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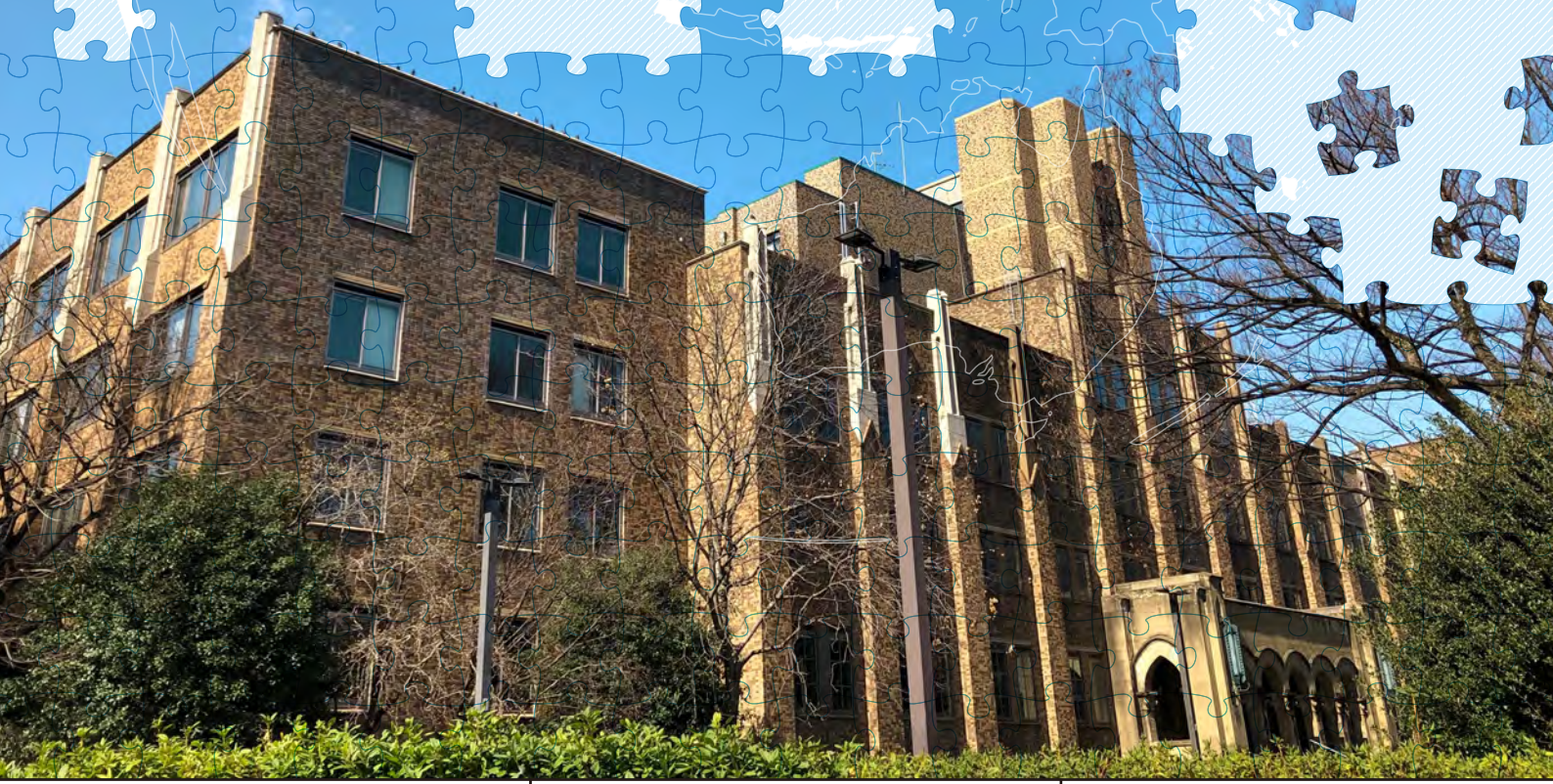
Measuring the Demand for Medical Access Improvement Policy via a Randomized Conjoint Field Experiment in Remote and Aging Municipalities in Japan



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SDGs 3 GOOD HEALTH AND WELL-BEING, 10 REDUCED INEQUALITIES

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Measuring the Demand for Medical Access Improvement Policy via a Randomized Conjoint Field Experiment in Remote and Aging Municipalities in Japan*

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Abstract

Improved transportation plays a vital role in increasing the accessibility of medical services, especially in remote and aging municipalities. In this study, we identify the attributes that are crucial for improving access to medical services in such municipalities in Japan, namely, Shinhidaka and Urakawa in Hokkaido. Via a randomized conjoint field experiment, we identify individuals' preferences regarding the duration and mode of transportation to hospitals that can provide high-level medical services, along with their willingness to pay to support these services as a welfare measure of the medical access improvement policy. We find, inter alia, that respondents have the strongest preference for reducing emergency ambulance transportation time to high-function hospitals. We also estimate that the respondents are willing to pay at least JPY 60 thousand (approximately USD 500) in additional taxes to the municipal government per year to sustain the policy.

Keywords: Hokkaido, medical services, transportation, conjoint experiment

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1 Introduction

Aging is an acute issue, especially in remote municipalities in Japan. The Cabinet Office of Japan reports that the aging ratio (ratio of the population 65 years or older to the total population) was 28.8 percent nationwide in 2020 and is forecasted to increase to 42.8 percent by 2045 in Hokkaido. Aging municipalities have an immediate need to improve the availability of medical services for emergencies, such as brain strokes and cardiovascular symptoms, and for more chronic medical needs, such as cancer treatment. However, many of these municipalities do not possess sufficient medical capacity, while their remoteness simultaneously inhibits their residents' ability to access hospitals with the necessary capacity, which are typically long distances away.

This study thus quantitatively identifies residents' need for improved access to medical services in the most remote municipalities with the highest levels of aging in Japan. Via a randomized conjoint field experiment in these municipalities, we find, inter alia, that respondents have the highest demand for reducing ambulance transportation time to high-capacity hospitals in the case of emergencies. We also estimate the minimum average willingness to pay for these services and find that respondents are willing to pay at least an additional JPY 5,000 in taxes to the municipal government per month to reduce emergency transportation time to high-function hospitals.

The study area includes two municipalities in Hokkaido Prefecture, namely, Shinhidaka and Urakawa (see Figure 1). Both are small towns that are aging and depopulated, with populations of only approximately 20 thousand or less. These towns do not have high-function hospitals that can provide high-level medical services such as emergency care for brain strokes, cardiovascular symptoms, or cancer, resulting in the need for residents to travel to larger cities such as Sapporo or Tomakomai, which are approximately 100 km or more away.[1] Emergency transportation time from Shinhidaka to Tomakomai by ambulance is over one hour, and it is approximately two hours from Urakawa to Tomakomai. Unless the patient is found and transported soon after the onset of symptoms, the chances of survival are very low. For more chronic diseases, residents must also commute to large cities. However, the commuting time from Shinhidaka to Sapporo by public transportation is approximately three hours one way, and from Urakawa, it is approximately four hours. This challenge gives rise to the need for a policy to improve access to high-function hospitals for these remote municipalities.

Emergency medical services play a crucial role in saving people's lives. There is growing research interest in ways to improve access to emergency medical services. Brotcorne et al. (2003) reviewed the problem of ambulance location and relocation by categorizing the available models into deterministic, probabilistic, and dynamic models. Ueno et al. (2019) compared patients with brain stroke who were transported from rural areas in Japan via a physician-staffed helicopter with those who were transported via a ground-based emergency ambulance and found that emergency helicopter services reduce transport time for the rural population in Japan.

Discrete choice experiments are the typical methodology used in the literature on access to medical services. Hanson et al. (2005) applied a discrete choice experiment to identify patient preferences for hospital quality in Zambia. They stated that the quality of the medical examination, the behavior of the hospital staff, and the availability of drugs are the most important attributes for patients. Pavlova

[1] Sapporo is the capital of Hokkaido Prefecture, and its population is approximately two million. Tomakomai's population is approximately 170 thousand.

Figure 1: The two municipalities, Urakawa and Shinhidaka in the study area

et al. (2004) used rating conjoint analysis to explore the importance of quality, access, and price among Bulgarian healthcare users. They found that compared to the quality of the medical services, travel time was less salient. However, a short travel time was significantly positively associated with the choice of hospital. Van de Schoot et al. (2017) conducted a discrete choice experiment with 1,003 Bulgarian medical services users and found that quality-related attributes were more important to them than waiting and travel times. Older patients tend to prefer shorter travel times and hospitals in closer proximity (Tai et al., 2004).

De Guzman et al. (2014) used a conjoint survey to identify the preferences of elderly people in the Philippines regarding their health service-seeking behavior. They found that the attribute valued most highly by respondents is doctor experience. Jan et al. (2000) also conducted a conjoint analysis to understand the preferences of South Australian people regarding hospital services. They found that attributes such as wait times for treatment in the emergency room, wait times for surgery, and parking and transport facilities negatively influenced hospital choice. However, they found no significant results for travel time to the hospital. Jens and Stausberg (2007) conducted a conjoint analysis in Germany and found that distance to the hospital is the single most important factor that patients consider when choosing a hospital.

Pavel et al. (2015) estimated patients' willingness to pay (WTP) for improvements to the healthcare attributes of hospitals in Bangladesh by using contingent valuation. They found that one of the most important attributes is a close doctor–patient relationship. However, patients living far from a hospital are willing to pay more than those living in closer proximity to hospitals to improve the attribute of geographical proximity.

The above studies utilized conventional stated preference approaches. In this research, drawing on Hainmueller et al. (2014), we employ a randomized conjoint field experiment to construct a primary data

set of 1,332 observations. A randomized conjoint experiment measures the probability that respondents accept a policy with respect to different levels of the policy's attributes. In a randomized conjoint experiment, respondents face a choice set consisting of two alternative hypothetical policy packages and must make a simple binary choice. Each choice set is created by randomizing the levels of the attributes every time the set is presented, which guarantees orthogonality. This process also allows the same respondent to face multiple choice sets.[2] These features of a randomized conjoint experiment yield robust results despite it being a stated preferences approach (c.f., Hainmueller et al., 2015.)[3]

This paper is organized as follows. Section 2 presents the empirical strategy, including the survey design and data, as well as the estimation methods. Section 3 discusses the estimation results and the lower bound on the average WTP. Finally, Section 4 concludes the paper.

2 Empirical Strategy

As mentioned above, the survey was conducted in two municipalities: Urakawa and Shinhidaka in Hokkaido Prefecture, Japan. Urakawa is a town of 12 thousand people, and the population of Shinhidaka is approximately 21 thousand. Between the two municipalities, 136 respondents were surveyed, of whom 78 live in Urakawa and 58 live in Shinhidaka.[4]

The survey questionnaire has two parts. The first part consists of demographic information such as age, gender, and questions related to current access to medical services. The second part of the survey is the randomized conjoint experiment, where we asked each respondent five questions . In each question, two hypothetical policies are presented to the respondent. This gave us a total of 1,360 ($= 136 \times 5 \times 2$) observations; however, six respondents did not answer all five questions. Therefore, the total number of observations was reduced to 1,332.

Demographic data

Table 1 shows basic demographic information for the survey respondents, i.e., the gender and age of the respondents in each town. Figures 2 through 5 summarize the current access to medical services in these towns. Figure 2 presents the departments in those hospitals that the respondents visit regularly.[5] While the department with the largest share of regular visits is general internal medicine, there is considerable variation in which departments the respondents visit, as shown in Figure 3. Approximately 31 percent of respondents visit hospitals in Tomakomai or Sapporo for higher-level medical services, while the majority commute to a more local hospital. Figure 4 shows the frequency of hospital visits. The great majority of respondents visit hospitals at least once a year, while approximately 42 percent visit once a month or more frequently. Figure 5 shows the mode of transportation taken for hospital visits. A slight majority of respondents commutes by private cars that they drive themselves, though this includes those who commute to local hospitals for minor symptoms.

[2] We use robust standard errors clustered at the respondent level in the estimation.

[3] Hainmueller, Hangartner, and Yamamoto (2015) confirmed the validity of this method as reflecting real-life behavior. This approach is essentially nonparametric and thus free from model specification problems as well (see, for example, Hensher and Greene, 2003.)

[4] Convenience (or snowball) sampling was used.

[5] The numbers in the figure are answer frequencies, and as multiple answers are allowed, they do not sum to the total number of respondents.

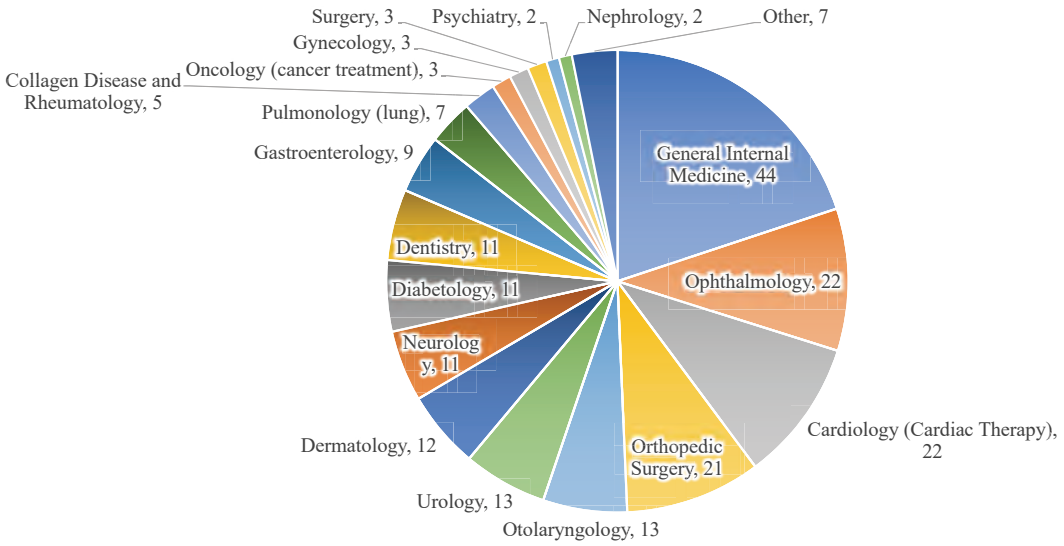

Figure 2: Departments in hospitals that the respondents in each town regularly visit.

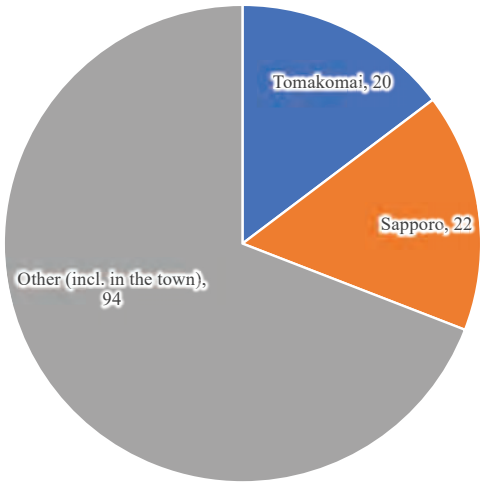

Figure 3: Locations of hospitals that respondents visit regularly.

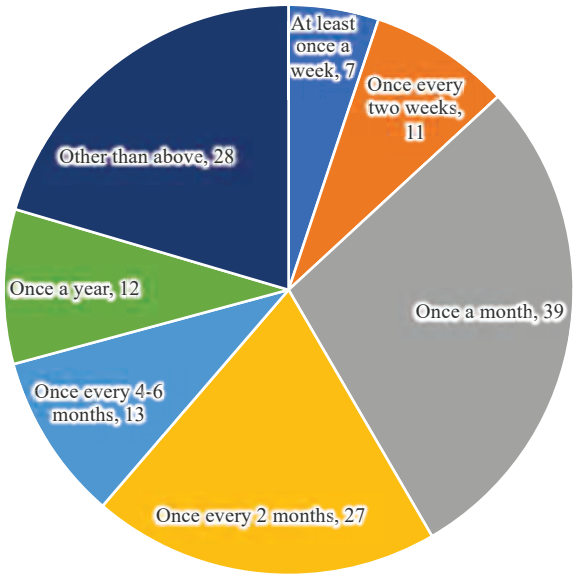

Figure 4: Frequency of hospital visits.

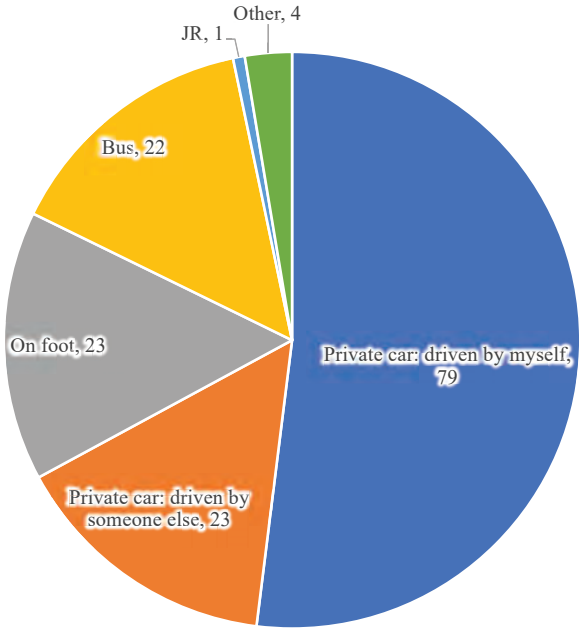

Figure 5: Mode of transportation taken to hospital visits.
Note: JR stands for Japan Railway, a public railway corporation in Hokkaido.

Table 1: Demographic data: Gender and age of the respondents in each municipality.

Variable	*Category*	Urakawa	Shinhidaka	*All*
Sex	Male	32.1	32.8	32.4
	Female	67.9	65.5	66.9
Age	0-20	2.6	1.7	2.2
	21-30	3.8	0.0	2.2
	31-40	10.3	5.2	8.1
	41-50	10.3	5.2	8.1
	51-60	9.0	10.3	9.6
	61-70	25.6	17.2	22.1
	71-80	26.9	39.7	32.4
	81-90	9.0	19.0	13.2
N. Obs.		78	58	136

Notes: Numbers represent percentages within each town. The numbers do not sum to one due to missing observations.

Experimental design

The randomized conjoint experiment in the second part of the survey first provides respondents with the following background information on the survey.

> A high-function hospital is a hospital that has specialized doctors who can provide advanced treatment for difficult diseases such as brain diseases, heart diseases, and cancer. In case of emergency, these hospitals treat all sudden illnesses 24 hours a day, including the three main areas of hematemesis/bleeding in digestive organs, neurosurgery for strokes, and heart attack (cardiac arrest). Currently, many patients are transported to Tomakomai over the course of two hours (more than three hours in the case of Urakawa) because local hospitals are not able to cope with their needs.
>
> There are no facilities in town that provide walk-in medical services for treating chronic diseases such as cancer. Currently, it takes approximately three hours (or four to five hours in the case of Urakawa) to travel to a major hospital in Tomakomai or Sapporo by public transportation.
>
> A "low-functioning" hospital is a hospital located in town. It provides only primary care, such as treatment for colds or minor stomachaches, or more regular medical treatment for issues such as hypertension, diabetes, etc.

Then, the survey proceeds to the choice task experiment. Each respondent faces five choice tasks, one at a time. In each choice task, the respondent sees a choice set. Each choice set contains two alternative hypothetical policies, along with the outside option of maintaining the status quo. The respondent is first asked to rank the two alternative policies and then to rank each of the two policies against the status quo. The former ranking or preference is referred to as the *internal* choice, and the latter is the *external* choice.

In our randomized conjoint experiment, each hypothetical policy consists of five attributes. Each attribute has multiple levels, as shown in Table 2, and a hypothetical policy is constructed by randomly selecting a level for each attribute each time that it is presented to the respondent.

The first attribute concerns travel time to a hospital with an emergency room by ambulance. This attribute has three levels: “no change,” “approximately 1 hour,” and “less than 30 minutes.” The current

Table 2: Attributes and their levels

Attribute	*Level*
(1) Emergency transport time to a high-function hospital by ambulance	***Level* 1:** No change
	***Level* 2:** Approximately 1 hour
	***Level* 3:** Less than 30 minutes
(2) Public transportation travel time to a high-function hospital for walk-in medical services	***Level* 1:** No change
	***Level* 2:** Approximately 2 hours one way
	***Level* 3:** Approximately 1 hour one way
	***Level* 4:** A high-function hospital is established in town
(3) Availability of a free direct bus service to the high-function hospital	***Level* 1:** Not available
	***Level* 2:** Available with departures from your neighborhood
(4) Availability of a free circular bus service to the in-town low-functioning hospital	***Level* 1:** Not available
	***Level* 2:** Available with departures from your neighborhood
(5) Additional tax payment to the municipal government per person	***Level* 1:** 1,000 JPY/month (approximately $100 annually)
	***Level* 2:** 2,000 JPY/month (approximately $200 annually)
	***Level* 3:** 4,000 JPY/month (approximately $400 annually)
	***Level* 4:** 8,000 JPY/month (approximately $800 annually)

Table 3: Sample choice set faced by a respondent in the choice task

	Alternative A	***Alternative B***	***Staus quo***
Additional tax payment to the municipal government per person	2,000 JPY/month	4,000 JPY/month	(none)
Emergency transport time to a high-function hospital by ambulance	about 1 hour	no change	(no change)
Commuting time to a high-function hospital for walk-in medical service by public transportation	about 2 hours one-way	about 1 hour one-way	(no change)
Availability of a free circular bus service to the in-town low-function hospital	not available	not available	(not available)
Availability of a free direct bus service to the high-function hospital	available from your neighborhood	not available	(not available)

ambulance transportation time to a high-function hospital in Tomakomai for an emergency is over one hour from Shinhidaka and is approximately two hours from Urakawa.

The second attribute concerns the commuting time to a high-function hospital for walk-in medical services via public transportation and has four levels: "no change," "approximately 2 hours," "approximately 1 hour," and "a high-function hospital is established in town." The current commuting time to a high-function hospital in Sapporo is approximately three hours from Shinhidaka, and it is approximately four hours from Urakawa.

The third attribute concerns the availability of a free direct bus service to a high-function hospital, which is currently not available. This attribute has just two levels, namely, "not available" and "available with departures from your neighborhood."

The fourth attribute concerns the availability of a free within-town Circular bus service to the small in-town hospital, which provides primary care only. This service is currently not provided. This attribute also has only two levels, namely, "not available" and "available with departures from your neighborhood."

Finally, the fifth attribute is the cost burden to maintain the policy in the form of additional tax payments to the municipal government. There are four levels associated with this attribute: 1,000 JPY, 2,000 JPY, 4,000 JPY, and 8,000 JPY per month per person, which are approximately \$100, \$200, \$400, \$800 per annum, respectively.[6]

Table 3 shows a sample choice set that a respondent may face in the choice task. Not only the levels of the attributes but also the order of attributes are randomized for each respondent in order to avoid any potential bias due to the order of attribute presentation. The respondents indicate their preferences between alternatives A and B as well as for each of alternative relative to the status quo.[7] Each respondent repeats this choice task five times, with a different choice set generated randomly for each choice task.

[6]Figures are based on an exchange rate of 1 USD = 120 JPY.

[7]We elicit these preferences simply by asking respondents to rank the three alternatives.

Estimation method

We estimate respondents' preference for the community medical system following Hainmueller et al. (2014). Their design allows us to identify respondents' policy acceptance probability with respect to each of the abovementioned attribute levels, which we call the average marginal component effect (AMCE.) AMCEs are estimated for both internal and external choices. Specifically, the following regression model yields the AMCEs:

$$y_{itj}^k = \beta_0^k + \sum_{l=1}^{5}\sum_{d=2}^{D_l} \beta_{ld}^k z_{itjld} + u_{itj}^k$$

where $y_{itj}^k \epsilon \{0,1\}$ is a choice indicator variable, β_{ld}^k indicates the AMCEs of attribute l and its level d, z_{itjld} is a dummy variable for the dth level of an attribute l of alternative $j \in \{A,B\}$ in task t for respondent i, D_l is the number of levels of attribute l, and u_{itj}^k is the error term for $k = \{internal, external\}$. For $k = internal$, the choice indicator variable y_{itj}^k takes on a value of 1 if alternative j in task t for respondent i is preferred over the other alternative $\tilde{j} \neq j$, $j, \tilde{j} \in \{A,B\}$. For $k = external$, the choice indicator variable y_{itj}^k takes on a value of 1 if the alternative j in task t for respondent i is preferred over the status quo. AMCE β_{ld}^k therefore captures the marginal effect of the level d of attribute l on the respondents' policy acceptance probability.

Lower bound on the average willingness to pay

Finally, we conduct a welfare analysis to measure the potential benefit of introducing a policy to improve access to medical services in terms of additional tax payments to the municipal government. We can compute the lower bound on the respondents' average WTP for each policy that we propose by using the estimation results regarding the external choice probabilities. Here, we let $f(X|\boldsymbol{a})$ be the density of people whose WTP for the policy, of which all attribute values except that of the payment attribute are given by a vector $\boldsymbol{a}$, is equal to X. Then, the average WTP is simply $\int_0^\infty x f(x|\boldsymbol{a})\, dx$.[8] Let $F(X|\boldsymbol{a})$ be the cumulative density such that $F(X|\boldsymbol{a}) = \int_0^X f(x|\boldsymbol{a})\, dx$ with $F(0|\boldsymbol{a}) = 0$ for all $\boldsymbol{a}$. Let us denote as $q(X, \boldsymbol{a})$ the external choice probability for a policy with payment X and other attributes $\boldsymbol{a}$. Then, we have

$$F(X|\boldsymbol{a}) = 1 - q(X, \boldsymbol{a}).$$

From the estimation results for $q(X, \boldsymbol{a})$, we know the piecewise distribution of the cumulative marginal WTP distribution $F(X)$ at the payment values indicated in the four levels of the payment attribute. Representing these four payment levels as X_1 through X_4, we have

$$\int_0^\infty x f(x|\boldsymbol{a})\, dx \geq \sum_{i=0}^{4} X_i \left[F(X_{i+1}) - F(X_i)\right]$$

[8] We assume that the willingness to pay is nonnegative, as the proposed policy is an improvement relative to the status quo for all possible combinations of policy attributes $\boldsymbol{a}$ in our experiment.

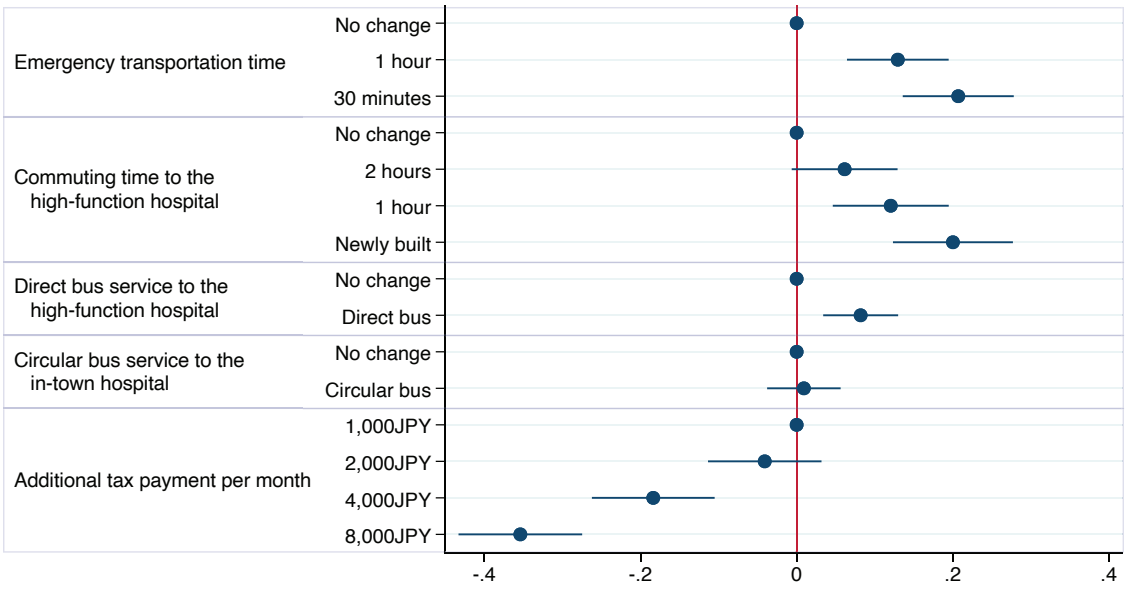

Figure 6: Average marginal component effects (AMCEs) on internal choice probabilities

where $X_0 = 0$, and $X_5 = \infty$. The right-hand side of the above equation gives the lower bound on the average WTP for the policy.

3 Results and Interpretations

The AMCEs of the attribute levels on the external and internal choice probabilities are presented in Figures 6 and 7, respectively. The left side of the figures shows the five attributes mentioned above and their levels. A solid circle shows the point estimate of the AMCE, or the marginal effect of the level of each attribute on respondents' policy acceptance probability, and the horizontal bar indicates its 95 percent confidence interval.[9]

Internal choice probabilities

The internal choice probabilities show which alternative policy in the choice set respondents more strongly prefer, absent the status quo. The internal choice probability results in Figure 6 show the respondents' preferences for (i) a reduction in emergency transportation time, (ii) a reduction in commuting time (via public transportation) to high-function hospitals to one hour or less by building a facility in town, (iii) the provision of a free direct bus service to high-function hospitals, (iv) and an in-town circular bus service to the local hospital.

The first attribute, namely, the reduction in emergency transportation time to a high-function hospital to one hour or 30 minutes, increases the probability of respondents choosing that policy by 12 percent or 20 percent, respectively, relative to the base level of "no change." However, the difference between the estimated coefficients on these two levels is statistically insignificant.

[9]Solid circles without whiskers indicate the baseline levels.

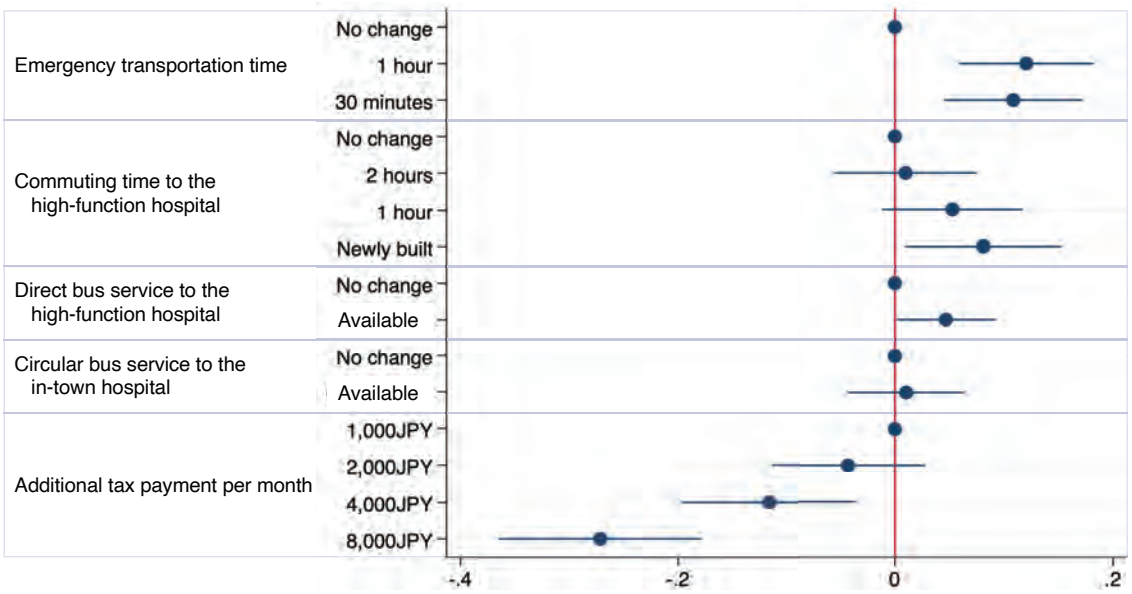

Figure 7: Average marginal component effects (AMCEs) on external choice probabilities

For the attribute "commuting time to the high-function hospital," the point estimate for level two, "2 hours," is positive but only weakly significant at the 10 percent level. However, level three, "1 hour," increases the respondents' internal choice probability by 12 percent, and level four, "a new hospital is built in town," increases the internal choice probability by 20 percent.

Regarding the attribute of a direct bus service to a high-function hospital, level two, i.e., "a direct bus service is available with departures from your neighborhood," increases the choice probability by 8 percent compared to the base level of "no change." For the corresponding attribute for transportation to the local hospital, respondents are indifferent between the status quo and the free-of-cost circular bus.

Finally, for the payment attribute, respondents prefer the two lowest payment levels of JPY 1,000 and 2,000; however, they are indifferent between paying JPY 1,000 and 2,000, as the point estimate for JPY 2,000 is statistically insignificant. The levels JPY 4,000 and 8,000 unambiguously decrease respondents' choice probability by 11 percent and 27 percent, respectively.

External choice probabilities

The external choice probability refers to the probability that a respondent chooses an alternative over the status quo. The external choice probability results in Figure 7 are similar to the internal choice probability results, except that a reduction in the commuting time to a high-function hospital down to one hour is not strictly preferred over the status quo.

As shown in the figure, the attribute of emergency transportation time again has a statistically significant effect on the external choice probability, as the levels "1 hour" and "30 minutes" increase respondent choice probabilities by approximately 10% over their probability of choosing the current situation. Regarding commuting times, respondents are indifferent among the first three levels, i.e., "no change," "2 hours," and "1 hour.," The point estimate for the level "1 hour" is positive but statistically

Table 4: Lower bounds on the WTP

	Lower bound on WTP
Overall	50,567
Emergency transportation time: 30 minutes	51,744
Commuting time to high-function hospital: Newly built within the town	60,150
Direct bus service to a high-function hospital is available	50,514
Circular bus service to in-town hospital is available	48,769

Notes: The numbers are in JPY and are reported per annum per person.

insignificant. However, the fourth level, "a new hospital is built in town," increases respondents' external choice probability by 8 percent, which is statistically significant at the 5 percent significance level. A direct bus service to a high-function hospital increases respondents' choice probability by 5 percent, which is significant at the 5 percent level; however, the magnitude is smaller than that in the internal choice estimation. Furthermore, the results indicate no significant difference in respondents' choice probabilities for the circular bus service to the in-town hospital.

The results for the payment attribute are similar to those regarding the internal choice probability, but the coefficient representing the external choice probability is slightly smaller. To summarize, respondents have the strongest preference for the lowest payment levels, namely, JPY 1,000 and 2,000, with AMCEs for the higher payment levels being strictly negative. Additionally, we calculate the minimum average WTP based on the coefficients indicating the external choice probability for the payment attribute. The resulting value is provided in the next section.

Lower bound on the average willingness to pay (WTP)

Table 4 gives the lower bounds on the average WTPs. The first row, labeled "overall," shows the *marginal* lower bound on the average WTP when all attribute levels except the payment attribute are included. This result indicates that the respondents are willing to pay at least 50,567 JPY per annum per person for the policy.

The second row reports the lower bound on the WTP when the level of emergency transportation time attribute is 30 minutes. This value is slightly higher than the overall WTP and shows that respondents are willing to pay at least 51.7 thousand yen for such a policy.

The lower bound on the average WTP reaches its highest value, 60.15 thousand JPY, to establish a high-function hospital in town. For the bus services, the minimum average WTP for both the direct bus to a high-function hospital and the circular bus to the in-town hospital is lower than the overall WTP, at 50,514 and 48,769 JPY, respectively. This finding indicates the potential benefit of establishing a high-function hospital in Urakawa and Shinhidaka.

4 Conclusion

Aging and the resulting need for improved access to medical services is an acute issue on the policy agenda, especially for remote municipalities, such as those in our study area, namely, Urakawa and Shinhidaka in Hokkaido, Japan. However, the remoteness of these municipalities limits the ability of their residents to access the necessary medical services provided by high-function hospitals, which are available only in

larger cities. In this study, we quantitatively identified resident demand for improved access to medical services from these remote municipalities. Via a randomized conjoint field experiment conducted in these towns, we found that respondents have a strong preference for reducing the emergency ambulance transportation time to high-function hospitals. We also estimated the minimum average willingness to pay for these services, and the results showed that respondents are willing to pay at least JPY 50 thousand per year in additional taxes to the municipal government for the proposed policy, especially to establish a high-function hospital in town. In that case, they are willing to pay as much as JPY 60 thousand in additional taxes per year. These results indicate the large potential benefit of improving access to medical services in these remote areas with an aging population.

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