Forecasting of Future Medical Care Expenditure in Japan Using a System Dynamics Model

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Abstract

Background:

Japanese society is facing marked changes due to the aging population and concomitant rapid increase in the national medical care expenditure. To maintain a sustainable national health insurance system, it is important to pursue the efficient allocation of medical care resources. The aim of this study was to construct a system dynamics (SD) model to estimate the future medical care expenditure and to address the dynamic issues of health care that should be resolved. In particular, the measures for promoting the spread of generic drug (GE drug) usage in Japan and reducing cancer-related medical expenses were investigated regarding their future impact on medical finances.

Methods:

The SD model was constructed to estimate the medical care expenditure from FY 2018 to FY 2050. The change in the future GE drug quantity share was analyzed by using a regression equation, and the target value of the GE quantity share was set exceeding 90% by referring to trends in other countries. The impact of the increase in medical expense for cancer and the change in the future national medical care expenditure were also estimated assuming the current tendency of increase in the medical expense for cancer continues.

Results:

It was estimated that the annual total medical care expenditure in FY 2050 would arrive at 58.9–64.2 trillion JPY (1.3-1.5-times higher than that in FY 2018) with different trends in age groups. The cumulative total medical care expenditure was expected to decrease by about 787.0-989.4 billion JPY if the impact of the spread of GE drug usage was considered. On the other hand, due to the continuous increase in the cancer-related medical expense, the cumulative total medical care expenditure was estimated to increase about 7,554.3–11,715.0 billion JPY.

Conclusions:

If the cancer-related medical expense continues to increase in the future, an increase of 686.4-1,104.2 billion JPY in FY2050 is expected which suggests that this disease field should be prioritized regarding the measures to maintain medical finances. This study may serve as a reference for designing a policy in countries that will enter a super-aging society in the future such as that in Japan.

Trial registration: Not applicable

Background

Japan introduced a national health insurance (NHI) system in 1961. The entire nation is guaranteed the right to receive equal medical care if a copayment specified by the national regulations [1] is paid.

Technical fees for medical technology and practice are established publicly. Drug prices are determined according to the NHI drug price scheme that was enacted in September 1950 [2].

Circumstances surrounding the NHI system, which has existed for more than 50 years as an essential system for life, are changing. Japanese society is facing marked changes due to the aging population [3] and the concomitant rapid increase in the national medical care expenditure, resulting in tight medical finances [4]. The population aged 65 years or older accounted for 28.14% of the total population in Japan in 2018, being the highest among the Organization for Economic Co-operation and Development (OECD) member countries, and this is 1.6-times higher than the mean (17.20%) of the OECD member countries. In addition, the Gross Domestic Product (GDP) ratio vs. national medical care expenditure was ranked 14th among the OECD member countries in 2010, but it became 6th in 2018 (10.9%), reflecting a rapid rate of increase in the national medical care expenditure compared with those in other countries [5]. Based on the above, the national medical care expenditure will continue to increase if the current state continues. Moreover, regarding the condition of Japan's national finances, the financial deficit is increasing continuously. Indeed, the total expenditure in fiscal (FY) 2014 surpassed the total tax revenue by 46 trillion JPY and more than 40 trillion JPY of the national bond is floated [6]. In response to this situation, the reform of the medical care system for the efficient use of limited medical care resources has been proposed.

As a policy aiming at a sustainable NHI system, the full-scale introduction of cost-effectiveness evaluations (termed Japanese Health Technology Assessment [HTA]) started in April 2019 under an initiative by the Ministry of Health, Labour and Welfare (MHLW) [7]. The Japanese HTA is used for the pricing process of medical technology (drugs and medical devices) and enables us to evaluate innovations and price them logically in order to promote the efficient usage of limited medical resources.

In order to maintain a sustainable NHI system, it is also important to pursue the efficient allocation of medical care resources. To design efficient measures to achieve this, it is important to predict changes in the national medical care expenditure in the future and confirm them by simulating long-term benefits expected if the measures are implemented.

The system dynamics (SD) theory was developed in 1956 at the Massachusetts Institute of Technology (MIT), and SD simulation is used in a variety of business settings. SD modelling is suitable to predict the future medical care expenditure because there are many factors [8–10] that influence future medical care expenditure. In addition, future medical care expenditure will be influenced by the change in related variables over time. The SD model is simple to analyze for all scenarios by finding patterns of behavior, and evidence-based scenario analysis is highly important to discuss the efficient allocation of medical care resources.

The aim of this study was to forecast the future medical care expenditure in Japan using the SD model and to address the dynamic issues of health care that should be resolved. In particular, the measures for promoting the spread of generic drug (GE drug) usage and reducing the cancer-related medical expenses (i.e. part of the medical treatment expenditure and dispensing pharmacy expenditure), for which an increase in impact on national medical care expenditure is of concern from the viewpoint of the disease field, were investigated regarding their future impact on medical finances.

Method

Model construction

The SD model was constructed by referring to the estimation reported by Kitaura et al. [11]. The model consisted of three variables; medical care expenditure per capita, population number, and increase rate of medical care expenditure per year (Additional file 1). Total medical care expenditure was calculated in each age group; 0 to 14 years, 15 to 44 years, 45 to 64 years and ≥ 65 years group, and summed as the total medical expenditure. The simulation term was set from FY 2018 (index year) to FY 2050. The population number in each year was expressed as “stock” connected to the “flows”, the number increased (flow-in) and the number decreased (flow-out), controlled by the TIME function set in “converter”. The future population in Japan referred to the 2017 estimation (medium-fertility) from the National Institute of Population and Social Security Research [12]. Medical care expenditure per capita in each year (expressed by “stock”) fluctuated according to the increase rate per year (expressed by “converter”). For the increase rate per year, the mean of the increase rates from FY2010 to FY2017 (0 to 14 years group; 2.6% / year, 15 to 44 years group; 2.2% / year, 45 to 64 years group; 1.0% / year, and ≥ 65 years group; 0.9% / year) was used [13].

There are mainly 3 methods [14] for estimation of fluctuation of the future medical care expenditure per capita, i.e. increase rate per year (%). The 1st method employs the nominal GDP growth rate (nominal GDP formula), the 2nd method takes the increase in the excess growth cost by technological innovation in addition to the nominal GDP growth rate (OECD formula). In the 3rd method, a specific growth rate is set exogenously [15] (MHLW formula). The method described above was adjusted with the past increase rate of medical care expenditure per capita corresponds to the MHLW formula. Regarding the overall increase in the medical care expenditure, as it is considered desirable to use the nominal GDP formula and OECD formula focusing on the difference in the growth rate relative to economic growth [16, 17], the increase rate per year (%) using these 2 methods were also performed. For the nominal GDP growth rate, reported estimates were used from FY 2018 to FY2029 [18] under the assumption that the value in FY2029 was maintained thereafter because of the absence of data. In the OECD formula, the increase rate of the unit medical expense was assumed as follows:1.9% (advancement of medical treatment) + economic growth rate/3–0.1% (increase in efficiency due to drugs and devices)” [14, 17]. The SD model was constructed using SD software, iThink (isee systems, USA).

Scenario 1: Impact of the spread of GE drug usage

In Japan, ‘A *roadmap* for p*romotion* of the *use of generic drugs’* was formulated by the MHLW in April 2013 as a policy to help improve medical insurance finances and relevant activities are underway [19]. Furthermore, in ‘Basic Policy on Economic and Fiscal Management and Reform 2017’ (cabinet decision on June 9, 2017) [20], the target ratio of GE drug usage to be achieved by September 2020 is 80%. The ratio of GE drug usage is defined by the following equation:

GE drug quantity share = (Number of GE drugs)/ ((number of original drugs which are substitutable by GE drug) + (number of GE drugs))

The GE drug quantity share in FY2018 was 75.9% [21]. The GE drug quantity share in other countries in FY2018 [22] was 92% in the US and 87% in Germany, demonstrating that a spread rate higher than the target value in Japan has been realized in other developed countries. Thus, in this estimation, the GE drug quantity share after FY2018 was estimated using an estimate equation derived from the past GE quantity share from FY2013 to FY 2018:

GE drug quantity share = $-0.0027x^2 + 0.0402x + 0.7541$

x = TIME

(R^2 = 0.9914)

The GE drug quantity shares in 2020 and 2025 were estimated to be 82.37 and 90.32%, respectively. Considering the spread rates in other countries, 90.32% was assumed to be maintained in 2025 and thereafter in this scenario.

The calculation logic of the impact of the spread of GE drug usage on the future medical care expenditure in Japan was expressed using a contributing factor diagram (Additional file 2). The impact of the spread of GE drug share was incorporated in the “Medical care expenditure per capita”. The parameters that influence the impact of GE drug share were “Drug cost rate; proportion of total drug costs in total medical care expenditure”, “GE drug cost ratio; ratio of GE drug prices to the original drug prices” and “GE drug cost rate; proportion of GE drug costs in total drug costs” expressed by “converter”. “GE drug cost rate” was estimated from “GE drug quantity share” using the following equation derived from changes in the GE drug quantity share and GE drug cost rate in the past from FY2013 to FY 2018;

GE drug cost rate = $0.2647x - 0.0151$

x; GE drug quantity share
(R^2 = 0.9772)

The GE drug cost rate in FY2018 was estimated as 18.451%.

The spread of GE drug usage influences the portion of total drug costs in total medical care expenditure. The proportion of total drug costs in total medical care expenditure (i.e. Drug cost rate) was calculated as 13.329% using the data in 2017 [23]. The ‘Drug cost rate’ was assumed to be consistent through the simulation term.

Using the SD model under the assumption that the drug costs when the original drugs are changed to GE drugs will be reduced to 50% of the costs of the original drugs (i.e. GE drug cost ratio), the saving of future total medical care expenditure by the spread of GE drug usage were estimated.

Scenario 2: Impact of the increase in the medical treatment expenditure and dispensing pharmacy expenditure for cancer

Regarding the changes of the composition ratio in the medical expense for diseases from FY2010 to FY2017 (JPY per capita) (Fig. 1) [24], it was found that most of them are flat, but the composition ratio of the cancer-related medical treatment expenditure was not only high following the ratio of “circulatory system disease” but also continuously increase. A similar trend was noted in the composition ratio of anticancer drugs in the dispensing pharmacy expenditure [21]. Based on the above, the changes in the national medical care expenditure were estimated assuming that the current increasing tendency in the medical expense for cancer will continue in the future, and its financial impact was evaluated. For medical expenses other than the cancer-related medical expense, the increase rate per year set in the constructed SD model was retained.

The calculation logic of the impact of the increase in the medical expense for cancer in Japan was expressed using a contributing factor diagram (Additional file 3). The rates of the medical treatment expenditure and dispensing pharmacy expenditure in the national medical care expenditure in FY2017 by the age groups were set as follows: 0–14 age group, 69.3 and 19.0%, respectively; 15–44 age group, 64.7 and 19.1%, respectively; 45–64 age group, 69.0 and 19.0%, respectively; ≥ 65 age group, 74.2 and 17.5%, respectively [13], and expressed by “converter” in the model. The rates of medical expense for cancer in the medical treatment expenditure and dispensing pharmacy expenditure (per capita) in FY2017 by age group were as follows: Medical treatment expenditure, 2.9, 9.9, 17.9 and 14.7%, respectively [13]; dispensing pharmacy expenditure was uniformed to 4.2% [13]. The percent increase from the previous year in each cancer-related medical expense and dispensing pharmacy expenditure was calculated based on changes from FY2014 to FY2017 [13]. For the medical treatment expenditure, + 0.09%, 0% (i.e. flat), + 0.18% and + 0.28% were set for the age groups, respectively, and + 0.26% was uniformly set for the dispensing pharmacy expenditure. Assuming that this growth rate was retained during the simulation period, it was incorporated into the variable for medical care expenditure per capita.

The parameters used in the series of SD models are summarized in Table 1. The simplified whole SD model structure are shown in Fig. 2.

Table 1
Parameter list for the SD model.

Variables	Value		Reference
I. Estimation of future medical care expenditure			
Japanese population in FY2017, Thousand/year	0–14 years	15592	[25]
	15–44 years	42953	
	45–64 years	33009	
	≥ 65 years	35151	
National medical care expenditure in FY 2017, Thousand JPY/year	0–14 years	162.9	[13]
	15–44 years	122.7	
	45–64 years	282.1	
	≥ 65 years	738.3	
Increase rate, %/year (Ave. of FY2010-2017)	0–14 years	102.6%	[13]
	15–44 years	102.2%	
	45–64 years	101.0%	
	≥ 65 years	100.9%	
II. Impact of the spread of generic drug (GE drug) usage			
GE quantity share in FY2018, %	75.9		[21]
GE rate in FY2017, %	13.329		[23]
GE cost rate, %	50		[26]
III. Impact of the increase in the medical treatment expenditure and dispensing expenditure for cancer			
Rate of medical treatment expenditure in national medical care expenditure in FY2017, %	0–14 years	69.3	[13]

SD, system dynamics; GE, generic.

Variables	Value		Reference
	15–44 years	64.7	
	45–64 years	69.0	
	≥ 65 years	74.2	
Rate of dispensing pharmacy expenditure in national medical care expenditure in FY2017, %	0–14 years	19.0	[13]
	15–44 years	19.1	
	45–64 years	19.0	
	≥ 65 years	17.5	
Rate of medical treatment expense for cancer in medical treatment expenditure (per capita) in FY2017, %	0–14 years	2.9	[13]
	15–44 years	9.9	
	45–64 years	17.9	
	≥ 65 years	14.7	
Rate of drug cost for cancer in dispensing pharmacy expenditure (per capita) in FY2017, %	4.2		[13]
% increase from previous year in rate of each medical expense in medical treatment expenditure for cancer (Ave. of FY2014-2017), %	0–14 years	+ 0.09	[13]
	15–44 years	0	
	45–64 years	+ 0.18	
	≥ 65 years	+ 0.28	
% increase from previous year in rate of each drug cost in dispensing pharmacy expenditure for cancer (Ave. of FY2014-2017), %	+ 0.26		[13]
SD, system dynamics; GE, generic.			

Results

Model validation

Our SD model was validated by confirming that population changes in the future are reproduced by SD model simulation based on existing reports. The population estimate in 2050 in Japan published as 101,923,107 (2017 estimation) [12]. The population estimate in 2050 in the SD model was 101,923,093 and the difference from the reported population estimate in each year during the estimation period was within ± 10^{-5}%, confirming that changes in population in the future can be reproduced by the SD model.

Estimation of future medical care expenditure

Annual total medical care expenditure in FY 2050 was estimated as \ 58,858,188,615,230 (58.9 trillion JPY), being estimated to increase by 1.3-times over 32 years from FY2018 (43.8 trillion JPY) (Fig. 3). The annual total medical care expenditure in FY 2050 was estimated using two analysis settings with regard to the increase rate per year (%), i.e., the nominal GDP formula and OECD formula, and the estimates were \ 59,159,195,923,420 (59.2 trillion JPY) and \ 64,241,212,744,011 (64.2 trillion JPY), respectively, being estimated to increase by 1.4- and 1.5-times, respectively, over 32 years from FY2018. At either setting of the increase rates, the annual total medical care expenditure in FY2050 was 58.9–64.2 trillion JPY (1.3–1.5 times that in FY 2018), demonstrating no major difference in the estimated value due to differences in the definition of the increase rate in this analysis.

The trend of total medical care expenditure was different in each age group (Additional file 4). The total medical care expenditure in the ≥ 65 years group accounted for the highest rate in all FY. The trend in total medical care expenditure in FY 2018-FY 2050 was flat or a slightly increasing in the other 3 age groups, but it continuously increased in the ≥ 65 years group, reaching the peak in FY 2050, exhibiting an increase by 1.4-times from 26.4 trillion JPY in FY 2018 to 38.1 trillion JPY in FY 2049 in the base case (MHLW formula).

Impact of the spread of GE drug usage

Annual total medical care expenditure in FY 2050 was estimated as \ 58,803,573,237,874 (58.8 trillion JPY) to \ 64,170,630,801,280 (64.2 trillion JPY). Compared with the estimated value in FY 2050 without the impact of the spread of GE drug usage, total medical care expenditure was expected to be reduced 53.7 billion JPY to 70.6 billion JPY (Fig. 4).

The cumulative total medical care expenditure from FY 2018 to FY 2050 was estimated as \ 1,760,862,110,558 (1,760.9trillion JPY) to \ 1,839,898,162,067,340 (1,839.9 trillion JPY). Compared with the estimated value without the impact of the spread of GE drug usage, the cumulative total medical care expenditure was expected to be reduced 787.0 billion JPY to 989.4 billion JPY (Fig. 5).

Impact of the increase in the medical treatment expenditure and dispensing pharmacy expenditure for cancer

The annual total medical care expenditure in FY 2050 was estimated as \ 59,544,546,892,928 (59.5 trillion JPY) to \ 65,345,391,561,256 (65.3 trillion JPY). Compared with the estimated value in FY 2050 without the impact of the increase in the medical expense for cancer, the total medical care expenditure was estimated to be increased 686.4 billion JPY to 1104.2 billion JPY (Fig. 4).

The cumulative total medical care expenditure from FY 2018 to FY 2050 was estimated to be \ 1,769,203,387,696,570 (1,769.2 trillion JPY) to \1,852,602,519,078,590 (1,852.6 trillion JPY). Compared with the estimated value without the impact of the increase in the medical expense for cancer, the cumulative total medical care expenditure was estimated to increase 7,554.3 billion JPY to 11,715.0 billion JPY (Fig. 5).

Regarding changes in each age group, the annual total medical care expenditure in FY 2050 in the ≥ 65 years group was estimated as \ 38,595,861,387,617 (38.6 trillion JPY) to \ 45,962,157,002,657 (46.0 trillion JPY), and the increase compared with the estimated value without the impact of the increase in the medical expense for cancer was estimated as 485.9 billion JPY to 908.5 billion JPY.

Discussion

The main result from the SD model, built for forecasting the future medical care expenditure, shows the nation-wide medical care expenditure in FY 2050 to be 58.9–64.2 trillion JPY, which represents an increase of 1.3 to 1.5-times from that in FY 2018. As the increase rate used in this estimation was based on the baseline case published by the Cabinet Office, the estimation may be conservative. We tried estimation concerning the increase rate using 3 setting methods (MHLW formula, nominal GDP formula, and OECD formula) and there was no major difference in the estimation among their use in the analysis.

Multiple studies on future estimations of the national medical care expenditure in Japan have been reported. The estimation in 2050 was 38.7 trillion JPY in a report from Fukawa published in 2013 [27], whereas it was estimated to be 60 trillion JPY by the Ministry of Economy, Trade and Industry in the report in March 2016 [28]. In reports from the Cabinet Secretariat, Cabinet Office, Ministry of Economy and Finance, and MHLW in May 2018, the estimate in 2040 was 68.3 trillion-70.1 trillion JPY [29]. Although general comparison is not favorable because the estimation varies depending on the economic index expected at the time of executing estimation and changes in demographics, the values estimated by us were within the range of these reported values, demonstrating our estimates to be valid.

The time-course on GE drug quantity share has been periodically reported, aiming at achieving the goal laid out for “the roadmap for promotion of the use of generic drugs” by the Japanese government, but to our knowledge, there has been no report on quantitative verification of its medical expense-reducing effects. Under the assumption that a 90% GE drug quantity share is achieved based on the spreading speed of GE drug in Japan in the past, we performed the simulation in which the measures for promoting the spread of GE drug were added. The cumulative decrease over the 33-year period to FY 2050 was estimated to be 787.0 billion JPY to 989.4 billion JPY. On the other hand, the medical care expenditure in FY 2050 was estimated under the assumption that the increase rate of the cancer-related medical expense in the last

4 years will continue thereafter, the medical care expenditure in FY2050 was estimated to be 59.5 trillion to 65.3 trillion JPY and an increase by 686.4 billion to 1,104.2 billion JPY and cumulative increase by 7,554.3 billion to 11,715.0 billion JPY over the 33-year period to FY 2050 were expected. This estimation exceeded the cumulative decrease expected by the measures for promoting the spread of GE drug by more than 10-times. Accordingly, this fact suggested a policy issue to be focused on. Preparing a policy to increase the efficiency of treatment, such as development of innovative medical technology, financial investment for a policy promoting prevention and early discovery, and development of innovative testing techniques, may be important.

There are reports evaluating a policy that may contribute to reduce the cancer-related medical care expenditure in other countries. For example, Kuipers et al. investigated the relationship between mass media campaigns for smoking cessation and the success rate of quit attempts, and found that an increase in mass media expenditure of 10% of the monthly average was associated with a 0.51% increase in success rates of quit attempts (95% CI 0.10–0.91%) [30]. Holleman et al. evaluated the impact of alternative risk-sharing arrangements (RSAs) for non-small cell lung cancer therapies based on real-world data and concluded that RSAs can mitigate uncertainty around the incremental cost-effectiveness or budget impact of drugs [31]. Modi et al. reported that stronger engagement of urologists in accountable care organizations was associated with a lower likelihood of potential overtreatment (odds ratio: 0.29; 95% confidence interval: 0.10–0.86) in the US [32]. Shi et al. compared the cost-effectiveness of six common cancers from a priority setting perspective. Their preliminary analysis suggested that stomach cancer and colorectal cancer were the most cost-effective target cancers, and they concluded that they can be prioritized in future scaled-up screening in the general population [33].

If an efficient allocation of limited resources is considered as a national policy, it has to be considered based on 2 axes: not only reducing expenditure, but also pursuing improvement of the people's quality of life. Both the efficiency of treatment selection based on evaluation of cost-effectiveness and the efficient use of limited national financial resources must be investigated with a long-term vision. To investigate the efficient allocation of resources, it is essential to discuss about the prioritization of a nation's need and equity, and development of suitable indicator of social worth is also necessary [34]. Grépin et al. reported a survey that elicited preferences of different stakeholders for criteria guiding the allocation of external financing for health across countries using an online discrete choice experiment (DCE), and found that stakeholders assign a great deal of importance to health inequalities and the burden of disease [35]. Park et al. investigated whether the Ministry of Health and Welfare (MOHW)'s research and development (R&D) budget has responded to the burden of diseases evaluated using disability adjusted life years (DALYs) in Korea. As a result, a mismatch was observed between the R&D budget and the burden of disease in terms of DALYs, and they concluded that a novel approach for allocating government R&D funding based on the goal of minimizing the disease burden in the Korean population should be considered [36].

When a new medical technology is introduced and covered by financial resources, it is necessary to consider "affordability" in addition to the concept of "cost-effective". The institute for Clinical and Economic Review (ICER) in the US provides value frameworks for new drugs to guide the decisions of all stakeholders, including individual patients, clinicians, insurers, or payers. And a measure of affordability evaluated by a potential budget impact analysis is also included as one of the multiple domains of value, and decision-making considering permanent sustainability of limited medical financial resources is performed [37].

To consider efficient long-term allocation of resources, it is necessary to investigate not only changes in the expenditure, but also changes in the national revenue influenced by the national economic state and working population at the same time. To increase the accuracy of simulation, investigation considering the concept of fiscal health modelling [38,39] enabling political decision-making based on age-specific transfer cost (i.e. health care costs and disability) and changes in tax receipts may be necessary in the future. Last but not least, it should be kept in mind that the technological progress in healthcare and demographic trends, mostly structure of the population, are only part of a much wider set of influences on future health expenditure. Notably, technological advances in the healthcare interventions available and in the methods for delivering them will probably speed up in the coming decades. This means that attention should be paid on supply side drivers of the healthcare as an effective strategy to provide high quality care at an acceptable cost. Moreover, the future needs for long-term care cannot be projected in the same way as healthcare. Hence, the need for more specific indicators on healthcare needs as well as evidenced-based healthcare decision making will remain high on the agenda.

Conclusions

To address the dynamic issues of the tight medical finances, the SD model to estimate the future medical care expenditure was constructed and the national medical care expenditure in FY2050 in Japan was estimated to be 58.9–64.2 trillion JPY, which is 1.3–1.5 times higher than that in FY 2018. More specifically, assuming the increase rate of the cancer-related medical expense continue, the national medical care expenditure in FY2050 was estimated to be 59.5 trillion JPY to 65.3 trillion JPY, being expected to increase by 686.4 billion JPY to 1,104.2 billion JPY. This fact suggests the necessity of setting a policy for the maintenance of medical finances. This study may serve as a reference for designing a policy in countries that will enter a super-aging society in the future such as that in Japan.

Abbreviations

DALY, disability adjusted life year; DCE, discrete choice experiment; FY, fiscal year; GDP, Gross Domestic Product; GE, generic; HTA, Health Technology Assessment; ICER, the institute for Clinical and Economic Review; MHLW, Ministry of Health, Labour and Welfare; MIT, Massachusetts Institute of Technology; MOHW, Ministry of Health and Welfare; NHI, national health insurance; OECD, Organization for Economic Co-operation and Development; R&D, research and development; SD, system dynamics.

Declarations

Ethics approval and consent to participate

Not applicable.

Consent for publication

Not applicable.

Availability of data and material

Although all data generated or analyzed during this study are included in this published article and its supplementary information files, the datasets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request.

Competing interests

The authors have no conflicts of interest to declare that are relevant to the content of this article.

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Authors’ contributions

All authors contributed to the study conception and design. Material preparation, data collection and analysis were performed by Sachie Inoue. The first draft of the manuscript was written by Sachie Inoue and all authors commented on previous versions of the manuscript. All authors read and approved the final manuscript.

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NA

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Figures

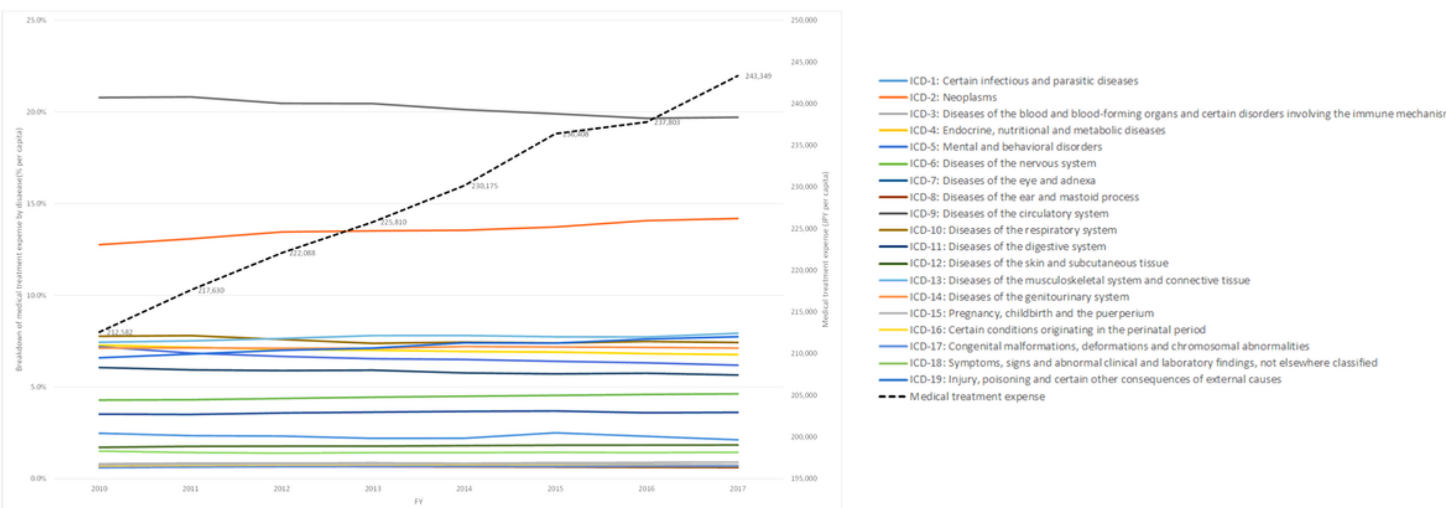

Figure 1

Medical treatment expense by disease (% per capita)

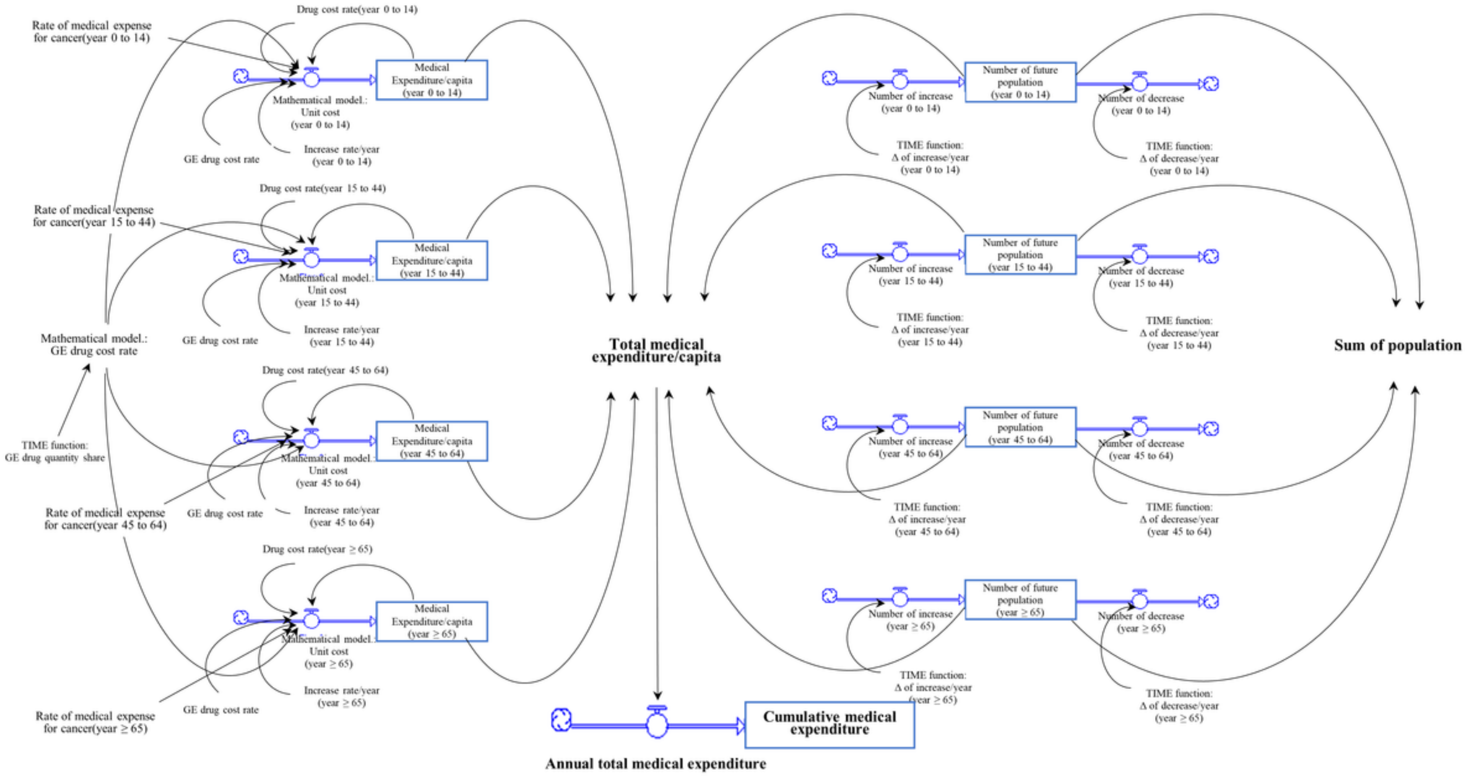

Figure 2

Simplified model structure. Boxes signify ‘stocks’, arrows in/out stocks represent ‘flows’ and boxes free represent ‘converters’.

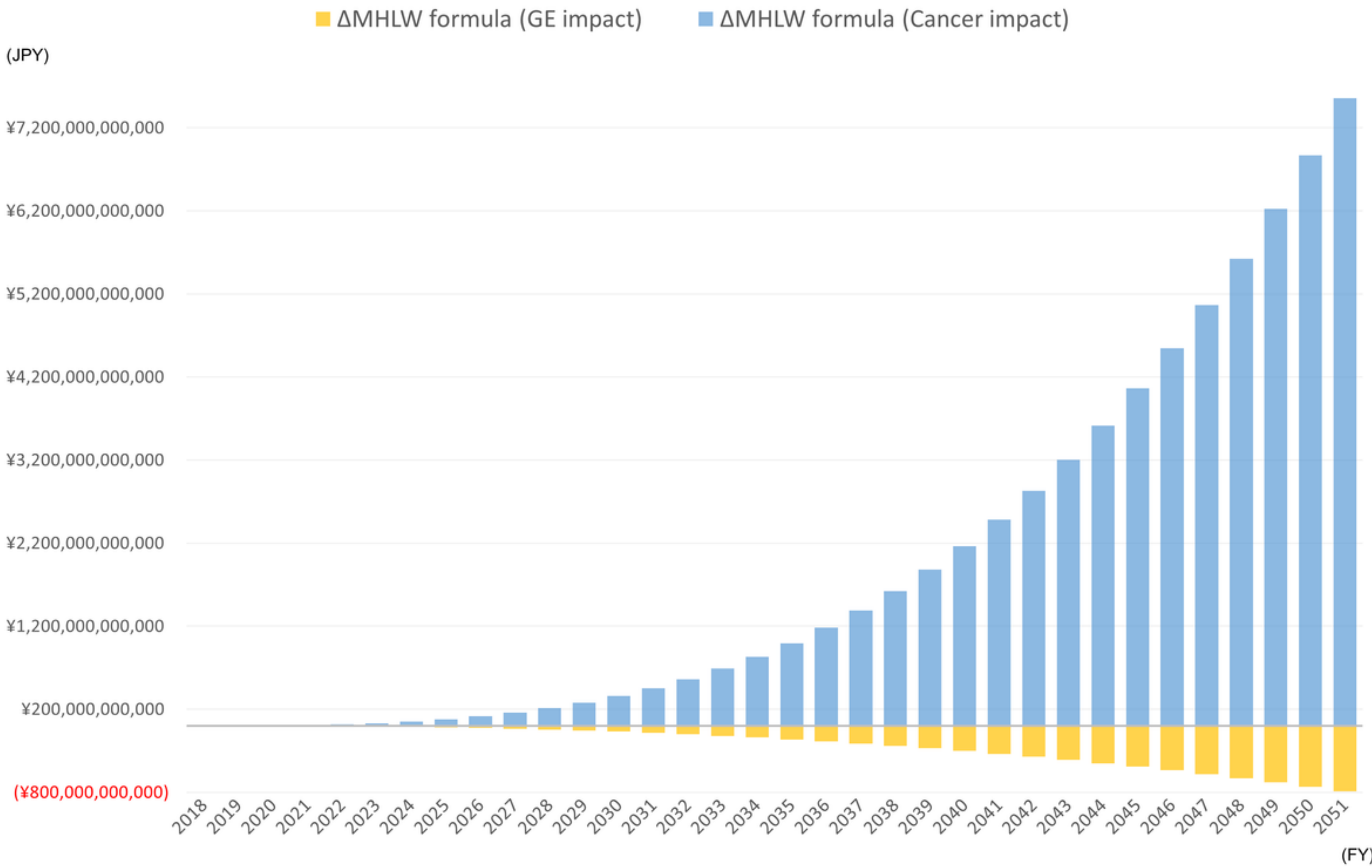

Figure 5

Impact on the cumulative medical expenditure (MHLW formula) GE, generic; MHLW, Ministry of Health, Labour and Welfare.

Supplementary Files

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- Additionalfile1.pdf
- Additionalfile2.pdf
- Additionalfile3.pdf