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(a) Title of project (in both English and Chinese languages)

A Feasibility Study on A Healthcare Voucher Scheme for Screening and Management of Cardiovascular Risk Factors Associated Chronic Diseases in the General Population: A Mixed Methods Evaluation (評估「慢性疾病管理醫療券計劃」於篩查普羅市民慢性疾病的可行性和混合研究)

Principal Investigator: Professor YEOH Eng-kiong (楊永強教授)

(b) Executive summary (in both English and Chinese languages)

(1) Abstract of the research

Background

Globally, increasing healthcare demand has arisen from the increasing prevalence of chronic diseases associated with an ageing population. Compounding this challenge in meeting the changing demand is how health systems have been organised to focus and invest in acute hospital care compromising their capacity to respond effectively. The global response and that advocated by the World Health Organisation is for [i] greater attention to health promotion to enable life style changes needed to reduce behavorial risk factors for chronic disease and [ii] reorientation of health systems to a primary care led integrated health system and increasing investments in preventive care to enable early detection and timely and effective management of chronic disease over the life course. Effective preventive care will impede disease progression, prevent disease complications and disability and reduce premature mortality. This should increase the Quality Adjusted Life Years [QUALY] for a jurisdiction and contribute to its economic growth in addition to reducing demand for hospital care and costs.

An effective and efficient response is particularly problematic in health systems typified by Hong Kong SAR where there is in effect a 'Segmentation' of a public healthcare system that emphasizes investments on specialist hospital care, while the major proportion of ambulatory

[out-patient] primary care is provided by the private healthcare system to be paid, predominantly 'out of pocket', by patients.

Research and Methods

Building on and learning from the evaluation of the 'Elderly Healthcare Voucher' we hypothesize a Healthcare Voucher for Screening for Cardiovascular Risk factors and Management of Associated Chronic Diseases will be able to redress the imbalances that have given rise to the 'Segmentation' and enable an effective health system response to meet the emerging demand.

The research comprises 3 related studies to study the feasibility of a healthcare voucher scheme for screening for cardiovascular risk factors and management of associated chronic diseases in the general population. Study 1 is a 3 part qualitative in-depth interviews of [i] practitioners, [ii] public and [iii] policy makers and academics and other key stakeholders. Study 2 is a quantitative telephone-based survey of the general public. Studies 1 and 2 evaluate the attitudes and perceptions of the proposed voucher and its design and the barriers and facilitators in implementation. Study 3 is a cost-effectiveness evaluation of such a screening program compared with no screening.

Key Findings

There was overwhelming support from the general public, practitioners and policy makers and key stakeholders for the chronic disease voucher. There was also a consensus of the potential benefits of the proposed voucher in encouraging preventive care, early detection of chronic disease, timely and effective management of chronic diseases and improving the health of the population, patients and their carers. Practitioners and policy makers saw the voucher as a tool for engaging the private sector for chronic disease management in a public-private partnership and could redress the current segmentation of the healthcare system and remove financial and supply barriers in access to primary care and had the potential to encourage a continuing doctor-patient relationship which is characteristic of family medicine.

However, there were different views in how the voucher should be designed, the frequency of screening, the age groups that should be covered, the diseases and risk factors that should be covered and clinical protocols and capacity required for the chronic disease program.

The capacity for screening for chronic disease was not seen to be a problem and was estimated to be within $1,000. Continuity of practitioner from screening to disease management programs was seen as desirable.

In study 3, the cost-effectiveness analyses compared screening for diabetes, hypertension and lipid disorder in individuals aged 45-64 with no screening. We estimated the ICER per Qaly was comparable to that found in a number of other countries of HK$97,686 per QALY gained. Testing different frequencies of screening from once to triannual, we found the more frequent screening would pick more chronic disease but would increase the cost of screening substantially from HK$1.6 billion to HK$6.5 billion. The capacity and logistics for increasing the frequency of screening would also be problematic. Our analyses support the selection of a one-off screening.

Barriers and Facilitators in Implementation

Public education was identified both by the general public and practitioners as necessary to foster a better understanding of the benefits of the program to facilitate uptake. Convenient and simple recruitment and administration was also seen as important to encourage screening and specific initiatives may be needed for groups that may be less likely to take up the screening program such as younger working men.

Capacity of the primary care workforce to meet the clinical workload generated from early detection of chronic diseases in the screening program was a critical factor identified. In addition to the training of the primary care workforce for chronic disease management, the clinical guidelines and clinical referral protocols between primary care physicians and specialists and the infrastructure for multidisciplinary care would also be required for implementation. The administrative requirements and the resource provided for infrastructure costs for participating in the program was seen to be a critical barrier for the private practitioners to enroll on the program. Adequate reimbursements for the chronic disease management was also highlighted which would include the different drugs needed for different types of patients.

Policy makers and Academic and Key Stakeholders commented a more comprehensive approach in PPPs was required for longer term sustainability and a strategic purchasing tool should be designed for this and to address the current segmentation ['fragmentation'] of the

current healthcare system. They also recommended in the design of any future programs the voices of patients should be sought and willingness-to-pay assessed.

Policy Implications

I. In the design of a chronic disease screening and management voucher the eligible population age group has to be first ascertained and estimates of the number of persons covered and how they will be phased in will need to be considered. Taking reference to the Colonic Cancer Screening, if the population age group envisaged is 45-64, the first cohort to be screened could be the population aged 45 initially adding older age groups gradually when capacity and experience has been built up and recurrent resources secured. This could be justified on the basis of the objective of early detection. Whether patients already diagnosed, either already on treatment or not under care should be included needs to be considered.

   The likely disease profile of the cohort who opt to be screened needs to be estimated to predict the likely resources and organisation of the program.

   The voucher would be an effective demand side instrument to incentivise screening but may not be the best instrument for chronic disease management in view of the complexities of the patient profiles and corresponding needs. A supply side instrument such as contracting may be better suited.

II. The capacity and capability of the healthcare system will need to be assessed to match the new demands generated from early diagnosis and detection of new cases in excess of the numbers currently presenting. Screening capacity is likely to be less problematic and can be planned for. However, the chronic disease program will be substantially more demanding as many more patients at different stages of their disease will be identified, leading to the need of well-designed disease guidelines and clinical management programs to optimize outcomes. Patients should, preferably, be followed up through their life course by the same physician. Clinical referrals protocols between specialists and primary care physicians will also be needed for coordination and integration of care as disease may still progress as part of the natural history despite effective management. The primary care workforce will have to be developed to meet the challenges and new training programs and carer structures will need to be considered.

III. The organisation of the healthcare system in response to the new demand and requirements will need to be considered to ensure the facilities, capacity, capabilities and coordination of care between the public and private sectors and between primary and specialist care is effective.

IV. The set up costs and the recurrent costs will be substantial and need to be estimated and secured, based on the population groups to be covered. Screening programs are more likely to be successful if no co-payments are involved. However co-payments could be considered based on capacity and willingness-to-pay.

Recommendations

I. Further studies are needed to estimate the take up rate of the population age group to be considered for a chronic disease screening and management program and to research the disease profile of the newly detected patients to assess the resources and organisation needed.

II. New studies are also required to have a more precise projection of natural disease progression and of the new model of care as the estimates in this study have been based on the RAMP program in the Hospital Authority which is the only data source available that best matches the intervention proposed for the program and needs to be supplement from a wider study.

III. Detailed studies will be needed to assess gaps in the current capacity and capability which should include workforce, training, facilities, equipment and infrastructure from that needed for the program planned and how this could be planned for and met.

IV. Further studies of the resources required with varying scenarios of costs and their sources and payment mechanisms would need to be conducted to ensure financial sustainability and should include willingness-to-pay for chronic disease management.

V. The design of the program should be constructed with input from all stakeholders and importantly with engagement of patients. Piloting of the programme would enable evaluation of implementation barriers and facilitators for scaling up.

研究摘要

背景

全球人口老齡化有關的慢性病罹患率日益高漲，導致醫療保健需求增加。現時衛生系統的資源集中投放於急性醫院護理，大大減低了醫療體系對長期病患的管理及醫療需求。世界衛生組織倡導的全球對策是：[i] 增強健康促進的重視，以便改變生活方式，減少慢性病的行為風險因素：[ii] 將醫療體系重新定位以基層醫療為本，強化綜合保健，並增加預防保健的資源，以便市民在人生過程中能夠及早發現和及時有效地管理慢性病。有效的預防性護理將減低疾病惡化，預防疾病併發症和殘疾，降低過早死亡率。這些措施應可增加質量調整壽命年[QALY]，並有助於社會的經濟發展，減少對醫院的需求和成本。香港的醫療體系充滿挑戰，特別在效果和效率方面，因為公共醫療體系是分割的，只集中對專科醫院護理的資源投放，大部分的基層護理(門診)在私營市場，主要由市民自行繳費。

研究與方法

在「長者醫療券」的評估研究基礎上，我們假設一個用於「篩查心血管危險因素和管理相關慢性病的醫療券」將能夠糾正導致醫療市場「分割」的不平衡，並能夠有效地改善醫療系統，以應對持續的需求。此科研報告包括三項相關研究，評估篩查心血管危險因素和管理相關慢性病之醫療券在人群中的可行性。研究(1)是對三種人包括[i]醫療從業者、[ii] 公眾和 [iii] 決策者以及學術界和其他主要持份者的定性深入訪談。研究 (2) 是對普羅大眾的定量電話調查。研究 (1) 和 (2) 評估有關醫療券及其設計的態度和看法，以及執行中可能出現的障礙和促進因素。研究 (3)的目標是評估篩查計劃對比沒有任何篩查下的成本效益。

主要發現

公眾人士、醫療從業者、決策者和其他主要持份者對慢性病醫療券均表示大力支持。此外，他們還一致認為，此醫療券可鼓勵預防保健、慢性病的早期發現、及時和有效管理慢性病以及改善市民、病人及其照顧者的健康。醫療從業員和決策者認為此醫療券是促使私營部門參與公私夥伴合作的一種驅使因素，可以糾正目前醫療系統的分割，並消除就接受基層醫療護理的金錢和供應障礙；有可能鼓勵持續的醫患關係，推廣家庭醫學的實踐。

然而，在如何設計醫療券、篩查頻率、應涵蓋的年齡組、應涵蓋的疾病和危險因素以及慢性病方案所需的臨床指引和實施方面卻有不同的意見。慢性病篩查的能力普遍不被視為問題，而每人所需金額估計在 1 000 港元以內。就有關醫療從業者在醫療券中從篩查到疾病管理計劃的連續性方面被認為是可行的。

在研究 (3) 中，我們進行成本效益分析，比較 45 歲至 64 歲的人士在接受和不接受糖尿病、高血壓和高血脂篩查的結果。我們估計每 QALY 的 ICER 可與其他一些國家的 ICER 互相媲美，即每 QALY 增加約 97，686 港元。我們根據不同頻率的篩查對其效益和成本的推算，發現較頻繁的篩查雖然可找出更多慢性病，但篩查成本會由 16 億港元(一次性篩查)大大增至 65 億港元(每三年篩查一次)，而額外的篩查亦會令檢測量超出負荷，令整體運行出現不少困難。所以我們的分析結果支持選擇一次性篩查。

執行中的障礙和促進因素

公眾和醫療從業人員都認為公眾健康教育是必要的，以便更好地了解該方案的好處，增加參與率。鼓勵篩查的方法包括方便和簡單的篩查過程，以及針對較低可能參加篩查計劃的群體（如有工作的年輕男性）的特別措施。

基層醫療服務從業者的人手能否應付因篩查計劃而提早發現的慢性病所產生的臨床工作量是成功的關鍵因素。此外，除了對基層醫療人員進行慢性病管理培訓，有效的慢性病管理還需要基層醫生和專科醫生之間的臨床指南和轉診協定，以及跨學科管理的

基礎設施。私人醫療從業者是否參加該計劃的一個關鍵障礙是有關計畫對私人醫療從業者的行政和基礎設施的資源要求，我們認為慢性疾病管理的充足補償是重要的，其中包括不同類型患者所需的不同藥物。

決策者、學術人士和關鍵持份者認為，為了建構長期可持續性的慢性病管理體系，一個全面性的公私營合作方案是必要的，亦要設計一個策略性的採購工具和解決當前醫療體系的分割（"碎片化"）問題。他們還建議，在設計未來的計劃時，須收集病人的意見，並評估他們的支付意願。

政策含義

一、 在設計慢性病篩查和管理醫療券時，必須首先確定符合條件的人口年齡組，並考慮所涵蓋的人數以及如何分階段進行評估。參照結腸癌篩查，如果設想的人口年齡組為 45-64 歲，第一批進行篩查的群體可能是 45 歲人口，之後當積累了能力和經驗，並獲得經常性資源，可逐漸增加年齡組別。這可以基於早期發現的目標作為根據。我們也要考慮是否涵蓋已經診斷的患者，或是已經接受治療還是未接受治療。我們亦需要估計接受篩查的群體可能有的疾病種類，以預測該計劃的需要的資源和組織。

醫療券將是鼓勵篩查的有效需求工具，但鑒於患者的複雜性和相應的需要，它可能不是慢性病管理的最佳工具。反之， 供應工具（如直接跟醫護人員的患者承包合同）可能更適合。

二、 需要評估保健系統的能力和容量，以滿足早期診斷和發現新病例所產生超過目前數字的新需求。篩查能力的問題可能較小，可以依計劃進行。然而，由於處於疾病不同階段的病人將被識別，對慢性病管理計劃(如精心設計的疾病指南和臨床管理計劃)的需求將大大提高，此外， 病人在可行情況下應由同一個醫生跟進他們的人生疾病歷

程。專科醫生和基層醫生之間的臨床轉介協定也需要協調和整合護理，因為儘管管理有效，疾病仍可能自然地進展，慢慢漸趨嚴重。我們必須發展基層醫療人手，以迎接挑戰，及考慮新的培訓方案和照料結構。

三、 需要根據新的需求來組織醫療系統，另外以確保公共和私營部門之間，以及基層和專科護理之間的有效性，亦需要考慮相關設施，人手，能力，和護理協調方面的因素。

四. 醫療券的「成立費用」和「經常性費用」將是巨大的，需要根據要涵蓋的人口群體加以估計和確保。雖然在沒有共同付款的情況下，篩查計劃更有可能成功， 但是亦可以根據病人的能力和支付意願考慮共同付款。

建議

一、 需要進一步研究，以估計參與慢性病篩查和管理計劃的人口年齡組的接受率，並研究新發現的患者的疾病種類，以評估所需的資源和護理組織。

二。 還需要進行新的研究，以便更準確地預測自然疾病的進展和新的護理模式，因為本研究中的估計數值是基於醫院管理局的 RAMP 計劃，該方案的數據是唯一最符合是次計劃提議的干預措施，但是我們亦需要從更廣泛的研究中加以補充。

三。 需要進行詳細的研究，以評估現有能力和容量方面的差距，其中包括規劃方案所需的人手、培訓、設施、設備和基建方面，以及如何規劃和應對這些差距。

四. 根據不同的成本方案，進一步研究所需的資源，其來源和收費機制，以確保持續性的財政，並應考慮病人就慢性病管理的共同付款意願。

五、 方案的設計應在所有持份者的投入參與下進行，重要的是病人的參與。為該方案進行試點計劃可有助評估執行中的障礙和找出促進因素使其發展。

Layman summary on policy implications and recommendations

This study aims to examine the perception and cost-effectiveness of a voucher scheme that offers subsidy for screening of hypertension, diabetes and lipid disorders for the general public. It consists of three sub-studies, including (1). Qualitative interviews with patients, physicians and key stakeholder; (2). Telephone interviews with the general public; and (3). A cost-effectiveness analysis (CEA). The findings indicated that the scheme was supported by the general public, health service providers, policymakers and key stakeholders in health policymaking. The CEA also highlighted that the voucher scheme is cost-effective. We recommend this strategic purchasing initiative should be formulated and implemented in the community.

此研究旨在探討有關資助高血壓、糖尿病、及高血脂篩查的醫療卷計劃的意見，以及其可行性及成本效益。此報告共有三項相關研究，包括 1. 向病人、醫生、及主要持份者的訪談； 2. 公衆電話訪問；及 3. 成本效益分析。結果發現公衆人仕、醫療服務提供者、政策制定者、及有關持份者皆支持此計劃，成本效益分析亦發現此計劃具有潛在成本效益。團隊建議此策略性採購計劃可在社區中制定及實施。

(c) Main Body:

(1) Introduction

Hong Kong has gained global recognition for its public health efficiency and its population has the longest life expectancy in the world [1]. Still, similar to other health systems around the world, Hong Kong continues to face pressing challenges posed by non-communicable diseases (NCDs) as major causes of death, disability and ill health [2]. Increasing healthcare demands brought about by the increasing prevalence of chronic disease associated with an ageing population substantially contributes to the burdens of our healthcare system, depicted by the full occupancy of hospital wards and long waiting times at public hospitals [3, 4]. Our continuous, heavy reliance on public provided acute hospital-centric care, financed from taxation coupled with the rapid inversion of the population pyramid contribute to an unsustainable financing structure [3, 5-6]. The total health expenditure is projected to increase from 5.3% to 9.2% of GDP in 2033 could potential compromise the quality and provision of healthcare delivery. Concomitantly, a steep rise in long term care expenditure from 1.4% to 4.9% of GDP has been projected to occur in 2036, which is one of the highest expenditures in industrialised countries [3]. The private healthcare sector that provides the majority of primary care services remains unaffordable to vulnerable groups, affecting not just access to healthcare but importantly, to affordable primary care. This unsustainable health system structure calls for a solution that necessitates collaboration between public and private healthcare sectors to promote the uptake of primary care services - and specifically, early detection of diseases and chronic disease management [7-9]. Emphasis should be placed on preventive care that can facilitate the early detection and management of chronic conditions, delay disease progression, prevent disease complications and the accompanying disability, reduce the demand for health care and ultimately contribute to curbing associated healthcare costs. In view of this, we have

carried out an extensive review of the literature to justify the necessity for assessing the feasibility and eventually, implementation of a chronic disease screening and management voucher scheme. Here, we provide an overview of our review.

The burden of chronic diseases

Of the 40 million global deaths caused by NCDs in 2016 [10], an estimated 32 million NCD-related deaths were attributable to diabetes, cardiovascular diseases, chronic respiratory diseases and cancers. Concurrently, a rising prevalence of multiple chronic conditions (MCC), shown to impose significant burdens on healthcare costs and utilisation [11], has been observed by epidemiological studies across the world. Population ageing, improved diagnosis and detection of diseases, and lifestyle changes (including sedentary lifestyle and high-calorie diets) are among the key contributors to this rising prevalence [12].

In Hong Kong, the increasing prevalence of NCDs poses significant challenges to our already overburdened health system. Specifically, according to updated statistics issued by the Department of Health, diseases associated with diabetes, lipid disorders and heart diseases were among the top 10 leading causes of death in 2017 [13]. Notably, hypertension, diabetes, obesity and lipid disorders are among the most commonly diagnosed chronic diseases in Hong Kong. The co-occurrence of these diseases is widely observed. According to the 2014/15 Population Health Survey conducted by the Department of Health (DH), the prevalence of hypertension increased across age groups, where 15.2% of citizens aged 35-44 were found to be hypertensive compared to a notably high prevalence of 26.7% among those aged 45-54. Importantly, as many as two thirds of all hypertensive individuals detected in the survey had not previously been diagnosed as hypertensive [14]. Similar patterns have been observed for diabetes and lipid disorders. Diabetes continues to be a major cause of morbidity and mortality in Hong Kong,

accounting for 0.9% of all deaths in 2017 [15]. The estimated prevalence of diabetes stands at approximately 10% of the local adult population [15] and 7.3% among those aged 45-54, of which 36.4% have not previously been diagnosed. A study by Quan et al. (2017) also demonstrated a rising prevalence of diabetes in Hong Kong, accounting for a significant increment in morbidity, premature mortality and healthcare expenditure from 2006 to 2014 [16]. Also increasing is the overall prevalence of pre-diabetes [17], a condition that could progress and lead to a diagnosis of diabetes if not detected and addressed in a timely manner. From the 2014 to 2015 Population Health Survey conducted by the DH, an estimated 49.5% of the Hong Kong population aged 15 to 84 years had hyperlipidaemia, referred to as elevated blood lipid levels and hypercholesterolemia. Yet, 70.2% of cases were undiagnosed before the administration of the health survey [18].

The observations of the prevalence of hypertension, diabetes and lipid disorders in younger age groups and the high proportion of undiagnosed individuals necessitate preventive care and early detection for a desirable prognosis. Studies have shown that chronic diseases usually develop as early as at 45 years, and the risk for these people diagnosed with at least one chronic disease at this age is 6 times higher than that for younger people [19]. For example, a recent simulation study in Thailand suggested that undiagnosed diabetes was most prevalent among those aged under 39 years, and that the mortality of those with undiagnosed diabetes was ten-fold greater than that of those with diagnosed diabetes [20] - supporting the importance of early detection and intervention. Furthermore, age has an important implication on patterns of health-seeking behaviour. Studies reported a variation in adherence with doctors' recommendations between different age groups, namely 45 to 64 years and 65 to 74 years. Health seeking behaviour would also be attuned to the level of needs and availability of time [21]. An international study looked at the uptake rate of the NHS Health Checks programme in a deprived, culturally diverse setting, and found that the uptake of screening was significantly

lower among younger men and smokers, but higher among individuals from South Asian or mixed ethnic backgrounds, those with diagnosed hypertension; and individuals registered with smaller practices.

Statistics indicate the necessity for screening programmes to be targeted at 'younger' age groups to encourage early detection and intervention, an implication consistent with study findings elsewhere - while also identifying key facilitators or barriers in health seeking behaviour to consider interventions targeting at different age groups [22]. Early detection of chronic conditions through screening is essential for better long-term management, reducing morbidity and disability, lowering avoidable hospital admissions, and alleviating the burden on clinical settings. All these favourable outcomes can eventually lead to more efficient health services and overall cost savings [7].

Screening and its effects on individuals, health system and society

There are generally no signs or symptoms associated with high blood pressure, elevated blood glucose, or lipid disorders in the early stage, yet these disorders are recognised as important risk factors for cardiovascular diseases (CVD), stroke and all-cause mortality [23]. A literature review was conducted on the effectiveness of screening with a focus on CVD-related disorders. A large body of evidence supports screening as a simple and effective measure for earlier diagnosis of hypertension, diabetes and hyperlipidaemia that in turn, promotes timely treatment which save costs for citizens, the healthcare system and the society [24].

The benefit of screening is mostly associated with reduced incidence of cardiovascular events. For example, one recent large-scale Anglo-Danish-Dutch Study of Intensive Treatment in People with Screen-Detected Diabetes in Primary Care (ADDITION) found that the risk of CVD and mortality were lower among individuals with diabetes in the screening group

compared with diabetes patients in the no-screening group in the Danish population. Evidence has also suggested that screening was related to lower CVD risk through early detection of diseases and promotion of healthy lifestyle habits. Further, an economic study on ADDITION found that the cost of screening/person discovered to have developed diabetes was offset within 2 years by savings in the healthcare system [25, 26].

International experience on screening for CVD-related chronic diseases

Screening for CVD-related chronic diseases has been shifted to the forefront of international efforts, resulting in adoption of screening programmes which have been supported by clinical guidelines globally [27 - 30]. In the UK, people aged 40-74 years receive complimentary health checks from the National Health Services (NHS), including assessments of blood pressure, glucose levels, plasma cholesterol, and BMI. Besides health checks, a nationwide NHS Diabetes Prevention Programme (NHS DPP) was also launched in 2016 to screen out people who are at high risk of developing Type 2 diabetes. This programme was a joint commitment from the NHS, Public Health England and Diabetes UK. Although the programme is still ongoing and the final evaluation report has not been released, one of its progress reports published recorded that over 40,000 people with the non-diabetic hyperglycaemia condition were referred to the programme for intervention [31].

In a separate example, an expert panel of stakeholders on diabetes recently proposed a new screening approach in Australia [32]. The Pharmacy Diabetes Screening Trial was established to provide community screening across regional remote areas and metropolitan regions of Australia, with thorough research to support the feasibility and value of pharmacy as a component of population screening efforts. Pharmacists would assess a patient's risk of developing diabetes and refer the patient to their general practitioners for follow-up. The trial

had successfully screened out more than 14,000 patients and detected over 100 undiagnosed type 2 diabetes patients according to its preliminary results. In the Asia Pacific region, the Ministry of Health in Singapore launched a national screening programme, namely "Screen for Life (SFL)" in 2017. This SFL programme subsidizes citizens from age 25 and above to screen for hypertension, hyperlipidaemia, diabetes, cervical cancer and colorectal cancer [33].

Preventive care and screening programmes in Hong Kong

The existing population based screening for adults in Hong Kong are primarily cancer-focused. The recent Colorectal Cancer Screening Pilot Programme was initiated by the government in 2016 to enrol individuals for subsidised screening tests for prevention of colorectal cancer. The programme has now been regularised and extended to cover asymptomatic Hong Kong residents aged between 50 and 75 for follow-up consultation and additional subsidy for those whose Faecal Immunochemical Tests (FITs) were positive. The Department of Health reported that a total of 115,000 of 253,000 eligible participants registered under the Electronic Health Record Sharing System (eHRSS) have joined the programme, out of which 12,117 persons (13%) were tested positive for the FIT [34].

The earlier Cervical Screening Programme was launched as a territory wide-programme for women aged 35-64 years by the Department of Health in 2004. Of the 583,155 tests conducted from 2004 to 2017, 6.3% of the tests were found abnormal, and of which 1.1% were diagnosed as having cervical carcinoma, adenocarcinoma and other abnormalities. A low uptake rate of 3.6% in 2004 increased only to 20.5% in 2017. Later in 2017, to improve uptake a complementary screening programme was initiated funded by the Community Care Fund, for a 3-year period. This particular programme aims to target subsidies for low income women for cervical cancer screening [35].

Even for cancer screening programmes heavily subsidised by the government with suboptimal uptake rates. Conversely, there have not been any population with screening programmes for non-communicable diseases such as diabetes. The current diabetes screening programmes are only available privately from certain service providers that include diabetes assessment, screening for complications and disease management support.

It is worth noting that the Government has expended efforts to enhance the provision of primary care and encourage the uptake of preventive care among the elderly. The Elderly Health Care Voucher Scheme (EHCVS) was launched as a pilot on 1 January 2009, and was converted into a recurrent programme in 2014. Currently, eligible residents aged 60 or above have access to an annual voucher amount of HK$2,000 for utilizing primary healthcare services, provided by healthcare practitioners in the private sector. The goal of the scheme was to provide recipients with monetary incentives to utilise primary care services in the private sector.

However, statistics show that less than 20% of EHCVS participants used the vouchers for preventive care. A study conducted by the Chinese University of Hong Kong (2018) found that the scheme failed to reduce the number of public hospital visits. There was still minor growth in the utilisation rates of public clinics, where 78% of the elderly citizens made continued visits compared to just 73% prior to the launch of the scheme, and only 8.6% self-reported using the vouchers for chronic disease management in 2016. [36]. A study assessing the failure of the EHCVS in reducing demand on public healthcare services despite increasing utilization of private services was attributed to the inappropriate design and an apparent absence of a implementation strategy of the scheme [36]. One qualitative study with eight Focus Group Discussions evaluating the vouchers from the perspective of the elderly recipients found that the more expensive private health services, lack of trust in the private sector, low public fees and good service quality of the public sector, inadequate private practitioners were factors contributing to the low utilization of the vouchers for chronic disease prevention and

management services [37]. Evidently, there remains to have much capacity to further encourage the uptake of primary care services and long-term management of chronic diseases via effective community-based outpatient coordination to render improved health outcomes [17].

Building on the current EHCVS

If no further action is taken to preventive care for prevalent chronic diseases including hypertension, hyperlipidaemia and diabetes, the cost of treatment is estimated to double by 2056 [4]. Apart from high costs, complications associated with chronic disease can be prevented or delayed through earlier detection and management by delaying disease progression. In the light of this, building on the lessons learned from the EHCVS that is already in place, there is a substantial impetus for the government to consider implementing a population-based chronic disease screening and management voucher programme. This not only promotes prevention through early detection of targeted chronic illnesses, but also supports follow-up chronic disease management plans that should take place in the community rather than in hospitals.

Rooting from the economic theories of supply and demand, the use of vouchers as demand side mechanism aims to employ subsidised health services for individuals who were in need. Nevertheless, the preventive initiatives are likely to be neglected in the absence of the voucher. This has been shown to be effective in overcoming financial, social and psychological barriers to facilitate the uptake of services prescribed by the scheme [38]. Also, the grounds were to encourage more consumption of services, hence shifting the supply curve to the left and offering maximum positive externalities (wealth/health) to the rest [39]. In other words, covering the majority of the populations and contracting healthcare providers to see the voucher

clients without ‘cherry picking’ will stimulate both supply and demand for services which are the aim of the Voucher programmes. Learning from international experiences, most voucher schemes implemented in low or middle income countries targeting on specific health services (i.e. mental health services, reproductive health services) had proven effective to enhance screening uptake [38, 40 - 43].

Studies on how individuals receive national screening programmes are informative on the design of local screening programmes as well as its promotional strategies. Research on the French national breast, cervical, and colorectal cancer screening programmes reported the trends of screening rates decreased for breast and cervical cancers, but increased for colorectal cancer, which was started in 2009 with two important strategic actions. These included a voucher mailed to eligible individuals on the demand side, and a lump sum payment to GPs on the supply side [43].

Affordability could be an important determinant of screening uptake. Even minimal co-payments could deter potential patients from seeking health service – a co-payment as low as US$8 can deter patients from using screening services in Hong Kong [44]. All together, these academic evidence highlighted the importance to conduct a feasibility study to ensure effective uptake through evidence-based design, properly formulated structure, and appropriate implementation strategies. Voucher programmes focusing on chronic disease screening acquired the potential to reduce gaps in equitable healthcare utilisation. They provide an economic incentive to accredited facilities by reimbursing them for services offered. By doing so, the programme could stimulate market for services, and may consequently motivate improvement in screening practice. Thus, building on the current EHCVS, we envision the proposed population-based chronic disease screening and management voucher programme to be used by the Government as an instrument to not only promote early detection and disease management, but importantly further promote well-coordinated public-private partnerships,

shifting the care burden from the public to private sector and thus easing the burden of our overburdened public healthcare system.

Principles and Practices of Screening for Specific Chronic Conditions in Hong Kong

According to the World Health Organisation (WHO), James Maxwell Glover Wilson and Gunner Jungner published a report in 1968 entitled "Principles and practice of screening for disease" in which they formulated 10 criteria to enable policymakers to screen for diseases [45]. The Wilson and Jungner Criteria has since served as a public health classic and remains a gold standard guide for selection of conditions on the basis of capacity of detecting the condition at an early stage and the availability of an acceptable treatment. In line with these criteria, Hong Kong has yet to develop a population-wide screening programme that targets chronic conditions. In an attempt to explore the feasibility of developing a voucher scheme to target chronic disease screening and its management, the Wilson and Jungner's screening criteria have been used in this proposal to illustrate the current landscape and the potential in developing a screening and treatment voucher programme for chronic diseases.

The current study focuses on three most prevalent chronic diseases in Hong Kong, namely hypertension, hyperlipidaemia and hyperglycaemia as targets for screening in Hong Kong. In 2018, the Primary Care Office of the Department of Health in Hong Kong released several reference frameworks as a tool to facilitate primary health care professionals to deliver continuing, comprehensive and evidence-based care in the community [46 - 49]. Therefore, the proposal follows the guidelines provided by the corresponding reference frameworks for defining these three chronic conditions (diabetes mellitus, hypertension and hyperlipidaemia).

According to the Wilson and Jungner principles, the current landscape for the selected chronic conditions in Hong Kong reflect that there is a great potential for developing a screening

programme. The criteria checks illustrate that there is a need for screening of selected conditions based on prevalence, significance of the health problems, and availability of acceptable tests. Moreover, there is generally minimal harm induced by the screening programme, and even if found they are minor or short-term in nature. Studies have shown that most participants did not perceive screening for hypertension, diabetes or lipid disorders was burdensome, or it might impose a substantial consequence if diagnosed; and thought it was good to get screened.

However, the screening programme must reconsider failed criteria 3 “facilities for diagnosis and treatment should be available” and criteria 9 “the cost of case finding (including diagnosis and treatment of patients diagnosed) should be economically balanced in relation to possible expenditure on medical care as a whole” as an information gap on the capacity and cost-effectiveness in providing treatment to those screened exists.

To assess local capacity, we reviewed health screening service providers that provides screening services for the three major chronic diseases of our interest in Hong Kong. We gauged current practice among public and non-government organizations (NGOs), insurance companies and banks, health clinics and private hospitals, in terms of the type of services and charges they command in the market. Overall, we estimate that there is sufficient capacity in Hong Kong to handle the extra demand if a health-screening voucher is implemented in a targeted manner. NGOs, private and public health service providers alike are likely able to absorb the incremental screening workload. In addition to considering the feasibility of providing a screening programme for selected conditions, the current study will also plug the existing information loopholes as depicted against the Wilson and Jungner’s screening criteria.

(2) Objectives of the study

1. To provide a comprehensive overview of the availability of resources inherent in the health system to enable the screening and chronic disease management programme. We also identified how the existing Elderly Health Care Voucher Scheme can be cost-effective, allowing refinement of future projects to ensure successful implementation of the programme (**study 1**)

2. Highlight the strengths of the health system and identify potential gaps that need to be addressed to ensure successful implementation of the programme (**studies 1 and 2**)

3. Evaluate the comparative cost-effectiveness of the healthcare voucher programme for screening every 3 years vs. no healthcare voucher programme among older residents living in Hong Kong (**study 3**).

(3) Research methodology

STUDY 1. Focus Group and key stakeholder interviews

Part 1. Qualitative interviews for primary care practitioners (PCP)

Subjects

In-depth interviews were conducted in a designated interview room inviting doctors from different sectors to participate in the study. Only those who were eligible to participate in the voucher scheme and offered screening services for diabetes and lipid disorders were invited.

Methods

A purposive sampling methodology was employed to recruit six types of service providers. The service provider groups included: (1). Group-practicing doctors working in the private sector, including doctors running group practice or working in Health Maintenance Organizations (HMOs); (2). PCPs working in Non-Government Organizations (NGOs); (3). PCPs who are in solo practice; (4) PCP in District Health Centres; (5) PCPs in Community Health Centres and (6) Practitioners in Public Care Settings, such as the General Out Patient Clinic (GOPC) under the jurisdiction of the Hospital Authority. As a result, there were a total of 6 distinct groups. This led to more comprehensive representation of a wide spectrum of service providers in Hong Kong. We interviewed each subject, who was informed on the interview process and the study objectives via face-to-face discussion. They were reminded of the interview the day before the study. We conducted at least 2 interviews in each of these six groups, and data saturation was achieved. In order to examine the meaning, process interpretation or theory, we evaluated the opinions across different group characteristics, allowing the researchers to gain a more in-depth understanding or insight into the phenomenon

under investigation. In summary, a minimum of 12 interviews were conducted among the eligible subjects.

Data processing and analysis

In line with the approach of thematic analysis, all the interviews were transcribed verbatim from audio-records by the research team after the completion of each interview session, and the transcription was doubly checked to ensure accuracy. The data were analysed by NVivo 11 software (QSR international, Australia). If there was difficulty in understanding the transcripts, the notes taken at the sessions were consulted. Each comment was given content codes to designate content issues contained in the comment. Each of the transcribed interviews was closely read to identify particular narrative themes. To summarize the essence of the individual narrative, portions of the narrative themes were extracted, and these transcript segments were re-analysed. The data were subsequently analysed in relation to the established topic areas before the interview and any other new categories arising during the interview. For all the interviews, coding from the verbatim transcripts was conducted by two researchers independently from each other. In the presence of any disputes, the two researchers reached agreement by discussion on coding and categorization of the narrative themes. The verbatim transcripts were translated into English, which were considered for incorporation into the survey instrument in subsequent years.

Themes identification:

We 1). captured the capacity of service providers in supplying the services; and 2) identified the role of various stakeholders in the overall screening and management programme. The

collected data were able to provide a comprehensive overview of the availability of resources inherent in the health system to devise the screening and management programme. It also identified the room for improvement of the programme, allowing refinement of future projects to facilitate successful implementation of the programme.

Part 2. Qualitative interviews for general public

Subjects

Subjects who (1). were aged 45 years or above; (2). could communicate in Cantonese; and (3) resided in a Hong Kong household at the time of the study were recruited.

Methods

Face-to-face individual interviews were conducted among purposively sampled residents. At least 2 interviews were conducted per age group (45-64 vs. 65 or above) until data saturation. Before the commencement of each interview, participants were invited to complete a survey on the socio-demographic factors. Subsequently, open-ended questions related to their attitude, perception, and feasibility of the proposed Chronic Disease Management Voucher Scheme (CDMVS) were used in the interview. After all the manual questions were addressed, the participants were asked for any additional comments. If important and new insights were raised during the second interview in both groups, additional interviews were held until data saturation. To enhance the response rate, each participant was offered a non-monetary incentive of $100 after the interview. Ethics application to the respective ethics committees was sought before study commencement.

Data processing and analysis

Please see 'Data processing and analysis' section in Part 1.

Themes identification

We captured: 1). their knowledge and attitude towards the screening and management programme, as well as 2). the level of need and level of demand for the proposed services. The collected data were able to highlight the strengths of the health system and identify the potential gaps in the health system that needed to be addressed to ensure successful implementation of the programme.

Part 3. Key stakeholder interviews

Subjects

Government representatives; academics, policymakers and key stakeholders in health policymaking were recruited to join the interviews.

Methods

Key stakeholder interviews were open-ended and conducted in English and/or Cantonese Chinese over 60-to-120-minute sessions. Discussions revolved mainly around five critical themes surrounding: health system fragmentation, health financing, primary care development, strategic purchasing and the proposed Chronic Disease Screening Voucher & Management Scheme. Stakeholder-specific questions were also asked to gain further perspective into the

considerations of each stakeholder, explore the stakeholders' unique perspectives towards the topic in question and garner views on areas for improvement. Snowball sampling was utilised by having participants enlisting colleagues and newly identified key stakeholders to provide views.

Data processing and analysis

Please see the section 'Data processing and analysis' in Part 1.

Identification of themes

We captured stakeholders' attitude and perception towards the introduction of a screening and management programme from a health system policy perspective. Insights on necessary considerations and the potential impact of the programme evaluated against the long-term development of primary care and PPP were obtained. The collected data were able to highlight barriers and facilitators in the health system that needed to be addressed at a policy level to ensure successful implementation of the programme.

STUDY 2. Telephone surveys for general public

Subjects

All subjects who (1). were aged 45 years or above; (2). could communicate in Cantonese, Putonghua or English; and (3) resided in a Hong Kong household at the time of the study were eligible to participate. These eligibility criteria were adopted as subjects aged 45 or above were invited to participate in the proposed CDMVS organized by the Hong Kong Government.

Survey Instrument

The questionnaire consisted of survey items in Chinese (or Putonghua or English as applicable), which collected data on subjects' attitude, perception and perceived feasibility of the medical voucher scheme. Socio-demographic information; family and personal history of chronic diseases; self-perceived health status; and screening histories of chronic diseases were also included. The survey was designed according to the opinions collected from qualitative interviews.

The different parts of the validated survey include:

1. Socio-demographic information: age, sex, educational level, marital status, employment status, occupation, and household income;

2. Family history of chronic diseases: hypertension, diabetes, high blood cholesterol;

3. Personal medical history of chronic diseases: hypertension, diabetes, high blood cholesterol;

4. Self-perceived health status; and

5. Screening histories: hypertension, obesity, diabetes and dyslipidaemia, as well as factors required for a cost-effective analysis.

Sampling frame and subject recruitment

The sampling frame consisted of all eligible subjects for the scheme. Based on the sample size calculated, we used a computer randomizer to generate random numbers to select individuals for the surveys. The selection of the sample population was conducted using simple random sampling. One telephone number was used as one unit of randomization. We invited the Centre for Behavioural Research of the School of Public Health and Primary Care, CUHK to perform these telephone interviews. Since a minority of family households had more than one fixed telephone line, all participants were asked if they have already been recruited in the survey to avoid double counting. Cell phone numbers were included in the telephone directories and they were not used for direct survey. Those with mobile phone numbers were contacted to ask if another telephone number was more convenient for the purpose of telephone survey. If the target subject was not available, at least five call attempts in two different daytimes and three different evenings were given. If the target subject was available but busy to receive the telephone interview, a mutually convenient time was scheduled to administer the survey. According to standard methodology, only one subject was recruited from each household to avoid clustering effect within household. Non-response was defined as non-completion of the survey after five telephone attempts. Non-respondents were replaced by the next subsequent household telephone number. The interviewed subjects were briefed about the purpose of the study, assured of the confidentiality of the telephone interview, and requested to provide informed consent. Enquiry telephone numbers of the survey were provided to the respondents for any inquiries arising from study participation.

Training of telephone interviewers

A team of experienced interviewers on the administration of telephone interviews performed the interviews using a fieldwork manual highlighting standard operation procedure, which guided the interviewers to conduct qualified interviews. The training sessions included: (1). Overview of the survey; (2). Procedures in conducting telephone questionnaire; (3). Guidelines for completing the survey; (4). Quality control measures; (5). Strategies to enhance response rate; and (6). Standardized questions and answers to enquiries. An experienced project coordinator supervised the team of telephone interviewers throughout the study, and was responsible for administering quality assurance of the telephone interviews by implementing relevant quality checks.

Quality Assurance (QA) program for the telephone survey

The interviewed subjects in the database randomly received our QA phone calls to ask about our interviewers' telephone manner, to confirm the answers from the survey with the database within 2 weeks of their first interview to avoid recall bias. At least 10% of all the successfully interviewed subjects were randomly selected from the database for this QA programme.

Data processing and analysis

All the data were entered into a software spreadsheet and analysed by the Statistical Package for Social Sciences (SPSS) version 21.0. Frequencies, means and the Cronbach alpha values of the scales which indicated their internal reliability were presented. A descriptive analysis of the levels of attitude, perception, and feasibility of the voucher scheme was performed. The association between each predictor variable was examined with the outcome variables by

univariate analysis. Binary logistic regression models were constructed to examine the independent association between the predictors having $p \leq 0.10$ in the univariate analysis and each outcome variable, separately. All p values ≤ 0.05 in the final regression model were regarded as statistically significant.

Sample size calculation

We assumed 50% as the proportion in all the outcomes which would provide the maximum sample size. A sample size of approximately 1,200 participants would achieve a precision level of 0.03, from the formula: "precision=1.96 x √[(p) x (1-p)/N]". Based on the Hong Kong telephone survey performed in 2006 [20], a total of 8,078 telephone numbers were generated from the directory, 1,119 were disconnected numbers and non-household numbers like fax lines and business numbers, 1,943 were non-contacts after at least 5 calls made at different hours and days of the week, and 1,761 participants refused to join without acknowledgment of the purpose of the study. A total of 3,540 households were contacted and 1,729 had an eligible prospective respondent in the household. Finally, 1,004 eligible respondents completed the survey. Therefore, we aimed to generate more than 9,655 randomized telephone numbers from the most updated telephone directory.

STUDY 3. Cost-effective analysis - screening vs. non-screening ICER score differences

The aim of study 3 is to estimate the cost-effectiveness of a healthcare voucher program (Chronic Disease Management Voucher Scheme, CDMVS) for diabetes, hypertension, and lipid disorder screening among Hong Kong residents aged 45-64.

The target population in this study were community-dwelling individuals aged 45-64 years in Hong Kong. According to census statistics, the total population in Hong Kong was about 7,481,800 in 2020, and 30.8% (2,308,800) of them were 45-64 years old [50]. Among these 2.3 million middle-aged people, 10% have diabetes mellitus (DM), with 4.1% being diagnosed cases and 5.9% undiagnosed cases [51]. Therefore, a hypothetical closed-cohort of 2,200,000 individuals aged 45-65 without a historical diagnosis of diabetes in Hong Kong constructed our study sample after excluding individuals who were diagnosed with diabetes before.

Study population

We used a validated state-transition Markov Monte Carlo simulation model, named CDC-RTI Diabetes Cost-Effectiveness Model, to simulate the natural history of diabetes, hypertension, and lipid disorder [ref 3,4]. We modified this model to fit the context of Hong Kong. We used individuals' lifetime health care costs (up to age 100), disease-related complications, and quality-adjusted life-years (QALYs) as the outcome measures in our evaluation. The underlying age-dependent risk of diabetes are provided in **Tables A2 and A7**. This model has two modules: the screening module and the disease progression module (**Figure 1**).

The overall construction of the Markov Monte Carlo simulation model

We used a validated state-transition Markov Monte Carlo simulation model, named CDC-RTI Diabetes Cost-Effectiveness Model, to simulate the natural history of diabetes, hypertension, and lipid disorder [52, 53]. We modified this model to fit the context of Hong Kong. We used individuals' lifetime healthcare costs (up to age 100), disease-related complications, and

quality-adjusted life-years (QALYs) as the outcome measures in our evaluation. This model has two modules: the screening module and the disease progression module (**Figure 1**).

In the disease progression module, an individual can progress from normal to pre-diabetes (which can return to normal inversely) and progress from pre-diabetes to the onset of diabetes (assuming reversibility is not possible). Comorbidities of hypertension (HT) and hyperlipidemia (HL), and their effects on costs and health outcomes, are also included in the model.

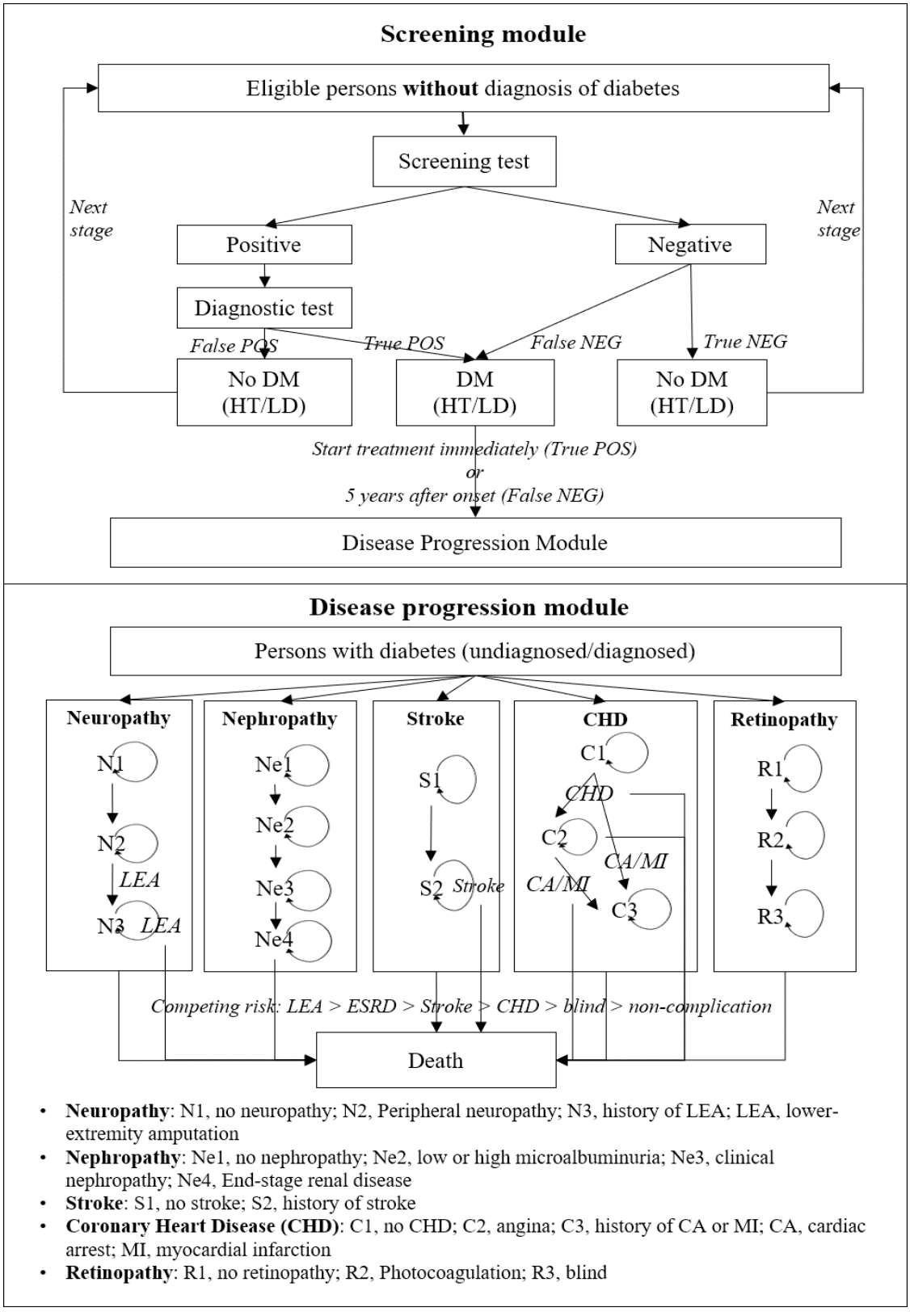

Figure 1. Disease progression and Markov model

During the disease progression of diabetes, individuals may suffer from five different types of complications: neuropathy, nephropathy, stroke, coronary heart disease (CHD), and

retinopathy. Several categories of adverse events may occur more than one time in the whole life of individuals, such as lower extremity amputation (LEA), stroke, myocardial infarction (MI), and cardiac arrest (CA). In this model, all individuals would end up alive; death related to diabetes; having disease-related complications; or death due to other reasons.

A screening module is incorporated in the disease model to reflect the impacts of screening. Considering that the disease progression of diabetes is relatively slow and insidious in the early stage, we assume a time lag of five years between the onset of diabetes and the clinical diagnosis in routine practice. Therefore, the introduction of screening allows five years earlier detection and timely treatment of diabetes, hypertension, or hyperlipidaemia. After screening, individuals could receive a positive or negative result, and those screened positive would undergo diagnostic tests to confirm the prevalence of the disease. Individuals confirmed with diabetes in the screening program were assumed to be immediately referred for further assessment and treatments. Otherwise, if individuals with onset of diabetes receive a false negative result, they would continue the routine pathway and could not obtain a formal diagnosis and treatment until the fifth year after the disease onset.

Markov model: screening module

For screening, we considered the following scenarios. In the first scenario (base case), we assumed the government introduced a one-time opportunistic screening program for DM, HT, and HL. This program screened all eligible participants in the starting year of the program and then followed up until they died or exited the model (at 100 years old). The second scenario is a two-time opportunistic screening program. All eligible participants without a clinical diagnosis of DM/HT/HL in the first wave of screening will be screened in the fourth year (or three years since the first screening). Again, individuals in this scenario were also followed until death or their exit from the model. The last scenario is a triennial screening program,

which offers regular screening every three years until 65 year-olds. In all scenarios, we are assuming a close cohort. For an open cohort (getting new entries by immigration or age becoming eligible), the results are assumed to be comparable to the first scenario (one-off) screening program. The comparison group was "no screening program" (Scenario 0), representative of the routine practice in Hong Kong. The details of the screening program are as following:

1. Frequency: no screening (Scenario 0); one-time off (Scenario 1); two times at the first and fourth year after the initiation of program (Scenario 2); or every three years (Scenario 3)
2. Screening tests: a package of (a) glycated haemoglobin (HbA1c), Fasting Plasma Glucose (FPG), and Oral Glucose Tolerance Test (OGTT) (if required) for confirming diabetes; (b) blood pressure measurement for hypertension; and (c) blood test on cholesterol and triglycerides for lipid disorders.
3. Diagnostic accuracy: diagnostic tests would be offered to those screened positive by screening tests; thus, we assumed a 90-100% sensitivity and 100% specificity for all the three diseases (DM, HT, and HL).
4. Diagnostic criteria for diabetes, hypertension, and hyperlipidaemia (**Table 1**). Administration: we assumed that screening would be provided in a regular physician visit, and the cost of administration was set as an additional 30% of the price of the screening tools.

Table 1. Diagnostic criteria for diabetes, hypertension and hyperlipidaemia

Disease	Criteria
Diabetes	• FPG≥7.0 mmol/L
	• HbA1c≥6.5%
	• FPG=6.1–6.9 mmol/L & post OGTT≥11.1 mmol/L
Pre-diabetes	• FPG=6.1-6.9 mmol/L & post OGTT<7.8 mmol/L
	• FPG<7 mmol/L & post OGTT=7.8-11.0 mmol/L
No diabetes	• FPG<6.1 mmol/L & post OGTT<7.8 mmol/L
Hypertension among those with established diabetes	• Systolic blood pressure (sBP) ≥ 130 mmHg
	• Diastolic blood pressure (dBP) ≥ 80 mmHg
Hyperlipidaemia	• Total cholesterol in S.I. unit ≥ 5.2 mmol/L

Markov model: treatment module

For treatment, we hypothesized that screening could bring early treatments and therefore could slow down the disease progression of diabetes through reductions in the transition probability from milder to severer stages and declines in the risk of complications. In this model, treatments for diabetes, hypertension, and hyperlipidaemia were separate. However, we only included treatments of hypertension and hyperlipidaemia among patients with diabetes in our analysis. The differences in treatments between the screening program and no screening program only laid in the duration since the onset of disease. We assumed that diabetes would be treated immediately after being screened positive in the screening program. Otherwise, diabetes would be diagnosed and treated five years after the onset in routine practice if there was no screening or false-negative results. Treatments aiming at DM, HT and HL in our model are described as below:

1. Diabetes treatment: Risk Assessment and Management Program – Diabetes Mellitus (RAMP-DM), as an intensive glycaemic control treatment in public sectors in Hong

Kong, is provided for individuals with diabetes, either immediately (after being screened positive) or in the fifth year after the onset of DM (with no screening or false-negative results). Previous studies have shown that RAMP-DM is a cost-effective program for DM management [55, 56].

2. Treatment for hypertension (among DM patients): Risk Assessment and Management Program – Hypertension (RAMP-HT) [57] as usual care in public sectors in Hong Kong, plus intensive hypertension control (two doses of atenolol per day and additional 1-3 community care visits per year), is provided for individuals with hypertension, immediately after being screened positive [51] or in the fifth year after the onset of DM (with no screening or false-negative results).
3. Treatment for hyperlipidemia (among DM patients): daily drug use (Pravastatin: 40mg per day or Gemibrozil: 900mg per day) and additional 1-3 community care visits per year. Treatments are provided immediately after being screened positive [52] or in the fifth year after the onset of DM (with no screening or false-negative results).

Key parameters

We set a lifetime time horizon for analysis, and individuals would exit the model either reaching 100 years old or going through 50 life years after entering the model. We used a public health care payer (also referring to public sectors or public health care system) perspective. The annual discount rate was set as 3% for costs and health-related quality of life.

Demographic characteristics of the included population (age, gender, and diabetes by hypertension and cholesterol level) were projected from the 2020 Hong Kong Census Statistics and the 2014/2015 Population Health Survey in Hong Kong.

The disease progression of each of the five selected complication paths depends on the duration of disease, time after clinical diagnosis, disease treatment, and clinical measurements (**Table 2**) [54]. The model estimates of the costs and effects of interventions for DM and HT were based on the RAMP-DM [55, 56] and RAMP-HT [57] study in Hong Kong. Based on the CDC-RTI model, the reduction in HbA1c from RAMP (as intensive glycaemic control) compared to standard care was also modelled in slowing down the progression of macrovascular complications (CHD and stroke). Key parameters used in the Markov model, involving the distribution of cohort, diagnostic accuracy of screening tools, transition probabilities between disease stages, costs, and health utility data, are presented in **Table 3** and **A1-A10** in Appendix.

Table 2. Factors associated with transitional probability

	Glycaemic levels	Neuropathy	Nephropathy	Stroke	Coronary Heart Disease	Retinopathy
Lag between onset and diagnosis	yes			yes		
Time since diagnosis		yes	yes	yes	yes	yes
Glycaemic levels		yes	yes	yes	yes	yes
Hypertension		yes	yes	yes (sBP)	yes (sBP)	yes
Cholesterol level				yes (cholesterol level)	yes (cholesterol level)	
Age				yes	yes	
Sex				yes	yes	

In addition, to better reflect the effects of early treatments on the risk of complications among patients with diabetes, the UKPDS Risk Engine combined with Framingham equations was used to calculate the probability of myocardial infarction and stroke, taking different varying factors into consideration [54].

Myocardial Infarction: From UKPDS, the probability of a first myocardial infarction at period *t* is given by:

$$MI(t) = 1 - \exp(-qd^{t-1})$$

where

$$Q = q_0 \beta_1^{AGE-55} \beta_2^{SEX} \beta_3^{AC} \beta_4^{SMOK} \beta_5^{h-6.72} \beta_6^{(SBP-135.7)/10} \beta_7^{ln(LR)-1.59}$$

and

q_0 = Intercept = 0.0112
β_1 = Risk ratio for one year of age at diagnosis of diabetes = 1.059
β_2 = Risk ratio for female sex = 0.525
β_3 = Risk ratio for Afro-Caribbean ethnicity = 0.390
β_4 = Risk ratio for smoking = 1.350
β_5 = Risk ratio for 1% increase in HbA1c = 1.183
β_6 = Risk ratio for 10 mmHg increase in systolic BP = 1.088
β_7 = Risk ratio for unit increase in logarithm of lipid ratio = 3.845
d = Risk ratio for each year increase in duration of diagnosed diabetes = 1.078

and

AGE = Age (yrs) at diagnosis of diabetes
SEX = Individual's sex
1 = female, 0 = male
AC = Indicator of Afro-Caribbean race
1 = Afro-Caribbean,

0 = Caucasian or Asian-Indian
(By default, set to represent African-American)
SMOK = Indicator of smoking status
1 = current smoker at diagnosis of diabetes,
0 = non-smoker at diagnosis of diabetes
H = HbA1c (%), mean of values at years 1 and 2
SBP = Systolic BP, mean of values at years 1 and 2
LR = Total cholesterol/HDL cholesterol ratio, mean of values at years 1 and 2
T = Years since diagnosis

Stroke: UKPDS Risk Engine uses the following method to calculate the probability of a first stroke (P(s)) during period *t*. This calculation involves the same equation used to calculate the risk of CHD, except that the value of *q* is calculated using a slightly different formula and different coefficients.

$$\text{Stroke}(t) = 1 - \exp(-qd^{t-1})$$

where

$$q = q_0 \beta_1^{AGE-55} \beta_2^{SEX} \beta_4^{SMOK} \beta_5^{h-6.72} \beta_6^{(SBP-135.5)/10} \beta_7^{LR-5.11} \beta_8^{AF}$$

and

q_0 = Intercept = 0.00186

β_1 = Risk ratio for one year of age at diagnosis of diabetes = 1.092

β_2 = Risk ratio for female sex = 0.700

β_4 = Risk ratio for smoking = 1.547

β_6 = Risk ratio for 10 mmHg increase in systolic BP = 1.122

β_7 = Risk ratio for unit increase in lipid ratio = 1.138

β_8 = Risk ratio for atrial fibrillation = 8.554

d = Risk ratio for each year increase in duration of diagnosed diabetes = 1.145

$$h^*_{i,j}(t) = h_{i,j}(t) \times [g(t)/G(t)]^{\beta i,j}$$

where

$h^*_{i,j}(t)$ = the adjusted hazard rate for going from state i to state j at time t,

$h_{i,j}(t)$ = the baseline hazard rate for going from state i to state j at time t,

$g(t)$ = the glycemic level under intensive glycemic control,

$G(t)$ = the glycemic level under conventional glycemic control, and

$\beta i,j$ = a positive exponent associated with the transition from i to j.

$$g(t) = \min(mx, ini + rcbf*on - imp + rcaf*t)$$
$$G(t) = \min(mx, ini + rcbf*on - imp + rcaf*t)$$

where

mx	=	maximum level
ini	=	initial HbA_{1c} at onset
rcbf	=	rate of change for HbA_{1c} before treatment
on	=	time between onset of disease and diagnosis (assumed to be the same for each cohort)
imp	=	treatment impact
rcaf	=	rate of change after treatment
t	=	time since diagnosis

Effect of RAMP interventions on HbA1c

Finally, the comparative effect of intensive glycaemic control (RAMP) vs. usual care was also incorporated into the model, by adjusting the baseline hazard rate, using the ratio between HbA1c under intensive control and HbA1c under conventional treatment raised to an exponent that varies across progression steps. The adjusted hazard rates are given by:

$$h^*_{i,j}(t) = h_{i,j}(t) \times [g(t)/G(t)]^{\beta i,j}$$

where

$h^*_{i,j}(t)$	=	the adjusted hazard rate for going from state i to state j at time t,
$h_{i,j}(t)$	=	the baseline hazard rate for going from state i to state j at time t,
g(t)	=	the glycemic level under intensive glycemic control,
G(t)	=	the glycemic level under conventional glycemic control, and
$\beta i,j$	=	a positive exponent associated with the transition from i to j.

g(t) = min(mx, ini + rcbf*on – imp + rcaf*t)
G(t) = min(mx, ini + rcbf*on – imp + rcaf*t)

where

mx = maximum level

ini = initial HbA_{1c} at onset

rcbf = rate of change for HbA_{1c} before treatment

on = time between onset of disease and diagnosis (assumed to be the same for each cohort)

imp = treatment impact

rcaf = rate of change after treatment

t = time since diagnosis

In this case, the initial HbA1c at onset was set at 6.8% for both RAMP and usual care. The annual rate of change for HbA1c before and after treatment for both interventions was set at 0.2%. Time between onset and diagnosis in routine care was set at 5 years. The treatment impact of RAMP was set at -2.13%, while that of usual care was set at -2.0%. Finally, the max level with treatment was set at 9.0% for RAMP and 11.0% for usual care, and was set at 12.0% in the absence of any treatment.

Table 3. Key parameters used in the Markov model

Parameter	Distribution	Value (95%CI)	Range	Source
Cohort characteristics				
Population distribution	Table by age, gender	Table A1 (Appendix)	-	Hong Kong C&SD[1]
Prevalence of undiagnosed DM	Table by age, gender	Table A2 (Appendix)	-	CHP[9]; QUAN et al. (2017)[10]
Prevalence of HT	Table by age, gender, diabetes	Table A3 (Appendix)	-	PHS[2]; CHEUNG et al. (2008)[11]
Blood pressure level at start	Table by age, hypertension	Table A4 (Appendix)	-	PHS[2]; SHAO et al. (2019)[5]
Prevalence of HL	Table by age, gender	Table A5 (Appendix)	-	PHS[2]
Total cholesterol at start	Table by age, hyperlipidaemia	Table A6 (Appendix)	-	SHAO et al. (2019)[5]
Transition probability				
Incidence of DM and pre-DM	Table by age, gender	Table A7 (Appendix)	-	QUAN et al. (2017)[10]
Mortality rate of general population	Table by age, gender	Table A8 (Appendix)	-	Hong Kong C&SD[12]
Nephropathy				

p from normal to microalbuminuria	Table by age, gender, HT, duration since onset	Table A9(a) (Appendix)	-	Calculation from HA data
p from microalbuminuria to clinical nephropathy		Table A9(b) (Appendix)	-	SHAO et al. (2019)[5]
p from nephropathy to end-stage disease		Table A9(c) (Appendix)	-	Same as above
Neuropathy				
p from normal to peripheral neuropathy	Table by age, gender, HT, duration since onset	Table A9(d) (Appendix)	-	Calculation from HA data
p from peripheral neuropathy to LEA		Table A9(e) (Appendix)	-	SHAO et al. (2019)[5]
p of additional amputations		Table A9(f) (Appendix)	-	Same as above
p of death from LEA		Table A9(g) (Appendix)	-	Same as above
Retinopathy				
p from normal to photocoagulation	Table by age, gender, HT,	Table A9(h) (Appendix)	-	Same as above
p from photocoagulation to blindness	duration since onset	Table A9(i) (Appendix)	-	Same as above
Coronary Heart Disease			-	
p from normal to CHD	Table by age, gender, HT,	Table A9(j) (Appendix)	-	Same as above
% of angina among CHD	duration since onset	Table A9(k) (Appendix)	-	Same as above
p from angina to death		Table A9(l) (Appendix)	-	Same as above
p from first MI to death		Table A9(m) (Appendix)	-	Same as above
p from recurred MI to death		Table A9(n) (Appendix)	-	Same as above
p from CA/MI history to death		Table A9(o) (Appendix)	-	Same as above
p from recurred CA event	UKPDS Risk Engine	-	-	Same as above
p from recurred MI event	UKPDS Risk Engine	-	-	Same as above
Stroke				

p from normal to stroke	UKPDS Risk Engine	-	-	SHAO et al. (2019)[5]
p from stroke to death	Table by age, gender, HT, duration since onset	Table A9(s) (Appendix)	-	Same as above
p from history stroke to death		Table A9(t) (Appendix)	-	Same as above
Effects of intervention on clinical measurements or risk of complications				
DM intervention (RAMP) on HbA1c%	Constant	level: -2.13	-2.9 to -2.13	JIAO et al. (2015)[7]; SHAO et al. (2019)[5]
DM intervention (RAMP) on risk of CHD	Normal for Log-RR	RR: 0.57 (0.47, 0.69)	0.57 to 0.84	Same as above
DM intervention (RAMP) on risk of normal to photocoagulation	Normal for Log-RR	RR: 0.48 (0.38, 0.60)	0.48 to 0.72	Same as above
DM intervention (RAMP) on risk of stroke	Normal for Log-RR	RR: 0.65 (0.55, 0.78)	-	Same as above
DM intervention (RAMP) on risk of end-stage renal disease	Normal for Log-RR	RR: 0.59 (0.49, 0.71)	-	Same as above
DM intervention on risk of normal to peripheral neuropathy	Constant	RR: 0.82	-	Same as above
DM intervention on risk of normal to low or high microalbuminuria	Constant	RR: 0.73	-	Same as above
HL intervention (Pravastatin) on risk of normal to CHD	Constant	RR: 0.69	-	Same as above
HL intervention (Pravastatin) on risk of CA/MI event after CHD	Constant	RR: 0.75	-	Same as above
HT intervention (RAMP) on risk of CHD	Normal for Log-RR	RR: 0.93 (0.86, 1.01)	0.60 to 1	YU et al. (2017)[8]; SHAO et al. (2019)[5]

HT intervention (RAMP) on risk of normal to photocoagulation	Normal for Log-RR	RR: 0.93 (0.86, 1.01)	0.60 to 1	Same as above
HT intervention (RAMP) on risk of stroke	Normal for Log-RR	RR: 0.93 (0.86, 1.01)	0.60 to 1	Same as above
Costs data (HK$)				
Intensive HT treatment only	Constant	2,795	1,905 to 3,000	Assumed & Private market
Conventional LP treatment only	Constant	4,985	2,306 to 5,500	Same as above
Intensive DM treatment only	Gamma	Table A10 (Appendix)	8,000 to 15,000	JIAO et al. (2019)[6]
RAMP program	Constant	First/Following year: 507/231	200 to 507	Same as above
Screening	Constant	751	500 to 1,500	Same as above
Treating complications	Gamma	Table A10 (Appendix)	-	
Death	Constant	104,797	0 to 187,880	Assumed
Health utility				
Utility of DM subjects without complications	Beta	0.883 (0.778,0.989)	-	JIAO et al. (2019)[5]
Utility loss of female	Gamma	-0.024 (-0.041, -0.007)	-	Same as above
Utility loss of MI	Gamma	-0.017 (-0.042, 0.008)	-	Same as above
Utility loss of other IHD	Gamma	-0.017 (-0.042, 0.008)	-	Same as above
Utility loss of heart failure	Gamma	-0.017 (-0.042, 0.008)	-	Same as above
Utility loss of stroke	Gamma	-0.042 (-0.072, -0.012)	-	Same as above
Utility loss of ESRD	Gamma	-0.055 (-0.093, -0.017)	-	Same as above
Utility loss of STDR	Gamma	-0.043 (-0.075, -0.010)	-	Same as above

Note: CA, cardiac arrest; CHD, Coronary Heart Disease; CHP, Centre for Health Protection; C&SD, Census & Statistics Department; DM, diabetes mellitus; ESRD, end-stage related disease; PHS, Population Health Survey 2014/2015; HA, Hospital Authority; HL, hyperlipidaemia; HT,

hypertension; LEA, lower-extremity amputation; LP, lipid; MI, myocardial infarction; STDR, sight threatening diabetic retinopathy

Analytical plan

Sum of cost, diabetes-related complications aforementioned (microvascular events: retinopathy, nephropathy, neuropathy; and macrovascular events: CHD, cerebrovascular disease), total life years, and QALYs were calculated for all participants as well as persons with diabetes. Average cost per DM patient detected, cost per life-year, and cost per QALY, were calculated based on each screening strategy. The incremental cost and incremental effectiveness were then calculated in the comparisons between different screening strategies. Finally, incremental cost-effectiveness ratios (ICERs) of different health outcomes (life year, QALY, inverted complication, inverted death) were calibrated to compare the relative costs and effects across various strategies.

One-way sensitivity involving different key parameters was conducted to examine the variability of the results (ICERs per QALY gained) (see **Table 2**). Probability sensitivity analyses (PSA) based on the distributions of transition probability, cost data and health utility were also conducted. Cost-effectiveness results based on 1,000 iterations of a sampling cohort of 500,000 people were summarized using the cost-effectiveness acceptability curve (CEAC), and ICER thresholds between HK$0 to HK$1,000,000 were used. As a reference, the common willingness-to-pay threshold for QALY is £50,000 (around HK$540,000). All analyses in this study were conducted using Treeage 2021 software.

(4) Research results/findings

Part 1. Qualitative interviews for primary care practitioners

A total of 14 physicians and one administrator were interviewed from October 28th 2019 to April 14th 2021 (Table 4), representing NGO, solo practitioners, DHC, public GOPC, CHC and private medical institutions/groups. All participants welcomed the idea of using a voucher to enable early screening of chronic disease for population under 65. They each offered valuable insights on factors that might hinder as well as facilitate such a program, driven by the unique background of each interviewee. Collectively, insights and opinions are grouped under 5 main themes as below.

Interviewee number	Sector	Practice	Interview Date
1	Private	NGO	28-Oct-19
2	Private	Solo	29-Oct-19
3	Private	Group	31-Oct-19
4	Public	Public GOPC	29-Apr-20
5	Private	Group	8-May-20
6	Private	Group	13-May-20
7	Private	Solo	22-May-20
8	Private	DHC	25-May-20
9	Private	DHC	29-May-20
10	Public	Public GOPC	28 -July-20
11	Public	Public GOPC	7-Aug-20
12	Public	Public GOPC	11-Aug-20
13	Private	NGO	4 Feb 2021

14	Public	CHC	8 Feb 2021
15	Public	CHC	14 Apr 2021

Table 4: Distribution of sector and practice of Interviewees

Theme 1: Views on the screening voucher and chronic disease management program and its perceived impact

Encourage the concept of preventive care and empower patient on self-management

All agreed that the program could be an opportunistic approach to promote the message and deliver preventive care. They foresaw that more patients would take up health screening with the introduction of a free screening voucher. One of them pointed to the fact that approximately 50% of Hypertension-Diabetes-Hyperlipidemia (H-D-H) patients might be under-diagnosed and were unaware of their condition. Although early screening might induce anxiety for patients, and financial stress related to payment for ongoing treatment, early detection of those who had risky metabolic signs but not yet in full-blown disease state could help raise their awareness and to engage them in lifestyle modifications or minimum pharmacology interventions. Behavioral changes such as smoking cessation, weight loss, balanced diet, moderate drinking, and increase in physical exercise are well known to be beneficial for patients at risk of H-D-H to slow down disease progression. However, patients' willingness to comply with prescription drugs or to participate in lifestyle changes vary from person to person, and depend greatly on socioeconomic and psychological factors. Based on their interactions with patients, physicians observed that patients with family risk of H-D-H sometimes refuse treatments or could not sustain lifestyle changes. Patients' contextual and living environment played a large role in their attitude and decision toward self-management of chronic disease. For instance, it is difficult for patients who have jobs with many social engagements to adopt

a simple diet or to engage in an exercise routine. Respondents suggested that the government should deploy more resources for public health education via social media and engage providers at community setting, e.g. private sector, NGO, District Health Centre (DHC), and Community Health Centre (CHC) as much as possible.

> "health -seeking behavior- 睇病就並非單純醫生決定，佢會好多自己的諗法，佢有佢的 psychology，social consideration，financial，佢身邊會有好多人有唔同的諗法會影響佢，有些就會影響別人，所以有人可能覺得這會引伸一些 anxiety problem，譬如自殺，或飲食不協調，跟住佢會用好多錢去驗, 搞到佢屋企 financial ，即係個 psychosocial 會亂咗。" (Interviewee 3)

> "其實社區入面都有好多我們叫做 hidden 隱形慢性病, 譬如糖尿血壓都好常見, 一般估計應該有 50% 慢性病病人都係隱形 (自己有但係唔知), 適當的 時候做 screening, 早些治療, 可以避免這些病越嚟越嚴重, 亦都可以減少併發症過早出現, 對醫療系統同埋病人其實都係好" (Interviewee 2)

> "都應該可以。因為個 program 都係 preventive，你又畀個 voucher 佢，佢又免費，鼓勵佢做，我相信啲人係會 take up" (Interviewee 1)

Enhance service capacity e.g. tapping into private sector to maximize resources

Most of the interviewees were skeptical on the potential of early screening in redirecting the flow of patients to private primary care because the choice of care is highly price sensitive. Only one thought a patient would consult the same private doctor for other acute problems once a long-term relationship is linked up. Currently, the percentage of walk-in patients who seek chronic diseases treatment varied from 10 – 50% for our respondents who are working in the private sector. Those with private health insurance with coverage for primary care, could afford to visit physicians in their insurance network for on-going disease management since they only had to bear the cost of the co-payment. However, those who lacked coverage for primary care,

including those newly diagnosed, might flock to public facilities such as GOPC given the comparatively high on-going cost of consultations and related prescription expenses in the private sector. Moreover, public GOPC is constantly improving their chronic disease management programs, e.g. risk assessment, triage of patients' risk through RAMP (Risk Assessment Management Program) and complication screening program which explains why patients still prefer public healthcare over private services despite long waits. This potential increased demand from increased screening uptake rate could worsen the pre-existing vulnerabilities of the public healthcare system, including manpower shortage and long waiting time.

> "對於 GOPC attendance, 未必構成很大幫助。因為 GOPC 始終有一個 service commitment, 即係我們要提供幾多服務畀市民。當然公營 primary care 服務始終都係求過於供。所以就算有部分病人去私家，仍然會有好多病人去睇 GOPC，所以對於 GOPC 的工作, 門診數量, 就未必有幫助減少。" (Interviewee 4)

> "佢睇開三高時有 episodic 嘅嘢, 佢會返來搵我醫, 所以佢去 GOPC (public)都會少咗。.... 如果佢有 elderly health voucher 佢咪可以照用 elderly health voucher。" (Interviewee 6)

> "你搵多咗 100 個糖尿, 血壓病人, 這些病人選擇去公家就 一定會對已經 overload 的 GOPC \ SOPC 系統 的負擔更加大, 這是必然會發生" (Interviewee 2)

Long term savings on healthcare cost e.g. reduce avoidable hospital admission

While the screening program might increase the chance of identifying more cases, it would also drive up the overall service demand. Nevertheless, all of them agreed that the benefits of early screening should outweigh the costs of ongoing expenses to care for these patients as it allowed early detection of diseases, enabling them to intervene and manage their conditions

much earlier before the onset of other complication and comorbidities (e.g. cardiovascular diseases, stroke, renal failure etc). This could potentially bring along long term savings on healthcare cost with reduced demand of A&E and hospitalization services.

In addition, one of our respondents commented if the screening voucher could change health seeking behavior, it could lower the overall healthcare cost because the cost of a GOPC attendance ranges from HK$ 600 – 800. This cost is much higher than that in the private sector, which ranges from $300-400. Hence, the number of patients who were shifted from public to private sectors would be proportionate to the amount saved. Empirical data from longitudinal study will need to be conducted to validate this assumption.

> "這方面我一定相信。 因為我睇返醫管局年報, 佢一個普通科都要 $600 至$800 一個症, 一個專科要成 $1300 一個症, 仲有其他 cost 未計落去。私家睇一定平過這個數 , 我仲要賺到錢。" (Interviewee 6)

Foster family doctor model

Although many observed the development of family doctors, "doctor shopping" is still common in Hong Kong. The perceived benefits of a long-term relationship with a family doctor, and the possibility of government financial subsidies were still the main factors that influenced choice of care. Likewise, without the government commitment to subsidize the screened patients to receive treatments in private sector, it would be difficult to keep patients in the private and to build up a long term relationship between patients and physicians.

The screening program could be a first step to introduce the public to private healthcare, but to implement family doctor model in Hong Kong, the Government would need to put in more

effort in long term planning, e.g. a role delineation of public and private sectors and more public education on the concept of family doctor.

> “我 screen 咗佢就知道佢有無 hypertension 或 hyperlipidemia , 跟住佢如果冇 financial support , 佢就好自然會同我講可唔可以轉介我返去政府 。 ”(Interviewee 6)

> “當然只係一個 voucher 做唔做到, 就仲需要好多其他配套。 不過起碼你都有一個誘因, 令到佢發現自己的問題, 從而就再去配合其他 existing 或將來有的資源去做更多 health education, 或者係 patient empowerment, 或者再好有系統地處理搵到出來的 chronic disease, 咁幾樣配套係有幫助。 不過你要有一個誘因去畀人哋, 除教育之外, 你都要有誘因去畀人早去 screening, 都係其中最重要的一步.” (Interviewee 4)

> “family doctor concept 都推行了好長時間， 問題是 public 接受程度，有些都是喜歡 doctor shopping 四圍去睇。 當然如果有更多 health screening program， family doctor concept 就會慢慢趨向接受。 如果能幫他們做 health screening， 如有血壓，糖尿就幫他們看，再跟進 他們的 chronic disease，patient 就會慢慢接受跟住一個醫生來護理自己。 現在無， 就鍾意四圍去睇。 但如果有了 chronic disease 他們慢慢接受盡量跟某一個 family doctor 來護理自己。” (Interviewee 8)

Theme 2. Design of the Screening Program

Delivery tool

All of them considered voucher as a good vehicle to deliver the Screening Program, not only could it provide financial incentive for the public to choose private healthcare services, it also enabled patient choice. They suggested the new voucher could adopt a similar design as the Elderly Healthcare Voucher, e.g. each patient has individual account and can accumulate unused voucher; and operational approach (eHealth System) in which they are mostly familiar with already.

"我覺得 elderly Health Care voucher 係幾好。基本上你有張身份證，你去過機構讀到個身份證就自然可以去用到個醫療券，其實對長者都方便。" (Interviewee 9)

Target Age Group

Although all physicians interviewed agreed on the potential benefits of utilizing a voucher for H-D-H screening, there was no consensus in terms of the age group that this program should target. Some of them believed that age 45 would be an appropriate range, while three doctors voiced the concern that people are showing symptoms of H-D-H as young as 35, based on observations of patient behaviors in terms of dietary habits, long working hours, and physical inactivity. They proposed to advance the screening onset to age 35 or 40. Empirical evidence, in addition to availability of resources and cost-effectiveness analysis should be taken into consideration when setting the appropriate age range for Screening.

"我覺得可以更早, 其實我們都正在做這件事，幾個月前剛剛 launch 個三高 urban express，我們 target 35 歲。 因為我們都做幾多 adult health check，其實 三十幾歲有糖尿，或者 hypertension 都唔少。..... 我哋睇咁多 case 都睇到係年輕化。Diet 係其中一樣，再者係個 inactivity， 同埋返工時間好長， 所以少活動，20-30 歲都 ok，一開始踏入 40 就真係唔係咁好。" (Interviewee 1)

Frequency

Most agreed that there is no protocol on frequency for non- communicable disease (NCD) screening, but common practice would be to base upon the initial screening. In general, they agreed that the target age group (45-64) could be screened once every two years if the results are normal, whereas those who are identified as high risk e.g. those with family history or borderline cases should be screened every year. Alternatively, one respondent suggested that

blood pressure could be taken every year, but diabetes and hyperlipidemia could be screened every other year.

Screening Scope

Diverse opinions were observed in terms of the types of chronic diseases that should be included in the screening program. Three interviewees observed the obesity situation is prevalent and insisted on the measurement of Body Mass Index (BMI), which are highly related to chronic disease risk factors, should be covered. If resources allowed, some respondents suggested to include uric acid and electrocardiogram (EKG), which would be a more comprehensive diagnosis of a person's health profile. Others including screening for osteoporosis, cancer, liver diseases (fatty liver), anemia and mental health were also suggested. One respondent shared that cervical and colon cancer are suitable for an early screening objective and evidences showed it is effective to manage the development by an early identification. On the contrary, some thought the screening program should focus on H-D-H as it is one of the NCDs with the highest prevalence in Hong Kong, and there is an increasing trend in the younger population because of unhealthy lifestyle. Taking experience from the Vaccination Subsidy Scheme (VSS), the program would be more effective if the program is more target oriented.

"我覺得如果要推行呢一樣嘢就要簡單，同清晰，要好容易令人理解，所以只係要做三高。你太多其他東西會 complicate the picture ，跟住 loose 咗 focus。" (Interviewee 6)

"obesity 都緊要....因為 obesity 本身都係 related to 三高 ，佢都係三高的 risk factor。 如果你分開嗰三高唔理 obesity 都唔會完全睇到個問題" (Interviewee 10)

"cervical cancer 如果做得好個 screening 就真是可以 prevent 很多這類 cases，這類 patients 希望可以少點 suffer from 這個 disease。因為其實很多 cervical cancer 來找我們都頗差的. " (interviewee 13)

Subsidy amount

To enhance accessibility to good quality health services and to promote efficient and sustainable service delivery, there needs to be ways to incentivize providers and patients in order to tap into the private market resources. The screening program should include two consultations: the first one for taking blood sample and patient history, and the second one for explanation of the laboratory results. Some doctors suggested an amount ranging from HKD400 - 1000 covering both consultations as well as lab fees would be reasonable. Certain extents of flexibility should be allowed for other added-value services (e.g. other clinical investigation). They suggested that the voucher amount should be paid directly to physicians and they should be given the flexibility to choose which lab they want to use and how much they compensate the laboratory work.

As for the chronic disease management program, similar to the screening program, they suggested there could be a standard package around HKD500 – 600/month based on the drug cost from GOPC-PPP list, but a copayment should be allowed if branded drugs were used. One respondent reminded a surveillance mechanism should be in place in order to avoid any overcharging situation.

"but I guess 可能我估會否是最少 5 千吧 (每年) ...以前我見(GOPC-PPP)大概是 3 千, 每次 3 百元吧" (Interviewee 15)

"我覺得有好有唔好(added-value services)。好處就係彈性較大。的確有好多唔同症狀，就算係同一樣，譬如膝關節痛，但處理手法同繁複程度牽涉的人力物力都可以好唔同， 所以如果要使用者付出些都合理。 但我覺得個配套又要做得更好，因為如果太多彈性, 個機構可以用其他方法從中獲利，可能佢本身冇需要一些服務就遊說佢用多啲，可能監管或後續事項要多作跟進。" (Interviewee 9)

Operational Arrangement e.g. distribution channels and service provider

DHC and CHC are alternative venues for conducting screening but whether these two types of centers would have the capacity to cover population health screening for everyone between the ages 45 to 64 came into question. Furthermore, the question of who would provide continuity of care for patients identified with H-D-H by DHC was another challenge that needed to be resolved. Some respondents commented on the current practice of identifying patients at DHC and referring them to private network GP for screening then back to DHC for exercise and patient empowerment program. They expressed that this practice not only induced a lot of administrative work and cost, but also created a lot of hassle to patients. In addition, because doctor's involvement was very minimal in the process, there lacked a sense of patient ownership for the participating doctors, which was a major flaw of existing practice.

If the objectives are to foster family doctor concept and maximize private capacity, GPs in primary care will need to be the first point of care. Ideally the patient should be identified, screened, and managed by the same private GP. DHC, on the other hand, with its spacious environment and multidisciplinary team, could take on a supplementary role in providing lifestyle modification and patient empower programs. To uphold the standards and quality of care, some respondents further suggested that only physicians on the Primary Care Directory (Directory) should be allowed to participate in the Screening program since it sets a minimum training and requirement, e.g. CME for the enrolled doctors. One respondent raised the

possibility of emanating the practice of NHS in the UK by assigning a small group of doctors on the Directory to each person eligible for screening. It might be a logistical challenge to implement, but the novel idea could offer choices for the public rather than having them to randomly pick from a list. More research is needed to understand how the NHS is able to operationalize the concept.

> "這是一個 NHS 的諗法，即係而家政府 assign 病人俾醫生，但個病人都可以揀，當然不是畀 200 個醫生你揀， .... 可能得幾個醫生揀， 或者 assign 指定一個畀你，當然你有自由搵第二個，但呢個就係我(政府)assign 畀你， 這樣就可以 promote 家庭醫生。..... 雖然一定有唔好處 ，.... 可能就係我唔鍾意 assign 個醫生， 所以都係要俾自由度佢，即首先我 assign 俾你, 但我都畀你揀，咁就好過我又唔 assign 又唔畀你揀" (Interviewee 3)

Theme 3: Barriers in Implementation

Unattractive compensation structure under GOPC-PPP

All respondents pointed out that many primary care physicians are reluctant to join GOPC PPP program because of insufficient compensation to cover their time, the associated additional workload, and the high setup costs etc. The GOPC PPP program was launched in 2014 with the aims to help the Hospital Authority (HA) manage demand for general outpatient service and enhance patient access to primary care services. It also helps promote family doctor concept and foster the use of the Electronic Health Record Sharing System (eHRSS). However, one respondent mentioned that it took their organization more than $100,000 to set up the eHRSS. Her organization tried to apply for a Government grant to cover the expenses but the application was declined. Despite the significant investment, the extent of eHRSS access to patient record was limited to patient demographics, allergies, and drug utilization. Also, it was not easy to navigate the system, such as requiring multiple logins to access patient data. With

such high overhead costs, it would be impractical to attract service providers, especially physicians in solo practice, to join the GOPC PPP program given its low remuneration.

To avoid similar occurrence, respondents urged the Screening program to offer an amount that could balance out the extra workload, and was enough to show respect to their professional service. They also emphasized the importance of transparency in the calculation of the subsidy amount and the need for a review mechanism every 2-3 years to maintain its competitiveness.

Burden of administrative work

Another major reason why solo practitioners steered away from participating was the heavy administrative duties and complicated logistics associated with the GOPC PPP program that they foresaw might be a barrier for the screening program as well. For instance, if blood samples for the Screening have to be sent to designated labs selected by the Government, then they will have to allocate a place at the clinic to keep the screening blood samples separate from the blood sample of the other patients. The staff would also need to arrange specimen collection from two different labs thus demanding more time. Most physicians worked in solo practice, and have to attend to the end-to-end process related to patient visits. Many of them might prefer to use their time to see more patients than to join the screening program and deal with additional administrative duties for an unattractive compensation. Hence it is important for the Government to streamline processes, paperwork, data entries, and documentation to a minimum in order for small clinics/ solo practitioners to participate at ease. Two respondents also expressed a need to enhance the communication with Government so as to regularly discuss and inform any problems aroused, e.g. conduct regular meetings and setup a real-time enquiry hotline.

> “而家 GOPC PPP reimbursement 係有個 limitation, 病人每次畀$50, 政府就畀一個 fixed amount subsidize 個醫生 , 醫生如果畀咗一些特別藥物, 醫生係唔可以額外 charge patient, 變咗個彈性唔大, …. ~$200 仲要包藥, 醫生會覺得呢個唔係一個吸引的 scheme。第二, 有些病人可能一次過攞兩三個月藥, 可能有兩三隻藥, 那要用好多空間儲存啲藥, 這些又跟一直用啲糖尿/血壓藥不同, 但因為參加咗 GOPC PPP, 又要 order 新的藥, 儲存空間有限, 人手管理又有限, 一派又要派幾個月藥畀病人, 醫生又會驚數錯, 又多咗行政工作, 譬如入藥或管理藥物. 醫生又覺得好似冇特別 recognized, …. 而有啲 GOPC PPP 病人有時候睇血壓高, 如果佢有其他傷風咳, 醫生又要處理佢, 處理完又冇得收額外 consultation 費用, 可能畀多幾日藥, 你 charge 個病人少少 medication 費用, 好似對個醫生唔係好公平. 亦有啲醫生唔想用個電腦系統入資料, 有好多原因. “ (Interviewee 2)

Expensive private healthcare cost

While screening could be considered a first step in view of redirecting the flow of patients to the private market, the biggest challenge is whether the diagnosed patients are willing to stay in the private market for post screening management. All of our respondents were not optimistic if there was no subsidy from the Government because the price difference between the private and public sectors was too big. Despite that some clinics would offer generic drugs which are 1/3 of the price of branded drugs, chronic disease management required long term medication and could easily cost a fortune.

Therefore, it is crucial for the Screening program to incorporate details on how to intend the flow of patients in order to tap into the capacity of the private sector. One proposed to keep the hypertension patients in private as it is estimated that 30% of the population are suffering and the price variation of drugs used is minimal. For those with severe hyperglycemia condition and need insulin injection, it can redirect to public sector since the treatment cost could be big, and varied in range. Some suggested that if there could be a corresponding voucher scheme or other financial subsidies of around HKD500 – 600/month for chronic disease management, the amount might be enough to incentivize patients to remain in the private sector. In terms of

lowering the drug cost, they suggested to use the drug list from GOPC PPP but if more patients wanted to use brand name drugs, they believed that the market could also drive the price down if patient volume was large enough.

> "其實我們已經盡量用 generic，唔用 brand name，盡量減低 cost 畀個 patient。... 以我自己病人返嚟 follow up， 又冇乜特別, 我哋 consultation fee 都唔收，只收 drug cost。" (Interviewee 5)

> "是不是一定要覆診三高呢? 可能糖尿...膽固醇要交回給公營機構要, 你(私營市場)就只是辦血壓覆診，因為血壓藥相對就不是太貴...血壓佔了最多人口，可能 10 個人有 3 個有，糖尿 10 個人只有 1 個有，血壓就相對簡單的，一年抽一次血也 okay，但糖尿真的可能一年抽 3-4 次血的, ...打胰島素真的很貴." (Interviewee 14)

Lack of public awareness

Despite a plethora of public promotion and health education, the uptake rate for seasonal flu shoot remains low and the intended effect of reducing crowdedness in A&E service during peak season is still elusive. Our interviewees believed that public trust regarding safety and efficacy of the seasonal flu vaccine remained a key reason why many people decided to holdout from the preventive care. It was difficult to change mindset and the perception that there were risks associated with the flu vaccine was still pervasive.

Likewise, just having a free program for health Screening would not automatically translate into high participation rate. Corresponding public health education on the benefits of early screening to raise awareness of the Screening Voucher would be crucial to the uptake rate. Public message aimed to inform the general population of a free Screening program at private clinics should be accompanied by clinical information, such as the prevalence of chronic diseases and the benefits of early detection and management.

"對公眾要更多教育, 話畀他們知有呢一樣嘢, 去私家醫生度做喺免費, 點解要做呢一樣嘢, 40 歲以上的人有 20%有高血壓, 要早些處理, 因為每降低兩度 mmHg 減少幾個百分比的中風機會, 這些簡單的訊息要話畀人聽." (Interviewee 2)

Standardization of similar programs in different settings

From government perspective, screening and the subsequent follow-up is a continuous spectrum of disease management. Although the private could handle the screening process, public doctor raised concern about whether the private sector could provide uniform chronic disease management services. Given most settings already have similar screening and chronic disease management programs, it would be a challenge to have everyone comply with a standard protocol to deliver equal quality of care.

"原來社會上除 HA 之外, 其實都有不同的人做不同的事 (Screening & Chronic disease management)。 咁你有冇辦法串連到, 或者係你覺得都未必串連得到, 因為唔係你一個機構嘅事, 係成個政府問題, 咁你只係做到某一啲嘢去幫手, 咁你可能去做呢一個定位。" (Interviewee 4)

Theme 4: Facilitators for a successful screening and chronic disease management program

Accessibility to service and ability to attract private physicians

Introducing a health screening voucher should be beneficial to both the patient and the doctor since identification of patients at risk will lead to follow-up services and potentially more diagnostic examinations and treatments; driving revenue while improving customer care; and delivering better patient satisfaction. Most of the respondents repeatedly pointed out that many primary care physicians, especially those in solo practice, were reluctant to join PPP program because of insufficient compensation and heavy administrative burden. Hence the Government

would need to step up in terms of the reimbursement amount for doctors and simplifying logistic work, e.g. improving the eHRSS user interface, in order to attract more physicians to participate in the program. Moreover, respect for their professional autonomy such as how to execute the lab work was also of high priority for the doctors.

Given the majority of primary care is provided by physicians in the private sector, increasing the participation rate of private physicians can largely facilitate the accessibility to service and enhance the success rate of the new program.

> "最簡單就係要易用, 因為現在醫生要入幾組密碼, log in ID 或插身份證, 一係就入 access code, 要入幾次, 變咗就好唔方便。 當然佢有 security 的考慮, 但係進入系統的方法比較麻煩，要諗下如何盡量簡化。.... 不過第一個 step 就係要簡化 log-in." (Interviewee 2)

Public awareness

Having a voucher for screening is a necessary step, but not a sufficient condition, towards better disease management, given most people prefer to maintain status quo. To overcome inertia, people need to be motivated to take the first step of going to a clinic for screening. Most of the respondents urged the Government to leverage the advantages of social media to emphasize the role of personal responsibility and highlight the benefits of how lifestyle management could help to reduce the risk of cardiovascular events and multi-morbidity. As the government promotes the new program, an incentive could be given to a patient if he/she refers another patient to use the screening service. This is a powerful advertisement by the patient's mouth.

On top of that, the Government had to be very specific with the objectives of the screening program which was specifically designed to screen H-D-H. With a clear positioning and

straightforward initiative, it would be easier for service providers to communicate with their patients, which could potentially improve the program success rate.

> "只要政府個 message 好清晰就可以。例如近年政府做得比較好就係流感針。政府講得好清楚，我有一個 subsidy 係畀你打流感針 ，有幾多錢，你唔使畀錢，但我會 subsidize 你到某一個價錢。病人就好清楚政府嘅 subsidy 只係可以打流感針，咁佢咪會去搵有什麼地方可以打。 如果你畀 health voucher， 佢冇個 direction，佢會唔知點 decide 筆錢要用喺邊，跟住老人家或者有 health voucher 啲人，佢哋就好驚好似用盡自己啲錢。其實唔用筆錢都係會充公。所以如果你 message 係清晰，無論佢 subsidize 幾多錢 ，$300， $400， $500。。。呢一個係畀你每一年，或者每兩年去做一次體檢，而個體檢係量三高， 咁個病人就好容易去 decide 到，佢只係需要揀醫生，或者附近醫生有冇做呢一樣嘢，幾多錢，我需唔需要畀錢，咁樣就會好 encourage 到病人去做。另外亦會 encourage 到 healthcare provider 去告知個病人，並問佢會唔會有興趣去做 screening。政府推 program，其實都係希望有人用。所以我哋亦可以好簡單清晰話畀病人聽政府有呢一筆錢 $300，如果你做就唔使再畀錢，或者要畀多 $10，$100 ，你有冇興趣做? 所以呢一個係一個好容易嘅 script 畀 provider 去講，亦畀病人去 understand。但係你要規限呢一筆錢係驗三高體檢。" (Interviewee 6)

> "所以一定要加強宣傳工作, 或者已經成立一個網絡, 你同佢合作嗰個私家醫生, 正如我所講, 睇一個病人, 本來係睇另一種病, 如果佢係 target group 都可以問下佢做唔做呢一個 screening。 …. 可能都需要 empower 個私家醫生先。 咁你就 empower 佢其實可以喺佢個 clinic recruit patients。" (Interviewee 4)

> "另外看看會不會有 gimmick…譬如一個 candidate (patient)去參加…會不會就令他有類似的 incentive to encourage…介紹另一個 45 歲的人去做這些 screening，會不會有這些 incentive encourage 到越多人去看吧。" (Interviewee 15)

Follow up arrangement after screening

Our respondents would like to see a well-designed screening program that goes beyond the initial diagnosis of H-D-H. Patient follow-up after screening, for instance a well-coordinated

and comprehensive chronic disease management program, would be a key towards success of the program. In an ideal scenario, patients should be receiving continuous care services by the same primary care provider who helped to conduct the screening, and established a long-term doctor-patient relationship, which is at the heart of primary care development. However, an intensive assessment on the subsidy amount and service scope of the chronic disease management program, e.g. complication screening, must be done before execution.

Furthermore, patients should have access to multidisciplinary care after screening, including consultation with a dietitian on healthy eating and consumption of balanced meals to promote sustainable lifestyle modification. In this aspect, DHC with its multidisciplinary team could take on a supplementary role in providing lifestyle modification and patient empowerment programs. There should also be a referral mechanism to the public setting for further screening/ investigation if needed.

> "如果你話純粹係一個資助, 你就要睇資助金額係唔係去到咁多。 因為 Chronic Disease 除咗食藥抽血之外, 其實仲有少少 complication screening. 特別係 DM 為例 就更加複雜。所以糖尿病, 如果你哋要做的話, 你可能要 think twice, 究竟你要做幾多, 或者你背後到唔到嗰啲, 有什麼方法可以接住。 譬如你要做 DM complication screening , 要做眼底相可以喺邊度做呢?" (Interviewee 4)

> "一定要有(referral)。 所以唔係只係嗰三樣嘢。當你 start 高血壓開始時就驗三高，但係你 start 高血壓之前個 standard protocol 你都要驗 urine，如果我冇睇過佢 chest X-ray, ECG ，我感到不太自在。.....如果我無 ECG 我唔 comfortable 睇呢個病人...但如果佢驗到之後，但係你冇人幫我接住，咁如果出事就係我的事 .... 我就對佢有責任。" (Interviewee 7)

Theme 5: Role of family doctor to propel primary care

Family medicine development in Hong Kong

Most agreed that the family doctor model would be a possible solution for an effective primary care system, especially chronic disease and preventive care. However, factors including limited number of fully qualified family medicine physicians, and the lack of such information available to the public have been hindering the development of family medicine in Hong Kong. One respondent identified the lengthy family medicine specialist training (6 years) and a small salary difference between GPs with and without family medicine qualification in the private market as the main reasons for their low intention to become family medicine specialists. He suggested the Hong Kong College of Family Physicians could organize a 2-to-4-year family doctor training program for those who only wished to be qualified as a family doctor instead of being a specialist. He believed this change could fill up the supply of family doctors in Hong Kong. In view of The UK NHS system, one suggested mandatory consultation of patients' family doctor before any referral is an effective way to safeguard their wellbeing and could facilitate development of the Family Doctor concept. Moreover, continuous support to those in solo practice should be enhanced, namely the areas of information access of new government initiatives/programs and policies and also the networking among themselves. For chronic disease management in private sector, one reminded that service guidelines and disease treatment protocol should be followed in order to uphold the service standard and some suggested CME is a good way to secure the necessary knowledge update.

> "多咗病人會講話搵家庭醫生, 但係個趨勢都唔夠成效。第二，training and recognition 方面都做得唔夠。政府有宣傳每個病人都要有家庭醫生，但有無實際支持去鼓勵社會 train up 更多家庭醫生? 又冇喎。 點樣鼓勵病人去睇家庭醫生? 又係冇。點樣將冇受訓過的基層醫生幫佢做更多家庭醫學培訓? 又係冇。 變咗就係得個講字。" (Interviewee 2)

> "我哋不會因為你係 family medicine specialist 畀多, 最多畀多 $5,000-$10,000。你個 differentiation 唔大, 所以好多讀咗兩年就會去私家, 寧願早些賺個 income 同儲一批客人。..... 個 program 2 年又好，3-4 年都好 ，at the end 佢係 certify

咗佢係 family doctor 。當佢 certify as family doctor，佢就 entitled to 政府 subsidy，可以睇埋一啲症, 跟住個錢跟病人走，你要賺政府筆錢，你咪去攞這個 qualification，但係唔係 difficult 到你要 go through 6 年甚至 7 年個 family medicine specialist training。” (Interviewee 6)

“家庭醫生我諗自己本身個網絡和支援都可能要做得好少少，因為可能佢自己 solo practice 的時候, 都缺乏一些支援, 有時候可能想去參與一些計劃, 或者想做其他，資訊方面唔係太過流通，唔係好明白政策方面係點，自己搞掂就搞得掂，搞唔掂就冇。 咁就變咗可能有多少少網絡去幫到他們，多些資訊畀到他們。同埋可能因為經營成本，香港經營成本都好貴，有時又多咗好多經濟因素去考慮不同的政策, 這些對於家庭醫生的發展可能都有 barrier。.....其實香港政府 Primary Care Office 都有出幾個 disease guideline。 可能你以前從來都唔接觸呢一個病, 咁你點會太過著意個 management? 如果你慢慢多咗, 質素保證應該係點? 就係有番相應嘅知識, 咁你話讀返多啲關於 DM, Hypertension。 香港出的 guideline 都應該包括香港嘅 consideration, 希望佢哋都會 adopt guideline 去處理番 chronic disease 有關的問。 當然再多少少期望就係希望佢參加咗呢個 progra 之後, 都 fulfill 而家 voluntary base 嘅 CME . “ (Interviewee 4)

“我覺得是制度的問題, 香港是很容易就看到一個 specialist，以及個 system 是很不同，外國有一些地方例如英國的 NHS，就要求你一定要先看 family doctor，然後個 family doctor 覺得 indicated 了，是要看 specialist，他就 refer 給你，那你才去看 specialist...是比較健康的。病人就不會就耽誤了一些時間，他以為自己是心臟病但是輾轉看了幾個心臟醫生後才發現他是有腸胃問題，...其實他用了很多錢的 which 其實是不需要的. 香港的醫療制度不同，所以令到家庭醫生的制度很難好像外國般去實行得好” (Interviewee 13)

Significant public investment is needed to build-up primary care

Responsiveness and accessibility of private doctors are considered the upside of private sector. The screening program is a good starting point for chronic disease management, but the Government ought to invest more resources to develop the concept of family doctors as well as to train more family medicine professionals to meet future demand. Using evidence-based

findings, family medicine can tailor make patient care for each individual, leading to optimal outcome.

> "我諗我哋個 setting 一定係 sell responsiveness 同埋 speed 。另外 就係 continuity 。我知道政府而家盡量都有 continuity of care。我哋個 setting 就係個 speed, 病人來到佢驗血 within 幾日之內就會叫佢返嚟, 如果有 follow up 就 follow up , 所有 reaction 好快 , 基本上冇排期 。個病人 access to primary care doctor 其實係會更容易 , 因為基本上喺 private sector 睇 GP 係 walk in , 我唔需要打電話 make appointment 。我哋個 setting 都希望盡量做到同一個醫生去睇佢 , 佢喺 GOPC 都唔一定係同一個醫生 , 除非係好 specialize clinic。 所以你話要去 build 一個 family medicine 或者 family doctor setting , 其實你應該要喺 empower private sector 去 build。 " (Interviewee 6)

> "但我覺得 private 醫生俾個 service 要物有所值，你是否可以在這個 settlement 提供同等價值。 當然價值有不同定義，除錢 /藥物之外，亦有 emotional，有好多 value，你就要係你個 practice 裡面提供到這個 value 先能夠鼓勵人 out of pocket 。.... 始終病人要有選擇，佢唔鍾意可以去第二個醫生，錢要跟病人走。 佢要 voluntary 跟個醫生，因為個醫生好，所以先跟佢。" (Interviewee 7)

Study 2. Qualitative interviews for the general public

We individually interviewed 4 patients aged 54-66 on January 21st, 2021. All participants welcomed the idea of using a voucher to enable early screening of chronic disease for the population. They all offered valuable insights on factors that might hinder as well as facilitate such a program. Collectively, their opinions are classified into 5 main themes as below.

Theme 1: Low awareness of health check and theirs concerns about cost

Most of them expressed they never received a health check before because they perceived themselves were healthy with no apparent symptoms. Someone also pointed out that the expense of health care was another key factor for not receiving a regular check. Even though

they encountered healthcare check promotions from the government, TV, commercial mailing materials, or pamphlet distribution; they usually discovered their chronic health problem from an episodic visit to doctors who manage their other illnesses or from an annual body check of a company healthcare benefits package.

> “一方面我覺得自己...沒有這個經濟能力，可以這樣說...即是你問我有沒有買保險，我真的沒有買的，本身不是說很富裕的家庭。去健康院也要收錢的吧...那些有做...你說平時自己出去做心肺檢查或其他檢查呢...我就真的沒有。” (Interviewee 2)

> “有時在街或醫院都有廣告叫人去做身體檢查及有什麼優惠，政府都有在電視宣傳鼓勵我們去做身體檢查.....因為金錢上的問題，經常覺得要用一筆錢做身體檢查好像很肉赤，身體又沒有問題，要突然用一筆錢無故去檢查身體又好像...心態就是想拖。”(Interviewee 3)

Theme 2: Adequate knowledge about chronic diseases and risk factors

All realized chronic disease was a long-term problem and which they had to live with for the rest of their life, naming examples of hypertension, hyperglycemia, hyperlipidemia, and cardiovascular disease. The usual symptoms of tiredness, weight loss, and thirst could often be observed in a diabetes patient. Nevertheless, the symptoms were vague and not prominent for hypertension or hyperlipidemia. Usually, problems were discovered in medical consultation of other illnesses. They ascertained the risk factors like unhealthy diet, physical inactivity, long working hours, stress, aging or even family history could induce the diseases. Adequate exercises, a healthy diet, and lifestyle modification can help to reduce the risk to a large extent. Half of them were satisfied with the chronic disease status under medication but the rest thought the risk would increase along with age.

> “Yeah… that was interesting. That was some time ago but my wife suffered hypertension because she had a medical check. And so to keep an eye on her blood pressure, we got a blood pressure testing machine, and tested my blood

pressure and it was high. And then I went through the process of visiting the GP and getting an appointment at the government hospital and so on. (Interviewee 1)"

"我初初常覺得踏在地下是空的，常常在街上走路時覺得地下是軟綿綿，我就大力踩在地上，但當時自己又不知道是高血壓的，後來有一次就去看中醫，那個教授就幫我量血壓，血壓很高。他叫我同一個時間連續去他那裡七次，都是160 幾，就確定我是高血壓，叫我吃藥。....很多(誘發)原因的...例如家族遺傳也會，飲食不配合也會，還有工作環境，我當時是剛剛轉工作。...但是隨著年紀增長也不會是低的，隨著年紀大概率(風險)會高了"（Interviewee 2)

"就像高血壓，糖尿病或心臟病等問題就是長期病患..... 小心飲食。我想是做運動，都沒有其他方法。(Interviewee 3)

Theme 3: Adequate knowledge and its benefits but avoidance attitude towards disease screening

From the colorectal cancer screening promotion on TV, they understood the objective of early disease screening was to find out potential patients who have no symptoms. Indeed, they agreed early detection provided substantial benefit to the individuals, caregivers, and society. To the individual, early intervention could minimize healthcare spending and economic impact. To the caregiver, the patient might be less dependent and reduce emotional conflict. To society, the healthcare cost of treating a hypertension patient was far less than a stroke patient. In addition, one's control of his/her chronic disease status in an optimal manner may be a success story, and may influence the peer group/family to be aware of their health status. It really helps to reduce the total healthcare expenditure in long run. However, the avoidance mentality was still present in some people. They would perceive they were healthy and refuse screening tests. In reality, they were apprehensive of getting an unsatisfactory result after health checks.

"篩查即是找到沒有症狀，隱藏的病。政府的健康篩查，比較多是一些長期病三高之類是吧，癌症那些也有。 " (interviewee 2)

"那當然有好處。因為我現在年紀都愈來愈大了，雖然現在沒事但不代表未來沒事。就像我剛說當時年輕不知道自己會高血壓，現在慢慢年紀大就有高血壓了。那如果有篩查的話有很多病在初初形成時你已經可以知道。...那一定有，即是對屋企人都有好處的，因為如果你突然病了，全家人都突然之間會手足無措。如果你預早知道了，那他們就可以趁輕微時求醫。...對社會都有好處。如果你到很嚴重才去看醫生，那政府在醫療上都要用一大筆錢。...就像我們現在高血壓預早知道就食藥，食藥不會用到很多錢，但我如果突然間中風那便麻煩了，又要去醫院，又要花費一大筆錢。" (Interviewee 3)

"如果我不做檢查...或者我有病發現了，他(Caregiver)也會 suffer，他要照顧我(包括情緒, 經濟).... 或者可能自己朋友輩知道你 check 了之後，原來早知道有問題，其他人也覺得 check 下也好" (Interviewee 4)

Theme 4: Attitude and perception towards the healthcare voucher program

Motivation and eagerness to join

Although all perceived this as a good initiative to identify asymptomatic patients, only 50% were keen to join the new initiative. One correspondent expressed there was no urgent need since she was being covered by a company healthcare insurance plan while another was using the elderly healthcare voucher to take care of own illnesses.

"I don't need to join the screening, if I feel like I need help, I will go out and get it, I will ask for it. I am now 65 and I can get the government coupon (free elderly voucher) to help me with my medical care…. but if I have a problem, I will go to a GP and they will write me an introduction letter and I will get it to the government system somehow" (Interviewee 1)

Facilitators

All appreciated the new initiative with 100% allowance from the Government, one interviewee was willing to co-pay up to 30% of an affordable amount. In return, they expected responsive services and a dedicated doctor to follow up in the private sector. Screening logistics must be

easy and not complicated or time-consuming. In addition, they pressed a streamlined or hassle-free process to save time, especially important for the working population.

> "專人幫我看診(私營市場)。.... 你什麼時候就算 book 也好。今次是這個醫生(公營市場)，下次就不是, 他派給你誰就是誰。如果一直(由同一位醫生)跟蹤著...很好" (Interviewee 2)

> "就像我今日約了三時正(覆診)，但我二時多已經預備來這個診所(公營)，我可能看完醫生要五時前才可以走，即是變了沒了接近半天的時間。...即是排的時間就浪費了，如果私家的話可以預約，即是有個準確時間，不會去到還要排很長時間 ....現在你驗身起碼要數千元...或者有些會很貴的，如果收兩三萬的話那我三成都已經很多了。" (Interviewee 3)

> "如果你只有二百或三百元(資助)，你要我自己從荷包裏付。當然不願意。尤其是對於沒有工作的人，更加是一個 concern..... (檢查過程)不要那麼麻煩，我雖然可以隨時出來看醫生，但也不希望要為了一件事出來走幾趟。" (Interviewee 4)

Barriers and improvement areas

A positive attitude or a mentality of avoiding early screening is particularly critical, and needs more education or promotion. For those who are currently using elderly healthcare vouchers in the private sector, seeking regular consultation in public GPOC, or being covered with company insurance plans, there could be less incentive to actively switch to the new initiative. Also, one could mention the confusing experience of using elderly healthcare vouchers. He suggested that a clear guideline of eligible situations or service providers was essential to make it successful.

> "其實我哥哥最近也有糖尿病的 symptoms 出來了， 他不去檢查。他覺得只要他不去檢驗，就什麼問題也沒有。...是個人的 mentality 問題。" (Interviewee 4)

"我不知道可以用在那些地方能夠用呢?... 還有...那中醫又可以嗎? ...那還有什麼途徑可以用到(新)醫療券呢，就不太清楚。即是最好政府就講清楚那些地方可以用到醫療券。(Interviewee 3)

Theme 5: Voucher design preference and promotion is needed

All considered the age of 45 years was too early for the new initiative, and commented it was a formidable subsidy set at that age. It would be better to start by 50-55 since it was believed that those aged 45 years or younger were still under a working population, and it was likely that they were covered by company healthcare benefits or was affordable to self-pay healthcare check. Half of them had no knowledge of the screening frequency of related diseases, and commended it should be based on empirical evidence. Half thought that once per year was good enough for the first time, and the frequency of testing could be adjusted accordingly to their health condition. In the light of the new voucher promotion channels, the views were diversified from traditional to trendy social media. Older interviewees thought TV was their main entertainment channel at home and it was easy to capture the attention of people. They regarded the colorectal cancer screening program promotion on TV as a successful example. Whereas, a younger interviewee said the consumer behavior during leisure time has shifted to social media, spending less time on TV. She truly deemed promotion on social media, like Facebook and Instagram, was more effective than traditional medicine.

"現在的人普遍是長壽了。其實 50 歲也可以，45 歲會否早了些...45 仍然是在工作的 group，他們 normally 都有公司的 insurance cover 的吧"
(Interviewee 4)

"如果一年做兩次就當然最好。就像現在我來這裡看高血壓，他們都會幫我們抽血驗，一年抽兩次，那就知道我的糖尿、血脂，起碼你都會知道情況。如果這個篩查一年兩次可能比較多，一年一次應該差不多。" (Interviewee 3)

"電視是最直接的我覺得，最多人留意到，正如你說大腸癌篩查，我都是從電視看到才知道更多，途徑是多數從電視，電視不停宣傳你要去做大腸癌篩查呀，電視我覺得最直接的。我覺得手機的話人們會轉眼略過了，但電視就會不斷重播吧。因為始終無論如何都會看電視。" (Interviewee 3)

"網上吧，Social media ... 因為現在人們由早到晚都用電話。電視也沒有人收看" (Interviewee 4)

Part 3. Qualitative interviews with Government representatives, academics, policymakers and key stakeholders in health policymaking

A total of 15 key stakeholders from 13 institutions were interviewed. Thematic coding from interview transcripts revealed five key themes surrounding primary care implementation through strategic purchasing as a health financing lever and the role of PPPs.

Fragmentation in Hong Kong's health system can be bridged through leveraging the private sector

Hong Kong's pluralistic health system has led to an imbalance in resource distribution between the public and private sectors, particularly as both employ similar numbers of doctors while the public sector caters to approximately 90% of all inpatient care. To counteract the growing healthcare demand in the public sector, stakeholders emphasised the need to abolish barriers between the public and private sectors, thus allowing the private sector to take on a larger role in the provision of timely care and to minimize the duplication of resources in the healthcare system. Academic stakeholders advocated for a paradigm shift toward a more collaborative and interlinked public and private sectors. Similarly, academic stakeholders pointed to the need for a stronger role of the government in providing regulatory oversight to the private sector. Stakeholders opined that "private doctors essentially are very powerful, and they will resist all

kinds of regulation," suggesting that significant change would be necessary to reduce the duplication of resources between the public and private sectors.

Improving existing health financing mechanisms

Many stakeholders expressed concerns about the financing mechanisms of the public sector, and the possibility for reorganisation to maximise health system performance. Notably, some academic and policymaking stakeholders elaborated that the perception of the Hospital Authority as a safety net, paired with a fear of 'missing out' on using this governmental resource, has led to a decrease in quality of care and efficiency. Possible considerations for relieving the pressure on the 'safety net' were discussed, including implementing a co-payment system for public healthcare services and using targeted distribution in line with patients' capacity to pay. The opposite problem was cited in the private sector, wherein stakeholders pointed out the opacity of fees and negotiation protocols toward service provision. As a result, the private sector's autonomy in setting pricing rules can hinder greater use of private sector services. The lack of transparency in price setting was also attributed to the low uptake of medical insurance by patients, given that unclear prices for service led to higher premiums for patients. As one policymaker pointed out, even the "Voluntary Health Insurance Scheme is very complicated and very expensive, with some terms not being covered," thus highlighting the difficulty in bridging the public-private gap. Some stakeholders called for stronger efforts to further develop the insurance sector in Hong Kong, as "everyone wants to pay for health insurance if it really helps."

Propelling primary care development to alleviate stress through Government actions

As a key effort to relieve the growing pressure on the public sector, many stakeholders advocated for developing strong public primary care, provided by diverse teams of medical and social professionals. In particular, academic stakeholders referenced the importance of primary care services, such as allied health services, in providing more holistic, integrated, and patient-centred care for patients with chronic conditions, as "they need a lot of those support services." Many stakeholders also lamented the slow development of primary care in Hong Kong, pointing to the Government's key role in creating a vision for the involvement of the public and private sectors. For a primary care system to manifest, stakeholders pointed out the importance of a centralised government plan, and the delegation of primary care development efforts to a separate governing body away from the Hospital Authority. Crucially, key stakeholders repeatedly expressed the importance of a paradigm shift from a disease-centred medical care model to a primary care-based, patient-centred framework. Beyond having a designated authority and services, stakeholders advocated for a framework shift that is tailored to fit the comprehensive needs of an individual. Stakeholders also pushed for stronger efforts to appeal to the general population because "mainly the public needs to understand the importance of prevention as well".

Investing in strategic purchasing as a health financing lever

Stakeholders pointed to the importance for the Government to strategically prioritise the services to be funded given the available budget. In general, stakeholders expressed support toward PPPs and the use of strategic purchasing to fill service gaps in the public sector and address unmet needs. For example, some noted that patients without access to PPPs may be unable to access services, such as screening services due to high costs of access in the private sector. Nonetheless, stakeholders also acknowledged that such proposals may be difficult to

implement, especially within the current political landscape in Hong Kong and due to the slow momentum to make drastic changes to the healthcare system. To successfully implement PPP in the context of primary care, stakeholders advocated for the Government to "set out clear priorities, a long-term direction, and identify gaps in implementation." Suggestions were made for the Government to look into the potential of contracting private service providers as a means to implement PPPs with consideration for clear service protocols, guidelines and standards in place for regulatory purposes. Nonetheless, stakeholders have pre-emptively identified low enthusiasm for PPP among doctors, pointing out that the private sector often operates in a 'fee for service' model, hence limited financial compensation and additional logistic and administration work would be disincentives. Furthermore, doctors in the private sector would need to "adhere to evidence-based guidelines and protocols …[rather than] switch between ultra-expensive medications", thus requiring Government efforts to coordinate and ensure consistent standards of screening and treatment. There was also significant mention of the necessity of gaining further patient uptake through extensive advertisement and publicity efforts. Despite the general enthusiasm surrounding the use of PPP and strategic purchasing for primary care development, many stakeholders expressed reservations toward its implementation and long-term sustainability. For instance, stakeholders were uncertain of the long-term effectiveness of strategic purchasing due to the limited scope of current programmes and its capacity to serve "a finite amount of coverage." Similarly, stakeholders also feared that PPPs may instead worsen the fragmentation of care between the public and private sectors. Stakeholders pointed out the current limited flow of patients between the two sectors, adding that the uncertainty of a coordinating body would "create more problems". Stakeholders also warned against a lack of specificity of a strategic purchasing programme; a policymaker stakeholder added that the "current use of health vouchers will be wasted if we are only looking at the health vouchers for treatment of minor ailments instead of health promotion."

Planning for a chronic disease screening voucher and management scheme

Drawing on insights garnered from the Elderly Health Care Voucher Scheme (EHCVS), stakeholders overwhelmingly agreed on identifying certain population targets when designing voucher schemes. Many further agreed with service stratification by age and other demographic characteristics, such as financial capacity. Looking ahead, the Government should impose regulations on the use (and prevent misuse) of the vouchers and position the vouchers as an effort to detect symptoms before the progression into chronic diseases. Furthermore, the Government should consider patients' voices and plan for potential additional costs attributable to additional procedures or for the screening and management of multiple medical conditions.

STUDY 2. Telephone surveys for general public

Participant characteristics

A total of 1,200 respondents were recruited in the current study (**Table 5**). The majority of the individuals were aged ≥ 65 years (63.4%), followed by subjects aged 55-64 years (26.6%) and 45-54 years (10.0%). More respondents were female (69.2%), and attained primary educational level or lower (45.3%). The majority of them were retired (54.0%) or housewives (29.8%). Among them, 63.5% had been using medications for chronic diseases or attending regular follow-up, where most healthcare consultations took place in the private sector (56.8%). Approximately 51.9% reported family history of hypertension, diabetes, lipid disorders or stroke. Majority of them (74.5%) were not covered by self-purchased health insurance. A substantial proportion of the respondents perceived their financial resource to pay healthcare expenditure as inadequate (37.3%) and very inadequate (12.7%).

Factors associated with not screening for hypertension, diabetes and lipid disorders

The overall rates of having received at least one type, two types and all three types of screening test are 81.1%, 80.7%, 79.3%, respectively. From univariate analysis on the factors associated with not having received at least one type of screening test (**Table 6a**), younger age (cOR for 55-64 years: 0.550, 95% C.I. 0.355, 0.855, p=0.008; cOR for ≥65 years: 0.191, 95% C.I. 0.125, 0.293, p<0.001); higher educational level (cOR for secondary and tertiary educational level= 2.725 and 2.183, respectively); being employed (cOR for being employed= 2.033, 95% C.I. 1.399, 2.959, p<0.001); non-receipt of comprehensive social security assistance (receipt of CSSA cOR 0.360, 95% C.I. 0.128, 1.099, p=0.052); perception of screening being beneficial (cOR 0.565, 95% C.I. 0.411, 0.778, p<0.001); and family history without chronic diseases (family history with chronic diseases cOR 0.422, 95% C.I. 0.310, 0.573, p<0.001) were significant covariates. With confounders considered in the multiple regression analysis on the factors associated with not having received at least one type of screening test (**Table 6b**), younger individuals (reference, aOR for ≥65 years 0.338, 95% C.I. 0.161, 0.711, p=0.004); higher educational level (aOR for secondary and tertiary educational level=1.825 and 1.391, respectively); being employed (aOR =3.030, 95% C.I. 1.068, 8.621, p=0.037); the lower perception of screening as beneficial (aOR 0.495, 95% C.I. 0.345, 0.710, p<0.001), older individuals who have family history of chronic diseases (aOR for ≥65 years with family history=0.284, 95% C.I. 0.109, 0.736, p=0.010); and employed individuals with high educational level (aOR for secondary by employed=0.270, 95% C.I. 0.084, 0.864, p=0.027; aOR for tertiary by employed=0.136, 95% C.I. 0.034, 0.548, p=0.005) were significantly associated with no regular screening for at least one medical condition. The significant covariates from regression analysis for not having received at least two (**Table 7**) or all three types (**Table 8**) of screening tests were similar.

Factors associated with no willingness to join the voucher scheme programme for screening

The overall rates of willingness to join voucher scheme (among those aged ≥ 45) is 83.7%. We excluded subjects who were attending regular follow-up in clinics for hypertension, diabetes, lipid disorders or stroke since they were often receiving regular check for chronic conditions. In univariate analysis for "not willing to join the EHCVS for preventive screening" (**Table 9a**), male individuals (crude odds ratio [cOR] =2.198, 95% C.I. 1.309, 3.690, p=0.003) and those without family history of the above-mentioned chronic diseases (reference, with family history cOR=0.341, 95% C.I. 0.182, 0.638, p=0.001) were significantly more likely to express unwillingness to join the screening programme. Being male (adjusted odds ratio (aOR)=2.049, 95% C.I. 1.183, 3.546, p=0.010) and the absence of family history (reference, with family history aOR=0.362, 95% C.I. 0.192, 0.680, p=0.002) remained to be the significant predictors of unwillingness to join the preventive screening for conditions in the multivariate regression model (**Table 9b**).

Table 5. Characteristics of the respondents

	n	%
Age (years)		
45-54	120	10.0
55-64	319	26.6
≥ 65	761	63.4
Gender		
Male	370	30.8
Female	830	69.2
Educational level		
Primary or below	543	45.3
Secondary	479	39.9
Tertiary or above	154	12.8
Refused to answer	24	2
Job status		
Full-time or part-time	164	13.7
Retired	648	54.0
Housewife	358	29.8
Student	0	0

Unemployed	22	1.8
Refused to answer	8	0.7
Monthly personal income (HK$)		
<10,000	20	1.7
10,000-19,999	47	3.9
20,000-29,000	33	2.8
30,000-60,000	22	1.8
>60,000	10	0.8
Unstable income	6	0.5
Refused to answer	26	2.2
N/A as no current job	1036	86.3
Recipient of CSSA		
Yes	52	4.3
No	1140	95.0
Refused to answer	8	0.7
Regular follow-up or use of medication for chronic diseases		
Yes	762	63.5
No	436	36.3
Refused to answer	2	0.2
Healthcare consultations mainly in		
Public sector	274	22.8
Private sector	682	56.8
Public or private (more or less equal)	194	16.2
Don't know/no opinions	38	3.2
Others (Chinese Medicine, over-the-counter drugs)	12	1.0
Family history of hypertension, diabetes, lipid disorders or stroke		
Yes	623	51.9
No	492	41.0
Don't know/no opinions	78	6.5
Refused to answer	7	0.6
Medical insurance provided by employers		
Yes	87	7.2
No	70	5.8
Not applicable (no employers)	1031	85.9
Don't know/no opinions	1	0.1
Refused to answer	11	0.9
Self-purchased health insurance		
Yes, Voluntary Health Insurance Scheme (VHIS)	3	0.3
Yes, personal health insurance	253	21.1
Both VHIS and personal health insurance	9	0.8
No	894	74.5

Don’t know/no opinions	0	0.0
Refused to answer	41	3.4
Perceived adequacy of financial resource to pay healthcare expenditure		
More than adequate	9	0.8
Adequate	166	13.8
Just enough	196	16.3
Inadequate	447	37.3
Very inadequate	152	12.7
Don’t know/no opinions	212	17.7
Refused to answer	18	1.5

Table 6. Factors associated with not screening for at least one factor

Table 6a: Univariate Analysis

		n	%	COR	95% C.I.		Sig.
Age	45-54	120	40.8	Reference			
	55-64	316	27.5	0.550	0.355	0.855	0.008
	65 or Above	747	11.6	0.191	0.125	0.293	<0.001
Gender	Male	365	19.2	1.031	0.753	1.412	0.847
	Female	818	18.7	Reference			
Educational Level	Primary or below	531	11.5	Reference			
	Secondary	475	26.1	2.725	1.946	3.817	<0.001
	Tertiary or above	154	22.1	2.183	1.372	3.472	0.001
Job Status	Employed	164	29.3	2.033	1.399	2.959	<0.001
	Not employed (including unemployed, homemaker, retired)	1011	16.9	Reference			
Income	Below 20,000	67	31.3	Reference			
	20,000 – 30,000	33	30.3	0.952	0.386	2.353	0.916
	Above 30,000	32	15.6	0.406	0.137	1.200	0.103
CSSA	Yes	51	7.8	0.360	0.128	1.009	0.052
	No	1124	19.1	Reference			
Perceive screening as beneficial		1169	18.6	0.565	0.411	0.778	<0.001
Family history of hypertension, diabetes, lipid disorders or stroke	With family history	616	13.3	0.422	0.310	0.573	<0.001
	Without family history	487	26.7	Reference			
Insurance	With insurance	294	19.7	2.299	0.816	1.603	0.435
	Without insurance	848	17.7	Reference			

Table 6b: Multivariate Analysis (variable interaction considered)

		n	%	AOR	95% C.I.		Sig.
Age	45-54	111	38.7		Reference		
	55-64	298	27.9	0.749	0.366	1.534	0.429
	65 or Above	658	11.6	0.338	0.161	0.711	0.004
Educational Level	Primary or below	468	11.5		Reference		
	Secondary	454	25.8	1.825	1.189	2.801	0.006
	Tertiary	145	21.4	1.391	0.750	2.584	0.295
Job Status	Employed	157	28.7	3.030	1.068	8.621	0.037
	Not employed (including unemployed, homemaker, retired)	910	17.3		Reference		
Perceive screening as beneficial		1067	18.9	0.495	0.345	0.710	<0.001
Family history of hypertension, diabetes, lipid disorders or stroke	With family history	608	13.3	0.962	0.436	2.128	0.925
	Without family history	459	26.4		Reference		
Age x Family History	55-64 by with family history	171	21.1	0.476	0.184	1.233	0.127
	65 or above by with family history	379	5.8	0.284	0.109	0.736	0.010
Education level x Job Status	Secondary by Employed	89	33.7	0.270	0.084	0.864	0.027
	Tertiary by Employed	47	21.3	0.136	0.034	0.548	0.005

Table 7. Factors associated with not screening for at least two factors

Table 7a: Univariate Analysis

		n	%	COR	95% C.I.		Sig.
Age	45-54	120	40.8		Reference		
	55-64	316	28.5	0.577	0.372	0.894	0.014
	65 or Above	747	11.9	0.196	0.128	0.300	<0.001
Gender	Male	365	19.5	1.016	0.744	1.389	0.917
	Female	818	19.2		Reference		
Educational Level	Primary or below	531	11.9		Reference		
	Secondary	475	26.7	2.710	1.946	3.774	<0.001
	Tertiary or above	154	22.1	2.105	1.325	3.344	0.002
Job Status	Employed	164	29.3	2.037	1.403	2.950	<0.001
	Not employed (including unemployed, homemaker, retired)	1011	16.9		Reference		
Income	Below 20,000	67	32.8		Reference		
	20,000 – 30,000	33	30.3	0.890	0.361	2.188	0.799
	Above 30,000	32	15.6	0.379	0.128	1.117	0.079
CSSA	Yes	51	7.8	0.350	0.125	0.981	0.046
	No	1124	19.6		Reference		
Perceive screening as beneficial		1169	19	0.579	0.423	0.793	0.001
Family history of hypertension, diabetes, lipid disorders or stroke	With family history	616	14	0.441	0.326	0.597	<0.001
	Without family history	487	26.9		Reference		
Insurance	With insurance	294	20.1	1.131	0.810	1.580	0.469
	Without insurance	848	18.2		Reference		

Table 7b: Multivariate Analysis (variable interaction considered)

		n	%	AOR	95% C.I.		Sig.
Age	45-54	111	38.7	Reference			
	55-64	298	28.9	0.739	0.361	1.511	0.407
	65 or Above	658	11.9	0.344	0.164	0.721	0.005
Educational Level	Primary or below	468	12	Reference			
	Secondary	454	26.4	1.873	1.227	2.865	0.004
	Tertiary	145	21.4	1.353	0.732	2.506	0.334
Job Status	Employed	157	29.3	3.597	1.304	9.901	0.013
	Not employed (including unemployed, homemaker, retired)	910	17.7	Reference			
Perceive screening as beneficial		1067	19.4	0.507	0.355	0.724	<0.001
Family history of hypertension, diabetes, lipid disorders or stroke	With family history	608	14	0.964	0.437	2.128	0.928
	Without family history	459	26.6	Reference			
Age x Family History	55-64 by with family history	171	22.8	0.525	0.204	1.355	0.183
	65 or above by with family history	379	6.1	0.288	0.112	0.745	0.010
Education level x Job Status	Secondary by Employed	89	32.6	0.217	0.070	0.677	0.008
	Tertiary by Employed	47	19.1	0.117	0.030	0.461	0.002

Table 8. Factors associated with not screening for all three factors

Table 8a: Univariate Analysis

		n	%	COR	95% C.I.		Sig.
Age	45-54	120	43.3	Reference			
	55-64	316	30.4	0.571	0.370	0.880	0.011
	65 or Above	747	13	0.195	0.128	0.297	<0.001
Gender	Male	365	20.8	1.010	0.745	1.368	0.949
	Female	818	20.7	Reference			
Educational Level	Primary or below	531	13.7	Reference			
	Secondary	475	27.6	2.387	1.736	3.289	<0.001
	Tertiary or above	154	24	1.984	1.272	3.096	0.003
Job Status	Employed	164	31.7	2.033	1.410	2.924	<0.001
	Not employed (including unemployed, homemaker, retired)	1011	18.6	Reference			
Income	Below 20,000	67	34.3	Reference			
	20,000 – 30,000	33	30.3	0.832	0.339	2.041	0.687
	Above 30,000	32	18.7	0.442	0.159	1.225	0.116
CSSA	Yes	51	9.8	0.411	0.162	1.046	0.062
	No	1124	20.9	Reference			
Perceive screening as beneficial		1169	20.4	0.611	0.451	0.827	0.001
Family history of hypertension, diabetes, lipid disorders or stroke	With family history	616	15.1	0.450	0.335	0.605	<0.001
	Without family history	487	28.3	Reference			
With insurance or not	With insurance	294	21.8	1.143	0.826	1.582	0.419
	Without insurance	848	19.6	Reference			

Table 8b: Multivariate Analysis (variable interaction considered)

		n	%	AOR	95% C.I.		Sig.
Age	45-54	111	41.4		Reference		
	55-64	298	30.5	0.829	0.407	1.686	0.605
	65 or Above	658	12.6	0.345	0.165	0.719	0.004
Educational Level	Primary or below	468	13.5		Reference		
	Secondary	454	27.1	1.634	1.080	2.469	0.020
	Tertiary	145	23.4	1.297	0.713	2.358	0.394
Job Status	Employed	157	31.2	3.381	1.412	10.417	0.008
	Not employed (including unemployed, homemaker, retired)	910	18.8		Reference		
Perceive screening as beneficial		1067	20.6	0.513	0.362	0.728	<0.001
Family history of hypertension, diabetes, lipid disorders or stroke	With family history	608	15	1.212	0.553	2.653	0.631
	Without family history	459	28.1		Reference		
Age x Family History	55-64 by with family history	171	23.4	0.370	0.145	0.945	0.038
	65 or above by with family history	379	6.6	0.236	0.093	0.600	0.002
Education level x Job Status	Secondary by Employed	89	33.7	0.200	0.065	0.615	0.005
	Tertiary by Employed	47	21.3	0.106	0.028	0.404	0.001

Table 9. Factors associated with no participation in voucher scheme for screening

Table 9a: Univariate Analysis

		n	%	COR	95% C.I.		Sig.
Age	45-54	92	15.2	Reference			
	55-64	178	14	0.911	0.448	1.848	0.795
	65 or Above	173	19.1	1.314	0.663	2.604	0.435
Gender	Male	131	24.4	2.198	1.309	3.690	0.003
	Female	312	12.8	Reference			
Educational Level	Primary or below	104	14.4	Reference			
	Secondary	241	17.4	1.252	0.660	2.375	0.491
	Tertiary or above	87	13.8	0.950	0.419	2.155	0.901
Job Status	Employed	100	20	1.370	0.773	2.427	0.730
	Not employed (including unemployed, homemaker, retired)	337	15.4	Reference			
Income	Below 20,000	37	18.9	Reference			
	20,000 – 30,000	21	23.8	1.339	0.366	4.902	0.659
	Above 30,000	20	20	1.072	0.272	4.219	0.921
CSSA	Yes	4	25	1.739	0.178	16.949	0.634
	No	435	16.1	Reference			
Perceive screening as beneficial		437	16	0.900	0.530	1.527	0.696
Family history of hypertension, diabetes, lipid disorders or stroke	With family history	171	8.2	0.341	0.182	0.638	0.001
	Without family history	251	20.7	Reference			
Insurance	With insurance	172	18	1.266	0.751	2.132	0.377
	Without insurance	250	14.8	Reference			

Table 9b: Multivariate Analysis

		n	%	AOR	95% C.I.		Sig.
Gender	Male	122	23.8	2.049	1.183	3.546	0.010
	Female	300	12.3		Reference		
Family history of hypertension, diabetes, lipid disorders or stroke	With family history	171	8.2	0.362	0.192	0.680	0.002
	Without family history	251	20.7		Reference		

STUDY 3. Cost-effectiveness analysis

The results of total costs and effectiveness based on different screening strategies, aiming at diabetes, hypertension and hyperlipidemia, covering 2.2 million adults aged 45-65 years in Hong Kong, are presented in **Table 10.**

Scenario 0: No screening

The total costs (HK$138.6 billion) and per person cost (HK$62,994) under "no screening" were the lowest among the four scenarios. However, the average survival years after the disease onset among DM patients in this scenario was the shortest (10.58 years per person). The average time for treating DM, HT and HL of DM patients was also the shortest, at 6.27 years, 2.01 years and 3.20 years, respectively. The per person life years gained of all participants under no screening was 30.57 years, and after adjustment, the per person QALYs gained was 19.00 years, accordingly. The average cost-effectiveness (C-E) ratio for life years and QALYs was HK$2,061 and HK$3,315, respectively. The incidence rates of myocardial infarction, cardiac arrest, stroke, photocoagulation, blindness, and angina among DM patients in this scenario were the highest. However, the incidence rates of microalbuminuria, nephropathy, end-stage renal disease and peripheral neuropathy were in turn the lowest under this strategy.

Finally, the number of death due to DM-related complications among DM patients were also the largest under this scenario.

Scenario 1: One-time screening (base case)

The total costs (HK$144.1 billion) and per person cost (HK$65,490) under one-time screening program were higher than those who did not join the screening program, but lower than that of the other two screening strategies (two-time screening or triennial screening). Under the one-time screening program, 53,691 cases with diabetes were newly detected from screening, at a total screening cost of HK$1.65 billion. The number needed to screen to detect one new case was 41, and the screening cost per newly detected case was HK$30,773. The average survival years among DM patients in this scenario was 10.81 years per person. The average time for treating DM, HT and HL among DM patients was 7.06 years, 2.25 years and 3.51 years, respectively. The per person life years gained of total population under the one-time screening program was 30.62 years, and after adjustment, the per person QALYs gained was 19.03 years. The average cost-effectiveness ratio for life years and QALYs was HK$2,139 and HK$3,442, accordingly. The incidence rates of myocardial infarction, cardiac arrest, stroke, photocoagulation, blindness, and angina among DM patients in this scenario were lower than those who received no screening. However, the total number of occurrence as well as the incidence rates of microalbuminuria, nephropathy, end-stage renal disease and peripheral neuropathy were inversely higher than those without screening. Finally, the number of death due to DM-related complications also decreased after introducing the one-time screening program, compared to that of the no screening program.

Scenario 2: Two-time screening

In this scenario, the total costs (HK$148.2 billion) and per person cost (HK$67,375) were further higher than those with no screening and one-time screening. Under the two-time screening strategy, 57,453 new cases with diabetes were detected, at a total screening cost of HK$3.01 billion, nearly two times of that of the one-time screening. The number needed to screen to detect one new case in this scenario was higher at 70, and the screening cost per newly detected case was HK$52,358. The average survival years after DM onset among DM patients in this scenario was only a few longer than that in one-time screening (10.82 vs 10.81 years per person). The average time of treating DM, HT and HL of DM patients was also slightly longer at 7.10 years, 2.26 years and 3.53 years, respectively. The per person life years gained and QALYs gained of total population under the two-time screening program was the same as those in the one-time screening program. The average C-E ratio for life years and QALYs was slightly higher at HK$2,200 and HK$3,541 in this scenario, respectively. The incidence rates of myocardial infarction, cardiac arrest, stroke, photocoagulation, blindness, and angina among DM patients in this scenario were further lower than those of one-time screening and no screening. However, the total number as well as the incidence rates of microalbuminuria, nephropathy, end-stage renal disease and peripheral neuropathy were inversely higher. Finally, the number of death due to DM-related complications further decreased after introducing the two-time screening program.

Scenario 3: Triennial screening

Screening was provided for individuals without diagnosis of DM every three years in this scenario. The total costs (HK$155.9 billion) and per person cost (HK$70,859) were the highest among all screening and no screening scenarios. Under the triennial screening strategy, 82,271 new cases with diabetes were detected, at a total screening cost of HK$6.52 billion, more than twice as that of the two-time screening. The average frequency of screening among the total population was 3.9 times. The number needed to screen to detect one new case in this scenario

was the highest (NNS=106) and an average screening cost of HK$79,301. The average survival years of DM patients in this scenario was longest in this scenario, at a number of 10.90 years per person. The average time for treating DM, HT and HL of DM patients was also the longest, at 7.40 years, 2.29 years and 3.62 years, respectively. The per person life years gained (30.65 life years) and QALYs gained (19.040 QALYs) among all participants under the triennial screening program was higher than those in the two-time, one-time, and no screening strategies. The average cost-effectiveness ratios for life years and QALYs in this scenario were also the highest, at HK$2,312 and HK$3,722, respectively. At the same time, the total number of events and the incidence rates of myocardial infarction, cardiac arrest, stroke, photocoagulation, blindness and angina among DM patients in this scenario were the lowest among all screening strategies, which revealed the positive effects of early screening and timely treatment to prevent disease-related complications. Nevertheless, the total number and risks of microalbuminuria, nephropathy, end-stage renal disease and peripheral neuropathy inversely increased under this scenario, which might reflect the lack of effective interventions for DM patients on these types of complications. Finally, the number of deaths due to DM-related complications among DM patients were the lowest under the triennial screening, when compared with other screening strategies.

Table 10. Total cost and effectiveness of different screening strategies

	unit	Triennial screening	Two-time screening	One-time screening	No screening
Total population	total number	2,200,000	2,200,000	2,200,000	2,200,000
Number of patients with diabetes	total number	469,586	470,239	470,232	470,239
Lifetime incidence of DM	per person	21.3%	21.4%	21.4%	21.4%
Total Cost (HK$)					
Screening cost	total population	6,524,200,057	3,008,098,158	1,652,222,000	0
RAMP intervention	total population	888,465,871	857,279,511	852,039,705	765,999,478
Routine care – DM	total population	42,900,422,316	41,279,237,489	41,005,671,511	36,555,749,915
Routine care – HT/LP	total population	11,478,695,580	11,233,926,451	11,188,448,150	10,127,743,989
Treatment on complications	total population	32,291,484,825	32,687,800,807	32,701,683,042	33,798,451,671
Death	total population	219,811,225,434	219,883,849,755	219,852,955,599	219,867,480,463
Total cost (undiscounted)	total population	313,894,494,083	308,950,192,170	307,253,020,007	301,115,425,517
Total cost (discounted)	total population	155,889,507,313	148,224,971,608	144,078,261,295	138,587,432,280
Per person cost (HK$)					
Screening cost	per person	2,966	1,367	751	0
RAMP intervention	per person	404	390	387	348
Routine care – DM	per person	19,500	18,763	18,639	16,616
Routine care – HT/LP	per person	5,218	5,106	5,086	4,604
Treatment on complications	per person	14,678	14,858	14,864	15,363
Death	per person	142,679	140,432	139,660	136,871
Total cost (undiscounted)	per person	185,444	180,917	179,388	173,802
Total cost (discounted)	per person	70,859	67,375	65,490	62,994
Effectiveness					
Frequency of screening	total number	8,687,235	4,005,404	2,200,000	0
	per person	3.9	1.8	1.0	0.0
Newly detected case by screening	total number	82,271	57,453	53,691	0
Survival years after onset of DM	per DM patient	10.90	10.82	10.81	10.58

Treatment time during DM (years)					
Diabetes	per DM patient	7.40	7.10	7.06	6.27
Hypertension	per DM patient	2.29	2.26	2.25	2.01
Lipid disorder	per DM patient	3.62	3.53	3.51	3.20
Life years	total number	67,427,788	67,361,015	67,359,679	67,245,826
	per person	30.65	30.62	30.62	30.57
QALYs	total number	41,887,796	41,861,470	41,860,502	41,804,293
	per person	19.040	19.028	19.028	19.002
Incidence of complications (among DM patients)					
Myocadiac infarction	total event	157,454	159,201	159,702	164,424
	incidence rate	0.0308	0.0313	0.0314	0.0330
Cardiac arrest	total event	48,422	49,053	48,959	49,859
	incidence rate	0.0095	0.0096	0.0096	0.0100
Coronary Heart Disease (CA/MI)	total person	174,434	176,249	176,394	180,189
	cumulative incidence	0.3715	0.3748	0.3751	0.3832
Stroke	total event	212,322	214,658	214,749	220,147
	incidence rate	0.0415	0.0422	0.0423	0.0442
	total person	159,075	160,578	160,679	164,523
	cumulative incidence	0.3388	0.3415	0.3417	0.3499
Lower extremity amputation	total event	2,343	2,354	2,237	2,308
	incidence rate	0.0005	0.0005	0.0004	0.0005
	total person	1,668	1,685	1,621	1,650
	cumulative incidence	0.0036	0.0036	0.0034	0.0035
Microalbuminuria	total person	199,681	199,335	199,430	197,771
	cumulative incidence	0.4252	0.4239	0.4241	0.4206
Nephropathy	total person	28,376	28,237	28,002	26,998
	cumulative incidence	0.0604	0.0600	0.0595	0.0574
End-Stage Renal Disease	total person	2,343	2,385	2,365	2,270
	cumulative incidence	0.0050	0.0051	0.0050	0.0048

Peripheral Neuropathy	total person	32,355	32,331	32,241	32,124
	cumulative incidence	0.0689	0.0688	0.0686	0.0683
Photocoagulation	total person	35,988	36,289	36,456	37,382
	cumulative incidence	0.0766	0.0772	0.0775	0.0795
Blindness	total person	16,856	17,178	17,193	17,820
	cumulative incidence	0.0359	0.0365	0.0366	0.0379
Angina	total person	88,070	89,126	89,133	91,722
	cumulative incidence	0.1875	0.1895	0.1896	0.1951
Mortality					
Death due to complications	total number	245,307	248,160	248,211	253,851
Death due to LEA event	total number	229	235	227	227
Death due to Stroke event	total number	30,408	30,558	30,545	31,297
Death due to CA/MI event	total number	89,124	89,971	89,993	91,263
Death due to Angina stage	total number	42,013	42,711	42,526	43,791
Death due to ESRD	total number	1,701	1,742	1,705	1,641
Death due to history of CA/MI	total number	38,366	38,911	39,068	40,080
Death due to history of stroke	total number	43,465	44,031	44,147	45,553
Death due to other reason (DM)	total number	213,849	211,935	211,776	206,329
Death due to other reason (non-DM)	total number	1,638,340	1,638,094	1,637,907	1,637,852
Total death	total number	2,097,495	2,098,188	2,097,894	2,098,032

Note: CA, cardiac arrest; CHD, Coronary Heart Disease; DM, diabetes mellitus; ESRD, end-stage related disease; LEA, lower-extremity amputation; MI, myocardial infarction

Comparison among different screening strategies

The comparative cost and effectiveness of different screening strategies are shown in Table 11, where no screening was primarily used as the comparison group.

One-time screening vs. No screening

Compared to no screening, one-time screening among the population aged 45-64 increased the per person cost by HK$2,496 and the total costs by HK$5.5 billion. Among the undiscounted increased costs (HK$6.1 billion in total or HK$5,586 per person), most were due to the earlier initiation of interventions (increased HK$5.6 billion or increased HK$2,544 per person), followed by the introduction of screening (increased HK$1.7 billion or increased HK$751 per person). Inversely, the savings in costs due to reduced DM-related complications could reach HK$1.1 billion in total, or HK$499 per person before discounting.

The increases in total costs of one-time screening compared to no screening also resulted in more newly detected DM cases (53,691 persons), longer treatment time (an addition of 0.78, 0.24 and 0.32 year per DM patient in DM, HT, and HL treatment), longer life years gained (0.052 year per person), and longer QALYs gained (0.026 QALY per person). The ICER of one-time screening on life year and QALY gained was HK$48,277 and HK$97,686, respectively, when compared with no screening.

As for DM-related complications, the average cost to avert a complication event (i.e., MI, CA, stroke, photocoagulation, blindness, angina, and LEA) could range from HK$1,017,046 to HK$77,994,730 per inverted case. Finally, the incremental cost per averted complication-related death in one-time screening compared to no screening could reach HK$973,413.

Two-time screening vs. No screening

Compared to no screening, two-time screening among the population aged 45-64 years increased the average cost per person by HK$4,381 and the total costs by HK$9.6 billion after discounting. Among the undiscounted increased costs (HK$15.7 billion in total or HK$7,115 per person), most were due to earlier initiation of interventions (increased HK$5.9 billion or increased HK$2,691 per person), and the introduction of screening (increased HK$3.0 billion or increased HK$1,367 per person). In turn, the savings in costs related to DM complications in this strategy could reach HK$1.1 billion in total or HK$505 per person before discounting, similar to those under the one-time screening program.

The increases in total costs of the two-time screening compared to no screening also led to more newly detected cases (57,453 persons), longer treatment time (an addition of 0.83, 0.25 and 0.33 year per DM patient in DM, HT, and HL treatment), longer life years gained (0.052 year per person), and longer QALYs gained (0.026 QALY per person). However, the increased gains in life years and QALYs in this scenario were no different from those under the one-time strategy. On the contrary, the ICERs of per life year and per QALY gained were largely higher as HK$83,667 and HK$168,557 than those in the one-time screening, when compared to the no screening strategy.

As for DM-related complications, the average cost to avert a complication event (i.e., MI, CA, stroke, photocoagulation, blindness, angina) could range from HK$1,755,791 to HK$15,002,396 per averted case. The incremental cost per averted death due to complication in the one-time screening could also reach a high value at HK$1,693,351 per averted death, when compared to no screening.

Triennial screening vs. No screening

Compared to no screening, triennial screening among the population aged 45-64 increased the average cost per person most by HK$7,865 and the total costs by HK$17.3 billion after discounting. Among the undiscounted increased costs (HK$25.6 billion in total or HK$11,643 per person), most were due to earlier initiation of interventions (increased HK$7.8 billion or increased HK$3,554 per person) and the introduction of screening (increased HK$6.5 billion or increased HK$2,966 per person). In turn, the savings in costs due to reduced DM-related complications could reach HK$1.5 billion in total or HK$685 per person before discounting, which were the highest when compared with two-time screening and one-time screening.

The increases in total costs after initiating triennial screening also resulted in most newly detected cases (82,271 persons), longer treatment time (additional 1.13, 0.28 and 0.43 year per DM patient in DM, HT, and HL treatment), longer life years gained (0.083 year per person), and longer QALYs gained (0.038 QALY per person). However, the ICER per life year and per QALY gained also increased to HK$95,086 and HK$207,203, respectively.

As for DM-related complications, the average cost to avert a complication event (i.e., MI, CA, stroke, photocoagulation, blindness, angina) could range from HK$2,211,015 to HK$17,955,661 per averted case, much higher than the ICERs under two-time or one-time screening. The average cost per averted death due to complication of triennial screening compared to no screening could also reach a higher value, at HK$2,024,866 per averted death.

Triennial screening vs. One-time screening

Because the health benefits of two-time screening and one-time screening were approximate, we finally investigated the incremental cost and effectiveness of triennial screening compared to one-time screening (not shown in the table). Compared to one-time screening, triennial screening among the population aged 45-64 increased the total costs by HK$11.8 billion and

the average cost per person by HK$5,369 after discounting. Among the undiscounted increased costs (HK$13.3 billion in total or HK$6,057 per person), most were due to the screening (increased HK$4.9 billion or increased HK$2,215 per person) rather than earlier initiation of interventions (increased HK$2.2 billion or increased HK$993 per person). The savings in costs due to reduced DM-related complications after increasing one-time screening to triennial screening were much lower at HK$0.4 billion in total or HK$186 per person.

The increases in total costs of triennial screening when compared with one-time screening also resulted in more newly detected cases (28,580 persons), longer treatment time (additional 0.34, 0.04 and 0.11 year per DM patient in DM, HT, and HL treatment), longer life years gained (0.03 year per person), and longer QALYs gained (0.01 QALY per person). The incremental gains in life years and QALYs of triennial screening were relatively lower when compared to one-time screening, which also caused a relatively high ICER value of life years (HK$173,418) and QALY (HK$432,740), respectively.

As for DM-related complications, the average cost to avert a complication event (i.e., MI, CA, stroke, End-Stage Renal Disease, photocoagulation, blindness, and angina) could range from HK$11,115,421 to HK$536,874,819 per averted case, much higher than the values under two-time or one-time screening. The average cost per averted death due to DM complications in triennial screening could also reach a high value at HK$4,067,233 per averted death, when compared with one-time screening.

Finally, the comparative cost and effectiveness (measured by QALYs gained) of different screening strategies is shown in **Figure 2**. It also revealed a trend of increasing cost as well as QALY gained per person with higher frequency of screening in routine practice.

Table 11. Incremental cost and effectiveness of different screening strategies compared to no screening

	Unit	Incremental value (compared to no screening)			ICER (compared to no screening)		
		Triennial screening	**Two-time screening**	**One-time screening**	**Triennial screening**	**Two-time screening**	**One-time screening**
Total Cost (HK$)							
Screening cost	total population	6,524,200,057	3,008,098,158	1,652,222,000			
RAMP intervention	total population	122,466,392	91,280,033	86,040,227			
Routine care – DM	total population	6,344,672,401	4,723,487,574	4,449,921,596			
Routine care – HT/LP	total population	1,350,951,591	1,106,182,462	1,060,704,161			
Treatment on complications	total population	-1,506,966,846	-1,110,650,864	-1,096,768,629			
Total cost	total population	25,614,600,000	15,653,000,000	12,289,200,000			
Total cost (discounted)	total population	17,302,075,033	9,637,539,328	5,490,829,016			
Per person cost (HK$)							
Screening cost	per person	2,966	1,367	751			
RAMP intervention	per person	56	41	39			
Routine care – DM	per person	2,884	2,147	2,023			
Routine care – HT/LP	per person	614	503	482			
Treatment on complications	per person	-685	-505	-499			
Total cost	per person	11,643	7,115	5,586			
Total cost (discounted)	per person	7,865	4,381	2,496			
Effectiveness							
Frequency of screening	total number	8,687,235	4,005,404	2,200,000			

	per person	3.9	1.8	1.0			
Newly detected case	total number	82,271	57,453	53,691			
Survival years after onset of DM	per DM patient	0.32	0.24	0.22			
Treatment years during DM							
Diabetes	per DM patient	1.13	0.83	0.78			
Hypertension	per DM patient	0.28	0.25	0.24			
Lipid disorder	per DM patient	0.43	0.33	0.32			
Life years	total number	181,962	115,189	113,853	95,086	83,667	48,227
	per person	0.083	0.052	0.052			
QALYs	total number	83,503	57,177	56,209	207,203	168,557	97,686
	per person	0.038	0.026	0.026			
Incidence of complications (negative incremental values indicated better outcomes)							
Myocadiac infarction	total event	-6,970	-5,223	-4,721	2,482,506	1,845,282	1,163,016
Cardiac arrest	total event	-1,437	-805	-900	12,043,767	11,969,125	6,102,277
CA/MI	total person	-5,755	-3,940	-3,795	3,006,338	2,445,952	1,446,859
Stroke	total event	-7,825	-5,489	-5,399	2,211,015	1,755,791	1,017,046
LEA	total event	35	46	-70	dominated	dominated	77,994,730
Microalbuminuria	total person	1,910	1,564	1,659	dominated	dominated	dominated
Nephropathy	total person	1,377	1,239	1,003	dominated	dominated	dominated
End-Stage Renal Disease	total person	73	114	95	dominated	dominated	dominated
Peripheral Neuropathy	total person	231	207	117	dominated	dominated	dominated
Photocoagulation	total person	-1,395	-1,093	-926	12,404,700	8,814,285	5,928,341
Blindness	total person	-964	-642	-627	17,955,661	15,002,396	8,757,303
Angina	total person	-3,652	-2,596	-2,589	4,737,699	3,712,457	2,120,502
Mortality (negative incremental values indicated better outcomes)							
Death due to complication		-8,545	-5,691	-5,641	2,024,866	1,693,351	973,413
Death due to LEA event	total number	2	9	0	dominated	dominated	dominated
Death due to Stroke event	total number	-889	-739	-752	19,466,781	13,037,797	7,297,753

Death due to CA/MI event	total number	-2,138	-1,291	-1,269	8,091,131	7,462,861	4,325,531
Death due to Angina stage	total number	-1,778	-1,080	-1,265	9,733,391	8,921,995	4,340,576
Death due to ESRD	total number	59	101	64	dominated	dominated	dominated
Death due to CA/MI history	total number	-1,714	-1,168	-1,012	10,095,738	8,249,905	5,425,720
Death due to stroke history	total number	-2,088	-1,522	-1,406	8,287,228	6,330,491	3,905,839
Death due to others (DM)	total number	7,520	5,606	5,447	dominated	dominated	dominated
Death due to others (non-DM)	total number	488	242	55	dominated	dominated	dominated
Total death	total number	-537	156	-139	32,231,883	dominated	39,616,371

Note: CA, cardiac arrest; CHD, Coronary Heart Disease; DM, diabetes mellitus; ESRD, end-stage related disease; LEA, lower-extremity amputation; MI, myocardial infarction

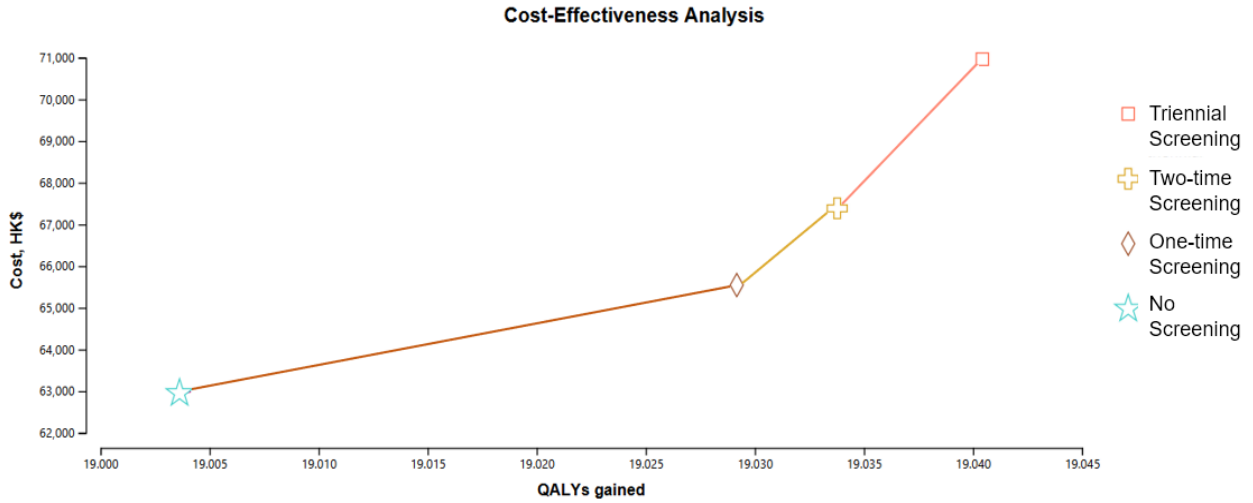

Figure 2. Comparative cost and effectiveness of four screening strategies

Sensitivity analysis and CEAC curve

One-way sensitivity analysis

One-way sensitivity analysis was conducted for different key parameters to investigate the variations in the comparative costs and effects of one-time screening and no screening. Results of one-way analysis were compiled in the Tornado diagram (**Figure 3**). We can see that among different factors associated with ICER values of per QALY gain, the cost of routine treatment for DM mattered most (positive relationship with ICER values), followed by the cost of screening (positive) and effects of DM intervention on clinical measurements (positive). In addition, the time lag between onset and diagnosis of diabetes in reality also affected the cost-effectiveness of the screening program, where more benefits could be derived from screening programs if such time lag was longer in routine practice (positive). Finally, lower diagnostic accuracy of screening tools, and the higher intervention cost of RAMP program were also associated with higher ICER values to a lesser extent. In summary, although the values of key parameters could vary widely, the according variations in ICER values of one-time screening in comparison to no screening were within an acceptable threshold (HK$75,000 to 125,000, lower than the common threshold for each gain in QALY [HK$54,000]).

Probability sensitivity analysis (PSA)

PSA was conducted based on the distribution of different parameters, using 1,000 interactions of a cohort of 500,000 individuals aged 45-64 years. The CEAC curve of selection between no screening, one-time screening, and triennial screening, is presented in **Figure 4**. We can see that when the willingness-to-pay (WTP) for each QALY gained was lower than HK$100,000, the probability of acceptance of no screening was higher than that of one-time screening strategy and triennial screening strategy. Within the WTP of HK$100,000 to HK$650,000, the probability of acceptance of one-time screening was higher than that of no screening or

triennial screening. When the WTP was higher than HK$650,000, the probability of accepting triennial screening surpassed that of one-time screening and no screening. When we choose a WTP as £50,000 (HK$540,000) for per QALY gain, the probability of one-time screening being cost-effective was 67%.

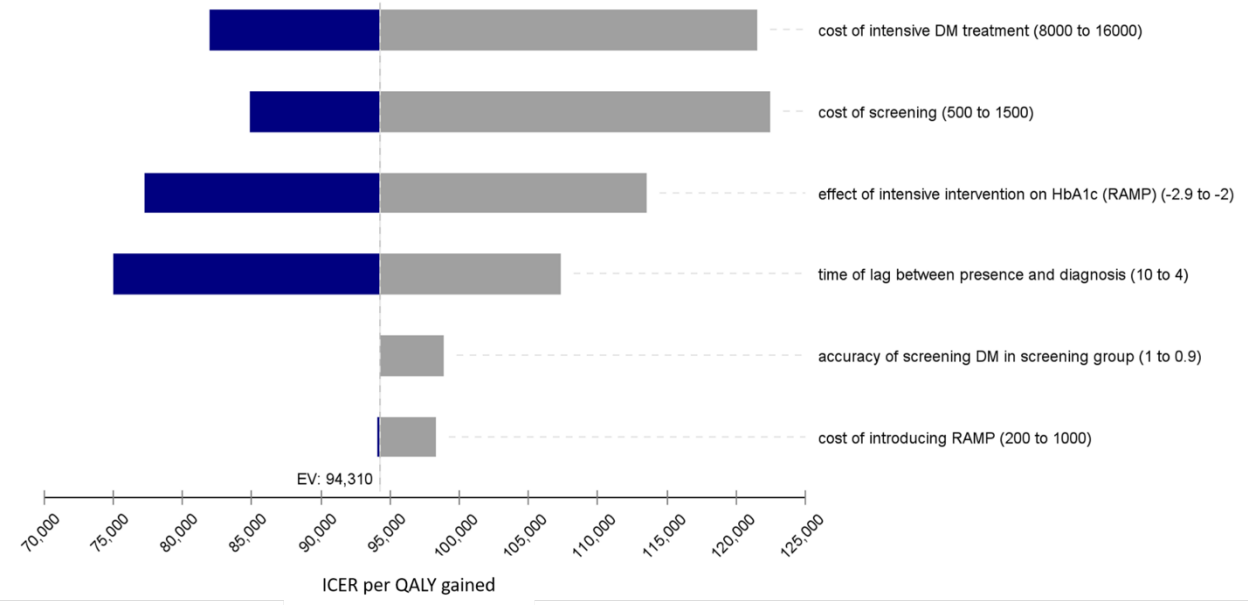

Figure 3. Tornado diagram based on one-way sensitivity (one-time screening vs. no screening)

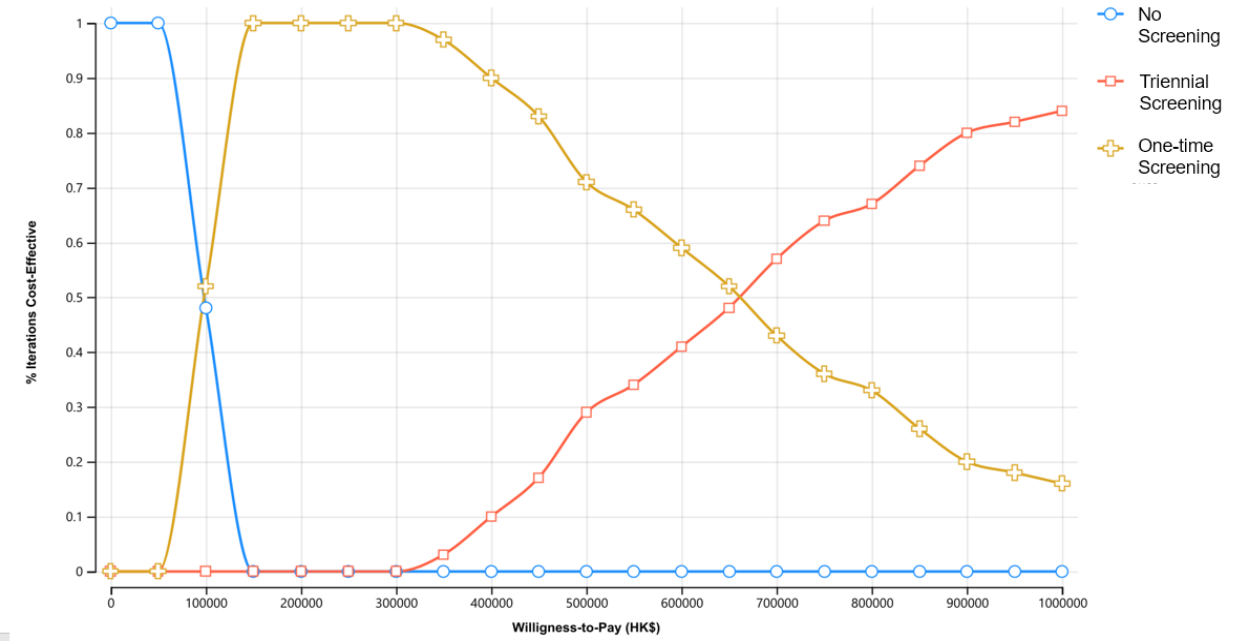

Figure 4. CEAC curve under different Willingness-to-Pay

(5) Policy implications and recommendations

Overall policy implications of the studies

Health systems around the world have been, and remain, oriented around acute and episodic care. These systems are challenged to cater for rapidly ageing populations in an effective and efficient manner - and concurrently, handle costly yet preventable chronic conditions requiring a lifecourse approach and complex interventions. Addressing this fundamental mismatch between health services provision and changing healthcare needs of the population requires health system reorientation and refocusing on new investments in primary care. The proposed programme draws on a wealth of evidence that has shown early detection through screening to encourage early disease management, delay disease progression, relieve hospital care burden and curb healthcare costs associated with chronic disease complications and is in response to the 2018 Chief Executive Policy Address calling for identification of measures to enhance primary care.

The proposed programme continues efforts to promote primary and preventive care learning from the experiences the Elderly Health Care Voucher Scheme (EHCVS) in the development of a targeted chronic disease screening and management programme for citizens aged 45 years or above. The expenditure of the EHCVS was HKD$2.8 billion in 2018, an increase from HKD$14 million in 2009. Yet, the EHCVS has not been effective in encouraging preventive care, and chronic disease management and has not reduced the demand on public healthcare services. Through a targeted approach, a clearer policy goal will be developed for the design of an effective programme and enable participants to bridge the knowledge gap that was inherent in the EHCVS design. Health literacy enhancement among members of the targeted population will foreseeably facilitate improvements in uptake of targeted screening and chronic disease management services.

Furthermore, enhanced awareness of the target population and increased uptake of related services by patients will enable continuity of care. The programme is expected to facilitate patients in developing doctor-patient relationship and long-term partnerships inherent in the family doctor approach which will lead to improvements in the quality of care and health outcomes. The role of primary care providers as gatekeepers of specialised services to decrease demand on hospital services will also be promoted.

Additionally, rooting from the economic theories of supply and demand, vouchers are an effective demand-side mechanism to encourage uptake of targeted services. The programme will be a useful instrument for involving the private sector through promoting public-private sector collaboration and redress the current segmentation of the health system. Market demand for needed preventive services will be induced while ensuring a steady supply of service providers through reallocation of unmet healthcare demand from the public to the private sector, thereby contributing to the shift towards a more sustainable health system in the long term.

Implications from qualitative studies

All service providers (physicians) agreed that the program could be an opportunistic approach to promote the message of and deliver preventive care. They foresaw that more patients would take up health screening with a free screening voucher. But they were skeptical of the potential of early screening in redirecting the flow of patients to private primary care because the choice of care is highly price sensitive. They commented that the benefits of early screening should outweigh the costs of ongoing expenses of care caused by other complications and comorbidities. They suggested the new voucher could adopt a similar design as the Elderly Healthcare Voucher, not only providing a financial incentive for the public to choose private healthcare services, but also enabling patient choice. Although some believed age 45 would be

appropriate for the program while some proposed to lower the age onset to 35 or 40 as their patients are showing symptoms of H-D-H as young as 35. They considered that the target age group (45-64) could be screened once every two years if the results are normal, whereas those who are identified as high-risk group should be screened every year. Besides targeting H-D-H, some proposed to include other risk factors e.g. uric acid, EKG, osteoporosis, cancer, liver diseases (fatty liver), anemia and mental health, which would be a more comprehensive assessment of a person's health profile, when resources are sufficient. A screening voucher amount of HKD 400 – 1,000 covering 2 consultations as well as lab fees would be reasonable and flexibility should be allowed for other added-value services. Another voucher for chronic disease management could be a standard package around HKD500 – 600/month based on the GOPC-PPP drug list, but a copayment should be allowed if brand name drugs were used. Ideally, the patient should be identified, screened, and managed by the same private GP. Most of them proposed GPs in the Primary Care Directory will need to be the first point of care. And further collaboration with the DHC may take a supplementary role in providing lifestyle modification and patient empower programs by a multidisciplinary team. To engage more GPs, the Government needs to streamline processes, paperwork, data entries, and documentation that are required in the current GOPC-PPP program. It was advised to use the drug list from GOPC-PPP given drug cost reduction. For upholding the service standard of GPs, service guidelines and chronic disease treatment protocol of delivering equal quality of care were essential. To increase the supply of family doctors, one proposed a 2-to-4-years family doctor training program for those that only wished to be qualified as a family doctor instead of being a specialist. CME is a good way to secure the necessary knowledge update continuously. To increase the take-up rate of the public, a well-coordinated and comprehensive chronic disease management program, would be a key initiative. An intensive assessment on the subsidy amount and service scope of the chronic disease management program, e.g. complication

screening, must be done before execution. Corresponding public health education on the benefits of early screening & lifestyle modification, the role of personal responsibility, accompanied by the clinical information of the prevalence of chronic diseases, would be further crucial to the take-up rate.

From qualitative studies among the general public, they indicated they have no habit to conduct regular body checks and are aware of their chronic disease situation via consultations for episodic illnesses. Presentation of vague symptoms, cost concerns, and mentality of health check avoidance are the main reasons for not being subject to disease screening although they have received healthcare education and information through media. All agreed the new initiative will be beneficial for individuals, caregivers, and the society. But only half of them expressed interest to join since they are enjoying similar services by company insurance benefits or seeking consultations in public GPOC. They appreciate the free voucher of the initiative and also accept the copayment arrangement of an affordable range. They thought the eligible age for the application should be 50-55. Furthermore, they urged the application and screening/consultation processes should be streamlined, time-saving, and hassle-free, which are particularly important to the working population. In return, they expected responsive services and a dedicated doctor follow up in the private sector. A put right of avoidance mentality of early screening is particularly critical and needs more education and promotion through different media channels. Also, a clear guideline of the eligible situation and service providers was essential to making it successful.

Turning to the qualitative study among the key stakeholders including interviews with government representatives, academics, policymakers and other key stakeholders in health policymaking, we found that there was general support for and willingness to strengthen primary care development through strategic purchasing and PPPs. Academic and policymaking stakeholders alike agreed that the current fragmentation in the health system between the public

and private sectors is unsustainable and unconducive to promoting health within the general population. The limited role of the private sector in engaging with the broader health needs and demands of the population leaves future room for improvement, especially as the specific financing mechanisms of the private sector act as a barrier to entry for many. Stakeholders agreed that reconfiguring the health financing mechanisms presently used can alleviate the burden on the public sector and push primary care forward. Nonetheless, primary care development cannot occur alone or solely through health financing reform. Rather, a multi-pronged approach is critical to creating the paradigm shift necessary for primary care implementation and uptake within the context of strategic purchasing. Policymakers and health system planners will need to educate the public on the benefits of primary care over a predominant reliance on specialist care. A long-term vision, with abundant planning and public engagement with patients and doctors alike, will be central to its success. Furthermore, management plans after screening will need to be well designed to achieve the population health impact that is desired. The design of future programmes such as a *chronic disease screening voucher and management scheme* should draw on lessons learnt from existing initiatives, including better defining targeted beneficiary groups and having in place defined regulations to prevent misuse.

Furthermore, from our telephone interviews of the general population., we found that the overall rates of having received at least one type, two types and all three types of screening tests were 81.1%, 80.7%, 79.3%, respectively. It has examined the factors independently associated with previous participation in screening for hypertension, diabetes and lipid disorders; and their willingness to join the voucher scheme for screening. Based on this study, it was found that female individuals and those with family history of cardiovascular diseases were most willing to receive hypertension, diabetes and lipid disorder screening as compared to other individual factors. Policymakers should allocate more resources on screening towards

male as well as those without any family history. The awareness of the general population on screening of these cardiovascular risk factors could be enhanced through health education, promotion campaigns, and incentives to increase screening uptake. These constructs and independent predictors identified provide evidence-based formulation and implementation of screening strategies that aim to enhance screening uptake, and thus lower the impact of hypertension, diabetes and lipid disorder to the healthcare system in the future.

In addition, the cost-effectiveness analyses indicate that a healthcare voucher screening program for diabetes, hypertension, and lipid disorder screening among individuals aged 45-64 in Hong Kong is likely to be cost-effective. The excellent current RAMP (DM, HT) program was the main reason for these positive results, as previous studies demonstrated its clinical effectiveness and cost-effectiveness [6, 13, 14]. Our estimated ICER per QALY (HK$97,686 per QALY gained) was comparable to earlier studies in other countries, including the UK (£14,150 per QALY gained) [15] and the US ($34,375, $33,800, or $48,500 per QALY gained) [3, 16].

The design of screening programs for DM and related diseases should also consider the frequency of screening. Our results indicate that more frequent screening (triennial vs. one-off screening) can lead to more newly detected cases, more reductions in diabetes-related complications (mainly coronary heart disease, stroke, angina, photocoagulation, and blindness) and complication-related death, and more benefits on life year and QALY gains. Nevertheless, the incremental cost and resources required to input also increase in a substantial manner. For example, the number of screening tests needed to detect a new case increased from 41 under one-time screening to 106 under triennial screening, and the related cost per detection increased from HK$30,733 to HK$79,301 (while the total screening cost increased from HK$1.6billion to HK$6.5billion), accordingly. Our analyses support the selection of a one-off screening strategy rather than the triennial or two-time screening strategy for the moment, regarding the

ICER values per life-year gain, per QALY gain, per diabetes-related complication inverted, and death due to complication inverted.

Despite the CEA results favor a population-based screening program, policymakers need to consider factors related to the feasibility of such implementations. For example, the increase of DM patients due to the early detection by the screening will cause a higher demand of health care providers (doctors and nurses). The general outpatient services in public sectors, which general practitioners and community nurses provide, served over 200,000 patients (enrolees) with diabetes or hypertension through the RAMP program [17]. Today, there are ~200 nurses working in general outpatient clinics (GOPC) in the New Territory East Clusters. Assuming all clusters have on average similar number of GOPC nurses, then the total GOPC nurses will be 1,400. Thus the ratio of DM patients and nurses is approximately 142:1. Based on our estimates, the one-off screening will add 53,691 (26.8% additional demands) new DM patients. To keep the DM patient-nurse ratio, Hospital Authority will need to provide 375.2 GOPC nurses vacancy, not to mention GOPC doctors. Furthermore, some participants will be screened as pre-DM patients (with impaired glucose tolerance) and require interventions (e.g., lifestyle modification, glucose control).

The CEA is based on the assumption that all patients with diabetes, hypertension, and hyperlipidemia will receive treatments (RAMP program) in public sector. Services in private sectors among the population are not considered in this model. Departing on the design future studies are needed to investigate the roles played by the private sectors in caring for patients with diabetes, hypertension, and hyperlipidemia, and costs of the public-private partnership in providing screening and treatment services.

Because no local data is available we also assumed that no patients would receive treatment during the first five years after the disease onset unless they were screened positive and that all participants with the disease onset of diabetes in our model would start with mild symptoms (HbA1c=6.8%), which may not conform to the real-world situation. Further studies will be needed to estimate the disease profile of the newly detected cases.

Policy Implications

I. In the design of a chronic disease screening and management voucher the eligible population age group has to be first ascertained and estimates of the number of persons covered and how they will be phased in will need to be considered. Taking reference to the Colonic Cancer Screening, if the population age group envisaged is 45-64, the first cohort to be screened could be the population aged 45 initially adding older age groups gradually when capacity and experience has been built up and recurrent resources secured. This could be justified on the basis of the objective of early detection. Whether patients already diagnosed, either already on treatment or not under care should be included needs to be considered.

   The likely disease profile of the cohort who opt to be screened needs to be estimated to predict the likely resources and organisation of the program.

   The voucher would be an effective demand side instrument to incentivise screening but may not be the best instrument for chronic disease management in view of the complexities of the patient profiles and corresponding needs. A supply side instrument such as contracting may be better suited.

II. The capacity and capability of the healthcare system will need to be assessed to match the new demands generated from early diagnosis and detection of new cases in excess of the numbers currently presenting. Screening capacity is likely to be less problematic and

can be planned for. However, the chronic disease program will be substantially more demanding as many more patients at different stages of their disease will be identified and will need well designed disease guidelines and clinical management programs to optimise outcomes and will need to be followed up through their life course preferably by the same physician. Clinical referrals protocols between specialists and primary care physicians will also be needed for coordination and integration of care as disease may still progress as part of the natural history despite effective management. The primary care workforce will have to be developed to meet the challenges and new training programs and carer structures will need to be considered.

III. The organisation of the healthcare system in response to the new demand and requirements will need to be considered to ensure the facilities, capacity, capabilities and coordination of care between the public and private sectors and between primary and specialist care is effective

IV. The set up costs and the recurrent costs will be substantial and need to be estimated and secured, based on the population groups to be covered. Screening programs are more likely to be successful if no co-payments are involved. However, co-payments could be considered based on capacity and willingness-to-pay.

Recommendations

I. Further studies are needed to estimate the take up rate of the population age group to be considered for a chronic disease screening and management program and to research the disease profile of the newly detected patients to assess the resources and organisation needed.

II. New studies are also required to have a more precise projection of natural disease progression and of the new model of care as the estimates in this study have been based

on the RAMP program in the Hospital Authority which is the only data source available that best matches the intervention proposed for the program and needs to be supplement from a wider study.

III. Detailed studies will be needed to assess gaps in the current capacity and capability which should include workforce, training, facilities, equipment and infrastructure from that needed for the program planned and how this could be planned for and met.

IV. Further in studies of the resources required with varying scenarios of costs and their sources and payment mechanisms would need to be conducted to ensure financial sustainability and should include willingness-to-pay for chronic disease management.

V. The design of the program should be constructed with input from all stakeholders and importantly with engagement of patients. Piloting of the program would enable evaluation of implementation barriers and facilitators for scaling up.

Limitation

This study has several limitations which could affect the findings. Firstly, the quantitative survey mainly included subjects with fixed telephone lines, and hence those who with mobile phones only could not be interviewed. This might lead to a potential selection bias. In addition, all the responses to the questionnaire items were self-reported. Family history of chronic diseases might be under-reported if the family members have not received regular health assessment or disclosed their medical history to the participants. In addition, the cost-effectiveness analysis used figures which are based on assumptions, and therefore cautious is needed in the application in real-life settings.

(6) Details of the public dissemination held

The findings of the Study (2) have been presented in the Diabetes Preventing the Preventables (DPP) virtual Forum (02 May, 2021). The title of the speech is: “Screening for blood glucose and lipids among Hong Kong people.”

(7) Conclusion

The study of the perceptions and cost-effectiveness of a voucher for chronic disease screening and disease management to redress the public-private imbalances in Hong Kong's segmented healthcare system found overwhelming support from key stakeholders including the general population, primary care practitioners, healthcare providers and policy makers. There is a consensus the voucher for chronic disease screening would be of benefit in encouraging preventive care - early detection of chronic disease, timely and effective management of chronic disease, reduce disabilities and improve the health of the population, patients and their carers. This would also reduce the demand for healthcare from the prevalence of chronic diseases associated with an ageing population. The voucher is an effective demand side instrument to incentivise screening. However, in view of the complexities of the clinical and socio-economic profiles of patients with chronic disease, a supply side instrument of 'contracting' is better suited. Cost-effectiveness analyses estimated the ICER per QALY of HK$97,686 per QALY gained to be comparable to that found in a number of other jurisdictions, and can be considered cost-effective contingent on the willingness-to-pay. There was also support for the use of strategic purchasing in the prioritisation of healthcare services needed, with public private partnership for the development of primary care in the healthcare system.

With the experiences of the public sector in population-based screening programs, capacity and capability exists. It is recommended that resources should be secured and planning for the program should proceed as a priority. The design, funding and implementation of a population chronic disease management program is more complex - but should nevertheless be considered as a matter of priority, as this is critical to address the structural problems of Hong Kong's segmented health system, the challenges of an ageing population and the sub-optimal development of the primary care system.

Further studies are needed to inform the design and implementation of this chronic diseases program, which may include:

[i] Estimates of the likely uptake rate, the disease profile, and willingness-to pay for chronic disease screening;

[ii] Projection of chronic disease progression, clinical management and referral guidelines, patient care pathways and reorienting models of health service delivery;

[iii] Assessment of the current capacity and capability to meet the demand generated from early detection of chronic disease. This should include workforce, training, facilities, equipment and infrastructure;

[iv] Estimates of the resources, their sources, and the payment mechanisms to ensure financial sustainability and value for money; and

[v] Piloting of the program to evaluate barriers and facilitators for scaling up.

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Appendix

Table A1. General population distribution

Age group	Number (1,000)	Excluding diagnosed diabetes (1,000)	Proportion among 45-64	Female	Male
45-49	546.3	532.6	24.2%	56%	44%
50-54	537.3	507.7	23.1%	55%	45%
55-59	637.4	602.3	27.4%	53%	47%
60-64	587.8	555.5	25.3%	50%	50%

Table A2. Prevalence of diagnosed and undiagnosed diabetes

Age group	Total[a]			Female[a]			Male[a]		
	Undetected diabetes	Pre-diabetes	Normal	Undetected diabetes	Pre-diabetes	Normal	Undetected diabetes	Pre-diabetes	Normal
45-54	5.0%	8.1%	86.9%	3.6%	8.0%	88.4%	6.8%	8.3%	84.9%
55-59	7.2%	8.4%	84.4%	5.0%	8.2%	86.8%	9.7%	8.6%	81.8%
60-64	7.2%	20.2%	72.6%	5.0%	19.7%	75.3%	9.5%	20.7%	69.8%

a. total population already excluded cases with already diagnosed diabetes

Table A3. Prevalence of hypertension among patients with diabetes

Age group	All population		Diabetes	
	female	male	female	male
45-54	13.2%	13.0%	29.3%	28.8%
55-59	28.1%	27.7%	56.2%	61.3%
60-64	28.1%	27.7%	56.3%	61.3%

Note: Prevalence of hypertension among diabetes was calculated based on RR from CHEUNG et al. (2008)'s study.

Table A4. Blood pressure level at start

Age group	No Hypertension		Hypertension	
	Systolic Blood Pressure	Diastolic Blood Pressure	Systolic Blood Pressure	Diastolic Blood Pressure
45–54	122	76	168	93
55-59	128	74	164	92
60-64	128	74	164	92

Table A5. Prevalence of hyperlipidaemia

Age group	Female (abnormal)	Male (abnormal)	Total (abnormal)
45–54	33.50%	46.00%	39.10%
55-59	55.00%	60.30%	57.40%
60-64	55.00%	60.30%	57.40%

Note: Borderline high or above (abnormal): total cholesterol in S.I. unit ⩾ 5.2 mmol/L

Table A6. Total cholesterol at start

Age group	mg/dL		SI units (mmol/L)	
	Normal	Abnormal	Normal	Abnormal
45–54	174	238	4.49964	6.15468
55-59	175	243	4.5255	6.28398
60-64	175	243	4.5255	6.28398

Note: conversion rate from mg/DL to SI units: 0.02586

Table A7. Incidence of DM and pre-DM (2014)

Age group	Female		Male	
	DM incidence	pre-DM incidence	DM incidence	pre-DM incidence
45-54	0.77%	1.80%	1.10%	1.89%
55-59	0.76%	1.80%	1.09%	1.89%
60-64	1.68%	4.47%	2.40%	4.69%
65-79	1.68%	4.47%	2.40%	4.69%
80-84	1.99%	4.68%	2.84%	4.91%
85-100	2.06%	4.70%	2.94%	4.94%

Table A8. Mortality rate of general population (2018)

Mortality rate	per 1000		%	
	Male	Female	Male	Female
45 - 49	1.9	1.1	0.19%	0.11%
50 - 54	3.2	1.8	0.32%	0.18%
55 - 59	4.7	2.6	0.47%	0.26%
60 - 64	7.7	3.7	0.77%	0.37%
65 - 69	12.2	5.5	1.22%	0.55%
70 - 74	19.3	8.7	1.93%	0.87%
75 - 79	34	15.5	3.40%	1.55%
80 - 84	55.3	31.8	5.53%	3.18%
85+	115.5	83.9	11.55%	8.39%

Table A9. Transition probability

(a) Normal to microalbuminuria

AT 3.1 Norm	Female	Female	Female	Female	Female	Female	Female	Female	Female	Female	Male	Male	Male	Male	Male	Male	Male	Male	Male	Male
Ne1 to Ne2	HT	HT	HT	HT	HT	no HT	no HT	no HT	no HT	no HT	HT	HT	HT	HT	HT	no HT	no HT	no HT	no HT	no HT
	0–5y	6-10y	11-15y	16-20y	>21y	0–5y	6-10y	11-15y	16-20y	>21y	0–5y	6-10y	11-15y	16-20y	>21y	0–5y	6-10y	11-15y	16-20y	>21y
	HT_0–5y_	HT_6-10y_	HT_11-15	HT_16-20	HT_>21y_	no HT_0–!	no HT_6-1	no HT_11-	no HT_16-	no HT_>2	HT_0–5y_	HT_6-10y_	HT_11-15	HT_16-20	HT_>21y_	no HT_0–!	no HT_6-1	no HT_11-	no HT_16-	no HT_
45-54 y	0.042	0.042	0.042	0.042	0.042	0.033	0.033	0.033	0.033	0.033	0.046	0.046	0.046	0.046	0.046	0.041	0.041	0.041	0.041	0.041
55-64 y	0.035	0.035	0.035	0.035	0.035	0.031	0.031	0.031	0.031	0.031	0.042	0.042	0.042	0.042	0.042	0.037	0.037	0.037	0.037	0.037
65-74 y	0.045	0.045	0.045	0.045	0.045	0.041	0.041	0.041	0.041	0.041	0.043	0.043	0.043	0.043	0.043	0.042	0.042	0.042	0.042	0.042
75-84 y	0.059	0.059	0.059	0.059	0.059	0.057	0.057	0.057	0.057	0.057	0.058	0.058	0.058	0.058	0.058	0.056	0.056	0.056	0.056	0.056

(b) Microalbuminuria to clinical nephropathy

AT 3.4 Microalbumi	Female	Female	Female	Female	Female	Female	Female	Female	Female	Female	Male	Male	Male	Male	Male	Male	Male	Male	Male	Male
Ne2 to Ne3	HT	HT	HT	HT	HT	no HT	no HT	no HT	no HT	no HT	HT	HT	HT	HT	HT	no HT	no HT	no HT	no HT	no HT
	0–5y	6-10y	11-15y	16-20y	>21y	0–5y	6-10y	11-15y	16-20y	>21y	0–5y	6-10y	11-15y	16-20y	>21y	0–5y	6-10y	11-15y	16-20y	>21y
	HT_0–5y_	HT_6-10y_	HT_11-15	HT_16-20	HT_>21y_	no HT_0–!	no HT_6-1	no HT_11-	no HT_16-	no HT_>2	HT_0–5y_	HT_6-10y_	HT_11-15	HT_16-20	HT_>21y_	no HT_0–!	no HT_6-1	no HT_11-	no HT_16-	no HT_>21
15-24 y	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019
25-34 y	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019
35-44 y	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019
45-54 y	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019
55-64 y	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019
65-74 y	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019
75-84 y	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019
subtotal	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019

(c) Nephropathy to end-stage disease

AT 3.7-3.11 Nephrop	Female	Female	Female	Female	Female	Female	Female	Female	Female	Female	Male	Male	Male	Male	Male	Male	Male	Male	Male	Male
Ne3 to Ne4	HT	HT	HT	HT	HT	no HT	no HT	no HT	no HT	no HT	HT	HT	HT	HT	HT	no HT	no HT	no HT	no HT	no HT
	0–5y	6-10y	11-15y	16-20y	>21y	0–5y	6-10y	11-15y	16-20y	>21y	0–5y	6-10y	11-15y	16-20y	>21y	0–5y	6-10y	11-15y	16-20y	>21y
	HT_0–5y_	HT_6-10y_	HT_11-15	HT_16-20	HT_>21y_	no HT_0–!	no HT_6-1	no HT_11-	no HT_16-	no HT_>2	HT_0–5y_	HT_6-10y_	HT_11-15	HT_16-20	HT_>21y_	no HT_0–!	no HT_6-1	no HT_11-	no HT_16-	no HT_>21
15-24 y	0.022	0.022	0.022	0.022	0.022	0.022	0.022	0.022	0.022	0.022	0.022	0.022	0.022	0.022	0.022	0.022	0.022	0.022	0.022	0.022
25-34 y	0.022	0.022	0.022	0.022	0.022	0.022	0.022	0.022	0.022	0.022	0.022	0.022	0.022	0.022	0.022	0.022	0.022	0.022	0.022	0.022
35-44 y	0.022	0.022	0.022	0.022	0.022	0.022	0.022	0.022	0.022	0.022	0.022	0.022	0.022	0.022	0.022	0.022	0.022	0.022	0.022	0.022
45-54 y	0.022	0.022	0.022	0.022	0.022	0.022	0.022	0.022	0.022	0.022	0.022	0.022	0.022	0.022	0.022	0.022	0.022	0.022	0.022	0.022
55-64 y	0.022	0.022	0.022	0.022	0.022	0.022	0.022	0.022	0.022	0.022	0.022	0.022	0.022	0.022	0.022	0.022	0.022	0.022	0.022	0.022
65-74 y	0.022	0.022	0.022	0.022	0.022	0.022	0.022	0.022	0.022	0.022	0.022	0.022	0.022	0.022	0.022	0.022	0.022	0.022	0.022	0.022
75-84 y	0.022	0.022	0.022	0.022	0.022	0.022	0.022	0.022	0.022	0.022	0.022	0.022	0.022	0.022	0.022	0.022	0.022	0.022	0.022	0.022

(d) Normal to peripheral neuropathy

AT 4.1 Normal to pe	Female	Female	Female	Female	Female	Female	Female	Female	Female	Female	Male	Male	Male	Male	Male	Male	Male	Male	Male	Male
N1 to N2	HT	HT	HT	HT	HT	no HT	no HT	no HT	no HT	no HT	HT	HT	HT	HT	HT	no HT	no HT	no HT	no HT	no HT
	0–5y	6-10y	11-15y	16-20y	>21y	0–5y	6-10y	11-15y	16-20y	>21y	0–5y	6-10y	11-15y	16-20y	>21y	0–5y	6-10y	11-15y	16-20y	>21y
	HT_0–5y_	HT_6-10y_	HT_11-15	HT_16-20	HT_>21y_	no HT_0–!	no HT_6-1	no HT_11-	no HT_16-	no HT_>2	HT_0–5y_	HT_6-10y_	HT_11-15	HT_16-20	HT_>21y_	no HT_0–!	no HT_6-1	no HT_11-	no HT_16-	no HT_>21
15-24 y	0	0	0	0	0	0.00505	0.00505	0.00505	0.00505	0.00505	0	0	0	0	0	0	0	0	0	0
25-34 y	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
35-44 y	0.00123	0.00123	0.00123	0.00123	0.00123	0.00048	0.00048	0.00048	0.00048	0.00048	0.00318	0.00318	0.00318	0.00318	0.00318	0.00198	0.00198	0.00198	0.00198	0.00198
45-54 y	0.00062	0.00062	0.00062	0.00062	0.00062	0.00058	0.00058	0.00058	0.00058	0.00058	0.00178	0.00178	0.00178	0.00178	0.00178	0.002	0.002	0.002	0.002	0.002
55-64 y	0.00107	0.00107	0.00107	0.00107	0.00107	0.00125	0.00125	0.00125	0.00125	0.00125	0.00244	0.00244	0.00244	0.00244	0.00244	0.00245	0.00245	0.00245	0.00245	0.00245
65-74 y	0.00228	0.00228	0.00228	0.00228	0.00228	0.00231	0.00231	0.00231	0.00231	0.00231	0.00299	0.00299	0.00299	0.00299	0.00299	0.00325	0.00325	0.00325	0.00325	0.00325
75-84 y	0.00453	0.00453	0.00453	0.00453	0.00453	0.00453	0.00453	0.00453	0.00453	0.00453	0.0045	0.0045	0.0045	0.0045	0.0045	0.00493	0.00493	0.00493	0.00493	0.00493
subtotal	0.00228	0.00228	0.00228	0.00228	0.00228	0.00216	0.00216	0.00216	0.00216	0.00216	0.00296	0.00296	0.00296	0.00296	0.00296	0.00301	0.00301	0.00301	0.00301	0.00301

(e) Peripheral neuropathy to lower-extremity amputation

AT 4.2-4.6 Peripher	Female	Female	Female	Female	Female	Female	Female	Female	Female	Female	Male	Male	Male	Male	Male	Male	Male	Male	Male	Male
N2 to LEA	HT	HT	HT	HT	HT	no HT	no HT	no HT	no HT	no HT	HT	HT	HT	HT	HT	no HT	no HT	no HT	no HT	no HT
	0–5y	6-10y	11-15y	16-20y	>21y	0–5y	6-10y	11-15y	16-20y	>21y	0–5y	6-10y	11-15y	16-20y	>21y	0–5y	6-10y	11-15y	16-20y	>21y
	HT_0–5y_	HT_6-10y_	HT_11-15	HT_16-20	HT_>21y_	no HT_0–!	no HT_6-1	no HT_11-	no HT_16-	no HT_>2	HT_0–5y_	HT_6-10y_	HT_11-15	HT_16-20	HT_>21y_	no HT_0–!	no HT_6-1	no HT_11-	no HT_16-	no HT_>21
15-24 y	0.0067	0.0067	0.0067	0.0067	0.0067	0.0067	0.0067	0.0067	0.0067	0.0067	0.0067	0.0067	0.0067	0.0067	0.0067	0.0067	0.0067	0.0067	0.0067	0.0067
25-34 y	0.0067	0.0067	0.0067	0.0067	0.0067	0.0067	0.0067	0.0067	0.0067	0.0067	0.0067	0.0067	0.0067	0.0067	0.0067	0.0067	0.0067	0.0067	0.0067	0.0067
35-44 y	0.0067	0.0067	0.0067	0.0067	0.0067	0.0067	0.0067	0.0067	0.0067	0.0067	0.0067	0.0067	0.0067	0.0067	0.0067	0.0067	0.0067	0.0067	0.0067	0.0067
45-54 y	0.0067	0.0067	0.0067	0.0067	0.0067	0.0067	0.0067	0.0067	0.0067	0.0067	0.0067	0.0067	0.0067	0.0067	0.0067	0.0067	0.0067	0.0067	0.0067	0.0067
55-64 y	0.0067	0.0067	0.0067	0.0067	0.0067	0.0067	0.0067	0.0067	0.0067	0.0067	0.0067	0.0067	0.0067	0.0067	0.0067	0.0067	0.0067	0.0067	0.0067	0.0067
65-74 y	0.0067	0.0067	0.0067	0.0067	0.0067	0.0067	0.0067	0.0067	0.0067	0.0067	0.0067	0.0067	0.0067	0.0067	0.0067	0.0067	0.0067	0.0067	0.0067	0.0067
75-84 y	0.0067	0.0067	0.0067	0.0067	0.0067	0.0067	0.0067	0.0067	0.0067	0.0067	0.0067	0.0067	0.0067	0.0067	0.0067	0.0067	0.0067	0.0067	0.0067	0.0067
subtotal	0.0067	0.0067	0.0067	0.0067	0.0067	0.0067	0.0067	0.0067	0.0067	0.0067	0.0067	0.0067	0.0067	0.0067	0.0067	0.0067	0.0067	0.0067	0.0067	0.0067

(f) Probability of additional amputations

AT 4.7 Probability o	Female	Female	Female	Female	Female	Female	Female	Female	Female	Female	Male	Male	Male	Male	Male	Male	Male	Male	Male	Male
N3 to LEA	HT	HT	HT	HT	HT	no HT	no HT	no HT	no HT	no HT	HT	HT	HT	HT	HT	no HT	no HT	no HT	no HT	no HT
	0–5y	6-10y	11-15y	16-20y	>21y	0–5y	6-10y	11-15y	16-20y	>21y	0–5y	6-10y	11-15y	16-20y	>21y	0–5y	6-10y	11-15y	16-20y	>21y
	HT_0–5y_	HT_6-10y_	HT_11-15	HT_16-20	HT_>21y_	no HT_0–!	no HT_6-1	no HT_11-	no HT_16-	no HT_>2	HT_0–5y_	HT_6-10y_	HT_11-15	HT_16-20	HT_>21y_	no HT_0–!	no HT_6-1	no HT_11-	no HT_16-	no HT_>21
15-24 y	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11
25-34 y	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11
35-44 y	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11
45-54 y	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11
55-64 y	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11
65-74 y	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11
75-84 y	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11
subtotal	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11

(g) Death from LEA

Death from LEA	Female HT 0–5y HT_0–5y_	Female HT 6-10y HT_6-10y_	Female HT 11-15y HT_11-15	Female HT 16-20y HT_16-20	Female HT >21y HT_>21y_	Female no HT 0–5y no HT_0–5	Female no HT 6-10y no HT_6-1	Female no HT 11-15y no HT_11	Female no HT 16-20y no HT_16	Female no HT >21y no HT_>2	Male HT 0–5y HT_0–5y_	Male HT 6-10y HT_6-10y_	Male HT 11-15y HT_11-15	Male HT 16-20y HT_16-20	Male HT >21y HT_>21y_	Male no HT 0–5y no HT_0–5	Male no HT 6-10y no HT_6-1	Male no HT 11-15y no HT_11	Male no HT 16-20y no HT_16	Male no HT >21y no HT_>21
15-24 y	0.105	0.105	0.105	0.105	0.105	0.105	0.105	0.105	0.105	0.105	0.105	0.105	0.105	0.105	0.105	0.105	0.105	0.105	0.105	0.105
25-34 y	0.105	0.105	0.105	0.105	0.105	0.105	0.105	0.105	0.105	0.105	0.105	0.105	0.105	0.105	0.105	0.105	0.105	0.105	0.105	0.105
35-44 y	0.105	0.105	0.105	0.105	0.105	0.105	0.105	0.105	0.105	0.105	0.105	0.105	0.105	0.105	0.105	0.105	0.105	0.105	0.105	0.105
45-54 y	0.105	0.105	0.105	0.105	0.105	0.105	0.105	0.105	0.105	0.105	0.105	0.105	0.105	0.105	0.105	0.105	0.105	0.105	0.105	0.105
55-64 y	0.105	0.105	0.105	0.105	0.105	0.105	0.105	0.105	0.105	0.105	0.105	0.105	0.105	0.105	0.105	0.105	0.105	0.105	0.105	0.105
65-74 y	0.105	0.105	0.105	0.105	0.105	0.105	0.105	0.105	0.105	0.105	0.105	0.105	0.105	0.105	0.105	0.105	0.105	0.105	0.105	0.105
75-84 y	0.105	0.105	0.105	0.105	0.105	0.105	0.105	0.105	0.105	0.105	0.105	0.105	0.105	0.105	0.105	0.105	0.105	0.105	0.105	0.105
subtotal	0.105	0.105	0.105	0.105	0.105	0.105	0.105	0.105	0.105	0.105	0.105	0.105	0.105	0.105	0.105	0.105	0.105	0.105	0.105	0.105

(h) Normal to photocoagulation

AT 5.1 Normal to pH R1 to R2	Female HT 0–5y HT_0–5y_	Female HT 6-10y HT_6-10y_	Female HT 11-15y HT_11-15	Female HT 16-20y HT_16-20	Female HT >21y HT_>21y_	Female no HT 0–5y no HT_0–5	Female no HT 6-10y no HT_6-1	Female no HT 11-15y no HT_11	Female no HT 16-20y no HT_16	Female no HT >21y no HT_>2	Male HT 0–5y HT_0–5y_	Male HT 6-10y HT_6-10y_	Male HT 11-15y HT_11-15	Male HT 16-20y HT_16-20	Male HT >21y HT_>21y_	Male no HT 0–5y no HT_0–5	Male no HT 6-10y no HT_6-1	Male no HT 11-15y no HT_11	Male no HT 16-20y no HT_16	Male no HT >21y no HT_>21
15-24 y	0.0166	0.0166	0.0166	0.0166	0.0166	0.011	0.011	0.011	0.011	0.011	0.0166	0.0166	0.0166	0.0166	0.0166	0.011	0.011	0.011	0.011	0.011
25-34 y	0.0166	0.0166	0.0166	0.0166	0.0166	0.011	0.011	0.011	0.011	0.011	0.0166	0.0166	0.0166	0.0166	0.0166	0.011	0.011	0.011	0.011	0.011
35-44 y	0.0166	0.0166	0.0166	0.0166	0.0166	0.011	0.011	0.011	0.011	0.011	0.0166	0.0166	0.0166	0.0166	0.0166	0.011	0.011	0.011	0.011	0.011
45-54 y	0.0166	0.0166	0.0166	0.0166	0.0166	0.011	0.011	0.011	0.011	0.011	0.0166	0.0166	0.0166	0.0166	0.0166	0.011	0.011	0.011	0.011	0.011
55-64 y	0.0166	0.0166	0.0166	0.0166	0.0166	0.011	0.011	0.011	0.011	0.011	0.0166	0.0166	0.0166	0.0166	0.0166	0.011	0.011	0.011	0.011	0.011
65-74 y	0.0166	0.0166	0.0166	0.0166	0.0166	0.011	0.011	0.011	0.011	0.011	0.0166	0.0166	0.0166	0.0166	0.0166	0.011	0.011	0.011	0.011	0.011
75-84 y	0.0166	0.0166	0.0166	0.0166	0.0166	0.011	0.011	0.011	0.011	0.011	0.0166	0.0166	0.0166	0.0166	0.0166	0.011	0.011	0.011	0.011	0.011

(i) Photocoagulation to Blindness

AT5.2 Photocoagula	Female	Female	Female	Female	Female	Female	Female	Female	Female	Female	Male	Male	Male	Male	Male	Male	Male	Male	Male	Male
R2 to R3	HT	HT	HT	HT	HT	no HT	no HT	no HT	no HT	no HT	HT	HT	HT	HT	HT	no HT	no HT	no HT	no HT	no HT
	0–5y	6-10y	11-15y	16-20y	>21y	0–5y	6-10y	11-15y	16-20y	>21y	0–5y	6-10y	11-15y	16-20y	>21y	0–5y	6-10y	11-15y	16-20y	>21y
	HT_0–5y_	HT_6-10y_	HT_11-15	HT_16-20	HT_>21y_	no HT_0–!	no HT_6-1	no HT_11-	no HT_16-	no HT_>2	HT_0–5y_	HT_6-10y_	HT_11-15	HT_16-20	HT_>21y_	no HT_0–!	no HT_6-1	no HT_11-	no HT_16-	no HT_>21
15-24 y	0.101	0.101	0.101	0.101	0.101	0.101	0.101	0.101	0.101	0.101	0.101	0.101	0.101	0.101	0.101	0.101	0.101	0.101	0.101	0.101
25-34 y	0.101	0.101	0.101	0.101	0.101	0.101	0.101	0.101	0.101	0.101	0.101	0.101	0.101	0.101	0.101	0.101	0.101	0.101	0.101	0.101
35-44 y	0.101	0.101	0.101	0.101	0.101	0.101	0.101	0.101	0.101	0.101	0.101	0.101	0.101	0.101	0.101	0.101	0.101	0.101	0.101	0.101
45-54 y	0.101	0.101	0.101	0.101	0.101	0.101	0.101	0.101	0.101	0.101	0.101	0.101	0.101	0.101	0.101	0.101	0.101	0.101	0.101	0.101
55-64 y	0.101	0.101	0.101	0.101	0.101	0.101	0.101	0.101	0.101	0.101	0.101	0.101	0.101	0.101	0.101	0.101	0.101	0.101	0.101	0.101
65-74 y	0.101	0.101	0.101	0.101	0.101	0.101	0.101	0.101	0.101	0.101	0.101	0.101	0.101	0.101	0.101	0.101	0.101	0.101	0.101	0.101
75-84 y	0.101	0.101	0.101	0.101	0.101	0.101	0.101	0.101	0.101	0.101	0.101	0.101	0.101	0.101	0.101	0.101	0.101	0.101	0.101	0.101
subtotal	0.101	0.101	0.101	0.101	0.101	0.101	0.101	0.101	0.101	0.101	0.101	0.101	0.101	0.101	0.101	0.101	0.101	0.101	0.101	0.101

(j) Normal to CHD

AT 6.1 Normal to CHI	Female	Female	Female	Female	Female	Female	Female	Female	Female	Female	Male	Male	Male	Male	Male	Male	Male	Male	Male	Male
C1 to C2: p3 (CA)	HT	HT	HT	HT	HT	no HT	no HT	no HT	no HT	no HT	HT	HT	HT	HT	HT	no HT	no HT	no HT	no HT	no HT
	0–5y	6-10y	11-15y	16-20y	>21y	0–5y	6-10y	11-15y	16-20y	>21y	0–5y	6-10y	11-15y	16-20y	>21y	0–5y	6-10y	11-15y	16-20y	>21y
	HT_0–5y_	HT_6-10y_	HT_11-15	HT_16-20	HT_>21y_	no HT_0–!	no HT_6-1	no HT_11-	no HT_16-	no HT_>2	HT_0–5y_	HT_6-10y_	HT_11-15	HT_16-20	HT_>21y_	no HT_0–!	no HT_6-1	no HT_11-	no HT_16-	no HT_>21
15-24 y	0.0803	0.0803	0.0803	0.0803	0.0803	0.0803	0.0803	0.0803	0.0803	0.0803	0.1024	0.1024	0.1024	0.1024	0.1024	0.1024	0.1024	0.1024	0.1024	0.1024
25-34 y	0.0803	0.0803	0.0803	0.0803	0.0803	0.0803	0.0803	0.0803	0.0803	0.0803	0.1024	0.1024	0.1024	0.1024	0.1024	0.1024	0.1024	0.1024	0.1024	0.1024
35-44 y	0.0803	0.0803	0.0803	0.0803	0.0803	0.0803	0.0803	0.0803	0.0803	0.0803	0.1024	0.1024	0.1024	0.1024	0.1024	0.1024	0.1024	0.1024	0.1024	0.1024
45-54 y	0.0917	0.0917	0.0917	0.0917	0.0917	0.0917	0.0917	0.0917	0.0917	0.0917	0.107	0.107	0.107	0.107	0.107	0.107	0.107	0.107	0.107	0.107
55-64 y	0.0852	0.0852	0.0852	0.0852	0.0852	0.0852	0.0852	0.0852	0.0852	0.0852	0.1085	0.1085	0.1085	0.1085	0.1085	0.1085	0.1085	0.1085	0.1085	0.1085
65-74 y	0.0998	0.0998	0.0998	0.0998	0.0998	0.0998	0.0998	0.0998	0.0998	0.0998	0.1297	0.1297	0.1297	0.1297	0.1297	0.1297	0.1297	0.1297	0.1297	0.1297
75-84 y	0.1793	0.1793	0.1793	0.1793	0.1793	0.1793	0.1793	0.1793	0.1793	0.1793	0.1527	0.1527	0.1527	0.1527	0.1527	0.1527	0.1527	0.1527	0.1527	0.1527

(k) Proportion of Angina among CHD

AT 6.1 Normal to CHI	Female	Female	Female	Female	Female	Female	Female	Female	Female	Female	Male	Male	Male	Male	Male	Male	Male	Male	Male	Male
proportionof Angina a	HT	HT	HT	HT	HT	no HT	no HT	no HT	no HT	no HT	HT	HT	HT	HT	HT	no HT	no HT	no HT	no HT	no HT
	0–5y	6-10y	11-15y	16-20y	>21y	0–5y	6-10y	11-15y	16-20y	>21y	0–5y	6-10y	11-15y	16-20y	>21y	0–5y	6-10y	11-15y	16-20y	>21y
	HT_0–5y_	HT_6-10y_	HT_11-15	HT_16-20	HT_>21y_	no HT_0–!	no HT_6-1	no HT_11-	no HT_16-	no HT_>2:	HT_0–5y_	HT_6-10y_	HT_11-15	HT_16-20	HT_>21y_	no HT_0–!	no HT_6-1	no HT_11-	no HT_16-	no HT_>2:
15-24 y	0.3333	0.3333	0.3333	0.3333	0.3333	0.3333	0.3333	0.3333	0.3333	0.3333	0.2805	0.2805	0.2805	0.2805	0.2805	0.2805	0.2805	0.2805	0.2805	0.2805
25-34 y	0.3333	0.3333	0.3333	0.3333	0.3333	0.3333	0.3333	0.3333	0.3333	0.3333	0.2805	0.2805	0.2805	0.2805	0.2805	0.2805	0.2805	0.2805	0.2805	0.2805
35-44 y	0.3333	0.3333	0.3333	0.3333	0.3333	0.3333	0.3333	0.3333	0.3333	0.3333	0.2805	0.2805	0.2805	0.2805	0.2805	0.2805	0.2805	0.2805	0.2805	0.2805
45-54 y	0.4141	0.4141	0.4141	0.4141	0.4141	0.4141	0.4141	0.4141	0.4141	0.4141	0.349	0.349	0.349	0.349	0.349	0.349	0.349	0.349	0.349	0.349
55-64 y	0.4949	0.4949	0.4949	0.4949	0.4949	0.4949	0.4949	0.4949	0.4949	0.4949	0.4176	0.4176	0.4176	0.4176	0.4176	0.4176	0.4176	0.4176	0.4176	0.4176
65-74 y	0.4086	0.4086	0.4086	0.4086	0.4086	0.4086	0.4086	0.4086	0.4086	0.4086	0.3774	0.3774	0.3774	0.3774	0.3774	0.3774	0.3774	0.3774	0.3774	0.3774
75-84 y	0.3224	0.3224	0.3224	0.3224	0.3224	0.3224	0.3224	0.3224	0.3224	0.3224	0.3372	0.3372	0.3372	0.3372	0.3372	0.3372	0.3372	0.3372	0.3372	0.3372

(l) Angina to death

AT 6.3 C2 to death	Female	Female	Female	Female	Female	Female	Female	Female	Female	Female	Male	Male	Male	Male	Male	Male	Male	Male	Male	Male
C2 to death	HT	HT	HT	HT	HT	no HT	no HT	no HT	no HT	no HT	HT	HT	HT	HT	HT	no HT	no HT	no HT	no HT	no HT
	0–5y	6-10y	11-15y	16-20y	>21y	0–5y	6-10y	11-15y	16-20y	>21y	0–5y	6-10y	11-15y	16-20y	>21y	0–5y	6-10y	11-15y	16-20y	>21y
	HT_0–5y_	HT_6-10y_	HT_11-15	HT_16-20	HT_>21y_	no HT_0–!	no HT_6-1	no HT_11-	no HT_16-	no HT_>2:	HT_0–5y_	HT_6-10y_	HT_11-15	HT_16-20	HT_>21y_	no HT_0–!	no HT_6-1	no HT_11-	no HT_16-	no HT_>2:!
15-24 y	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
25-34 y	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
35-44 y	0.00249	0.00249	0.00249	0.00249	0.00249	0.00249	0.00249	0.00249	0.00249	0.00249	0.0046	0.0046	0.0046	0.0046	0.0046	0.0046	0.0046	0.0046	0.0046	0.0046
45-54 y	0.00618	0.00618	0.00618	0.00618	0.00618	0.00618	0.00618	0.00618	0.00618	0.00618	0.0107	0.0107	0.0107	0.0107	0.0107	0.0107	0.0107	0.0107	0.0107	0.0107
55-64 y	0.01196	0.01196	0.01196	0.01196	0.01196	0.01196	0.01196	0.01196	0.01196	0.01196	0.01841	0.01841	0.01841	0.01841	0.01841	0.01841	0.01841	0.01841	0.01841	0.01841
65-74 y	0.02507	0.02507	0.02507	0.02507	0.02507	0.02507	0.02507	0.02507	0.02507	0.02507	0.03267	0.03267	0.03267	0.03267	0.03267	0.03267	0.03267	0.03267	0.03267	0.03267
75-84 y	0.09638	0.09638	0.09638	0.09638	0.09638	0.09638	0.09638	0.09638	0.09638	0.09638	0.10591	0.10591	0.10591	0.10591	0.10591	0.10591	0.10591	0.10591	0.10591	0.10591

(m) first MI to death

AT 6.4 MI/CA to dea	Female	Female	Female	Female	Female	Female	Female	Female	Female	Female	Male	Male	Male	Male	Male	Male	Male	Male	Male	Male
first MI to death	HT	HT	HT	HT	HT	no HT	no HT	no HT	no HT	no HT	HT	HT	HT	HT	HT	no HT	no HT	no HT	no HT	no HT
	0–5y	6-10y	11-15y	16-20y	>21y	0–5y	6-10y	11-15y	16-20y	>21y	0–5y	6-10y	11-15y	16-20y	>21y	0–5y	6-10y	11-15y	16-20y	>21y
	HT_0–5y_	HT_6-10y_	HT_11-15	HT_16-20	HT_>21y_	no HT_0–!	no HT_6-1	no HT_11-	no HT_16-	no HT_>2:	HT_0–5y_	HT_6-10y_	HT_11-15	HT_16-20	HT_>21y_	no HT_0–!	no HT_6-1	no HT_11-	no HT_16-	no HT_>21
15-24 y	0.0154	0.0154	0.0154	0.0154	0.0154	0.0154	0.0154	0.0154	0.0154	0.0154	0.0154	0.0154	0.0154	0.0154	0.0154	0.0154	0.0154	0.0154	0.0154	0.0154
25-34 y	0.0154	0.0154	0.0154	0.0154	0.0154	0.0154	0.0154	0.0154	0.0154	0.0154	0.0154	0.0154	0.0154	0.0154	0.0154	0.0154	0.0154	0.0154	0.0154	0.0154
35-44 y	0.0154	0.0154	0.0154	0.0154	0.0154	0.0154	0.0154	0.0154	0.0154	0.0154	0.0154	0.0154	0.0154	0.0154	0.0154	0.0154	0.0154	0.0154	0.0154	0.0154
45-54 y	0.0336	0.0336	0.0336	0.0336	0.0336	0.0336	0.0336	0.0336	0.0336	0.0336	0.0336	0.0336	0.0336	0.0336	0.0336	0.0336	0.0336	0.0336	0.0336	0.0336
55-64 y	0.073	0.073	0.073	0.073	0.073	0.073	0.073	0.073	0.073	0.073	0.073	0.073	0.073	0.073	0.073	0.073	0.073	0.073	0.073	0.073
65-74 y	0.1587	0.1587	0.1587	0.1587	0.1587	0.1587	0.1587	0.1587	0.1587	0.1587	0.1587	0.1587	0.1587	0.1587	0.1587	0.1587	0.1587	0.1587	0.1587	0.1587
75-84 y	0.2953	0.2953	0.2953	0.2953	0.2953	0.2953	0.2953	0.2953	0.2953	0.2953	0.2953	0.2953	0.2953	0.2953	0.2953	0.2953	0.2953	0.2953	0.2953	0.2953

(n) recurred MI to death

AT 6.4 MI/CA to dea	Female	Female	Female	Female	Female	Female	Female	Female	Female	Female	Male	Male	Male	Male	Male	Male	Male	Male	Male	Male
recur MI to death	HT	HT	HT	HT	HT	no HT	no HT	no HT	no HT	no HT	HT	HT	HT	HT	HT	no HT	no HT	no HT	no HT	no HT
	0–5y	6-10y	11-15y	16-20y	>21y	0–5y	6-10y	11-15y	16-20y	>21y	0–5y	6-10y	11-15y	16-20y	>21y	0–5y	6-10y	11-15y	16-20y	>21y
	HT_0–5y_	HT_6-10y_	HT_11-15	HT_16-20	HT_>21y_	no HT_0–5	no HT_6-1	no HT_11-	no HT_16-	no HT_>2	HT_0–5y_	HT_6-10y_	HT_11-15	HT_16-20	HT_>21y_	no HT_0–5	no HT_6-1	no HT_11-	no HT_16-	no HT_>21
15-24 y	0.086	0.086	0.086	0.086	0.086	0.086	0.086	0.086	0.086	0.086	0.086	0.086	0.086	0.086	0.086	0.086	0.086	0.086	0.086	0.086
25-34 y	0.086	0.086	0.086	0.086	0.086	0.086	0.086	0.086	0.086	0.086	0.086	0.086	0.086	0.086	0.086	0.086	0.086	0.086	0.086	0.086
35-44 y	0.086	0.086	0.086	0.086	0.086	0.086	0.086	0.086	0.086	0.086	0.086	0.086	0.086	0.086	0.086	0.086	0.086	0.086	0.086	0.086
45-54 y	0.112	0.112	0.112	0.112	0.112	0.112	0.112	0.112	0.112	0.112	0.112	0.112	0.112	0.112	0.112	0.112	0.112	0.112	0.112	0.112
55-64 y	0.1446	0.1446	0.1446	0.1446	0.1446	0.1446	0.1446	0.1446	0.1446	0.1446	0.1446	0.1446	0.1446	0.1446	0.1446	0.1446	0.1446	0.1446	0.1446	0.1446
65-74 y	0.1867	0.1867	0.1867	0.1867	0.1867	0.1867	0.1867	0.1867	0.1867	0.1867	0.1867	0.1867	0.1867	0.1867	0.1867	0.1867	0.1867	0.1867	0.1867	0.1867
75-84 y	0.2953	0.2953	0.2953	0.2953	0.2953	0.2953	0.2953	0.2953	0.2953	0.2953	0.2953	0.2953	0.2953	0.2953	0.2953	0.2953	0.2953	0.2953	0.2953	0.2953

(o) history of CA/MI to death

AT 6.5 MI/CA to dea	Female	Female	Female	Female	Female	Female	Female	Female	Female	Female	Male	Male	Male	Male	Male	Male	Male	Male	Male	Male
history of CA/MI to	HT	HT	HT	HT	HT	no HT	no HT	no HT	no HT	no HT	HT	HT	HT	HT	HT	no HT	no HT	no HT	no HT	no HT
	0–5y	6-10y	11-15y	16-20y	>21y	0–5y	6-10y	11-15y	16-20y	>21y	0–5y	6-10y	11-15y	16-20y	>21y	0–5y	6-10y	11-15y	16-20y	>21y
	HT_0–5y_	HT_6-10y_	HT_11-15	HT_16-20	HT_>21y_	no HT_0–5	no HT_6-1	no HT_11-	no HT_16-	no HT_>2	HT_0–5y_	HT_6-10y_	HT_11-15	HT_16-20	HT_>21y_	no HT_0–5	no HT_6-1	no HT_11-	no HT_16-	no HT_>21
15-24 y	0.00249	0.00249	0.00249	0.00249	0.00249	0.00249	0.00249	0.00249	0.00249	0.00249	0.0046	0.0046	0.0046	0.0046	0.0046	0.0046	0.0046	0.0046	0.0046	0.0046
25-34 y	0.00249	0.00249	0.00249	0.00249	0.00249	0.00249	0.00249	0.00249	0.00249	0.00249	0.0046	0.0046	0.0046	0.0046	0.0046	0.0046	0.0046	0.0046	0.0046	0.0046
35-44 y	0.00249	0.00249	0.00249	0.00249	0.00249	0.00249	0.00249	0.00249	0.00249	0.00249	0.0046	0.0046	0.0046	0.0046	0.0046	0.0046	0.0046	0.0046	0.0046	0.0046
45-54 y	0.00618	0.00618	0.00618	0.00618	0.00618	0.00618	0.00618	0.00618	0.00618	0.00618	0.0107	0.0107	0.0107	0.0107	0.0107	0.0107	0.0107	0.0107	0.0107	0.0107
55-64 y	0.01196	0.01196	0.01196	0.01196	0.01196	0.01196	0.01196	0.01196	0.01196	0.01196	0.01841	0.01841	0.01841	0.01841	0.01841	0.01841	0.01841	0.01841	0.01841	0.01841
65-74 y	0.02507	0.02507	0.02507	0.02507	0.02507	0.02507	0.02507	0.02507	0.02507	0.02507	0.03267	0.03267	0.03267	0.03267	0.03267	0.03267	0.03267	0.03267	0.03267	0.03267
75-84 y	0.09638	0.09638	0.09638	0.09638	0.09638	0.09638	0.09638	0.09638	0.09638	0.09638	0.10591	0.10591	0.10591	0.10591	0.10591	0.10591	0.10591	0.10591	0.10591	0.10591

(p) recurred CA event

AT 6.6 recur CA/MI recur CA event	Female HT 0–5y HT_0–5y_	Female HT 6-10y HT_6-10y_	Female HT 11-15y HT_11-15	Female HT 16-20y HT_16-20	Female HT >21y HT_>21y_	Female no HT 0–5y no HT_0–5	Female no HT 6-10y no HT_6-1	Female no HT 11-15y no HT_11	Female no HT 16-20y no HT_16	Female no HT >21y no HT_>2	Male HT 0–5y HT_0–5y_	Male HT 6-10y HT_6-10y_	Male HT 11-15y HT_11-15	Male HT 16-20y HT_16-20	Male HT >21y HT_>21y_	Male no HT 0–5y no HT_0–5	Male no HT 6-10y no HT_6-1	Male no HT 11-15y no HT_11	Male no HT 16-20y no HT_16	Male no HT >21y no HT_>21
15-24 y	0.01132	0.01132	0.01132	0.01132	0.01132	0.01132	0.01132	0.01132	0.01132	0.01132	0.01432	0.01432	0.01432	0.01432	0.01432	0.01432	0.01432	0.01432	0.01432	0.01432
25-34 y	0.01132	0.01132	0.01132	0.01132	0.01132	0.01132	0.01132	0.01132	0.01132	0.01132	0.01432	0.01432	0.01432	0.01432	0.01432	0.01432	0.01432	0.01432	0.01432	0.01432
35-44 y	0.01132	0.01132	0.01132	0.01132	0.01132	0.01132	0.01132	0.01132	0.01132	0.01132	0.01432	0.01432	0.01432	0.01432	0.01432	0.01432	0.01432	0.01432	0.01432	0.01432
45-54 y	0.01132	0.01132	0.01132	0.01132	0.01132	0.01132	0.01132	0.01132	0.01132	0.01132	0.01432	0.01432	0.01432	0.01432	0.01432	0.01432	0.01432	0.01432	0.01432	0.01432
55-64 y	0.01132	0.01132	0.01132	0.01132	0.01132	0.01132	0.01132	0.01132	0.01132	0.01132	0.01432	0.01432	0.01432	0.01432	0.01432	0.01432	0.01432	0.01432	0.01432	0.01432
65-74 y	0.01132	0.01132	0.01132	0.01132	0.01132	0.01132	0.01132	0.01132	0.01132	0.01132	0.01432	0.01432	0.01432	0.01432	0.01432	0.01432	0.01432	0.01432	0.01432	0.01432
75-84 y	0.01132	0.01132	0.01132	0.01132	0.01132	0.01132	0.01132	0.01132	0.01132	0.01132	0.01432	0.01432	0.01432	0.01432	0.01432	0.01432	0.01432	0.01432	0.01432	0.01432

(q) recurred MI event

AT 6.6 recur CA/MI recur MI event	Female HT 0–5y HT_0–5y_	Female HT 6-10y HT_6-10y_	Female HT 11-15y HT_11-15	Female HT 16-20y HT_16-20	Female HT >21y HT_>21y_	Female no HT 0–5y no HT_0–5	Female no HT 6-10y no HT_6-1	Female no HT 11-15y no HT_11	Female no HT 16-20y no HT_16	Female no HT >21y no HT_>2	Male HT 0–5y HT_0–5y_	Male HT 6-10y HT_6-10y_	Male HT 11-15y HT_11-15	Male HT 16-20y HT_16-20	Male HT >21y HT_>21y_	Male no HT 0–5y no HT_0–5	Male no HT 6-10y no HT_6-1	Male no HT 11-15y no HT_11	Male no HT 16-20y no HT_16	Male no HT >21y no HT_>21
15-24 y	0.0453	0.0453	0.0453	0.0453	0.0453	0.0453	0.0453	0.0453	0.0453	0.0453	0.0573	0.0573	0.0573	0.0573	0.0573	0.0573	0.0573	0.0573	0.0573	0.0573
25-34 y	0.0453	0.0453	0.0453	0.0453	0.0453	0.0453	0.0453	0.0453	0.0453	0.0453	0.0573	0.0573	0.0573	0.0573	0.0573	0.0573	0.0573	0.0573	0.0573	0.0573
35-44 y	0.0453	0.0453	0.0453	0.0453	0.0453	0.0453	0.0453	0.0453	0.0453	0.0453	0.0573	0.0573	0.0573	0.0573	0.0573	0.0573	0.0573	0.0573	0.0573	0.0573
45-54 y	0.0453	0.0453	0.0453	0.0453	0.0453	0.0453	0.0453	0.0453	0.0453	0.0453	0.0573	0.0573	0.0573	0.0573	0.0573	0.0573	0.0573	0.0573	0.0573	0.0573
55-64 y	0.0453	0.0453	0.0453	0.0453	0.0453	0.0453	0.0453	0.0453	0.0453	0.0453	0.0573	0.0573	0.0573	0.0573	0.0573	0.0573	0.0573	0.0573	0.0573	0.0573
65-74 y	0.0453	0.0453	0.0453	0.0453	0.0453	0.0453	0.0453	0.0453	0.0453	0.0453	0.0573	0.0573	0.0573	0.0573	0.0573	0.0573	0.0573	0.0573	0.0573	0.0573
75-84 y	0.0453	0.0453	0.0453	0.0453	0.0453	0.0453	0.0453	0.0453	0.0453	0.0453	0.0573	0.0573	0.0573	0.0573	0.0573	0.0573	0.0573	0.0573	0.0573	0.0573

(r) Normal to stroke

AT 7.1 Normal to st	Female	Female	Female	Female	Female	Female	Female	Female	Female	Female	Male	Male	Male	Male	Male	Male	Male	Male	Male	Male
S1 to S2	HT	HT	HT	HT	HT	no HT	no HT	no HT	no HT	no HT	HT	HT	HT	HT	HT	no HT	no HT	no HT	no HT	no HT
	0–5y	6-10y	11-15y	16-20y	>21y	0–5y	6-10y	11-15y	16-20y	>21y	0–5y	6-10y	11-15y	16-20y	>21y	0–5y	6-10y	11-15y	16-20y	>21y
	HT_0–5y_	HT_6-10y_	HT_11-15	HT_16-20	HT_>21y_	no HT_0–!	no HT_6-1	no HT_11-	no HT_16-	no HT_>2:	HT_0–5y_	HT_6-10y_	HT_11-15	HT_16-20	HT_>21y_	no HT_0–!	no HT_6-1	no HT_11-	no HT_16-	no HT_>2:
15-24 y	0	0	0.14286	0.14286	0.14286	0.00379	0.13333	0.14286	0.14286	0.14286	0	0.16667	0.16667	0.16667	0.16667	0	0	0.2	0.2	0.2
25-34 y	0.00787	0	0.14286	0.14286	0.14286	0.00172	0.13333	0.14286	0.14286	0.14286	0.015	0.16667	0.16667	0.16667	0.16667	0.00499	0	0.2	0.2	0.2
35-44 y	0.01764	0	0.14286	0.14286	0.14286	0.01077	0.13333	0.14286	0.14286	0.14286	0.0298	0.16667	0.16667	0.16667	0.16667	0.0187	0	0.2	0.2	0.2
45-54 y	0.03142	0.33333	0.14286	0.14286	0.14286	0.02188	0.07692	0.14286	0.14286	0.14286	0.04448	0.16667	0.16667	0.16667	0.16667	0.03467	0.06897	0.2	0.2	0.2
55-64 y	0.04621	0.05263	0.14286	0.14286	0.14286	0.0392	0.06383	0.14286	0.14286	0.14286	0.0734	0.16667	0.16667	0.16667	0.16667	0.06297	0.04255	0.5	0.2	0.2
65-74 y	0.07491	0.1	0.14286	0.14286	0.14286	0.07081	0.13333	0.14286	0.14286	0.14286	0.10638	0.16667	0.16667	0.16667	0.16667	0.09803	0.06667	0.2	0.2	0.2
75-84 y	0.12745	0.4	0.14286	0.14286	0.14286	0.12384	0.25	0.14286	0.14286	0.14286	0.15251	0.16667	0.16667	0.16667	0.16667	0.14701	0.2	0.2	0.2	0.2
subtotal	0.07267	0.13158	0.14286	0.14286	0.14286	0.0617	0.09709	0.14286	0.14286	0.14286	0.09376	0.03333	0.16667	0.16667	0.16667	0.07997	0.06	0.2	0.2	0.2

(s) Stroke to death

AT 7.2 Stroke to dea	Female	Female	Female	Female	Female	Female	Female	Female	Female	Female	Male	Male	Male	Male	Male	Male	Male	Male	Male	Male
stroke to death	HT	HT	HT	HT	HT	no HT	no HT	no HT	no HT	no HT	HT	HT	HT	HT	HT	no HT	no HT	no HT	no HT	no HT
	0–5y	6-10y	11-15y	16-20y	>21y	0–5y	6-10y	11-15y	16-20y	>21y	0–5y	6-10y	11-15y	16-20y	>21y	0–5y	6-10y	11-15y	16-20y	>21y
	HT_0–5y_	HT_6-10y_	HT_11-15	HT_16-20	HT_>21y_	no HT_0–!	no HT_6-1	no HT_11-	no HT_16-	no HT_>2:	HT_0–5y_	HT_6-10y_	HT_11-15	HT_16-20	HT_>21y_	no HT_0–!	no HT_6-1	no HT_11-	no HT_16-	no HT_>21
15-24 y	0.142	0.142	0.142	0.142	0.142	0.142	0.142	0.142	0.142	0.142	0.142	0.142	0.142	0.142	0.142	0.142	0.142	0.142	0.142	0.142
25-34 y	0.142	0.142	0.142	0.142	0.142	0.142	0.142	0.142	0.142	0.142	0.142	0.142	0.142	0.142	0.142	0.142	0.142	0.142	0.142	0.142
35-44 y	0.142	0.142	0.142	0.142	0.142	0.142	0.142	0.142	0.142	0.142	0.142	0.142	0.142	0.142	0.142	0.142	0.142	0.142	0.142	0.142
45-54 y	0.142	0.142	0.142	0.142	0.142	0.142	0.142	0.142	0.142	0.142	0.142	0.142	0.142	0.142	0.142	0.142	0.142	0.142	0.142	0.142
55-64 y	0.142	0.142	0.142	0.142	0.142	0.142	0.142	0.142	0.142	0.142	0.142	0.142	0.142	0.142	0.142	0.142	0.142	0.142	0.142	0.142
65-74 y	0.142	0.142	0.142	0.142	0.142	0.142	0.142	0.142	0.142	0.142	0.142	0.142	0.142	0.142	0.142	0.142	0.142	0.142	0.142	0.142
75-84 y	0.142	0.142	0.142	0.142	0.142	0.142	0.142	0.142	0.142	0.142	0.142	0.142	0.142	0.142	0.142	0.142	0.142	0.142	0.142	0.142
subtotal	0.142	0.142	0.142	0.142	0.142	0.142	0.142	0.142	0.142	0.142	0.142	0.142	0.142	0.142	0.142	0.142	0.142	0.142	0.142	0.142

(t) History Stroke to death

AT 7.3 History Strok	Female	Female	Female	Female	Female	Female	Female	Female	Female	Female	Male	Male	Male	Male	Male	Male	Male	Male	Male	Male
S2 to death	HT	HT	HT	HT	HT	no HT	no HT	no HT	no HT	no HT	HT	HT	HT	HT	HT	no HT	no HT	no HT	no HT	no HT
	0–5y	6-10y	11-15y	16-20y	>21y	0–5y	6-10y	11-15y	16-20y	>21y	0–5y	6-10y	11-15y	16-20y	>21y	0–5y	6-10y	11-15y	16-20y	>21y
	HT_0–5y_	HT_6-10y_	HT_11-15	HT_16-20	HT_>21y_	no HT_0–!	no HT_6-1	no HT_11-	no HT_16-	no HT_>2	HT_0–5y_	HT_6-10y_	HT_11-15	HT_16-20	HT_>21y_	no HT_0–!	no HT_6-1	no HT_11-	no HT_16-	no HT_>21
15-24 y	0.0915	0.0915	0.0915	0.0915	0.0915	0.0915	0.0915	0.0915	0.0915	0.0915	0.0915	0.0915	0.0915	0.0915	0.0915	0.0915	0.0915	0.0915	0.0915	0.0915
25-34 y	0.0915	0.0915	0.0915	0.0915	0.0915	0.0915	0.0915	0.0915	0.0915	0.0915	0.0915	0.0915	0.0915	0.0915	0.0915	0.0915	0.0915	0.0915	0.0915	0.0915
35-44 y	0.0915	0.0915	0.0915	0.0915	0.0915	0.0915	0.0915	0.0915	0.0915	0.0915	0.0915	0.0915	0.0915	0.0915	0.0915	0.0915	0.0915	0.0915	0.0915	0.0915
45-54 y	0.0915	0.0915	0.0915	0.0915	0.0915	0.0915	0.0915	0.0915	0.0915	0.0915	0.0915	0.0915	0.0915	0.0915	0.0915	0.0915	0.0915	0.0915	0.0915	0.0915
55-64 y	0.0915	0.0915	0.0915	0.0915	0.0915	0.0915	0.0915	0.0915	0.0915	0.0915	0.0915	0.0915	0.0915	0.0915	0.0915	0.0915	0.0915	0.0915	0.0915	0.0915
65-74 y	0.0915	0.0915	0.0915	0.0915	0.0915	0.0915	0.0915	0.0915	0.0915	0.0915	0.0915	0.0915	0.0915	0.0915	0.0915	0.0915	0.0915	0.0915	0.0915	0.0915
75-84 y	0.0915	0.0915	0.0915	0.0915	0.0915	0.0915	0.0915	0.0915	0.0915	0.0915	0.0915	0.0915	0.0915	0.0915	0.0915	0.0915	0.0915	0.0915	0.0915	0.0915
subtotal	0.0915	0.0915	0.0915	0.0915	0.0915	0.0915	0.0915	0.0915	0.0915	0.0915	0.0915	0.0915	0.0915	0.0915	0.0915	0.0915	0.0915	0.0915	0.0915	0.0915

Table A10. Cost data

Type	Value or Expression	Low	High	Explanation	Source
Intensive DM treatment only	EXP(9.381) * if(start_age+_stage>65;1.05;1) * if(event_Stroke>0;1.79;1) * if(event_MI>0;1.50;1) * if(occur_R2>0;1.23;1) * if(occur_Ne4>0;1.86;1) * if(event_CA>0;1.44;1)	8000	15000	should include drug, physician visit, nurse visit (insulin or not)	JIAO et al. (2019)
Intensive HT treatment only	2795	1905	3000	two drug use (atenolol: $30 30s*50mg; 100mg per day=HK$2) + additional 1-3 community care per year HK$445*3	Private sector: https://www.loksintong.org/lok-sin-tong-community-pharmacy
Conventional LP treatment only	4985	2306.5	5500	drug use (Pravastatin: $150 30s*20mg; 40mg per day=HK$10) or (gemfibrozil: $1.7 300mg; 900mg per day=HK$5.1) + additional 1-3	Same as above

				community care per year HK$445*3	
RAMP program	if(time_treatment=1;507;231)	200	507		JIAO et al. (2019)
Screening	751	500	1500	should include DM (HbA1c + FPG: HK$400-650; 15% OGTT HK$650), HT (HK$10), LP cost (HK$350), admistrative cost: 30%	Same as above
Treating C2 angina	1190*4	0	5950	assume 4 (0-5) specialist per year	assumed
Treating C3 history of CA or MI	(calculated as multiplier)	-	-	multiplier	JIAO et al. (2019)
Treating event CA	if(occur_intensive=1;cTreatment_DM_intensive*(5.18-1); cTreatment_DM_conventional*(2.64-1))	-	-	multiplier	Same as above
Treating event LEA	48850	37800	55950	major II 第二類大型手術 48850-59950	Same as above
Treating event MI	if(occur_intensive=1;cTreatment_DM_intensive*(5.18-1);	-	-	multiplier	Same as above

	cTreatment_DM_conventional *(5.18-1))				
Treating event stroke	if(occur_intensive=1;cTreatment_DM_intensive*(5.94-1); cTreatment_DM_conventional *(5.94-1))	-	-	multiplier	Same as above
Treating N2 Peripheral neuropathy	if(occur_N2=1;1190;0)	-	-	only first-time treatment, assume 1 specialist	assumed
Treating N3 history of LEA	(calculated as multiplier)	-	-	multiplier	JIAO et al. (2019)
Treating NE2 low or high microalbuminuria	(calculated as multiplier)	-	-	multiplier	Same as above
Treating NE3 clinical nephropathy	if(occur_Ne3=1;5100*2;0)	-	-	only first-time treatment, assume 2-day inpatient	assumed
Treating NE4 End-stage renal disease	(calculated as multiplier)	-	-	multiplier	JIAO et al. (2019)
Treating R2 Photocoagulation	(calculated as multiplier)	-	-	multiplier	Same as above
Treating R3 blindness	(calculated as multiplier)	-	-	multiplier	Same as above
Treating S2 stroke	(calculated as multiplier)	-	-	multiplier	Same as above
Death	104797	0	187880	7.67 inpatient night	Assumed

Major source of data:

(1) HA private service (laboratory test) blood test: HK$120-1860 (https://www3.ha.org.hk/fnc/Pathology.aspx?lang=ENG)

(2) HA non-eligible fee (https://www.ha.org.hk/haho/ho/cs/238767_tc.pdf)

(3) HA private procedure fee (https://www.ha.org.hk/haho/ho/cs/238768_tc.pdf)

(4) Category of surgery (https://www.csb.gov.hk/english/admin/benefits/files/AXA_SSO.pdf)

(5) Private sector blood test price (https://health.esdlife.com/shop/hk/product/%E8%A1%80%E8%84%82%E5%85%A8%E5%A5%97-i)

(6) Jiao F, Wan EYF, Fung CSC, Chan AKC, McGhee SM, Kwok RLP, Lam CLK. Cost-effectiveness of a primary care multidisciplinary Risk Assessment and Management Program for patients with diabetes mellitus (RAMP-DM) over lifetime. Endocrine. 2019 Feb;63(2):259-269.