in general practice (e.g. frequency of general practice visits and pre-existing prescriptions) including recent uptake of preventive health care (e.g. measurements of blood pressure (BP), serum lipids and blood glucose).

In Australia a health check for individuals aged 45-49 years, at risk of developing chronic disease, was initiated in 2006. It is funded by Medicare, a universal health scheme for all Australians.[1] General practitioners are encouraged to either systematically, using mailed invitations, or opportunistically, during routine medical consultations, invite eligible patients to have a health check. Since the initiation in 2006, the national uptake rates have dropped from 7.2% in 2007/08 to 4.4% in 2009/10.[130] Despite the decline in the number of health checks being done, there is still great interest in preventive health care in general practice. Increasingly, self-administrated health questionnaires about lifestyle risk factors have been recommended and used as part of preventive health care in general practice, either for the purpose of medical information collection[2] or as a pre-screening procedure for health checks.[62] Acknowledging there may be differences between respondents and non-respondents to a pre-visit health questionnaire, no study has investigated whether these groups differentially attend after receiving a health check invitation.

Given these gaps in the existing literature, this study aims to investigate whether past health service use, including preventive health care, demographic characteristics (i.e. gender, age and socio-economic status (SES)) or response to a pre-visit questionnaire predict attendance at a 45-49 year old health check.

6.5 Methods

6.5.1 Study design and settings

A prospective cohort design was adopted. Participants were recruited from two general practices affiliated with the University of Adelaide. Both had electronic medical records and had not systematically invited patients to a health check. Practice 1 was located in a beachside suburb of Adelaide, with two regular General Practitioners (GPs) and four practice staff members. Practice 2 was located in a busy outer suburb of Adelaide, with 13 regular GPs (6 full time equivalent GPs) and three practice nurses.

6.5.2 Sample selection

Inclusion criteria for the study participants were:

a. Patients aged 45-49 years at the date of participant recruitment (22/02/2012);
b. Patients had visited the general practice at least once in the last 24 months.

Patients who were being treated for risk factors such as high blood pressure, high cholesterol, smoking or depression were included because they were eligible, under Medicare rules, for the 45-49 year old health check.

Patients were excluded if: they were deemed to have left the practice by the practice manager; their mail was returned due to an incorrect or old address; they self-reported having had this health check before; they had been prescribed anti-diabetic medication or had received a chronic disease management plan from a GP.

6.5.3 Study process

A self-administrated health questionnaire was sent to all study participants. Questions about lifestyle and biomedical risk factors were included. The questionnaire details are reported elsewhere. A health check invitation was later mailed to all participants, with an invitation reminder 3 months after that. A record of health check attendance was collected six months after the first invitation.

6.5.4 Data collection

Medical data were extracted from the electronic medical record system in each practice. Participants' demographic characteristics (i.e. gender, date of birth, and residential postcode) and relevant medical records of health service use including total number of practice visits (in-hours and after-hours visits), existing prescriptions and uptake of preventive health care (measurements of blood pressure, serum lipids and blood glucose) from 12 months prior to the health check were extracted. The prescriptions were coded into one of the following four categories based on their indications: anti-hypertensive (e.g. diuretic, beta-blockers or ACEI), lipid control, anti-depressive, and smoking cessation. Participants were then grouped into having 0, 1 or 2+ of the four prescription categories. Similarly, participants' recent uptake of preventive health care was categorized into having had 0, 1 or 2+ types of relevant tests (BP, serum lipids and blood glucose test). Participants' SES was inferred from the Index of Relative Socioeconomic Advantage and Disadvantage (IRSD) decile, using their residential postcode.[171]

6.5.5 Statistical analysis

Participants' demographic characteristics and past health service use were examined using descriptive statistics. Chi-square tests, t tests and ANOVA were used, as appropriate, to test associations of health check attendance with predictive variables. Multivariable logistic regression models were fitted to examine how demographic characteristics and health service use jointly affected health check attendance and questionnaire response. Regressions on attendance were performed separately when subgroup analysis was indicated. Results from these models are reported as Odds Ratios (OR) and 95% Confidence Intervals (CI). Since there were only two practices involved in this study, practice was included as a fixed effect variable in the statistical models. All analyses were carried out using Stata version 12.

6.6 Results

A total of 616 patients aged 45-49 years were identified from the two general practices; 515 were eligible for this health check. Among all eligible patients, 293

(57%) returned the pre-visit health questionnaire (including both completed and partially completed questionnaires) and 117 (23%) attended the health check (Figure 18).

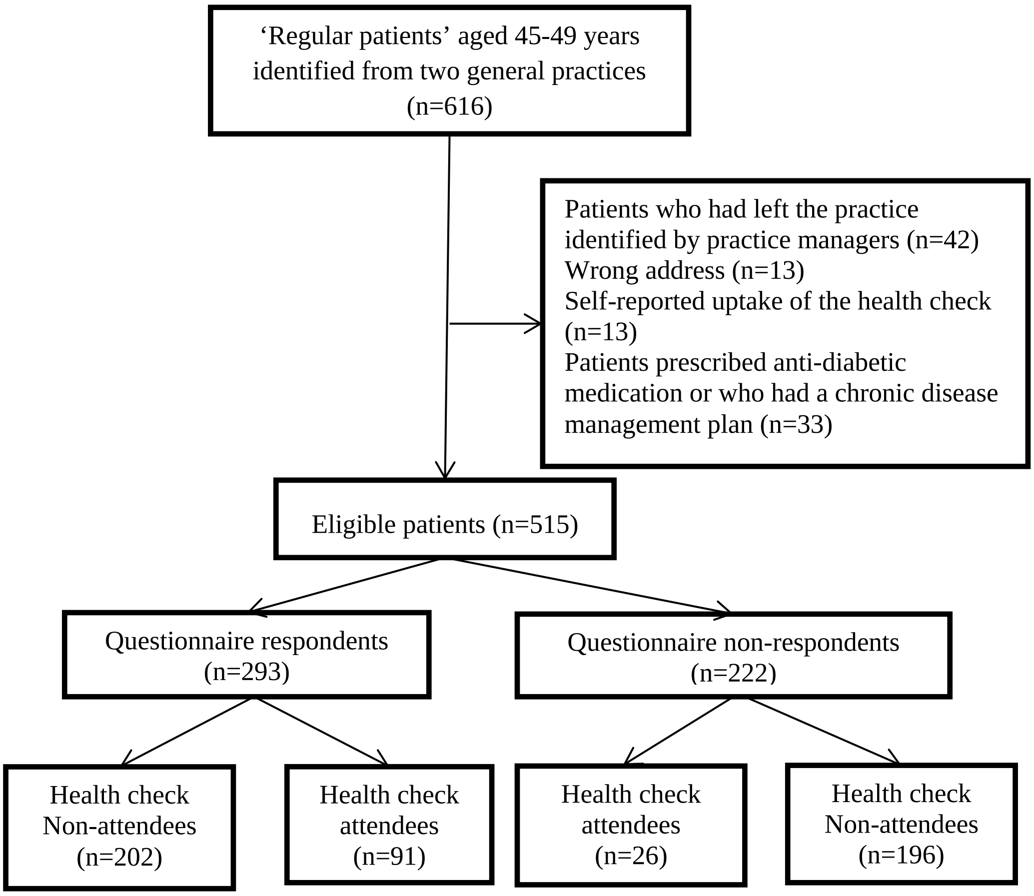

Figure 18: Study flow chart (medical record analysis)

Of the 515 study participants, 56% were female, the mean age was 47.6 years (SD 1.44) and 60% were from the upper socio-economic groups (IRSD decile 7-10). About 85% (439/515) of all participants had visited the practice at least once in the past 12 months. The median number of practice visits was 3 (range from 0 to 30). Almost a quarter of them (24%) were prescribed medicines for at least one of the following conditions: high blood pressure (9%); abnormal lipid levels (7%); depression (13%); and smoking cessation (2%). Of all participants, 31%, 30% and 25% had documented measurements of blood pressure, serum lipids and blood glucose respectively. The characteristics of study participants with regard to their attendance at health check are summarized in Table 9 (in bold). Comparisons between attendees and non-attendees yielded no significant differences in any of the demographic or health service use variables (p value in bold).

Table 9: Characteristics of health-check attendees and non-attendees

Study variables	***Non-attendees***			***Attendees***			***P****	***P*****
	Non-respondents (n=196)	Respondents (n=202)	**Sum (n=398)**	Non-respondents (n=26)	Respondents (n=91)	**Sum (n=117)**		
Demographics								
Gender							**0.813**	0.194
• Females	100 (51.0)	123 (60.9)	**223 (56.0)**	13 (50.0)	54 (59.3)	**67 (57.3)**		
• Males	96 (49.0)	79 (39.1)	**175 (44.0)**	13 (50.0)	37 (40.7)	**50 (42.7)**		
Age (SD)	47.6 (1.40)	47.6 (1.47)	**47.6 (1.43)**	47.8 (1.39)	47.8 (1.46)	**47.8 (1.44)**	**0.185**	0.625
IRSD (SES)							**0.660**	0.913
• 1 (deprived)	18 (9.2)	16 (7.9)	**34 (8.5)**	3 (11.5)	8 (8.8)	**11 (9.4)**		
• 2	3 (1.5)	3 (1.5)	**6 (1.5)**	0	1 (1.1)	**1 (0.8)**		
• 3	8 (4.1)	11 (5.5)	**19 (4.8)**	1 (3.8)	3 (3.3)	**4 (3.4)**		
• 4	18 (9.2)	15 (7.4)	**33 (8.3)**	2 (7.7)	11 (12.1)	**13 (11.1)**		
• 5	11 (5.6)	11 (5.4)	**22 (5.5)**	0	5 (5.5)	**5 (4.3)**		
• 6	28 (14.3)	23 (11.4)	**51 (12.8)**	2 (7.7)	7 (7.7)	**9 (7.7)**		
• 7	44 (22.5)	32 (15.8)	**76 (19.1)**	5 (19.2)	21 (23.1)	**26 (22.2)**		
• 8	24 (12.2)	31 (15.3)	**55 (13.8)**	5 (19.2)	10 (11.0)	**15 (12.8)**		
• 9	41 (20.9)	56 (27.7)	**97 (24.4)**	7 (26.9)	22 (24.2)	**29 (24.8)**		
• 10 (affluent)	1 (0.51)	4 (2.0)	**5 (1.3)**	1 (3.8)	3 (3.3)	**4 (3.4)**		
General Practice							**0.616**	0.151
• 1	53 (27.0)	50 (24.8)	**103 (25.9)**	3 (11.5)	30 (33.0)	**33 (28.2)**		
• 2	143 (73.0)	152 (75.2)	**295 (74.1)**	23 (88.5)	61 (67.0)	**84 (71.8)**		

Table 9 (continues): Characteristics of health-check attendees and non-attendees

Study variables	***Non-attendees***			***Attendees***			***P****	***P*****
	Non-respondents (n=196)	Respondents (n=202)	**Sum (n=398)**	Non-respondents (n=26)	Respondents (n=91)	**Sum (n=117)**		
Past health service use								
No. of GP visits (SD)	3.7 (4.5)	3.7 (3.8)	**3.7 (4.12)**	3.9 (3.4)	3.8 (5.1)	**3.8 (4.8)**	**0.703**	0.985
Prescriptions							**0.868**	0.111
• Hypertension	12 (6.1)	24 (11.9)	**36 (9.1)**	4 (15.4)	6 (6.6)	**10 (8.5)**		
• Abnormal lipids	12 (6.1)	16 (7.9)	**28 (7.0)**	5 (11.5)	3 (3.3)	**6 (5.1)**		
• Depression	20 (10.2)	28 (13.9)	**48 (12.1)**	6 (23.1)	11 (12.1)	**17 (14.5)**		
• Smoking	5 (2.6)	2 (1.0)	**7 (1.8)**	1 (3.8)	2 (2.2)	**3 (2.6)**		
No. of pre-existing Prescriptions**							**0.950**	***0.018***
• 0	157 (80.1)	146 (72.3)	**303 (76.1)**	18 (69.2)	71 (78.0)	**89 (76.1)**		
• 1	31 (15.8)	43 (21.3)	**74 (18.6)**	3 (11.5)	18 (19.8)	**21 (17.9)**		
• 2+	8 (4.1)	13 (6.4)	**21 (5.3)**	5 (19.2)	2 (2.2)	**7 (6.0)**		
Preventive health care								
Blood Pressure	52 (26.5)	68 (33.7)	**120 (30.1)**	9 (34.6)	30 (33.0)	**39 (33.3)**	**0.512**	0.419
Lipids test**	44 (22.4)	80 (39.6)	**124 (31.2)**	8 (30.8)	25 (27.5)	**33 (28.2)**	**0.542**	***0.003***
Glucose test**	32 (16.3)	66 (32.7)	**98 (24.6)**	8 (30.8)	21 (23.1)	**29 (24.8)**	**0.971**	***0.002***
No. of preventive health care**							**0.936**	***0.005***
• 0	117 (59.7)	90 (44.5)	**207 (52.0)**	12 (46.2)	48 (52.7)	**60 (51.3)**		
• 1	47 (24.0)	42 (20.8)	**89 (22.4)**	7 (26.9)	21 (23.1)	**28 (23.9)**		
• 2+	32 (16.3)	70 (34.7)	**102 (25.6)**	7 (26.9)	22 (24.2)	**29 (24.8)**		

**Chi^2 test or ANOVA of attendees and non-attendees; ** Chi^2 test or ANOVA of 4 subgroups*

6.6.1 Health check attendance

In the multivariable regression model, no significant differences were found between attendees and non-attendees in any demographic or health service use variable (Table 10; column 1). Only the attendance rate was significantly higher among questionnaire respondents than non-respondents (p<0.01).

Table 10: Multiple logistic regression on health-check attendance

Variables	***All participants (n=515)***		***Questionnaire non-respondents(n=222)***		***Questionnaire respondents (n=293)***	
	OR (95%CI)	**P**	**OR (95%CI)**	**P**	**OR (95%CI)**	**P**
Age	1.11 (0.95, 1.28)	0.189	1.15 (0.85, 1.57)	0.365	1.10 (0.92, 1.31)	0.280
Gender		0.630		0.720		0.722
• Female	1.00		1.00		1.00	
• Male	1.11 (0.72, 1.73)		1.17 (0.49, 2.82)		1.10 (0.65, 1.85)	
IRSD (SES)	1.02 (0.92, 1.13)	0.672	1.08 (0.86, 1.36)	0.516	1.03 (0.91, 1.16)	0.648
General practice		0.911		0.227		0.296
• 1	1.00		1.00		1.00	
• 2	0.97 (0.54, 1.72)		2.48 (0.57, 10.82)		0.70 (0.35, 1.37)	
GP Visits	1.03 (0.98, 1.08)	0.322	0.99 (0.88, 1.11)	0.871	1.04 (0.98, 1.10)	0.236
No. of Pre-existing prescriptions		0.701		**0.033**		0.274
• **0**	1.00		1.00		1.00	
• **1**	0.80 (0.45, 1.45)	0.467	0.88 (0.23, 3.39)	0.856	0.77 (0.39, 1.52)	0.456
• **2+**	1.15 (0.44, 3.01)	0770	7.01 (1.52, 32.27)	**0.012**	0.30 (0.07, 1.43)	0.131
No. of preventive health care		0.448		0.952		0.284
• **0**	1.00		1.00		1.00	
• **1**	1.05 (0.60, 1.81)	0.874	1.16 (0.38, 3.47)	0.796	0.95 (0.49, 1.84)	0.872
• **2+**	0.73 (0.41, 1.27)	0.263	1.17 (0.36, 3.79)	0.790	0.61 (0.32, 1.15)	0.125
Q response		**0.000**	N/A		N/A	
• **No**	1.00					
• **Yes**	3.63 (2.22, 5.93)					

CI: confidence interval

6.6.2 Questionnaire response

A multivariable logistic regression was performed to investigate the potential differences between questionnaire respondents and non-respondents in terms of their demographic characteristics and past health service use (Table 11). Compared to non-respondents, questionnaire respondents were more likely to be female (p=0.01) and to have had more recent preventive health care tests (p<0.01).

Table 11: Multiple logistic regression on questionnaire response

Variables	***Odds Ratio (95% CI)***	***P***
Age	0.99 (0.88, 1.13)	0.931
Gender		**0.013**
• Male	1.00	
• Female	1.59 (1.09, 2.33)	
IRSD (SES)	1.06 (0.97, 1.15)	0.179
General practice		0.055
• 1	1.00	
• 2	0.62 (0.38, 1.01)	
GP Visits	0.98 (0.93, 1.02)	0.231
No. of pre-existing prescriptions		0.284
• 0	1.00	
• 1	1.38 (0.84, 2.27)	0.204
• 2+	0.74 (0.32, 1.71)	0.481
No. of preventive health care		**<0.001**
• 0	1.00	
• 1	1.09 (0.69, 1.72)	0.715
• 2+	2.53 (1.56, 4.10)	**<0.001**

CI: confidence interval

To examine the difference in attendance between respondents and non-respondents to a pre-visit health questionnaire, multivariate logistic regressions were fitted to the two sub-groups of patients separately (Table 10; columns 2,3). Among questionnaire respondents, those who had more pre-existing prescriptions or preventive health care tests were slightly less likely to attend the health check, although the comparison was not statistically significant. In contrast, among questionnaire non-respondents, those who had more pre-existing prescriptions were significantly more likely to attend the health check than those without (p=0.03). However, the wide confidence intervals (CIs) in the subgroup analyses suggested considerable uncertainty.

6.7 Discussion

In this study, 117 (23%) of invited patients attended a health check. Past health service use including uptake of preventive health care, gender, age or SES did not predict overall attendance. Questionnaire respondents were almost 3 times as likely to attend as non-respondents (31% vs 12%). Subgroup analysis of attendance suggested that the characteristics associated with attendance were different in questionnaire respondents and non-respondents. Among respondents, those with more pre-existing prescriptions and preventive health care tests were slightly less likely to attend. Conversely, among non-respondents, the ones with two or more types of pre-existing prescriptions were significantly more likely to attend than those with no pre-existing prescriptions.

The overall health check attendance rate in our study is comparable to other relevant studies in Australia (ranging from 15.9% to 27.4%).[92, 119] However, it is considerably lower than the average 44% attendance rate reported in the UK studies.[94, 95, 182] The difference may reflect the wider age band (40-74 years) targeted in England. According to the medical records from the participating practices, 85% of the 45-49 year olds visited their practice at least once in the past 12 month. This is close to the 83% estimate from the national Bettering the Evaluation and Care of Health study.[183] The overall uptake of blood pressure, serum lipids, and blood glucose measurements were around 30% in 12 months. However, the recording of lifestyle risk factors (except smoking status) was generally low. This does not necessarily mean that lifestyle risk factors were not routinely assessed, but at the very least they were not often being documented. Similar findings suggesting gaps in preventive health care, especially the recording of lifestyle risk factors have been reported in other countries.[77, 81]

No difference was found between attendees and non-attendees in any of the potential predictive variables including past health service use (number of visits and pre-existing prescriptions), uptake of preventive health care, gender age or SES.

Our study suggests that a pre-visit health questionnaire can help to identify those who might attend a health check and who might be most likely to benefit. Not only were respondents almost three times as likely to attend the health check as non-respondents, they were significantly more likely to have had more preventive health care than non-respondents, despite an equivalent number of practice visits in the past 12 months and similar pre-existing prescription rates. This suggests that questionnaire respondents tend to be more conscious and proactive about their health. Nevertheless, there is also a possibility that responding to a health questionnaire may have, to a certain extent, promoted health check attendance. A small randomized controlled trial investigated whether introducing a pre-invitation questionnaire (asking simple questions about attendance) would promote health check attendance.[184] The study reported a significantly higher attendance rate in the intervention group than that in the control group.[184] Further studies are required to confirm this effects and its applicability in the context of a general practice-based health check.

The subgroup analysis of attendance highlighted the differences in characteristics associated with attendance in respondents and non-respondents to the pre-visit questionnaire. Among respondents, those who had had more preventive health care, and thus probably did not need any more in the short-term, seemed less likely to attend the health check. Arguably, this suggests that some of these patients are making conscious choices about selective uptake of preventive health care. Therefore, it is likely that a medical information sheet from general practice summarizing health conditions and past health service use could facilitate decision making among these patients. A pilot study has demonstrated the feasibility and acceptability of using pre-consultation prevention summaries in Australian general practice.[93] However, further evidence is required to confirm its use in improving health check attendance among target patients.

Conversely, among non-respondents, the non-attendees were least likely to have preventive health care, while attendees were more likely to have already had risk factors identified and treated. This may imply that a group of patients who could benefit most from a health check are missing out whilst those who have already been diagnosed and managed (with prescriptions) may be attending unnecessarily. We suggest that targeted invitations should be tested among those patients who are missing out.

6.7.1 Strengths and limitations

This study has several strengths. First, all data were extracted from the electronic medical record system in each practice. Compared to self-reported data, practice records are subject to less bias. Second, equivalent medical record information was obtained from all study participants regardless of their response to a pre-visit questionnaire or attendance at the health check. To our knowledge, this is the first study in Australian general practice investigating the association between patients' past health service use and their health check attendance.

Like any other research using medical records, the quality of this study is subject to the accuracy and comprehensiveness of the electronic medical records in the participating general practices. Since lifestyle risk factors were not consistently documented in the two practices, they could not be included in the analysis. Second, Australians are not exclusively registered with one general practice. Therefore, our study may have underestimated patients' past health service use.

We tried to minimise its influence by recruiting regular patients to the general practices and by asking the practice managers to review the list of potential participants and delete those known to have moved from the practices. Another limitation is that patients were given only 6 months to participate in the health check. It is possible that some patients would undergo a health check at a later date. Additionally, the relatively wide confidence intervals in the subgroup analysis suggested uncertainty in the magnitude of effects. It is therefore possible that our study was underpowered to detect some effects as statistically significant. Finally, this study recruited two general practices located in the Adelaide metropolitan area. Furthermore, our sample is over-represented with females and higher socio-economic groups. Thus, the results may not be generalizable to all patients across Australia.

6.7.2 Implications

Gaps exist in the provision of preventive health care in general practice. Lifestyle risk factors are not being recorded comprehensively for all. Health checks are potentially a good opportunity to bridge this gap. Overall, no significant differences were found between attendees and non-attendees in either demographic or past health service use. However, the characteristics associated with attendance were different in respondents and non-respondents to a pre-visit health questionnaire. Based on the preliminary results, we suggest a stepwise invitation strategy. First, pre-visit questionnaires assessing lifestyle and biomedical risk factors would be distributed to a target population. Their response to the questionnaire would not only facilitate the collection of health information, also automatically separate non-respondents from respondents. Then, by providing more accurate health information to respondents and opportunistically inviting non-respondents who are due for preventive health care, the effectiveness of health checks could be improved.

CHAPTER 7: Effectiveness and cost estimates for the 45-49 year old health check in Australian general practice: a modelling study

7.1 Preface

This chapter presents the results of an economic modelling study of the effectiveness and cost estimates of the 45-49 year old health check program in Australia. This paper was submitted to Applied Health Economics and Health Policy in July 2014 and is currently under review.

The model simulated the effectiveness and costs for a health check program on a hypothetic cohort of 45-49 year old Australians. The health check effects on surrogate outcomes reported in the systematic review (Chapter 3) were translated and extrapolated into life-course Life Years and QALYs gained in the cohort simulation. Then, by applying the cost-effective threshold of $50,000 per QALY, we calculated the threshold costs for this health check program for it to be considered cost-effective in the Australian context. Deterministic and probabilistic sensitivity analyses were applied to quantify parameter uncertainty. Furthermore, to validate the hypothetical cohort simulation and to evaluate structural uncertainty, an alternative model was constructed and the relevant results are presented in Appendix 16.

7.2 Statement of Authorship

The following manuscript was submitted to *Applied Health Economics and Health Policy* in July 2014 and is awaiting a response:

Si S, Stocks NP, Moss JR, Karnon J. Effectiveness and cost estimates for the 45-49 year old health check in Australian general practice: a modelling study.

By signing below, the authors declare that they give consent for this paper to be presented by Si Si towards examination for the Doctor of Philosophy.

Si Si (Candidate)

Constructed the model; performed the analyzed and interpreted the outputs; drafted the manuscript and submitted to the journal.

John Moss

Reviewed the drafts of the manuscript and provided comments

Signed: Date: ….2/9/2014……

Jonathan Karnon

Provided feedbacks on the model construction, reviewed the drafts of the manuscript; and contributed to the manuscript revision and acting as the corresponding author to this manuscript.

7.3 Abstract

Background: A 45-49 year old health check is funded by the Australian government. It aims to detect and manage early onset of chronic disease and risk factors. No trials or modelling studies have assessed its effectiveness and economic impact.

Aims and rationale: To evaluate health outcomes and threshold costs for this health check program.

Methods: A Markov chain model was constructed. Risk factor profiles were generated for a hypothetical cohort of 10,000 Australians using data from the Australian National Health Survey. Intervention effects were based on a published meta-analysis that reported changes in risk factors due to health checks over a five-year time horizon. The Framingham Risk Equation was applied to estimate cardiovascular disease incidence in the control and intervention groups, from which health care costs and Quality Adjusted Life Years (QALYs) were extrapolated over the cohorts' remaining lifetime. The threshold costs for the health check, including the initial consultation and subsequent interventions were calculated using a cost-effective threshold of $50,000 per QALY.

Findings: Compared to usual care, the health check reduced cardiovascular disease events for both males (RR=0.87) and females (RR=0.91) in a five year projection. In a lifetime projection, it led to 0.86% and 0.26% QALYs gained per male and female, respectively. The threshold costs for the program to be considered cost-effective were $465 for males and $140 for females in base-case scenario.

Implications: A 45-49 year old health check for Australian males is likely to be a cost-effective use of resources. Women of the same age are at lower cardiovascular risk, and so it may be more efficient to delay the health check in women to an older age group.

7.4 Introduction

Government funded health check programs have recently been initiated in several countries including England[70] and Australia[1], but the effectiveness of such programs has been questioned. Two recently published systematic reviews reported no significant benefits in total mortality after health checks.[44, 132] However, one of them reported significant improvements in surrogate outcomes (i.e. blood pressure, total cholesterol BMI and smoking cessation) after general practice-based health checks.[132] Even though it is biologically plausible that improved control of risk factors should prevent or delay the onset of chronic disease and improve patient's Quality of Life (QOL), very few studies have reported morbidity and QOL changes after health checks.[132] Therefore, modelling studies have been widely used to bridge the gap and to predict the cost-effectiveness of such programs.[71-73]

In Australia, a 45-49 year old health check was introduced in 2006. This Medicare funded 'well person' check-up targets patients with at least one identifiable risk factor (lifestyle, biomedical or family history).[1] The objective was to detect early stage chronic disease or risk factors and promote healthy lifestyles. Unlike other government funded health checks, this program is a one-off check-up. No further subsidized follow-up or intervention programs are specified by Medicare, except for the routine care of identified risk factors and medications. Pathology tests are ordered if deemed necessary by General Practitioners (GPs). Completion a health check usually takes another 1-2 practice visit(s) depending on the identified risk factors and whether pathology results need to be reviewed.[3] Follow-up interventions including further consultations, medications or referrals are indicated if risk factors are detected. Currently, Medicare Australia employs a time-dependent payment mechanism to reimburse this health check program.

There has been a lack of evidence on the effectiveness of this health check program and its economic impact on the health care system. The cost-effectiveness is one of the crucial criteria in health service assessment and decision making. The National Institute for Health and Clinical Excellence (NICE) in the UK has set a threshold of £20,000 per QALY for health service to be considered cost-effective, which is equivalent to $50,000 AUD per QALY.[185] Even though there has not been an official statement about the threshold value of the incremental cost-effectiveness ratio for health services in Australia, a number of Australian policy reviews have suggested that medications [186, 187] and preventive health services[188] with estimated costs under $50,000 AUD per QALY were more likely to be approved and funded. Alternatively, a lower threshold value of $25,000 AUD per QALY is recommended for more conservative estimates in the Australian context.[186, 187] The aim of this study was to use secondary data sources, to provide a novel evaluation of the 45-49 year old health check in Australian general practice, and to inform the need for primary data collection to (re-)evaluate this program.

7.5 Methods

In the absence of secondary data describing the use and uptake of risk prevention strategies following health assessment, there was too much uncertainty regarding the associated costs. We estimate the cost savings associated with health assessment to inform a threshold total health assessment cost (assessment and management of risk factors), above which health assessment would not be considered cost-effective. The threshold cost is estimated as the largest cost, which when combined with any cost savings and incremental health benefits (quality adjusted life years (QALYs)), would result in an acceptable incremental cost-effectiveness ratio. The threshold cost informs the need for further, primary, research to obtain more accurate estimates of the cost-effectiveness of the health assessment MBS item. A detailed description of methods is provided in Appendix 16. Here a summary is provided.

7.5.1 Procedures

A decision analytic model was developed, including a short-term (5 years) decision tree (Figure19), to represent the direct intervention effects (changes in CVD incidence), and a lifetime (50 years) Markov model (Figure 20), to extrapolate the intervention effects over individuals' remaining lifetime. The analysis was undertaken from the perspective of the Australian health care system (both federal and state government), and a discount rate of 5% per annum was applied.

The model simulated health outcomes (cardiovascular disease) of a hypothetical cohort of 10,000 Australians aged 45-49 years (5,000 males and 5,000 females). Risk factor values (age, gender, systolic blood pressure, total cholesterol, HDL and smoking status) were derived from the stratified population distributions reported in the 2011Australian National Health Survey (ANHS) (Table 12).[172] For instance, population age and gender specific SBP distributions were reported in 9 categories (<100; 100-110; 110-120; 120-130; 130-140; 140-150; 150-160; 160-170 and >170 mmHg). For each simulated individual, he/she was firstly proportionally allocated into one of the nine SBP risk categories. Then, a SBP reading was randomly selected (from the range of the risk category) and assigned to the individual. The allocation was repeated to assign everyone in the cohort a SPB reading. The same process was repeated with TC and HDL. Co-existence of risk factors (i.e. smoking, TC and HDL) was represented using conditional prevalence data reported in the 2011 ANHS (see Appendix 16).[172] In the 2011 ANHS, a threshold level of 5.5mmol/L was used to define high TC; while 1.0mmol/L and 1.3mmol/L were adopted to categorize abnormal HDL in males and females respectively.

Using data from a recently published meta-analysis of general practice-based health check studies,[132] intervention effects were modelled by applying Relative Risk (RR) of patients remaining at high risk after intervention to the following risk factors: systolic blood pressure (SBP>140mmHg), total cholesterol (TC>6mmol/L) and smoking (Table 12). A new set of proportional distributions of risk factors was generated by applying RR to high risk categories of each baseline risk factor distribution. Two different assumptions were made with regard to the re-allocation of high risk patients to normal risk:

> **Assumption 1 (base-case)**: same proportional distributions of patients across the normal risk categories as in the baseline distribution;

Assumption 2 (alternative-case): all reduced high risk patients moved to the highest category within the normal range (e.g. the 130-140mmHg category).

With the generated risk factor profiles, individual five-year CVD incidence rates were calculated using the Framingham Risk Equation (FRE).[189] By averaging the individual CVD risks, aggregate CVD incidence rates in the control and intervention arms were calculated, which were validated against CVD hospitalization data from the National Hospitalization Morbidity Database (NHMD).[190] Two study scenarios (base-case and alternative-case scenario) were generated based on the two assumptions made to estimate the intervention effects.

The simulated annual CVD incidence in the cohort were then allocated to the three Coronary Heart Disease (CHD) sub-states: Myocardial Infarction (MI), Unstable Angina (UA) and Stable Angina (SA) and two Cerebral Vascular Abnormality (CVA) sub-states: Transient Ischemia Attack (TIA) and stroke using data from the NHMD.[190]

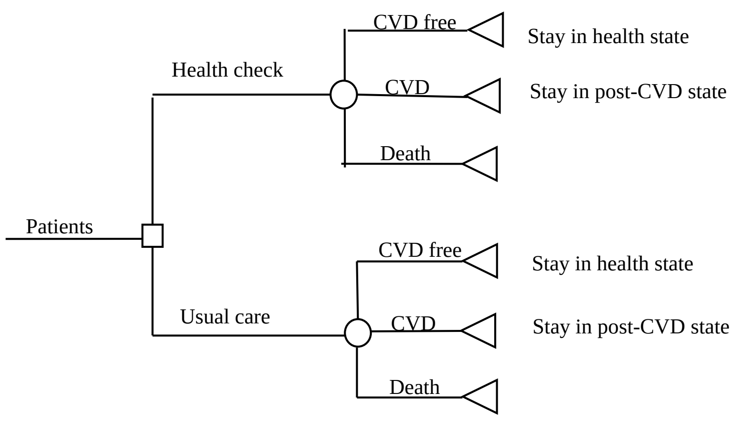

Figure 19: Decision tree (short-term model)

A Markov model was then constructed for a lifetime projection (Figure 20). Because we assumed a 5-year health benefit period after the initial health check, outputs (annual CVD incidence) from the short-term model were applied to the first five annual cycles of the Markov model. From year six onwards, the same transition probabilities were applied to both intervention and control arms. Age and gender specific CVD free mortality rates were derived from the 2011 national cause of death report.[191] Standardized Mortality Ratios (SMRs) were multiplicatively applied to the population mortality data to estimate transition probabilities to death from the CVD sub-states.[192-196] Quality of life weights for the seven health states (acute events)[197, 198] were applied to generate total QALY estimates in both arms. We also assumed a 50% reduction in the utility decrement of CVD states beyond year one (post-CVD states) in the model.

To simulate the economic impact of averted CVD events after a health check, subsequent hospitalization costs for CVD events were estimated in the lifetime projection in both arms. The cost differences were incorporated in the calculation of threshold costs of this health check program. The hospitalization costs were extracted from the National Hospital Cost Data Collection (NHCDC) database.[199] The average costs of post-CVD states were estimated by applying a coefficient of 15% to the acute event costs.[192, 200] The maximum costs for the health check and short-term subsequent medical intervention was then calculated by applying a cost-effectiveness threshold of $50,000 per QALY to the estimated QALYs gained attributed to the intervention. Further adjustments were made with regard to the cost differences in the lifelong projection of CVD related hospitalization and medical costs. Relevant model inputs are summarized in Table 12.

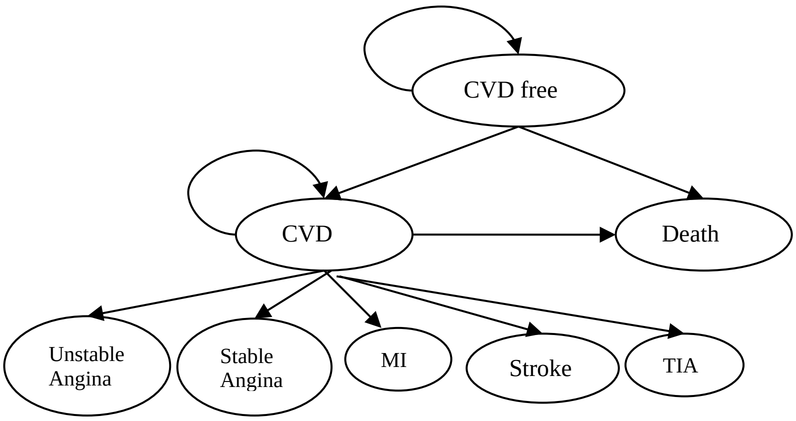

Figure 20: Health states (Markov model)

Table 12: Markov model inputs

Variable	***Subgroups***	***Value***		***Distributions***
		Males	***Females***	
Population risk factor distributions				
SBP	<100 mmHg	1.90%	7.40%	Fixed
	≥100 to <110 mmHg	12.80%	19.10%	
	≥110 to <120 mmHg	22.60%	24.30%	
	≥120 to <130 mmHg	25.80%	22.10%	
	≥130 to <140 mmHg	16.50%	12.60%	
	≥140 to <150 mmHg	11.40%	7.50%	
	≥150 to <160 mmHg	5.70%	3.50%	
	≥160 to <170 mmHg	2.20%	2.40%	
	≥170 mmHg	1.10%	1.10%	
TC	<4.0 mmol/L	11.94%	9.63%	Fixed
	≥4.0 to <4.5 mmol/L	11.94%	12.47%	
	≥4.5 to <5.0 mmol/L	15.90%	16.66%	
	≥5.0 to <5.5 mmol/L	16.06%	15.99%	
	≥5.5 to <6.0 mmol/L	19.22%	20.23%	
	≥6.0 to <6.5 mmol/L	12.67%	12.30%	
	≥6.5 to <7.0 mmol/L	7.22%	6.56%	
	≥7.0 mmol/L	5.04%	6.15%	
HDL	<1.0 mmol/L	19.1%	4.86%	Fixed
	≥1.0 to <1.3 mmol/L	41.7%	22.69%	
	≥1.3 to <1.5 mmol/L	21.3%	23.17%	
	≥1.5 to <2.0 mmol/L	16.0%	38.92%	
	≥2.0 to <2.5 mmol/L	1.5%	9.55%	
	≥2.5 mmol/L	0.3%	0.81%	
Smoking	Current smoker	24.0%	18.9%	Fixed

Table 12 (continues): Markov model inputs

Variable	*Subgroups*	*Value*	*Distributions*
Health check effects (up to 5 years)			
High TC (RR)	TC>6mmol/L	0.63 (0.50, 0.79)	Lognormal
High SBP (RR)	SBP>140mmHg	0.71 (0.55, 0.9)	
Smoking (RR)	Current smoker	0.90(0.84,0.97)	
Mortality			
Population mortality rates	45-54 years	M: 0.277%; F: 0.176%	Fixed
	55-64 years	M: 0.658%; F: 0.378%	
	65-74 years	M: 1.628%; F: 0.990%	
	75-84 years	M: 5.004%; F: 3.292%	
	85-94 years	M: 11.803%; F: 11.257%	
SMR *Mean(95% CI)*	UA	2.19 (2.05; 2.33)	Lognormal
	SA	1.95 (1.65; 2.31)	
	MI	M: 2.28 (2.12; 2.46) F: 3.07 (2.70; 3.48)	
	Stroke	M: 2.58 (2.43; 2.75) F: 2.85 (2.66; 3.05)	
	TIA	1.4 (1.1; 1.8)	
Utility weights			
CVD free *Mean(SD)*	40-49 years	M: 0.84 (0.19); F: 0.86 (0.17)	Beta
	50-59 years	M: 0.82 (0.20); F: 0.79 (0.23)	
	60-69 years	M: 0.80 (0.18); F: 0.77 (0.21)	
	70-79 years	M: 0.79 (0.22); F: 0.72 (0.26)	
	80+ years	M: 0.71 (0.30); F: 0.63 (0.28)	
Acute CVD events (utility decrement) *Mean(SE)*	UA	0.770 (0.038)	Beta
	SA	0.808 (0.038)	
	MI	0.760 (0.018)	
	Stroke	0.629 (0.04)	
	TIA	1	
Hospitalization Cost			
Acute event costs	UA	$2,682	Fixed
	SA	$2,146	
	MI	$5,572	
	Stroke	$6,496	
	TIA	$3,128	
CVD incidence*		**%**	
Annual incidence *Mean(2.5 & 97.5 percentile)*	Control group	M:0.762 (0.746, 0.777) F: 0.295 (0.288, 0.302)	Fixed
	Intervention group (base-case)	M:0.663 (0.642, 0.687) F:0.267 (0.258, 0.276)	Random selection from 1,000 cohort simulations
	Intervention group (alternative-case)	M:0.721 (0.701, 0.740) F:0.276 (0.269, 0.285)	

**data from 1,000 cohort simulations in the short-term model*

7.5.2 Sensitivity analysis

Both deterministic and probabilistic sensitivity analysis were performed in this study.

7.5.2.1 Deterministic sensitivity analysis (DSA)

DSAs were applied to the following input parameters:

- Alternative utility decrements of 0%, 25%, 75% and 100% were applied to the acute event utility weights to generate alternative sets of utilities for post-CVD states.
- Alternative weights of 10% and 20% were applied to the acute event costs to generate the costs of post-CVD states.
- A 3.5% annual discount rate was applied.
- A cost-effectiveness threshold of $25,000 per QALY was used.

7.5.2.2 Probabilistic sensitivity analysis (PSA)

Probability distributions were constructed to represent the uncertainty around input variables, including the intervention effects (RR of risk factor changes), SMRs, utility weights and utility decrements of post-CVD states (ranging from 25% to 75%). To represent the uncertainties associated with the simulation of the risk factor profiles in the hypothetic cohort, we repeated the cohort simulation (short-term model) 1,000 times. A PSA was undertaken to represent the combined effects of uncertainties across all input parameters in the model. We ran the Markov model 1,000 times, each time randomly drawing values of input variables from their respective distributions (Table 12). A 5% annual discount rate was applied in the PSA. The mean values and 2.5th and 97.5th percentiles values were summarized for LYs and QALYs.

7.6 Results

7.6.1 Short-term outcomes

The short-term model simulated 5-year CVD incidence in 10,000 individuals (5,000 males and females respectively) aged 45-49 years. The application of the short-term model on the middle-aged Australian population has been validated against the national CVD incidence statistics (Appendix 16, Table 28). The results of 1,000 cohort simulation repetitions are summarized in Table 13.

Table 13: CVD incidence prevented in 5 years (FRE 5-year risks)

CVD risks	*Control*	*Intervention*	*Diff.**	*RR***
Base-case	**Mean% (2.5, 97.5 percentile)**		**(%)**	
Males	3.752 (3.675, 3.826)	3.273 (3.169,3.386)	0.479	0.872
Females	1.466 (1.431, 1.501)	1.328 (1.284, 1.372)	0.138	0.906
Alternative-case				
Males	3.752 (3.675, 3.826)	3.553 (3.454, 3.646)	0.199	0.947
Females	1.466 (1.431, 1.501)	1.374 (1.336, 1.417)	0.092	0.937

**Diff.= CVD incidence$_{intervention}$ -CVD incidence$_{control}$; **RR= CVD incidence$_{intervention}$ /CVD incidence$_{control}$*
Alternative-case: all reduced high risk patients were allocated to the highest risk category within the normal range

Under the base-case scenario, the CVD event rates would decrease 0.48% in five years after the health check (with RR=0.87); the estimate dropped to 0.20% (with RR=0.95) assuming a lower level of reduction in the risk factor (alternative-case scenario). The health check was less effective among female attendees due to their low baseline risks. Among female attendees, 0.14% CVD events would potentially be avoided in five years (RR=0.91) in the base-case scenario. The alternative-case scenario yielded 0.09% event prevented (RR=0.94).

7.6.2 Long-term costs and QALYs

Under the base-case scenario, assuming a 50% reduction in the utility decrement and a 15% reduction in the cost weights for the post-CVD states, the health check resulted in 1.93% LYs or 0.86% QALYs gained per male attendees over 50 years.

For every female attendee, the estimated LYs and QALYs gained were 0.67% LYs and 0.26% QALYs. Under the alternative-case scenario (assumption 2 was applied to simulate intervention effects), the estimated LYs or QALYs gained dropped to 0.80% LYs or 0.36% QALYs per male attendee, and 0.45% LYs or 0.17% QALYs gained per female attendee. Correspondingly, the threshold costs for the health check (using $50,000 per QALY gained as cost-effective threshold) were AUD$465 for male and AUD$140 for female patients under the base-case scenario; and AUD$193 and $94 for male and female patients, respectively under the alternative-case scenario (Table 14).

Table 14: The effectiveness and cost of the 45-49 year old health check

		Control	*Intervention*	*Gained (%)*	***Threshold cost***	
					$50,000/QALY	**$25,000/QALY**
Base-case						
Male	LYs	33.364	33.384	1.926		
	QALYs	12.409	12.417	0.856	$465	$251
Female	LYs	37.423	37.430	0.667		
	QALYs	12.759	12.762	0.257	$140	$76
Alternative-case						
Male	LYs	33.364	33.372	0.801		
	QALYs	12.409	12.412	0.356	$193	$104
Female	LYs	37.423	37.427	0.445		
	QALYs	12.759	12.761	0.172	$94	$51

Assumptions: 50% utility decrement of acute events applied for post-CVD states; 15% of acute event costs for post-CVD states

7.6.3 Deterministic Sensitivity Analysis (DSA)

The results associated with different post-CVD utility decrements (0%, 25%, 50%, 75% and 100%) are summarized in Table 15. The estimated QALY gains among males ranged from 0.40% to 1.31% per attendee. For a female attendee, the estimated ranged from 0.11% to 0.40% QALYs gained. The corresponding threshold costs for the health check varied between $238 to $692 for male and $68 to $213 for female patients using a cost-effective threshold of $50,000 per QALY. The estimates halved when using the threshold of $25,000 per QALY.

Compared to the base-case, the alternative-case scenario presented relatively robust results in the DSA. The QALYs gained among males varied between 0.17% to 0.55% per attendee and 0.08% to 0.27% per female attendee. When using $50,000 per QALY, the average threshold costs varied between $99 and $288 for male and $45 to $142 for female patients. Again, the costs estimates were sensitive to the cost-effective threshold adopted. The estimated program costs ranged between $57 to $152 for male and $27 to $75 for female patients if using $25,000 per QALY gained as threshold. When 3.5% annual discount rate was applied, the estimated QALYs gained and threshold costs increased under both scenarios (Table 15).

Table 15: Deterministic Sensitivity Analysis (DSA)

	QALYs	*Control (QALYs)*	*Intervention (QALYs)*	*Gained (%) (QALYs)*	*Threshold costs(AUD) $50,000 per QALY gained*			*Threshold costs(AUD) $25,000 per QALY gained*		
Base-case					10%*	**15%***	20%*	10%*	**15%***	20%*
M	***50% Utility decrement***	***12.409***	***12.417***	***0.856***	***$455***	***$465***	***$475***	***$241***	***$251***	***$261***
	100% utility decrement	12.216	12.229	**1.311**	$682	**$692**	$703	$355	**$365**	$375
	75% utility decrement	12.312	12.323	**1.083**	$569	**$579**	$589	$298	**$308**	$318
	25% utility decrement	12.505	12.511	**0.629**	$341	**$351**	$362	$184	**$194**	$204
	0% utility decrement	12.601	12.605	**0.401**	$228	**$238**	$248	$127	**$137**	$148
	**Discount rate 3.5%	15.026	15.037	**1.120**	$	**$603**	$	$	**$323**	$
F	***50% Utility decrement***	***12.759***	***12.762***	***0.257***	***$137***	***$140***	***$144***	***$73***	***$76***	***$79***
	100% utility decrement	12.657	12.661	**0.402**	$210	**$213**	$216	$109	**$112**	$116
	75% utility decrement	12.708	12.701	**0.330**	$173	**$177**	$180	$91	**$94**	$97
	25% utility decrement	12.810	12.812	**0.184**	$101	**$104**	$107	$55	**$58**	$61
	0% utility decrement	12.861	12.862	**0.112**	$64	**$68**	$71	$37	**$40**	$43
	**Discount rate 3.5%	15.582	15.585	**0.342**	$	**$185**	$	$	**$99**	$
Alternative-case										
M	***50% Utility decrement***	***12.409***	***12.412***	***0.356***	***$189***	***$193***	***$198***	***$100***	***$104***	***$109***
	100% utility decrement	12.216	12.222	**0.545**	$284	**$288**	$292	$147	**$152**	$156
	75% utility decrement	12.312	12.317	**0.450**	$236	**$241**	$245	$124	**$128**	$132
	25% utility decrement	12.505	12.508	**0.261**	$142	**$146**	$150	$77	**$81**	$85
	0% utility decrement	12.601	12.603	**0.167**	$95	**$99**	$103	$53	**$57**	$61
	**Discount rate 3.5%	15.026	15.031	**0.465**	$	**$251**	$	$	**$134**	$
F	***50% Utility decrement***	***12.759***	***12.761***	***0.172***	***$92***	***$94***	***$96***	***$49***	***$51***	***$53***
	100% utility decrement	12.657	12.660	**0.269**	$140	**$142**	$144	$73	**$75**	$77
	75% utility decrement	12.708	12.710	**0.220**	$116	**$118**	$120	$61	**$63**	$65
	25% utility decrement	12.810	12.811	**0.123**	$67	**$69**	$72	$37	**$39**	$41
	0% utility decrement	12.861	12.862	**0.075**	$43	**$45**	$47	$24	**$27**	$29
	**Discount rate 3.5%	15.582	15.584	**0.228**		**$124**			**$66**	

** Cost weights for post-CVD states applied to the acute event costs; **50% utility decrement applied to simulate post-CVD states utilities*

7.6.4 Probabilistic Sensitivity Analysis (PSA)

The PSA suggested relatively robust estimates of LYs and QALYs gained for both male and female patients (Table 16). For every male attendee, 0.009 (95% CI: 0.006 to 0.012) QALYs were gained over 50 years and 0.003 (95% CI: 0.002 to 0.004) per female attendee. The estimated threshold health check costs (using a threshold of $50,000 per QALY) were $476 (95% CI: 338 to 643) for a male and $144 (95% CI: 97 to 210) for a female patient. In the alternative-case scenario, the estimated QALY gains were 0.004 (95% CI: 0.002 to 0.006) and 0.002 (95% CI: 0.001 to 0.003) per for male and female attendee respectively, with threshold costs estimates (for a threshold of $50,000 per QALY gained) of $198 (95% CI: 112 to 305) for a male and $109 (95% CI: 71 to 157) for a female patient.

Table 16: Probabilistic Sensitivity Analysis (PSA)

		LYs Gained Mean (2.5, 97.5 percentiles)	***QALYs Gained*** Mean (2.5, 97.5 percentiles)	***Threshold costs*** **($50,000/QALY)**	***Threshold costs*** **($25,000/QALY)**
Base-case					
All variables	***M***	0.019 (0.014, 0.024)	0.009 (0.006, 0.012)	$476 ($338, $643)	$262 ($198, $339)
	F	0.007 (0.004, 0.009)	0.003 (0.002, 0.004)	$144 ($97, $210)	$79 ($59, $110)
Alternative-case					
All variables	***M***	0.008 (0.004, 0.012)	0.004 (0.002, 0.006)	$198 ($112, $305)	$98 ($57, $151)
	F	0.004 (0.002, 0.007)	0.002 (0.001, 0.003)	$109 ($71, $157)	$55 ($37, $78)

7.7 Discussion

Due to the time-dependent reimbursement schemes and the relatively poorly defined management guidelines for follow-up, it is difficult to estimate the direct costs associated with this Australian health check program. Rather than a cost-effectiveness analysis, we estimated the threshold costs of this program including the initial consultation and subsequent interventions, at which it would be considered cost-effective, using threshold values of $50,000 AUD per QALY.

The estimated average costs for the health check ranged from $95 AUD to $703 AUD for a male and $43 AUD to $216 AUD for a female patient in the DSA. When a threshold of $25,000 per QALY was used, the estimates ranged from $53 AUD to $375 AUD for a male and $24 AUD to $116 AUD for a female patient. The health check program is less likely to be cost-effective among females compared to males, because the estimated threshold costs for a female patient is close to the Medicare reimbursement rate for the initial consultation.

In this study, we applied the RR of patients remaining at high risk after intervention to simulate the health check effects.[132] Two alternative assumptions were tested concerning the distributions of risk factors post-intervention: (1) patients moving from high risk BP and TC had the same distributions to that of the normal risk population (base-case); (2) patients experienced a risk reduction to their BP and TC categories just below the high risk threshold (alternative-case). Under the base-case scenario, the 5-year CVD events decreased by 13% among males (RR_{males}=0.87) and 9% among females ($RR_{females}$=0.91) after the health check, which is comparable to relevant cohort studies that reported a RR of CVD around 0.9 after a health check.[117, 118] In the alternative-case scenario, a 5% (RR_{males}=0.95) and 4% ($RR_{females}$=0.94) decrease in CVD events was predicted in males and females respectively.

Previous studies have assessed the cost-effectiveness of middle-aged health check programs in six European countries [71, 72, 123, 124] and one in Australia[73]. These studies simulated regular health checks (5 yearly) for patients aged 40-75 years with no pre-existing diagnosis of CVD or diabetes; subsequent interventions were specified to manage detected risk factors.[70] Three of these modelling studies adopted Cost-Effectiveness Analysis (CEA),[71-73] and the other two were Cost-Consequence Analysis (CCA).[123, 124] All of them used micro-simulation to predict individual risk of chronic disease based on their medical records. Effectiveness of the health checks was estimated by simulating the screening and intervention procedures incorporating detection rates; intervention rates; compliance rates and the effectiveness of intervention strategies (e.g. smoking cessation; prescriptions for anti-hypertensive, statins and lifestyle interventions). Three CEA studies concluded that the five yearly health checks for 40-75 year olds were likely to be cost-effective or cost saving in six European countries (the UK, Denmark, France, Germany, Poland and Italy) [71, 72] and in Australia[73]. Furthermore, both CCA studies concluded that targeted screening of high risk or socio-economically deprived patients would be more effective than universal screening.[123, 124]

In comparison to these studies, our model was designed to investigate the effectiveness and threshold costs for the one-off 45-49 year old health check program in Australian general practice. Methodologically, we adopted a cohort simulation technique to estimate CVD incidence and mortality; and a Markov model to extrapolate health outcomes over an individual's life time. Furthermore, given the lack of details about subsequent interventions following the 45-49 year old health check program, rather than simulating the screening and intervention processes, we directly applied risk factor changes (derived from a systematic review) to the baseline population distributions to simulate the intervention effects of a health check.

To simulate baseline cohort CVD incidence, the Framingham risk equation (FRE) was applied to individuals in the hypothetical cohort. Acknowledging concerns about the generalizability of the FRE, and its applicability to all CVD outcomes,[201] we carefully considered its application to the current study. Firstly, the application of the FRE to Australian cohorts has been validated and recommended in medical practice.[2, 202] Secondly, the target population of this health check was healthy persons with no pre-existing chronic disease, which is consistent with the Framingham cohort. Furthermore, the model outputs were validated against national CVD hospitalization data. However, although the model presented reasonable estimates of CHD incidence, it consistently underestimated CVA incidence. It has been argued that the FRE was initially developed to predict CHD risks but not other forms of CVD.[201] However, the influence was not substantial given the generally low CVA incidence in the 45-49 year old Australian population (0.12% among males and 0.10% among females). Therefore, when the incidence of CHD and CVA were combined, the model presented reasonable estimates of overall CVD incidence to the national estimates (within the 95% confidence interval of CVD estimates). These results validated the simulation of cohort CVD incidence using the FRE and population-based risk factors distributions.

7.7.1 Assumptions and Limitations

Since it is biologically plausible to prevent or delay the onset of chronic disease through early detection and management of risk factors, we assumed the improved control of risk factors would translate into morbidity and mortality benefits in subsequent years.

It is likely that our model may have underestimated the effects of the 45-49 year old health check program due to conservative assumptions adopted in the simulation regarding the magnitude and longevity of the intervention effects. Firstly, the reported risk factor changes in the systematic review are likely to be underestimates, since most of the included trials were conducted in the 1990s, when preventive health care guidelines were relatively conservative and clinical management of risk factors was less effective because the available pharmacotherapy was limited (e.g. statins and anti-hypertensive drugs). Secondly, we assumed a duration of intervention effects of five years, because most trials followed up for less than 5 years. It is likely that the benefits could persist beyond 5 years. Thirdly, we did not simulate repeat CVD events in the Markov model. Since patients with history of CVD events are more likely to suffer another CVD event, the single event assumption is likely to underestimate the cost savings and quality of life benefits of the health check program. Fourthly, we only simulated potential benefits of averted CVD in this study. However, the 45-49 year old health check program can also incorporate assessments of depression and selective screening for cancers (e.g. skin cancer; cervical and colorectal etc.) among high risk participants.[1] Therefore, this health check could potentially lead to other health benefits beyond CVD morbidity and mortality.

On the other hand, we did not consider the potential harmful effects of medical treatment on participants' quality of life. However, in medical practice, medications are not usually the first choice for the majority patients with elevated risk factors, especially for the young and otherwise healthy patients. Lifestyle modification is often the first recommendation. As reported in a few health check trials, no significant increase in prescription rates were observed in the intervention arms compared to the control.[37, 39] Furthermore, the side-effects of anti-hypertensive or lipid lowering medications are generally uncommon and there are multiple alternative medicines if this does occur. Therefore, the influence of omitting such effects would not be substantial.

7.7.2 Strengths

Given the limitations, this study provides conservative estimates of the threshold costs for the 45-49 year old health check program in Australian general practice. This is also the first study to investigate the economic impact of this Medicare funded program.

7.7.3 Future studies

To better inform the cost-effectiveness of this health check program, further research should examine both the direct and subsequent costs associated with it, including the length of the initial consultation, number of related follow-up practice visits, pathology tests, referrals and prescriptions. Methodologically, studies could also be conducted to compare the estimates from cohort simulation model and micro-simulation model using individual level data.

7.7.4 Implications

The results suggest that under the current Medicare scheme, the 45-49 year old health check program is unlikely to be cost-effective in females. For females, delaying the health check by 5 -10 years or targeting those at high risk (e.g. those with a family history of premature heart disease) may improve the cost-effectiveness of this program. Furthermore, the lack of definable intervention protocols after the initial check-up imposes considerable uncertainties on both the effectiveness and cost estimates for this program. Guideline oriented intervention strategies for at-risk patients may improve the performance and cost-effectiveness of the 45-49 year old health check program.

CHAPTER 8: Discussion and conclusion

This thesis has examined several aspects of the 45-49 year old health check program in Australian general practice, including patients' attendance; potential clinical effectiveness; and the economic impact on the Australian health care system. This evidence would potentially inform policy changes or improve the performance of this health check in general practice. Different research methods were used to generate the best evidence given the resources available to the researcher.

A systematic review and meta-analysis evaluated the effectiveness of general practice-based health checks using both surrogate (biomedical risk factors) and final (mortality) outcome indicators. Then, a prospective cohort study was conducted to inform the determinants of patients' attendance at a health check. Information from a study questionnaire and participants' past medical records was used to predict their attendance. Finally, a model (Markov model on a hypothetic cohort) was constructed to inform the long-term effectiveness (Life-Years gained and QALY gained) and the threshold costs for the 45-49 year old health check. This concluding chapter outlines the key findings of this thesis, comments on the strengths as well as limitations of this research and describes implications and future studies.

8.1 Key findings and contributions

8.1.1 The effectiveness of general practice-based health checks

The aim of the systematic review and meta-analysis was to investigate the health impact of general practice-based health checks on middle-aged population. In the literature review chapter (Chapter 2), a summary of the history of general health checks outlined the persisting controversies on this topic. As controversial as the issues were, no definitive evidence had been generated regarding the effectiveness of general health checks prior to the publication of a systematic review by Krogsbøll et al. in 2012.[44] This review concluded that health checks did not reduce morbidity or mortality.[44] In my systematic review (Chapter 3), a critical appraisal of Krogsbøll's review raised some concerns and questions regarding the interpretation of their analysis. First, they did not differentiate study settings, for instance, separating general practice-based studies from the other settings. In addition, the authors dismissed the use of surrogate outcomes. My systematic review focused on general practice-based health checks. Both surrogate and final outcomes were examined (as presented in Chapter 3). It demonstrated that, even though general practice-based health checks did not reduce total mortality, they were effective in improving patients' cardiovascular risk factor profiles (surrogate outcomes) for at least 5 years, especially among high risk patients. The magnitude of improvement in surrogate outcomes was associated with the characteristics of the recruited participants; the screening protocols; and follow-up interventions adopted in each study. A supplementary analysis of non-practice based studies demonstrated no significant differences in either surrogate or final outcomes. However, due to the limited number of studies in the literature, further meta-regression did not yield significant differences in any investigated outcome between practice-based and non-practice based studies. It was worth noting that the majority of general practice-based studies were not originally designed to investigate mortality. Therefore, almost all of them introduced a bias against health checks. Additionally, the influence of health checks on morbidity (the incidence of chronic disease) was not consistently reported in the general practice-based studies. In conclusion, this study suggested that for health checks to be most effective, they should be delivered in general practice.

8.1.2 Determinants of attendance

A prospective cohort study was conducted to investigate the determinants of patients' attendance at the 45-49 year old health check, in which a questionnaire survey and an analysis of medical records were included. Chapters 5 and 6 present the results of the two studies respectively.

A study questionnaire was developed to investigate patients' demographic characteristics, medical history and psychological determinants of health check attendance. An attendance rate of 30.3% (87/287) among questionnaire respondents was attained. The majority of respondents reported strong attendance intention (median score of 6.5 on a 1-7 scale). The analysis further demonstrated that patients' perceptions about the potential outcomes of a health check, the recommendation from GP and the perceived barriers to attendance influenced their attendance intention. Three significant predictors of health check attendance emerged: stronger attendance intention, a lack of self-reported pre-existing risk factors, and less recent uptake of preventive health care. The perceived barriers did not directly influence attendance. The results suggested that the questionnaire respondents were making decisions about attendance by considering medical information relevant to their health.

Comparison of questionnaire respondents and non-respondents found a higher proportion of females in the former group (61% vs 51%). No other differences in demographic characteristics were found, including age and SES. Analysis of the medical records yielded a higher recent uptake of preventive health care among questionnaire respondents (OR: 2.53, 95%CI: 1.56, 4.10), despite a similar number of GP visits in the past 12 months and comparable pre-existing prescriptions between the respondents and non-respondents. This suggested that questionnaire respondents were more conscious and proactive about preventive health care than non-respondents.

In chapter 6, selected data from the electronic medical records (one year prior to the health check invitation) of all participants were analysed against their subsequent attendance at a health check. An overall 22.7% (117/515) attendance rate was attained, which was consistent with similar studies conducted in Australian general practice.[92, 119] No significant differences in any of the demographic or past health service use variables were observed between attendees and non-attendees. However, the analysis suggested that the characteristics associated with attendance were different in respondents (31.1%) and non-respondents (11.7%).

Consistent with the questionnaire study (Chapter 5), respondents were more likely to attend the health check if they had no pre-existing prescriptions and less recent uptake of preventive health care. However, unlike the questionnaire study, this trend, in the medical record study, was not statistically significant. The discrepancies could potentially be explained by patients' inaccurate recollections about their preventive health care use. Therefore, it is possible that a pre-consultation summary of medical conditions and recent preventive health care use would facilitate the decision making process among these patients. This idea has been piloted in Australian practices and was regarded positively by most patients.[93]

Conversely, among questionnaire non-respondents, only 11.7% attended the health check and the attendees were likely to be those who had already been recently checked and managed (with prescription). In addition, those questionnaire non-respondents and non-attendees had the lowest recent preventive health care use of all study participants. Thus, these patients, who may be most at need of preventive health care, appeared to be missing out. Alternative invitation strategies should be developed and trialled to motivate attendance among these patients. Monetary incentives have been tried with limited success,[92] but opportunistic invitations may be a sensible option given that these patients seemed to visit their general practice as regularly as the other patients.

8.1.3 Economic impact of the 45-49 year old health check

A Markov model was constructed to simulate the lifelong effectiveness and the threshold costs for the 45-49 year health check program. The base-case model yielded 19.3 LYs gained among 1,000 male participants, equivalent to 8.6 QALYs gained. The average costs, including the initial consultation and subsequent costs (in the following 5 years) should not exceed $465 AUD for a male patient using a cost-effectiveness threshold of $50,000 per QALY. Correspondingly, among female patients, the health check was associated with 6.7 LYs and 2.6 QALYs gained per 1,000 attendees. The threshold average costs were $140 AUD. The estimates were relatively robust with regard to the variance of input variables (parameter uncertainty).

Under the current Medical reimbursement scheme ($58.20 AUD for a less than 30 minutes consultation; $135.20 AUD for a 30-45 minutes consultation; $186.55 AUD for a 45-60 minutes consultation), the 45-49 year old health check for males is likely to be a cost-effective use of resources. Since women of the same age are at lower CVD risk, it may be more efficient to delay the check in woman to an older age group or to target those at high risk.

8.2 Strengths

This is the first study evaluating the performance, potential effectiveness and costs for the 45-49 year old health check program. The systematic review differentiated general practice-based health checks from those performed in other settings (e.g. workplace, community clinic, pharmacy) by demonstrating surrogate outcome benefits only in the former. The medical record study acquired equivalent demographic and past health service use information from all study participants regardless of their response to the study questionnaire and attendance at a health check to allow further subgroup analysis of health check attendance. Furthermore, to the best of our knowledge, this is the first study examining the association between patients' recent uptake of preventive health care and their attendance at a health check. Finally, a Markov model was constructed to simulate cohort CVD incidence using public accessible national survey data (aggregated data). The results of the cohort CVD incidence simulation were validated against national estimates. This technique could be used as a methodological alternative when individual level medical records of a representative sample are unavailable.

8.3 Limitations

Detailed descriptions of study limitations have been discussed in relevant chapters. This section summarizes the overall limitations and their influence on the thesis conclusions.

8.3.1 Cohort study

Generally speaking, the findings of the cohort study may not be generalizable to the entire 45-49 year old population in Australia, because only two general practices were recruited and the study sample was slightly over-represented with females (56.3%) and upper SES groups (IRSD deciles 6-10: 71.3%) . However, the influence may not be substantial because none of the demographic characteristics emerged as significant predictors of either attendance intention or the actual attendance at a health check. Moreover, even though our study obtained a comparable questionnaire response (56%) and health check attendance rates (22%) to relevant studies in Australia, the reliability of the study results could have been improved if a higher questionnaire response rate had been achieved.

Due to budget and time constraints, medical records were extracted from one year prior to the health check. According to the Red Book, regular blood pressure measurements, and serum lipids and blood glucose tests are recommended at intervals of 2, 5 and 3 years respectively for the general population (low risk patients) aged 45 years and over.[2] Therefore, I was unable to further examine the gaps between guideline-based and the real practice of preventive health care in the two general practices and how a health check program would potentially bridge the gap. However, these were not the main objectives of this thesis.

8.3.2 Modelling study

Due to the budget and time constrains, I was unable to obtain individual-level medical records from a representative sample of 45-49 year old Australian population to construct the micro-simulation model. Instead, I simulated the risk profiles of 10,000 participants in a hypothetical cohort using aggregated national survey data, which inevitably gave rise to uncertainty. To control the associated uncertainties, the cohort simulation was repeated 1,000 times and the mean of the 1,000 simulations was used to represent the cohort incidence. In addition, the results of the cohort simulation were validated against the national CVD incidence estimates.

Surrogate outcome changes reported in the meta-analysis (Chapter 3) were used to estimate health check benefits in this model. It is further assumed that the duration of intervention effects was five years. It is likely that the model underestimated the health check effects because most studies included in the systematic review were conducted in the 1990s, when clinical guidelines and the management of risk factors were more conservative than current medical practice and that most of them followed participants for less than five years. However, this is by far the best available evidence to inform the effectiveness of general practice-based health check. Furthermore, both scenario and sensitivity analysis were performed in this study to evaluate the uncertainty associated with the estimates of health check effect.

Finally, due to the lack of evidence on subsequent medical resource use after the initial consultation, I was unable to obtain data on subsequent costs for this health check to enable a cost-effectiveness analysis. Instead, I estimated the threshold costs for this program for it to be cost-effective in the Australian context.

8.4 Future studies

Despite the best efforts in participant recruitment (by waiving gap fees for participants and repeated mailing invitations) the cohort study achieved a relatively low attendance rate (22%), especially among questionnaire non-respondents (11.7%). A group of patients who were not responding to either the study questionnaire or the health check invitations were the least frequent users of preventive health care in routine health care. Further research is required to investigate their perceptions and understandings about preventive health care and health checks. This will inform effective recruitment strategies for these patients.

A prospective cohort study or preferably a randomized controlled trial should be carried out to examine the effectiveness (in terms of risk factor control) and costs of the 45-49 year old health check program in general practice. The trial data could be further used to construct a micro-simulation model to inform the cost-effectiveness of this program.

8.5 Implications and recommendations

My research suggested that health checks should preferably be performed in conjunction with a patient's routine health care in general practice. Selective patient invitation strategies should be adopted with a focus on patients who would have otherwise missed preventive health care opportunities. As primary health care providers, general practice has the advantage of identifying target patients using electronic medical records. However, research needs to be conducted to inform tailored intervention strategies to motivate attendance among different patient groups.

To optimize clinical benefits, health check procedures should be further clarified. Although templates for the 45-49 year old health check have been developed by the Australian Department of Health, unlike other established health check programs, no standardized intervention procedures or referral pathways have been suggested or subsidized by Medicare. The lack of organizational and financial support for subsequent interventions inevitably introduces variations in the quality of this health check program across general practices. A comprehensive and continuous program protocol needs to be developed and endorsed by health professionals and policy makers.

Finally, as indicated in the systematic review (Chapter 3), high risk patients are more likely to benefit from health checks. This is further justified in the modelling study (Chapter 7), which demonstrated that a health check in 45-49 year old female population (with relatively low baseline risks of CVD) was unlikely to be cost-effective compared to males. Therefore, to improve the effectiveness and cost-effectiveness of this health check program, especially among female patients, potential policy change to be considered include delaying the health check by 5-10 years; introducing pre-screening procedures to identify high risk individuals or those who are less likely to use preventive health care; or targeting the vulnerable groups with low socio-economic backgrounds or less access to health services.

In conclusion, this thesis provided a preliminary evaluation of the 45-49 year old health check in Australian general practice. A group of patients who were missing out on preventive health care has been identified and should be the subject of further study. Additionally, policy changes may be required to improve the effectiveness and cost-effectiveness of the existing program.

Reference list

1. Department of Health. Health assessment for people aged 45 to 49 years who are at risk of developing chronic disease. Australia: Department of Health; 2012 [cited 07/2014]. Available from: https://www.health.gov.au/internet/main/publishing.nsf/Content/mbsprimarycare_mbsitem701_703_705_707.

2. Royal Australian Collage of General Practitioners. Guidelines for Preventive Activities in General Practice (the red book) 7th edition. Australia: RACGP; 2009.

3. Amoroso C, Harris M, Ampt M, Laws R, McKenzie S, Williams A, et al. 45-49 year old chronic disease prevention health checks in general practice: utilisation, acceptability and effectiveness. Sydney: Centre for Primary Health Care and Equity, UNSW; 2007.

4. Department of Health. Medicare Benefits Schedule - Note A25. Australia: Department of Health; 2010 [cited 07/2014]. Available from: http://www9.health.gov.au/mbs/fullDisplay.cfm?type=note&q=A25&qt=noteID&criteria=health%20assessment.

5. Department of Health. Healthy Kids Check - Fact Sheet. Australia: Department of Health; [cited 07/2014]. Available from: http://www.health.gov.au/internet/main/publishing.nsf/Content/Health_Kids_Check_Factsheet.

6. Wilkinson D, McElroy H, Beilby J, Mott K, Price K, Morey S, et al. Are socio-economically disadvantaged Australians making more or less use of the Enhanced Primary Care Medicare Benefit Schedule item numbers? Aust Health Rev. 2003; 26(3):43-9.

7. Department of Health. Health assessment for people aged 75 years and older. Australia: Department of Health; 1999 [cited 07/2014]. Available from: http://www.health.gov.au/internet/main/publishing.nsf/Content/mbsprimarycare_mbsitem_75andolder.

8. Department of Health. Health assessment for people aged 40 to 49 years with a high risk of developing type 2 diabetes. Australia: Department of Health; 2007 [cited 07/2014]. Available from: http://www.health.gov.au/internet/main/publishing.nsf/Content/mbsprimarycare_mbsitem_type2diabetes.

9. Harris MF, Laws RA, Amoroso CL. Moving Towards a More Integrated Approach to Chronic Disease Prevention in Australian General Practice. Aust J Prim Health. 2008; 14(3):112-119.

10. Rasmussen SR, Thomsen JL, Kilsmark J, Hvenegaard A, Engberg M, Lauritzen T, et al. Preventive health screenings and health consultations in primary care increase life expectancy without increasing costs. Scand J Public Health. 2007; 35(4):365-372.

11. World Health Organization. Preventing Chronic Diseases: A Vital Investment. Geneva: WHO; 2005.

12. Australian Institute of Health and Welfare. Risk factors contributing to chronic disease. Australia: AIHW; 2012.

13. Stampfer MJ, Hu FB, Manson JAE, Rimm EB, Willett WC. Primary prevention of coronary heart disease in women through diet and lifestyle. New Engl J Med. 2000; 343(1):16-22.

14. Rosengren A, Dotevall A, Eriksson H, Wilhelmsen L. Optimal risk factors in the population: Prognosis, prevalence, and secular trends. Eur Heart J. 2001; 22(2):136-144.

15. Stamler J, Stamler R, Neaton JD, Wentworth D, Daviglus ML, Garside D, et al. Low risk-factor profile and long-term cardiovascular and noncardiovascular mortality and life expectancy. JAMA. 1999; 282(21):2012-2018.

16. Harris M, Lloyd J. The role of Australian primary health care in the prevention of chronic disease. Australian Government: Australian National Preventive Health Agency; 2012.

17. Rogers WA, Veale B. Primary health care and general practice: a scoping report. Department of Evidence-Based Care and General Practice, Flinders University; 2000.

18. World Health Organization. Reducing Risks, Promoting Healthy Life. Geneva: WHO 2002.

19. UK National Screening Committee. UK screening portal. [cited 07/2014]. Available from: http://www.screening.nhs.uk/programmes.

20. U.S. Preventive Service Task Force. USPSTF Recommendations. [cited 07/2014]. Available from: http://www.uspreventiveservicestaskforce.org/recommendations.htm.

21. Dobell H. Lectures on the Germs and Vestiges of Disease, and on the Prevention of the Invasion and Fatality of Disease by Periodical Examinations. London: Churchill; 1861: 142-63.

22. Gould G. A system of personal biologic examinations: the condition of adequate medical and scientific conduct of life. JAMA. 1900; 35:134-137.

23. Tobey J. The health examination movement. The Nation's Health. 1923; 5:610-611.

24. Fisk E, Crawford J. How to make the periodic health examination: A manual of Procedure. New York: Macmillan; 1927; 174(2):268.

25. Knignt A. The value of the periodic examinations of life insurance policy-holders. Proceedings of the Association of Life Insurance Medical Directors of America. 1921-22;8:25

26. Breslow L. An historical review of multiphasic screening. Prev Med. 1973; 2(2):177-196.

27. Collen M. Multiphasic testing as a triage to medical care. Philadelphia: WB Saunders Co; 1974.

28. Siegel G. An American dilemma—the periodic health examination. Arch Environ Health. 1966; 13(3):292-295.

29. Roberts N. An Evaluation of the Periodic Health Examination: A Preface. Ann Intern Med. 1964; 61(6):997-998.

30. Holland W, Creese A, D'Souza M, Partridge J, Shannon D, Stone D, et al. A controlled trial of multiphasic screening in middle-age: results of the South-East London Screening Study. Int J Epidemiol. 1977; 6(4):357-63.

31. Dales LG, Friedman GD, Collen MF. Evaluating periodic multiphasic health checkups: A controlled trial. J Chron Dis. 1979; 32(5):385-404.

32. Frame P, Carlson S. A critical review of periodic health screening using specific screening criteria. Part 1: Selected diseases of respiratory, cardiovascular, and central nervous systems. J Fam Practice. 1975; 2(1):29-36.

33. Lawrence R, Mickalide A. Preventive services in clinical practice: designing the periodic health examination. JAMA. 1987; 257(16):2205-2207.

34. Hill N, Frappier-Davignon L, Morrison B. The periodic health examination. CMA Journal. 1979; 121:1193.

35. Han PKJ. Historical changes in the objectives of the periodic health examination. Ann Intern Med. 1997; 127(10):910-917.

36. Kornitzer M, Rose G. WHO European Collaborative Trial of multifactorial prevention of coronary heart disease. Prev Med. 1985; 14(3):272-278.

37. OXCHECK Study Group. Effectiveness of health checks conducted by nurses in primary care: final results of the OXCHECK study. BMJ. 1995; 310(6987):1099-104.

38. Wood D, Kinmonth A, Davies G, Yarwood J, Thompson S, Pyke S, et al. Randomised controlled trial evaluating cardiovascular screening and intervention in general practice: principal results of British family heart study. Brit Med J. 1994; 308(6924):313.

39. Engberg M, Christensen B, Karlsmose B, Lous J, Lauritzen T. General health screenings to improve cardiovascular risk profiles: a randomized controlled trial in general practice with 5-year follow-up. J Fam Practice. 2002; 51(6):546-552.

40. de Backer G, Kornitzer M, Thilly C. Multifactorial trial in the prevention of coronary heart disease: 2. Risk factor changes at two and four years. Eur Heart J. 1982; 3(2):184-190.

41. World Health Organization European Collaborative Group. Multifactorial trial in the prevention of coronary heart disease: 3. incidence and mortality results. Eur Heart J. 1983; 4(3):141-7.

42. Evans P, Langley P, Gray DP. Diagnosing type 2 diabetes before patients complain of diabetic symptoms--clinical opportunistic screening in a single general practice. Fam Pract. 2008; 25(5):376-81.

43. Thomsen JL, Parner ET, Karlsmose B, Thulstrup AM, Lauritzen T, Engberg M. Effect of preventive health screening on long-term primary health care utilization. A randomized controlled trial. Fam Pract. 2005; 22(3):242-248.

44. Krogsbøll LT, Jørgensen KJ, Grønhøj Larsen C, Gøtzsche PC. General health checks in adults for reducing morbidity and mortality from disease: Cochrane systematic review and meta-analysis. BMJ. 2012; 345(e7191).

45. Fleming TR, DeMets DL. Surrogate end points in clinical trials: are we being misled? Ann Intern Med. 1996; 125:605-613.

46. Department of Health. Putting prevention first: vascular checks. London: Department of Health; 2009.

47. Boulware L, Marinopoulos S, Phillips K, Hwang C, Maynor K, Merenstein D, et al. Systematic review: the value of the periodic health evaluation. Ann Intern Med. 2007; 146(4):289.

48. Connelly J, Cooper J, Mann A, Meade TW. The psychological impact of screening for risk of coronary heart disease in primary care settings. J Cardiovasc Risk. 1998; 5(3):185-91.

49. Stoate HG. Can health screening damage your health? J Roy Coll of Gen Pract. 1989; 39(322):193.

50. Park P, Simmons RK, Prevost AT, Griffin SJ. Screening for type 2 diabetes is feasible, acceptable, but associated with increased short-term anxiety: a randomised controlled trial in British general practice. BMC Public Health. 2008; 8:350.

51. Spijkerman AMW, Dekker JM, Nijpels G, Adriaanse MC, Kostense PJ, Ruwaard D, et al. Microvascular complications at time of diagnosis of type 2 diabetes are similar among diabetic patients detected by targeted screening and patients newly diagnosed in general practice. Diabetes Care. 2003; 26(9):2604.

52. Sheridan S, Crespo E. Does the routine use of global coronary heart disease risk scores translate into clinical benefits or harms? A systematic review of the literature. BMC Health Serv Res. 2008; 8(1):60.

53. Christensen B. Psychological reactions to information about risk of ischaemic heart disease in general practice. Scand J Prim Health. 1995; 13(3):164-167.

54. Christensen B, Engberg M, Lauritzen T. No long-term psychological reaction to information about increased risk of coronary heart disease in general practice. Eur J Cardiovasc Prev Rehabil. 2004; 11(3):239-43.

55. Harris R, Donahue K, Rathore SS, Frame P, Woolf SH, Lohr KN. Screening adults for type 2 diabetes: a review of the evidence for the US Preventive Services Task Force. Ann Intern Med. 2003; 138(3):215.

56. Spurling G, Hayman N. Self-rated health status in an urban indigenous primary care setting: implications for clinicians and public health policy. Aust N Z J Public Health. 2010; 34(6):598-601.

57. Panaretto K, Coutts J, Johnson L, Morgan A, Leon D, Hayman N. Evaluating performance of and organisational capacity to deliver brief interventions in Aboriginal and Torres Strait Islander medical services. Aust N Z J Public Health. 2010; 34(1):38-44.

58. Macdonald L, Sackett D, Haynes R, Taylor D. Labelling in hypertension: a review of the behavioural and psychological consequences. J Chron Dis. 1984; 37(12):933-942.

59. Marteau TM. Screening in practice: Reducing the psychological costs. BMJ. 1990; 301(6742):26.

60. Royal Collage of General Practitioner. Prevention of Arterial Disease in General Practice. London: RCGP; 1981.

61. Devroey D, Coigniez P, Vandevoorde J, Kartounian J, Betz W. Prevention and follow-up of cardiovascular disease among patients without a personal GP. Fam Pract. 2003; 20(4):420-4.

62. Assendelft WJJ, Nielen MMJ, Hettinga DM, van der Meer V, van Vliet M, Drenthen AJM, et al. Bridging the gap between public health and primary care in prevention of cardiometabolic diseases. Fam Pract. 2012; 29(SUPPL. 1):i126-i131.

63. Marshall B, Floyd S, Forrest R. Clinical outcomes and patients perceptions of nurse-led healthy lifestyle clinics. J Prim Health Care. 2001; 3(1):48-52.

64. Mahomed R, St John W, Patterson E. Understanding the process of patient satisfaction with nurse-led chronic disease management in general practice. J Adv Nurs. 2012; 68(11):2538-2549.

65. Harris M. The role of primary health care in preventing the onset of chronic disease, with a particular focus on the lifestyle risk factors of obesity, tobacco and alcohol. Sydney: UNSW; 2008.

66. Laurant M, Reeves D, Hermens R, Braspenning J, Grol R, Sibbald B. Substitution of doctors by nurses in primary care. Cochrane DB Syst Rev. 2004; 4

67. Halcomb EJ, Peters K, Davies D. A qualitative evaluation of New Zealand consumers perceptions of general practice nurses. BMC Fam Pract. 2013; 14

68. Godefrooij MB, van de Kerkhof RM, Wouda PJ, Vening RA, Knottnerus JA, Dinant GJ, et al. Identification of risk factors in primary care: development, implementation and yield of a cardiometabolic health check. Fam Pract. 2011;

69. Goodyear-Smith F. Government’s plans for universal health checks for people aged 40-75. BMJ. 2013; 347

70. Department of Health. NHS Health Check. London: Department of Health; 2011 [cited 6/2014]. Available from:http://webarchive.nationalarchives.gov.uk/+/www.dh.gov.uk/en/Healthcare/Longtermconditions/Vascular/NHShealthcheck/index.htm.

71. Department of Health. Economic modelling for vascular checks. London: Department of Health; 2008 [cited 6/2014]. Available from: http://www.dh.gov.uk/publications.

72. Schuetz CA, Alperin P, Guda S, van Herick A, Cariou B, Eddy D, et al. A Standardized Vascular Disease Health Check in Europe: A Cost-Effectiveness Analysis. PloS one. 2013; 8(7):e66454.

73. Walker A, Butler J, Colagiuri S, Lee C Cardiovascular disease and diabetes in Australia: Cost effectiveness of an integrated vascular risk assessment

and management intervention. International Conference on Microsimulation and Policy Design; 2011.

74. Department of Health. Australian Better Health Initiative (ABHI). Australia: Department of Health; 2006 [cited 1/2014]. Available from: http://www.healthnetworks.health.wa.gov.au/abhi/home/.

75. NHS Choices: NHS Health Check. London: Department of Health; 2010 [cited 1/2014]. Available from: http://www.nhs.uk/Planners/NHSHealthCheck/Pages/NHSHealthCheck.aspx.

76. Graham I, Atar D, Borch-Johnsen K, Boysen G, Burell G, Cifkova R, et al. European guidelines on cardiovascular disease prevention in clinical practice: executive summary. Eur Heart J. 2007; 28(19):2375.

77. Ngwakongnwi E, Hemmelgarn B, Quan H. Documentation of preventive screening interventions by general practitioners: a retrospective chart audit. BMC Fam Pract. 2010; 11:21.

78. Webster RJ, Heeley EL, Peiris DP, Bayram C, Cass A, Patel AA. Gaps in cardiovascular disease risk management in Australian general practice. Med J Aust. 2009; 191(6):324-329.

79. Wood D Clinical reality of coronary prevention in Europe: a comparison of EUROASPIRE I, II and III surveys. 29th Annual Congress of the European Society of Cardiology. Vienna, Austria; 2007 p. 1-5.

80. Heeley EL, Peiris DP, Patel AA, Cass A, Weekes A, Morgan C, et al. Cardiovascular risk perception and evidence–practice gaps in Australian general practice (the AusHEART study). Med J Aust. 2010; 192(5):254-9.

81. Dalton AR, Bottle A, Okoro C, Majeed A, Millett C. Implementation of the NHS Health Checks programme: baseline assessment of risk factor recording in an urban culturally diverse setting. Fam Pract. 2011; 28(1):34-40.

82. Heeley EL, Peiris DP, Patel AA, Cass A, Weekes A, Morgan C, et al. Cardiovascular risk perception and evidence--practice gaps in Australian general practice (the AusHEART study). MJA. 2010; 192(5):254-259.

83. McElwaine KM, Freund M, Campbell EM, Slattery C, Wye PM, Lecathelinais C, et al. Clinician assessment, advice and referral for multiple health risk behaviors: Prevalence and predictors of delivery by primary health care nurses and allied health professionals. Patient Educ Couns. 2013.

84. World Health Organization. Handbook on health inequality monitoring with a special focus on low-and middle-income countries. Geneva: WHO; 2013.

85. House of Commons. Health Inequalities, 2009. London: House of Commons: The Stationery Office Limited; 2010.

86. World Health Organization. Closing the health inequalities gap: an international perspective. Geneva: WHO Regional Office for Europe; 2005 [cited 12/2013]. Available from: http://www.who.int/social_determinants/resources/closing_h_inequalities_gap.pdf

87. University of Queensland Technology. Health inequalities in Australia: morbidity, health behaviours, risk factors and health service use, 2006. Australia: AIHW.

88. Department of Health. Putting Prevention First: Vascular Checks: Risk Assessment and Management. London: Department of Health; 2008.

89. Dalton ARH, Soljak M, Samarasundera E, Millett C, Majeed A. Prevalence of cardiovascular disease risk amongst the population eligible for the NHS Health Check Programme. Eur J Prev Cardiol. 2013; 20(1):142-150.

90. Van der Meer V, Nielen MM, Drenthen AJ, Van Vliet M, Assendelft WJ, Schellevis FG. Cardiometabolic prevention consultation in the Netherlands: screening uptake and detection of cardiometabolic risk factors and diseases–a pilot study. BMC Fam Pract. 2013; 14(1):1-9.

91. Norman P. Predicting the uptake of health checks in general practice: invitation methods and patients' health beliefs. Soc Sci Med. 1993; 37(1):53-9.

92. Stocks N, Allan J, Frank O, Williams S, Ryan P. Improving attendance for cardiovascular risk assessment in Australian general practice: An RCT of a monetary incentive for patients. BMC Fam Pract. 2012; 13.

93. Frank OR, Stocks NP, Aylward P. Patient acceptance and perceived utility of pre-consultation prevention summaries and reminders in general practice: pilot study. BMC Fam Pract. 2011; 12(1):40.

94. Dalton ARH, Bottle A, Okoro C, Majeed A, Millett C. Uptake of the NHS Health Checks programme in a deprived, culturally diverse setting: cross-sectional study. J Public Health. 2011; 33(3):422-429.

95. Cochrane T, Gidlow CJ, Kumar J, Mawby Y, Iqbal Z, Chambers RM. Cross-sectional review of the response and treatment uptake from the NHS Health Checks programme in Stoke on Trent. J Public Health UK. 2013; 35(1):92-98.

96. Norman P, Conner M. Health checks in general practice: the patient's response. Fam Pract. 1992; 9(4):481-7.

97. Ochera J, Hilton S, Bland JM, Jones DR, Dowell AC. Patients' experiences of health checks in general practice: a sample survey. Fam Pract. 1994; 11(1):26-34.

98. Peterson GM, Fitzmaurice KD, Kruup H, Jackson SL, Rasiah RL. Cardiovascular risk screening program in Australian community pharmacies. Pharm World Sci. 2010; 32(3):373-80.

99. Dowell AC, Ochera JJ, Hilton SR, Bland JM, Harris T, Jones DR, et al. Prevention in practice: results of a 2-year follow-up of routine health promotion interventions in general practice. Fam Pract. 1996; 13(4):357-62.

100. Miller D, Acton T, Hedge B. The worried well: their identification and management. J Roy Coll of Phys Lond. 1988; 22(3):158.

101. Waller D, Agass M, Mant D, Coulter A, Fuller A, Jones L. Health checks in general practice: another example of inverse care? BMJ. 1990; 300(6732):1115-8.

102. Thorogood M, Coulter A, Jones L, Yudkin P, Muir J, Mant D. Factors affecting response to an invitation to attend for a health check. BMJ. 1993; 47(3):224.

103. Christensen B. Characteristics of attenders and non-attenders at health examinations for ischaemic heart disease in general practice. Scand J Prim Health Care. 1995; 13(1):26-31.

104. Pill R, French J, Harding K, Stott N. Invitation to attend a health check in a general practice setting: comparison of attenders and non-attenders. J R Coll Gen Pract. 1988; 38(307):53-6.

105. Davis BS, McWhirter MF, Gordon DS. Where needs and demands diverge: Health promotion in primary care. Public Health. 1996; 110(2):95-101.

106. Jones A, Cronin PA, Bowen M. Comparison of risk factors for coronary heart disease among attenders and non-attenders at a screening programme. BJGP. 1993; 43(374):375-7.

107. Public Health Information Development Unit. Social Health Atlas of Australia (South Australia). Adelaide: PHIDU; 2010 [cited 6/2014]. Available from: www.publichealth.gov.au.

108. Nielsen KD, Dyhr L, Lauritzen T, Malterud K. "Couldn't you have done just as well without the screening?". A qualitative study of benefits from screening as perceived by people without a high cardiovascular risk score. Scand J Prim Health. 2009; 27(2):111-6.

109. Munley GA, McLoughlin A, Foster JJ. Gender differences in health-check attendance and intention in young adults: An application of the health belief model. Behav Change. 1999; 16(4):237-245.

110. Nexøe J, Kragstrup J, Søgaard J. Decision on influenza vaccination among the elderly: a questionnaire study based on the Health Belief Model and the Multidimensional Locus of Control Theory. SCAND J Prim Health. 1999; 17(2):105-110.

111. Norman P. Applying the health belief model to the prediction of attendance at health checks in general practice. Br J Clin Psychol. 1995; 34 (Pt 3):461-70.

112. Sladden MJ, Ward JE, Del Mar CB, Lowe JB. Skin cancer screening by Australian family physicians: variation with physician beliefs and geographic locality. Am J Prev Med. 1999; 17(2):142-6.

113. Bennett P, Norman P, Moore L, Murphy S, Tudor-Smith C. Health locus of control and value for health in smokers and nonsmokers. Health Psychol. 1997; 16(2):179-82.

114. Sonntag U, Esch T, von Hagen L, Renneberg B, Braun V, Heintze C. Locus of control, self-efficacy and attribution tendencies in obese patients - implications for primary care consultations. Med Sci Monit. 2010; 16(7):CR330-5.

115. Pill R, Stott N. Invitation to attend a health check in a general practice setting: the views of a cohort of non-attenders. J R Coll Gen Pract. 1988; 38(307):57-60.

116. Boyle T, Heyworth J, Bull F, McKerracher S, Platell C, Fritschi L. Timing and intensity of recreational physical activity and the risk of subsite-specific colorectal cancer. Cancer Causes & Control. 2011; 22(12):1647-1658.

117. Brett T, Arnold-Reed D, Phan C, Cadden F, Walker W, Manea-Walley W, et al. The fremantle primary prevention study: A multicentre randomised trial of absolute cardiovascular risk reduction. BJGP. 2012; 62(594):e22-e28.

118. Cochrane T, Davey R, Iqbal Z, Gidlow C, Kumar J, Chambers R, et al. NHS health checks through general practice: randomised trial of population cardiovascular risk reduction. BMC Public Health. 2012; 12(1):944.

119. Amoroso C, Harris MF, Ampt A, Laws RA, McKenzie S, Williams AM, et al. The 45 year old health check - feasibility and impact on practices and patient behaviour. Aust Fam Physician. 2009; 38(5):358-62.

120. Harris MF, Fanaian M, Jayasinghe UW, Passey ME, McKenzie SH, Powell Davies G, et al. A cluster randomised controlled trial of vascular risk factor management in general practice. MJA. 2012; 197(7):387-393.

121. Lakerveld J, Bot SD, van der Ploeg HP, Nijpels G. The effects of a lifestyle intervention on leisure-time sedentary behaviors in adults at risk: The Hoorn Prevention Study, a randomized controlled trial. Prev Med. 2013.

122. Lakerveld J, Bot S, Chinapaw M, van Tulder M, Kingo L, Nijpels G. Process Evaluation of a Lifestyle Intervention to Prevent Diabetes and Cardiovascular Diseases in Primary Care. Health Promot Pract. 2012; 13(5):696-706.

123. Chamnan P, Simmons R, Khaw K, Wareham N, Griffin S. Estimating the population impact of screening strategies for identifying and treating people at high risk of cardiovascular disease: modelling study. BMJ. 2010; 340(apr23 2):c1693.

124. Lawson KD, Fenwick EA, Pell AC, Pell JP. Comparison of mass and targeted screening strategies for cardiovascular risk: simulation of the effectiveness, cost-effectiveness and coverage using a cross-sectional survey of 3921 people. Heart. 2010; 96(3):208-212.

125. Australian Institute of Health and Welfare. Australia's health. Canberra: AIHW; 2012.

126. Australian Bureau of Statistics. Australian Health Survey: Updated Results, 2011-2012 Australia: ABS; 2013 [cited 1/2014]. Available from: http://www.abs.gov.au/AUSSTATS/abs@.nsf/Lookup/4364.0.55.003main+features12011-2012.

127. Australian Bureau of Statistics. Australian Health Survey: Biomedical Results for Chronic Diseases, 2011-12. Australia: ABS; 2013 [cited 1/2014]. Available from: http://www.abs.gov.au/AUSSTATS/abs@.nsf/Lookup/4364.0.55.005Main+Features12011-12?OpenDocument.

128. O'Brien K. Living dangerously: Australians with multiple risk factors for cardiovascular disease. Canberra:AIHW; 2005.

129. Deeks A, Lombard C, Michelmore J, Teede H. The effects of gender and age on health related behaviors. BMC Public Health. 2009; 9:213.

130. Public Health Information Development Unit. Social Health Atlases of Australia. Adelaide: PHIDU; 2011 [cited 3/2014]. Available from: http://www.adelaide.edu.au/phidu/help-info/about-our-data/indicators-notes/sha-aust/.

131. Hart T. The inverse care law. Lancet. 1971; 297(7696):405-412.

132. Si S, Moss JR, Sullivan TR, Newton SS, Stocks NP. Effectiveness of general practice-based health checks: a systematic review and meta-analysis. BJGP. 2014; 64(618):e47-e53.

133. Department of Health. Healthy lives, Healthy People: Our strategy for public health in England. London: Department of Health; 2010.

134. Meland E, Laerum E, Maeland JG. Life style intervention in general practice: effects on psychological well-being and patient satisfaction. Qual Life Res. 1996; 5(3):348-54.

135. Ebrahim S, Beswick A, Burke M, Davey Smith G. Multiple risk factor interventions for primary prevention of coronary heart disease. Cochrane DB Syst Rev. 2006; Issue 4. Art. No.: CD001561.

136. Higgins JPT, Green S, Collaboration C. Cochrane handbook for systematic reviews of interventions. Wiley Online Library; 2008.

137. Higgins J, Thompson SG. Quantifying heterogeneity in a meta-analysis. Stat Med. 2002; 21(11):1539-1558.

138. DerSimonian R, Laird N. Meta-analysis in clinical trials. Control Clin Trials. 1986; 7(3):177-188.

139. Wood D, Kotseva K, Connolly S, Jennings C, Mead A, Jones J, et al. Nurse-coordinated multidisciplinary, family-based cardiovascular disease prevention programme (EUROACTION) for patients with coronary heart disease and asymptomatic individuals at high risk of cardiovascular disease: a paired, cluster-randomised controlled trial. Lancet. 2008; 371(9629):1999-2012.

140. Rahman M, Simmons R, Hennings S, Wareham N, Griffin S. Effect of screening for Type 2 diabetes on population-level self-rated health outcomes and measures of cardiovascular risk: 13-year follow-up of the Ely cohort. Diabetic Med. 2012; 29(7):886-892.

141. OXCHECK Study Group. Prevalence of risk factors for heart disease in OXCHECK trial: implications for screening in primary care. BMJ. 1991; 302(6784):1057-60.

142. Engberg M, Christensen B, Karlsmose B, Lous J, Lauritzen T. General health screenings to improve cardiovascular risk profiles: A randomised controlled trial in general practice with a 5-year follow-up. Ugeskrift for Laeger. 2002; 164(25):3354-3360.

143. Simmons R, Rahman M, Jakes R, Yuyun M, Niggebrugge A, Hennings S, et al. Effect of population screening for type 2 diabetes on mortality: long-term follow-up of the Ely cohort. Diabetologia. 2011; 54(2):312-319.

144. Wood D, Kinmonth A, Davies G, Yarwood J, Thompson S, Pyke S, et al. British family heart study: Its design and method, and prevalence of cardiovascular risk factors. BJGP. 1994; 44(379):62-67.

145. Nielsen KDB, Dyhr L, Lauritzen T, Malterud K. "You can't prevent everything anyway": A qualitative study of beliefs and attitudes about refusing health screening in general practice. Fam Pract. 2004; 21(1):28-32.

146. Davies G, Pyke S, Kinmonth AL. Effect of non-attenders on the potential of a primary care programme to reduce cardiovascular risk in the population. Family Heart Study Group. BMJ. 1994; 309(6968):1553-6.

147. Stewart S, Carrington MJ, Swemmer CH, Anderson C, Kurstjens NP, Amerena J, et al. Effect of intensive structured care on individual blood pressure targets in primary care: Multicentre randomised controlled trial. BMJ (Online). 2012; 345(7884).

148. Benner J, Erhardt L, Flammer M, Moller R, Rajicic N, Changela K, et al. A novel programme to evaluate and communicate 10 year risk of CHD reduces predicted risk and improves patients' modifiable risk factor profile. Int J Clin Pract. 2008; 62(10):1484-1498.

149. Tiessen AH, Smit AJ, Broer J, Groenier KH, van der Meer K. Randomized controlled trial on cardiovascular risk management by practice nurses supported by self-monitoring in primary care. BMC Fam Pract. 2012; 13(1):90.

150. OXCHECK Study Group. Effectiveness of health checks conducted by nurses in primary care: results of the OXCHECK study after one year. BMJ. 1994; 308(6924):308-12.

151. 45 and Up Study Collaborators. Cohort profile: the 45 and up study. Int J Epidemiol. 2008; 37(5):941.

152. Taylor A, Dal Grande E. Chronic disease and risk factor surveillance using the SA Monitoring and Surveillance System (SAMSS)–history, results and future challenges. Public Health Bulletin SA. 2008; 5(3):17-21.

153. World Health Organization. Global Recommendations on Physical activity for Health. Geneva: WHO; 2010 [cited 6/2014]. Available from: http://www.who.int/dietphysicalactivity/factsheet_recommendations/en/.

154. National Health and Medical Research Council. Dietary Guidelines for all Australians. Australia: NHMRC; 2013 [cited 6/2014]. Available from: http://www.nhmrc.gov.au/guidelines/publications/n29-n30-n31-n32-n33-n34.

155. National Health and Medical Research Council. Alcohol guidelines: reducing the health risks. Australia: NHMRC; 2009 [cited 6/2014]. Available from: http://www.nhmrc.gov.au/your-health/alcohol-guidelines.

156. Conner M, & Sparks, P. (1996). The theory of planned behaviour and health behaviours. In M. Conner & P. Norman (Eds.), Predicting health behaviour (pp. 121-162). Buckingham: Open University Press.

157. Armitage CJ, Conner M. Efficacy of the theory of planned behaviour: A meta-analytic review. Brit J Soc Psychol. 2001; 40(4):471-499.

158. Cooke R, French D. How well do the theory of reasoned action and theory of planned behaviour predict intentions and attendance at screening programmes? A meta-analysis. Psychol Health. 2008; 23(7):745-765.

159. McEachan RRC, Conner M, Taylor NJ, Lawton RJ. Prospective prediction of health-related behaviours with the Theory of Planned Behaviour: a meta-analysis. Health Psychol Rev. 2011; 5(2):97-144.

160. Ajzen I. From intentions to actions: A theory of planned behavior. In J. Kuhl & J.Beckmann (Eds.), Action-control: From cognition to behavior (pp. 11-39). 1985; Heidelberg: Springer

161. Ajzen I. TPB questionnaire design. [cited 6/2014]. Available from: http://people.umass.edu/aizen/tpb.html.

162. Francis JJ, Eccles MP, Johnston M, Walker A, Grimshaw J, Foy R, et al. Constructing questionnaires based on the theory of planned behaviour. A manual for health services researchers. 2004; University of Newcastle upon Tyne, UK: Centre for Health Services Research, ISBN 0-9540161-5-7.

163. Rutter D. Attendance and reattendance for breast cancer screening: A prospective 3 year test of the Theory of Planned Behaviour. Brit J Health Psych. 2000; 5(1):1-13.

164. McQueen A, Tiro J.A, Vernon S.W. Construct validity and invariance of four factors associated with colorectal cancer screening across gender, race, and prior screening. Cancer Epidem Biomar. 2008; 17(9):2231-2237.

165. Medicare Australia. Medicare Item Reports. Australia: Medicare; 2009 [cited 10/2013]. Available from: http://www.medicareaustralia.gov.au/statistics/mbs_item.shtml.

166. Ajzen I. The theory of planned behaviour: Reactions and reflections. Psychol Health. 2011; 26(9):1113-1127.

167. Griffiths C, Cooke S, Toon P. Registration health checks: inverse care in the inner city? BJGP. 1994; 44(382):201.

168. Wall M, Teeland L. Non-participants in a preventive health examination for cardiovascular disease: Characteristics, reasons for non-participation, and willingness to participate in the future. Scand J Prim Health. 2004; 22(4):248-251.

169. Sargeant LA, Simmons RK, Barling RS, Butler R, Williams KM, Prevost AT, et al. Who attends a UK diabetes screening programme? Findings from the ADDITION-Cambridge study. Diabet Med. 2010; 27(9):995-1003.

170. Roland M, Mayor V, Morris R. Factors associated with achieving continuity of care in general practice. J Roy Coll of Gen Pract. 1986; 36(284):102.

171. Australian Bureau of Statistics. Census of Population and Housing: Socio-Economic Indexes for Areas (SEIFA), Australia 2011. Australia: ABS; 2012 [cited 6/2014]. Available from: http://www.abs.gov.au/ausstats/abs@.nsf/mf/2033.0.55.001/.

172. Australian Bureau of Statistics. National Health Survey. Australia: ABS; 2011 [cited 5/2014]. Available from: http://www.abs.gov.au/.

173. Pett MA, Lackey NR, Sullivan JJ. Making sense of factor analysis: The use of factor analysis for instrument development in health care research. 2003; Sage, London.

174. Hosmer DW, Lemeshow S. Applied logistic regression. New York, NY: Wiley & Sons; 1989.

175. Armitage C, Norman P, Conner M. Can the Theory of Planned Behaviour mediate the effects of age, gender and multidimensional health locus of control? Brit J Health Psychol. 2002; 7(3):299-316.

176. Sheeran P, Conner M, Norman P. Can the Theory of Planned Behavior Explain Patterns of Health Behavior Change? Health Psychol. 2001; 20(1):12-19.

177. Luzzi L, Spencer AJ. Factors influencing the use of public dental services: An application of the Theory of Planned Behaviour. BMC Health Serv Res. 2008;

178. Tolonen H, Laatikainen T, Helakorpi S, Talala K, Martelin T, Prättälä R. Marital status, educational level and household income explain part of the excess mortality of survey non-respondents. Eur J Epidemol. 2010; 25(2):69-76.

179. Asch DA, Jedrziewski MK, Christakis NA. Response rates to mail surveys published in medical journals. Journal of clinical epidemiology. 1997; 50(10):1129-1136.

180. Martikainen P, Laaksonen M, Piha K, Lallukka T. Does survey non-response bias the association between occupational social class and health? Scand J Public Health. 2007; 35(2):212-215.

181. Lambert AM, Burden AC, Chambers J, Marshall T. Cardiovascular screening for men at high risk in Heart of Birmingham Teaching Primary Care Trust: the 'Deadly Trio' programme. J Public Health. 2012; 34(1):73-82.

182. Artac M, Dalton AR, Majeed A, Car J, Huckvale K, Millett C. Uptake of the NHS Health Check programme in an urban setting. Fam Pract. 2013. [Epub ahead of print]

183. Britt H, Miller GC, Charles J, Henderson J, Bayram C, Pan Y, et al. General practice activity in Australia 2009-10. Australia: AIHW & University of Sydney; 2010.

184. Conner M, Godin G, Norman P, Sheeran P. Using the question-behavior effect to promote disease prevention behaviors: Two randomized controlled trials. Health Psychol. 2011; 30:300-309.

185. National Institute for Health and Clinical Excellence. Guide to the methods of technology appraisal 2004. London: NICE; 2015 [cited 6/2014]. Available from: http://www.nice.org.uk/page.aspx?o=201973

186. Raftery JP. Paying for costly pharmaceuticals: regulation of new drugs in Australia, England and New Zealand. MJA. 2008; 188(1):26.

187. George B, Harris AH, Mitchell AJ. Cost effectiveness analysis and the consistency of decision making: evidence from pharmaceutical reimbursement in Australia 1991-96. Centre for Health Program Evaluation Melbourne, Australia; 1999.

188. Vos T, Carter R, Barendregt J, Mihalopoulos C, Veerman L, Magnus A, et al. Assessing cost-effectiveness in prevention (ACE-Prevention): final report. Melbourne:The University of Queensland, Brisbane and Deakin University; 2010.

189. Anderson KM, Odell PM, Wilson PWF, Kannel WB. Cardiovascular disease risk profiles. Am Heart J. 1991; 121(1, Part 2):293-298.

190. Australian Institute of Health and Welfare. National hospital morbidity database (NHMD). Canberra: AIHW; 2012 [cited 03/2013]. Available from: http://www.aihw.gov.au/hospitals-data/national-hospital-morbidity-database/#t3.

191. Australian Bureau of Statistics. Causes of Death, Australia, 2011. Australia: ABS; 2013 [cited 03/2013] Available from: http://www.abs.gov.au/ausstats/abs@.nsf/Lookup/3303.0Chapter42011.

192. Lovibond K, Jowett S, Barton P, Caulfield M, Heneghan C, Hobbs F, et al. Cost-effectiveness of options for the diagnosis of high blood pressure in primary care: a modelling study. Lancet. 2011;378:1219-30

193. Rosengren A, Wilhelmsen L, Hagman M, Wedel H. Natural history of myocardial infarction and angina pectoris in a general population sample of middle-aged men: a 16-year follow-up of the Primary Prevention Study, Göteborg, Sweden. J Intern Med. 1998; 244(6):495-505.

194. Brønnum-Hansen H, Davidsen M, Thorvaldsen P. Long-term survival and causes of death after stroke. Stroke. 2001; 32(9):2131-2136.

195. Brønnum-Hansen H, Jørgensen T, Davidsen M, Madsen M, Osler M, Gerdes LU, et al. Survival and cause of death after myocardial infarction: The Danish MONICA study. J Clin Epidemiol. 2001; 54(12):1244-1250.

196. Dennis M, Bamford J, Sandercock P, Warlow C. Prognosis of transient ischemic attacks in the Oxfordshire Community Stroke Project. Stroke. 1990; 21(6):848-853.

197. Hawthorne G, Osborne R. Population norms and meaningful differences for the Assessment of Quality of Life (AQoL) measure. Aust NZ J Public Heal. 2005; 29(2):136-142.

198. Ward S, Jones ML, Pandor A, Holmes M, Ara R, Ryan A, et al. A systematic review and economic evaluation of statins for the prevention of coronary events. Cochrane DB Syst Rev. 2007.

199. Department of Health. Round 14 (2009-10) National Public Cost Weight Tables - version 6.0x and version 5.2. Australia: Department of Health; 2012 [cited 20/04]. Available from: http://www.health.gov.au/internet/main/publishing.nsf/Content/Round_14-cost-reports.

200. Palmer S, Sculpher M, Philips Z, Robinson M, Ginnelly L, Bakhai A, et al. A cost-effectiveness model comparing alternative management strategies for the use of glycoprotein IIb/IIIa antagonists in non-ST-elevation acute coronary syndrome. London: NICE 2002.

201. Tzoulaki I, Seretis A, Ntzani EE, Ioannidis JPA. Mapping the expanded often inappropriate use of the Framingham Risk Score in the medical literature. J Clin Epidemiol. 2014; 67(5):571-577.

202. National Vascular Disease Prevention Alliance. Absolute cardiovascular disease risk. Australia: National Vascular Disease Prevention Alliance; 2006.

Appendices

Appendix 1: Checklist for 45-49 year old health check

NOTE:
This appendix is included on page 175 of the print copy of the thesis held in the University of Adelaide Library.

Appendix 2: Search strategy (Chapter 3)

Search Strategies (PubMed)

Participants	General Practice	Health check	Outcomes	Study types
Adult[mh:noexp] OR middle aged[mh] OR adult*[tiab] OR middle age*[tiab]	General practice[mh] OR General practitioners[mh] OR Physicians, primary care[mh] OR family practice[mh] OR Physicians, family[mh] OR nursing care[mh:noexp] OR primary care nursing[mh] OR General practice[tiab] OR General practitioner*[tiab] OR Family practice[tiab] OR Family physician*[tiab] OR Family doctor*[tiab] OR family practitioner*[tiab] OR practice nurse*[tiab] OR nurse practitioner*[tiab] OR primary health provider*[tiab] OR primary health care provider*[tiab] OR primary care provider*[tiab] OR primary health care professional*[tiab] OR primary health professional*[tiab] OR primary care professional*[tiab] OR primary care physician*[tiab] OR primary health care physician*[tiab] OR primary health physician*[tiab]	Preventive Health Services[mh:noexp] OR Mass screening[mh:noexp] OR Multiphasic Screening[mh] OR Health promotion[mh:noexp] OR preventive medicine[mh] OR Preventive Health Service*[tiab] OR Mass screen*[tiab] OR Multiphasic screen*[tiab] OR Health promotion[tiab] OR Health check*[tiab] OR preventive medicine*[tiab] OR physical examination[mh:noexp] OR physical exam*[tiab] OR checkup* [tiab] OR check-up*[tiab]	treatment outcome[mh:noexp]OR treatment outcome*[tiab] OR treatment effectiveness[tiab] OR treatment efficacy[tiab] OR outcome assessment OR health care[mh:noexp] OR outcome assessment*[tiab] OR outcome stud*[tiab] OR patient* outcome*[tiab] OR outcome measure*[tiab] OR research outcome*[tiab] OR health behaviour[mh:noexp] OR life style[mh:noexp] OR diet[mh] OR exercise[mh] OR smoking[mh:noexp] OR body mass index[mh] OR health status[mh:noexp] OR risk factors[mh] OR blood pressure[mh:noexp] OR cholesterol/blood[mh] OR cardiovascular disease/diagnosis[mh:noexp] OR coronary disease/diagnosis[mh] OR health behaviour*[tiab] OR lifestyle*[tiab] OR life style*[tiab] OR diet*[tiab] OR exercise*[tiab] OR physical activit*[tiab] OR smoking[tiab] OR cigarette*[tiab] OR tobacco*[tiab] OR BMI[tiab] OR body mass index[tiab] OR health stat*[tiab] OR risk factor*[tiab] OR blood pressure[tiab] OR BP[tiab] OR cholesterol[tiab] OR blood lipid*[tiab] OR cardiovascular disease*[tiab] OR CVD[All Fields] OR coronary heart disease*[tiab]	clinical trial[pt] OR clinical trial*[tw] OR "phase 1 trial"[tw] OR "phase 1 trials"[tw] OR "phase i trial"[tw] OR "phase i trials"[tw] OR "phase 2 trial"[tw] OR "phase 2 trials"[tw] OR "phase ii trial"[tw] OR "phase ii trials"[tw] OR "phase 3 trial"[tw] OR "phase 3 trials"[tw] OR "phase iii trial"[tw] OR "phase iii trials"[tw] OR "phase 4 trial"[tw] OR "phase 4 trials"[tw] OR "phase iv trial"[tw] OR "phase iv trials"[tw] OR multicentre stud*[tw] OR multicenter stud*[tw] OR multicentre trial*[tw] OR multicenter trial*[tw] OR randomised controlled trial*[tw] OR randomised controlled trial*[tw] OR randomised controlled screening trial*[tw] OR randomised clinical trial*[tw] OR randomised clinical trial*[tw] OR randomised controlled clinical trial*[tw] OR randomised controlled clinical trial*[tw] OR double blind[tw] OR placebo[tw] OR rct[tw] OR random allocation[mh] OR random allocation*[tw]
Participants + GP+ Health Check+ Outcome+ Study type: n=468				

Search Strategies (EMBASE)

Participants	General Practice	Health check	Outcomes	Study types
'adult'/exp OR 'adult' OR 'middle aged'/exp OR 'middle aged' OR (middle NEXT/1 age*):ab,ti	'general practice'/exp OR 'general practice' OR 'general practitioner'/exp OR 'general practitioner' OR 'nursing care'/exp OR 'nursing care' OR (general NEXT/1 practi*):ab,ti OR (family NEAR/1 (practi* OR physician* OR doctor*)):ab,ti OR (primary NEXT/3 (provider* OR professional* OR physician*)):ab,ti OR (practi* NEAR/1 nurse*):ab,ti OR gp:ab,ti OR gps:ab,ti	'preventive health service'/exp OR 'preventive health service' OR 'mass screening'/exp OR 'mass screening' OR 'health promotion'/exp OR 'health promotion' OR 'preventive medicine'/exp OR 'preventive medicine' OR (preventive NEXT/2 service*):ab,ti OR 'mass screening':ab,ti OR 'mass screenings':ab,ti OR 'multiphasic screening':ab,ti OR 'health promotion':ab,ti OR 'health check':ab,ti OR 'health checks':ab,ti OR 'preventive medicines':ab,ti OR 'preventive medicine':ab,ti OR checkup*:ab,ti	'health behavior'/exp OR 'health behavior' OR 'behavioral risk factor surveillance system'/exp OR 'behavioral risk factor surveillance system' OR 'high risk behavior'/exp OR 'high risk behavior' OR 'risk reduction'/exp OR 'risk reduction' OR 'lifestyle'/exp OR 'lifestyle' OR 'blood pressure'/exp OR 'blood pressure' OR 'diastolic blood pressure'/exp OR 'diastolic blood pressure' OR 'systolic blood pressure'/exp OR 'systolic blood pressure' OR 'cholesterol blood level'/exp OR 'cholesterol blood level' OR 'cardiovascular risk'/exp OR 'cardiovascular risk' OR 'coronary risk'/exp OR 'coronary risk' OR 'heart disease'/exp OR 'heart disease' OR 'ischemic heart disease'/exp OR 'ischemic heart disease' OR 'health status'/exp OR 'health status' OR 'diet'/exp OR 'diet' OR 'exercise'/exp OR 'exercise' OR 'smoking habit'/exp OR 'smoking habit' OR 'weight'/exp OR 'weight' OR (health NEXT/1 behavio*):ab,ti OR lifestyle*:ab,ti OR (life NEAR/1 style*):ab,ti OR diet*:ab,ti OR exercise*:ab,ti OR (physical NEXT/1 activit*):ab,ti OR smok*:ab,ti OR cigarette*:ab,ti OR tobacco*:ab,ti OR 'bmi':ab,ti OR 'body mass index':ab,ti OR 'blood pressure':ab,ti OR 'bp':ab,ti OR cholesterol:ab,ti OR (blood NEXT/1 lipid*):ab,ti OR (cardiovascular NEXT/1 disease*):ab,ti OR 'cvd':ab,ti OR (coronary NEXT/2 disease*):ab,ti OR (health NEXT/1 stat*):ab,ti OR 'risk factor':ab,ti OR 'risk factors':ab,ti OR 'treatment outcome'/exp OR 'treatment outcome' OR outcome:ab,ti	'clinical trial'/exp OR 'clinical trial' OR (clinical NEXT/1 trial*):ab,ti OR ('phase 1' NEXT/1 trial*):ab,ti OR ('phase i' NEXT/1 trial*):ab,ti OR ('phase 2' NEXT/1 trial*):ab,ti OR ('phase ii' NEXT/1 trial*):ab,ti OR ('phase 3' NEXT/1 trial*):ab,ti OR ('phase iii' NEXT/1 trial*):ab,ti OR ('phase 4' NEXT/1 trial*):ab,ti OR ('phase iv' NEXT/1 trial*):ab,ti OR (multicent* NEXT/1 stud*):ab,ti OR (multicent* NEXT/1 trial*):ab,ti OR ('randomised controlled' NEXT/2 trial*):de,ab,ti OR ('randomised controlled' NEXT/2 trial*):ab,ti OR ('randomised clinical' NEXT/1 trial*):ab,ti OR ('randomised clinical' NEXT/1 trial*):ab,ti OR 'double blind':ab,ti OR placebo:ab,ti OR rct*:ab,ti
Participants + GP+ Health Check+ Outcome+ Study type: n=533				

Search Strategies (Central)

Participants	General Practice	Health check	Outcomes	Study type
adult [mh:noexp] OR middle aged[mh] OR (middle NEXT/1 age*): ab,ti	General practice[mh] OR General practitioners[mh] OR Physicians, primary care[mh] OR family practice[mh] OR Physicians, family[mh] OR nursing care[mh:noexp] OR primary care nursing[mh] OR (general NEXT/1 practi*):ab,ti OR (family NEAR/1 (practi* OR physician* OR doctor*)):ab,ti OR (primary NEXT/3 (provider* OR professional* OR physician*)):ab,ti OR (practi* NEAR/1 nurse*):ab,ti OR gp:ab,ti OR gps:ab,ti	Preventive Health Services[mh:noexp] OR Mass screening[mh:noexp] OR Multiphasic Screening[mh] OR Health promotion[mh:noexp] OR preventive medicine[mh] OR (preventive NEXT/2 service*) OR (mass screening) OR (mass screenings) OR (multiphasic screening) OR (health promotion) OR (health check) OR (health checks) OR (preventive medicines) OR (preventive medicine) OR checkup*	treatment outcome[mh:noexp] OR outcome assessment (health care)[mh:noexp] OR health behaviour[mh:noexp] OR life style[mh:noexp] OR diet[mh] OR exercise[mh] OR smoking[mh:noexp] OR body mass index[mh] OR health status[mh:noexp] OR risk factors[mh] OR blood pressure[mh:noexp] OR cholesterol/blood[mh] OR cardiovascular disease/diagnosis[mh:noexp] OR coronary disease/diagnosis[mh] OR (health NEXT/1 behavio*) OR lifestyle* OR (life NEAR/1 style*) OR diet* OR exercise* OR (physical NEXT/1 activit*) OR smok* OR cigarette* OR tobacco* OR bmi OR (body mass index) OR (blood pressure) OR bp OR cholesterol OR (blood NEXT/1 lipid*) OR (cardiovascular NEXT/1 disease*) OR cvd OR (coronary NEXT/2 disease*) OR (health NEXT/1 stat*) OR (risk factor) OR (risk factors) OR (treatment outcome*) OR (treatment effective*) OR (treatment efficacy) OR (outcome assessment*) OR (outcome stud*) OR (patient* outcome*) OR (outcome measure*) OR (research outcome*)	'clinical trial'/exp OR 'clinical trial' OR (clinical NEXT/1 trial*):ab,ti OR ('phase 1' NEXT/1 trial*):ab,ti OR ('phase i' NEXT/1 trial*):ab,ti OR ('phase 2' NEXT/1 trial*):ab,ti OR ('phase ii' NEXT/1 trial*):ab,ti OR ('phase 3' NEXT/1 trial*):ab,ti OR ('phase iii' NEXT/1 trial*):ab,ti OR ('phase 4' NEXT/1 trial*):ab,ti OR ('phase iv' NEXT/1 trial*):ab,ti OR (multicent* NEXT/1 stud*):ab,ti OR (multicent* NEXT/1 trial*):ab,ti OR ('randomised controlled' NEXT/2 trial*):de,ab,ti OR ('randomised controlled' NEXT/2 trial*):ab,ti OR ('randomised clinical' NEXT/1 trial*):ab,ti OR ('randomised clinical' NEXT/1 trial*):ab,ti OR 'double blind':ab,ti OR placebo:ab,ti OR rct*:ab,ti
Participants + GP+ Health Check+ Outcome+ Study type: n=957				

Appendix 3: Characteristics of included studies (Chapter 3)

Study country year of study conducted	Study design	Follow-up	Sample size (recruited /responded)	Sampling frame	Settings	Intervention	Comparison	Outcomes
OXCHECK, UK, 1989 (25, 29, 38)	RCT	Surrogate outcomes: 3 years Mortality: 4 years	I: 2,776 C: 2,783 ——— I: 2,205 C: 1,916	Patients aged 35-64 years registered with 2 cooperating general practices and returned the initial health questionnaire (**80%** of the identified patients)	PN-led practice-based health check with subsequent intervention plans GPs were aware of the allocation	Health check → (subgroup: annual recheck) →risk factor intervention →4th year re-check (attendees of the 1st initial check-up) uptake rate: **1st round: 82.2%** *(of all randomised patients)* **final round: 81.7%** *(of all patients who attended the 1st health check)*	Health check at the 4th year uptake rate: **final round: 81.3%** *(of all randomised patients)*	Mean levels of TC, BP and BMI Self-report saturated fat intake; Proportion of patients with elevated TC , BP and BMI Prevalence of smoking and alcohol use Numbers of GP, PN visits Total and CVD mortality
BFH, UK, 1990 (30, 31)	Cluster RCT	Surrogate outcomes: 1 year	I: 2,984 C: 3,576 ——— I: 724 C: 369	All male patients aged 40-59 years registered with general practices were identified and randomised. The male patient and their families were invited for a health check	PN-led practice-based health check with intensive subsequent intervention plans Unclear if GPs were aware of the allocation	Health check → intensive intervention (man & partner)→1st year recheck (attendees of the 1st initial check-up) uptake rate: **1st round: 68% of (households)** *(of all randomised households)* **final round: 88% (M); 85% (F)** *(of all patients who attended the 1st health check)*	Health check at 1st year uptake rate: **73% of households** *(of all randomised households)*	Absolute CVD risk score; Mean levels of BP, TC, weight and glucose Prevalence of smoking, high BP and cholesterol

Study country year of study conducted	Study design	Follow-up	Sample size (recruited /responded)	Sampling frame	Settings	Intervention	Comparison	Outcomes
Denmark**,** Denmark, 1992 (8, 26, 32)	RCT	Surrogate outcomes: 5 years Mortality: 8 years	I: 1,006 C: 501	All patients aged 30-49 years registered with local general practices were approached (n=2,000); **75%** of the approached patients (n=1,507) agreed to participant	Practice-based health check with subsequent intervention plans Both GPs and patients were aware of the allocation	Baseline questionnaire → Health check (subgroup: health check + regular health discussion)→1st & 5th year re-check (attendees of the 1st initial check-up) uptake rate: *(of all randomised patients)* **1st round**: **89.9%** **final round: 71.9%**	Baseline questionnaire→ Heath check at 5th year follow-up **uptake rate: 73.7%** *(of all randomised patients)*	Absolute CVD risk score; Mean levels of BP, TC and BMI Proportion of patients with elevated absolute CVD score, BMI, BP and TC Total mortality Medical service use
Euroaction, Denmark, Italy, Poland, Spain, the Netherlands, the UK, 2003 (16)	Cluster RCT	Surrogate outcomes: 1 year	Patients: I: 1,189 C: 1,128 Partners: I: 356 C:542 Patients: I: 1,019 C: 1,005 Partners: I: 225 C:363	Consecutive patients aged 50-80 years registered with general practices 1) At high risk of CVD; 2) Newly diagnosed high BP or TC patients with no history of DM; 3) Newly diagnosed DM patients within 3 years;4) NO other severe chronic conditions Both patients and their partners were identified (1,257+805); patients and partners who agree to participate were invited for a health check (1,154+365)	PN-led practice-based health check with subsequent intervention plans Cluster RCT, GPs were aware of their allocation	Health check → intensive intervention on high risk patients (nurse-lead multidisciplinary family-based 16 weeks intervention) → 1st year re-check (all eligible patients in intervention practice regardless of attendance at the initial screening) uptake rate: **1st round**: *(of all randomised patients)* **Patients: 94%** **Partners: 71%** **Final round**: *(of all randomised patients)* **Patients: 86%** **Partners: 63%**	Subsample of patients received health check at baseline Health check at 1st year follow-up on all patients and their partners uptake rate: *(of all randomised patients)* **Patients: 89%** **Partners: 67%**	Self-reported lifestyle change; Proportion of patients attaining BP, TC treatment goal; Prescription rates of anti-hypertensive drug & statins

Study country year of study conducted	Study design	Follow-up	Sample size (recruited /responded)	Sampling frame	Settings	Intervention	Comparison	Outcomes
Ely Cohort, UK, 1990 (17, 28)	RCT	Surrogate outcomes: 13 years Mortality: 18 years	first round: I: 1,705 C: 3,231 final round I: 1,696 C: 1,694 I: 731 C: 711	Participants were randomly selected from all patients aged 40-65 years registered with a single practice in Ely and with no prior diagnosis of DM.	Screening was conducted at a local screening clinic. GPs were informed of the results and advised to undertake further interventions	Heath check (DM) → 4.5 and 10th year re-check (patients without diagnosis of DM at the time of 10th year) uptake rate: **1st round: 68%** *(of all randomised patients)* **final round: 43.1%** *(of all randomised patients without DM registered at the practice)*	Health check at 10th year follow-up **uptake rate: 42.0%** *(of all randomised patients without DM registered at the practice)*	Mean levels of BP; TC and BMI Total and CVD mortality
South-East London, UK, 1967 (27)	RCT	Mortality: 9 years	I: 3,876 C: 3,353 smoking: I: 1,978 C: 1,950 mortality: I: 3,292 C: 3,132	Patients aged between 40-64 years registered with cooperating general practices	General practice-based screening GPs were aware of the allocation	Health check→2nd year re-check→health survey at the 4th year follow-up uptake rate: **1st round: 73.4%** *(of all invited patients)* **2nd round : 65.5%** *(of all invited patients)* **final survey response rate:51.0%** *(of all randomised patients)* *note: inconsistent reporting of sample size within the report*	Health survey at 4 years follow-up **final survey response rate: 58.2%** *(of all randomised patients)* *note: inconsistent reporting of sample size within the report*	Consultation and hospital admission rates; Total and CVD mortality

I: intervention; C: control; PN: practice nurse; GP: general practitioner; BMI: body mass index; DM: diabetes mellitus

Appendix 4: Study quality assessment (Chapter 3)

Table a: Quality assessment of studies reporting surrogate outcome changes (mean levels of BP, TC)

Study	Study design	Selection bias				Performance bias	Notes
		Random sequence generation	Notes	Allocation concealment	Notes		
BFH	RCT	Unclear risk	‘in the intervention practices each five year age band was randomly divided into two equal size groups’	Low risk	Two groups were identified at the same time	Unclear risk	The study was conducted by practice nurses. Unclear whether GPs were blinded to group allocation
OXCHECK	RCT	Low risk	Randomization was generated by a third party	Low risk		High risk	HCs were conducted by practice staff or GPs were informed about HC results. Even though GPs were aware of the trial and group allocation, it was unlikely that they would treat a patient differently in their routine practice.
Denmark	RCT	Low risk		Low risk		High risk	
Euroaction	Cluster RCT	Unclear risk	“consecutive patients were prospectively identified ” **Comments**: patients were identified prior to the allocation of intervention	Low risk	“A matched, paired cluster RCT was conducted in 12 practices”	High risk	
Ely cohort	RCT	Unclear risk	unclear description	Low risk	Two groups were identified at the same time	High risk	
South-East London	RCT	Unclear risk	‘individuals in the screening group…along with a control individual of the same sex and registered with the same GP’	Low risk		High risk	

Continue: Quality assessment of studies reporting surrogate outcome changes (mean levels of BP, TC, BMI)

Study	Detection bias	Notes	Attrition bias	Notes	Reporting bias	Notes	Other bias	Notes
BFH	Low risk	These outcomes were objective, based on the readings of test results	Unclear risk	ITT applied Analysis conducted using data from attendees of final health check Non-returners had slightly higher smoking rate and BMI, but lower self-reported morbidity compared to returners	Low risk	No evidence indicating reporting bias regarding investigated outcomes	Low risk	**Baseline comparison:** "the mean ages of the men and women were almost identical between groups” **External validity:** 'the entire list of men aged 40-59 in each of the intervention and comparison practices was randomly ordered within five year age bands' In addition, the study used an external control group as quality control. Comparison between attendees and non-attendees indicated differences in smoking rate, but not other risk factors. (25)
OXCHECK	Low risk		Unclear risk	ITT applied	Low risk		Unclear risk	**Baseline comparability:** 'the trial did not differ significantly in the distribution of age, sex, marital status or social class' **External validity:** The entire sample was chosen from patients who responded to an initial questionnaire (response rate: 80.3%). No comparison between attendees and non-attendees
Denmark	Low risk		Unclear risk	ITT applied : ‘participants received follow-up…according to their group of randomization’ Analysis conducted using data from attendees of final health check No comparison between returners and non-returners	Low risk		High risk	**Baseline comparison**: 'no significant differences between groups were found in the distribution of SES and CVD risk factors' **External validity:** The entire sample was chosen from patients who responded to an initial questionnaire (response rate: 75%). More females (80%) than males (71%) participated.

Continue: Quality assessment of studies reporting surrogate outcome changes (mean levels of BP, TC, BMI)

Study	Detection bias	Notes	Attrition bias	Notes	Reporting bias	Notes	Other bias	Notes
Euroaction	Low risk		Unclear risk	ITT applied by inviting all patients to the final check-up regardless of their attendance at the 1st check. Analysis conducted using data from attendees of final health check However, the attrition rates in patients were low	Low risk		High risk	**Baseline comparison:** 'initial assessment revealed some unexpected differences in patient's characteristics in both directions' **External validity:** 'consecutive patients were prospectively identified' **Comment**: Consecutive patients in general practices were recruited prior to the intervention allocation of general practices No comparison was made between those selected and the remaining patients in the practice.
Ely cohort	Low risk		High risk	Non-ITT: Only patients without the diagnosis of DM were invited to the final check-up Analysis conducted using data from attendees of final health check 'in the 2nd screening, 45% accept the invitation. attendees were significantly younger and lived in **less** deprived areas'	Unclear risk	The study was originally designed to investigate aetiology of DM; only health check relevant reports were reviewed	High risk	Inconsistent description of sample size and group study design (fact sheets): 'Of the initial 1100 participants, over 900 agreed to be re-tested…We also recruited a similar group of new volunteers in 2000' This review used the information reported in the formal study report **Baseline comparison**: 'participants who were offered screening were older at baseline, lived in more deprived areas and included a smaller proportion of men' **External validity:** 'all men and women aged 40-65 without known DM were randomised' **Comments:** The sampling frame was the target population
Study	Detection bias	Notes	Attrition bias	Notes	Reporting bias	Notes	Other bias	Notes
Study	Detection bias	Notes	Attrition bias	Notes	Reporting bias	Notes	Other bias	Notes

Continue: Quality assessment of studies reporting surrogate outcome changes (mean levels of BP, TC, BMI)

Study	Detection bias	Notes	Attrition bias	Notes	Reporting bias	Notes	Other bias	Notes
South-East London	N/A		N/A		High risk	No report was found on prescription, referral and investigations ordered	Unclear risk	Inconsistent report of sample size and group study design **Baseline comparison:** No differences in age and SES status between intervention and control group **External validity:** 'all persons aged 40-64 years in 1967 were randomly allocated by family within GP list into intervention and control group' **Comments:** The sampling frame was the target population

Note: 'Other bias' includes the assessment of baseline comparability and external validity

Table b: Quality assessment of studies reporting smoking cessation

Study	Detection bias	Notes	Attrition bias	Notes
BFH	High risk	Self-reported smoking rate **Comments**: more self-reported ex-smokers had high CO level than controls	High risk	
OXCHECK	High risk	Self-reported smoking rate	High risk	analysis conducted among attendees at the final screening or survey
Denmark	High risk	Self-reported smoking rate	High risk	
Euroaction	High risk	Self-reported smoking rate	High risk	
South-East London	High risk	Self-reported smoking rate	High risk	
Ely cohort	High risk	Self-reported smoking rate	High risk	

Table c: Quality assessment of studies reporting mortality

Study	Detection bias	Notes	Attrition bias	Notes
OXCHECK	Low risk	mortality information was derived from national registration	Low risk	attrition rates were low in national registry
Denmark	Low risk		Low risk	
South-East London	Low risk		Low risk	
Ely cohort	Low risk		Low risk	

Appendix 5: Subgroup analyses of recruitment strategy (Chapter 3)

Study or Subgroup	Health check Mean	Health check SD	Health check Total	Usual care Mean	Usual care SD	Usual care Total	Weight	Mean Difference IV, Random, 95% CI
3.2.1 High risk patient-oriented recruitment								
BFH 1990	5.58	0.94	1767	5.72	0.94	2174	29.2%	-0.14 [-0.20, -0.08]
BFH 1990	5.48	1.79	1217	5.6	1.79	1402	13.1%	-0.12 [-0.26, 0.02]
Subtotal (95% CI)			**2984**			**3576**	**42.3%**	**-0.14 [-0.19, -0.08]**
Heterogeneity: Tau² = 0.00; Chi² = 0.07, df = 1 (P = 0.79); I² = 0%								
Test for overall effect: Z = 4.95 (P < 0.00001)								
3.2.2 General population-oriented recruitment								
OXCHECK 1989	5.99	1.1	2205	6.18	1.17	1916	26.3%	-0.19 [-0.26, -0.12]
Denmark 1992	5.54	1.03	724	5.68	1.06	369	13.9%	-0.14 [-0.27, -0.01]
Ely 1990	5.6	1	731	5.6	1.1	711	17.5%	0.00 [-0.11, 0.11]
Subtotal (95% CI)			**3660**			**2996**	**57.7%**	**-0.11 [-0.23, 0.01]**
Heterogeneity: Tau² = 0.01; Chi² = 8.34, df = 2 (P = 0.02); I² = 76%								
Test for overall effect: Z = 1.86 (P = 0.06)								
Total (95% CI)			**6644**			**6572**	**100.0%**	**-0.13 [-0.19, -0.07]**
Heterogeneity: Tau² = 0.00; Chi² = 8.41, df = 4 (P = 0.08); I² = 52%								
Test for overall effect: Z = 4.08 (P < 0.0001)								
Test for subgroup differences: Chi² = 0.12, df = 1 (P = 0.73), I² = 0%								

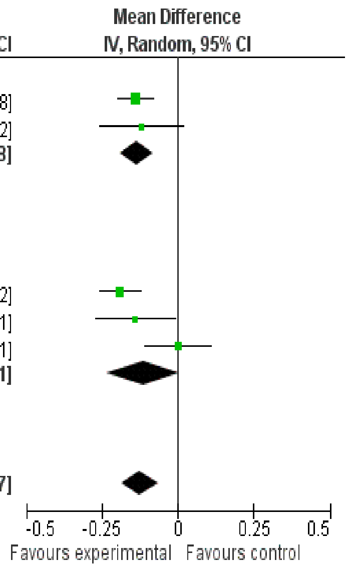

Figure a: Outcome: Mean difference in TC (by recruitment strategy)

Study or Subgroup	Health check Mean	Health check SD	Health check Total	Usual care Mean	Usual care SD	Usual care Total	Weight	Mean Difference IV, Random, 95% CI
4.2.1 High risk patient-oriented recruitment								
BFH 1990	131.6	19.23	1767	139	19.23	2174	20.7%	-7.40 [-8.61, -6.19]
BFH 1990	123.2	20.43	1217	129.6	20.43	1402	20.2%	-6.40 [-7.97, -4.83]
Subtotal (95% CI)			**2984**			**3576**	**40.8%**	**-7.03 [-7.98, -6.07]**
Heterogeneity: Tau² = 0.00; Chi² = 0.98, df = 1 (P = 0.32); I² = 0%								
Test for overall effect: Z = 14.40 (P < 0.00001)								
4.2.2 General population-oriented recruitment								
OXCHECK 1989	126.5	19.3	2205	129	20.4	1916	20.7%	-2.50 [-3.72, -1.28]
Denmark 1992	130.9	18.2	724	132.6	19.9	369	18.6%	-1.70 [-4.12, 0.72]
Ely 1990	132	16	731	132	17	711	19.9%	0.00 [-1.70, 1.70]
Subtotal (95% CI)			**3660**			**2996**	**59.2%**	**-1.45 [-3.10, 0.19]**
Heterogeneity: Tau² = 1.32; Chi² = 5.47, df = 2 (P = 0.06); I² = 63%								
Test for overall effect: Z = 1.73 (P = 0.08)								
Total (95% CI)			**6644**			**6572**	**100.0%**	**-3.65 [-6.50, -0.81]**
Heterogeneity: Tau² = 9.80; Chi² = 69.42, df = 4 (P < 0.00001); I² = 94%								
Test for overall effect: Z = 2.52 (P = 0.01)								
Test for subgroup differences: Chi² = 32.89, df = 1 (P < 0.00001), I² = 97.0%								

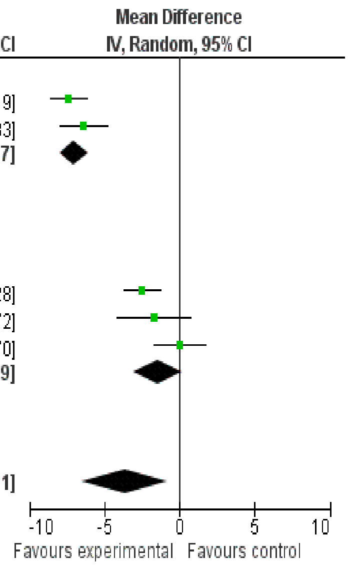

Figure b: Outcome: Mean difference in SBP (by recruitment strategy)

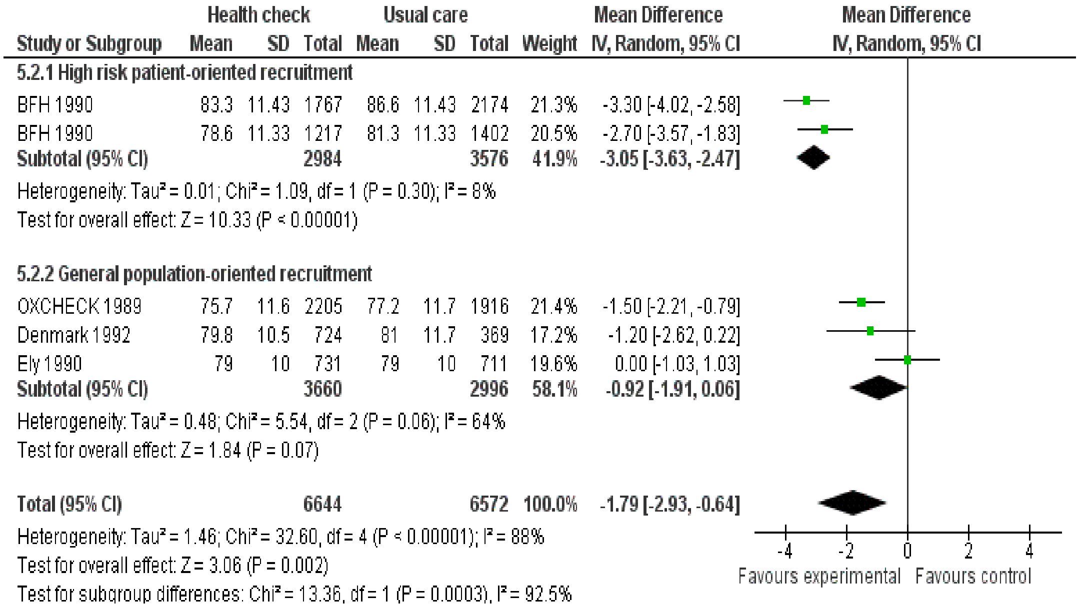

Figure c: Outcome: Mean difference in DBP (by recruitment strategy)

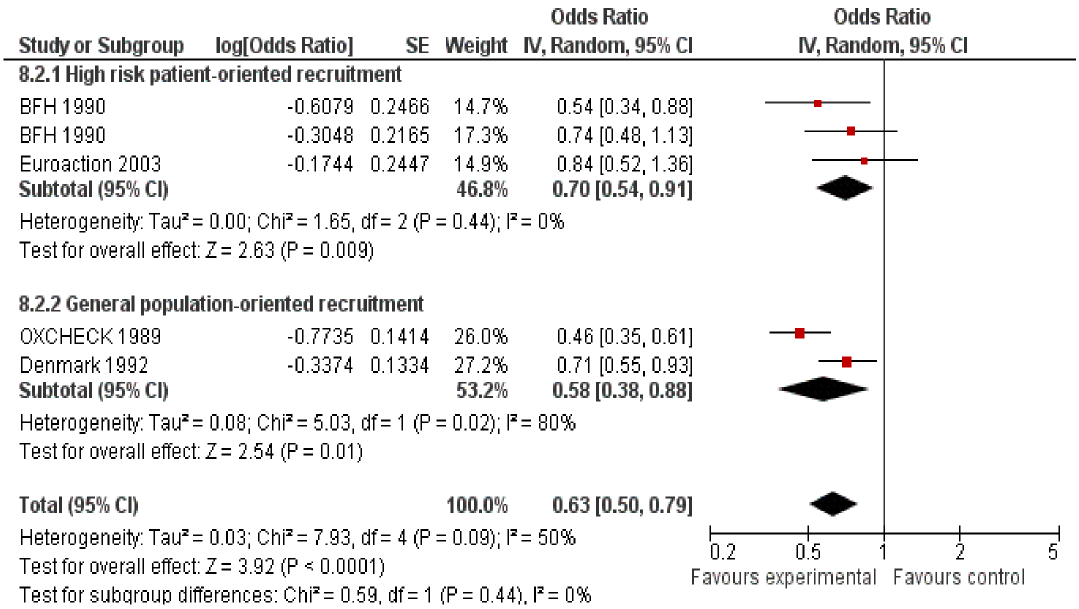

Figure d: Outcome: High TC (by recruitment strategy)

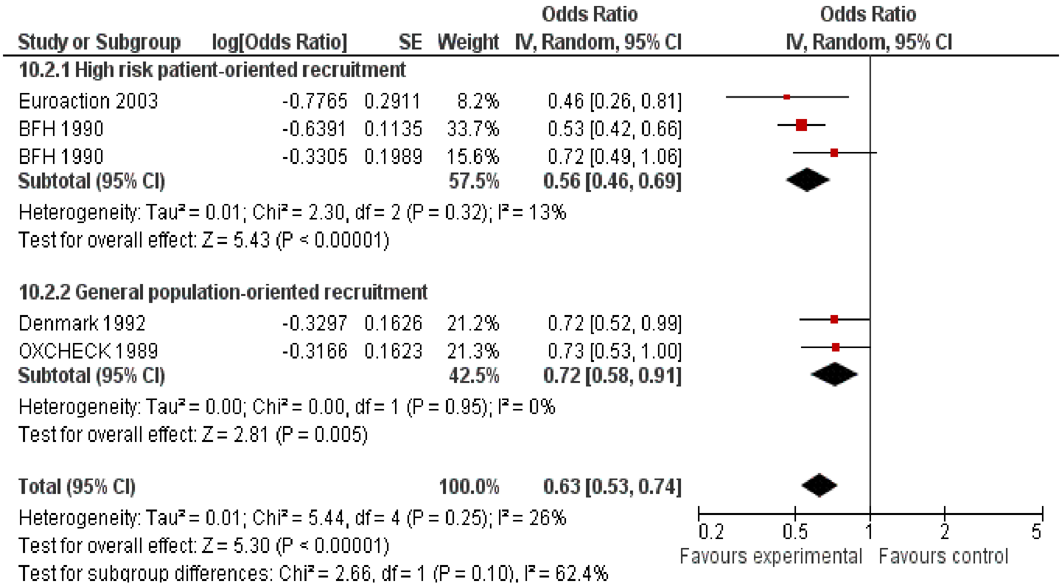

Figure e: Outcome: High DBP (by recruitment strategy)

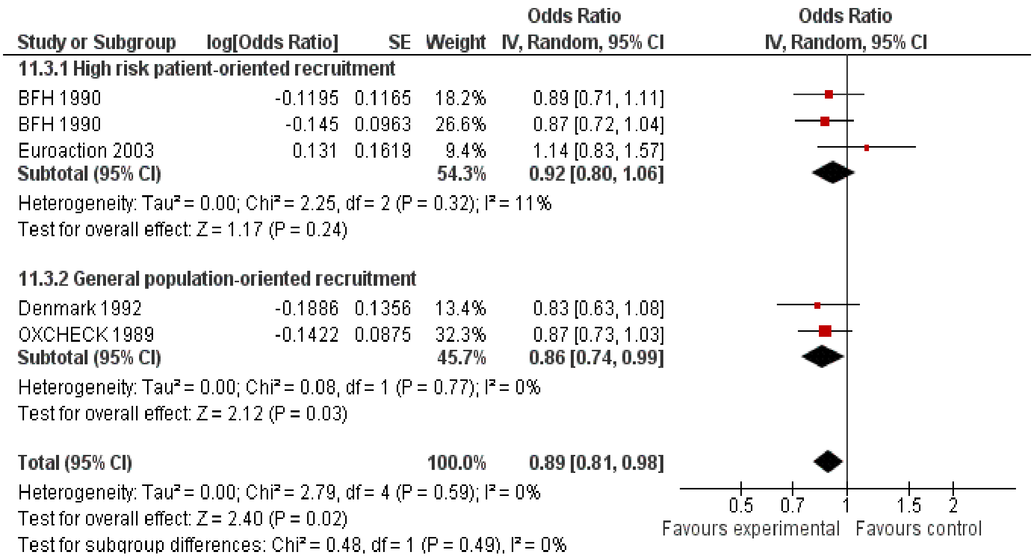

Figure f: Outcome: High BMI (by recruitment strategy)

Appendix 6: Subgroup analysis of length of follow-up (Chapter 3)

Study or Subgroup	health check Mean	health check SD	health check Total	usual care Mean	usual care SD	usual care Total	Weight	Mean Difference IV, Random, 95% CI
3.3.1 up to 5 years follow-up								
OXCHECK 1989	5.99	1.1	2205	6.18	1.17	1916	26.3%	-0.19 [-0.26, -0.12]
BFH 1990	5.58	0.94	1767	5.72	0.94	2174	29.2%	-0.14 [-0.20, -0.08]
Denmark 1992	5.54	1.03	724	5.68	1.06	369	13.9%	-0.14 [-0.27, -0.01]
BFH 1990	5.48	1.79	1217	5.6	1.79	1402	13.1%	-0.12 [-0.26, 0.02]
Subtotal (95% CI)			**5913**			**5861**	**82.5%**	**-0.16 [-0.20, -0.11]**
Heterogeneity: Tau² = 0.00; Chi² = 1.52, df = 3 (P = 0.68); I² = 0%								
Test for overall effect: Z = 7.48 (P < 0.00001)								
3.3.2 more than 5 years follow-up								
Ely 1990	5.6	1	731	5.6	1.1	711	17.5%	0.00 [-0.11, 0.11]
Subtotal (95% CI)			**731**			**711**	**17.5%**	**0.00 [-0.11, 0.11]**
Heterogeneity: Not applicable								
Test for overall effect: Z = 0.00 (P = 1.00)								
Total (95% CI)			**6644**			**6572**	**100.0%**	**-0.13 [-0.19, -0.07]**
Heterogeneity: Tau² = 0.00; Chi² = 8.41, df = 4 (P = 0.08); I² = 52%								
Test for overall effect: Z = 4.08 (P < 0.0001)								
Test for subgroup differences: Chi² = 6.89, df = 1 (P = 0.009), I² = 85.5%								

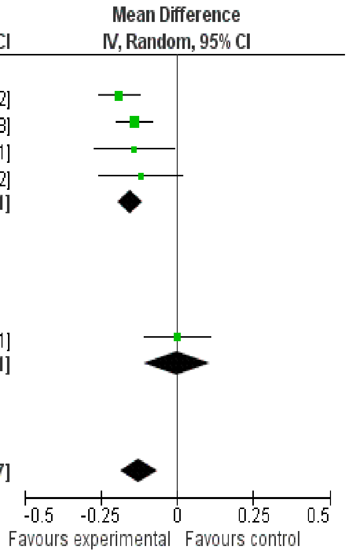

Figure a: Outcome: Mean difference in TC (by length of follow-up)

Study or Subgroup	health check Mean	health check SD	health check Total	usual care Mean	usual care SD	usual care Total	Weight	Mean Difference IV, Random, 95% CI
4.3.1 upto 5 years follow-up								
BFH 1990	131.6	19.23	1767	139	19.23	2174	20.7%	-7.40 [-8.61, -6.19]
BFH 1990	123.2	20.43	1217	129.6	20.43	1402	20.2%	-6.40 [-7.97, -4.83]
OXCHECK 1989	126.5	19.3	2205	129	20.4	1916	20.7%	-2.50 [-3.72, -1.28]
Denmark 1992	130.9	18.2	724	132.6	19.9	369	18.6%	-1.70 [-4.12, 0.72]
Subtotal (95% CI)			**5913**			**5861**	**80.1%**	**-4.58 [-7.37, -1.79]**
Heterogeneity: Tau² = 7.38; Chi² = 41.54, df = 3 (P < 0.00001); I² = 93%								
Test for overall effect: Z = 3.22 (P = 0.001)								
4.3.2 more than 5 years follow-up								
Ely 1990	132	16	731	132	17	711	19.9%	0.00 [-1.70, 1.70]
Subtotal (95% CI)			**731**			**711**	**19.9%**	**0.00 [-1.70, 1.70]**
Heterogeneity: Not applicable								
Test for overall effect: Z = 0.00 (P = 1.00)								
Total (95% CI)			**6644**			**6572**	**100.0%**	**-3.65 [-6.50, -0.81]**
Heterogeneity: Tau² = 9.80; Chi² = 69.42, df = 4 (P < 0.00001); I² = 94%								
Test for overall effect: Z = 2.52 (P = 0.01)								
Test for subgroup differences: Chi² = 7.54, df = 1 (P = 0.006), I² = 86.7%								

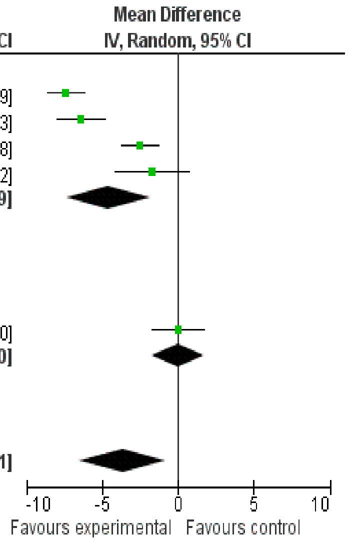

Figure b: Outcome: Mean difference in SBP (by length of follow-up)

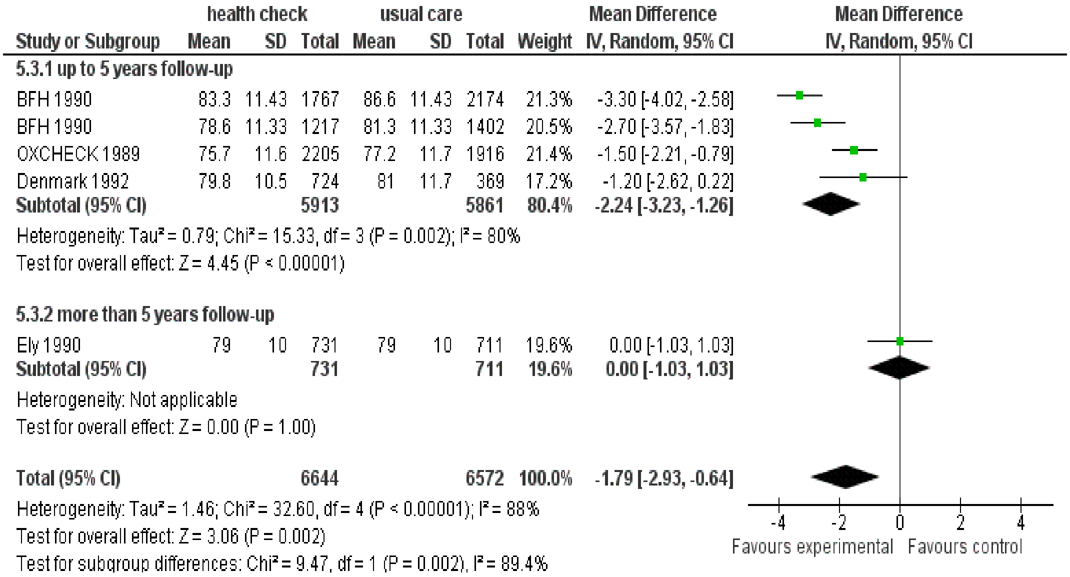

Figure c: Outcome: Mean difference in DBP (by length of follow-up)

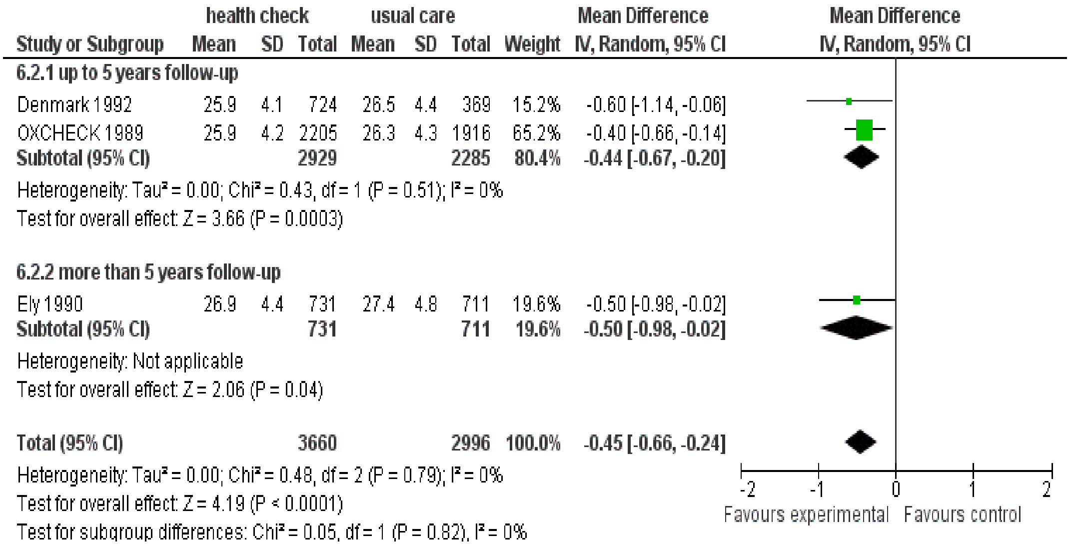

Figure d: Outcome: Mean difference BMI (by length of follow-up)

Study or Subgroup	Health check Events	Health check Total	Usual care Events	Usual care Total	Weight	Odds Ratio M-H, Random, 95% CI
7.3.1 up to 5 years follow-up						
BFH 1990	215	1217	301	1402	16.0%	0.78 [0.65, 0.95]
BFH 1990	337	1767	500	2174	19.4%	0.79 [0.68, 0.92]
OXCHECK 1989	552	2205	506	1916	20.8%	0.93 [0.81, 1.07]
Denmark 1992	345	724	181	369	12.2%	0.95 [0.74, 1.22]
Subtotal (95% CI)		**5913**		**5861**	**68.4%**	**0.86 [0.78, 0.94]**
Total events	1449		1488			
Heterogeneity: Tau² = 0.00; Chi² = 3.79, df = 3 (P = 0.28); I² = 21%						
Test for overall effect: Z = 3.09 (P = 0.002)						
7.3.2 more than 5 years follow-up						
Ely 1990	97	731	92	711	9.4%	1.03 [0.76, 1.40]
south-east London 1967	1034	1978	991	1950	22.2%	1.06 [0.94, 1.20]
Subtotal (95% CI)		**2709**		**2661**	**31.6%**	**1.06 [0.94, 1.19]**
Total events	1131		1083			
Heterogeneity: Tau² = 0.00; Chi² = 0.03, df = 1 (P = 0.86); I² = 0%						
Test for overall effect: Z = 0.91 (P = 0.36)						
Total (95% CI)		**8622**		**8522**	**100.0%**	**0.91 [0.82, 1.02]**
Total events	2580		2571			
Heterogeneity: Tau² = 0.01; Chi² = 11.82, df = 5 (P = 0.04); I² = 58%						
Test for overall effect: Z = 1.58 (P = 0.11)						
Test for subgroup differences: Chi² = 7.28, df = 1 (P = 0.007), I² = 86.3%						

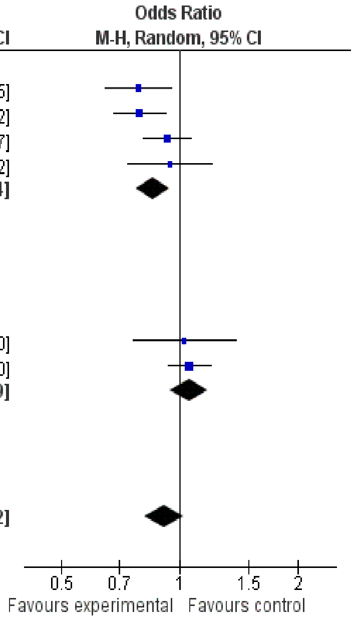

Figure e: Outcome: Smoking status (by length of follow-up)

Study or Subgroup	log[Odds Ratio]	SE	Weight	Odds Ratio IV, Random, 95% CI
1.2.1 up to 5 years follow-up				
OXCHECK 1989	0.2012	0.1771	14.4%	1.22 [0.86, 1.73]
Subtotal (95% CI)			**14.4%**	**1.22 [0.86, 1.73]**
Heterogeneity: Not applicable				
Test for overall effect: Z = 1.14 (P = 0.26)				
1.2.2 more than 5 years follow-up				
Denmark 1992	-0.2169	0.2061	10.8%	0.81 [0.54, 1.21]
Ely 1990	-0.0409	0.11	34.9%	0.96 [0.77, 1.19]
south-east London 1967	0.0984	0.102	39.9%	1.10 [0.90, 1.35]
Subtotal (95% CI)			**85.6%**	**1.00 [0.87, 1.16]**
Heterogeneity: Tau² = 0.00; Chi² = 2.17, df = 2 (P = 0.34); I² = 8%				
Test for overall effect: Z = 0.03 (P = 0.98)				
Total (95% CI)			**100.0%**	**1.03 [0.90, 1.18]**
Heterogeneity: Tau² = 0.00; Chi² = 3.23, df = 3 (P = 0.36); I² = 7%				
Test for overall effect: Z = 0.44 (P = 0.66)				
Test for subgroup differences: Chi² = 1.08, df = 1 (P = 0.30), I² = 7.1%				

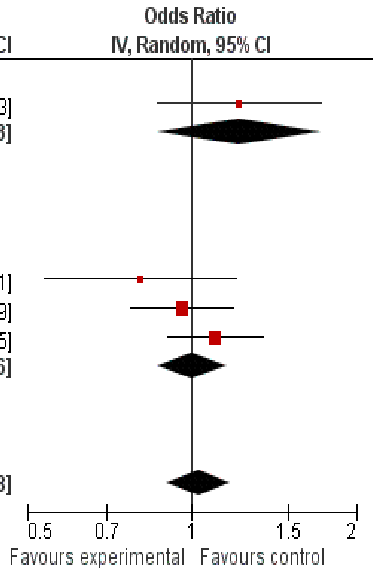

Figure f: Outcome: Total mortality (by length of follow-up)

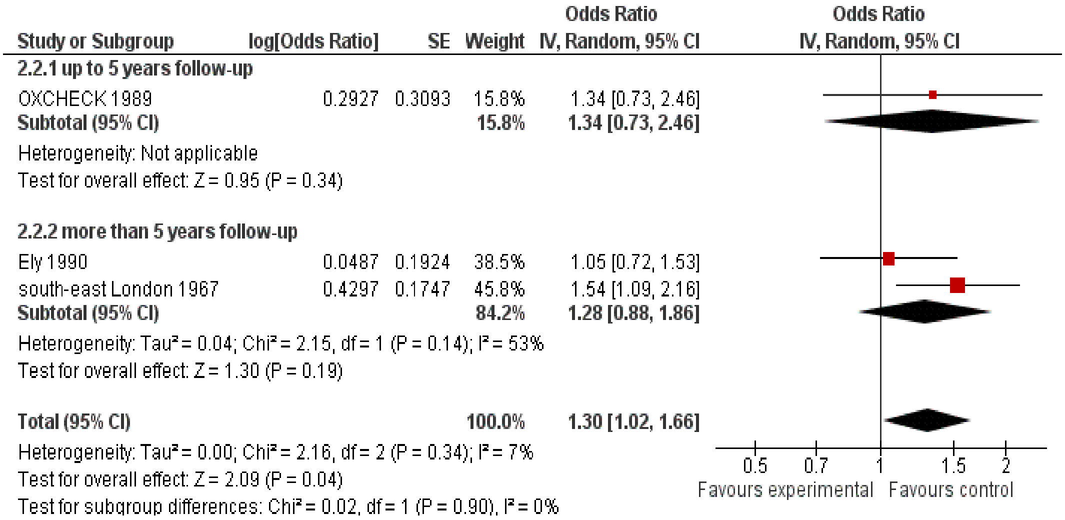

Figure g: Outcome: CVD mortality (by length of follow-up)

Appendix 7: Funnel plots (Chapter 3)

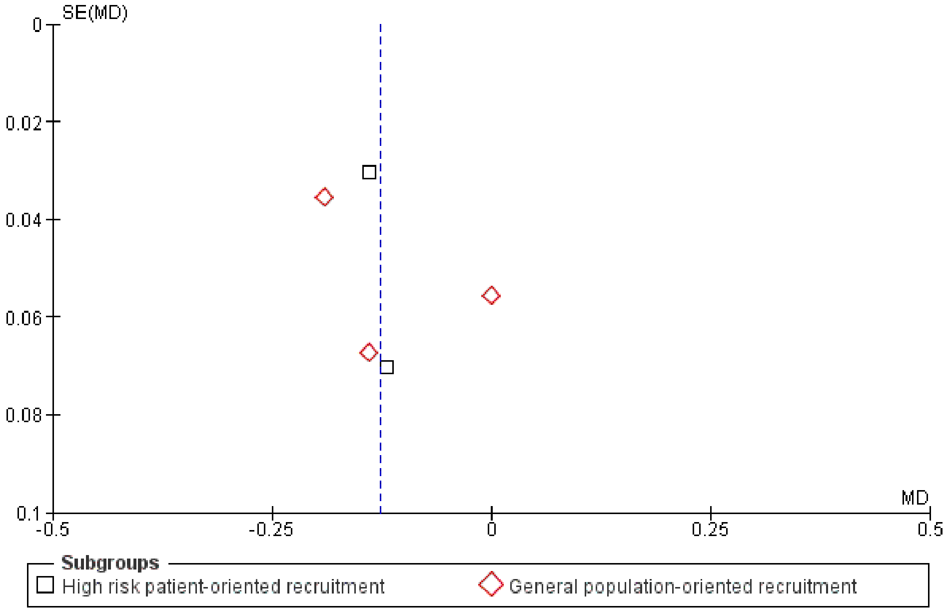

Figure a: Funnel plot of comparison: Mean difference in TC

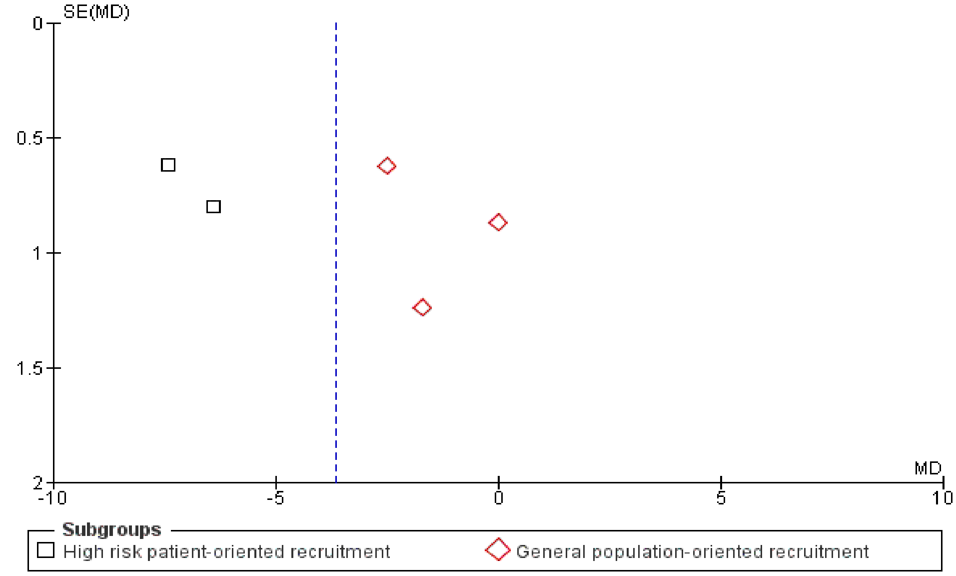

Figure b: Funnel plot of comparison: Mean difference in SBP.

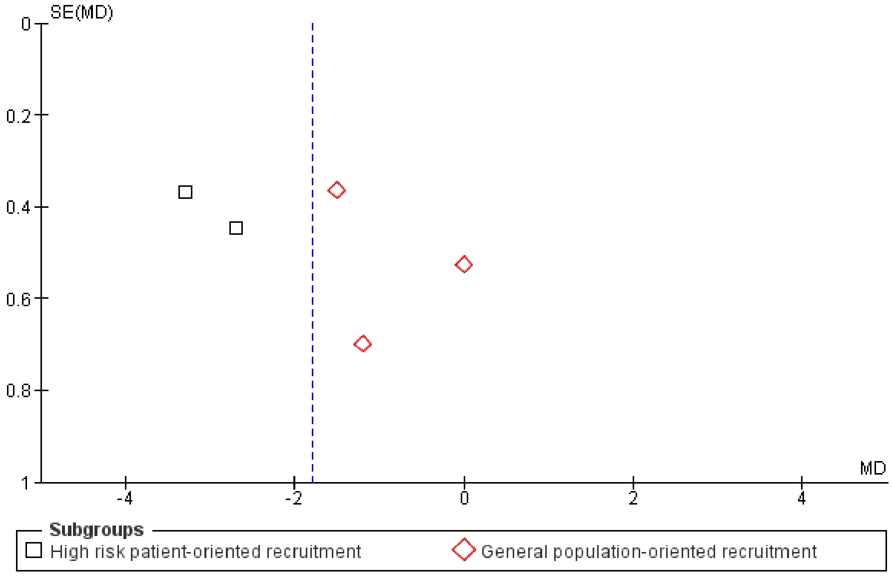

Figure c: Funnel plot of comparison: Mean difference in DBP

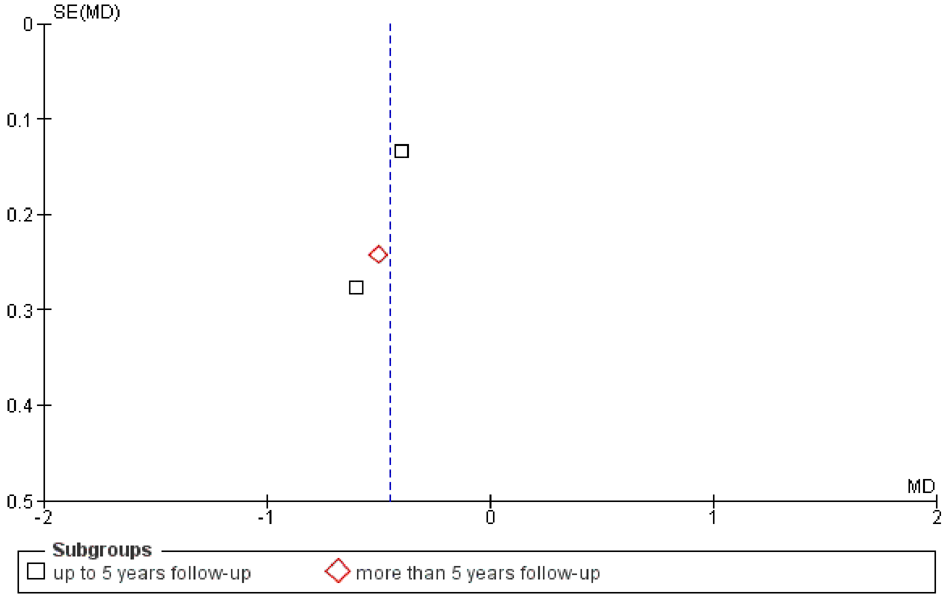

Figure d: Funnel plot of comparison: Mean difference in BMI.

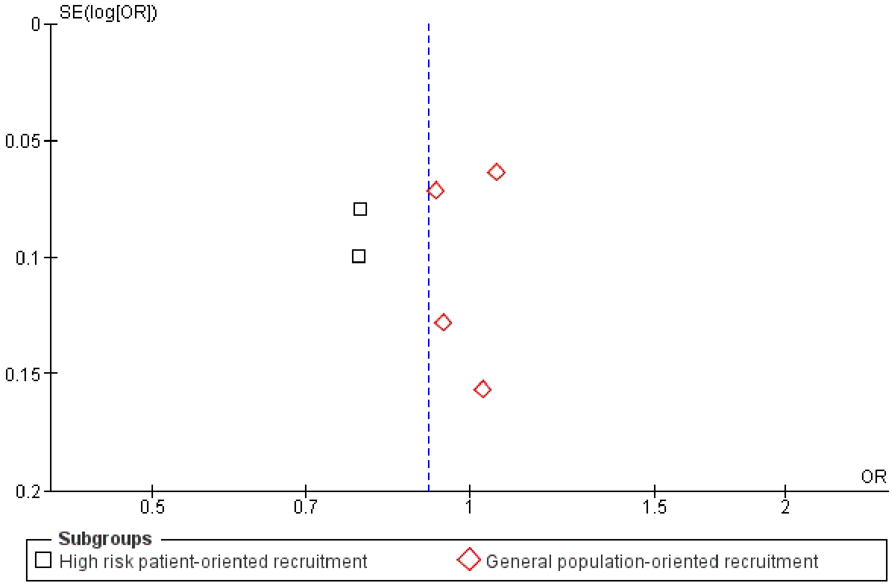

Figure e: Funnel plot of comparison: Smoking status

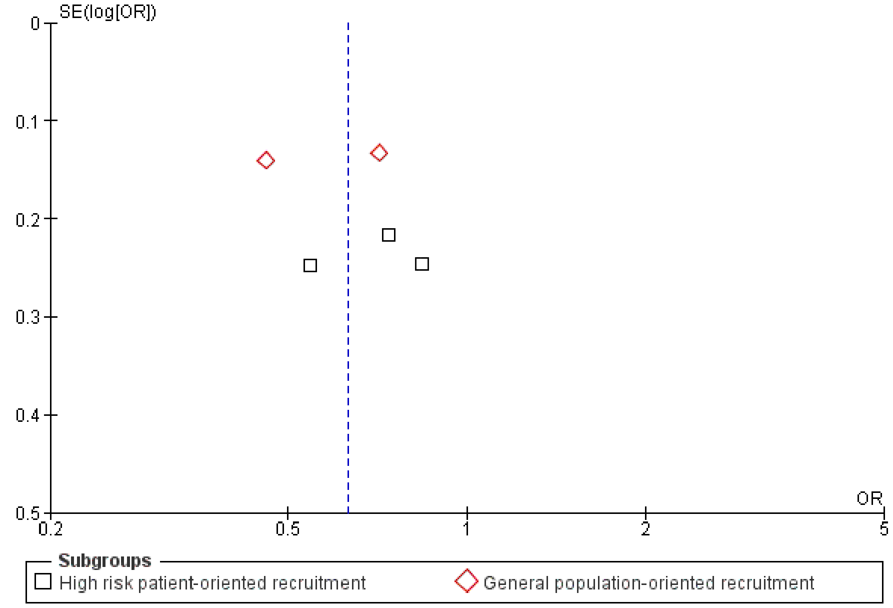

Figure f: Funnel plot of comparison: High TC

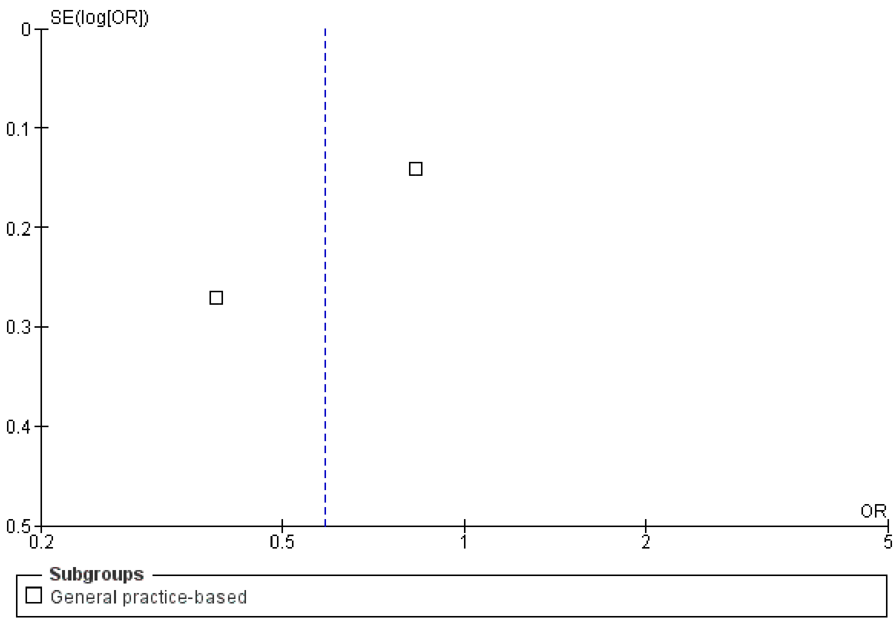

Figure g: Funnel plot of comparison: High SBP

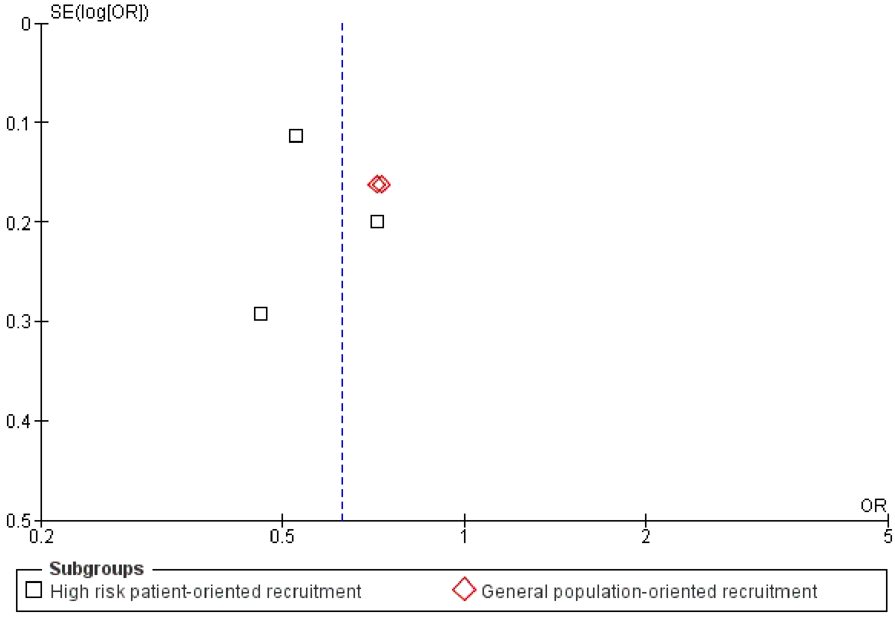

Figure h: Funnel plot of comparison: High DBP

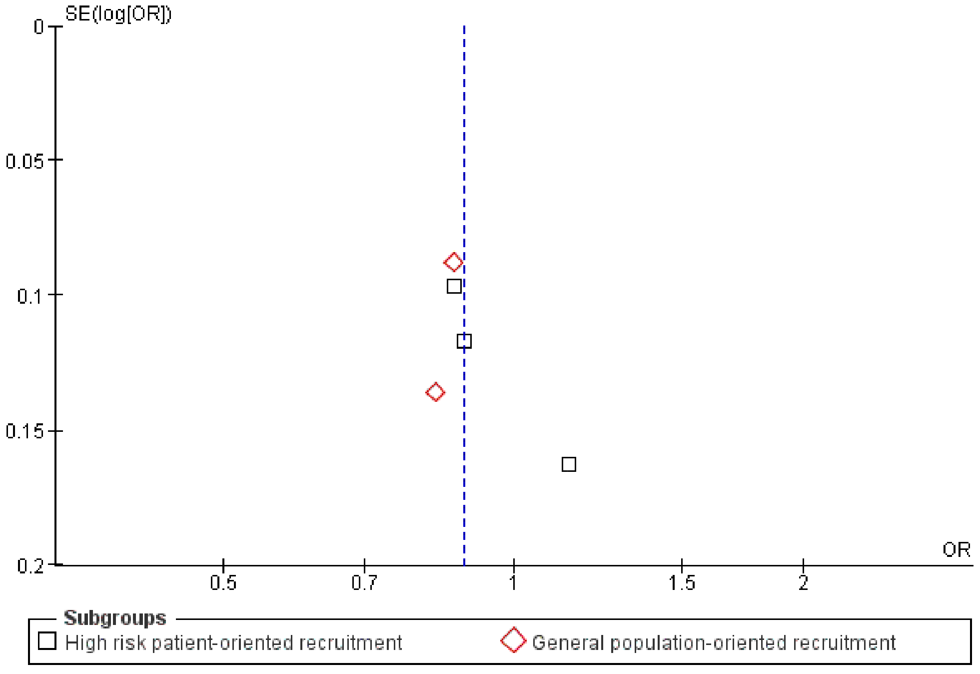

Figure i: Funnel plot of comparison: High BMI

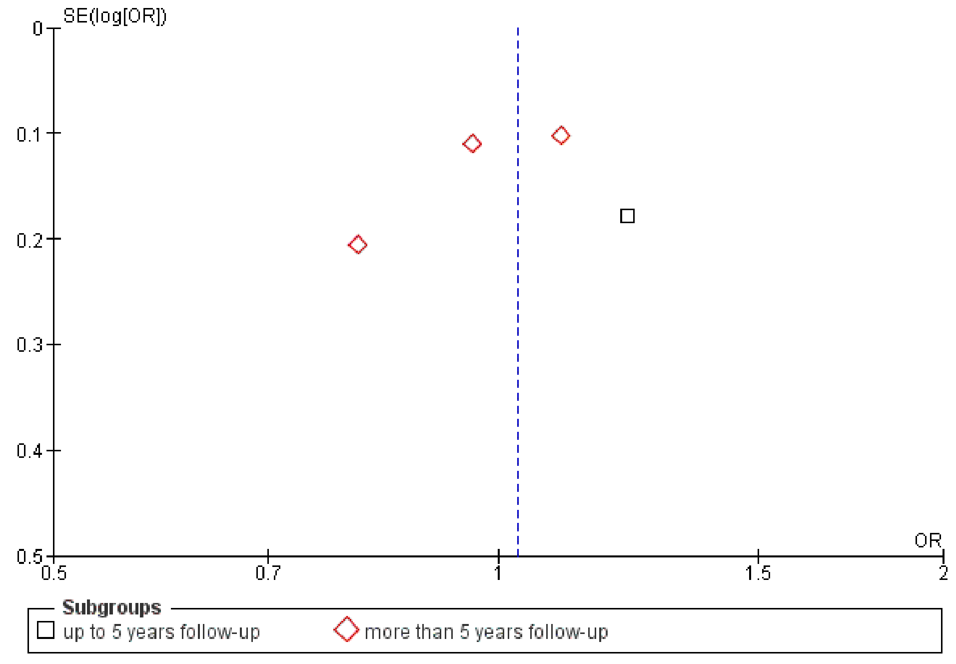

Figure j: Funnel plot of comparison: Total mortality

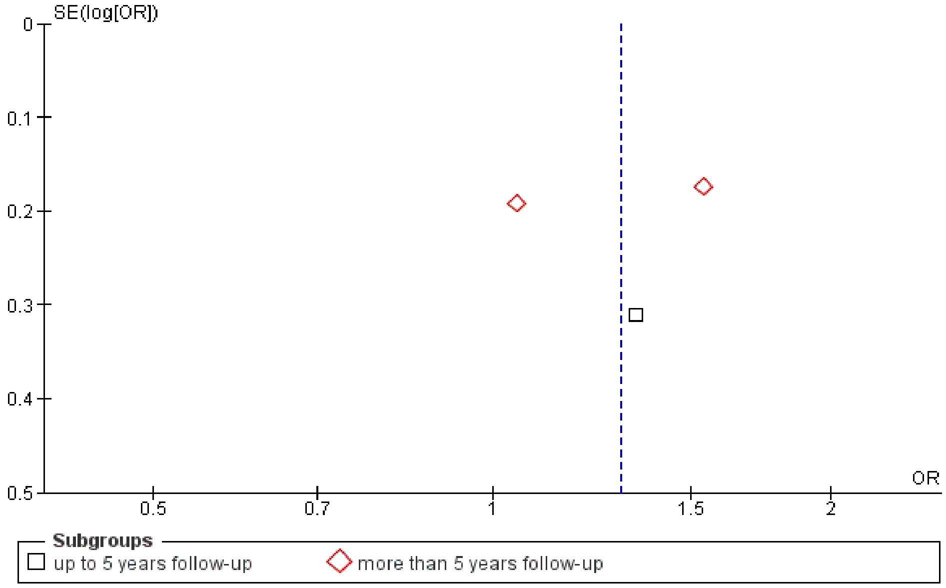

Figure k: Funnel plot of comparison: CVD mortality

Appendix 8: Study questionnaire (Chapter 5)

The 45-49 Years Health Check Survey Questionnaire

Study ID	1002	*[office use only]*
Date received	☐☐/☐☐/☐☐☐☐	*[office use only]*

- ***This questionnaire seeks to obtain information about your lifestyle and your view on preventive health care provided by your regular GP.***
- ***It will take you 10-15 minutes to complete the questionnaire***
- ***Please answer the questions below as best as you can, by placing a ✔ in the box that best describes you.***
- ***All information will remain confidential. Answers to questions will be combined from all participants and described in a report. No individual answers will be presented.***

A. Background information

Q1. Are you

Female ☐ Male ☐

Q2. What was your age last birthday?

☐☐ years

Q3. What is your postcode where you have lived most of the time in the last 12 months?

☐☐☐☐

Q4. What best describes your marital status?

☐ Married or Living with a partner
☐ Separated or Divorced
☐ Widowed
☐ Single or Never married

Q5. What is your ancestry?
(Tick up to 2 boxes)

☐ Caucasian/ European
☐ Aboriginal or Torres Strait Islander
☐ Asian
☐ African
☐ Other, please specify___________

Q6. Do you speak a language other than English at home?

☐ No
☐ Yes, please specify__________

Q7. Which of these best describes your current work status? (**Tick one only**)

☐ Working full-time
☐ Working part-time
☐ Not working
☐ Home duties
☐ Studying
☐ Others, please specify___________

Q8. What is the highest level of education you have completed? (**Tick one box only**)

☐ Never attend school
☐ Some primary school
☐ Completed primary school
☐ Some high school
☐ Completed high school (Year 12; Form 6; HSC)
☐ TAFE or trade certificate or diploma
☐ University, CAE or other tertiary degree

B. General health information

Q9. In general, how would you rate your health?

☐ Excellent
☐ Very good
☐ Good
☐ Fair
☐ Poor

Q10. Which of the following best describes your smoking status?

☐ I've never smoked (***Go to Q11)***

- ☐ I don't smoke now but I used to
- ☐ I smoke occasionally
- ☐ I smoke daily

If you are a **current** or an **ex-smoker,**

10.1. How many years have you been smoking/ did you smoke ☐☐ years

10.2. On average, how many cigarette(s) do/did you smoke per day?

☐☐ Cigarette per day

Q11. How often do you have a drink containing alcohol?

- ☐ Never ***(Go to Q14)***
- ☐ Monthly or less
- ☐ 2-4 times a month
- ☐ 2-3 times a week
- ☐ 4 or more times a week

Q12. How many standard drinks do you usually have on a typical drinking session?

(*A* ***Standard Drink*** *is equivalent to* ***a schooner or midi of full strength beer***, ***a glass of wine*** *or* ***a nip of spirits;***

OR *please refer to the "****standard drinks guide****" attached with the questionnaire)*

- ☐ 1 or 2
- ☐ 3 or 4
- ☐ 4 to 6
- ☐ 7 to 9
- ☐ 10 or more

Q13. How often do you have six or more standard drinks at one time?

- ☐ Never
- ☐ Monthly or less
- ☐ Monthly
- ☐ Weekly
- ☐ Daily or almost daily

Q14. How many serves of **fruits** do you usually eat each day?

Examples of a single serve of Fruits

- ✓ *1 medium size apple, banana, orange or A quarter rockmelon or 8 strawberries or 20 grapes or 20 cherries or 2 kiwi* fruit
- ✓ *Half a cup of fruit juice*
- ✓ *4 dried apricots or 1.5 tablespoons of sultanas*
- ✓ *1 cup of canned or fresh fruit salad*

- ☐ Less than one serve per day
- ☐ 1 serve per day
- ☐ 2 serves per day
- ☐ 3 or more serves per day

Q15. How many serves of **vegetables** do you usually eat each day?

Examples of a single serve of Vegetables

- ✓ *Half a cup of cooked vegetables (75g)*
- ✓ *1 cup of salad vegetables*

- ☐ Less than one serve per day
- ☐ 1-2 serves per day
- ☐ 3-4 serves per day
- ☐ 5-6 serves per day
- ☐ 7 or more serves per day

Q16. How many times a week do you do 30 minutes or more (all together or in shorter amounts) of **moderate-intensity** physical activities that increase your heart rates or make you breathe harder than normal? ***(e.g. brisk walking, carrying light loads, cycling at a regular pace, golf or doubles tennis)***

- ☐ 5 or more times a week
- ☐ 3-4 times a week
- ☐ 1-2 times a week
- ☐ Less than once a week

Q17. How many times a week do you do 20 minutes or more of **vigorous-intensity** physical activity that makes you sweat or puff and pant? ***(e.g. heavy lifting, digging, jogging, aerobics, or fast cycling)***

- ☐ 3 or more times a week
- ☐ 1 to 2 times a week
- ☐ Less than once a week

Q18. How much do you weigh?

___________ **kilograms** OR

_________ **stone** ___________ **pounds**

Q19. How tall are you without shoes?

___________ Centimetres OR

_________feet ___________inches

Q20. Has your father, mother, brother(s) or sister(s) ever had any of these chronic conditions?
(**Tick all that apply**)

☐ Heart disease	☐ Stroke
☐ High blood pressure	☐ Diabetes
☐ Parkinson's disease	☐ Cancer
☐ Severe arthritis	☐ Hip fracture
☐ Severe depression	☐ Osteoporosis
☐ Dementia/Alzheimer's	☐ Don't know

Q21. Have you ever been told by a doctor that you have the following conditions?

- ☐ High blood pressure
- ☐ High cholesterol (fats in blood)
- ☐ High glucose (blood sugar)
- ☐ Not sure
- ☐ Others, specify_________

C. Preventive health care

Q22. How important is preventive health care to you? (e.g. check-ups, lifestyle advice)

- ☐ Very important
- ☐ Fairly important
- ☐ Neutral
- ☐ Not so important
- ☐ Not at all important

Q23. Did you receive any check-ups in the last 12 months? **(Tick all that apply)**

- ☐ Not at all
- ☐ Blood pressure
- ☐ Cholesterol (Fats in the blood)
- ☐ Blood sugar
- ☐ Cancer screening (e.g. colon/skin/prostate cancer; Pap smear; mammography)
- ☐ Not sure
- ☐ Others, please specify _______________

Q24. Have you ever heard of the 45-49 year health check before?

Yes ☐ ▼ No ☐ Not sure ☐

If **Yes,**

Have you ever received an invitation to the 45-49 year health check before?

Yes ☐ No ☐ Not sure ☐

Have you ever attended for the 45-49 year health check before?

Yes ☐ No ☐ Not sure ☐

D. Perceptions about attendance at a health check

*The "**health check**" mentioned here refers to general health check-ups including lifestyle consultation, physical examinations and relevant tests (e.g. blood pressure, blood lipids and blood sugar). The health check will be performed by your regular GP with the cooperation of practice nurses .*

All questions in this section make use of rating scales with seven options; please circle one number that best describes your opinion.
e.g. The 7-point scale should be interpreted as:
Very unlikely: __1__:__2__:__3__:__4__:__5__:__6__:__7__: Very likely
very quite slightly neutral slightly quite very

Some of the items may seem similar, but they are important for this research. We highly appreciate your patience and cooperation.

The following questions are about your beliefs on attending a health check

NO	Statement	Very **unlikely**			Neutral			Very **likely**
1	Attending a health check could lead to detection of previously unknown medical conditions	1	2	3	4	5	6	7
2	If I attend a health check, I would receive lifestyle recommendations from my GP	1	2	3	4	5	6	7
3	Attending a health check would reassure me that everything is all right	1	2	3	4	5	6	7
4	Attending a health check could lead me to change my lifestyle in the future	1	2	3	4	5	6	7
5	Attending a health check would help me better understand my health status	1	2	3	4	5	6	7

NO	Statement	Extremely **undesirable**			Neutral			Extremely **desirable**
6	For me, detection of unknown medical conditions would be	1	2	3	4	5	6	7
7	For me, receiving lifestyle recommendations from my GP would be	1	2	3	4	5	6	7
8	For me, being reassured that everything is all right would be	1	2	3	4	5	6	7
9	For me, changing lifestyle in the future would be	1	2	3	4	5	6	7
10	For me, having better understanding of my health status would be	1	2	3	4	5	6	7

The following questions are about your perceived social support for attending a health check

NO	Statement	Very **unlikely**			Neutral			Very likely
11	I believe my GP would want me to have a health check	1	2	3	4	5	6	7
12	I believe members of my immediate family would want me to have a health check	1	2	3	4	5	6	7
13	I believe my friends would want me to have a health check	1	2	3	4	5	6	7
14	When it comes to matters of health, I want to do what my GP suggests	1	2	3	4	5	6	7
15	When it comes to matters of health, I want to do what my family suggests	1	2	3	4	5	6	7
16	When it comes to matters of health, I want to do what my friends suggest	1	2	3	4	5	6	7

The following questions are about your general ideas on attending a health check

NO	Statement	Strongly **disagree**			Neutral			Strongly **agree**
17	I intend to have a health check if my GP invites me	1	2	3	4	5	6	7
18	Most people who are important to me would want me to attend a health check	1	2	3	4	5	6	7
19	Attending a health check would be easy if I wanted to	1	2	3	4	5	6	7
20	Attending a health check would be the right thing to do	1	2	3	4	5	6	7
21	Most people of my age would attend a health check	1	2	3	4	5	6	7
22	Whether I attend a health check or not is completely up to me	1	2	3	4	5	6	7
23	Attending a health check could make me feel anxious	1	2	3	4	5	6	7
24	if my GP invited me, I would be very likely to attend a health check	1	2	3	4	5	6	7
25	Attending a health check could make me feel more in control over my life	1	2	3	4	5	6	7
26	If I **missed** a health check, I would feel disappointed	1	2	3	4	5	6	7

The following questions are about your obstacles for attending a health check

NO	Statement	Never			Neutral			Frequently
27	I find it **hard** to rearrange my daily schedule	1	2	3	4	5	6	7
28	I think I have **no** health problems or symptoms	1	2	3	4	5	6	7
29	I find it **hard** to get a convenient appointment with my GP	1	2	3	4	5	6	7
30	I think I have already had health checks that I need	1	2	3	4	5	6	7
31	I find it **hard** to arrange transport to get to my general practice	1	2	3	4	5	6	7
32	I think I have already taken good care of my health	1	2	3	4	5	6	7

NO	Statement	Strongly **disagree**			Neutral			Strongly **agree**
33	If I had to rearrange my daily schedule, I would be **less** likely to attend a health check	1	2	3	4	5	6	7
34	If I had **no** health problems or symptoms, I would be **less** likely to attend a health check	1	2	3	4	5	6	7
35	If it was **hard** to get a convenient appointment, I would be **less** likely to attend a health check	1	2	3	4	5	6	7
36	If I have already had all the check-ups that I need, I would be **less** likely to attend a health check	1	2	3	4	5	6	7
37	If I had to arrange transport, I would be **less** likely to attend a health check	1	2	3	4	5	6	7
38	If I have already taken good care of my own health, I would be **less** likely to attend a health check	1	2	3	4	5	6	7

END OF QUESTIONNAIRE!!

Please return the questionnaire in the pre-paid reply envelope provided, if the reply envelope is damaged, please address any envelop to the following address:

Ms Si Si
Discipline of general practice
The University of Adelaide
Reply paid 498
Adelaide SA 5005

Thank you again for your time and efforts

Appendix 9: Pilot study questionnaire feedback sheet (Chapter 5)

Questionnaire feedback:

1. How long did it take you to finish the questionnaire? _______minutes
2. Are the instructions clear enough for you? What else would you expect to be informed by the instructions?

   ____

   ____

3. Do you think some of the questions are repetitive? ☐ Yes ☐ No

If **YES**, Please specify:________________________________

____

4. Are any questions ambiguous or difficult to answer? ☐ Yes ☐ No

If **YES**, Please specify ________________________________

____

5. Are there sensitive questions to which you did not want to respond? ☐ Yes ☐ No

If **YES**, Please specify:________________________________

6. Are there any annoying features of the wording or formatting?

____

____

7. Is the questionnaire easy to follow/respond? ☐ Yes ☐ No

If **NO** please specify (length, logic…)______________________

____

____

8. Are there any comments you have on the questionnaire?

____

____

Thank you again for your patience and cooperation

Appendix 10: Study information sheet (Chapter 5)

The 45-49 Years Health Check Survey study

We write to ask for your help in a study being conducted by the Discipline of General Practice at the University of Adelaide. The study is about the 45-49 year health check a program that is funded by the Australian Government Department of Health and Ageing through Medicare to help prevent chronic medical conditions such as diabetes, heart and lung disease. You have been asked to help in this study because your GP is among the relatively few who currently conduct this health check in South Australia and you are one of their patient's who are eligible.

The study aims to understand the factors influencing attendance at the 45-49 year health check and what people think about it. We are very interested in your thoughts and opinions about prevention. We would also like to understand better the range of health behaviours, such as smoking, eating, exercise and alcohol consumption in the community.

Your participation is completely voluntary and ***will not*** affect your medical care at your general practice. **By returning the completed questionnaire you will be consenting to be part of the study**. The questions will take you about **15 minutes** to complete although sometimes it does take a little longer. **After completing the questionnaire please enclose and send it to us using the reply-paid envelope**.

Your confidentiality will be maintained at all times. The questionnaire will be **de-identified** using a study identification number. Your name will never be placed on the questionnaire.

The results will be compiled and submitted to the University of Adelaide as a PhD thesis. Results of the study may also be published in scientific journals and presented at conferences. **There will be no way to identify you in any documents produced**.

By taking a few minutes to share your thoughts and opinions, you will be helping us provide important information for health professionals and policy makers to improve the delivery of health services to all Australians. In appreciation of your time, all participants who respond to the questionnaire will be entered into a prize draw to win a Foodland shopping voucher to the value of either $50, $100 or $150. The three winners will be notified by mail and with permission their names displayed at the Clinic.

We would be most happy to answer any questions you might have. Please write or call.

Many Thanks,

Si Si, PhD candidate, Discipline of General Practice, The University of Adelaide

Tel: (08) 8313 0617; E-mail: si.si@adelaide.edu.au

Prof. Nigel Stocks, Head of Discipline of General Practice, Deputy Head, School of Population Health and Clinical Practice, The University of Adelaide

Tel: (08) 8313 3460; E-mail: nigel.stocks@adelaide.edu.au

Assoc Prof. John Moss, Postgraduate Research Coordinator of the Discipline of Public Health, The University of Adelaide

Tel: (08) 8313 4620; E-mail: john.moss@adelaide.edu.au

Appendix 11: General practice endorsement statement (Chapter 5)

Dear______,

Our practice is participating in a research project conducted by the Discipline of General Practice at the University of Adelaide.

This research wishes to understand your opinion about attending the 45-49 years health check. A program that is funded by the Australian Government Department of Health and Ageing through Medicare to help prevent chronic medical conditions such as diabetes, heart and lung disease. We are very interested in the potential results of this study to help improve the preventive health care services we offer you.

We have sent you this questionnaire on behalf of the researchers. If you are willing to participate in this research, please complete and return the questionnaire in the reply pre-paid envelope provided. Participants will enter a luck draw to win Foodland shopping vouchers. Your participation and cooperation would be greatly appreciated.

With kindest regards

Signature (of practice manager):

Appendix 12: Questionnaire reminder letter (Chapter 5)

Reminder: The 45-49 Years Health Check Survey study

In early April the Clinic sent you a questionnaire asking about your attitude towards general health checkups.

We are writing to you again in case you did not receive or have misplaced the previous letter. Your answers will be very helpful in improving the delivery of health care services to all Australians.

As mentioned before, the questions will take you about **15 minutes** to complete. **After completing the questionnaire please enclose and send it to us using the reply-paid envelope**. Your participation is completely voluntary and ***will not*** affect your medical care at the Clinic.

In appreciation of your time, all participants who respond to the questionnaire will be entered into a prize draw to win a Foodland shopping voucher to the value of either $50, $100 or $150. The three winners will be notified by mail and with permission their names displayed at the Clinic.

Your privacy will be maintained at all times. The questionnaire will have a study identification number but will otherwise be de-identified. Your name will never be placed on the questionnaire. The study has been reviewed and approved by the University of Adelaide human research ethics committee.

If you have any questions about this survey, we will be happy to help. Please write or call.

Many Thanks,

Si Si, PhD candidate, Discipline of General Practice, The University of Adelaide

Tel: (08) 8313 0617; E-mail: si.si@adelaide.edu.au

Prof. Nigel Stocks, Head of Discipline of General Practice, Deputy Head, School of Population Health and Clinical Practice, The University of Adelaide

Tel: (08) 8313 3460; E-mail: nigel.stocks@adelaide.edu.au

Assoc Prof. John Moss, Postgraduate Research Coordinator of the Discipline of Public Health, The University of Adelaide

Tel: (08) 8313 4620; E-mail: john.moss@adelaide.edu.au

Appendix 13: Health check invitation letter (Chapter 5)

Dear______,

The federal government has introduced a health check for everyone aged between 45 and 49 who may be at risk of developing a health complaint, like diabetes or heart problems.

The aim of the health check is to help find, prevent or lessen the effect of disease - it is better to avoid disease than to treat it. This health check will give us the opportunity to look at your lifestyle and medical/family history to find out if you are at risk.

The health check would involve:

- updating your medical history and looking at your health issues
- doing tests (such as blood pressure tests), if required
- follow up of any problems identified
- advice and information, for example on how to make lifestyle changes to improve your health

Our records show that you are within the age range for the health check. If you also have a 'risk factor', meaning anything that increases your chance of developing a disease, then you are entitled to a health check. Risk factors include:

- High blood pressure
- Extra weight
- High cholesterol
- Smoking
- Lack of physical activity
- Poor diet
- Family history of disease (eg. cancer)

- The health check will be **FREE** to you.

If you would like to have a health check, please phone the practice for an appointment. Also, if you have any friends or family members that would be entitled, talk to them about it and encourage them to visit their usual doctor.

Yours sincerely

Appendix 14: Invitation reminder (Chapter 5)

Dear _____,

Recently we sent you an invitation to attend our practice and have a 45-49 year old health check. We understand that you may be very busy or have had a recent blood pressure or even cholesterol check. You may be very healthy and think a check-up is not required but we believe everyone can benefit from discussing risk factors for heart disease and cancer. Our check-up is very comprehensive and will cover all the preventive activities for your age group. Importantly there is no cost to you except the 30-40 minutes that it takes to see the nurse and doctor.

The health check will involve:

- updating your medical history and looking at your health issues
- a relevant physical examination (e.g. for skin cancers such as melanoma)
- doing tests (such as blood pressure and blood tests), if required
- follow up of any problems identified
- advice and information, for example on how to make lifestyle changes to improve your health

We encourage you to consider again the value of having a health check. Please phone the practice for an appointment.

Yours sincerely

Appendix 15: ethics approval (Chapter 5 & Chapter 6)

THE UNIVERSITY of ADELAIDE

RESEARCH BRANCH
RESEARCH ETHICS AND COMPLIANCE UNIT

SABINE SCHREIBER
SECRETARY
HUMAN RESEARCH ETHICS COMMITTEE
THE UNIVERSITY OF ADELAIDE
SA 5005
AUSTRALIA
TELEPHONE +61 8 8303 6028
FACSIMILE +61 8 8303 7325
email sabine.schreiber@adelaide.edu.au
CRICOS Provider Number 00123M

15 December 2011

Professor N Stocks
General Practice

Dear Professor Stocks

PROJECT NO: H-310-2011
The 45-49 health assessment program in Australian general practice: determinants of attendance and predictors of subsequent medical care utilization and associated cost

I write to advise you that on behalf of the Human Research Ethics Committee I have approved the above project. Please refer to the enclosed endorsement sheet for further details and conditions that may be applicable to this approval.

The ethics expiry date for this project is: 31 December 2012

Where possible, participants taking part in the study should be given a copy of the Information Sheet and the signed Consent Form to retain.

Please note that any changes to the project which might affect its continued ethical acceptability will invalidate the project's approval. In such cases an amended protocol must be submitted to the Committee for further approval. It is a condition of approval that you immediately report anything which might warrant review of ethical approval including (a) serious or unexpected adverse effects on participants (b) proposed changes in the protocol; and (c) unforeseen events that might affect continued ethical acceptability of the project. It is also a condition of approval that you inform the Committee, giving reasons, if the project is discontinued before the expected date of completion.

A reporting form is available from the Committee's website. This may be used to renew ethical approval or report on project status including completion.

Yours sincerely

PROFESSOR GARRETT CULLITY
Convenor
Human Research Ethics Committee

THE UNIVERSITY of ADELAIDE

RESEARCH BRANCH
OFFICE OF RESEARCH ETHICS, COMPLIANCE AND INTEGRITY

SABINE SCHREIBER
SECRETARY
HUMAN RESEARCH ETHICS COMMITTEE
THE UNIVERSITY OF ADELAIDE
SA 5005
AUSTRALIA

TELEPHONE [illegible]
FACSIMILE [illegible]
email: [illegible]
CRICOS Provider Number [illegible]

15 August 2012

Professor N Stocks
School of Population Health and Clinical Practice

Dear Professor Stocks

PROJECT NO: H-181-2011
The 45-49 health assessment program in Australian general practice: determinants of attendance and predictors of subsequent medical care utilization and associated cost

Thank you for your report on the above project. I write to advise you that I have endorsed renewal of ethical approval for the study on behalf of the Human Research Ethics Committee.

The expiry date for this project is: 31 August 2015

Where possible, participants taking part in the study should be given a copy of the Information Sheet and the signed Consent Form to retain.

Please note that any changes to the project which might affect its continued ethical acceptability will invalidate the project's approval. In such cases an amended protocol must be submitted to the Committee for further approval. It is a condition of approval that you immediately report anything which might warrant review of ethical approval including (a) serious or unexpected adverse effects on participants (b) proposed changes in the protocol; and (c) unforeseen events that might affect continued ethical acceptability of the project. It is also a condition of approval that you inform the Committee, giving reasons, if the project is discontinued before the expected date of completion.

A reporting form is available from the Committee's website. This may be used to renew ethical approval or report on project status including completion.

Yours sincerely

pp **Dr John Semmler**
Acting Convenor
Human Research Ethics Committee

Appendix 16: Technical details of the modelling study

1. Methods

Analysis was undertaken to examine the threshold costs for the 45-49 year health check program (and associated treatments) such that it would be cost-effective (using a threshold of $50,000 per QALY) in the Australian context. The study adopted the perspective of the Australian health system (Medicare Australia). An annual discount rate of 5% was applied.

This model simulated the cardiovascular outcomes of a hypothetical cohort of 10,000 Australians aged 45-49 years (5,000 males and 5,000 females) with no prior diagnosis of cardiovascular disease (CVD) or diabetes. Comparisons were made between the health check (intervention) arm and the routine health care (usual care) arm (Figures 21). The model comprised a short-term (5 years) decision analytic model and a long-term (50 years) Markov model. The model streamline is outlined in Figure 21.

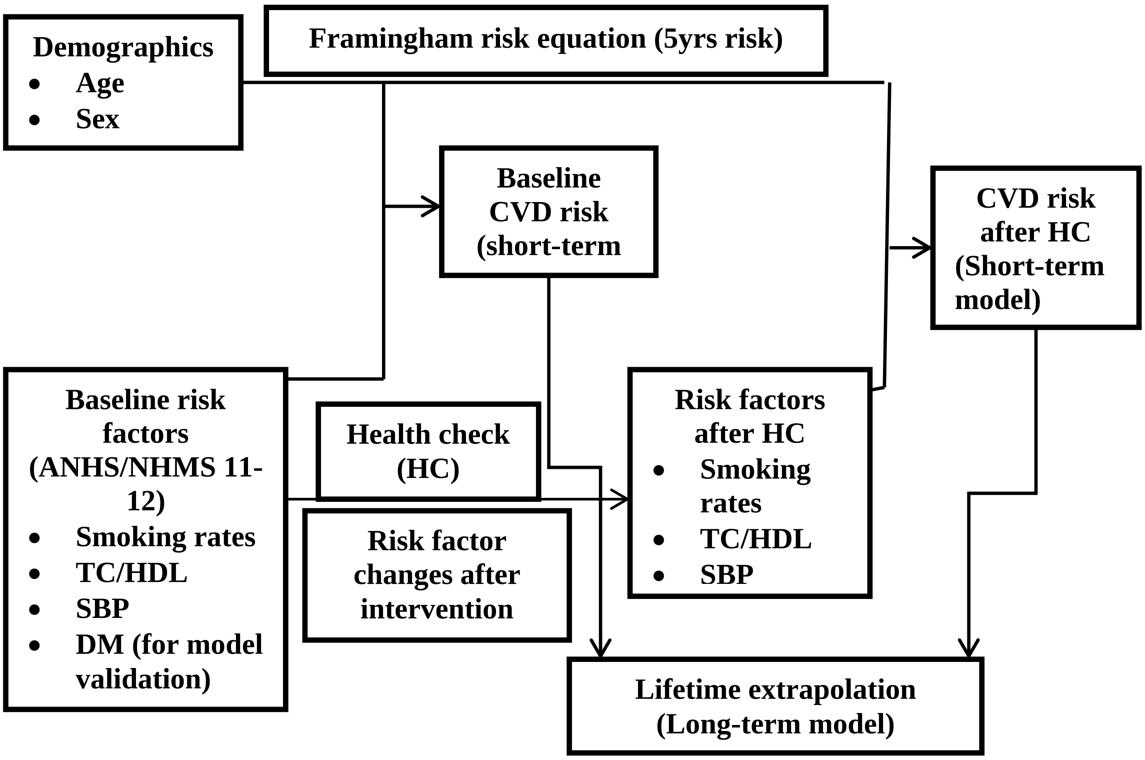

Figure 21: Model streamline

1.1.Short-term model

The short-term model simulated cohort CVD incidence in both intervention and control arms within 5 years of the health check. The Framingham Risk Equation (FRE) was used to simulate individual 5-year CVD incidence rates,[189] which were later converted to annual incidence rates. The average incidence rates of 10,000 individuals were calculated to represent the cohort CVD incidence. The use of the FRE in the Australian population has been validated in cohort studies[2, 202] and was recommended by the Royal Australian College of General Practitioners (RACGP) in routine medical practice.[2] In this study, we adopted two FRE formulas for Coronary Heart Disease (CHD) and Cerebral Vascular Abnormality (CVA) to form an overall estimate of CVD incidence for each individual in the cohort. According to the definitions, FRE of CHD incidence comprises new events of angina pectoris, coronary insufficiency, Myocardial Infarction (MI) and CHD death; while

CVA incidence includes new events of stroke and TIA (Transient Ischemia Attack). The following FRE formula and procedures were applied to the calculation. The relevant coefficients in the FRE formulas are listed in Table 17:

1) $\mu = \beta0 - \beta1*female + \beta2*\ln(age) + \beta3*\ln(age)*female + \beta4*[\ln(age)]^2*female + \beta5*\ln(SBP) + \beta6*cigarettes + \beta7*\ln(TC/HDL) + \beta8*DM + \beta9*DM*female$

2) $\sigma = \exp(\Theta0 + (\Theta1*\mu))$

3) $u = (\ln(5) - \mu) / \sigma$

4) $P(5\ years) = 1 - \exp(-\exp(u))$

Table 17: FRE coefficients for CHD and CVA incidence

Coefficients	***CHD***	***CVA***
Θ0	0.9145	-0.4312
Θ1	-0.2784	-
β0	15.5305	26.5116
Female (β1)	28.4441	0.2019
ln (age) (β2)	-1.4792	-2.3741
ln(age)*female (β3)	-14.4588	-
$\ln(age)^2$*female (β4)	1.8515	-
ln(SBP) (β5)	-0.9119	-2.4643
Cigarettes (y/n) (β6)	-0.2767	-0.3914
ln(TC/HDL) (β7)	-0.7181	-0.0229
DM (β8)	-0.1759	-0.3087
DM*Female (β9)	-0.1999	-0.2627

Two arms were simulated in the model: the health check and the usual care arm (Figure 19). Three health states were defined in the short-term model: CVD free, CVD and death. CVD incidence was derived from the application of FRE with risk factor inputs of the intervention and control arm respectively. The same all-cause mortality rates (from CVD free to death) derived from the Australian life tables[191] were applied to both arms.

1.1.1. Baseline CVD incidence estimates (control arm)

Individual risk factor profiles were generated using population distributions of risk factors. Adjustments were made for co-existence of relevant risk factors. FRE was applied to individual risk profiles to calculate the 5-year CVD incidence, which was later converted to annual incidence rate.

1.1.1.1. Baseline risk factor inputs

Model inputs were derived from the latest 2011 Australian National Health Survey (ANHS) and the National Health Measurement Survey (NHMS).[172] The proportional distributions of relevant risk factors were used in the reference model (Table 18). For each simulated individual, one was firstly proportionally allocated into one of the risk categories of individual risk factors. Then, a specific reading of each risk factor was randomly generated (from the range of the risk category) and assigned to the individual. The allocation was repeated till everyone in the cohort was assigned a SPB, TC and HDL reading.

Table 18: Age and sex specific proportional distribution of risk factors

Variables	*Categories*	*Males*	*Females*
SBP	<100 mmHg	1.90%	7.40%
	≥100 to <110 mmHg	12.80%	19.10%
	≥110 to <120 mmHg	22.60%	24.30%
	≥120 to <130 mmHg	25.80%	22.10%
	≥130 to <140 mmHg	16.50%	12.60%
	≥140 to <150 mmHg	11.40%	7.50%
	≥150 to <160 mmHg	5.70%	3.50%
	≥160 to <170 mmHg	2.20%	2.40%
	≥170 mmHg	1.10%	1.10%
TC	<4.0 mmol/L	11.94%	9.63%
	≥4.0 to <4.5 mmol/L	11.94%	12.47%
	≥4.5 to <5.0 mmol/L	15.90%	16.66%
	≥5.0 to <5.5 mmol/L	16.06%	15.99%
	≥5.5 to <6.0 mmol/L	19.22%	20.23%
	≥6.0 to <6.5 mmol/L	12.67%	12.30%
	≥6.5 to <7.0 mmol/L	7.22%	6.56%
	≥7.0 mmol/L	5.04%	6.15%
HDL	<1.0 mmol/L	19.1%	4.86%
	≥1.0 to <1.3 mmol/L	41.7%	22.69%
	≥1.3 to <1.5 mmol/L	21.3%	23.17%
	≥1.5 to <2.0 mmol/L	16.0%	38.92%
	≥2.0 to <2.5 mmol/L	1.5%	9.55%
	≥2.5 mmol/L	0.3%	0.81%
Smoking	Current smoker	24.0%	18.9%

Co-existence of risk factors (i.e. smoking; TC>5.5mmol/L; and HDL <1.0mmol/L for males and 1.3mmol/L for females) was represented in the simulation of individual risk profiles. The conditional prevalence of smoking versus high TC; and high TC versus low HDL was reported in the NHMS.[172] To account for the co-existence of the three risk factors (smoking, high TC and low HDL), the following procedures were applied:

1) Relative Risks (RR) of conditional prevalence of risk factor (reported at a population level) were calculated using the following formula:

$$RR(b|a) = \frac{P(a \cap b)}{P(a)}$$

2) RRs were applied to the age and gender specific risk factor prevalence (P′):

$$P'(a \cap b) = RR(b|a) * P'(a)$$

3) The conditional prevalence of multiple risk factors was calculated using the formula:

$$P(A_1 \cap \cdots \cap A_n) = \prod_{i=2}^{n} P(A_i \mid A_1 \cap \cdots \cap A_{i-1}) P(A_1)$$

A stepwise random drawing of risk factors was performed. The drawing of subsequent risk factor was conditioned on the existence of previously drawn risk factor(s) (step 2 and 3). The correlations of SBP with other risk factors were not accounted because it was not reported in the 2011 NHMS.

1.1.1.2. Estimation of annual CVD incidence rate

By applying the FRE to the randomly generated risk factor sets (5,000 sets for males and females respectively), individual 5-year CHD and CVA incidence rates were calculated and combined; then converted to annual CVD incidence using the formula:

$$\text{Instantaneous rate} = -(\text{LN}(1 - '\text{5\_year probability}'))/60$$

$$\text{Probability over 12 months} = 1 - \text{EXP}(-\text{rate} * 12)$$

The average of 10,000 CVD incidence rates per annum was used as estimates of cohort CVD incidence in the Markov model.

1.1.2. CVD incidence after health check (intervention arm)

CVD incidence in the intervention arm was estimated using similar simulation procedures as described for the control arm. FRE was applied to a revised set of risk factor inputs.

Risk factor distributions after the health check (intervention arm) were generated by applying health check effects data[132] to the baseline distributions of risk factors.

1.1.2.1. Estimates of health check effect

To estimate the intervention effects, RRs of patients remaining at high risk (>140mmHg for SBP; >6mmol/L for TC, and smoking) after a health check,[132] were applied to high risk patients (regardless of severity) from the baseline distributions. Relevant inputs of health check effects are summarized in Table 19. We further assumed intervention benefit duration of 5 years. For each risk factor, the proportions of patients who were estimated to reduce their risk to within the normal range were re-allocated. Two assumptions were made with regard to the risk re-allocations:

Assumption 1 (base-case): same proportional distributions of patients across the normal risk categories as observed in the baseline data;

Assumption 2 (alternative-case): all reduced high risk patients moved to the highest category within the normal range (e.g. for SBP, the 130-140mmHg category).

Table 19: Health check effects (surrogate outcome changes)

Subgroup (Mean/RR (95%CI))	***Effect size***	
	Total	***Up to 5 years***
High TC (>6mmol/L) (RR)	0.63 (0.50, 0.79)	**0.63 (0.50, 0.79)**
High SBP(>140mmHg)* (RR)	0.63 (0.5, 0.79)	**0.71 (0.55, 0.9)**
Smoking (RR)	0.93 (0.86,1.02)	**0.90(0.84,0.97)**
SBP (Mean)	-3.65 (-6.50, -0.81)	**-4.58(-7.37, -1.79)**
TC (Mean)	-0.13 (-0.19,-0.07)	**-0.16(-0.20,-0.11)**

**fixed effect model in meta-analysis*

1.1.2.2. CVD incidence allocation

CVD incidence in both arms was allocated to five CVD sub-states (MI, UA, SA, TIA and stroke). Data from the National Hospital Morbidity Database (NHMD) were used to calculate the allocation rates.[190] The NHMD summarized episodes of health care from private and public hospitals in Australia. All major diagnoses were coded with the International Classification of Diseases Version 10 (ICD-10). The following ICD-10 codes were used to define CVD episodes in this model:

Unstable Angina (UA): ICD-10 codes I20.0 (Unstable Angina) and I20.1 (Angina with documented spasm)

Stable Angina (SA): ICD-10 code I20.8 (other form of angina) and I20.9 (unspecified angina)

MI: ICD-10 code I21(Myocardial infarction), I23 (current complication after AMI) and I24 (other acute IHD)

Stroke: ICD-10 code I60 (Subarachnoid haemorrhage), I61(intracerebral haemorrhage), I62 (other nontraumatic inteacranial haemorrhage), I63 (cerebral infarction), I64 (stroke not specified) and I66 (occlussion and stenosis of cerebral arteries bit resulting in cerebral infarction)

TIA: ICD-10 code I65 (occlusion and stenosis of precerebral arteries not resulting in cerebral infarction), and I67 (other cerebrovascular diseases).

To calculate the allocation rates of the five CVD sub-states, the number of hospitalization episodes of UA, SA, MI, stroke, TIA, and CHD death in a year were extracted from the NHMD. The allocation of CVD incidence was calculated using formula:

$$P(\text{UA}) = \frac{\text{No. (UA)}}{\text{No. (UA + SA + MI + stroke + TIA + CHD death)}}$$

CHD death was included in the calculation because the FRE of CHD incidence includes this sub-state. The incidence allocations of the five CVD sub-states are summarized in Table 20.

Table 20: Allocation of CVD events (Australia, 2010)

45-54 Yrs	*UA*	*SA*	*MI*	*Stroke*	*TIA*
Males	22.19%	17.05%	42.87%	11.37%	1.91%
Females	26.47%	16.89%	26.73%	20.39%	6.99%

NHMD: age & gender specific hospitalization episodes; updated to 2009-2010

1.1.3. Long-term model

A cohort Markov model was constructed for a life-course projection (50 yearly cycles), in which seven health states, including five CVD sub-states were defined (Figure 20). All patients entered from CVD-free state. After experiencing a non-fatal CVD event, patients remained in the same CVD sub-state until death. Since we assumed health check benefits of 5 years, the annual CVD incidences from the short-term model were applied to the first five cycles of the Markov model. From the sixth cycle onwards, we assumed no differences in CVD incidence between the intervention and control arms. An annual discount rate of 5% was applied to both the effectiveness and costs simulation in the model.

1.1.3.1. Input variables

1.1.3.1.1. Age and gender specific CVD incidence

The age and gender specific CVD incidence of patients aged 50 years and above were calculated using data from the NHMD[190] and Australian National Census.[171] The number of disease specific hospitalization episodes and the population at risk were used in the calculation:

$$\text{CVD incidence} = \frac{\text{episodes of CVD related hospitalization}}{\text{popualtion at risk}}$$

The results are summarized in Table 21 and were used in the Markov model as transition probabilities from the sixth cycle onward.

Table 21: Age and gender specific CVD incidence

%	Males					Females				
	UA	SA	MI	Stroke	TIA	UA	SA	MI	Stroke	TIA
45-54	0.205	0.157	0.395	0.105	0.018	0.101	0.064	0.102	0.078	0.027
55-64	0.448	0.407	0.703	0.241	0.052	0.193	0.156	0.219	0.130	0.042
65-74	0.750	0.776	1.044	0.555	0.133	0.375	0.345	0.461	0.328	0.074
75-84	1.038	0.953	1.659	1.292	0.206	0.670	0.581	1.068	1.013	0.095
85+	0.992	0.813	2.503	2.093	0.162	0.631	0.587	1.719	1.996	0.083

Incidence =disease specific hospitalization episodes (NHMD)/population (national census, ABS)

1.1.3.1.2. Mortality rates

All-cause mortality was derived from the 2011 cause of death report.[191] Age and gender specific mortality rates were used as transition probabilities from CVD free to death in the model (Table 22).

Table 22: Age and gender specific annual mortality rates (all-cause mortality)

	45-54 years	*55-64 years*	*65-74 years*	*75-84 years*	*85-94 years*
Males	0.277%	0.658%	1.638%	5.004%	11.803%
Females	0.176%	0.378%	0.990%	3.292%	11.257%

Cause of death report 2011, ABS

Standardised Mortality Ratios (SMRs) were multiplicatively applied to the all-cause mortality to simulate death rates of CVD patients. The SMRs of CVD sub-states were derived from a literature review (Table 23).

Table 23: Standard Mortality Ratio (SMR) for CVD states

	Male	*Female*	*Source*
UA	2.19 (2.05; 2.33)		Calculated using the NICE guideline on UA and NSTEMI[192]
SA	1.95 (1.65; 2.31)*		Sweden cohort[193] 16 years follow-up of 51-59 years old men with uncomplicated angina
MI	2.28 (2.12; 2.46)	3.07 (2.70; 3.48)	Danish MONICA[195] 15 years follow-up of patients 30-74 years
Stroke	2.58 (2.43; 2.75)	2.85 (2.66; 3.05)	Danish MONICA[194] 15 years follow-up of patients 25+ years old
TIA	1.4 (1.1; 1.8)		Oxfordshire Community Stroke Project[196] 5-year program of all patients

** Age-adjusted RR of total mortality*

1.1.3.1.3. Utility weights

The age and gender specific QALYs of healthy individuals (CVD free) were derived from a state survey in South Australia (Table 24), in which the Assessment of Quality of Life

(AQoL) instrument was used.[197] Utility (or quality of life) weights of acute CVD events relative to a value of 1 for perfect health were derived from a systematic review (Table 25).[198] The CVD utility weights were multiplicatively applied to the utility of healthy individuals to generate utility values of CVD sub-states. Considering the potential improvements in utilities after an acute CVD event, a 50% utility decrement was applied to the respective post-CVD states from the second year/cycle onwards.

Table 24: Age and gender specific utility of healthy individuals

	40-49 years	*50-59 years*	*60-69 years*	*70-79 years*	*80+ years*
			Mean (SD)		
Females	0.86 (0.17)	0.79 (0.23)	0.77 (0.21)	0.72 (0.26)	0.63 (0.28)
Males	0.84 (0.19)	0.82 (0.20)	0.80 (0.18)	0.79 (0.22)	0.71 (0.30)
All	0.85 (0.18)	0.80 (0.22)	0.79 (0.19)	0.75 (0.25)	0.66 (0.29)

Utility scores were obtained using the Assessment of Quality of Life (AQoL) instrument.

Table 25: Utility weights for acute CVD events

CVD states	*Utility coefficients*	
	Mean	**SE**
UA	0.770	0.038
SA	0.808	0.038*
MI	0.760	0.018
Stroke	0.629	0.04
TIA	1	

**SE assumed to be equal to UA*

1.1.3.1.4. Cost estimates

Average hospitalization costs for CVD events were derived from the National Hospital Cost Data Collection (NHCDC) database using the Australian Refined Diagnosis-Related Group (AR-DRG) 6.0x coding system. Data in the 2009-10 round (round 14, public sector) were used (Table 26).[199] We assumed the post-event annual costs (from the second year of acute CVD events) were 15% of the acute event costs in the base-case model.[192, 200]

Table 26: Cost of acute CVD events and post-CVD states

CVD states	***AR-DRG code***	***Costs***	***Descriptions***	
MI event	F66A	$5,572	Coronary atherosclerosis W catastrophic or severe Cc	
UA event	F72B	$2,682	Unstable Angina W/O catastrophic or severe Cc	
SA event	F66B	$2,146	Coronary atherosclerosis W/O catastrophic or severe Cc	
Stroke event	B70B	$6,496	Stroke and Other Cerebrovascular Disorders W/O Catastrophic or severe Cc	
TIA event	B69A	$3,128	TIA & Precerebral occlusion+CSCC	
Cost weight*		**15%**	10%	20%
Post-MI		**$836**	$557	$1,114
Post-UA		**$402**	$268	$536
Post-SA	N/A	**$322**	$215	$429
Post-stroke		**$974**	$650	$1,299
Post-TIA		**$469**	$313	$626

** Application of weight to acute event costs*

1.1.4. Threshold costs for the 45-49 year health check

To estimate the threshold costs for the 45-49 year health check for it to be cost-effective, a threshold of $50,000 per QALY were used. After accounting for the costs for acute events and post-CVD states in both intervention and control arms, the threshold costs of this health check program were calculated by applying a cost-effectiveness threshold value ($50,000 AUD per QALY) to the estimated QALY gained in the intervention arm.

1.1.5. Sensitivity analysis

In the reference case model, parameter uncertainties were associated with the individual risk profile generation in the hypothetical cohort; the estimates of health check effects; and other input variables in the Markov model (e.g. SMRs, costs, and utility values). To quantify the parameter uncertainty, both deterministic and probabilistic sensitivity analysis were applied in the reference model.

1.1.5.1. Deterministic sensitivity analysis (DSA)

Deterministic sensitivity analyses were applied to the following input parameters in the reference model:

- Alternative utility decrements of 0%, 25%, 75% and 100% were applied to the acute event utility weights to simulate utilities for post-CVD states.
- Alternative coefficients of 10% and 20% were applied to the acute event costs to estimate the costs for post-CVD states.
- A 3.5% annual discount rate was applied.
- A cost-effective threshold of $25,000 per QALY

1.1.5.2. Probabilistic sensitivity analysis (PSA)

To represent uncertainty raised from the individual risk profile generation, in the reference model we repeated the cohort simulation (10,000 sets of individual risk profiles) 1,000 times in both control and intervention arms using deterministic inputs. The mean of 1,000 sample means was used to represent CVD incidence in the cohort and later, as input in the Markov model.

The parameter uncertainty was also associated with estimates of intervention effects (RRs of risk factor changes) in the short-term model and other variables in the Markov model (i.e. SMRs, utility for healthy individuals; the utility weights for acute events and post-CVD states). Probability distributions were assigned to relevant input variables in the reference model: Log normal distributions to RRs and SMRs; beta distributions to the utility estimates (baseline utility for the CVD free individuals and utility weights for CVD sub-states). Random draws between 25% and 75% (i.e. from a uniform distribution) were performed to generate utility decrements for post-CVD states. For each set of randomly drawn RRs (representing intervention effects), a hypothetical cohort was generated and the cohort CVD incidence (males and females separately) was calculated and recorded. We ran the PSA model 1,000 times. The mean and 2.5th and 97.5th percentiles of the LYs and QALYs were summarized.

1.1.5.3. Structural uncertainty (alternative model)

Structural uncertainty was further assessed in this study. An alternative model was constructed using different assumptions to simulate individual risk profiles and health check effects.

The structural uncertainty in this model was associated with the short-term model constructed to simulate CVD incidence in the cohort. In the reference model, proportional distribution of risk factors and RR of risk factor changes after intervention were used to simulate individual risk profiles in the control and intervention arm. An alternative model was constructed using different assumptions about risk factor distributions and estimates of intervention effects as opposed to the reference model.

In the alternative model, normal distributions were assigned to risk factors of continuous nature (i.e. SBP, TC and HDL). The means and Standard Deviations (SD) of their distributions were derived or calculated using data from the 2011 ANHS and NHMS.[172] We repeated the risk profile simulation 20 times in both control and intervention arms to control uncertainty associated with the simulation procedures.

1.1.5.3.1. Alternative model inputs

- **SBP**

Age and gender specific mean of SBP and the prevalence rate of high SBP (above 140 mmHg) were derived from the 2011ANHS.[172] Assuming normal distribution, SDs calculated using the formula:

$$SD = \frac{140 - \text{Mean}}{z}$$

z value: normal distribution table and prevalence rates

- **Lipids**

The NHMS reported age and gender specific prevalence of abnormal lipids; and the categorical distributions of TC (4.0-4.5; 4.5-5.0; 5.0-5.5; 5.5-6.0; 6.0-6.5; 6.5-7.0; and >7.0 mmol/L) and HDL (1.0-1.3; 1.3-1.5; 1.5-2.0; 2.0-2.5; >2.5 mmol/L) in the Australian population (not age and gender specific).[172] By applying the population categorical distributions to the age and gender specific (45-54 males and females respectively) prevalence of abnormal TC and HDL, age and gender specific categorical distributions were generated. Then, Monte Carlo Simulation was applied to transform the categorical distributions into normal distributions. To do so, the TC and HDL readings of 5,000 males and females (respectively) were simulated using the age and gender specific categorical distributions of TC and HDL. The means and SDs of TC and HDL from 5,000 random draws were then calculated and summarized. We assumed normal distributions of TC and HDL in the subsequent cohort simulation. The parameters of risk factor distributions are summarized in Table 27.

Table 27: Age and gender specific risk factor distributions

	Age	***N***	***BP***		***TC*****		***HDL*****		***DM#***	***Smoking***
			Mean	**SD***	**Mean**	**SD**	**Mean**	**SD**	**%**	**%**
M	45-54	5,000	126.0	16.9	5.29	1.08	1.24	0.37	6.2	24.0
F	45-54	5,000	120.9	18.0	5.33	1.07	1.54	0.41	3.9	18.9

**calculated using population mean and prevalence rates; ** Monte Carlo Simulation using NHMS data; #Diabetes Mellitus (type1&2)*

1.1.5.3.2. Baseline CVD incidence estimates

Same method was applied to estimate 5-year cohort incidence of CHD and CVA as described in the reference model. Instead of the proportional distributions, the FRE inputs were derived from normal distributions of relevant risk factors. Co-existence of risk factors (smoking status, abnormal TC and HDL) were adjusted using the same technique as described above.

1.1.5.3.3. CVD incidence after health check

In the alternative model, the Mean Differences (MDs) of risk factors change (SBP, TC and HDL) were applied to simulate the health check effects (Table 19). We assume the intervention would shift the distributions to the left by the amount of MDs without changing the shapes (same SDs). For categorical variables, RRs of patients remaining at high risk were applied.

As mentioned before, the simulation of individual risk profiles was repeated 20 times in the alternative model (both control and intervention arms). The results of the 20 simulations are summarized with mean and 2.5^{th} and 97.5^{th} percentiles.

1.2. Results and discussion

1.2.1. Model validation

To compare and validate the reference and alternative models, the estimated CVD incidence rates (of the 45-54 year old Australian population) are summarized in Table 28. The two models presented comparable estimates of CHD and CVA incidence in the cohort. However, when compared with the national estimates (hospitalization data from NHMD), both of them underestimated the incidence of CVA. When the risks of CHD and CVA were combined, the alternative model appeared to slightly underestimate CVD incidence in males.

Table 28: Model validation — Annual CVD incidence (45-54 year old Australians)

% (%, %)	***CHD***	***CVA***	***CVD***
Male	**Mean (2.5, 97.5 percentiles)**		
Observed*	0.80	0.12	0.92
Reference model**	0.810 (0.793, 0.827)	0.096 (0.094, 0.097)	0.905 (0.887, 0.923)
Alternative model**	0.789 (0.771, 0.809)	0.095 (0.093, 0.097)	**0.884 (0.865, 0.904)**
Female	**Mean (2.5, 97.5 percentiles)**		
Observed*	0.28	0.10	0.38
Reference model**	0.320 (0.312, 0.329)	0.060 (0.059, 0.061)	0.380 (0.371, 0.389)
Alternative model**	0.323 (0.314, 0.332)	0.059 (0.058, 0.060)	0.382 (0.373, 0.392)

**hospitalization episodes in the 45-54 years old Australian population (NHMD); **estimates from 1,000 runs of cohort simulations*

1.2.2. Parameter uncertainty

The results of both DSA and PSA in the reference model are presented in chapter 7.

1.2.3. Structural uncertainty

1.2.3.1. Short-term model

The alternative model yielded comparable estimates of short-term benefits after a health check (CVD incidence and events averted in 5 years) in males to the reference model; whereas, it seemed to overestimate the intervention effects in female patients (Table 29).

Table 29: Comparisons of reference and alternative model estimates

	Reference model*	***Alternative model*****	***Ref / Alt***
Males	**%**	**%**	
Baseline CVD incidence	0.762	0.747	1.020
CVD averted annually	0.098	0.102	0.961
LYs Gained	1.927	1.990	0.968
QALYs Gained	0.858	0.885	0.969
Females	**%**	**%**	
Baseline CVD incidence	0.295	0.299	0.987
CVD averted annually	**0.028**	**0.045**	0.622
LYs Gained	**0.667**	**1.078**	0.619
QALYs Gained	**0.258**	**0.415**	0.622

**Base-case scenario in the reference model & mean of 1,000 runs of cohort simulation;*
***mean of 20 runs of cohort simulation;*

Applying the same MDs of risk factors changes to a low risk population (females in this study) would overestimated the intervention effects. On the contrary, the influence was minimized in the reference model by applying RR of patients remaining at high risk after intervention, because rather than shifting the entire risk factor distributions to the left, the application of RR implies intervention benefits solely to those high risk patients in a cohort.

1.2.3.2. Long-term Markov model

Correspondingly, the alternative model yielded similar health check benefits (LYs and QALYs gained) and threshold costs to the reference model (base-case scenario) in males; but a more aggressive estimate of intervention benefits and threshold costs in females (Tables 29,30).

Table 30: Threshold costs of the 45-49 year old health check program

Outcomes		***Threshold costs(AUD) $50,000 per QALY gained***			***Threshold costs(AUD) $25,000 per QALY gained***		
Reference model (Base-case)		10%*	15%*	20%*	10%*	15%*	20%*
Male	QALYs**	$455	$465	$475	$241	$251	$261
Female	QALYs**	*$137*	*$140*	*$144*	*$73*	*$76*	*$79*
Alternative model							
Male	QALYs**		$483			$262	
Female	QALYs**		*$231*			*$127*	

** Post-event state costs weight applied on acute event costs; **50% QALY decrements of post-CVD states*

Appendix 17: Publication

Si, S., Moss, J.R., Sullivan, T.R., Newton, S.S. & Stocks, N.P. (2014) Effectiveness of general practice-based health checks: a systematic review and meta-analysis.
British Journal of General Practice, v. 64(618), pp. e47-e53

NOTE:
This publication is included on pages 234-240 in the print copy of the thesis held in the University of Adelaide Library.

It is also available online to authorised users at:

http://doi.org/10.3399/bjgp14x676456