

Long Term Effectiveness of Elderly Health Care Voucher Scheme Strategies: A System Dynamics Simulation Analysis

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Abstract

Background: The elderly healthcare voucher (EHCV) scheme is expected to increase the number of elders choosing private primary healthcare services and, on the other hand, to reduce reliance on the public sector in Hong Kong. Unfortunately, the scheme was not satisfactorily as reported in the literature to date. In this study, we examined the changes in the ratio of visits between public and private doctors in primary care (as a metric of reliance on the public sector) for different strategic scenarios in the scheme.

Methods: Based on the comments from the expertise discussion, a system dynamics model was formulated to simulate the impact of different enhanced strategy in the scheme: Increasing voucher amounts, lowering the age eligibility, and designating vouchers for chronic conditions follow-up. Data and statistics for model calibration were collected from different sources.

Results: The simulation results showed that the current EHCV scheme was unable to reduce the utilization of public healthcare services as well as the ratio of visits between public and private when the local population aging was taken into account. When comparing the 3 different tested scenarios, even if the increase of annual voucher amount could be kept with a current pace or the age eligibility could be lowered to 60 years old, the impacts on the shifts from public to private utilization were not apparent in which the public-to-private ratio could only drop slightly from 0.74 to 0.64 in the first several years. Nevertheless, introducing a chronic disease-oriented voucher could result in an apparent drop of public-to-private ratio to 0.50 in the early implementation phase but the effect could not be maintained for a period of time.

Conclusions: Our findings assist officials to further improve the design of EHCV scheme, within the bigger context of promoting primary care among the elderly. We suggested an additional chronic disease-oriented voucher could be an alternative strategy but the enhancement on the voucher amount should be considered if a long term planning was required. For not substantially rising the government expenditure for refining the scheme, health promotion works for encouraging co-payment from elderly for is recommended.

Background

According to projection statistics from the Hong Kong Census Department [1], the population of Hong Kong is projected to rise to 8.22 million in mid-2043. Compared with 2011, the proportion of the population aged 65 years old and over is expected to increase by 33% in 2064. With such an aging trend in Hong Kong, the overall public health expenditure is projected to be \$127 billion in 2025 [2]. Chronic diseases such as stroke, dementia, and diabetes, together with cognitive and physical decline associated with dying will be more prevalent with this demographic change. The primary care system is becoming more important to comprehensively manage patients with chronic diseases who often require continuous care and treatment.

In Hong Kong, primary care is mainly provided by the private sector. However, of those elderly aged 60 years old or above, the proportion of them consulted public primary care doctors was higher than that consulted private practitioners [3, 4], and for those with chronic conditions, the proportion of utilizing public healthcare service is much higher. To develop a long-term strategy for enhancing the provision of elderly primary care service, the Elderly Health Care Voucher (EHCV) scheme was started in 2009 for a pilot period of three years. By offering a financial incentive, it was expected that the elderly could choose private healthcare services as an alternative to relieve the burden of public healthcare services such as General and Specialist Outpatient Clinics. At the start of the EHCV scheme in 2009, five \$50 (in HKD) vouchers were given annually to each elder aged 70 years old or above. The annual amounts were increased to \$500 and \$1,000 in 2012 and 2013, respectively, after review of the scheme. In 2014, the amount was raised to \$2,000, and its cumulative amount was allowed to be carried forward up to \$4,000 for subsequent years [5]. In 2017, the age eligibility was lowered to 65 years old or above.

Financial incentives, such as voucher programs are common determinant of people's choice using public and private healthcare services [6-9]. The intervention helps balancing the demand for public and private services in a public-private mixed system [10, 11]. Some theoretical studies indicated that subsidy of private services can effectively reduce the demand for free public services in some circumstances [12]. Vouchers are a demand-side subsidy which aims to reduce financial hardship when accessing services [13]. It is a useful means when targeting at specific populations, and can improve the quality of services through incentivizing behaviour change on both demand and supply side [14-16]. Evidence of effectiveness of vouchers has been demonstrated in encouraging people to perform clearly defined, time-limited and simple behavioural tasks [14, 17, 18]. For example, the adolescent voucher program in Nicaragua could raise the accessibility of contraceptives through health services [17]. Vouchers for free mammography could also significantly improve compliance rates in rural regions [18]. Some evaluations of voucher programs reported positive associations to the increase of utilization [14, 19, 20]. However, there is insufficient evidence to demonstrate the effectiveness of vouchers for other

applications. With widespread acceptance of the governmental tool, the World Bank even issued a guide to vouchers, which identified their advantages and outlined the choices and decisions involved in using them [13]. Yam et al. found that voucher usage was low during the initial phase of the EHCV scheme [21, 22]; only 35% of elders had ever used it primarily due to the low amount of subsidy at that time. Particularly, only about 7% of health care vouchers claimed were from preventive service. Besides, the choices of healthcare provider were also limited as the electronic platform for claiming was unfriendly to use by providers. According to an interim report from the Department of Health [23], the estimated participation rate of medical practitioners was only about 34.1% in 2011. Although enhancement has been adopted since the interim review, a further survey conducted in 2015 revealed that several problems remain, such as low enrolment rate of private doctors [24]. Most of the respondents still thought the amounts of vouchers should be increased. As with the suggestions from the Nicaragua study [17], there is room for improvements of the voucher program—for example, sustaining a longer intervention period and enhancing quality improvements.

According to the Hong Kong Government, the EHCV scheme is expected to increase the number of elders choosing private primary healthcare services and, on the other hand, to reduce reliance on the public sector. Clearly, the scheme was not satisfactorily as reported in the literature to date [21-25]. The current barriers were difficulty stimulating behavioral changes in a proportion of users and healthcare services in the short period of the pilot time. If enhancements can be made by policymakers, what are their long-term effectiveness in reducing the reliance on public sector services? Our study aims fill this gap.

Method

Objectives

This is a system dynamics modelling study based on the settings of the EHCV scheme in Hong Kong. The study aims to evaluate the long-term effectiveness of the enhanced strategies of the EHCV scheme in reducing the reliance on of public primary care services. The objective of the modelling study is to examine changes in the ratio of visits between public and private doctors in primary care (as a metric of reliance on the public sector) given different strategic scenarios.

Design of scenarios

A qualitative phase was initiated to develop a conceptual model i.e. stock-and-flow as a preliminary sketch of the behaviour system which illustrates the pathway of individuals using the voucher and factors affecting the loop in order to design scenarios for testing. The factors were identified from the previous studies, the interim report of the EHCV scheme, a recent survey from the Hong Kong Medical Association, and some unpublished cross-sectional studies [21-25]. An expert panel was formed to comment on the importance of the factors in the system of using vouchers and to identify what adjustment or intervention should be introduced. Five independent private primary care professionals who have worked for at least 10 years in the private sector were invited for interviews through the networks of the investigators. They were also enrolled in the EHCV scheme and experienced the use of the claiming system. Their comments were noted in Chong et al. [26] and scenarios for increasing voucher amounts, lowering age eligibility criteria, and designating vouchers for chronic disease conditions were considered in simulation testing.

System Dynamics model

A System Dynamics (SD) model for testing different strategic scenarios was developed for computational simulations. In public health studies, SD modelling, involving the development of computational simulation, can address the dynamic complexity of different types of care in a health system and systematically evaluate policies for influencing changes. In our study, the SD model was stratified into 5 levels:

Generation of visits to healthcare services (Figure 1): A population model including new births and deaths was built. In the population model, total numbers of visits from different age groups (i.e. <60, 60–64, 65–69, and ≥ 70 years old) were generated depended on their average numbers of visits and population sizes. The numbers of visits to public and private healthcare services were generated assuming baseline proportions of visits to public and private which is independent to the uses of vouchers.

Generation of visits of using EHCV (Figure 2): Based on the settings of the voucher (e.g. voucher amounts and the purposes of uses), the expected numbers of visits for different services (i.e. non-preventive services, chronic conditions follow-up, dentistry, vaccination, and others) were generated. Inflation in service prices from supplier induced demand was considered according to the trends reported in

the historical claims information. The expected total number of voucher visits was the sum of expected numbers of visits for different services.

Generation of visits of using vouchers for chronic diseases (Figure 3): A designating voucher for chronic condition follow-up was suggested for a scenario testing. In the SD model, the total number of voucher visits for chronic conditions was determined by the eligible population size with chronic diseases in different age groups and their utilization patterns. The utilization patterns of the voucher varied by the voucher amount based on the assumption collected from the previous cross-sectional surveys.

Generation of actual number of visits using vouchers (Figure 4): Based on a proportion of the eligible population willing to join the scheme, the actual number of visits was determined with the corresponding total expenditure for the model calibration.

Changes in utilization of primary healthcare services (Figure 5): Based on utilization from the voucher uses, the net changes of visits to public and private providers were calculated based on the difference in the number of visits shifted from public to private and the baseline number of visits in each sector. The ratio of visits between public and private sectors over time was determined.

A set of corresponding deterministic and differential equations of SD model was developed and computerized to depict the flow of individuals seeking healthcare services in public and private sectors. The unit of time in the simulation settings was set as weeks. Time-based inputs were repeated for every week over a 15-years trend of aging (2017-2032). Euler's method was used to solve the differential equations. As utilization rate is the most widely used outcome measurement for different voucher programs [27], the primary endpoint in the simulations is the ratio of visits to public doctors and private doctors by years as a metric of reliance.

Scenario settings

The settings of tested scenarios were assumed plausibly as below:

Increasing voucher amounts: We tested the annual voucher amounts of increasing to \$3,000, \$4,000, and \$5,000 at year 2021, 2025, and 2029 respectively, keeping the rate of increment similar pace to the historical trends of the current EHCV scheme.

Lowering the age eligibility: We tested including the elderly aged 60-64 years into the scheme starting from year 2021.

Designating vouchers for chronic conditions follow-up: On top of the original EHCV, we tested an additional voucher for visits of chronic disease conditions. An extra amount of \$2,000 was given to eligible population every year starting from 2021 for treating their chronic diseases.

Data collection for model inputs

The data and statistics for inputs of the SD model were collected from different sources:

Demographics statistics from Hong Kong Census and Statistics (C&S) Department [1, 28]

Public healthcare services utilization statistics from Hospital Authority Statistical Reports and Thematic Household Survey Report [3, 29, 30]

Baseline EHCV statistics from literature, the Department of Health's (DH) interim report, the published survey from Hong Kong Medical Association [19-23], and the cross-sectional studies (unpublished). The cross-sectional studies include i. a repeated cross-sectional survey of elderly person aged 70 or above assessing their changes in attitudes towards, and usage of, vouchers among elderly persons in the community, and ii. a public opinion survey of the general public examining the potential use of voucher in primary care system e.g. enhancement of voucher for preventive care and chronic disease management from the general public perspectives.

Statistics of claimed amount from DH's administrative data and other relevant published statistics [31, 32].

Baseline calibration

Baseline scenario followed the current EHCV scheme: \$250 annually for elderly aged 70 years or above in 2009-2011; \$500 in 2012, \$1,000 in 2013, and \$2,000 in 2014-2016 annually; and \$2,000 annually for elderly aged 65 years or above after 2016. For the calibration of SD model, the model simulated total expenditure from the voucher visits was validated against the DH published total expenditure of voucher claims from 2009 to 2016 [31, 32]. The mean absolute percentage error (MAPE) of the calibrated model should

be kept below 40%. R-square was also obtained to assess the fitness of model calibration. Based on calibrated model, the numbers of visits that uses the vouchers for different services were simulated until year 2032. The variable specifications for model development was listed in Additional file 1.

Results

Baseline projections

Figure 6a shows the model simulated expenditure and actual expenditure of voucher uses provided by DH. The model calibration shows an acceptable of fitness with MAPE=30.5% and R-square=92.1%.

In the population model, the total number of visits from individuals aged 70 years or above gradually increased from 35% in 2009 to 54% in 2032, whereas the total number of visits from individuals aged below 60 years decreased from 54% in 2009 to 32% in 2032 (Figure 6b). Because of an aging population, the utilization of public healthcare services increased from 16.9 million in 2019 to 28.0 million in 2032, whereas the utilization of private healthcare services increased from 18.0 million in 2019 to 27.2 million in 2032 (Figure 6c).

Comparison of different tested scenarios

Three scenarios of increasing voucher amounts, lowering the age eligibility, and designating vouchers for chronic disease conditions were tested in the SD model with plausible price settings of voucher amounts. The simulation results showed that the current EHCV scheme (i.e. \$2,000 annually for individuals aged 65 years or above starting from 2017) was unable to reduce the utilization of public healthcare services as well as the ratio of visits between public and private when population aging was taken into account in the generations of visits of healthcare services (Figure 7a and 7b). The total number of visits to public doctors increased from 16.3 million in 2018 to 25.6 in 2032, whereas the public-to-private ratio of visits increased from 0.70 in 2018 to 0.88 in 2032.

Of the tested strategies (Figure 7a and 7b), increasing the voucher amount was only able to shift a small proportion of healthcare services utilization from public to private during the first 1 to 2 years after the voucher amount increase. In the scenario design, we kept a similar pace of the current EHCV scheme with implementing an increase of annual voucher amount of \$1,000 4 years apart. The setting shows a steady increase of total number of visits to public doctors as well as the ratio of visits between public and private doctors by years due to the population aging and market price inflation from supplier induced demands. Only a 0.7 million shifts from public to private utilization was observed from the first year of increase to \$3,000, whereas the ratio dropped slightly from 0.72 to 0.64. The impact on the reduction in utilization of public healthcare services was not apparent in later years in which the ratio between public and private kept around 0.80, only a small difference to that of the baseline scenario.

Comparing with the strategy of increasing annual voucher amount, lowering the age eligibility to 60 years old generated a similar effect in reducing the reliance in public sector (Figure 7a and 7b). According to the simulation results, the strategy was only able to shift 0.7 million more healthcare visits from public to private sector in the first year of implementation when comparing with the baseline scenario. The strategy even tended to be ineffective in later years with no more than 0.05 difference in the public-to-private ratio and only 0.5 to 1 million shift in visits could be resulted.

When an additional voucher for chronic conditions follow-up could be offered to the elderly, a larger impact could be observed during the first several years in the post-implementation period (Figure 7a and 7b). The enhanced strategy was able to result in a shift of 3.2 million visits from public to private and to have a drop of public-to-private ratio to 0.50 that was more effective than the strategy of increasing the annual voucher amounts in the first year of implementation. However, as with the first strategy of increasing the annual voucher amounts, an additional voucher for chronic conditions follow-up was not suitable for a long term planning strategy as the effect on reducing public healthcare utilization was not long lasting and the public-to-private ratio rose back gradually to a higher level, primarily because of the population aging and the market price inflation of private healthcare services.

Discussion

EHCV scheme is expected to increase the number of elders choosing private primary healthcare services and, on the other hand, to reduce reliance on the public sector in Hong Kong as reported in the literature [21-25]. Improvements on the scheme are required to enhance a shift of healthcare utilization from public to private. In this study, we proposed a framework of SD modelling analysis to

investigate the long-term effectiveness of a number of potential enhancements of the EHCV scheme. A SD model was formulated to simulate the impact of different enhanced strategies. Some key research questions were addressed:

1. *Is current EHCV scheme with an annual amount of \$2,000 for individuals aged 65 years or above sufficient for a long run?*

The current EHCV scheme was hard to relieve the burden of over-utilization of public healthcare services along with the local aging trend. Our simulation results showed that the current scheme was unable to reduce the utilization in public sector and the ratio of visits between public and private.

2. *Should officials increase the voucher amounts in the scheme?*

The impact of increasing the voucher amount was not apparent on the reduction of the reliance of public healthcare utilization in general. With keeping a similar pace of amount increment under the current scheme, the strategy could only shift a small proportion of healthcare services utilization from public to private during the first 1 to 2 years after the voucher amount increase, which was likely due to the population aging and the market price inflation from supplier induced demands.

3. *Should lower the age eligibility to 60 years old in the scheme?*

Our simulation showed that lowering the age eligibility to 60 years old could not result in a large reduction of the reliance to the public sector. The strategy could only draw an insignificant difference in the public-to-private ratio in the later years.

4. *Should an additional voucher for chronic conditions follow-up be introduced?*

An additional voucher for chronic conditions follow-up could be more effective than the strategy of solely increasing the annual voucher amounts during the first several years in the post-implementation period because of a substantially increase of utilizations on voucher uses from the aging population. Yet, the enhancement effect of reducing public healthcare utilization could not maintain for a period of time reflected from a steady growth of public-to-private ratio in later years.

Undoubtedly, EHCV scheme is a simple mean for balancing private-to-public healthcare. Despite multiple increases in voucher amounts in the past, low (as perceived by elderly individuals) subsidy value was still a persistent concern since the implementation of the EHCV. Our simulation investigation indicated the current voucher setting on the reduction in the reliance of public sector was ineffective. However, providing an additional voucher for chronic conditions follow-up to the elderly could result a drop of the reliance in the public healthcare services, especially for the elderly with chronic conditions have a much higher proportion in utilizing public healthcare service when comparing with those without chronic conditions. Along with the local aging trend, chronic diseases such as stroke, dementia, and diabetes, together with cognitive and physical decline, will definitely follow this ongoing demographic change. The effect of the additional voucher in increasing private care usage ensures the capital is being invested into the previously lacking chronic disease management of elderly. It prevents the elderly paying extra for consultations or their unwillingness to pay especially for some drugs for chronic conditions could be expensive in private clinics or for diseases requiring multiple follow-ups. Nevertheless, the effect was not long lasting in later years and an enhancement on the voucher amount should thus be considered if a long term planning was required. The strategy on the other hand requires an additional expenditure from government and to this end, improving elderly individuals' willingness to pay (WTP) was recommended [25]. Improving perceived benefit of using private healthcare and awareness of the scheme should be further promoted as local elderly often expresses concerns over the price, quality, and unfamiliarity of private services, which significantly limits elderly individuals' WTP. Liu et al. also showed that elderly individuals were willing to pay more for the same service with an increased subsidy [25].

In the study, we showed that lowering the age eligibility to 60 years old as well as increasing the eligible population in the scheme was not effective in a long run. One of the reasons was that many elderly spent their vouchers mainly for general outpatient visits in acute conditions [22-24], in which a younger group individuals may not present as much acute conditions as the elderly. Other purposes of utilizations were even fewer in this group including the preventive services. More health promotion works should be conducted in the local community before a consideration of lowering the age eligibility in the scheme.

The current EHCV scheme in Hong Kong has several concerns it has yet to address at the moment. The healthcare vouchers is likely not to be an effective strategy to decrease the public primary care works for more efficient allocation of medical resources. Compared to the relatively matured voucher program of Medicare in the United States, the voucher scheme has only been implemented for a bit more than 10 years. At the beginning, when the United States government began giving out voucher options around the mid-1980s, the

participation rate was below 5% [33]. They faced many challenges such as low area coverage, low awareness, and huge variations between different regions and states [11]. The voucher scheme only began to gain success after years of adjustment, advertising, and government assistance. Although regional variation is not a problem for Hong Kong, Hong Kong faces similar challenges such as lack of service provider participants and voucher expenditure not as intended. Lack of provision in the public sector for a long term planning and the "competition" from public healthcare service are also a local difficulty for running the EHCV scheme. It took the United States over 30 years of improvement, and it will certainly also take time for Hong Kong to figure out what are the best settings of vouchers to make the scheme effective. The suggestions from this study could be the next steps for the EHCV.

Mathematical models evaluating interventions require systematic plausibility, and thus must account for the abstraction and generalization of realism. Because of it, our SD model only captured necessary variables into model parametrization that was reviewed in the qualitative phase. Some of the socio-demographic characteristics (e.g. gender and income level), geographical factors (e.g. accessibility to healthcare facilities and regional heterogeneity), and utilization characteristics (e.g. availability of services and number of healthcare staffs) were not included in the model development in consideration of the balance between model complexity and generalization of the results. We acknowledge some of these factors may affect the simulation results, for example, lower income group may have more utilizations in the public sector.

Another major limitation is that the unmet needs from the local population were not taken into account in the model development due to a lack of relevant data [34]. In Hong Kong, limited provision, long wait time, and limited quotas in public healthcare services may hinder some of the individuals to visit public doctors and they may also be unwilling to visit private doctors due to lower income particular for older patients with chronic disease who require frequent consultation and medication even though they got healthcare needs. The introduction of the voucher provides an incentive to this group of people to visit private doctors without generating an actual shift from the public healthcare services in the healthcare system. On the other hand, we assumed the provision of public healthcare service could be provided continuously in a long run in which the assumption may not be held well in the future when taking account of the workforce shortage and shrinking working population in Hong Kong. Because of these reasons, the simulation results could result in an over-estimation of the intervention effects.

Conclusion

Various recommendations have been purposed to improve the current EHCV scheme in order to reduce the reliance on the public sector in Hong Kong. In this study, we employed a SD modelling approach to examine the effectiveness of some enhanced strategies in a long run. The results showed that the current EHCV scheme was hard to relieve the burden of over-utilization of public primary healthcare services along with the local aging trend. Even if the increment rate of annual amount could be kept with a similar pace to the historical trends or the age eligibility could be lowered to 60 years old, the enhanced strategies were unable to maintain a steady drop of public healthcare services utilization. Nevertheless, introducing an additional chronic disease-oriented voucher could result in an apparent reduction in the reliance on the public sector in the early implementation phase but the effect could not be maintained for a period of time due to an increased demand from the elderly require more visits on chronic diseases conditions and the price inflation from the private market. For not substantially rising the government expenditure for refining the voucher scheme, health promotion works for encouraging co-payment from elderly is recommended.

Abbreviations

C&S	Census and Statistics
DH	Department of Health (Hong Kong)
EHCV	Elderly Health Care Voucher
MAPE	Mean absolute percentage error
SD	System dynamics
WTP	Willingness to pay

Declarations

Ethics

Not applicable.

Consent for publication

Not applicable

Availability of data and material

The datasets analyzed during the current study are available in the Additional File.

Competing interests

The authors declare that they have no competing interests.

Authors' contributions

CHKY, PYKC, and TYC collected the secondary data. KCC performed the investigation, analyzed the data and wrote the manuscript. CHKY, PYKC, HF, BCYZ, EWLY, MHW, and EKY interpreted the results and contributed substantially to its revision. All the authors read and approved the final manuscript.

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Figures

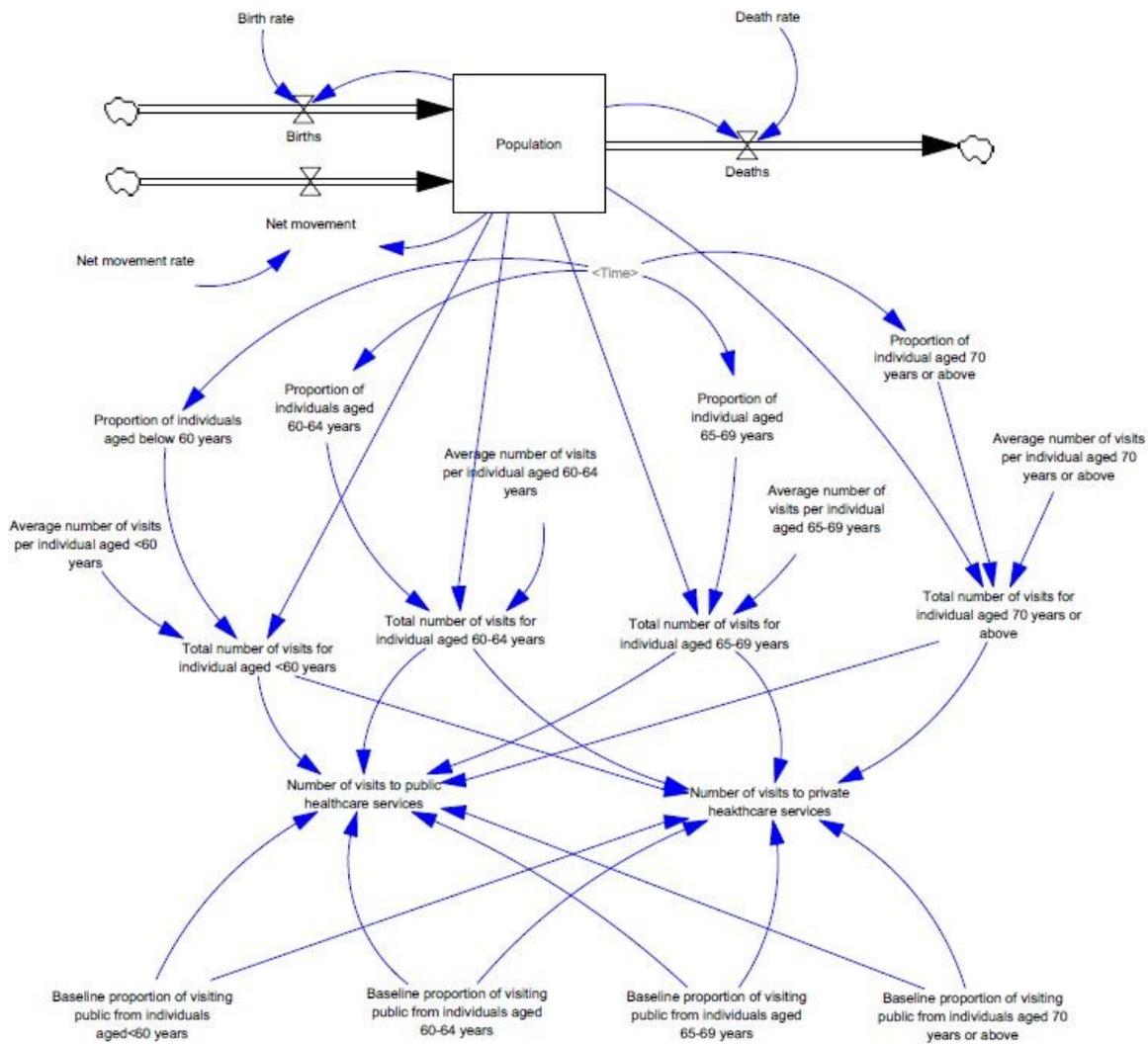


Figure 1

Diagram of the system dynamics model for generation of visits to healthcare services in a population

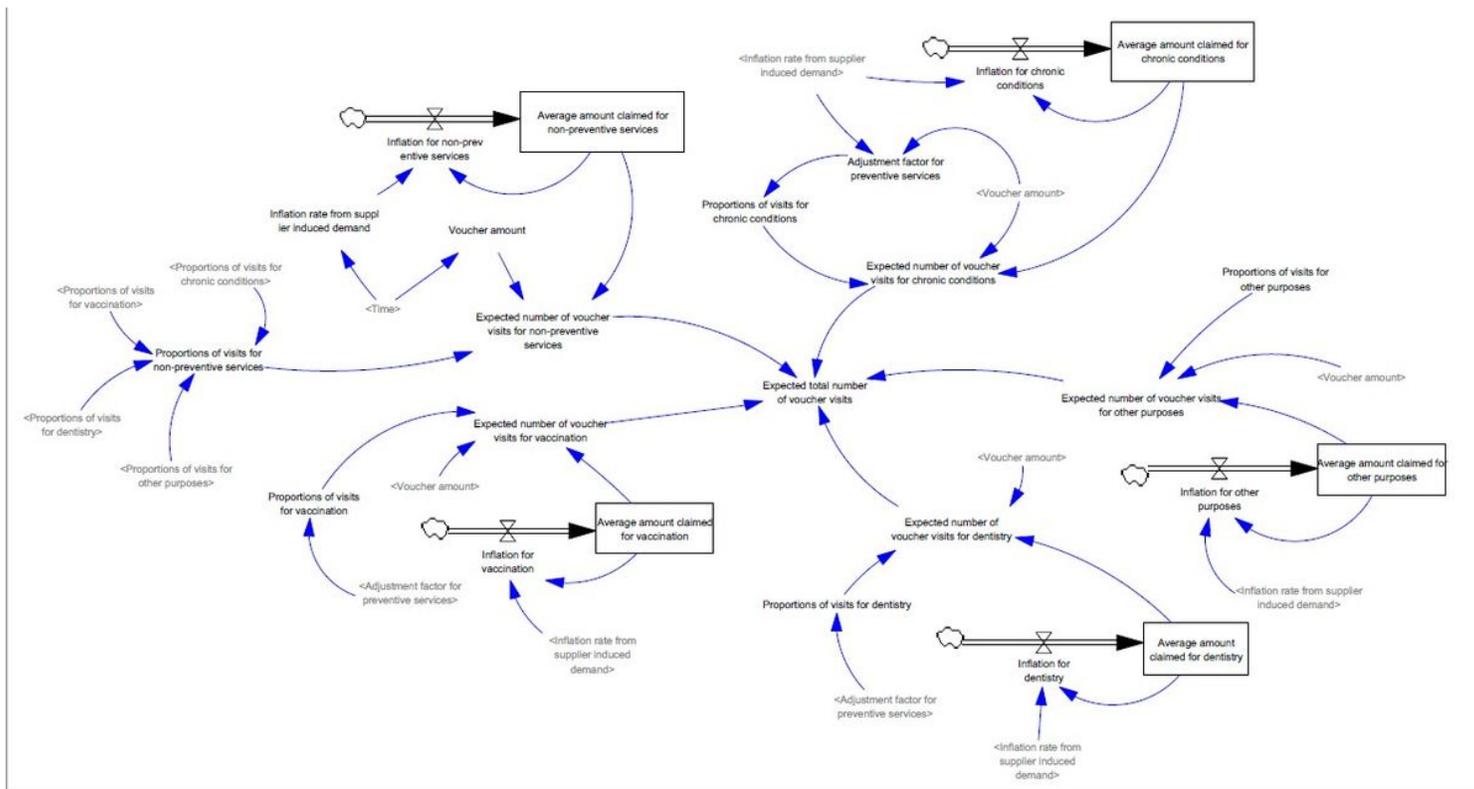


Figure 2

Diagram of the system dynamics model for generation of visits of using EHCV

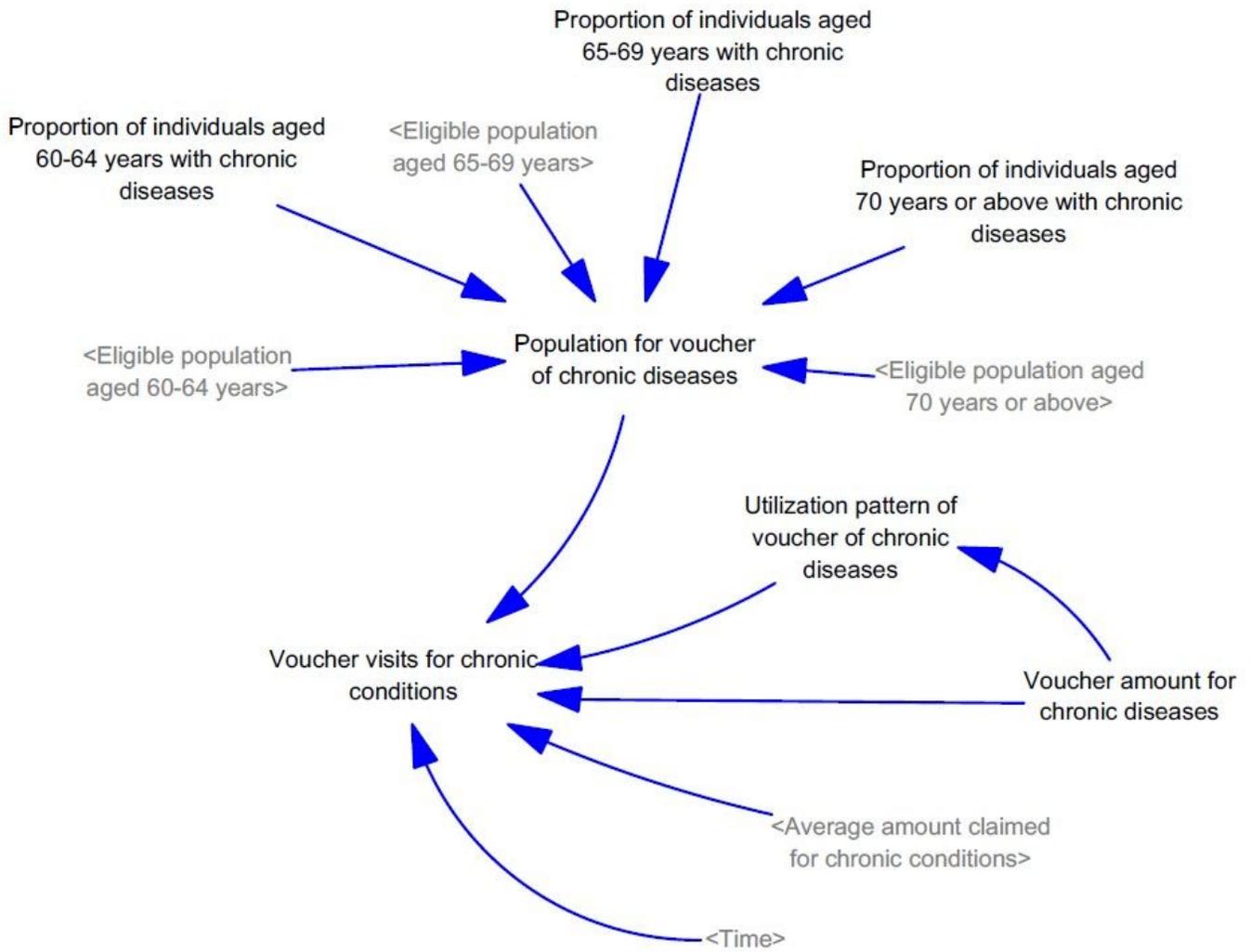


Figure 3

Diagram of the system dynamics model for generation of visits of using vouchers for chronic diseases

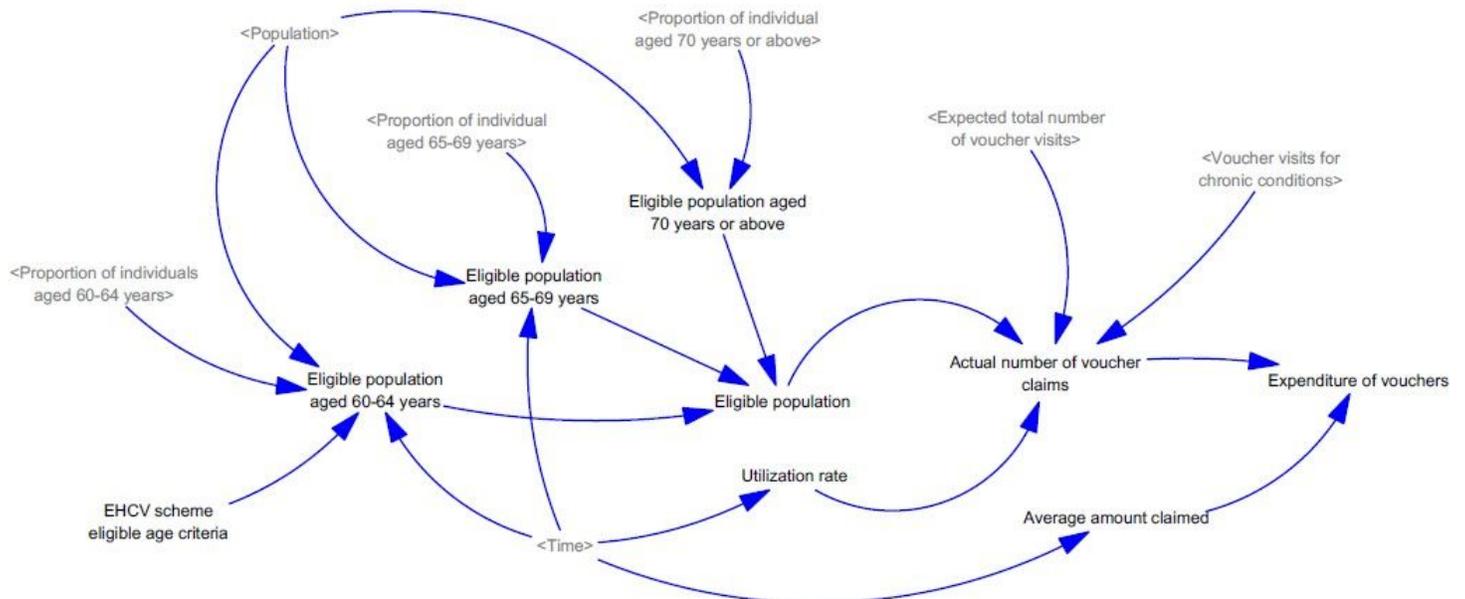


Figure 4

Diagram of the system dynamics model for generation of actual number of visits using vouchers

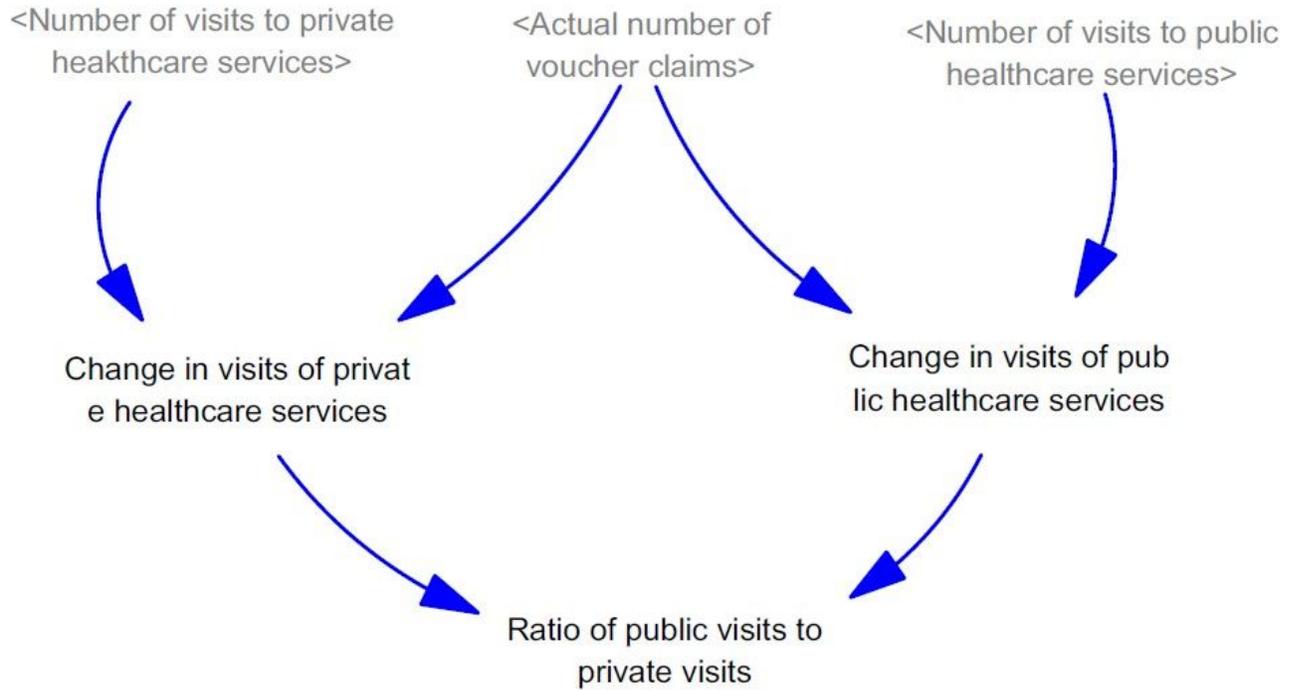


Figure 5

Diagram of the system dynamics model for changes in utilization of public healthcare services

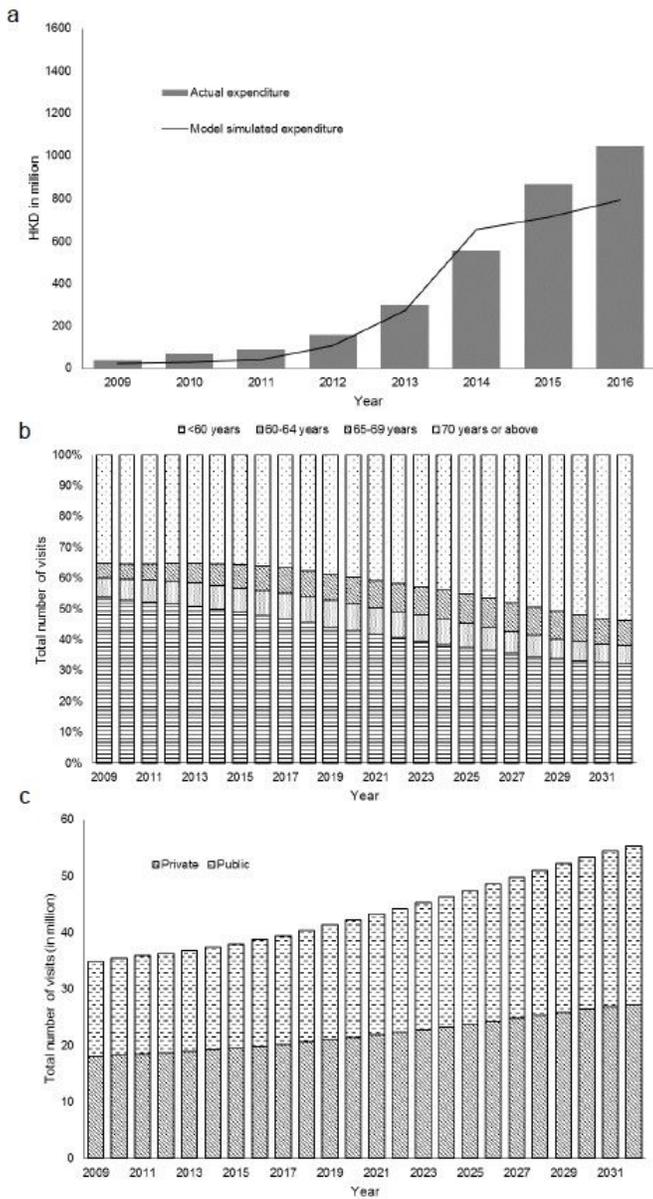


Figure 6

a) Model simulated expenditure and actual expenditure of voucher uses, (b) Proportions of total visits by age group in the baseline scenario, and (c) comparison of total visits between public and private in the baseline scenario

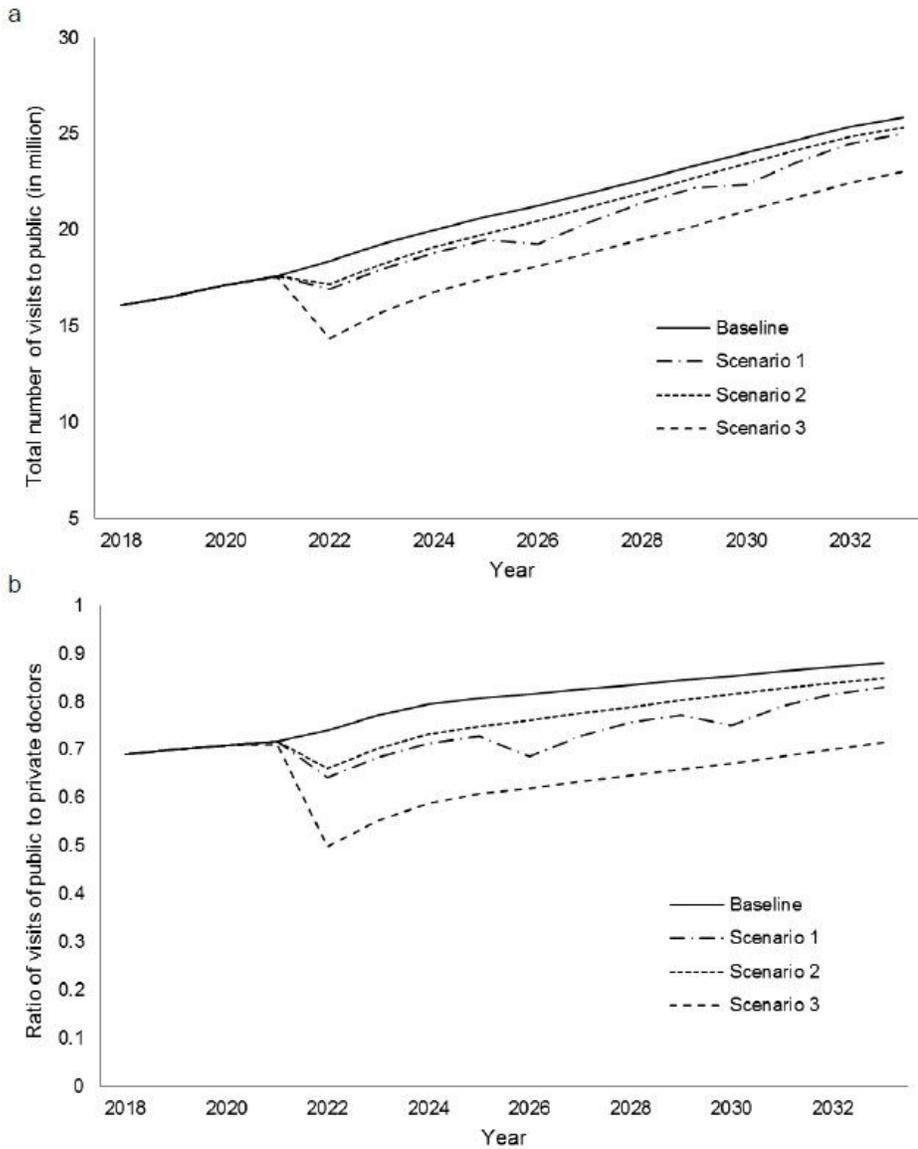


Figure 7

Changes in (a) public healthcare utilizations and (b) ratio of visits between public and private by years in different scenarios

Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- [AdditionalFile1VariableSpecifications.pdf](#)