Electronic Supplementary Material (ESI) for Environmental Science: Water Research & Technology.

Supplementary Information: Willingness to pay for nationwide wastewater surveillance system for infectious diseases in Japan

1 Supplementary Calculations and Explanations

1.1 Background

1.1.1 Budget of the proposed surveillance system ($33 million)

We estimated the annual budget to maintain the proposed nationwide wastewater surveillance system for infectious diseases in Japan, following a previous study.[1] Namely, the unit test costs were $607 and $1820 to measure (a) the viral density and (b) the proportions of the viral variants, respectively. The former test was assumed to be conducted twice a week for 50 weeks per year. The latter test was assumed to be implemented once a week for 25 weeks per year. Hence, the total annual cost per one site was estimated to be $0.106 million (= $607x2x50 + $1820x1x25). These wastewater tests were assumed to be performed at 286 wastewater treatment plants, covering 51 major cities (at least one major city in each prefecture) and Tokyo prefecture. Thus, the total test cost was approximately $30.38 million (=286 x $0.106 million). The additional cost to build and maintain the database system to integrate and publicly release the data was assumed to be $2.43 million. The grand total was estimated to be around $33 million per year.

1.2 Methods

1.2.1 Survey sampling method and detailed response rates

In our survey, at least one participant was obtained for each of three age categories (20-39, 40-59, > 59) and gender for all 47 prefectures. Based on the actual number of respondents for each prefecture and the response rates at the national level (as summarized in the table below), we calculated the sampling weights for each of 282 cells (3 age categories x 2 gender categories x 47 prefectures) that were used in our regression analyses.

Table S1. Survey response rates for age and gender categories

Age categories	Male	Female	Total
20-39	0.05348	0.06215	0.0572
40-59	0.07505	0.06238	0.0680
> = 60	0.06298	0.11779	0.0831
Total	0.0635	0.0790	0.0704

1.2.2 Comparison of the full sample characteristics with the national data

The table below indicates that the present study's full sample reasonably represent the national population in terms of age, income and education. For instance, compared to the national data, our full sample was slightly younger in mean and older in median. Additionally, the proportions of the age categories were quite comparable to the national sample. The mean and median income of our full sample was slightly higher than the national data. Educational attainment (2-year college or higher) was higher among the full sample than national data This could be partly because our study participants were required to complete the survey using a computer or mobile device and to understand a slightly complicated elicitation exercise and answering format. Also, this could be partly because the oldest subpopulation (with lower educational attainment) did not participate in our survey. For example, 95 and 99 percentiles in age of our full sample were 75.0 and 82.0 years old, respectively. These values were much lower than the corresponding values of 85.4 and 92.6 among the national data, respectively.

Table S2. Comparison of the present study's full sample with the national data in terms of age, income, and education

	The present study's full sample (N=2,538)	National data
Age (Mean and Median) among 20 years and over population[a]		
Mean	54.1	54.8
Median	56.0	53.6
95 percentile	75.0	85.4
99 percentile	82.0	92.6
The proportions of age categories[b]		
aged 20-39	23.4%	25.0%
aged 40-59	33.3%	33.2%
aged >59	43.4%	41.7%
Household income [million Japanese Yen][c]		
Mean	5.56	5.46
Median	4.50	4.23
Educational attainment: 2-year college or higher[d]	61%	45.4%

[a]The most recent national data was as of 2022[2]
[b]The most recent national data was as of 2023[3]
[c]The most recent national data was as of 2022[4]
[d]The most recent national data was as of 2022[5]

1.3 Results and Discussion

1.3.1 Association between age and WTP

Caution is needed to interpret the association between age and WTP since a quadratic term of age was also included in our regression models.
Given the regression was expressed below,

$$(\text{WTP}) = b_0 + b_1 (\text{age}) + b_2 (\text{age}^2) + b_3 (\text{all other covariates}) + (\text{error term}) \quad (1)$$

Age's incremental effect on WTP was mathematically expressed below by taking a differential of WTP with respect to age.

$$d(\text{WTP})/d(\text{age}) = b_1 + b_2 \times 2 \times (\text{age}) \quad (2)$$

The values in Table S3 below are calculated based on the estimated coefficients of the pooled regression for the main population reported in the manuscript's Table 4. That is, the point estimates of b_1 and b_2 in the equation above were (-)1.1 and 0.012, respectively. Age in this Table S3 ranged from 20 to 93, which was consistent with the age range among the corresponding main population.

Columns 3 and 6 of Table S3 indicate the effects of the two age-related variables on WTP. For instance, when age was 20, the value of column 3 was -17.20 (= (-)1.1 x 20 + 0.012 x (20^2) in equation (1) above). In columns 4 and 8 of Table S3, the age's incremental effects on WTP are presented. This incremental effect, from age 20 to age 21, was (-)$0.61 (= (age's effect on WTP at age 21) - (age's effect on WTP at age 20) = (-)$17.81) - (-)$17.20; shown in this Table). Thus, a one unit increase in age was associated with a "decrease" in WTP at age 20, i.e., a negative association between age and WTP.

However, this association changed to be positive when age was equal to or greater than 47, as shown in the shaded cell in Table S3. Namely, a one unit increase in age was associated with an increase in WTP by $0.02 at the age 47. Moreover, as columns 4 and 8 of Table S3 indicates, the magnitude of this increase in a WTP was estimated to be greater with the advancement in age. These estimates appear reasonable and align with the latest CDC clinical guideline stating that "age over 50 years" is the most important risk factor for severe outcomes of COVID-19, with risk increasing substantially at age ≥ 65 years.[6]

Table S3. Age's incremental effect on WTP, based on the estimated coefficients of the pooled regression for the main population reported in the manuscript's Table 4

1	2	3	4	5	6	7	8
age	age^2	age's effect on WTP[a]	age's incremental effect on WTP [b]	age	age^2	age's effect on WTP[a]	age's incremental effect on WTP [b]
20	400	-$17.20	-	57	3249	-$23.71	$0.26
21	441	-$17.81	-$0.61	58	3364	-$23.43	$0.28
22	484	-$18.39	-$0.58	59	3481	-$23.13	$0.30
23	529	-$18.95	-$0.56	60	3600	-$22.80	$0.33
24	576	-$19.49	-$0.54	61	3721	-$22.45	$0.35
25	625	-$20.00	-$0.51	62	3844	-$22.07	$0.38
26	676	-$20.49	-$0.49	63	3969	-$21.67	$0.40
27	729	-$20.95	-$0.46	64	4096	-$21.25	$0.42
28	784	-$21.39	-$0.44	65	4225	-$20.80	$0.45
29	841	-$21.81	-$0.42	66	4356	-$20.33	$0.47
30	900	-$22.20	-$0.39	67	4489	-$19.83	$0.50
31	961	-$22.57	-$0.37	68	4624	-$19.31	$0.52
32	1024	-$22.91	-$0.34	69	4761	-$18.77	$0.54
33	1089	-$23.23	-$0.32	70	4900	-$18.20	$0.57
34	1156	-$23.53	-$0.30	71	5041	-$17.61	$0.59
35	1225	-$23.80	-$0.27	72	5184	-$16.99	$0.62
36	1296	-$24.05	-$0.25	73	5329	-$16.35	$0.64
37	1369	-$24.27	-$0.22	74	5476	-$15.69	$0.66
38	1444	-$24.47	-$0.20	75	5625	-$15.00	$0.69
39	1521	-$24.65	-$0.18	76	5776	-$14.29	$0.71
40	1600	-$24.80	-$0.15	77	5929	-$13.55	$0.74
41	1681	-$24.93	-$0.13	78	6084	-$12.79	$0.76
42	1764	-$25.03	-$0.10	79	6241	-$12.01	$0.78
43	1849	-$25.11	-$0.08	80	6400	-$11.20	$0.81
44	1936	-$25.17	-$0.06	81	6561	-$10.37	$0.83
45	2025	-$25.20	-$0.03	82	6724	-$9.51	$0.86
46	2116	-$25.21	-$0.01	83	6889	-$8.63	$0.88
47	2209	-$25.19	$0.02	84	7056	-$7.73	$0.90
48	2304	-$25.15	$0.04	85	7225	-$6.80	$0.93
49	2401	-$25.09	$0.06	86	7396	-$5.85	$0.95
50	2500	-$25.00	$0.09	87	7569	-$4.87	$0.98
51	2601	-$24.89	$0.11	88	7744	-$3.87	$1.00
52	2704	-$24.75	$0.14	89	7921	-$2.85	$1.02
53	2809	-$24.59	$0.16	90	8100	-$1.80	$1.05
54	2916	-$24.41	$0.18	91	8281	-$0.73	$1.07
55	3025	-$24.20	$0.21	92	8464	$0.37	$1.10
56	3136	-$23.97	$0.23	93	8649	$1.49	$1.12

[a]The calculation method: (-)1.1 x (age) + 0.012 x (age^2), also expressed as the equation (1) above where the estimated coefficients are based on the pooled regression for the main population reported in the manuscript's Table 4.
[b]The calculation method: The change in the value in column (3), e.g., age's incremental effect from age 20 to age 21 = (-)$0.61 = (age's effect on WTP at age 21) - (age's effect on WTP at age 20) = (-)$17.81) - (-)$17.20

1.3.2 Budget for the wastewater surveillance at airports ($0.5 million)

We estimated the additional annual cost ($0.5 million) to expand the wastewater surveillance to four major international airports as follows. The annual cost per international airport followed the per-site cost of $0.106 million in Supplementary Information 1.1.1 above. We assumed one sampling site for each of four major airports in Japan, i.e., Tokyo, Narita, Kansai, and Chubu airports. Therefore, the total annual test cost was $0.424 million. To expand the nationwide database system to further include the data from airports was estimated to be around $0.07 million. Altogether, the total annual cost was estimated to be $0.5 million.

2 Survey questionnaire (modified questions in the study by Himmler *et al.*[7])

2.1 Introduction to the survey

For all local and prefecture governments, increasing the health safety of the residents is an important policy goal. Recent infectious outbreaks of the new coronavirus infectious disease (COVID-19), influenza, and other infectious diseases indicate that this policy goal cannot necessarily be achieved by a single local or prefecture government.

Conventional epidemiology information on infectious diseases is obtained by collecting the results of clinical antigen tests and clinical PCR tests for individual humans, which are aggregated at a regional level.

Triggered by the global epidemic of COVID-19, a new survey method called "wastewater surveillance " has been implemented at a large scale around the world. This new survey method can test and monitor the virus in wastewater, utilizing the shedding of viral RNA in feces and saliva by people infected with the new corona (SARS-CoV-2) virus or influenza virus, regardless of whether they are symptomatic or not.

Compared to conventional epidemiological surveys based on clinical antigen and PCR tests on individual humans, wastewater surveillance has three major advantages.

The first advantage is that wastewater surveillance can detect outbreaks of infectious diseases about a week earlier than conventional epidemiological surveys. As a result, medical institutions will have more time to secure sufficient medical resources such as (i) inpatient and ICU beds, (ii) ventilators, and (iii) medical staff.

The second advantage is that the results of wastewater surveillance are more representative than those of conventional epidemiological surveys. Conventional epidemiological surveys tend to underestimate an infection level when supply of clinical tests is limited or when many people avoid clinical tests. Even if you don't seek clinical antigen/PCR tests, you always use a restroom - so that wastewater surveillance can more accurately detect an infection level of an entire area.

The third advantage is that wastewater surveillance is less expensive and more cost-effective than conventional epidemiological surveys. For example, when a wastewater treatment plant covers 100,000 people, an objective indicator (e.g. increase or decrease in the number of infected people) that reflects the infection level of the entire area where these 100,000 people live will be obtained from wastewater surveillance (approximately 50,000 yen per test). In order to obtain the same indicator in conventional epidemiological surveys, clinical antigen/PCR tests need to be conducted among 100,000 people (assuming the cost per person is 2,000 yen, 200 million yen per 100,000 people).

In Japan, governments of Sapporo City [Link 1] and Kanagawa Prefecture [Link 2] have already been continuously conducting wastewater surveillance at wastewater treatment plants, monitoring SARS-CoV-2 and seasonal influenza viruses, and releasing the results to the public. However, at the national level, a very limited number of local governments conduct wastewater surveillance separately without any nationwide integrated system.

On the other hand, wastewater surveillance at treatment plants has been conducted at more than 1200 sites in the United States [Link 3]. Under the US nationwide integrated system, survey results are published and updated regularly. In the European Union (EU) [Link 4] member states, wastewater surveillance at treatment plants has been conducted at more than 1300 sites.

Note: In the paragraph above, clicking the underlined part will link to the URL below.
[Link 1]（NOTE: Click to https://www.city.sapporo.jp/gesui/surveillance.html）
[Link 2]（NOTE: Click to https://www.pref.kanagawa.jp/docs/ga4/covid19/simulation.html）
[Link 3]（NOTE: Click to https://covid.cdc.gov/covid-data-tracker/#wastewater-surveillance）
[Link 4]（NOTE: Click to https://environment.ec.europa.eu/news/coronavirus-response-monitoring-wastewater-contributes-tracking-coronavirus-and-variants-across-all-2022-03-17_en）

If such a nationwide integrated warning system based on wastewater surveillance is newly established in Japan, this system will enable us to respond more quickly to COVID-19 and other infectious diseases and help contain [Link 5] and mitigate [Link 6] outbreaks. Thus, this new nationwide wastewater surveillance system would help improve the health safety of residents.
This survey will ask how you would value the establishment and maintenance of this system.

Note: In the paragraph above, clicking the underlined part will link to a pop-up window including a definition below.
[Link 5] contain: control or restrain
[Link 6] mitigate: make something less severe or reduce its effects

Newly establishing this nationwide warning system has the three additional advantages explained hereafter:
The first additional advantage is that it notifies the warning level (high, medium, or low) of an ongoing epidemic based on wastewater surveillance results, which will be a useful criterion when you decide to (a) go out, (b) seek clinical antigen/PCR tests, and (c) seek an additional vaccination.

The second additional advantage is that it helps predict the longer term (more than a week) future epidemic level in your residential prefecture, using epidemic information based on wastewater surveillance from neighboring prefectures under the nationwide system.

The third additional advantage is that surveillance information demonstrating a low-level epidemic in your area would encourage people from outside your area to visit your area for the purpose of sightseeing, business, or returning home.

This survey consists of three parts and takes approximately 15 to 20 minutes to complete. Your responses will be collected anonymously by the research team. The survey results will be used for scientific research reports and policy implications. Participation in this survey is voluntary, and you are free to drop out of this survey at any time. If you drop out during the survey, all information provided up to that point will be discarded. There are no right or wrong answers in this survey. Therefore, your honest opinions are appreciated.

Please check the box below if you agree to participate in this survey and provide your anonymous answers for scientific research purposes.

2.2 Questions for awareness of outbreaks

[General interest]

- Whenever there is news about an emerging infectious outbreak, I follow it closely.

[General concern]

- I am more concerned about the risk of infectious outbreaks than about the risk of developing other diseases.
- Infectious outbreaks are a major public health concern.
- In case of an infectious outbreak in my prefecture, much harm will be caused to affected people.

[Severity of risk]

- I think there is a high risk of an infectious outbreak in my prefecture in the coming year.

[Susceptibility to risk]

- Compared to those around me, I feel more at risk of being affected by an infectious outbreak.

[Handling risk]

- In case of an emerging infectious disease in my prefecture, I would take all precautionary measures advised by the authorities.

[Protection from risk]

- In my prefecture, I generally feel protected against infectious outbreaks.

[Prevention of risk]

- By taking appropriate precautionary measures, the risk of infectious outbreaks can be lowered substantially.

[Origin of risk]

- Infectious outbreaks usually originate in other prefectures or countries; it is their responsibility to deal with them.

[Scope of risk]

- Infectious outbreaks do not only cause human suffering but also economic damage.
- Infectious outbreaks can affect everyone and, therefore, can be very disruptive for social life.

2.3 Two-stage willingness-to-pay approach

Currently, there is no nationwide warning system based on wastewater surveillance [Link 7] in order to help contain [Link 8] and mitigate [Link 9] COVID-19, influenza, and other infectious diseases. For example, ongoing fragmented warning systems in Japan focus on a specific type of disease or are operated by a single local or prefecture government.

Note: In the paragraph above, clicking the underlined part will link to a pop-up window including a more detailed explanation or definition below.

[Link 7] wastewater surveillance:

Compared to conventional epidemiological surveys based on antigen and PCR tests on individual humans, wastewater surveillance has three major advantages.

- The first advantage is that wastewater surveillance can detect outbreaks of infectious diseases about a week earlier than conventional epidemiological surveys. As a result, medical institutions will have more time to secure sufficient medical resources such as (i) inpatient and ICU beds, (ii) ventilators, and (iii) medical staff.
- The second advantage is that the results of wastewater surveillance are more representative than those of conventional epidemiological surveys. Conventional epidemiological surveys tend to underestimate an infection level when supply of clinical tests is limited or when many people avoid clinical tests. Even if you don't seek clinical antigen/PCR tests, you always use a restroom - so that wastewater surveillance can more accurately detect an infection level of an entire area.
- The third advantage is that wastewater surveillance is less expensive and more cost-effective than conventional epidemiological surveys. For example, when a wastewater treatment plant covers 100,000 people, an objective indicator (e.g. increase or decrease in the number of infected people) that reflects the infection level of the entire area where these 100,000 people live will be obtained from wastewater surveillance (approximately 50,000 yen per test). In order to obtain the same indicator in conventional epidemiological surveys, clinical antigen/PCR tests need to be conducted among 100,000 people (assuming the cost per person is 2,000 yen, 200 million yen per 100,000 people).

[Link 8] contain: control or restrain

[Link 9] mitigate: make something less severe or reduce its effects

If "the nationwide integrated warning system based on wastewater surveillance ("the warning system" hereafter)" [Link 10] is newly established in Japan, the proposed system will integrate information collected from all prefectures and, hence, enable us to respond more efficiently to infectious diseases due to viruses and bacteria. Moreover, this warning system is expected to help prevent damage (due to viruses and bacteria) to residents' health in every prefecture.

Note: In the paragraph above, clicking the underlined part will link to a pop-up window including a more detailed explanation or definition below.

[Link 10] nationwide integrated warning system based on wastewater surveillance ("the warning system"):

Newly establishing this nationwide warning system has three additional advantages explained hereafter:

- The first additional advantage is that it notifies the warning level (high, medium, or low) of an ongoing epidemic based on wastewater surveillance results, which will be a useful criterion when you decide to (a) go out, (b) seek clinical antigen/PCR tests, and (c) seek an additional vaccination.
- The second additional advantage is that it helps predict the longer term (more than a week) future epidemic level in your residential prefecture, using epidemic information based on wastewater surveillance from neighboring prefectures under the nationwide system.
- The third additional advantage is that surveillance information regarding a low-level epidemic in your area would encourage people from outside your area to visit your area for the purpose of sightseeing, business, or returning home.

Establishing and maintaining this warning system is not feasible without costs.
Thus, suppose that this warning system would be funded by taxation through a regular yearly installment, paid by all adults in your prefecture (over 20 years of age).

Note: Scenario description common to all three scenarios.
Suppose all residents in Japan face a 10% risk per year of becoming sick due to a viral infection. The risks, after you become infected and sick, include, on average, a 90% chance of being isolated for 10 days, a 9% chance of a hospital admission, and a 1% chance of death. These risks of hospitalizations and deaths are higher among older individuals and individuals with certain chronic diseases.

Note: Scenario description unique to Scenario 1.
Also, suppose that the infection risks due to SARS-CoV-2 and influenza viruses for you and people around you can be reduced from 10% to 8% through the proposed new nationwide integrated warning system based on wastewater surveillance.

<u>WTP question - lower interval:</u>
Suppose all adults in your prefecture, including you, would have to pay this annual installment tax starting now. Please consider the amounts on the scale below, ordered from low to high, and select the amount that <u>you would definitely be willing to pay</u> per year for establishing this integrated warning system. Please keep in mind your ability to pay (your net yearly household income) and think of other insurance premiums (e.g., health insurance, life insurance, auto insurance, home/liability insurance) you currently pay. For your reference, $0.22 covers the

Japanese government’s current system to monitor earthquake/tsunami (not including the earthquake mediating infrastructure cost, just the monitoring system), and $55 covers one dose of COVID-19 vaccination which was financed by the Japanese government.

$0	$0.11	$0.22	$0.33	$0.55	$1.1	$2.2	$3.3	$5.5	$11	$22	$33	$55	$110	$165	$220	More than $220

NOTE: If “More than $220” is chosen by a respondent, the follow-up question below will pop-up.
You have indicated that the maximum amount you would be willing to pay for the warning system is more than $200.
Please indicate exactly how much you are willing to pay, specifying the value that is more than $200 in the box below.

<u>WTP question - upper interval:</u>
Now consider the same amounts below, from low to high, and select the amount that <u>you would definitely not be willing to pay</u> per year for establishing this warning system. This amount would be a taxation paid by all adults in your prefecture. Please keep in mind your ability to pay (your net yearly household income) and think of other insurance premiums (e.g., health insurance, life insurance, auto insurance, home/liability insurance) you currently pay. For your reference, $0.22 covers the Japanese government’s current system to monitor earthquake/tsunami (not including the earthquake mediating infrastructure cost, just the monitoring system), and $55 covers one dose of COVID-19 vaccination which was financed by the Japanese government.

$0	$0.11	$0.22	$0.33	$0.55	$1.1	$2.2	$3.3	$5.5	$11	$22	$33	$55	$110	$165	$220	More than $220

NOTE: If “More than $220” is chosen by a respondent, the follow-up question below will pop-up.
You have indicated that the maximum amount you would be willing to pay for the warning system is more than $200.
Please indicate exactly how much you are willing to pay, specifying the value that is more than $200 in the box below.

<u>WTP question - open-ended question:</u>
You have indicated that <u>you would definitely pay $11</u> (*NOTE: Example of the value chosen by the respondent earlier*) and that <u>you would definitely not pay $22</u> (*NOTE: Example of the value chosen by the respondent earlier*) for the new system. Please indicate in the box below the amount between $11 and $22 that is closest to the maximum that you would be willing to pay per year. This amount would be a taxation paid by all adults in your prefecture. Please keep in mind your ability to pay (your net yearly household income) and think of other insurance premiums (e.g., health insurance, life insurance, auto insurance, home/liability insurance) you currently pay.

NOTE: If “$0” is chosen by a respondent, the follow-up question below will pop-up.
<u>WTP question - Zero WTP:</u>
You have indicated that the maximum amount you would be willing to pay to establish and maintain the warning system is $0.
Please indicate the reason for your response among the options below.

(1) The nationwide integrated warning system is not worth more than $0 to me.
(2) I am unable to pay more than $0.
(3) The current government budget should be reallocated to cover this system.
(4) Other reason (please specify)

3 Supplementary Tables

Table S4. Descriptive statistics among three populations

	Full sample (N=2,538)	Main Population[a] (N= 2,457)	Secondary Population[b] (N= 1,870)	Comparison of variables among two populations		
	Mean (SD)	Mean (SD)	Mean (SD)	Full sample vs. Main population	Full sample vs. Secondary population	Main vs. Secondary population
Annual household income [1000 US Dollars]	61.32 (44.01)	61.63 (44.24)	61.53 (44.13)	***		
Age	54.07 (14.92)	54.15 (14.97)	54.27 (14.63)			
Female[c]	0.50 (0.50)	0.51 (0.50)	0.51 (0.50)			
2-year college or higher educational attainment[c]	0.61 (0.49)	0.61 (0.49)	0.61 (0.49)			
Married[c]	0.59 (0.49)	0.59 (0.49)	0.59 (0.49)			
Employed, excluding self-employed[c]	0.60 (0.49)	0.60 (0.49)	0.59 (0.49)			
Self-employed[c]	0.09 (0.28)	0.09 (0.28)	0.10 (0.30)		**	**
Not employed[c]	0.40 (0.49)	0.40 (0.49)	0.41 (0.49)			
Health status[c,d]	0.16 (0.37)	0.16 (0.37)	0.17 (0.37)	***		***
Awareness of outbreaks[e]	43.02 (6.09)	43.05 (6.06)	43.08 (5.93)			
No COVID-19 infection experience for oneself or family[c]	0.68 (0.47)	0.68 (0.47)	0.69 (0.46)		**	**
COVID-19 infection experience for oneself[c]	0.06 (0.23)	0.06 (0.23)	0.05 (0.22)		***	***
COVID-19 infection experience both for oneself and family[c]	0.17 (0.37)	0.17 (0.37)	0.16 (0.36)		**	**
Ever smoking status[c]	0.35 (0.48)	0.35 (0.48)	0.34 (0.48)	**	*	
Mortality rate of COVID-19 [per million in a resident prefecture]	580 (160)	578 (159)	578 (158)	**		
WTP order[f]	0.51 (0.50)	0.51 (0.50)	0.51 (0.50)			

SD, standard deviation.
[a]Main population excluded outliers (defined as WTP exceeding 5% of annual income (N = 1)) and all individuals with at least one protest zero in any of 3 scenarios (protest zeros) from the full sample.
[b]Secondary population further excluded those who responded with at least one pair of "irrational WTP magnitude order" from the main population. "Irrational WTP magnitude order" was defined as either "WTP for scenario 1 > WTP for scenario 2," "WTP for scenario 1 > WTP for scenario 3," or "WTP for scenario 2 > WTP for scenario 3." Three scenarios varied in terms of the effectiveness of the proposed surveillance system: Mortality will decline from 10% to 8%, 5%, and 2% under Scenario 1, 2, and 3, respectively.
[c]Dichotomous variable.
[d]Best or second-best level of subjective general health status among 5 levels
[e]Awareness of outbreaks, scored from 12 to 60, 12 questions with 5 levels
[f]WTP order: 1 if WTP values presented from high-to-low in a survey; 0 if WTP values presented from low-to-high in a survey.

Table S5. Lower and upper intervals of the first stage of the WTP exercise [US dollars]

Category	Mean (SD)	Median	N
Full sample: Lower interval[a]	9.61 (18.76)	2.24	7,614
Full sample: Upper interval[b]	25.25 (35.73)	7.47	7,614
Main Population: Lower interval[a]	9.85 (18.76)	3.74	7,371
Main Population: Upper interval[b]	26.00 (35.91)	7.47	7,371
Secondary population: Lower interval[a]	9.52 (18.26)	3.74	5,610
Secondary population: Upper interval[b]	25.00 (35.00)	7.47	5,610

WTP, willingness to pay; SD, standard deviation.
[a]Lower interval: "definitely be willing to pay"
[b]Upper interval: "definitely not willing to pay"

Table S6. WTP per year in US dollars for 3 sample populations with different orders of WTP values in questionnaire

Category	Mean (SD)	Median	Min	Max	N
Full sample	22.95 (44.41)	7.72	0.00	1104	7,614
-order: from high-to-low	28.72 (53.97)	11.04	0.00	1104	3,855
-order: from low-to-high	19.82 (39.16)	5.52	0.00	552	3,759
Main Population	23.47 (44.29)	8.83	0.00	1104	7,371
-order: from high-to-low	29.62 (54.51)	11.04	0.00	1104	3,729
-order: from low-to-high	20.12 (37.95)	5.52	0.00	497	3,642
Secondary population	20.48 (42.11)	6.62	0.00	1104	5,610
-order: from high-to-low	28.76 (56.66)	11.04	0.00	1104	2,838
-order: from low-to-high	19.47 (37.99)	5.52	0.00	497	2,772

WTP, willingness to pay; SD, standard deviation.

Table S7. "Warm up" exercise of WTP for an umbrella [US dollars]

Category	Mean (SD)	Median	Min	Max	N
Full sample	21.84 (47.24)	11.04	0.00	1324	7,614
-order: from high-to-low	25.70 (55.31)	13.24			3,855
-order: from low-to-high	17.89 (36.78)	8.83			3,759
Main Population	22.19 (47.89)	11.04	0.00	1324	7,371
-order: from high-to-low	26.14 (56.13)	13.24			3,729
-order: from low-to-high	18.14 (37.19)	9.82			3,642
Secondary population	20.06 (44.14)	11.04	0.00	1324	5,610
-order: from high-to-low	23.16 (52.84)	11.04			2,838
-order: from low-to-high	16.89 (32.62)	8.83			2,772

WTP, willingness to pay; SD, standard deviation.

Table S8. Pooled regressions on WTP for three populations

Category	Full sample		Main population[a]		Secondary population[b]	
	Coefficient (SD)	p value	Coefficient (SD)	p value	Coefficient (SD)	p value
Log income	14.36 (2.83)	***	15.44 (2.81)	***	17.28 (3.38)	***
Age	-1.07 (0.41)	***	-1.10 (0.41)	***	-1.13 (0.51)	**
Age-squared	0.012 (0.004)	***	0.012 (0.004)	***	0.013 (0.005)	***
Female	-4.05 (2.12)	*	-3.96 (2.13)	*	-2.38 (2.47)	
Education 2 yr college or higher	3.58 (1.66)	**	3.81 (1.69)	**	4.15 (1.93)	**
Married	-0.91 (2.03)		-0.63 (2.08)		-1.77 (2.48)	
Sel-employed	-3.57 (2.78)		-3.48 (2.85)		-2.91 (3.15)	
Not-employed	-2.69 (2.00)		-2.90 (2.00)		-2.74 (2.34)	
Health status[c]	3.85 (3.89)		3.68 (4.06)		6.10 (4.92)	
Awareness 2nd quart.[d]	-1.19 (2.57)		-1.59 (2.72)		-1.35 (3.33)	
Awareness 3rd quart.[d]	8.01 (3.00)	***	7.67 (3.15)	**	8.58 (3.78)	**
Awareness 4th quart.[d]	13.60 (3.16)	***	12.85 (3.22)	***	12.49 (3.95)	***
No COVID-19 infection experience	-2.21 (2.03)		-2.30 (2.08)		-1.22 (2.49)	
Mortality rate of COVID-19 [per million in a resident prefecture]	0.004 (0.009)		0.003 (0.009)		0.005 (0.011)	
Smoke ever	0.13 (2.34)		0.03 (2.39)		-1.37 (2.88)	***
Scenario 1[e]	-0.99 (0.37)	***	-1.14 (0.36)	***	-3.47 (0.30)	***
Scenario 3[e]	2.13 (0.42)	***	2.12 (0.43)	***	4.076 (0.468)	***
WTP order[f]	8.24 (1.75)	***	8.78 (1.78)	***	8.56 (2.13)	***
Constant	-31.22 (19.4)		-34.92 (20.1)	*	-47.19 (25.2)	*
Observations	7,614		7,371		5,610	
R-squared	0.0517		0.0549		0.0569	
Root MSE	46.31		46.09		47.37	

WTP, willingness to pay; SD, standard deviation.

[a]Main population excluded outliers (defined as WTP exceeding 5% of annual income (N = 1)) and all individuals with at least one protest zero in any of 3 scenarios (protest zeros) from the full sample.

[b]Secondary population further excluded those who responded with at least one pair of "irrational WTP magnitude order" from the main population. "Irrational WTP magnitude order" was defined as either "WTP for scenario 1 > WTP for scenario 2," "WTP for scenario 1 > WTP for scenario 3," or "WTP for scenario 2 > WTP for scenario 3." Three scenarios varied in terms of the effectiveness of the proposed surveillance system: Mortality will decline from 10% to 8%, 5%, and 2% under Scenario 1, 2, (reference category in this regression) and 3, respectively.

***: p < .01; **: p < .05; *: p < .1

[c]Best or second-best level of subjective general health status among 5 levels

[d]Awareness 2nd/3rd/4th quart.: 2nd, 3rd, and 4th quartile of the awareness of outbreaks, scored from 12 to 60 based on 12 questions with 5 levels.

[e]The three scenarios varied in terms of the effectiveness of the proposed surveillance system: Mortality will decline from 10% to 8%, 5%, and 2% under Scenario 1, 2 (reference category in this regression), and 3, respectively.

[f]WTP order: 1 if WTP values presented from high-to-low in a survey; 0 if WTP values presented from low-to-high in a survey.

References

1. B. K. Yoo, R. Iwamoto, U. Chung, T. Sasaki and M. Kitajima, Economic Evaluation of City-level Warning Systems Based on Surveillance at Wastewater Treatment Plants to Recommend Optimal Clinical COVID-19 Screening Tests at Facilities, Japan, in peer review.
2. Statistics of Japan, Population by Age (Single Years), Sex and Sex ratio - Total population, Japanese population, October 1, 2022 [in Japanese], https://www.e-stat.go.jp/stat-search/files?page=1&layout=datalist&toukei=00200524&tstat=000000090001&cycle=7&year=20220&month=0&tclass1=000001011679&tclass2val=0, (accessed January 17, 2024).
3. Statistics of Japan, Population Estimates by Age (Five-Year Groups) and Sex - July 1, 2023 (Final estimates), December 1, 2023(Provisional estimates), https://www.e-stat.go.jp/en/stat-search/files?page=1&layout=datalist&toukei=00200524&tstat=000000090001&cycle=1&year=20230&month=24101212&tclass1=000001011678&tclass2val=0, (accessed December 30, 2023).
4. Ministry of Health, Labour and Welfare and Japan, Comprehensive Survey of Living Conditions: Overview on the 2022 survey results *[in Japanese]*, https://www.mhlw.go.jp/toukei/saikin/hw/k-tyosa/k-tyosa22/index.html, (accessed 4 January, 2024).
5. Ministry of Internal Affairs and Communications, Employment status survey 2022 [in Japanese], https://www.e-stat.go.jp/stat-search/files?page=1&layout=datalist&toukei=00200532&tstat=000001163626&cycle=0&tclass1=000001163627&tclass2=000001163628&tclass3val=0, (accessed January 4, 2024).
6. Centers for Disease Control and Prevention (CDC), Interim Clinical Considerations for COVID-19 Treatment and Pre-exposure Prophylaxis in Outpatients, https://www.cdc.gov/coronavirus/2019-ncov/hcp/clinical-care/outpatient-treatment-overview.html, (accessed May 19, 2024).
7. S. Himmler, J. van Exel, M. Perry-Duxbury and W. Brouwer, Willingness to pay for an early warning system for infectious diseases, *Eur J Health Econ*, 2020, **21**, 763-773.