Cost-Effectiveness of Preventive Intervention for Prediabetes in JAPAN

Hitomi Nakayama[1], Kensuke Moriwaki[2], Takako Kaneyasu[2,3], Kosuke Morimoto[2,4], Kojiro Shimozuma[1,2,3]

1 Graduate School of Life Sciences, Ritsumeikan University, 2 Comprehensive Unit for Health Economic Evidence Review and Decision Support, Ritsumeikan University; 3 Department of Biomedical Sciences, College of Life Sciences, Ritsumeikan University; 4 Graduate School of Medicine, Kyoto University

Background

As diabetes is a chronic disease with various complications, medical costs tend to be very expensive and places a financial burden on every country around the world. The Diabetes Prevention Program (DPP) demonstrates that lifestyle interventions could reduce incidence of type 2 diabetes (T2D) and treatment costs. However, the cost-effectiveness of preventive interventions for prediabetes, including impaired glucose tolerance (IGT), has not been seen in Japan. This study aims to investigate whether preventive intervention for prediabetes is cost-effective compared with the cost of non-intervention in order to contribute to health policy decision making in Japan.

Methods

Model-based cost-effectiveness analysis

A model-based analysis was conducted to evaluate the cost-effectiveness of lifestyle intervention compared to non-intervention from the perspective of Japan's insurance medical expenses payer. The target population was Japanese individuals with prediabetes who had not been diagnosed and treated for T2D. In this study, we set up a hypothetical cohort, which included a fasting glucose level of 100-125 mg/dL, a BMI of at least 24.0 kg/m^2, and a gender composition of 70% male and 30% female. A Markov model was developed, consisting of three health states: prediabetes, T2D, and death. T2D patients had complications (retinopathy, nephropathy, and neuropathy) with a fixed probability. The preventive intervention program used in this study was based on the intensive lifestyle intervention of the program conducted in the DPP and provided by public health nurses, like the specific health guidance in Japan. The intervention in the base case analysis was assumed to begin at age 50 and continue until the onset of T2D or death. The outcome of the intervention was set to be the probability of T2D.

A willingness to pay (WTP) threshold of USD 50,000 (JPY 5 million, based on USD 1 = JPY 100) per quality-adjusted life year (QALY) gained was used as the acceptable level for the incremental cost-effectiveness ratio (ICER). The time horizon and cycle length were set to lifetime and one year, respectively. Based on the Guideline for Preparing Cost-Effectiveness Evaluation to the Central Social Insurance Medical Council in Japan, an annual discount rate of 2% for both costs and QALYs was applied. The model was developed with TreeAgePro®2020 (TreeAge Software LLC., Williamstown, MA, USA).

Transition probabilities

A transition probability of T2D was assumed to be constant regardless of age[1]. The mortality of each health state was set to vary with the age of the cohort, using the life table in 2019 by the Ministry of Health, Labour, and Welfare in Japan. The mortality of T2D state was estimated by calculating the relative risk of death for T2D patients to the general population from the Japan Diabetes Complications Study[2] and multiplying it by the hazard of death for each age in the 2019 life tables. (Table 1).

Utility weights

Input values for utility parameters in this study were shown in Table 1. The utilities of T2D patients were calculated as a weighted average of the percentage of patients with complications[3]. The utilities of prediabetes were assumed '1'.

Costs

We considered only direct medical costs and set the following cost parameters in the model (Table 1). The cost of the intervention was based on the cost of Active Support of Specific Health Guidance in Japan (April 2021). For T2D medical costs, annual medical costs were estimated from the monthly medical expenses of patients with diabetes mellitus (exclusion of rule-out diagnoses) from January 2005 to June 2013[4]. The medical cost of T2D was calculated as a weighted average using the incidence of complications.

Table 1. Parameters and input values to be assigned to the model

Parameter		Base case analysis	Sensitivity analysis (Plausible range)	
Probability of T2D	non-intervention	0.056	-10%	+10%
	intervention	0.041	-10%	+10%
Mortality rate	prediabetes	Life table (2019)	-10%	+10%
	T2D	Life table adjusted by HR (2019)		
Hazard ratio of death (vs. prediabetes)		1.182	-10%	+10%
Utility	prediabetes	1	0.935	1
	T2D	0.935	0.842	1
Annual cost (USD)	Intervention costs	251	-10%	+10%
	Medical costs of T2D	2,451	-10%	+10%
Discount rate		0.02	0.01	0.05

Sensitivity analyses

Deterministic sensitivity analyses were performed to assess the influence of varying specific parameters on the base case results. The plausible ranges for costs, utilities, and transition probabilities were set at ±10%. The lower limit of the plausible range of utilities for prediabetes was set no less than the estimated value for T2D patients (Table 1). The results of the sensitivity analyses were summarized in a tornado diagram by converting ICER into Incremental net monetary benefit (INMB).

The scenario analyses were conducted in order to estimate the impact to ICER if the starting age of intervention was changed to 40 or 60 years, and if the intervention effect (risk reduction of T2D) was reduced by 50% or 20%.

Results

Base case analysis

The QALYs of the intervention group and non-intervention group were 23.74 and 23.54. Incremental QALYs of the intervention group was 0.20 QALYs compared to the non-intervention group, respectively. On the other hand, the total costs of the intervention group and control group were USD 28,727 and USD 30,337, respectively, and the intervention group saved USD 1,610. These results showed that intervention compared to non-intervention was dominant.

Sensitivity analyses

The parameter with the greatest impact on the base case outcome was the T2D mortality rate in non-intervention. If this parameter was varied by ±10%, ICER exceeded a societal WTP threshold (Fig. 1). Lifestyle interventions would also be dominant if the subject was aged 40 or 60 years, or if the effect was assumed to be 20% lower (Table 2).

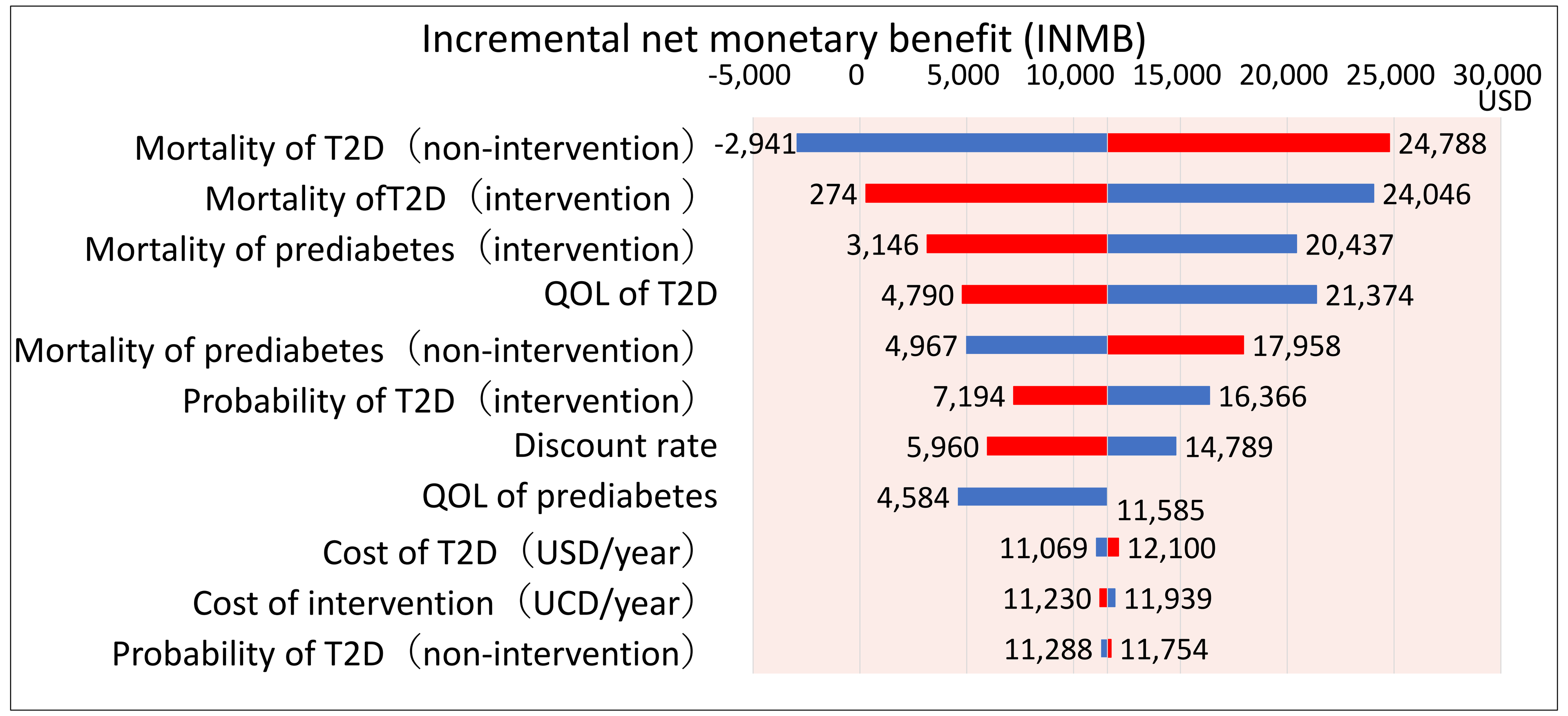

Fig. 1 The results of deterministic sensitivity analyses

Table 2. The results of scenario analysis

		QALYs	Incremental QALYs	Cost (USD)	Incremental Cost (USD)	ICER (USD per QALY)
Reduction in effectiveness of lifestyle intervention						
20%	non-intervention	23.54		30,337		
	intervention	23.69	0.15	29,756	-581	dominant
50%	non-intervention	23.54		30,337		
	intervention	23.63	0.09	31,193	857	9,343
Age at start of intervention						
Age 40	non-intervention	27.70		39,542		
	intervention	27.92	0.21	37,205	-2,337	dominant
Age 60	non-intervention	18.87		20,982		
	intervention	19.04	0.17	20,213	-769	dominant

Conclusion

This study revealed that lifestyle interventions for prediabetic patients in Japan were cost-effective in comparison to non-intervention, if the starting age of the individual was after age 40.

References

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Contact information: si0055rs@ed.ritsumei.ac.jp, Hitomi Nakayama

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