The Cost-Effectiveness of Life-saving Interventions in Japan

Do chemical regulations cost too much money?

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Abstract

This paper compares the cost-effectiveness of life-saving interventions in Japan, based on information collected from the health, safety and environmental literature. More than 50 life-saving interventions are analyzed. Cost-effectiveness is defined as the cost per life-year (LY) saved or as the cost per quality adjusted life-year (QALY) saved. We find a large cost-effectiveness disparity between chemical controls and healthcare intervention, and we discuss whether or not chemical regulations cost society too much. We point out the limitations of this study and propose a way to improve the incorporation of morbidity effects in cost-effectiveness analysis.

Key Words: cost-effectiveness analysis, life-year, quality adjusted life-year, chemical regulation

1. Introduction

The idea of prioritizing interventions based on the results of cost-effectiveness analysis has become widely accepted in the health, safety and environmental fields. In particular, the numbers of published reports on the cost-effectiveness of clinical and public health have increased continually, since 1960s (Elixhauser et al. 1998). Some countries have formally adopted cost-effectiveness analysis in their evaluations of pharmaceuticals. In that respect, guidelines regarding cost-effectiveness analysis have already been published in Australia, Canada, some European countries and elsewhere (Kanavos et al. 2000). In the United States, the Panel on Cost-Effectiveness and Medicine was commissioned by the US Public Health Service and made several recommendations (Gold et al. 1996). Since economic analysis has become universal in the journal articles, the British Medical Journal set up a working group and published guidelines for economic evaluation in order to improve the quality of submitted and published economics articles (Drummond and Jefferson 1996). To achieve comparability among studies, such guidelines usually recommend the use of "life-years" (LYs) or "quality adjusted life-years" (QALYs) as the measure of an intervention's effectiveness.

In the field of chemical risk management, the idea of "risk ranking" is more common than cost-effectiveness analysis in prioritizing control measures. While cancer risk can be described in terms of the number of lives lost or the number of life-years lost, the non-cancer risk of a chemical is ordinarily expressed by a hazard quotient, which is the ratio of the estimated dose and the reference dose. Therefore, in estimating health risks from air pollutants, Morello-Frosch et al. (2000) separated the risk rankings of carcinogens and non-carcinogens. Gamo et al. (1995) developed the method of comparing the risks of carcinogens and non-carcinogens using "loss of life expectancy" as the common effectiveness measure. Applying this method, Gamo et al. (2001) showed

the risk ranking of chemical substances in Japan. It is noted that the ranking of risk is not necessarily equal to the prioritizing of control measures, since not only "risk" but also "control cost" are taken into account in the context of both individual and public decision-making. Therefore, as is the case with healthcare, cost-effectiveness ratios should be calculated and priority given to policies with the best values. However, the number of articles reporting on the cost-effectiveness of chemical substance control measures is still small, and there are no guidelines for conducting cost-effectiveness analyses of chemical substance controls. We conducted several cost-effectiveness analyses of chemical control measures in Japan using the same methodology. Some of the results are shown in Figure 1.

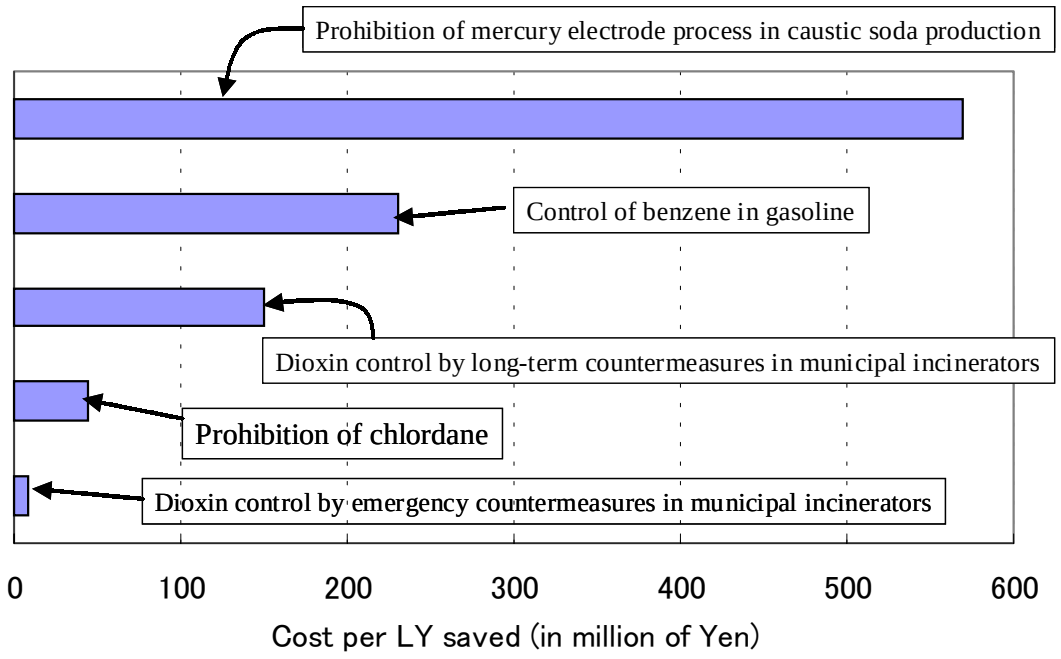

Fig. 1. Cost-effectiveness of various chemical substance control measures in Japan.

In this paper, we regard chemical risk reduction as a part of life-saving interventions and assess whether or not chemical regulations are justified from a cost-effectiveness

perspective. To begin that assessment, we collected information on the cost-effectiveness of life-saving interventions in the health and safety fields in Japan, allowing us to compare their cost-effectiveness with that of chemical substance control measures. We then discuss a way to gain intersector comparability.

2. Life-saving interventions

Since the purpose of chemical regulations is to avoid adverse health effects, we need to look at the problem of cost-effectiveness from a wider point of view. We recently estimated the "cost per LY saved" of dioxin control measures at municipal solid waste incinerators in Japan (Kishimoto et al. 2001). A schematic illustration is shown in Figure 2.

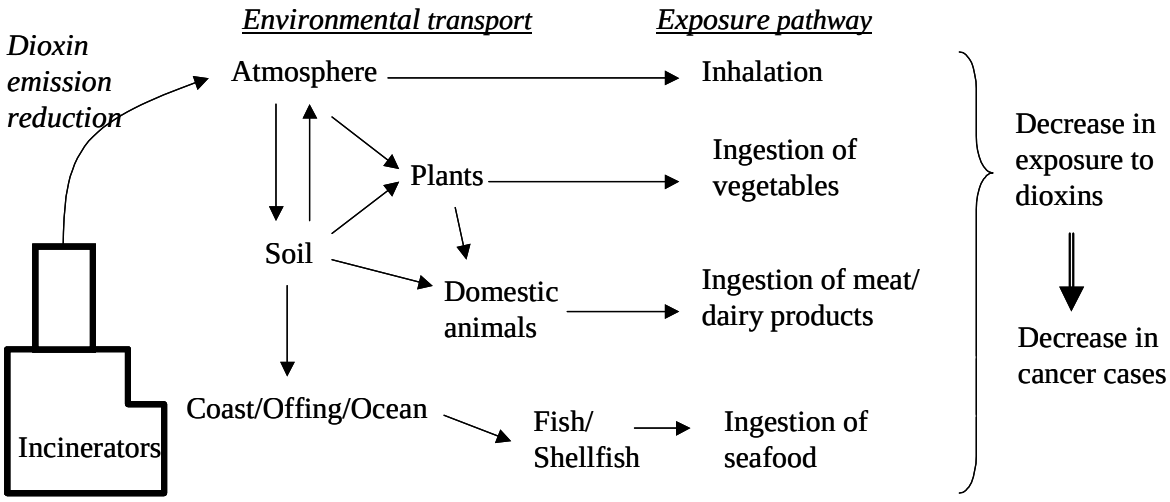

Fig. 2. Schematic illustration of dioxin control measures at municipal solid waste incinerators.

Although Figure 1 shows that emergency countermeasures to reduce dioxins are quite

cost-effective and that long-term countermeasures are of average cost-effectiveness compared to other environmental measures, we do not know whether emergency and long-term countermeasures are cost-effective or not compared to other primary, secondary and tertiary prevention measures. We need to know the place of chemical risk management in the overall picture of life-saving programs, which is shown in Figure 3. In the case of cancer prevention, too much focus on environmental carcinogens draws public attention away from the more important causal factors, such as tobacco use, diet, obesity and lack of exercise, since environmental pollution accounts for only 2% of all cancer cases (Harvard Center for Cancer Prevention 1996).

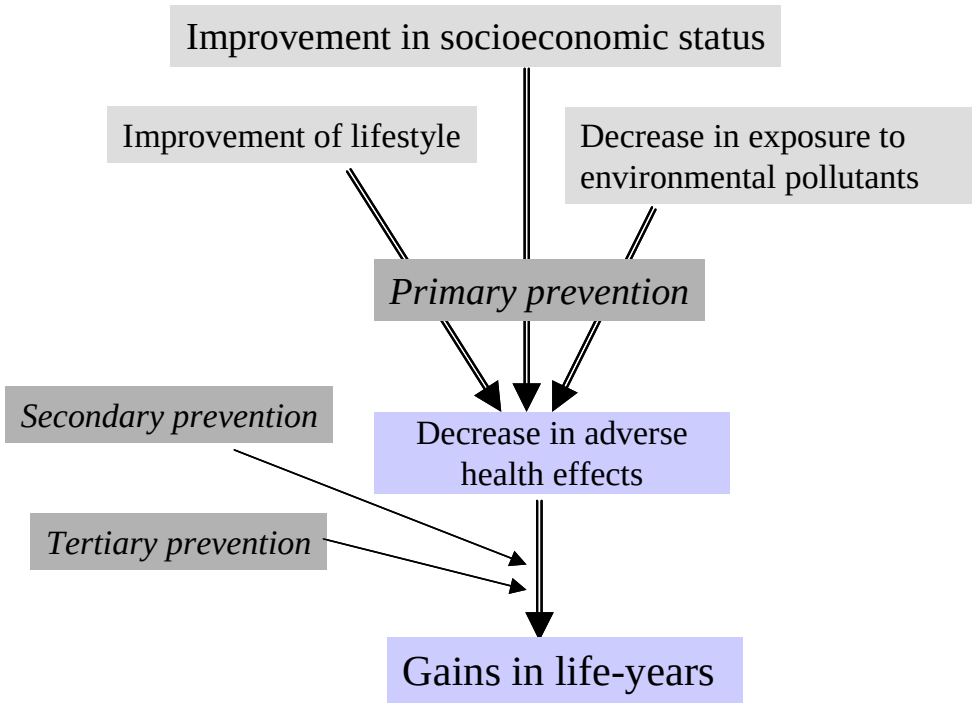

Fig. 3. Overall picture of life-saving interventions.

Tengs et al. (1995) compared more than 500 life-saving interventions in the U.S. in terms of “cost per LY saved” and found a large disparity in the median “cost per LY saved”

between chemical risk management and other forms of intervention. In that study, the median toxin control cost $2.8 million per LY, while the median medical intervention cost $19,000 per LY. Ramsberg and Sjorberg (1997) also found such disparities in Sweden. If secondary and tertiary preventions are much less expensive, it is possible to insist that primary preventions are not necessary. Therefore, information on the cost-effectiveness of life-saving interventions in Japan from the health and safety literature is collected and compared with the cost-effectiveness of chemical substance controls.

3. Cost per Life-Year Saved

3.1 *Method*

Various life-saving interventions were collected from the healthcare and safety literature. We define cost-effectiveness as the cost per LY saved or the cost per QALY saved. Although we did not recalculate those results using a common criterion for standardization (due to a lack of information for a basic data set), all analyses included in this study met the following criteria: They contain information on life-saving interventions in Japan, and they report cost per LY saved or cost per QALY saved (or information sufficient to calculate them). Although costs should be expressed in the value of the Yen for some standard year, they are not, since the studies are limited to those published within the past decade.

3.2 *Results*

The life-saving interventions are classified into four categories: chemical control, safety control, disease prevention, and medical treatment. The number of observations and

median numbers for these categories are shown in Table 1. The distribution of cost per LY saved and cost per QALY saved estimates are shown in Figure 4, ranging from those that save more resources than they consume, to those costing more than 10 billion Yen per LY saved. Those studies are classified into two study types: retrospective and prospective. A retrospective study deals with life-saving interventions that are actually in use, while a prospective study deals with alternative or hypothetical life-saving interventions. The Appendix lists all life-saving interventions.

Table 1. Mean and median of cost per LY or QALY saved.

Category		n	Mean	Median
Chemical control	retrospective	16	658,000	103,000
	prospective	4	1,670,000	1,030,000
	all	20	860,000	140,000
Safety control	retrospective	2	160,000	16,000
	prospective	1	30,000	30,000
	all	3	20,700	27,000
Disease prevention	retrospective	23	5,400	4,100
	prospective	17	13,300	2,100
	all	40	8,800	3,300
Medical treatment	retrospective	26	1,600	600
	prospective	5	5,000	6,200
	all	31	2,100	970
All	retrospective	67	160,000	4,400
	prospective	27	257,000	4,100
	all	94	188,000	4,100

* All costs are expressed in Yen. “N” indicates the number of observations.

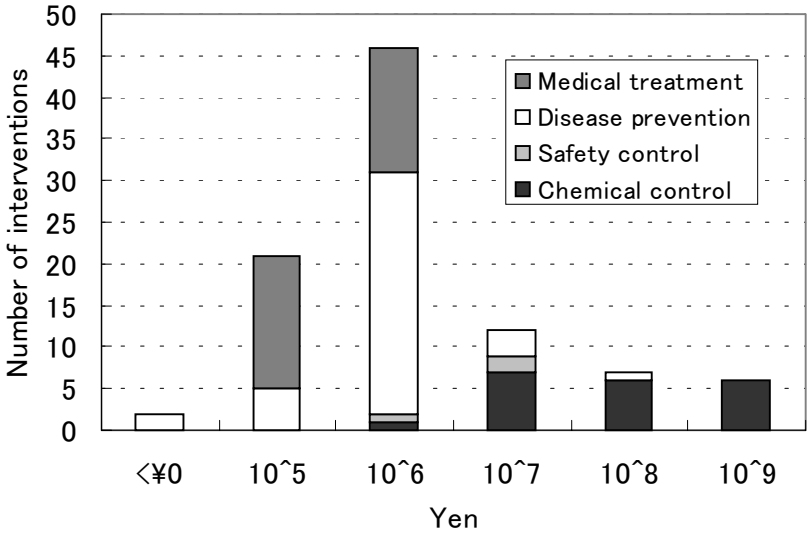

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Fig. 4. Distribution of cost-effectiveness ratios (n = 94).

Table 1 and Figure 4 show that the cost-effectiveness of risk-reduction policies varies enormously between different sectors, in the same manner as the findings of similar analyses in the United States and Sweden (Tengs et al. 1995, Ramsberg and Sjoberg 1997).

4. Discussion

Chemical regulations seem to be much less efficient than healthcare interventions. However, before drawing any conclusions, several caveats need to be noted in interpreting these results. First, as Tengs et al. (1995) pointed out, there are some limitations in this kind of study, such as the accuracy of the data, the validity of the assumptions upon which the original analyses were based and the representativeness of the interventions as a random sample of all life-saving interventions. Second, studies of this type can be classified into retrospective and prospective, as presented in Appendix A. The former interventions are already implemented, whereas the latter are only proposed. However, there is no significant difference between them in cost per LY or QALY saved estimates. Two factors may have some role here. For one, those interventions that have already been adopted are more cost-effective, since cost-effective measures are preferred and are followed by less cost-effective ones. For another, prospective studies may tend to take those potential interventions that are less expensive than those already done. Third, healthcare researchers have incentives to demonstrate that their interventions should be adopted widely and be covered by the national medical insurance. For example, the medical literature may contain an upward bias in the estimates of effectiveness and a

downward bias in the estimates of cost per LY or QALY saved. This is called "publication bias". Freemantle and Mason (1997) classified publication bias in economic analyses into three levels: first, in the health-outcomes data available for modeling; second, in the motivations for conducting an economic analysis; and third, in repeating the process of seeking publication. Fourth, many of the chemical regulations have benefits other than life-year saved, such as morbidity reductions and ecological impacts. In order to compare chemical regulations with healthcare interventions, we should incorporate into our calculations not only the loss of life expectancy that can be estimated quantitatively, but also various morbidity effects and ecological impacts. Some morbidity effects will be described using the quality of life index, such as quality adjusted life-years. However, since other potential effects are difficult to estimate quantitatively, it is necessary to develop a method to incorporate expert judgment and public risk perception into cost-effectiveness analysis.

In order to overcome these limitations, a standardized methodology of cost-effectiveness analysis should be developed for application to environmental, safety and healthcare interventions. One important attempt is being made by the WHO (Murray et al. 2000). The WHO is currently developing guidelines on generalized cost-effectiveness analysis of "environmental health interventions". That project aims to emphasize not only curative treatment, but also environmental and social measures.

Acknowledgement

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Appendix A. Life-saving interventions and their cost-effectiveness

Interventions	Cost per LY or QALY saved (thousand yen)	Sources	Endpoint	Type of Studies
<Chemical control>				
Asbestos control				
Abatement measure for sprayed-on asbestos	120,000	Murayama(1991)	LY	P
Abatement measure for sprayed-on asbestos	36,000	Kishimoto(1997)	LY	R
Mercury control				
Prohibition of the mercury electrode process in caustic soda production	570,000	Nakanishi et al. (1998)	LY	R
Removal of mercury in dry batteries	22,000	Nakanishi(1995)	LY	R
Benzene control				
Control of benzene in gasoline	230,000	Kajihara et al. (1998)	LY	R
Control of trihalomethane(THM)				
High-level treatment of water supply				
groundwater pollutant aerator	12,000	Akashi and Yasuda(1994)	LY	R
THM removal facility: treatment plant A	3,700,000	Akashi and Yasuda(1994)	LY	R
THM removal facility: treatment plant B	1,800,000	Akashi and Yasuda(1994)	LY	R
THM removal facility: treatment plant C	1,200,000	Akashi and Yasuda(1994)	LY	R
THM removal facility: treatment plant D	2,200,000	Akashi and Yasuda(1994)	LY	R
Water purifier for home				
in place of treatment plant A	4,500,000	Akashi and Yasuda(1994)	LY	P
in place of treatment plant B	1,900,000	Akashi and Yasuda(1994)	LY	P
Ozone layer protection				
Recovery of chlorofluorocarbons				
Fukui prefecture	40,000	Oka(1997)	LY	R
Gifu prefecture	68,000	Oka(1997)	LY	R
Hyogo prefecture	130,000	Oka(1997)	LY	R
Tokyo prefecture	390,000	Oka(1997)	LY	R
NOx reduction regulation	75,000	Oka(1997)	LY	R
Prohibition of chlordane	45,000	Oka et al.(1997)	LY	R
Dioxin control				
Emergency countermeasures at municipal incinerators	7,900	Kishimoto et al. (2001)	LY	R
Long-term countermeasures at municipal incinerators	150,000	Kishimoto et al. (2001)	LY	P
<Safety control>				
Road traffic				
Traffic safety facilities for pedestrians	27,000	Murayama(1991)	LY	R
Traffic safety facilities for pedestrians	5,000	Kishimoto(1997)	LY	R
Traffic safety facilities for Gifu city	30,000	Akiyama and Suzuki(1997)	LY	P
<Disease prevention>				
Cancer screening				
Mass screening for gastric cancer				
males	610	Tsuji et al.(1991a)	LY	R
females	1,500	Tsuji et al.(1991a)	LY	R
male, 40s	6,400	Babazono and Hillman(1995)	LY	R
male, 50s	2,100	Babazono and Hillman(1995)	LY	R
male, 60s	1,200	Babazono and Hillman(1995)	LY	R
male, 70s	800	Babazono and Hillman(1995)	LY	R
female, 40s	5,100	Babazono and Hillman(1995)	LY	R
female, 50s	4,100	Babazono and Hillman(1995)	LY	R
female, 60s	3,100	Babazono and Hillman(1995)	LY	R
female, 70s	2,400	Babazono and Hillman(1995)	LY	R
all (1984-1992)	860	Kishimoto(1997)	LY	R
Kagoshima prefecture(1985-1994)	3,200	Kusano et al. (1997)	LY	R
Kagoshima prefecture(annual participation)	21,000	Kusano et al. (1997)	LY	R
Mass screening for lung cancer				
all (1987-1992)	8,700	Kishimoto(1997)	LY	R
Mass screening for breast cancer				
physical examination(PE) alone	7,500	Okubo et al.(1991)	LY	R
mammography(MG)	2,100	Okubo et al.(1991)	LY	P
PE followed by MG if PE findings were abnormal	6,100	Okubo et al.(1991)	LY	P
PE combined with MG for all screened women	2,700	Okubo et al.(1991)	LY	P
all (1987-1992)	3,200	Kishimoto(1997)	LY	R
Mass screening for cervical cancer	4,900	Matsunaga et al.(1997)	LY	R

Mass screening for colorectal cancer				
two day method of screening program: male	4,100	Tsuji et al.(1991b)	LY	P
two day method of screening program: female	5,100	Tsuji et al.(1991b)	LY	P
total colonoscopy for workup strategy: male	3,300	Tsuji et al.(1991b)	LY	P
total colonoscopy for workup strategy: female	4,100	Tsuji et al.(1991b)	LY	P
starting age of screening: 40	1,800	Shimbo et al. (1994)	LY	P
starting age of screening: 50	1,700	Shimbo et al. (1994)	LY	P
starting age of screening: 60	2,100	Shimbo et al. (1994)	LY	P
Mass screening for prostatic cancer				
age 55–59	200	Nakagawa et al. (1997)	LY	P
age 60–69	<0	Nakagawa et al. (1997)	LY	P
age 70–79	<0	Nakagawa et al. (1997)	LY	P
Smoke cessation				
Smoke cessation with Nicotine TTS	1,800	Fujino et al. (1994)	LY	P
Human immunodeficiency virus infection(HIV) prevention				
HIV screening for the blood donors (in average)	140,000	Rahman et al. (1995)	LY	P
HIV screening for the blood donors (in Tokyo)	51,000	Rahman et al. (1995)	LY	P
Partner notification program	570	Rahman et al. (1998)	LY	P
Hepatitis type B viruses Vaccine				
Dsicount rate 3%	4,350	Katayakma et al. (2000)	LY	R
Discount rate 5%	20,600	Katayakma et al. (2000)	LY	R
Prevention of coronary artery disease				
Hypertensive care				
male	5,100	Hisamichi(1995)	LY	R
female	7,000	Hisamichi(1995)	LY	R
HMG-CoA reductase inhibitor (male, 50)	4200–4800/3620	Hisashige (1999)	LY/QALY	R
HMG-CoA reductase inhibitor (female, 50)	7500–8600/7180	Hisashige (1999)	LY/QALY	R
<Medical treatment>				
Cancer treatment				
Lung cancer treatment (male, 60)	1,500	Koinuma (1999)	QALY	R
Colorectal cancer treatment (male, 60)	450	Koinuma (1999)	QALY	R
Gastric cancer treatment (male, 60)	300	Koinuma (1999)	QALY	R
Prostatic cancer treatment (male, 60)	300	Koinuma (1999)	QALY	R
Lung cancer treatment (female, 60)	1,300	Koinuma (1999)	QALY	R
Colorectal cancer treatment (female, 60)	300	Koinuma (1999)	QALY	R
Cervical cancer treatment (female, 60)	300	Koinuma (1999)	QALY	R
Breast cancer treatment (female, 60)	200	Koinuma (1999)	QALY	R
Gastric cancer treatment (female, 60)	200	Koinuma (1999)	QALY	R
Breast cancer treatment				
Conservative treatment of breast cancer	320	Hisashige (2000)	QALY	R
Postoperative supprtive care (CMF)	160	Hisashige (2000)	QALY	R
Postoperative supprtive care (TAM)	440	Hisashige (2000)	QALY	R
Interferon therapy for liver cirrhosis type C	490/620	Hisashige(1999)	LY/QALY	R
Organ transplant				
Liver transplant	3600–8700	Miyasaka and Ohi (1994)	LY	P
Heart transplant	4700–9300	Miyasaka and Ohi (1994)	LY	P
Liver transplant from a living donor				
6 years followup	5,240	Hisashige (2000)	QALY	R
life-time followup	4,440	Hisashige (2000)	QALY	R
Heart transplant				
8 years followup	2640/2380	Hisashige(1999)	LY/QALY	P
life-time followup	1360/1210	Hisashige(1999)	LY/QALY	P
Acute lymphocytic leukemia treatment				
Chemotherapy (5 years followup)	4,500	Ohta (1996)	LY	R
Chemotherapy (life-time followup)	760	Ohta (1996)	LY	R
Bone marrow transplantation (5 years followup)	3,300	Ohta (1996)	LY	R
Bone marrow transplantation (life-time followup)	150	Ohta (1996)	LY	R
Chronic lymphocytic leukemia treatment				
Chemotherapy (5 years followup)	1,550	Hisashige (2000)	LY	R
Chemotherapy (life-time followup)	590	Hisashige (2000)	LY	R
Bone marrow transplantation (5 years followup)	2,940	Hisashige (2000)	LY	R
Bone marrow transplantation (life-time followup)	330	Hisashige (2000)	LY	R
Coronary artery disease treatment				
Coronary artery bypass grafting(CABG) in place of percutaneous transluminal coronary angioplasty(PTCA) for exertional angina pectoris (two vessel disease)	8,400	Hisamichi(1995)	QALY	P
Medical treatment (single vessel disease)	5,020	Hisashige (2000)	QALY	R
CABG (two-vessel disease)	5,240	Hisashige (2000)	QALY	R
CABG (three-vessel disease)	970	Hisashige (2000)	QALY	R

"R" represents retrospective analysis and "P" represents prospective analysis.

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