A Simulation model of Incidence of Cardiovascular Diseases using Risk Prediction Chart in Japanese men

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ABSTRACT

This study aimed to simulate incidence of cardiovascular diseases (CVDs) in Japanese men using risk prediction chart. We developed simulation models of calculating incidence of CVDs from 2003 to 2032 for Japanese men aged 40 to 79 by Vensim DSS 6.2. We used Japanese population data, number of total deaths from 2003 to 2013, and data for cardiovascular risk (systolic blood pressure, total cholesterol, smoking, and diabetes) to optimize parameters by 10-year age group. We used the WHO/ISH risk prediction chart (2010) for Group A in the Western Pacific Region of the World Health Organization, and set the incidence rate for 5 risk levels as 1%, 2%, 3%, 4%, and 6%, respectively (status quo). We also performed simulations assuming the 5th risk level as low as the 4th risk level (high-risk strategy) and the 5th, 4th, 3rd, and 2nd risk levels as low as the 4th, 3rd, 2nd and 1st risk levels, respectively (population strategy). In the status quo, the number of CVD incidence increases continuously for men aged 60 to 69 years until around 2025. The high-risk strategy showed almost the same results as the status quo, but the population strategy revealed that the number of incident CVDs would be reduced to two thirds of the status quo eventually. In conclusion, the effect of aging on CVD incidence among the Japanese population is inevitable, but the population strategy could decrease incidence of CVDs substantially.

Keywords: cardiovascular diseases, incidence, risk prediction chart, the Western Pacific Region, Japan

INTRODUCTION

Cardiovascular disease (CVD) is one of the leading causes of deaths both in developing and developed countries (WHO, 2014). Unhealthy lifestyles, originated from unhealthy environment, tend to cause accumulation of cardiovascular risk factors. It is important to estimate a number of cardiovascular incidence for better management of people with cardiovascular risk factors such as smoking, obesity, hypertension, diabetes and dyslipidemia and with history of cardiovascular diseases such as heart disease and stroke.

Risk prediction chart, which assesses overall cardiovascular risk using each risk factor data, is helpful for management of risk factors in individuals as well as in a population. Japan has a risk prediction chart for cardiovascular mortality (NIPPON DATA80 Research Group, 2006), but has developed few for cardiovascular incidence (Yatsuya 2016). Thus, WHO/ISH risk prediction charts (2010) for 14 WHO epidemiological sub-regions are useful for estimating cardiovascular incidence. This study aimed to simulate incidence of cardiovascular diseases using the risk prediction chart in Japan where the percentage of the elderly (Age>=65 years) has reached 25% of the total population since 2014.

METHODS

Model structure

We used the WHO/ISH risk prediction chart (2010) for Group A (very low child mortality and very low adult mortality) in the Western Pacific Region of the World Health Organization. This chart classifies individuals into five risk levels depending on sex, age, systolic blood pressure, total cholesterol, current smoking and presence of diabetes, and gives their 10-year accumulated risk of cardiovascular incidence: <10%, 10% to <20%, 20% to <30%, 30% to <40% and >=40%. These 10-year risks were converted to simple one-year risks of cardiovascular incidence as 1% ($1-0.95^{0.1}$), 2% ($1-0.85^{0.1}$), 3% ($1-0.75^{0.1}$), 4% ($1-0.65^{0.1}$) and 6% ($1-0.55^{0.1}$), respectively.

We used individual data of sex, age, systolic blood pressure, total cholesterol, current smoking and presence of diabetes in the National Health and Nutrition Survey from 2003 to 2010 to calculate percentages of five risk levels in each year.

We developed simulation models using aging chains of 10-year age groups from 40 to 79 years old with five risk levels from 2003 to 2032 by Vensim DSS 6.2 (Figure 1). As the percentages of risk levels differ greatly between age groups (Table 1), different risk levels as well as the same risk levels were connected by flows between the age groups to reflect average percentages of five risk levels from 2003 to 2010. No transfers between different risk levels in the same 10-year age group were considered.

Calibration

A calibration was performed using parameters for aging to the same or different risk levels and those for deaths to the Japanese population in Japan from 2003 to 2014 (Statistics Bureau, Ministry of Internal Affairs and Communication), the number of total deaths of the Vital Statistics from 2003 to 2015, and percentages of five risk levels in each 10-year age group derived from WHO/ISH risk prediction chart using the data of the National Health and Nutrition Survey from 2003 to 2010.

Scenarios

Besides the simulation using the one-year risks of cardiovascular incidence for five risk levels (status quo), we performed simulations based on high-risk strategy and population strategy (Rose G, 1985). High-risk strategy assumed that the 5th risk level is lowered to the 4th risk level in five years, and population strategy assumed that the 5th, 4th, 3rd, and 2nd risk levels are lowered to the 4th, 3rd, 2nd and 1st risk levels in five years, respectively.

Besides these scenarios, in order to examine CVD burden on working population, the simulation results of incidence of CVDs for men aged 40 to 79 years were compared with the change of male population in working age (40 to 69 years).

RESULTS

In the status quo, the number of CVD incidence increases continuously for men aged 60 to 69 years until around 2025 (Figure 2-1). The high-risk strategy showed almost the same results as the status quo (Figure 2-2), but the population strategy revealed that the number of incident CVDs would be reduced (Figure 2-3). In the population strategy, the number of incident CVDs for all ages (40 to 79 years) would be reduced to approximately the two thirds of that in the status quo in five years (Figure 3).

When the simulation results of incidence of CVDs for men aged 40 to 79 years were compared with the change of male population in working age (40 to 69 years), it is revealed that the number of incident CVDs of 40 to 79 years would continue to rise after the male population of 40 to 69 years would start to decrease (Figure 4).

DISCUSSION

We employed WHO/ISH Risk prediction chart to calculate CVD risk of the Japanese population. Simulation results showed that the number of incident CVDs would be reduced to two thirds of the status quo. To our knowledge, this is the first study to simulate the number of incident CVDs in Japan. A simulation model for women was similarly developed, but a valid model was not obtained due to a small number of women with high risk of CVD.

WHO/ISH Risk prediction chart is normally used on surveillance results of STEPS (STEPwise approach to noncommunicable disease risk factor surveillance) supported by the WHO. Ministry of Health, Labour and Welfare, Japan conducts the National Health and Nutrition Survey, and covers core items of the STEPS for WHO/ISH Risk prediction chart. Thus, we used the results of the National Health and Nutrition Survey, but we only used the data from 2003 to 2010 because the questions on current smoking has changed since 2011.

Due to a rapid population ageing, national health expenditure in Japan has risen continuously to reach 40.8 trillion yen in 2014 (Ministry of Health, Labour and Welfare, 2015). Although age-standardized mortality for heart diseases is decreasing, crude mortality for heart disease is increasing (Ministry of Health, Labour and Welfare, 2016). The results of this study is important in that the increase of incident CVDs is predicted and that a high burden of working population in the next several years has become obvious.

CONCLUSION

We developed system dynamics models for incidence of cardiovascular diseases in Japan. The effect of aging on CVD incidence among the Japanese population is inevitable, but the population strategy could decrease incidence of CVDs substantially. Health policies such as building healthy environment and assuring equal access to health screening and healthcare should be implemented further as population strategy rather than high-risk strategy in Japan.

ACKNOWLEDGEMENT

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Table 1 Percentages of risk levels for incidence of cardiovascular diseases from the WHO/ISH risk prediction chart using the National Health and Nutrition data (2003-2010)

Sex	Age (years)	Risk levels for incidence of cardiovascular diseases				
		Risk 1	Risk 2	Risk 3	Risk 4	Risk 5
Male	40-49	95.0	2.4	1.4	0.5	0.7
	50-59	82.3	10.1	4.0	1.6	2.0
	60-69	61.0	23.9	6.9	3.9	4.3
	70-79	22.3	47.6	15.7	8.1	6.3
Female	40-49	98.6	0.5	0.5	0.2	0.2
	50-59	94.9	2.8	1.0	0.9	0.3
	60-69	84.7	7.9	4.2	1.2	2.0
	70-79	63.2	26.4	7.8	1.0	1.6

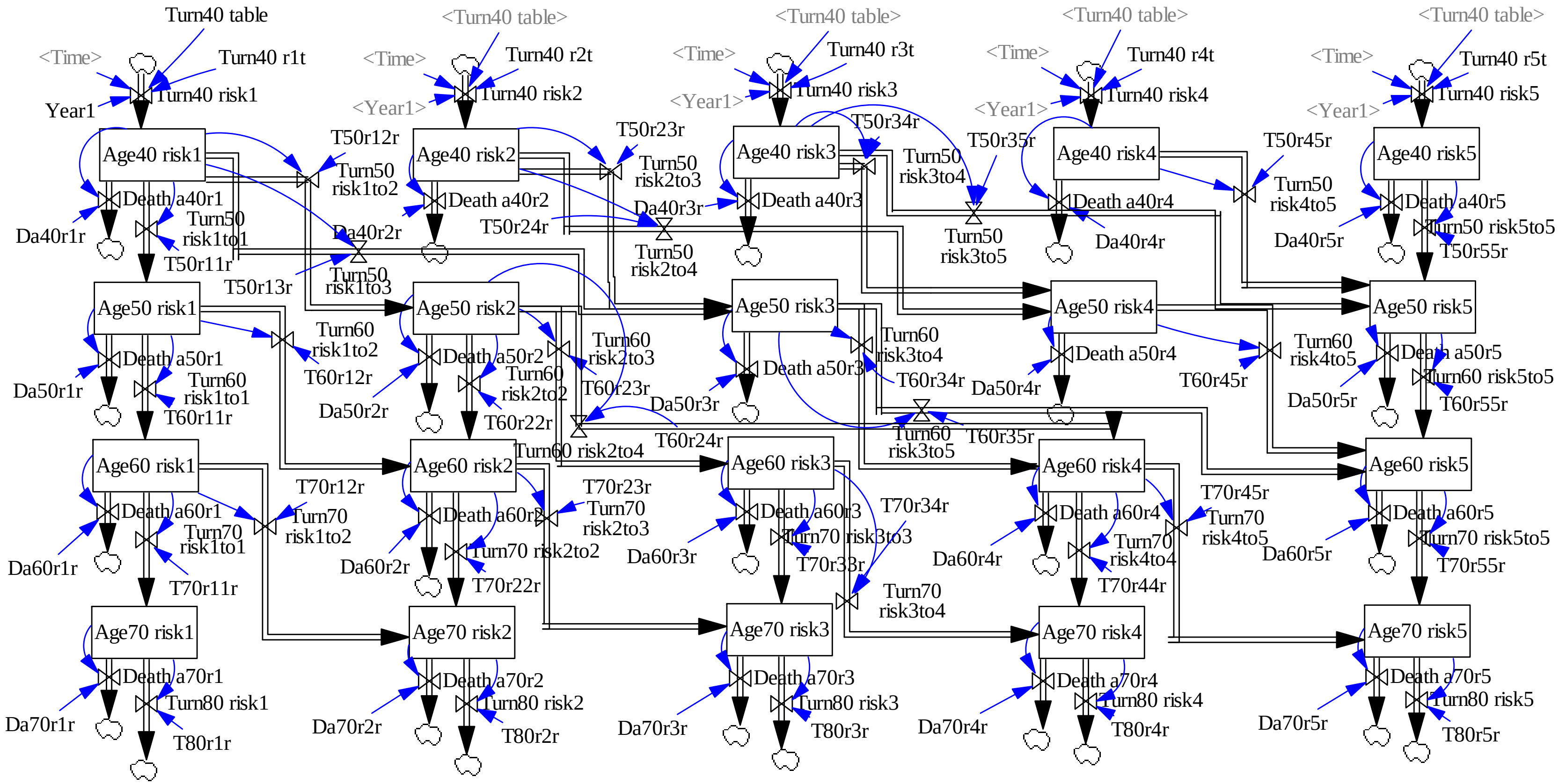

Figure 1. Structure of the simulation model

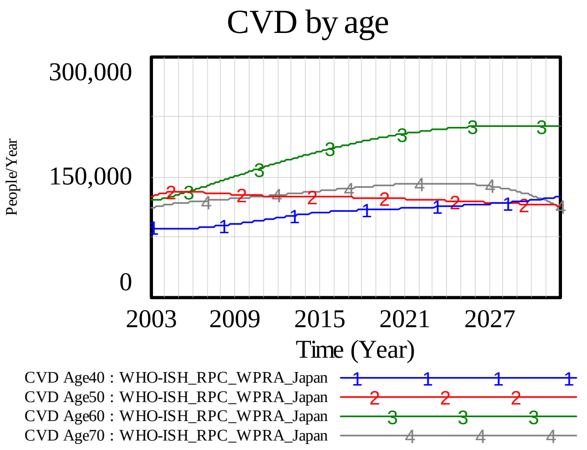

Figure 2-1. Simulation results of the status quo

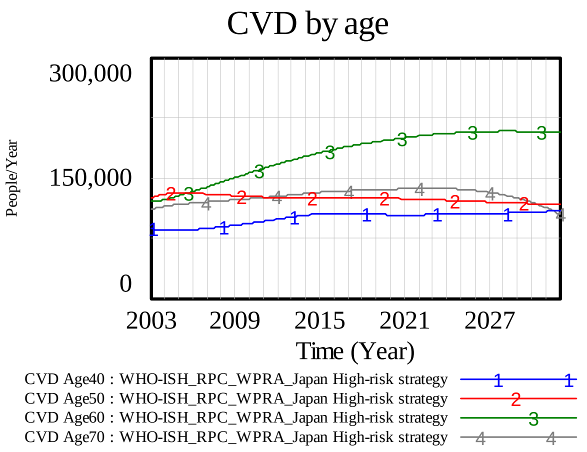

Figure 2-2. Simulation results of high-risk strategy

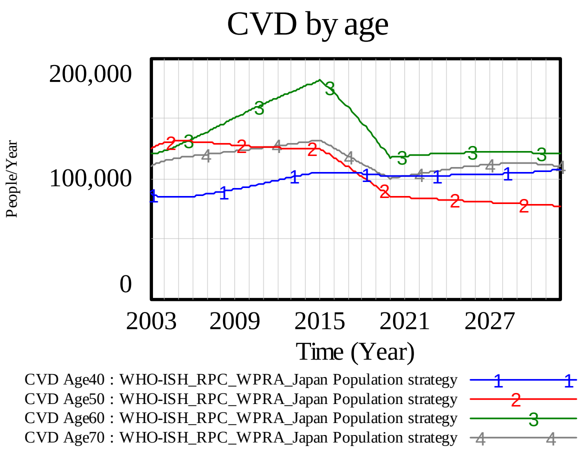

Figure 2-3. Simulation results of population strategy

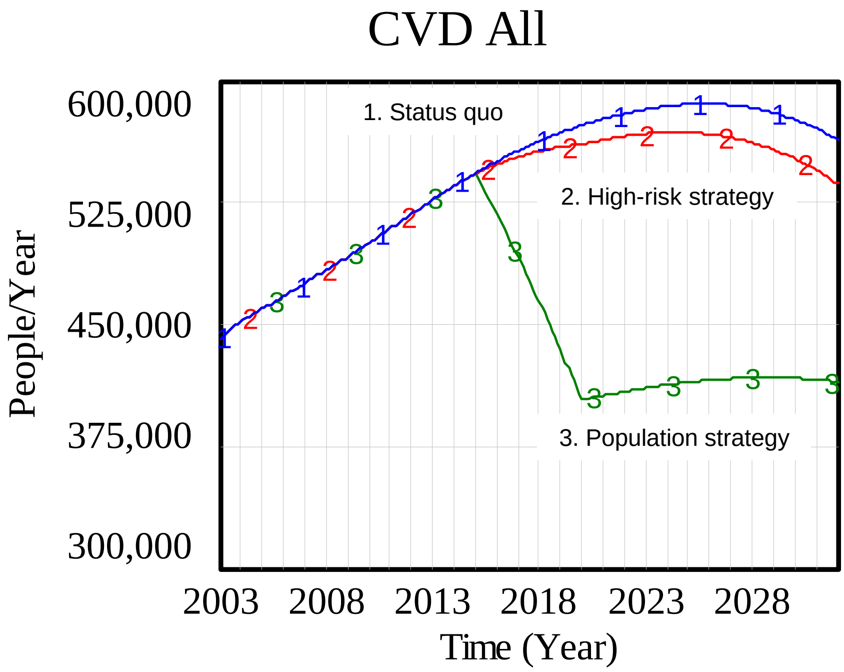

Figure 3. Simulation results of total cardiovascular incidence in constant model, high-risk strategy and population strategy

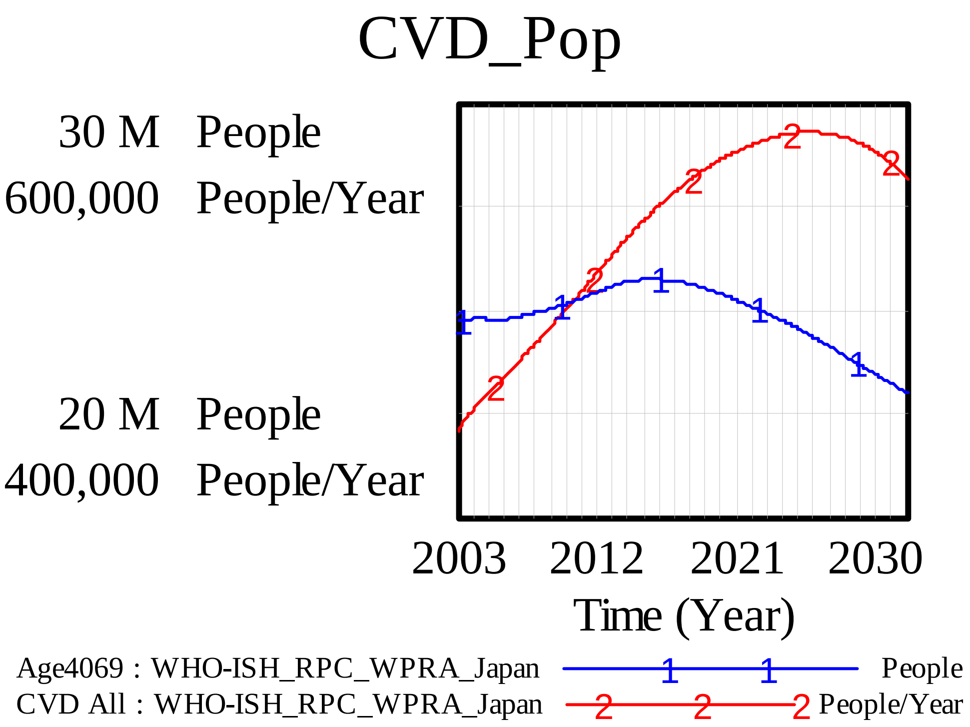

Figure 4. Comparison of simulation results of total cardiovascular incidence for men aged 40 to 79 years and male population aged 40 to 69 years