V.1.4. Discussion

(1) Evaluation of Estimation Results

From Table 3, showing the average shot rate and average copayment, we can see that the price elasticity of shot rate is −0.2606. It appears to be higher than the results of the previous study. That is, the study based on the conjoint analysis which is the most reliable technique with a hypothetical questionnaire indicates −0.02 to −0.04 for the elasticity, and the actual behavior in the '01/'02season indicates −0.1 for the elasticity[4]. Hence, the result in this paper shows that the shot rate is very elastic against price.

There are two main reasons for these differences. Firstly, this study focus on the metropolitan and big cities and so it may be biased toward extremely urban areas, whereas the previous studies cover the whole of Japan. If the residents in the urban areas have higher price elasticity to vaccination than rural areas, our results here may be reasonable. In this sense, the previous studies seem to be more general than this research.

Conversely, the data in this paper covers all residents in an area, while the previous study relied on survey by mail and it did not cover all the residents, of course, and they may not be representative. If the respondents of the questionnaire tend to have inclination toward vaccination for influenza compared with non-respondents, the shot rate may be insensitive to price. In this sense, the result in this study seems to be more reliable than the previous one. Though, it is not certain which estimate and reasoning is more reasonable, We have to remind ourselves that our final goal, namely the analysis with the BCR, is independent of price elasticity of shots as explained before.

On the other hand, the shot rate elasticity of mortality rate is −2.48, and thus mortality is elastic against shot rate. Combining these two estimation results, if copayment would be cut by a thousand yen (eight dollars), it raises the shot rate by 7 percentage points, and reduces the mortality rate due to pneumonia and influenza by .029 percentage point. It seems like a very small number, but since the average mortality rate due to pneumonia and influenza is very small, the effect certainly is quite high. In fact, this means this policy can reduce about 423 death in an average big city.

Since F statistics in the first equation is higher than ten, the fitted variables seems to be good instrument[5]. In other words, the reason of insignificance of the shot rate in the crude weighted least square can be inferred as positive simultaneous bias which offsets the shot rate effect on the mortality rate. Therefore, the instrument variable can solve this bias and it is a more appropriate method for this problem.

(2) Evaluation for BCR

The obtained BCR, 22.4, is quite high compared with the other countries or other vaccinations. In some other countries, since it is 1.93[6] for children before school and 1.81[7] or 2.92[8] for healthy adults, the obtained IBCR is much higher. Compared with other diseases, it is 2.5[9] for measles in Japan and it is just 1.4[10] in the case of hepatics B for all infants in China where there are epidemic areas. Overall, the policy of subsidy for shots for the elderly is quite cost-effective and there is concrete evidence for this.

(3) Problem and limitation in this analysis

At first, there are some differences in the definition of population among areas for the policy targeting or/and for the shot rate calculation. Especially, this policy also subsidizes the non-elderly, i.e. between 60 and 64 years old, who have heart, kidney, and respiratory problem or HIV career. Moreover, each city sometimes extend the target population more than the national policy requirement. Typically, some cities subsidize the institutionalized elderly even if they are younger than 65. These additional target populations are included in the denominator in some cities, but are not in other cities. The subsidized number in the numerator of the shot rate include such additional targeting populations, and thus the shot rate may be different depending on whether the denominator include such additional targeting populations or not. However, these additional target populations are quite small compared with the elderly, and it is less than just one percent. Therefore, such an inconsistency in the denominator of the shot rate may not substantially affect the result.

Moreover, the starting date of subsidy is not the same among areas. In particular, it is remarkable in the first season of this policy, i.e. the '01/'02 season. Our data of shot rate only includes those who received the subsidy, and does not include those who did not receive subsidy but received shots. So the shot rate may be lower than the actual rate in the area where the starting date of subsidy was delayed. In this sense, the data of shot rate is always lower than the actual shot rate among the elderly. This measurement error may lead to upper bias of the estimated coefficient of the shot rate in the second estimation. Hence, it also lead upper bias in IBCR. However, it is not sure how many elderly people received a shot but were not subsidized, and so we cannot evaluate this effect in detail.

On the other hand, it is questionable whether our sample in the metropolitan and big cities represents the whole of Japan or not. The coverage of the elderly population in our data is 21% of Japan, but it may not be the average population. Especially, there may be big differences from those in the rural areas as mentioned before. So as to check the robustness of the obtained result, we should extend our analysis to the other areas.

Additionally, the effect of the influenza epidemic on the mortality rate is measured by excess mortality which is defined by the difference between the actual number of deaths and the hypothetical number in the case of no influenza epidemic[11-14]. Therefore, we have to replace the mortality definition from the crude number of death to the excess mortality. In particular, excess death should be defined regardless of the cause of death[14] because it is very well known that the influenza epidemic raises the mortality rate from other causes than pneumonia or influenza and these death can be prevented by the vaccination and control of the influenza epidemic. Moreover, if we can limit the number of deaths to those of more than 65 years old, it would be a more precise measure. In this sense, the excess mortality of those older than 65 years old in all causes of death is the best measure to evaluate the vaccination effect.

At the same time, we also need more explanatory variables which affect the shot rate or mortality. For example, the hortative measure for vaccination may be much different among local governments and it may affect the shot rate. Even in this case, if such a measure did not change in an area in the two season, this effect can be controlled out completely by the area dummies and it does not affect the estimated coefficient.

On the other hand, there are many implicit assumptions in BCR. First of all, since we limit the effect of vaccination to the prevention of death, and thus it is certainly a finer measurement than the prevention of the severe conditions like hospitalization as emphasized. Since it is difficult to obtain the data of the number of patients and the hospitalized, these numbers would be based on the similar estimation. Hence, these are far less precise than the number of death. In other words, we choose preciseness rather than broadness in the definition of effectiveness. Obviously, this limitation lower BCR. If we take the effects of vaccination on the number of patients and the hospitalized into consideration, BCR definitely becomes higher than the BCR discussed in this paper. It strengthens our conclusion in favor of the subsidy and has never change it.

Conversely, the ignorance of opportunity cost for vaccination or side effects certainly raises BCR. However, almost all of them are retired, and suffered from chronic disease and thus they usually visit a doctor, their additional opportunity cost for vaccination seems to be small. Concerning side effects, on 28 August, 2003, the Ministry of health and welfare reported only two fatal cases and 18 severe side effects from 1998 to 2003. Therefore, we can safely ignore these cost and the obtained conclusion is probably not affected by the introduction of these costs.

Finally, we can extend the effectiveness of vaccination to the number of patients or the medical cost. The data limitations of these variables are already mentioned. Moreover, since the primary purpose of vaccination is the prevention of severe cases, if we extend to these aspects, the results may not be clear and BCR may decline. In extreme case, the fatal case may use less medical resources compared with severe cases where the patients survives. In this sense, the limitation of effectiveness on the number of deaths seems to be more appropriate for considering the vaccination policy. Nevertheless, the research on the number of patients and medical cost are unambiguously important and we need to overcome the data limitations.

V.2. *Example 2: Smoking Cessation Program*

We show *ex ante* policy evaluation for smoking cessation program as another example of cost-effectiveness analysis in policy for medicine or public health which is originally in Ohkusa and Sugawara(2005a).

V.2.1. *Objective*

There are many programs to cease smoking, such as group therapy, individual therapy by professional staff such as medical doctors or nicotine replacement therapy. The Tobacco Use and Dependence Clinical Guideline Panel, Staff, and Consortium Representatives (2000) recommend the use of nicotine replacement therapy for nicotine dependence. In Japan, nicotine replacement therapy uses nicotine patch or nicotine gum, but the former requires a prescription written by a medical doctor. The later does not require it and we can buy it as an OTC (Over-the-counter) drug at any pharmacy without consultation by medical doctors. The Nicotine patch is used in more than 60 countries, and is an OTC in more than 30 countries. However, it has not switched to the OTC, yet in Japan. On the other hand, individual consultation by a medical doctor is not covered by health insurance in Japan.

This paper tries to conduct an ex ante cost effective analysis to evaluate new policies for smoking cessation, such as switching the nicotine patch to OTC (PO) and insurance coverage for individual therapy by medical doctors (PI).

V.2.2. *Material and Method*

The survey collected information through the web site in December 2004. The respondents were limited to smokers aged 20 to 59, and randomly drawn stratified are, age, and gender which replicate the national average from the list of the contracted members with the survey company.

It employs the hypothetical questionnaire which is used in the Conjoint analysis (Halpern, Berns and Israni(2004), Ratcliffe, Buxton, McGarry, Sheldon and Chancellor(2004), Maddala, Phillips and Johnson(2003) Schwappach(2003), Phillips, Maddala and Johnson(2002), Gyrd-Hansen and Slothuus(2002), Aristides, Chen, Schulz, Williamson, Clarke and Grant(2002), Bryan, Roberts, Heginbotham and McCallum(2002), Ratcliffe, Van Haselen, Buxton, Hardy, Colehan and Partridge(2002), Telser and Zweifel(2002), Gabriel, leung, Chan, Chau and Chua(2001), Johnson, Banzhaf and Desvousges(2000), Ratcliffe(2000), Tilley and Chambers(2000)). It asks the respondent to choose visiting a doctor or going to a pharmacy under the hypothetical situations: about cost of medical services and OTC, traveling time to visit a doctor, insurance coverage of individual consultation by a medical doctor, and explanation by a pharmacist on now to use the OTC drug.

In each attribute, the levels are set as follows; traveling time to visit a doctor: 30 minutes, 60 minutes, and 120 minutes, cost for both medical service and OTC: 100 thousand yen (800 dollars) to 500 thousand yen (4000 dollars) by 100 thousand yen (800 dollars), explanation by pharmacist: none, 5 minutes and 10 minutes, insurance coverage and switching to OTC: yes or no.

In the case of insurance coverage for medical service, costs for medical services are reduced to be 30%, which is the coinsurance rate in Japan. The Cost for medical services and OTC are selected from estimations of cost in the current situation. Expected rate of those who quit smoking is supposed to be the same among programs.

Hence there are 900 possible scenarios. Of these, we select 50 scenarios orthogonally. Then we allocate 10 questions to each respondent and set 5 patterns.

We adopt random effects Probit model which is very common to estimate the Conjoint analysis. Especially, we estimate it separately, whether nicotine patch is switched or not, so as to fully evaluate its effect. In each estimation, the dependent variable is binary; if i th the individual choose OTC for j (j=1,2,...,10) th question, then $O_{i,t}=1$, and is zero otherwise. The estimation equation is

$$O^*_{i,j} = \alpha_0 + \alpha_M \log M_{i,j} + \alpha_T \log T_{i,j} + \alpha_I I_{i,j} + \alpha_C \log C_{i,j} + \alpha^5_E E^5_{i,j} + \alpha^{10}_E E^{10}_{i,j} + \mu_i + \varepsilon_{i,j}$$

$$O_{i,j} = \begin{cases} 1 & \text{if } O^*_{i,j} > 0 \\ 0 & \text{otherwise} \end{cases} \tag{12}$$

where $M_{i,j}$, $T_{i,j}$, $I_{i,j}$, $C_{i,j}$, $E^5_{i,j}$, $E^{10}_{i,j}$ are respectively the cost for medical service, the traveling time to visit a doctor, dummy for insurance coverage, the cost for OTC, dummy for a five minute explanation by a pharmacist, and dummy for a ten minute explanation by pharmacist. μ_i is the random effect that captures individual effects and $\varepsilon_{i,j}$ is a stochastic disturbance term.

Next, we perform a cost effective analysis of these two new policies, PO and PI, based on the estimated demand curve. We calculate the incremental benefit cost ratio (IBCR) with and without such an externality among the current situation and switching the nicotine patch to OTC, insurance coverage for smoking cessation therapy by a doctor, and both of them. Moreover, we refer to net benefit in this policy so as to evaluate its amount of gain or loss in monetary term.

V.2.3. Results

We collected information from 2,839 individuals and the response rate was 51.9%. The estimation results are summarized in Table 5. It shows that all coefficients are significant and the variance of the random effect is significantly more than zero. Therefore, its consideration is important.

Table 5 :Demand for OTC and Medical Services which Assists Quit Smoking

	Nicotine Patch		Nicotine Gum	
	Marginal Effect	*p* value	Marginal Effect	*p* value
Medical Cost(log)	0. 09595611	. 000	0. 23414278	. 000
Traveling Time(log)	0. 08233906	. 002	0. 09190193	. 000
Insurance Coverage	-0. 06234507	. 021	-0. 03687187	. 001
OTC Cost(log)	-0. 33815518	. 000	-0. 23327342	. 000
Explanation(5 min.)[a]	0. 09684908	. 000	0. 01804711	. 089
Explanation(10 min.)[a]	0. 07527379	. 050	0. 08756433	. 000
# of sample	4725		7066	
# of individuals	2375		2377	
p-value for χ^2 test[b]	<0.˙0000		<0. 0000	
Log Likelihood	-1531. 5		-3187. 5	
p-value for χ^2 test[c]	<0. 0000		<0. 0000	

Note:Dependent variable is binary variable whether they demand for OTC (nicotine patch or nicotine gum) or not.[a]:'Explanation (5 min.)' and 'Explanation (10 min.)' means that how long pharmacist explain about nicotine gum or patch when the consumer buy it at pharmacy.[b]: Likelihood ratio test for estimation model against constant term only.[c]: Likelihood ratio test for estimation model against the model without random effects.

The disease burden of smoking has been estimated as 3.7 to 7.3 trillion yen (Institute of Health Economics and Planning(1997), Ohkusa and Sugawara(2005b)). In this amount, externality is the insurance paid for the medical cost of treatment for smoking related disease. While it is not recognized as costs for smokers, it is actually the cost from the societal view point. Such externality is estimated as 0.88 to 1.12 trillion yen and rate of externality is estimated as 7.3/(7.3−1.12)−1=0.18.

The result of cost effective analysis is summarized in Table 6. It shows the results separately in terms of the externality considered. The first row indicates the case of switching nicotine patch to OTC. The second row presents the result of the case where the therapy by doctors does not become popular while it is covered by insurance, and where the traveling time is ninety minutes .The third and fourth rows summarize the result if the traveling time is reduced to be 60 or 30 minutes. Besides, the result if both PO and PI are implemented by traveling time is also shown. Table 7 shows the net benefit in OTC market and market of medical services.

Table 6:IBCR of Switching to OTC of Nicotine Patch and/or Insurance Coverage for Quit Smoking Therapy

Switching to OTC of Nicotine Patch	Insurance Coverage	Traveling Time (min.)	without Externality			with Externality		
				95% CI			95% CI	
			Median	Lower	Upper	Median	Lower	Upper
Yes	No	90	1.46	1.39	1.53	1.72	1.65	1.81
No	Yes	90	0.189	0.039	0.295	0.203	0.024	0.329
No	Yes	60	0.311	0.208	0.386	0.352	0.229	0.442
No	Yes	40	0.461	0.398	0.509	0.534	0.460	0.591
Yes	Yes	90	0.789	0.733	0.863	0.910	0.840	1.00
Yes	Yes	60	0.711	0.698	0.749	0.819	0.803	0.867
Yes	Yes	30	0.665	0.576	0.734	0.767	0.661	0.850

Table 7:Net Benefit of Switching to OTC of Nicotine Patch and/or Insurance Coverage for Quit Smoking Therapy by Doctor

Insurance Coverage	Traveling Time	After Switching		Before Switching	
		OTC	Medical Service	OTC	Medical Service
without Externality					
No	90	1321.0425 [929.8, 1805]	32.014884 [31.72, 32.27]	193.39717 [145.8, 252.9]	21.691252 [21.46, 21.92]
Yes	90	179.66613 [103.9, 207.5]	-211.5101 [-223.9, -198.7]	1.8866509 [1.193, .9411]	-712.20123 [-718.5, -705.7]
Yes	60	111.0619 [61.72, 191.2]	-214.41094 [-230.9, -197.6]	0.94754236 [.5874, 1.507]	-839.76731 [-848.4, -830.8]
Yes	30	44.870128 [23.23, 82.75]	-260.64714 [-288.6, -232.6]	0.27154143 [.1625, .4476]	-1013.9675 [-1028, -999.5]
with Externality					
No	90	2073.351 [1511, 2744]	47.488069 [47.23, 47.69]	303.77122 [231.9, 392.5]	36.81772 [36.55, 37.07]
Yes	90	340.16637 [206.1, 538.4]	-114.27436 [-128.1, -100.0]	3.4450426 [2.217, 5.282]	-571.11183 [-578.3, -563.7]
Yes	60	218.27756 [127.2, 358.7]	-106.47282 [-125.9, -86.70]	1.7637574 [1.112, 2.7599]	-654.23084 [-664.1, -644.0]
Yes	30	94.090628 [51.14, 165.4]	-9.1588703 [-39.45, 20.92]	0.52249262 [.3182, .8465]	-731.27581 [-747.5, -714.6]

These tables show obviously that the IBCR for PO exceeds one significantly and is 1.46 without externality, and is 1.72 with externality. The net benefit achieves 135 billion yen and it is higher than the current net benefit of 21 billion yen by more than 100 billion yen.

Conversely, the IBCR for PI is less than one, and thus it does not support the implementation of this reform. This policy reduces the net benefit in the OTC market to less than 0.2 billion yen due to the reduction in copayment by insurance coverage and the society loses 71.2 billion yen.

Moreover, if the number of medical institutions which provide smoking cessation therapy by doctors increases and traveling time is shortened to be 60 or 30 minutes, the net benefit in the OTC market is reduced to 30 million yen and the net loss in the market for medical service achieve more than 100 billion yen. Even if we take such an externality into consideration, it leads the negative net benefit amounts to 57 billion yen in the society as a whole. When we test PO and PI simultaneously, its IBCR is not larger than one significantly, even though the upper limit of a case reaches one.

V.2.4. *Discussion*

If we can assume that the expected benefit of quitting smoking is the same among smokers, the demand curve represents the subjective quit rate. In other words, the smokers who join the smoking cessation program are thought to have a higher subjective quit rate or have more aptitude of these programs than other smokers, those who do not join the program under the same price.

Conversely, almost all the cost effective analyses so far are usually based on the assumption of average individual or some artificial scenarios. Namely, the quit rate is assumed to be a certain level in all smokers in this case. It is true if we consider some nonexclusive public goods because the word "join" or "not join" does not make any sense. However it must not be true if we consider the private goods. In this sense, immunization, medical services or OTC drugs are exclusive private goods.

Even though there is heterogeneity among individuals, these studies ignore this clear fact and assume that they are homogenous. In our context, these typical cost effective analyses ignore the difference in the subjective quit rates which are represented by the demand curve for the smoking cessation program.

Especially, when we evaluate the policy with some subsidies including health insurance coverage, it is very important to recognized that such a policy enforces joining the programs whose subjected benefit is lower than those who join the program even though such a policy is not implemented. In other words, the average benefit among participants must be decreased by such a policy. It is very well known as a deadweight loss. Needless to say, such a policy for private goods must not be recommended because it worsens the welfare. Therefore the cost effective analysis must be based on the demand curve if we consider the policy for private goods, or the analysis leads to the wrong conclusion.

Moreover, almost all the cost effective analyses so far usually fail to consider externalities. As explained above, the cost effective analyses so far have been based on the average or hypothetical individual and summing them up into the aggregate benefit and cost. Hence the externality which does not count at the individual level may be ignored. This externality does not seem essential in the cost effective analyses and thus it can be incorporated in the analysis, but typically it is ignored.

On the other hand, we can easily take such an externality into consideration which is represented by the deviation of social benefit from the demand curve. This deviation is the only reasons for policy intervention. In the case of positive externality, since the deviation of social benefit other than individual's utility, the deadweight loss induced by the policy may be compensated. Hence, cost effectiveness analysis for private goods is not for considering whether such a positive externality is sufficiently large enough to compensate the deadweight loss. Therefore, externality is the most important and essential of cost effective analysis for private goods.

In our context, PI means to provide subsidy of 70% of the medical cost and thus it leads to some deadweight loss. Therefore, it needs some evidence that its externality is larger than the deadweight loss. On the other hand, switching the nicotine patch to OTC is a kind of deregulation and thus it does not lead to deadweight loss.

Table 6 and 7 imply that PI does not have evidence but PO has it to support implementation. The point to evaluate PI is whether the externality is so large that this deadweight loss can be compensated. Unfortunately, it cannot. Even if we perform PO and PI simultaneously, though the nicotine patch as OTC partially offset the demand for medical services, this strategy also does not have evidence to support implementation. Therefore we can conclude that PO is strongly recommended but PI is not.

If we calculate IBCR without using a demand curve, but assuming average individual even if a new policy is implemented, it should be as follows: Assume the quit rate is 30% in any program, PO and PI, and cost in both policies is 30 thousand yen (240 dollars), then the additional cost to quit per person is 70 thousand yen (560 dollars). On the other hand, the benefit of quitting smoking is supposed to be 3.7 to 7.3 as mentioned before, and its per capita term is 185-365 thousand yen (1.48-2.92 thousand dollars) if the smoking population is 20 million. We note that this number does not depend on how many person attend due to the new policy. Therefore IBCR is 2.6429(=185/70)- 5.2143(365/70).

Even though this extremely simple calculation ignores discounting, it does not seem to affect the its implication. It is clearly more than one, so this very simple calculation recommends the implementation of both PI and PO. However, we prove that PI make huge deadweight loss and externality cannot compensate it fully, so we cannot recommend it. This small example explain how such a simple cost effective analysis leads to a wrong conclusion.

However, we have some limitations. The most important of all would be environmental tobacco smoking (ETS). It must raise positive externality of quitting smoking. Even though its medical cost is very small compared with the medical costs of smokers, the bad smell of smoke worsen the QOL of non-smokers. Insurance coverage for smoking cessation therapy by doctors may be changed to be cost effective. Accumulation of knowledge about ETS in epidemiology and health economics is necessary as soon as possible so as to evaluate smoking cessation programs.

VI. Conclusion

As mentioned before,

In other countries, the smoking policy is based on the result of cost effectiveness analysis in the field of policy evaluation for medicine or public health. The more responsibility will be required for policy makers to explain for all citizens about the process of political decision they made. Taking this situation into consideration, additional research and discussion should be needed to respond this requirement.

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Policy evaluation for the subsidy for influenza vaccination in elderly

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Abstract

Objective: In Japan, the subsidy of influenza vaccination for the elderly was introduced in November 2001. This paper examines its policy evaluation from the viewpoint of cost–benefit analysis.
Materials: The data of copayment of influenza vaccination, population and shot rate of the elderly are surveyed by telephone interview to the correspondents in the local governments of Tokyo metropolitan and other 12 big cities in Japan. The mortality due to pneumonia or influenza is obtained from Vital Statistics of Population.
Method: At first, I examine the impact of amount of copayment, through its effect on shot rate, on the percentage of elderly receiving influenza vaccinations. Using these estimation results, benefit–cost ratio (BCR) is calculated.
Results: The estimated coefficient of copayment on shot rate is −0.007 and statistically significant. Shot rate significantly reduces pneumonia and influenza mortality and its magnitude is −0.0028. The obtained net benefit (NB) is 134.9 million yen or US$ 1.08 billion and benefit–cost ratio is 22.9 and its 95% confidence interval is [2.2, 43.7].
Discussion: If copayment would be cut by a 1000 yen (US$ 8), it could avoid about 400 deaths in average big city. The benefit–cost ratio is quite high compared with the other countries or other vaccinations.
Conclusion: We found the strong evidence in a sense of cost–benefit analysis in the subsidy for influenza vaccination in the elderly.

Keywords: Influenza; Cost-benefit analysis; Vaccination; Subsidy for the elderly

1. Objective

In 7 November 2001, the vaccination law was reformed and it started to subsidize of influenza vaccination for the elderly. This policy should be confirmed by the cost–effectiveness perspectives because it costs very much. This paper examines to evaluate this policy from the viewpoint of the cost effectiveness.

2. Material

The data of copayment of influenza vaccination, population and shot rate of the elderly in 2001/2002 and 2002/2003 seasons are surveyed by telephone interview to the correspondents in the local governments of metropolitan and other 12 big cities in Japan. This survey was performed by the author.

Copayment is determined by these local governments in every year and the excess cost more than the copayment is subsidized by the central and local governments directly to the medical institutions. Total cost of vaccination, which is charge by the medical institution to the elderly and local governments, is decided through the negotiation among local governments and physicians' association in each cities. Unfortunately, it is not informed publicly. In other words, we can only know the copayment in every year and in each city, while the total cost and, thus, the amounts of the subsidy are unknown. In this sense, total cost includes all components of items for the vaccination and the profit of medical institutions.

The mortality due to pneumonia or influenza is obtained from Vital Statistics of Population in 2002 and 2003. The data of total population is obtained from National Population Census in 2000.

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3. Method

3.1. Estimation

Estimation is performed with the following two parts. At first, we examine the impact of the variation of copayment on shot rate. Let $R_{i,t}$, $C_{i,t}$ and T_t, respectively, denote shot rate and copayment in i area and t year, and year variable for 2002/2003 season that captures the difference between sample seasons keeping constant all other aspects. The estimation equation is:

$$R_{i,t} = \alpha_i + \alpha_c C_{i,t} + \alpha_T T_t + \varepsilon_{i,t} \quad (1)$$

The second part is to estimate the relationship between shot rate and mortality rate due to pneumonia or influenza. The estimation equation is:

$$D_{i,t} = \beta_i + \beta_R R_{i,t} + \beta_T T_t + \nu_{i,t} \quad (2)$$

where $D_{i,t}$ is pneumonia and influenza mortality rate. Unfortunately, since pneumonia and influenza mortality rate of the elderly by area and season is not reported, we use the mortality rate of the total population irrelevant to the age.

Estimation method is the weighted least square with the elderly population and the total population as a weight, respectively, in the first and the second estimation.

Note that we have to remark, if $\varepsilon_{i,t}$ and $\nu_{i,t}$ are correlated, estimated coefficient β_R certainly has bias. Moreover, the direction of bias may be positive or negative depending on $E[\varepsilon_{i,t}, \nu_{i,t}]$. For example, increase in the number of weak elderly and residents in institutions, shot rate of them usually are higher than dwelling elderly and mortality rate may be still higher due to their weakness even if shot rate are the same. This correlation may lead to the upper bias in the coefficient. Conversely, shot rate may represent overall welfare spending or situation of the elderly in that area controlled out copayment. If these spending or situation improve the elderly's health condition and reduce mortality rate, this relationship make the lower bias in the coefficient.

In both case, these are very well known as the simultaneous bias and we have to adopt the method that corrects such bias. The method, called instrumental variable method, uses the fitted variables of $R_{i,t}$ in the first estimation as an explanatory variable in the second estimation rather than the observed raw $R_{i,t}$ [1].

3.2. Benefit–cost ratio

Using these estimation results, we can evaluate the policy by net benefit (NB) and benefit–cost ratio (BCR). NB is defined simply by the difference of benefit and cost due to the policy, and BCR is defined by its ratio.

NB can be calculated as follows: the perspective is of the society and time horizon is set to be 1 year because the effect of vaccination is lower than 1 year and vaccination can extend their life 1 year at maximum. The effectiveness of vaccination is limited to the prevention of the mortality due to data limitation.

Vaccination cost is defined as the sum of copayment and subsidy, but the opportunity cost for shot is not taken into consideration because they are typically retired. Moreover, side effects of vaccination are also ignored for simplicity.

Vaccination cost is assumed to be 4500 yen (US$ 36) and benefit of 1 year increasing in life expectancy is assumed to be 6 million yen (US$ 50,000). These numbers are widely used number in US [2] and it is confirmed to be plausible even in Japan [3].

Then NB is

Monetary value of avoidance in mortality by rising shot rate

- additional cost by rising shot rate = rising shot rate due to subsidy × reduction in mortality rate due to rising hot rate × million yen
- rising shot rate due to subsidy × 4500 yen = $\frac{4000}{3}$ × reduction in mortality rate due to rising shot rate

Similarly, BCR is

$$\frac{\text{monetary value of avoidance in mortality by rising shot rate}}{\text{additional cost by rising shot rate}}$$

$$= \frac{\text{rising shot rate due to subsidy} \times \text{reduction in mortality rate due to rising shot rate}}{\text{rising shot rate due to subsidy}} \times \frac{\text{6 million yen}}{\text{4500 yen}}$$

$$= \frac{4000 \times \text{reduction in mortality rate due to rising shot rate}}{3}$$

4. Result

4.1. Estimation result

Summary statistics are shown in Table 1. Estimation results are summarized in Table 2.

The first and second columns in Table 2 show that the increasing in copayments significantly reduces shot rate. As its coefficient is −0.007, since it means the shot rate would rise by 0.007% point in every 1 yen subisidy, if copayment is subsidized by 1000 yen (8), then shot rate rise by 7% point. Since the coefficient for 2002/2003 season is significantly positive, shot rate rise by 8.8% point in 2002/2003 season compared with the 2001/2002 season where other situations are completely the same. All area dummies, which indicate difference from Sapporo, are insignificant. Since degree of freedom adjusted R^2 is high, it fits quite well.

The third and fourth columns in Table 2 summarize estimation results of crude weighted least square about mortality

Table 1
Summary statistics

	Average	S.D.	Minimum	Maximum
Shot rate (%)	29.6695	6.067872	18.4074	45
Copayment (yen)	1171.429	427.618	1000	2200
Mortality rate (%)	0.0409995	0.0315513	0.0033683	0.1753567

rate and they indicate that the shot rate is negatively affect mortality rate but it is not significant. On the other hand, the fifth and sixth columns in Table 2 show the results for the instrument variable method. They show significant effect of shot rate on mortality rate and its estimated coefficient is −0.003, i.e. if shot rate is raised by 10% points, mortality rate of pneumonia and influenza would decrease by 0.03% point.

4.2. Net benefit and benefit–cost ratio

Suppose calculation of the net benefit and BCR of the policy change, which raise 1000 yen (8) in subsidy. At first, this policy increase the shot rate by 7% point as mentioned above and this reduces the mortality rate of the ehold population by 0.0196 (= 7 times 0.0028)% points. It means to avoid 23,520 (= 0.000196 times 120 million) death. This benefit can be evaluated as 141.2 billion yen (US$ 1.13 billion) (=23,520 times 6 million yen) if value of life is assumed to be 6 million yen or US$ 50,000.

On the other hand, additional cost of this policy change must be the product of 7% point rise in the shot rate, 4500 yen (cost of vaccination in social per one elderly) and 20 million (population of the elderly). It expends 6.3 billion yen or US$ 50.4 million. Therefore, the net benefit must be the difference of benefit and cost and it is 134.9 million yen or US$ 1.08 billion.

Following the similar way, we can calculate its BCR easily, i.e.

$$\frac{0.0028(-1000)(-0.007)\,6\,\text{million yen}/(2000/12000)}{-1000(-0.007)4500\,\text{yen}} = 22.4 \qquad (5)$$

where 2000/12,000 in the numerator is adjustment factor for the elderly because potential population of the numerator is the whole population but the counterpart in the denominator is of the elderly. Moreover, its 95% confidence interval is calculated as [2.2, 43.7] and we can confirm that this BCR is significantly greater than 1.

5. Discussion

5.1. Evaluation of estimation results

From Table 1, showing the average shot rate and average copayment, we can see that the price elasticity of shot rate is −0.2606. It appears to be higher than the results of the pre-

Table 2
Estimation result

Explanatory variable	Estimator	p-Value	Estimator	p-Value	Estimator	p-Value
Copayment shot rate (instrument)	−0.0066561	0.002	−0.0006669	0.304	−0.0027877	0.034
2002/2003 season	8.757308	0.000	0.0112177	0.088	0.0295542	0.015
Sendai	1.208579	0.727	−0.0047122	0.500	−0.0021133	0.780
Chiba	5.458579	0.153	0.0057438	0.475	0.0173561	0.141
Tokyo	−1.674325	0.300	0.0023957	0.727	−0.0144918	0.090
Yokohama	−0.6914208	0.781	−0.0021031	0.682	−0.0035337	0.464
Kawasaki	−5.184099	0.123	0.0056449	0.442	−0.0053089	0.455
Nagoya	−3.341421	0.222	0.0034983	0.561	−0.0035525	0.502
Kyoto	−4.723365	0.113	0.0073267	0.297	−0.0026762	0.680
Osaka	−4.441422	0.095	0.012161	0.065	0.0027774	0.618
Kobe	−4.691421	0.117	0.0034541	0.614	−0.0064597	0.325
Hiroshima	4.058578	0.225	0.0061583	0.394	0.0148015	0.141
Kitakyuushuu	−5.79142	0.076	0.0122467	0.137	0.0263081	0.548
Fukuoka	−2.991421	0.350	0.0009681	0.883	−0.0053403	0.376
Constant	34.46885	0.000	0.0437944	0.030	0.1028622	0.005
Sample size	28		26		26	
F statistics	10.81		2.53		2.60	
p-Value for F statistics	0.0001		0.0639		0.0537	
R^2	0.8357		0.4622		0.4548	

Note: Coefficients for 2002/2003 season indicate the structural difference of it from 2001/2002 season keeping constant all other aspects. Positive coefficient means that the average is larger in 2002/2003 season than in 2001/2002 season if the situation which is represented by figure of explanatory variables are the same in both season.

vious study. That is, the study based on the conjoint analysis which is the most reliable technique with hypothetical questionnaire indicates −0.02 to −0.04 of the elasticity, and actual behavior in 2001/2002season indicates −0.1 of the elasticity [4]. Hence, the result in this paper shows that the shot rate is very elastic against price.

There may be mainly two reasons for these differences. Firstly, this study focus on the metropolitan and big cities and so it may bias toward extremely urban areas, whereas the previous studies cover the whole Japan. If the residents in the urban areas have higher price elasticity to vaccination than rural areas, our results here may be reasonable. In this sense, the previous studies seem to be more general than this research.

Conversely, the data in this paper covers all residents in an area, while the previous study relied on survey by mail and it did not cover all the residents, of course, and they may not be representative. If the respondents of the questionnaire tend to have inclination toward to vaccination for influenza compared with non-respondents, shot rate may be insensitive to price. In this sense, the result in this study seems to be more reliable than the previous one. Though, it is not sure which estimate and reasoning is more reasonable, we have to remind that our final goal, namely the analysis with the BCR, is independent of price elasticity of shot as explained the before.

On the other hand, the shot rate elasticity of mortality rate is −2.48 and, thus, mortality is elastic against shot rate. Combining with these two estimation results, if copayment would be cut by a thousand yen (US$ 8), it raises shot rate by 7% points and reduce the mortality rate due to pneumonia and influenza by 0.029% point. It seems very small number, but since the average mortality rate due to pneumonia and influenza is very small, the effect certainly is quite high. In fact, this means that this policy can reduce about 423 death in an average big city.

Since F statistics in the first equation is higher than 10, the fitted variables seems to be good instrument [5]. In other words, the reason of insignificance of shot rate in the crude weighted least square can be inferred as positive simultaneous bias, which offsets the shot rate effect on the mortality. Therefore, the instrument variable can solve this bias and it is more appropriate method for this problem.

5.2. Evaluation for BCR

The obtained BCR, 22.4, is quite high compared with the other countries or other vaccinations. In some other countries, since it is 1.93 [6] for children before school and 1.81 [7] or 2.92 [8] for healthy adults, the obtained IBCR is much higher. Comparing with the other diseases, it is 2.5 [9] in measles in Japan and it is just 1.4 [10] in the case of hepatitis B for all infants in Chinese where epidemic area. Overall, the policy of subsidy to the elderly's shot is quite cost-effective and it has concrete evidence for it.

5.3. Problem and limitation in this analysis

At first, there are some differences in the definition of population among areas for the policy targeting or/and for the shot rate calculation. Especially, this policy also subsidize the non-elderly, i.e. between 60 and 64 years old, who has heart, kidney and respiratory problem or HIV career. Moreover, each city sometimes extend targeting population more than the national policy requirement. Typically, some cities subsidize the institutionalized elderly even if they are younger than 65. These additional target populations are included in the denominator in some cities, but are not in other cities. The subsidized number in the numerator of shot rate include, such additional targeting populations and, thus, the shot rate may be different whether the denominator include such additional targeting populations or not. However, these additional targeting population is quite small compared with the elderly, and it is less than just one percentage. Therefore, such an inconsistency in the denominator of shot rate may not affect substantially on the result.

Moreover, the starting dates of subsidy are not the same among areas. In particular, it is remarkable in the first season of this policy, i.e. 2001/2002 season. Our data of shot rate only include those who received the subsidy, and does not include those who did not receive subsidy but shot. So shot rate may be lower than the actual rate in the area where subsidy was delayed to start. In this sense, data of shot rate is always lower than the actual shot rate among the elderly. This measurement error may leads upper bias of the estimated coefficient of shot rate in the second estimation. Hence, it also lead upper bias in IBCR. However, it is not sure how many elderly receive shot but are not subsidized and so we cannot evaluate this effect in detail.

On the other hand, it is questionable that our sample in the metropolitan and big cities represent whole Japan. The coverage of the elderly population in our data is 21% of whole Japan, but it may not be the average population. Especially, there may be big differences from those in the rural areas as mentioned before. So as to check the robustness of the obtained result, we should extend our analysis to the other areas.

Additionally, the effect of influenza epidemic on the mortality is measured by excess mortality which is defined by the difference between the actual number of death and the hypothetical one if there is no influenza epidemic [11–14]. Therefore, we have to replace the mortality definition from crude number of death to the excess mortality. In particular, excess death should be defined regardless of the cause of death [14] because it is very well known that influenza epidemic raises the mortality from the other causes than pneumonia or influenza and these deaths can be prevented by the vaccination and control of the influenza epidemic. Moreover, if we can limit the number of death to those of more than 65 years old, it would be more precise measure. In this sense, excess mortality of more than 65 years old in all death causes is the best measure to evaluate the vaccination effect.

At the same time, we also need more explanatory variables which affect shot rate or mortality. For example, hortative measure for vaccination may be much different among local governments and it may affect the shot rate. Even in this case, if such a measure did not change in an area in the two seasons, this effect can be controlled out by the area dummies completely and it does not affect the estimated coefficient.

On the other hand, there are many implicit assumptions in BCR. First of all, since we limit the effect of vaccination to the prevention of the mortality and, thus, it is certainly finer measurement than the prevention of the severe conditions like hospitalization as emphasized. Since it is difficult to obtain the data of the number of patients and the hospitalized, these numbers would be based on the similar estimation. Hence, these are far less precise than the number of death. In other words, we choose preciseness than broadness in the definition of effectiveness. Obviously, this limitation lower BCR. If we take the effects of vaccination on the number of patients and the hospitalized into consideration, BCR definitely become higher than that in this paper. It strengthens our conclusion in favor of the subsidy and has never change it.

Conversely, the ignorance of opportunity cost for vaccination or side effects certainly rise BCR. However, almost all of them are retired and suffered from chronic disease and, thus, they usually visit a doctor, their additional opportunity cost for vaccination seems to be small. Concerning side effects, on 28 August 2003, Ministry of health and welfare reported only 2 fatal cases and 18 severe side effects from 1998 to 2003. Therefore, we can safely ignore these costs and the obtained conclusion is probably not affected by the introduction of these costs.

Finally, we can extend the effectiveness of vaccination to the number of patients or the medical cost. The data limitation of these variables are already mentioned. Moreover, since the primary purpose of vaccination is the prevention of severe cases, if we extend to these aspects, the results may not be clear and BCR may decline. In extreme case, the fatal case may use less medical resources compared with the severe but survival case. In this sense, the limitation of effectiveness on the number of death seems to be more appropriate for considering the vaccination policy. Nevertheless, the research of the number of patients and medical cost are unambiguously important and we need to overcome the data limitation.

6. Conclusion

We find subsidy of influenza vaccination for the elderly greatly reduce mortality rate due to pneumonia and influenza. Since BCR is more than 20, we can conclude that there is strong evidence, in a sense of cost–benefit analysis, supporting the subsidy for influenza vaccination among the elderly.

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3-3）Hibワクチン導入の医療経済学

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緒　言

インフルエンザ菌b型（以下，Hib）は，乳幼児にとってもっとも危険な細菌である。乳幼児は通常Hibに対する抗体を持たないため，Hibが鼻咽頭に存在すると，何らかのきっかけから菌血症を起こし，細菌性髄膜炎や，急性喉頭蓋炎，肺炎

Symposium：3-3）An Estimation of Disease Burden Due to Hib.
Yasushi Ohkusa et al

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といった重篤な感染症が引き起こされる。菌血症の段階では，症状は発熱のみであるため，通常の感冒と区別することはできず，早期発見は困難である。わが国においては過去に Hib の感染症は少なかったが，近年は Hib による重症感染症が増加しつつある。Hib ワクチンの導入は，日本の小児医療における緊急課題であると考えられる。そこで，Hib による疾病負担を計算し，ここに報告する。

方　法

疾病負担は，患者数と患者一人あたりの平均疾病負担から構成されるが，前者は文献から Hib の発生数，またその合併症，重篤症例，転帰等を推測する。また，後者は医療費と機会費用に分けられる。医療費の情報は，Hib の主要な病態である細菌性髄膜炎，菌血症，急性喉頭蓋炎，肺炎ごとに算出する。また，合併症，重篤化症例，転帰の別で必要となるので，その治療に当たった医療機関での事例を用いる。協力医療機関は 4 病院（病床規模でそれぞれ 380，320，177，550 床），3 診療所である。

機会費用は大きく分けて，死亡や後遺症によって QALY を失うことによる費用と，患者の看病に当たる保護者の機会費用に分けられる。軽快した場合には，患者本人の罹患中の QOL の低下は，乳幼児でもあり特に考慮しない。

QALY を金銭評価するにあたり，1 QALY 当たり 600 万円とする。また，家族看護者の一日当たり機会費用を，女性パートの時間給に相当する 4940.558 円とする。また，後遺症例の QALY を重症例で 0.2，軽症例で 0.8 とし，平均余命を 80 年とする。

結　果

1）細菌性髄膜炎

文献的には，Hib による細菌性髄膜炎の発症率はそれぞれ 4 歳以下人口 10 万対 4～10，5，5～10 とされているので，出生コーホートを 120 万人として 240～600 人の患者が発生していると推測される。予後は死亡率 1.6～5%，後遺症例 15～20 %，後遺症のうち 5～50% は重症で寝たきりの神経障害，50～95% は軽症では難聴，てんかんとされている。細菌性髄膜炎の死亡と後遺症による機会費用は 58～720 億円である。また家族看護に関する機会費用は，その入院期間を 3 週間，入院前と退院後の各 1 週間は家族看護を必要とするとすると，入院に関する家族看護の機会費用が 0.4 ～1.1 億円，後遺症の場合には 80 年間かかり，12 ～175 億円である。つまり，家族看護の機会費用は 12～176 億円となる。他方で，医療費は 1 病院における 2 例の事例から，軽症例で 50 万円，重症例で 120 万円とすると，医療費は合計で 1.8～7.3 億円になる。医療と機会費用の合計である細菌性髄膜炎の疾病負担は 72～903 億円となる.

2）菌血症

患者数は，Hib による細菌性髄膜炎の 4 倍程度とすると，患者数は 960～2400 人と推測される。菌血症だけで終われば死亡，後遺症はないので，本人の機会費用は発生しない。通院日数 4 日程度，家族看護が必要な期間は 9 日とすると，その家族看護の機会費用は，0.4～1.1 億円になる。他方で，医療費は 3 診療所における 3 例の事例から，1 件あたり 2 万円とすると，医療費の総額は 0.2～0.5 億円である。両者の合計である 0.6～1.6 億円が，菌血症の疾病負担となる。

3）急性喉頭蓋炎

患者数は，Hib による細菌性髄膜炎の 1.5 程度とすると，48～120 人と推定される。死亡率を 10 %，後遺症も 10% 程度とすると，死亡が 4.8～12 例，後遺症が 4.8～12 例発生している。後遺症における QOL を半分とすると，本人の機会費用は死亡例で 23～58 億円，後遺症の場合に 12～29 億円となる。入院日数は 10 日程度，入院前と退院後の各 1 週間は家族看護を必要とすると，家族看護の機会費用は 0.05～0.12 億円となる。他方，医療費は 1 病院における 1 例の事例とすると，医療費総額は 0.14～0.36 億円となる。両者の合計であ