Non-attendance is associated with work performance due to the side effects of COVID-19 vaccination: A cross-sectional study in a Japanese manufacturing industry

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M.Y. and K.M. conceived the ideas; M.Y. and H.I. collected the data; M.Y. and K.M. analyzed the data; S.D. and K.M. interpreted the data; M.Y. drafted the work; H.I., S.D., and K.M. revised it critically for important intellectual content. All the authors approved the final version of the manuscript to be published. They agreed to be accountable for all aspects of the work and ensured that the questions related to the accuracy or integrity of any part of the work were appropriately investigated and resolved.

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Running head:

Non-attendance is associated with work performance due to the side effects of vaccination.

Abstract

Objective: Although vaccines have promoted the socioeconomic normalization of the new coronavirus disease 2019 (COVID-19), adverse effects on work performance due to the post-vaccination side effects have been reported. Thus, we examined the relationship between the status of going to work the day following vaccination as a post-vaccination employment consideration and work performance among the Japanese workers in the manufacturing industry.

Methods: Overall, 1,273 employees who received the COVID-19 vaccine in a Japanese manufacturing district were surveyed using a self-administered web-based questionnaire that included fever, fatigue, workplace attendance the day after vaccination, work performance one week after vaccination, and the demographic and occupational characteristics (age, gender, work style, and psychological distress [K6 scale]). The effects of fatigue and attendance on declining work performance were estimated using a linear mixed model, with individuals as random effects and the rest as fixed effects.

Results: After adjusting for the demographic and occupational characteristics, the third-order interaction of fever, fatigue, and attendance on the day following vaccination was significant. The non-attendance group had a significantly higher work performance than the attendance group in those without fever and long-term fatigue [$F(1, 1559)=4.9$, $p=0.026$] and with fever and short-term fatigue [$F(1, 1559)=5.9$, $p=0.015$]. Fever and workplace attendance the following day were not directly related to a decrease in work performance after vaccination.

Conclusions: Our findings suggest that non-attendance at the workplace is associated with work performance due to the side effects after COVID-19 vaccination.

Keywords: COVID-19, vaccination, work performance, fatigue, attendance

Key Points

What is already known on this topic

Although the side effects of COVID-19 vaccines disturb work performance among healthcare workers, the association of the side effects with work performance is unclear among manufacturing workers.

What this study adds

The non-attendance was associated with higher work performance than attendance on the day following the COVID-19 vaccination.

How this study might affect research, practice or policy

This study could help maintain work performance against the side effects of vaccination in the manufacturing industry.

INTRODUCTION

Although vaccines against the coronavirus disease 2019 (COVID-19) are promoting economic normalcy, how to deal with the adverse effects on employment caused by their side effects is an urgent issue. Mild side effects of vaccines, such as fatigue and fever, occur frequently. Besides, cases of missing work owing to the vaccine-related side effects have been reported. However, which side effects adversely affect work performance and to what extent remains unexplored; further, despite the side effects on employment, no effective measures have been developed to date that do not decline work performance.

Fatigue, a side effect of the messenger ribonucleic acid (mRNA)-based COVID-19 vaccines, negatively affects work-related performance. The incidence of the side effects of the COVID-19 vaccine is higher than that of the influenza vaccine, with 66% of the people who have been administered the COVID-19 vaccine experiencing at least one general symptom.[1,2] The appearance of general symptoms, such as fever and fatigue, leads to increased absenteeism.[2] Although general symptoms did not result in absence from work, in a study of the Moderna vaccine's recipients, 25% of the healthcare workers had trouble performing their daily activities shortly after vaccination.[1] Unlike fever, fatigue is a subjective symptom, making it difficult to observe objectively and receive appropriate consideration from supervisors and co-workers. Therefore, there is a pressing need to consider the measures to minimize the impact of the side effects of the COVID-19 vaccine on work performance.

Although planned leaves from work after vaccination are helpful for business continuity, the effect of such leaves on work performance needs to be clarified. Avoiding same-day vaccinations in all departments to deal with sudden absences due to the side effects is

recommended.[2-4] If organizations schedule to get vaccinated immediately before employee's planned leaves or provide paid time off for two days after vaccination, then the impact on absenteeism will be reduced. [4,5] However, it is unclear whether planned leaves are associate with presenteeism.

This study focused on fatigue after vaccination and investigated the side effects, work attendance after vaccination, and work performance. Most studies have surveyed the side effects after vaccination, and their impact on work has been reported in healthcare workers;[1-5] however, no research has reported it in general workers. In addition, side effects and their impact on the attendance status and effective work considerations have not been scrutinized thus far. Therefore, we investigated the impact of the duration of the side effects and attendance status on work performance after vaccination in Japanese workers.

METHODS

Study design

This was an observational study based on a cross-sectional analysis of the survey data. A district of a manufacturing company in Japan vaccinated its employees with the COVID-19 vaccine (mRNA-1273 [Moderna]/first and second doses) at the workplace from July to September 2021. The company also conducted a web-based survey, wherein the participants were required to respond to items on their post-vaccination physical condition for management purposes. The survey form was emailed to the employees one week after each of the first and second doses, and the responses were collected between July 13 and September 16, 2021. This study was approved by the Research Ethics Committee of the University of Occupational and Environmental Health (R3-065).

Participants

Overall, 1,273 employees working in a manufacturing district were offered the opportunity to receive the COVID-19 vaccine at the workplace, of whom 934 requested to be vaccinated. A web-based questionnaire was sent to such 934 employees who received vaccinations at the workplace; the questionnaire was meant to follow up on their physical condition. We obtained participant's consent to use the survey results of the study and analyzed them. The participants included a mix of employees whose work was and was not teleworking eligible.

Measurements

Side effects

The number of days with side effects (fatigue and fever of 37.5℃ or higher) persisting in the week after each vaccination was measured. Fatigue and fever were selected because they are reported to occur frequently as adverse reactions, as indicated by the vaccine and clinical reports.[6-9] Fatigue was evaluated in three groups: no symptoms, short-term fatigue (one or two days), and long-term fatigue (three to seven days), with reference to the post-vaccination vacation system. Fever was examined in two groups: no symptoms and symptoms (one to seven days).

Attendance

The status of attendance at the workplace on the day after vaccination was measured using the choice of attendance at the workplace, telecommuting, paid leaves, or official holidays. As a special consideration for possible side effects after vaccination, manufacturing skilled workers, for whom telework was not normally part of their work schedule, were assigned tasks that they could perform at home. We evaluated two groups: the attendance (those who attended the

142 workplace) and non-attendance groups (those who did not attend the workplace
143 [telecommuting, paid leaves, and official holidays]).
144
145 Work performance
146 Work performance during the previous year and one week after vaccination was measured
147 using three questions extracted from the World Health Organization Health and Work
148 Performance Questionnaire; besides, the reduction in the work performance due to vaccination
149 was evaluated.[10] The performance was rated on an 11-point Likert scale ranging from 0 to 10.
150 The performance during the first week after vaccination was divided by performance during the
151 previous year; it was considered as declining if it was below 1.0.
152
153 Potential confounder
154 Age, sex, work style, the day of the week of vaccination, and psychological distress were
155 assessed. Age was evaluated in six age groups: 10s, 20s, 30s, 40s, 50s, and 60s and older. There
156 were two types of work styles in this manufacturing plant: shift and regular day. Accordingly,
157 we evaluated two groups: shift and non-shift workers. The day of the week when they were
158 vaccinated was measured because the number of consecutive days off varied depending on the
159 day after vaccination. This may have affected their choice of attendance on the day after the
160 vaccination and their work performance after the vaccination. Psychological distress was
161 measured using the K6[11] because poor mental status before vaccination might affect the
162 workplace performance. It consists of six items asking about the symptoms of psychological
163 distress frequently experienced during the past 30 days. The response options ranged from zero
164 (never) to four (always); the higher the score, the worse the evaluation. If the K6 score was 13,
165 the mental status was considered as poor.

Statistical analysis

The participants completed a questionnaire after each vaccination session. This was a cross-sectional study in which the results of each survey were analyzed as a single survey. First, to provide an overall view of the participants, the distributions of their demographic and occupational characteristics were calculated. Second, the direct effects of fatigue and attendance on the decline in work performance were estimated using a linear mixed design model, with individuals as random effects and the rest as fixed effects. The interactions between fatigue, fever, and attendance were confirmed. Third, we analyzed the decline in work performance only for those participants who could perform their normal work duties through teleworking (telework eligible workers). Finally, as a sensitivity analysis, we analyzed the decline in telecommuting performance among employees eligible for telework, excluding those who had a holiday or paid leave on the day after vaccination.

RESULTS

A total of 824 employees responded to the web-based survey (the responses after the second vaccination were not collected from 68 respondents). Table 1 shows the demographic and occupational characteristics and the scores for each scale. Among the vaccine recipients, 294 (35.6%) and 630 (83.3%) reported experiencing fatigue after the first and second doses, respectively. Overall, 487 (59.1%) and 672 (88.9%) recipients did not attend the workplace after the first and second vaccinations, respectively. Many employees requested the vaccination on earlier dates; moreover, there was no significant difference in the number of people vaccinated on different days of the week. The percentages of the recipients with a poor mental status before vaccination were 4.0% and 3.9% for the first and second doses, respectively. The mean work performance in the week following vaccination was lower than that in the year

before vaccination.

Table 2 shows the relationship between fatigue and fever during the week after vaccination, work performance, and workplace attendance on the day after vaccination. The main effect of fatigue was significant and multiple comparisons revealed that the greatest decline was observed for prolonged fatigue. Fever and attendance at the workplace the following day were not directly related to the workplace performance after the vaccination. The third-order interaction of fever, fatigue, and attendance the next day was significant. Among those who had long-term fatigue without fever, the non-attendance group had a significantly higher work performance compared with that of the attendance group. Among those with fever and short-term fatigue, the non-attendance group had a significantly higher work performance than that of the attendance group. In the cases of fever and long-term fatigue, work performance did not differ between the two attendance groups.

Table 3 presents the results of the analysis restricted to the telework eligible workers. In the model adjusted for the confounding factors, the main effects of fatigue and attendance at work on the day after the vaccination were significant. The interaction between fatigue and attendance was significant, and when the former persisted for a long period, the non-attendance group had a significantly higher work performance one week after the vaccination. Similar results were obtained in a comparison of attendance in the work and teleworking groups, which excluded those who were absent from work the next day and had paid time-off (Appendix).

DISCUSSION

Fatigue, which occurs at a high frequency after vaccination, adversely affects the work

performance during the first week after vaccination; however, this effect can be controlled by workstyle considerations on the day after vaccination. In this study, the post-vaccination fatigue occurred in 58.5% of the patients, similar to previous studies.[1,12,13] The appearance of fatigue significantly decreased the work performance during the first week after vaccination; however, the presence of fever, which could be objectively determined, was not significantly associated with performance. When we compared the groups that did (attendance group) and did not (non-attendance group) attend the workplace the day after vaccination, we noticed that the latter saw a lesser decline in performance when no fever and long-term fatigue persisted (three to seven days) and also when fever and short-term (one or two days) fatigue occurred. Thus, fatigue cannot be ignored when managers make considerations.

When the side effect of fever appears after vaccination, the status of non-attendance at the workplace on the day after vaccination is practical in terms of a lesser decline in work performance during the first week after vaccination due to short-term fatigue. In this study, even if the duration of fatigue was short-term (one or two days), non-attendance had a significantly higher work performance. According to the reports of the side effects of the COVID-19 vaccine, fever is often at its maximum severity the day after vaccination.[14] If employees do not attend the workplace on the day after vaccination, then it may have higher work performance during the first week after vaccination than if they attend the workplace. This is because it avoids the decline in performance that occurs by attending the workplace on the day after vaccination when a patient has a severe fever.

Even when the objectively determinable side effect of fever does not occur, the status of non-attendance on the day after the vaccination is feasible in terms of a lesser decline in work

performance in the cases of prolonged fatigue. In this study, when fever did not occur and fatigue was long-term (three to seven days), non-attendance had a significantly higher work performance. According to the reports on the side effects of the COVID-19 vaccine, the proportion of severe cases of fatigue was higher on the day after the vaccination.[14] On the day following the vaccination, when fatigue is the most serious, workplace attendance leads to poor work performance in the first week after the vaccination. The status of non-attendance at the workplace on the following day may have higher work performance than attendance during the first week after the vaccination in the case of prolonged fatigue by avoiding the performance decline on the day after vaccination. When fatigue was short-term (one or two days), the reason for the insufficient difference in the work performance between the attendance and non-attendance groups may be that the degree of fatigue was mild and had no adverse effects on the work performance. These results suggest that even if symptoms persist for a long period, the effect of short-term workstyle considerations on the work performance improvement is significant.

Non-attendance can be a practical measure after vaccination because it had higher work performance. For the telework eligible workers, non-attendance on the day after the vaccination has higher work performance than attendance, with or without fatigue. Although the decrease in the work performance is remarkable when fatigue persists over a long period, non-attendance is especially practical for the telework eligible workers because it had higher work performance. Even without limiting the participants, as mentioned above, non-attendance has higher work performance when there is fever and the duration of fatigue is short-term, or when there is no fever and fatigue is long-time. As the appearance and duration of fatigue are unknown prior to vaccination, preparing a non-attendance system for the post-vaccination work performance

decline may be a practical measure in offices with mixed work patterns, such as shift and indirect department work.

This is the first study to show the effectiveness of non-attendance at the workplace the day after vaccination in terms of a lesser decline in work performance due to fatigue (a common side effect of the COVID-19 vaccine) in the week following the vaccination. Nevertheless, it has some limitations. The number of days of fatigue is not an experience sampling method, and may be inaccurate because of a recall bias. Although a more precise assessment of the number of days could have been made using a method such as recording the presence or absence of fatigue at a regular time each day, the difference would have been minimal because the survey period was short (one week). Further, the survey period was short (one week), and considering the burden on the subjects, this survey was a realistic approach. Additionally, in severe cases involving fever and long-term fatigue, non-attendance at the workplace only on the day after the vaccination may be insufficient for work performance. In this study, as the results differed between the participants of the entire office and the telework eligible workers, more detailed effects could be obtained by assigning the number of non-working days to the participants and industry sectors and conducting intervention studies. Intervention studies were needed to prove the effects of non-attendance, but it was impractical in practice to assign work patterns by the researchers the day after vaccination, making intervention difficult. It was not possible to evaluate the association with the actual status of work and work performance. In this study, manufacturing skilled workers, for whom telework is not normally part of their work schedule, were assigned tasks that could be done at home, but the physical load was less than when they were at the workplace. Moreover, many manufacturing skilled workers may have chosen to telecommute because the manufacturing company assigned tasks that they could perform at

home as a special consideration for possible side effects after vaccination. Those who took paid leaves were to prepare for symptoms, a reality similar to waiting for work. Therefore, the actual conditions of teleworkers and paid leave takers may be similar, and the two could not be separated. Instead, the subjects were narrowed down to indirect departments where telework was implemented, and a sensitivity analysis was conducted to analyze the work-only results.

CONCLUSIONS

This study demonstrated the association with the non-attendance workstyle on the day following the COVID-19 vaccination and work performance. Fatigue occurs frequently after the COVID-19 vaccination and is difficult to objectively assess, making it tough to obtain consideration from others; however, avoiding attending the workplace the day after the vaccination may have higher work performance despite side effects during the first week after the vaccination. Considering productivity, it is important to choose a work style that results in a lesser decline in work performance rather than uniformly granting leave after vaccination. The results could help in planning vaccinations in the manufacturing industry, where telework programs are not available, when there is a need to promote vaccination against new emerging infectious diseases in the future. For other occupations that have telework programs, the results will help to consider employment considerations to maintain productivity. Many manufacturing skilled workers may have chosen to telecommute because the manufacturing company assigned tasks that they could perform at home as a special consideration for possible side effects after vaccination for manufacturing skilled workers. Research at other establishments and in other occupations would be desirable to determine the actual effects of telecommuting considerations on manufacturing skilled workers.

Data availability statement: Research data are not shared.

List of supporting information:

1) Appendix: Sensitivity analysis without absence (N=366 (1st), 151(2nd)).

Disclosure

Ethical approval: This study was approved by the ethics committee of the University of Occupational and Environmental Health, Japan (Reference No. R3-065).

Informed consent: Informed consent from all participants was obtained via website.

Registry and registration no. of the study/trial: N/A.

Animal studies: N/A.

Conflict of interest: Authors declare no Conflict of Interests for this article.

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Table 1. Demographic and occupational characteristics and scale scores

	Vaccination							
	1st				2nd			
	N	(%)	*M*	(*SD*)	*N*	(%)	*M*	(*SD*)
Gender								
Male	721	(87.5)			659	(87.2)		
Female	103	(12.5)			97	(12.8)		
Age (yrs.)			38.1	(12.0)			38.4	(12.1)
18–19	25	(3.0)			24	(3.2)		
20–29	228	(27.7)			208	(27.5)		
30–39	186	(22.6)			163	(21.6)		
40–49	211	(25.6)			191	(25.3)		
50–59	153	(18.6)			150	(19.8)		
≥ 60	21	(2.5)			20	(2.6)		
Side-effects								
Fatigue [†]								
No	530	(64.3)			126	(16.7)		
Short-term	250	(30.3)			497	(65.7)		
Long-term	44	(5.3)			133	(17.6)		
Fever								
No	715	(86.8)			107	(14.2)		
Yes	109	(13.2)			649	(85.8)		
Attendance [‡]								
No	487	(59.1)			672	(88.9)		
Yes	337	(40.9)			84	(11.1)		
Shift work								
Regular	553	(67.1)			511	(67.6)		
Shift	271	(32.9)			245	(32.4)		
Vaccination day								
Tuesday	453	(55.0)			406	(53.7)		
Thursday	371	(45.0)			350	(46.3)		
Distress[§]	31	(3.8)	2.7	(4.0)	23	(3.0)	2.5	(3.9)
Performance	824		0.920	(0.389)	756		0.934	(0.416)

[†] Duration of general fatigue. The participants with a duration of less than and more than 3 days were classified in the short- and long-term groups, respectively.

[‡] Attendance at the workplace on the day after vaccination.

[§] *Distress* was defined as a total score of the K6 scale ≥ 13. The means (*M*) and the standard deviations (*SD*) were calculated for all participants of each group.

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375 Table 2. Fatigue and fever in the week after vaccination and the association between attendance on the

376 day after vaccination and work performance

	Model 1[†]				*Model 2*[‡]			
	M[§]	(95% CI[¶])	*F*	*p*	*M*[§]	(95% CI[¶])	*F*	*p*
Fatigue								
No	0.974	(0.943, 1.005)	14.2	0.000	1.128	(1.048, 1.209)	5.8	0.003
Short-term	0.912	(0.880, 0.944)			1.049	(0.973, 1.125)		
Long-term	0.796	(0.735, 0.856)			0.976	(0.879, 1.072)		
Attendance								
No	0.899	(0.872, 0.926)	0.2	0.658	1.080	(1.011, 1.148)	2.7	0.101
Yes	0.889	(0.847, 0.930)			1.022	(0.935, 1.108)		
Interaction								
*Fatigue * Attendance*							0.7	0.485
*Fever * Fatigue*							1.3	0.283
*Fever * Attendance*							0.5	0.468
*Fever * Fatigue * Attendance*							3.6	0.027
Simple main effects								
Fever: No								
Fatigue: No								
Attendance								
No					1.114	(1.038, 1.190)	0.2	0.627
Yes					1.131	(1.049, 1.213)		
Fatigue: Short-term								
Attendance								
No					1.099	(1.010, 1.188)	0.0	0.902
Yes					1.092	(0.987, 1.197)		
Fatigue: Long-term								
Attendance								
No					1.126	(0.964, 1.288)	4.9	0.026
Yes					0.867	(0.687, 1.047)		
Fever: Yes								
Fatigue: No								
Attendance								
No					1.147	(1.047, 1.248)	0.1	0.784
Yes					1.120	(0.933, 1.308)		
Fatigue: Short-term								
Attendance								
No					1.077	(1.004, 1.150)	5.9	0.015
Yes					0.927	(0.793, 1.061)		

Fatigue: Long-term				
Attendance				
No	0.915	(0.822, 1.009)	0.5	0.467
Yes	0.994	(0.787, 1.201)		

† Crude model without adjusting any potential confounders.

‡ Adjusted for sex, age, rotation (shift or regular work), vaccination day (Tuesday or Thursday), and psychological distress (K6≥13 or not). Additionally, we included the interaction effects between side-effects (fatigue and fever) and attendance.

§ M: Estimated means of self-rated performance in a recent week.

¶ CI: confidence interval.

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378

379 Table 3 Association between post-vaccination fever, fatigue, attendance, and work performance

380 among the telework eligible workers

	Model 1[†]				*Model 2*[‡]			
	M[§]	(95% CI[¶])	*F*	*p*	*M*[§]	(95% CI[¶])	*F*	*p*
Fatigue								
No	0.996	(0.950, 1.041)	7.6	0.001	1.213	(1.104, 1.323)	3.5	0.030
Short-term	0.885	(0.838, 0.931)			1.107	(1.005, 1.208)		
Long-term	0.832	(0.739, 0.925)			1.049	(0.896, 1.202)		
Attendance								
No	0.915	(0.873, 0.956)	0.4	0.536	1.202	(1.107, 1.297)	8.0	0.005
Yes	0.894	(0.835, 0.952)			1.044	(0.920, 1.168)		
Interaction								
*Fatigue * Attendance*							3.2	0.040
*Fever * Fatigue*							3.1	0.044
*Fever * Attendance*							0.2	0.623
*Fever * Fatigue * Attendance*							1.3	0.276
Simple main effects								
Fever: No								
Fatigue								
No					1.194	(1.098, 1.290)	0.4	0.688
Short-term					1.159	(1.046, 1.271)		
Long-term					1.217	(1.038, 1.397)		
Fever: Yes								
Fatigue								
No					1.233	(1.074, 1.391)	4.3	0.014
Short-term					1.054	(0.936, 1.173)		
Long-term					0.881	(0.655, 1.107)		
Simple main effects								
Fatigue: No								
Attendance								
No					1.220	(1.111, 1.328)	0.0	0.870
Yes					1.207	(1.057, 1.358)		
Fatigue: Short-term								
Attendance								
No					1.136	(1.033, 1.238)	1.0	0.308
Yes					1.077	(0.950, 1.205)		
Fatigue: Long-term								
Attendance								

No	1.251	(1.100, 1.401)	8.5	0.004
Yes	0.848	(0.601, 1.095)		

† Crude model without adjusting any potential confounders.

‡ Adjusted for sex, age, rotation (shift or regular work), vaccination day (Tuesday or Thursday), and psychological distress (K6≥13 or not). Additionally, we included the interaction effects between side-effects (fatigue and fever) and attendance.

§ M: Estimated means of self-rated performance in a recent week.

¶ CI: confidence interval.

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