Socioeconomic Burden of Ischemic Heart Diseases in the Japanese Health System – A System Dynamics Simulation for Policy Decision-Making

EPH147

Akihito Uda[1*], Soshiro Ogata[2], Koki Idehara[3], Junko Morii[3], Yosuke Yamanaka[1], Ataru Igarashi[4], Kunihiro Nishimura[2]

[1]Novartis Pharma K.K., Tokyo, Japan; [2]National Cerebral and Cardiovascular Center, Osaka, Japan; [3]IQVIA Solutions Japan G.K., Tokyo, Japan; [4]Yokohama City University School of Medicine, Kanagawa, Japan

OBJECTIVES

This study aimed to understand the socioeconomic burden of ischemic heart disease (or myocardial infarction [MI]) on the future Japanese health system, and to estimate the impacts of health system interventions using system dynamics (SD) simulation.

INTRODUCTION

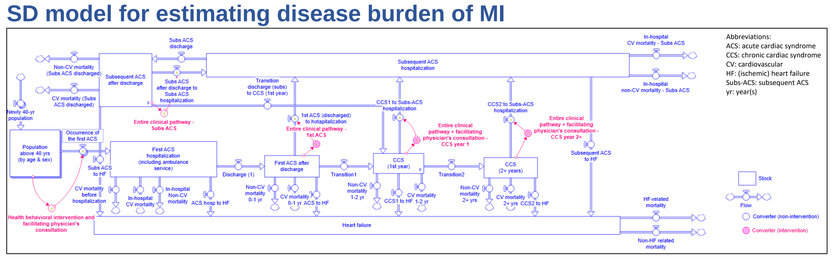
- Ischemic heart diseases (IHD) including MI remain the leading cause of death and disability with high healthcare and societal costs worldwide and in Japan [1, 2]. The disease burden is further pronounced within a Japanese society facing rapid population ageing [3].
- In 2020, the Japanese government published the National Plan for Promotion of Measures Against Cerebrovascular and Cardiovascular Disease, involving enhancement of service provision systems including promotion of health checkups, social cooperation, patient support and providing appropriate consultation [4].
- To assess interventions through cooperation of different healthcare players within the healthcare system on patients with different risk stages, a complex systems approach is needed [5, 6]. A System Dynamics (SD) model can capture the dynamic properties within complex health system and estimate the future burden of IHD (MI) and thus help prioritize the system-level interventions.

METHODS

Comparison between SD models and other types of models [5]

Criteria	SD models	Markov models	Analytic models
Mode of description	Implicitly (via rules or state equations)	Implicitly (via transition matrices)	Closed-form expressions
Indexing	Time and space	Time	Varies
Linearity	Generally nonlinear	Linear	Generally derivable only for linear
Solution procedure	Simulation	Closed-form solution or simulation	Direct evaluation
Population character	Generally open population	Cohorts	Varies

SD model for estimating disease burden of MI



Specification

Perspective	Japanese healthcare system & societal perspectives
Model period	2010 (initial parameter) – 2070
Cycle length	1 year (Integration method: Euler)

Health system interventions (3 types)

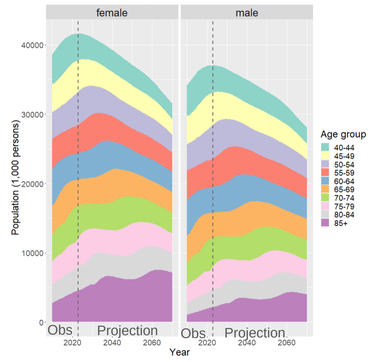
#	Scenario (base case: no health system intervention)
1	**Facilitating physician's consultation for high-risk population** • A public health nurse / care manager facilitate physician's consultation in patients with high risk estimated based on the JAS clinical guidelines [7].
2	**Lifestyle intervention + facilitating physician's consultation for high-risk population** • A 6-month lifestyle intervention instruction by a public health nurse for high-risk population who responded at the interim evaluation after 3-month (assumed as 20%), and a 3-month lifestyle intervention then facilitate physician's consultation for those who did not respond by the interim evaluation (40%). The other 40% of participants are supposed to discontinued.
3	**Introduction of lipid management pathway (for acute & chronic MI population) + facilitating continuous physician's consultation (for chronic MI population)** • Introducing of regional lipid management in patients with acute & chronic MI (including using a common lipid-lowering protocol) as well as physician's lipid control in chronic MI population.

INPUT PARAMETERS

Epidemiological parameters

- **Population ≥40 years old** will peak in 2024 (78.7M) and will decline thereafter. Older population will peak in later years.
- **Incidence rates of the first MI** (by age group and gender) were taken from Nobeoka Study [8].
- **Incidence rates of the subsequent MI** were estimated based on the Japanese real-world data analysis [9].
- **MI-related mortality** is assumed to decrease over time, as estimated by Kiyoshige et al. [3]
- **MI will transition to ischemic heart failure (HF)** [9], depending on age and gender, as estimated by Hwang et al. [10]

Population ≥40 years old



Cost parameters

Public healthcare cost parameters

Parameter	Cost		Ref.
	USD*	JPY	
MI: hospitalization (episode)	$14,669	¥2,156,290	[11]
MI: after discharge – chronic (annual)	$6,125	¥900,432	[12]
HF (annual)	$10,299	¥1,513,926	[12]
CV mortality (episode)	$13,299	¥1,955,000	[11]
Public long-term care cost (average cost over total MI population of ≥65 years)	$1,533	¥225,379	[13]

*1 USD = 147 JPY (as per Feb 1, 2024)

Productivity loss

Parameter	Prod. loss(%) [13]	
	Patients	Caregivers
MI: Hospitalization	16.6%	n.a.
MI: After discharge	14.7%	n.a.
Ischemic HF	10.3%	n.a.

Health system interventions

The effects of health system interventions were estimated in terms of reduction in LCL-C levels associated with implementation of the intervention, and avoidance of the first and subsequent acute MI occurrence using rate ratios by lowering LDL-C per 1 mmol/L [15]. Effects of intervention on other cardiovascular risk factors were not considered.

Risk reduction of major vascular events* by lowering LDL-C (CTT collaboration) [15]

First / subsequent event	Gender	RR for reduction of LDL-C	
		per mg/dL	per mmol/L
First	Male	0.992	0.72
	Female	0.996	0.85
Subsequent	Male	0.994	0.79
	Female	0.996	0.84

Effectiveness and cost for each health system intervention

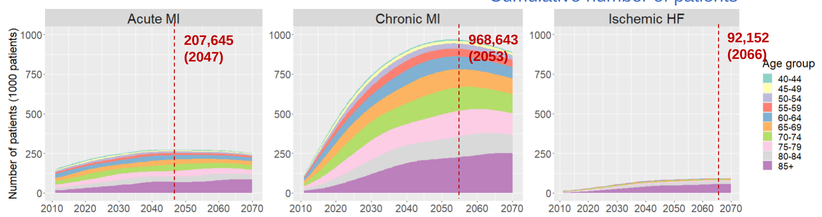
#	ΔLDL-C		Operational cost / person	
	mg/dL	mmol/L	USD*	JPY
1	-21 [16]	-0.543	$122	¥17,994 / year†
2	(Lifestyle interv.) -3.3 [17] (Physician's consultation) -21 [16]	-0.085 -0.543	$119 $122	¥17,500 / time ¥17,994 / year†
3	-41‡ [16]	-1.060‡	$122	¥17,994 / year†

*1 USD = 147 JPY (as per Feb 1, 2024)
†Cost for facilitating physician's consultation includes physician's practice fee as well as drug costs (statin).
‡Scenario #3 (introduction of lipid management pathway + facilitating physician's consultation) assumes using a common lipid-lowering protocol regarding lipid lowering therapy in the region as well as lipid control by physician. Nakao et al. (2022) [16] estimated the effectiveness of common lipid-lowering protocol including the prescription of the maximum tolerated dose of statin, ezetimibe, and eicosapentaenoic acid in a single hospital (Kansai Rosai Hospital) in Japan.

RESULTS

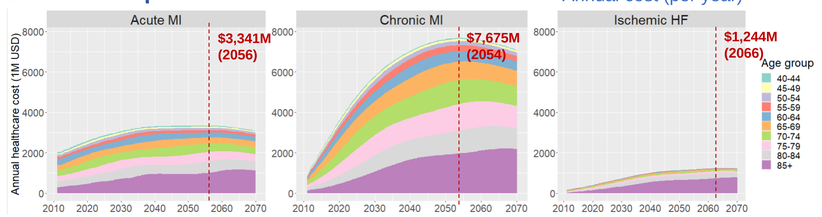
Epidemiological aspects

Cumulative number of patients



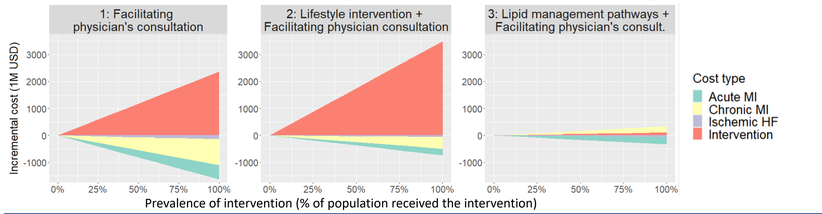
Economic aspects

Annual cost (per year)



Impact of health system interventions

Breakdown of incremental costs for implementation of each intervention (per year; as of 2040)



CONCLUSIONS

- Based on the latest epidemiological and cost evidence, people living with MI and ischemic HF and corresponding cost burden in Japan will increase by early 2050's and late 2060's, respectively. The peaking time of HF population is expected to be later than that previously expected based on Sado Heart Failure Study (expected for total HF as 2035) [18] since Sado City had been already advanced aging population and not represent the overall Japanese population.
- Secondary prevention with facilitating physician's consultation under lipid management pathways (Scenario #3) will be the least expensive intervention by reducing the costs for subsequent MI hospitalization and ischemic HF transition. In the implementation of the health system intervention programs, it is crucial to consider a combination of primary and secondary prevention strategies targeted for high-risk population.
- The effects of health system interventions were estimated in terms of reduction in LDL-C levels associated with implementation of the intervention. It could result in an underestimate of the effect of each intervention (especially lifestyle intervention) by neglecting effects on other cardiovascular risk factors.
- In Japan, "Special Health Guidance" (Tokutei Hoken-Shido) has been implemented as a lifestyle intervention for high-risk population nationwide. Further study is required to seek for the most efficient lifestyle intervention utilizing the existing health facility (e.g., combining early facilitation to physician for individuals with insufficient lipid control).

REFERENCES

1. WHO. The top 10 causes of death in 2019 - Global Health Estimates.
2. MHLW. [Annual Health, Labor and Welfare Report 2018] (in Japanese).
3. Kiyoshige E, Ogata S, O'Flaherty M, et al. Lancet Reg. Health West. Pac. 2023;31.
4. Kuwabara M, Mori M, Komoto S. Circulation 2021;143(20):1929-31.
5. Marshall DA, Burgos-Liz L, IJzerman MJ, et al. Value in Health 2015; 18(1):5-16.
6. Hirsch G, Homer J, Evans E, et al. Am J Public Health. 2010;100(4):616-22.
7. JAS. Guidelines for Prevention of Atherosclerotic Cardiovascular Diseases 2022.
8. Ogata S, Marume K, Nakai K, et al. Circ J. 2021;85:1722-1730.
9. Analysis of health insurance claims data (DeSC).
10. Hwang SY, Kim KA, Choi OJ. Int J Environ Res Public Health 2020;17(22).
11. Kodera S, Morita H, Kiyosue A, et al.Circ J. 2019;83(7):1498-505.
12. Eguchi S, Morita Y, Mitani H, et al. Drugs Real World Outcomes 2022;9(3):377-89.
13. MHLW. [Report on Long-Term Care Insurance Operation in 2021 (Reiwa-3)] (in Japanese)
14. Novartis Pharma, K.K. (2023)
15. CTT Collaboration. Lancet. 2015;385:1397-1405.
16. Nakao S, Ishihara T, Tsujimura T, et al. J Cardiol. 2022;79(3):391-9.
17. Tsushita K. (representative) Health and Labour Sciences Research 2011.
18. Okura Y, Ramadan MM, Ohno Y, et al. Circ J. 2008;72(3):489-491.

ISPOR 2024 (May 5–8 2024, Atlanta, GA, USA)

*Corresponding author: Akihito Uda (email: akihito.uda@novartis.com)

This research was funded by Novartis Pharma, K.K. (Tokyo, Japan)