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Gender Differences of the Effect of Vaccination on Perceptions of COVID-19 and Mental Health in Japan

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Abstract: Vaccination has been promoted to mitigate the spread of the coronavirus disease 2019 (COVID-19). Vaccination is expected to reduce the probability of and alleviate the seriousness of COVID-19 infection. Accordingly, this might significantly change an individual's subjective well-being and mental health. We observed the same individuals on a monthly basis from March 2020 to September 2021 in all parts of Japan. Then, large sample panel data (N = 54,007) were independently constructed. Using the data, we compared the individuals' perceptions of COVID-19, subjective well-being, and mental health before and after vaccination. Furthermore, we compared the effect of vaccination on the perceptions of COVID-19 and mental health for females and males. We used the fixed-effects model to control for individual time-invariant characteristics. The major findings were as follows: First, the vaccinated people perceived the probability of getting infected and the seriousness of COVID-19 to be lower than before vaccination. This was observed not only when we used the whole sample but also when we used subsamples of males and a subsample of females. Second, subjective well-being and mental health improved. The same results were also observed using the subsample of females, whereas the improvements were not observed when using a subsample of males. This implies that females' quality of life was more likely to be improved by vaccination than males' one. The novelty of the work is to show the gender difference in the vaccination effects.

Keywords: vaccination; COVID-19; subjective well-being; mental health; Japan; panel data

Citation: Yamamura, E.; Kohsaka, Y.; Tsutsui, Y.; Ohtake, F. Gender Differences of the Effect of Vaccination on Perceptions of COVID-19 and Mental Health in Japan. *Vaccines* **2023**, *11*, 822. https://doi.org/10.3390/vaccines11040822

Academic Editor: Don E. Albrecht

Received: 7 February 2023
Revised: 19 March 2023
Accepted: 4 April 2023
Published: 10 April 2023

1. Introduction

Vaccination against the coronavirus disease 2019 (COVID-19) is anticipated to play a critical role in mitigating the spread of COVID-19. Many newly reported cases of COVID-19 have been reduced in countries where vaccines have become rapidly pervasive [1]. Through scientific experiments, the COVID-19 vaccine reduced the probability of infection and the seriousness of COVID-19. The sufficient rate of vaccinated population in society must reach herd immunity to terminate the COVID-19 pandemic (Randolph and Barreiro, 2020). However, some individuals hesitate to receive the COVID-19 vaccine [1–7]. Their attitude may change if they know that vaccinated people have a more positive view of the vaccination after receiving the vaccine. Therefore, our research question is to examine how and the extent to which the subjective views about the effectiveness of the COVID-19 vaccine change after one gets vaccinated. The goal of this study is to provide the policy implication to promote vaccination.

The vaccination reduced the risk of being infected with COVID-19 and the predicted seriousness of the condition of a patient even if he/she is infected with COVID-19. Therefore, we propose the hypothesis that vaccinated people perceive a lower probability of infection than before vaccination. Accordingly, vaccination improves his/her subjective well-being and mental health. To test the hypothesis, we used regression analysis. Using

monthly individual-level panel data, we investigated how vaccinated people change their perceptions of COVID-19, subjective well-being, and mental health in Japan. The dependent variables are the subjective probability of getting COVID-19, subjective well-being, and measures for a mental health condition. The key independent variable is the dummy variable of being vaccinated. Consistent with the hypothesis, the independent variable showed a positive sign and statistical significance. However, the expected results were not obtained using a subsample of males when mental health was a dependent variable.

From the estimation results, we argue that (1) vaccinated people perceived a lower probability of infection than before vaccination and that (2) vaccinated females improved their subjective well-being and mental health, whereas vaccinated males did not change their subjective well-being and mental health. Therefore, providing information about the effect of vaccination on female mental health improvement may increase their motivation to be vaccinated.

Various measures against COVID-19, such as lockdown restrictions, cause significant economic loss [8,9] and exert a detrimental impact on individuals' mental health [10–13]. In Japan, even without enforcement, individuals voluntarily exhibit preventive behaviors, such as staying indoors and avoiding face-to-face conversations [14–16]. Accordingly, this changed lifestyle, for instance, lack of exercise and short sleep duration, results in declining mental health [14,17,18]. Vaccination is anticipated to reduce the probability of contracting COVID-19; thus, vaccinated individuals can return to normal daily life. This return to normal daily life improves subjective well-being and mental health, so vaccination for people with mental illness is necessary [19–22].

It is found that more than half population suffered from depression or distress directly after the appearance of COVID-19 [23]. The mental conditions of vaccinated individuals improved in the United States [24–26], the United Kindom [27], and India [28]. Meanwhile, other studies found no correlation between vaccination and mental health in the United States [29], in Sweden, and Peru [30]. However, hesitancy to be vaccinated was observed in various countries [5,31–33]. This has hampered the establishment of herd immunity and increased social costs caused by COVID-19. Furthermore, 23% of medical students were hesitant to receive the vaccination, although they were more likely to trust information from health experts than from non-experts [34]. People who are more hesitant about vaccination are less likely to obtain information about COVID-19 from traditional and authoritative sources and have similar levels of mistrust in these sources than those who accepted the vaccine [33]. Information provision is crucial to ensure trust in scientific evidence and to form norms to take collective action to mitigate the pandemic [35–38]. Therefore, researchers have studied what kind of messages, information, education, and social campaigns regarding vaccination reduce hesitancy [39,40]. To reduce hesitancy, it may be effective to provide information about the subjective evaluation of the effectiveness of the vaccine, subjective well-being, and mental health.

It is worth analyzing the influence of vaccination on vaccinated people's perceptions of COVID-19, subjective well-being, and mental health. Furthermore, the impact of unexpected shocks, such as COVID-19, differs between males and females [17,41–43]. To illustrate, the Japanese government's calling for preventive behaviors is less effective for men [16]. Therefore, males are less likely to change their lifestyles [41]. However, compared with males, females were less likely to be hesitant to receive the COVID-19 vaccine [33,40]. That is, women are more sensitive to COVID-19 vaccine hesitancy. These results are consistent with the argument that males are more likely to be overconfident than females [44]. Hence, examining gender differences in the effect of vaccination on perceptions and mental health is valuable.

2. Materials and Methods

2.1. Data Collection

The research company INTAGE, which has sufficient experience in academic research, was commissioned to conduct an internet survey for this study. Individuals registered

with INTAGE were recruited as participants in our project. The sampling method was designed to collect a representative sample of the Japanese population in terms of gender, age, and residential area. However, we restricted Japanese citizens aged 16–79 for the survey because other people were difficult to recruit.

INTAGE conducted internet surveys repeatedly for 15 separate cases almost every month with the same individuals to construct the panel data. However, in the exceptional period between July 2020 and September 2020, the surveys could not be conducted because of a shortage of research funds. The surveys were resumed after receiving additional funds in October 2020.

The first survey of queries was conducted in the early stage of COVID-19 from 13 March to 16 March 2020. We aimed to collect around 4000 respondents, distributed to 7965, and collected 4359 observations with a response rate of 54.7%. Respondents from the first survey were targeted in subsequent surveys to record how the same respondent changed their perceptions and behaviors during the COVID-19 pandemic. During the study period, until the 15th survey was conducted on 27 August 2021, although there were some attritions, the response rate exceeded 83% in any survey. Accordingly, the total number of observations used in this study was 54,007. In this study, we report results based on unbalanced panel data.

2.2. Ethical Considerations

Our study was performed according to the relevant guidelines and regulations. The ethics committee of Osaka University approved all survey procedures, and informed consent was obtained from all participants.

All survey participants provided their consent to participate in the anonymous online survey. After being informed about the purpose of the study and their right to quit the survey, participants agreed to participate. The completion of the entire questionnaire was considered to indicate the participants' consent.

2.3. Measurements

Table 1 presents a description of the variables and the mean difference test between men and women. The survey questionnaire included basic questions about demographics, such as age, gender, and educational background. As the main variables, the respondents were asked questions concerning perceptions about COVID-10 as follows:

> *According to you, what is the probability (%) of you getting infected with SARS-COV-2 within a month from now? "What percentage do you think is the probability of your contracting COVID-19? Choose a percentage from 0 to 100 (%)."*
>
> *"How serious are your symptoms if you are infected with the novel coronavirus?*
>
> *Choose from six choices: 1 (very small influence) to 6 (death)."*

The answers to the questions served as proxies for the subjective probability of contracting COVID-19 and their perceptions of the severity of COVID-19. Larger values indicated that respondents are more likely to perceive a higher risk of COVID-19. Further, as key variables to reflect subjective well-being and mental health, we also asked the following questions:

Concerning subjective well-being:

> *"How happy do you feel now?*
>
> *Please answer on a scale from 1 (very unhappy) to 11 (very happy)."*

Concerning mental health:

> *In the last two weeks, to what extent have you felt anger, fear, and anxiety? Please indicate from 1 (I have not felt the emotion in the slightest) to 5 (I have felt the emotion stronger than ever).*

Table 1. Definitions of key variables and their mean difference tests between males and females.

Variables	Definition	Male (1)	Female (2)	(2)–(1)
PROB_ COVID19	What percentage do you think is the probability of your getting COVID-19? 0 to 100 (%)	18.9	22.0	3.11 ***
SEVER_ COVID19	How serious are your symptoms if you are infected with the novel coronavirus? Choose from 6 choices: 1 (very small influence); 6 (death)	3.53	3.62	0.09 ***
HAPPYNESS	To what degree are you currently feeling happiness? Please answer on a scale from 1 (very unhappy) to 11 (very happy)	6.59	7.04	0.45 ***
FEAR	How much have you felt the emotion of fear? Please answer on a scale from 1 (I have not felt this emotion at all) to 5 (I have felt this emotion strongly).	2.94	3.20	0.25 ***
ANXIETY	How much have you felt the emotion of anxiety? Please answer on a scale from 1 (I have not felt this emotion at all) to 5 (I have felt this emotion strongly).	3.15	3.43	0.29 ***
ANGER	How much have you felt the emotion of anger? Please answer in a scale from 1 (I have not felt this emotion at all) to 5 (I have felt this emotion strongly).	2.94	3.03	0.09 ***
VACCINE FIRST	Did you take the first shot (but not yet the second one)? 1 (Yes) or 0 (No)	0.38	0.38	0.002
VACCINE SECOND	Did you take the second shot? 1 (Yes) or 0 (No)	0.06	0.06	0.001
VACCINE SECOND_1	1 if they took the second shot this month; 0 otherwise	0.03	0.03	0.0002
VACCINE SECOND_2	1 if they took the second shot the last month; 0 otherwise	0.02	0.02	0.001
VACCINE SECOND_3	1 if they took the second shot two months ago; 0 otherwise	0.006	0.006	−0.0003
VACCINE SECOND_4	1 if they took the second shot three months ago; 0 otherwise	0.001	0.001	0.00003

Note: *** $p < 0.01$.

Larger values indicated that the respondents' mental health was worse. Apart from subjective values, the important question was to ask the respondents whether they took the first shot of the vaccine against COVID-19 and whether they had completed the second shot after the 12th survey (28–31 May 2021). Using the data of the second shot, we also defined dummy variables, *VACCINE SECOND_1* to *VACCINE SECOND_4*, representing the time when they were vaccinated.

Table 1 suggests that the mean values of *PROB_COVID19* and *SEVER_COVID19* for females were significantly larger than for males. Hence, females are more likely to perceive COVID-19 as risky than males. Mean values of *HAPPYNESS*, *FEAR*, *ANXIETY*, and *ANGER* were significantly larger for women than for men. This implies that the happiness level in females was higher than that in males, even during the COVID-19 pandemic, whereas females' mental health was worse than that of males. The low level of female mental health is consistent with the observation that women's suicide rate increased after the spread of COVID-19 [40]. In contrast to subjective values, there were differences in the first vaccine and the second vaccine between men and women.

The Japanese government began vaccination in February 2021 [41]. During the early period of vaccination, the initial group receiving the shot was strictly restricted to health workers. Vaccination for general older people aged 65 and over has been implemented since April 2021. Accordingly, 75% of older people were vaccinated in July 2021 [42]. Subsequently, COVID-19 vaccination programs began at workplaces and campuses where workers and students received vaccinations in June [43].

In our project, we started asking about vaccines against SARS-CoV-2 during the period of 4–8 December 2020 (7th survey) when vaccination started worldwide. The question of which data were used in this study, asking whether respondents received their first and second shots, appeared from May 2021 when the 12th survey (28–31 May 2021) was conducted. At that time, the completed ratios of the first and second shots were 5.24% and 0.59% of the total nation, respectively. We created the dummy variables, *VACCINE SECOND_1* to *VACCINE SECOND_4*, to capture the timing of the second shot. Although their mean values may seem quite low, this is because we set the value of these variables before the 12th survey (28–31 May 2021) at zero, reflecting the reality in Japan. On 23 April 2021, as of the 11th survey (23–26 April 2021), the percentage of vaccinated individuals was 0.23% and 0.00% for the first and second shots, respectively.

To determine the change in the vaccination rate, Table 2 shows the percentages of vaccinated people in the whole sample, male sample, and female sample in each survey. Table 1 reports the aggregated values containing both the first and second shot vaccinated people, regardless of vaccination time point. Inevitably, the percentage of vaccinated individuals is expected to increase over time. In line with this inference, Table 2 shows that the percentage of vaccinated people rapidly increased from 8.2% in May 2021 to 64.2% in September in our sample. This rate is almost the same as that of 65.2% in September in a country-wide sample [44]. Thus, the data of this study reflect the actual situation in Japan. Further, a similar tendency was observed when we used a subsample of males and females.

Table 2. Percentage of those who took the COVID-19 vaccine.

Nubmer of Surveys	Dates	All %	Males %	Females %	First Shot %	Second Shot%
1	13–16 March 2020	0	0	0		
2	27–30 March 2020	0	0	0		
3	10–13 April 2020	0	0	0		
4	8–11 May 2020	0	0	0		
5	12–15 June, 2020	0	0	0		
6	23–28 October 2020	0	0	0		
7	4–8 December 2020	0	0	0		
8	15–19 January 2021	0	0	0		
9	17–22 February 2021	0	0	0		
10	24–29 March 2021	0	0	0		
11	23–26 April 2021	0.2	0.2	0.2	0.2	0
12	28–31 May 2021	8.2	8.2	8.2	5.2	0.6
13	25–30 June 2021	25.1	24.3	25.9	19.6	8.0
14	30 July–4 August 2021	50.0	48.5	51.4	39.5	26.9
15	27 August–1 September 2021	64.2	63.7	64.7	51.3	91.2

Note: We did not distinguish respondents who took only the first shot from those who took the second shot.

Figure 1 illustrates perceptions about COVID, such as *PROB_COVID19* and *SEVER_COVID19*, from the 1st to the 15th surveys (from 13–16 March 2020 to 27 August–1 September 2021) for vaccinated and non-vaccinated groups. In the Figure, the vaccinated group is defined as those who were vaccinated at any time point during our observation period. Further, the group includes both people who received the second shot and those who only received the first shot. For example, an individual who had their first shot in the 15th survey (27 August–1 September 2021) was included in the vaccinated group.

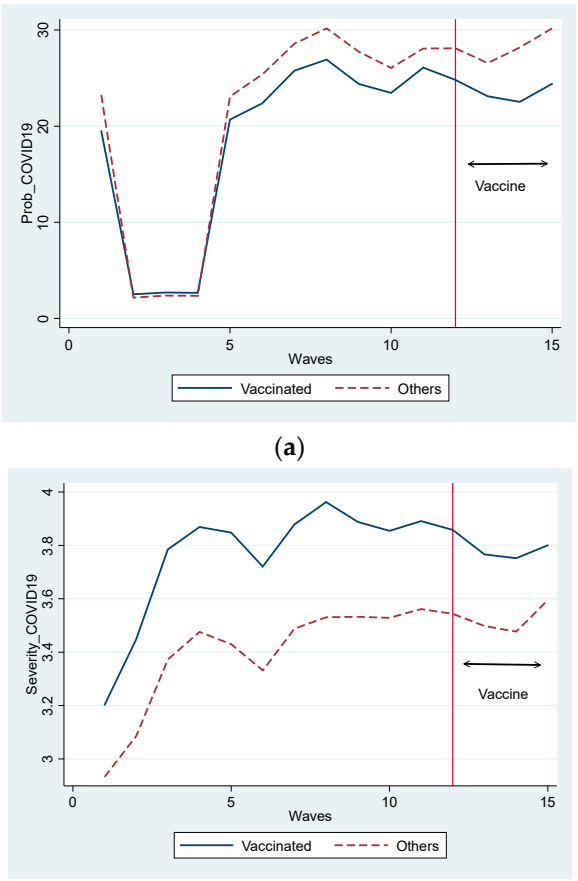

Figure 1. (**a**) Change of Probability of COVID-19. (**b**) Change of Severity of COVID-19.

Nobody was vaccinated before the 12th survey (28–31 May 2021), as shown in the left part of the vertical line in Figure 1. Figure 1 suggests how people who were not vaccinated behaved differently from vaccinated people in the period when the vaccine was not distributed.

Figure 1a indicates that the vaccinated group perceived the probability of getting COVID-19 to be lower than that of the non-vaccinated group, even before the distribution of the vaccine. The trends of both groups were similar. During the first declaration of a state of emergency in all parts of Japan from the third to fourth surveys (7 April–27 May 2020), the perceived probability drastically declined and remained at the lowest level. After the first declaration was terminated, its level increased to a level higher than that before the declaration. Later, its level did not remarkably change even though a state of emergency was declared and called off repeatedly four times. However, it should be noted that the gap between the groups increased after 2021 (the eighth survey during the period of 15–19 January 2021). Contrastingly, Figure 1b indicates that the subjective severity of COVID-19 was consistently higher in the vaccinated than in the non-vaccinated group. Even during the first declaration of a state of emergency, subjective severity increased drastically. After termination, the level of subjective severity was relatively stable. After the distribution of the vaccine, the gap between the groups was reduced. The only similarity between Figure 1a,b is that the levels of both variables increase in the non-vaccinated group.

In the panels in Figure 2, we illustrate *HAPPYNESS*, *FEAR*, *ANXIETY*, and *ANGER* in the same manner as in Figure 1. The *HAPPYNESS* level was consistently higher in the vaccinated than in the non-vaccinated group. During the first state of the emergency period, the level of *HAPPYNESS* declined, whereas it increased after its termination. There were cyclical changes throughout the period, although the amplitude of the changes was not large compared with the gap between the groups. After the initiation of the vaccine, the

happiness of the non-vaccinated people declined, whereas that of vaccinated people was stable. Hence, the gap in happiness levels between the groups widened.

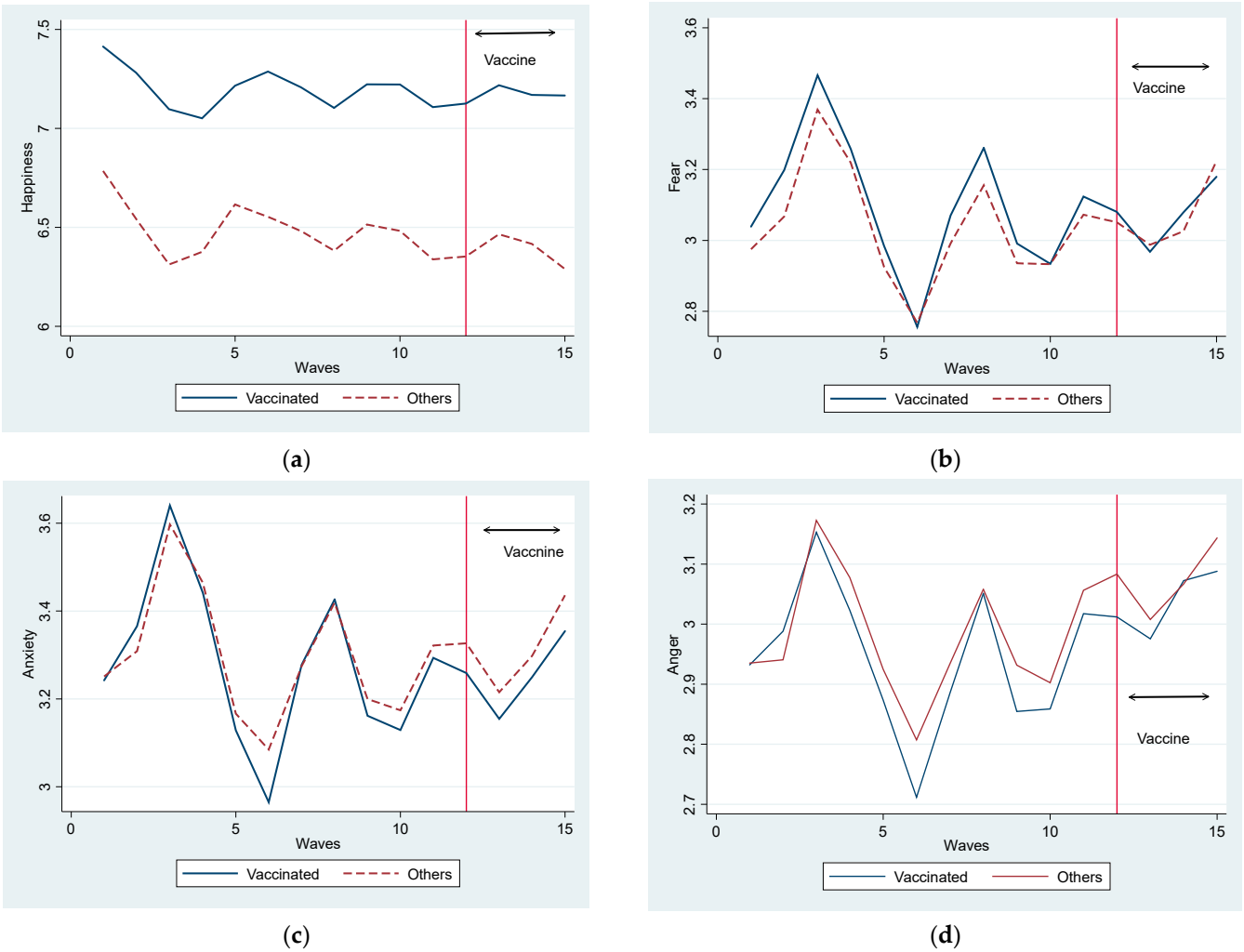

Figure 2. (**a**) Change in Happiness. (**b**) Change in Fear. (**c**) Change in Anxiety. (**d**) Change in Anger.

Regarding the three proxies for mental health, *FEAR*, *ANXIETY*, and *ANGER* changed similarly. These negative feelings increased drastically after entering the first state of emergency and dropped to the lowest level. Similar to *HAPPYNESS*, the three emotions showed cyclical changes. However, the gap between these three proxies did not show a remarkable systematic change.

Overall, as shown in Figures 1 and 2a, vaccination leads people to have more positive views. Meanwhile, in Figure 2b–d, we did not observe an apparent effect of vaccination before and after the distribution of the COVID-19 vaccine. However, these observations reflect changes in the mean values when various factors are not controlled. For a closer examination of the effects of vaccination, we examined the fixed-effects regression model.

2.4. Regression Model

In order to empirically test the hypothesis proposed in the introduction, the estimated model was specified. A fixed effects (FE) regression model was used to control the time-invariant individual characteristics. The estimated function took the following form:

$$\begin{aligned} Y_{it} = {} & \alpha_1 VACCINE\ FIRST_{it} + \alpha_2 VACCINE\ SECOND\_1_{it} \\ & + \alpha_3 VACCINE\ SECOND\_2_{it} + \alpha_4 VACCINE\ SECOND\_3_{it} \\ & + \alpha_5 VACCINE\ SECOND\_4_{it} + \alpha_6 EMERGENT_{it} + k_t + m_i \\ & + u_{it} \end{aligned}$$

In this formula, Y_{it} represents the dependent variable for individual i and number of surveys t. Seven dependent variables are included separately in different estimations. These dependent variables can be roughly classified into two groups. As a proxy for the perception of COVID-19, we used *PROB_COVID19* and *SEVER_COVID19*. As a proxy for mental health, *HAPPYNESS*, *FEAR*, *ANXIETY*, and *ANGER* were used. The regression parameters are denoted as α. The error term is denoted by u.

k_t represents the effects of different time points. This is controlled by including 14 survey dummy variables, where the first survey (13–16 March 2020) is taken as the reference group. Fourteen survey dummy variables captured various shocks that occurred simultaneously throughout Japan at each time point. For instance, a state of emergency was declared four times during the study period. The time-invariant individual-level fixed effects are represented by m_i. The FE model controls various individual characteristics that do not change over time. Therefore, the model controls for various time-invariant factors, including sex, birth year, and experiences in past personal history, such as the educational background.

Key independent variables were dummy variables for vaccination; *VACCINE FIRST* represents the effect of the first shot. The Japanese government approved only the Pfizer-BioNTech and the Moderna vaccines. The first vaccinated persons were obliged to take the second shot within a month to ensure the vaccine's effectiveness. This rule was applied to Pfizer, BioNTech, and Moderna vaccines. That is, the vaccine was effective enough for those who took only the first shot. Hence, we should scrutinize the effect of vaccination by considering the first and second shots separately. Further, it is noteworthy to investigate the effect of the vaccine on perceptions and mental health changes over time. To this end, we incorporated four dummy variables: *VACCINE SECOND_1*; *VACCINE SECOND_2*; *VACCINE SECOND_3*; and *VACCINE SECOND_4.*

Vaccination is expected to reduce the probability of contracting COVID-19 and its severity. Hence, the expected sign of the dummy variables for vaccination was negative for these variables. Moreover, vaccination is anticipated to improve negative emotions. Therefore, the coefficients of *FEAR*, *ANXIETY*, and *ANGER* were expected to show a negative sign, whereas *HAPPYNESS* was anticipated to exhibit a positive sign.

Concerning control variables, in Japan, declarations of a state of emergency significantly influenced individuals' behaviors [14,41]. The timing of the declarations varied according to the area where one resided. Therefore, the effect of the declaration could not be captured by survey dummy variables. Accordingly, we included *EMERGENT* to control this effect. We also controlled the following factors: the number of persons infected with COVID-19 and deaths caused by COVID-19 in residential areas at each time point, although their results were not reported due to space limits.

In addition to estimation using the whole sample, we report the estimates by dividing the sample according to the respondent's sex to compare the effect of vaccination between males and females.

3. Results

3.1. Full Sample Estimations

Tables 3 and 4 report the estimation results of the FE model using the entire sample. The model includes the number of deaths and infected persons in residential prefectures at the time of the surveys. However, these results have not been reported. We begin by interpreting the key vaccination dummy variables to capture the effects of the first vaccination, *VACCINE_FRIST*, and to capture the effects of the second vaccination and its duration effects, *VACCINE_SECOND_1*, *VACCINE_SECOND_2*, *VACCINE_SECOND_3*, and *VACCINE_SECOND_4*. Concerning the perceptions of COVID-19, in the estimation of *PROB_COVID19*, all vaccine dummy variables showed the expected negative sign with statistical significance at the 1% level. The absolute values of their coefficients were 1.25 for *VACCINE_FRIST*. This implies that respondents perceived that the probability of getting an infection was reduced by 1.25% directly after they got the first shot. The values for the second vaccination dummy variables were 4.37, 5.08, 4.98, and 4.82 for *VACCINE_SECOND_1*, *VACCINE_SECOND_2*, *VACCINE_SECOND_3*, and *VACCINE_SECOND_4*, respectively. In our interpretation, an individual's perceived probability was lower by 4.37% directly after the second shot than before the first shot. The effect of the second shot increased to 5.08% in the next month but slightly decreased to 4.98% after two months and then to 4.82% after three months. Overall, the effect of the second shot was about four times larger than that of the first shot and persisted over time. Estimations for *SEVER_COVID19* also showed similar results, although *VACCINE_SECOND_4* showed neither a negative sign nor statistical significance. This means that an individual's perception of the severity of COVID-19 returned to the level before vaccination after three months since they took the second shot. The absolute value of the coefficient of *VACCINE_FIRST* was 0.04, meaning that the perceived severity of COVID-19 decreased by 0.04 points on a five-point scale directly after they received the first shot. The values were 0.173, 0.181, and 0.142 for *VACCINE_SECOND_1*, *VACCINE_SECOND_2*, and *VACCINE_SECOND_3*, respectively. This can be interpreted as the perceived severity of COVID-19 decreasing by around 0.14–0.18 points on a five-point scale after they got the second shot compared to before they were vaccinated. Similar to the results of *PROB_COVID19*, the degree of the second shot effect was approximately four times larger than that of the first shot. These observations reasonably reflect that the second shot substantially leads to the vaccine being more effective. The effect was at its peak one month after the second shot, which is similar to the results of *PROB_COVID19.*

Table 3. FE model. Dependent variables are perceptions of COVID-19 and mental health. Sample including males and females.

	(1) *PROB_ COVID19*	(2) *SEVER_ COVID19*	(3) *HAPPY*	(4) *FEAR*	(5) *ANXIETY*	(6) *ANGER*
VACCINE FIRST	−1.248 ***	−0.044 **	0.024	−0.041 **	−0.026	−0.011
VACCINE SECOND_1	−4.369 ***	−0.173 ***	0.063 **	−0.078 ***	−0.059 ***	−0.023
VACCINE SECOND_2	−5.084 ***	−0.181 ***	0.042	−0.092 ***	−0.064 **	0.029
VACCINE SECOND_3	−4.980 ***	−0.142 *	0.160 **	−0.129 ***	−0.139 ***	−0.008
VACCINE SECOND_4	−4.821 ***	0.041	−0.188	−0.017 *	−0.073	−0.124
EMERGENT	−0.007	−0.005	−0.015	0.039 **	0.039 ***	0.013 **
SURVEY 1			<Default>			
SURVEY 2	−19.385 ***	0.184 ***	−0.173 ***	0.119 ***	0.083 ***	0.023
SURVEY 3	−19.033 ***	0.494 ***	−0.383 ***	0.390 ***	0.349 ***	0.215 ***
SURVEY 4	−19.107 ***	0.582 ***	−0.349 ***	0.181 ***	0.155 ***	0.081 ***
SURVEY 5	0.497	0.532 ***	−0.149 ***	−0.061 **	−0.106 ***	−0.036

Table 3. *Cont.*

	(1) *PROB_ COVID19*	(2) *SEVER_ COVID19*	(3) *HAPPY*	(4) *FEAR*	(5) *ANXIETY*	(6) *ANGER*
SURVEY 6	2.622 ***	0.416 ***	−0.140 ***	−0.253 ***	−0.227 ***	−0.179 ***
SURVEY 7	5.726 ***	0.563 ***	−0.216 ***	−0.011	0.017	−0.034
SURVEY 8	6.957 ***	0.627 ***	−0.326 ***	0.175 ***	0.146 ***	0.094 ***
SURVEY 9	4.486 ***	0.597 ***	−0.180 ***	−0.076 ***	−0.101 ***	−0.066 ***
SURVEY 10	3.474 ***	0.588 ***	−0.194 ***	−0.084 ***	−0.109 ***	−0.061 **
SURVEY 11	5.647 ***	0.609 ***	−0.308 ***	0.070 ***	0.036 *	0.081 ***
SURVEY 12	5.074 ***	0.588 ***	−0.294 ***	0.035	0.018 ***	0.097 ***
SURVEY 13	4.125 ***	0.551 ***	−0.231 ***	−0.018	−0.057 ***	0.058 ***
SURVEY 14	5.624 ***	0.579 ***	−0.298 ***	0.069 **	0.035 ***	0.121 ***
SURVEY 15	7.934 ***	0.674 ***	−0.343 ***	0.221 ***	0.150 ***	0.143 ***
Adj R^2	0.57	0.67	0.76	0.56	0.57	0.50
Obs.	54,007	54,007	54,007	54,007	54,007	54,007

Note: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$.

Table 4. FE model. Dependent variables are perceptions of COVID-19 and mental health. Sample including males and females. (Alternative specification).

	(1) *PROB_ COVID19*	(2) *SEVER_ COVID19*	(3) *HAPPY*	(4) *FEAR*	(5) *ANXIETY*	(6) *ANGER*
VACCINE FIRST	−1.253 ***	−0.044 **	0.023	−0.040 **	−0.025	−0.009
VACCINE SECOND_1	−4.676 ***	−0.169 ***	0.058 **	−0.085 ***	−0.064 ***	−0.004
Adj R^2	0.57	0.67	0.76	0.56	0.57	0.50
Obs.	54,007	54,007	54,007	54,007	54,007	54,007

*** $p < 0.01$, ** $p < 0.05$.

As for subjective happiness, in column (3) of *HAPPYNESS*, we observed the expected positive sign for vaccination dummy variables with the exception of *VACCINE_SECOND_4*. However, statistical significance was observed only for *VACCINE_SECOND_1* and *VACCINE_SECOND_3*. Therefore, the positive effect of vaccination was observed to a certain extent but was not robust. Concerning mental health estimations, for estimations of *FEAR*, all vaccine dummy variables exhibited the expected negative signs and were statistically significant. The absolute value of the coefficient of *VACCINE_FRIST* was 0.04, implying that the level of fear decreased by 0.04 points on a five-point scale directly after they received the first shot. The values were 0.08, 0.09, and 0.13 for *VACCINE_SECOND_1*, *VACCINE_SECOND_2*, and *VACCINE_SECOND_3*, respectively. Therefore, the second shot effect was approximately two to three times larger than that of the first shot. However, the degree of increase from the first to the second shot was smaller than the estimations for *PROB_COVID19* and *SEVER_COVID19*. The estimation results for *ANXIETY* were similar to those of *FEAR*, although *VACCINE_FIRST* and *VACCINE_SECOND_4* were not significant. In contrast, in the estimation of *ANGER*, all vaccination dummies were not statistically significant, implying that the vaccination weakened fear but not anger.

Table 4 shows alternative specifications where a second shot dummy variable was used to examine the effect of the second shot vaccination instead of using four dummy variables to capture the timing of the second shot. In Table 4, we focus on whether respondents completed the second shot. Hence, Table 4 reports the key variables, although the set of control variables is the same as in Table 3. Results were similar, as shown in Table 3. The

significant expected sign of *VACCINE SECOND* was observed in columns (1)–(5), but no statistical significance was observed in column (6). Except for column (6), the absolute values of coefficient and statistical significance were larger for *VACCINE SECOND* than for *VACCINE FIRST*. Therefore, individuals have more optimistic views about COVID-19, and their subjective well-being and mental health improved after they took the second shot.

3.2. Subsample Estimations (Male vs. Female Groups)

Based on a subsample divided by gender, we focused on key variables. The same set of control variables used in Table 3 was included but not reported in Tables 4–6. As for the results using a subsample of males, the perceptions of COVID-19, *PROB_COVID19*, and *SEVER_COVID19* in Table 5 show similar results to those in Table 3. Vaccination dummy variables showed the expected negative sign in all results and were statistically significant in most of the results. Comparatively, for results of *HAPPYNESS*, *FEAR*, and *ANGER*, we did not observe statistical significance with the exception of *VACCINE SECOND_1* in columns (6). This implies that males were more likely to have an optimistic view about COVID-19, whereas their mental health did not improve by receiving the vaccine.

Table 5. FE model: Dependent variables are perceptions of COVID-19 and mental health. Male sample.

	(1) *PROB_ COVID19*	(2) *SEVER_ COVID19*	(3) *HAPPY*	(4) *FEAR*	(5) *ANXIETY*	(6) *ANGER*
VACCINE FIRST	−1.876 ***	−0.017	0.005	0.001	0.006	0.009
VACCINE SECOND_1	−3.684 ***	−0.163 ***	0.019	−0.038	−0.052 *	−0.016
VACCINE SECOND_2	−5.018 ***	−0.193 ***	−0.043	−0.044	−0.032	0.040
VACCINE SECOND_3	−4.890 ***	−0.174 *	0.133	−0.023	−0.063	0.104
VACCINE SECOND_4	−4.123 **	−0.045	−0.207	−0.059	−0.055	−0.143
Adj R^2	0.57	0.65	0.77	0.56	0.57	0.57
Obs.	27,316	27,316	27,316	27,316	27,316	27,316

*** $p < 0.01$, ** $p < 0.05$,* $p < 0.10$.

Table 6. FE model: Dependent variables are perceptions of COVID-19 and mental health. Female sample.

	(1) *PROB_ COVID19*	(2) *SEVER_ COVID19*	(3) *HAPPY*	(4) *FEAR*	(5) *ANXIETY*	(6) *ANGER*
VACCINE FIRST	−0.617	−0.072 **	0.047	−0.084 ***	−0.060 **	−0.030
VACCINE SECOND_1	−5.068 ***	−0.184 ***	0.112 ***	−0.116 ***	−0.066 **	−0.029
VACCINE SECOND_2	−5.245 ***	−0.171 ***	0.131 **	−0.139 ***	−0.097 ***	0.017
VACCINE SECOND_3	−5.043 ***	−0.109	0.189 *	−0.241 ***	−0.217 ***	−0.127 *
VACCINE SECOND_4	−5.521 **	0.125	−0.157	−0.280	−0.098	−0.106
Adj R^2	0.56	0.68	0.73	0.54	0.55	0.48
Obs.	26,691	26,691	26,691	26,691	26,691	26,691

*** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$.

Turning to results using a subsample of females, Table 6 indicates that the coefficients of vaccination dummy variables are negative and statistically significant in most cases in the estimations of *PROB_COVID19* and *SEVER_COVID19*. Further, except for column (6), where *ANGER* results are shown, most of the vaccination results showed the expected sign and statistical significance.

In Supplementary Materials, we also reported the estimation results of the specification of Table 4 using a subsample of males (Table S1) and of females (Table S2). The tendency observed in Tables 5 and 6 was also observed in Tables S1 and S2.

Tables 5, 6, S1 and S2 jointly reveal the gender differences in the vaccination effect on subjective well-being and mental health. Thus, vaccination had a positive influence on women's but not on males' mental health.

For the robustness check, we conducted an estimation of a simpler fixed effects model. We used just a single *VACCINATED* variable instead of *VACCINE SECOND*, *VACCINE SECOND_1*, *VACCINE SECOND_2*, *VACCINE SECOND_3*, and *VACCINE SECOND_4*. The results of the simpler specification were consistent with Tables 3–6 (Tables S1–S3 in Supplementary Materials).

4. Discussion

People's hesitancy for COVID-19 vaccination has hampered the establishment of herd immunity and the termination of the COVID-19 pandemic. People who hesitate to vaccinate are less inclined to access information about COVID-19 from formal and authoritative sources but tend to distrust them [33]. Therefore, it is important to provide effective information that is more acceptable to them and, thus, motivate them to be vaccinated. This holds especially for females because they are more likely to be hesitant to be vaccinated [33,40]. Providing positive evaluations of vaccination from vaccinated females plays a key role because females with hesitation pay more attention to information from the same sex.

Existing related studies did not scrutinize the gender difference in the vaccination effects on mental health [26–28,30]. Any gender difference in the vaccination effect was not found [25,29], while vaccinated females showed lower anxiety symptoms than those not vaccinated [30]. Different from these studies, we put focus on gender differences to explore the comprehensively subjective probability of getting COVID-19 and mental health conditions. The contribution of this study is to make it evident that providing information about the effect of vaccination on female mental health improvement increases their motivation to be vaccinated.

Limitations of this study should be noted. The findings of this study cannot be generalized to other countries or other types of vaccines for other diseases. The fixed effects model may also have some limitations, partly due to linear assumptions. Further, we found a correlation between subjective mental condition and vaccination. However, the causality between them has not been scrutinized.

The estimation results made it evident that vaccinated females perceived a lower probability of getting infected and had better subjective well-being and mental health than before vaccination. Providing this information may lead unvaccinated females to view vaccination more positively, which, in turn, will motivate them to be vaccinated. In Japan, female suicide rates have increased during the COVID-19 pandemic. The evidence of this study reveals that vaccination can benefit women with mental illness [19–22]. Based on the findings, policymakers should display appropriate messages that target unvaccinated females.

Supplementary Materials: The following supporting information can be downloaded at: https://www.mdpi.com/article/10.3390/vaccines11040822/s1, Table S1: FE model: Dependent variables are perceptions of COVID-19 and mental health. Male sample. (Alternative specification); Table S2: FE model: Dependent variables are perceptions of COVID-19 and mental health. Fe-male sample. (Alternative specification); Table S3: FE model: Dependent variables are perceptions of COVID-19 and mental health. Sim-pler model where VACCINE is replaced by *VACCINE FIRST* and *VACCINE SECOND_1*.

Author Contributions: E.Y. and F.O. participated in the conceptualization of the study and analyzed the patient data. Y.T. and Y.K. designed the panel survey and performed data collection. E.Y. wrote the main text and made the tables for the original manuscript. All authors reviewed, edited, and approved the final manuscript. The authors are responsible for any errors in this study. All authors have read and agreed to the published version of the manuscript.

Funding: This study was supported by the Fostering Joint International Research B (Grant No. 18KK0048) and the Grant-in-Aid for Scientific Research S (Grant No. 20H05632) from the Japan Society for the Promotion of Science. The Fostering Joint International Research B (Grant No. 18KK0048) was to Yoshiro Tsutsui while the Grant-in-Aid for Scientific Research S (Grant No. 20H05632) was to Fumio Ohtake.

Institutional Review Board Statement: The study was conducted in accordance with the Declaration of Helsinki, and approved by the Osaka University Graduate School of Economics Ethics Committee (protocol code R021014 and 14 October 2020).

Informed Consent Statement: This study was conducted with the ex ante approval of the Ethics Committee of the Graduate School of Economics, Osaka University, and all methods were carried out in accordance with the relevant guidelines and regulations. The ethics approval number of Osaka University for this study is R021014. Informed consent for study participation was obtained from all subjects. Informed consent was obtained from all subjects involved in the study.

Data Availability Statement: The datasets used and analyzed in this study are available from the corresponding author upon reasonable request.

Conflicts of Interest: The authors declare no conflict of interest.

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