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Risk factors for psychological distress in electroencephalography technicians during the COVID-19 pandemic: A national-level cross-sectional survey in Japan

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z Abbreviations: COVID-19, coronavirus disease 2019; EEG, electroencephalography; PPE, personal protective equipment; SARS-CoV-2, severe acute respiratory syndrome coronavirus-2.

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1. Introduction

The coronavirus disease 2019 (COVID-19) pandemic has had a great influence on society worldwide [1]. Medical staff are vulnerable to psychological stress because they are at high risk of exposure to severe acute respiratory syndrome coronavirus-2 (SARS-CoV-2), and they see COVID-19 critically ill patients [2–4].

Clinical neurophysiology staff, like other medical staff, can be exposed to psychological stress due to the impact of COVID-19. The International Federation of Clinical Neurophysiology has described the importance of mental health considerations for clinical neurophysiology staff during a pandemic [5]. Electroencephalography (EEG) is one of the most common clinical neurophysiological examinations, which is helpful in multiple clinical settings, especially for the diagnosis of epilepsy [6]. Electroencephalography technologists could be vulnerable to stress during the COVID-19 pandemic because they are physically closer to the patient when performing EEG tests. In addition, EEG technicians have been warned about hyperventilation activation in EEG during the COVID-19 pandemic due to the risk of exposure to the virus for EEG technicians [7]. Therefore, EEG technicians who perform hyperventilation activation tests may experience high levels of psychological stress.

However, the actual burden on the mental health of EEG technicians has not yet been investigated. We hypothesized that during the COVID-19 pandemic, (1) EEG technicians in Japan have a psychological distress, and if so (2) there are some risk factors associated with it. Therefore, we conducted national-level cross-sectional survey across Japan.
2. Materials and methods

2.1. Survey design and data collection

This study adhered to the principles of the Declaration of Helsinki. The study was registered at each participating hospital/clinic in line with the applicable regulations. The study was approved by the ethical committee (#A201200010) of Yokohama City University, which is the initiating facility. We conducted a cross-sectional survey to achieve our objectives.

After the initial screening of applications from epilepsy centers and clinics throughout Japan by the official email list of the Japanese Epilepsy Society, 20 hospitals and 4 clinics were nominated. Our survey was conducted using Google Forms and sent to 173 clinical neurophysiology technicians who engaged in EEG by email. Details of the participating facilities are provided in Supplementary Fig. S1. The study was conducted from March 1 to April 30, 2021. The questionnaire included an informative letter summarizing the purpose of the research and an informed consent form, which was written briefly and clearly in Japanese to avoid misinterpretation. The questionnaire took 3–5 min to complete. This questionnaire was piloted by 12 volunteers from Japanese medical staff, and its validity was confirmed.

The inclusion criteria were as follows: (1) technicians who engaged in EEG tests at least once within two weeks before answering, and (2) technicians who completed all the questions of the survey.

2.2. Questions included in the survey

The questionnaire consisted of three parts. The first part included questions on participants’ profiles, the second part included questions about their work, and the third part examined psychological distress as an outcome measure.

2.3. Participant profile

In the first part of this survey, we asked about participants’ profiles: (a) sex, (b) age category (years, <24, 25–34, 35–44, 45–54, 55–64, >65), (c) type of facility (hospital or clinic), (d) whether the facility is located within an endemic area of COVID-19, (e) risk factors in the respondent for COVID-19 infection or stress related to the COVID-19 pandemic, (f) risk factors in the respondent’s cohabitants for COVID-19 infection or stress related to the COVID-19 pandemic [8], (g) presence of cohabitants who had to be separated from the respondent due to this pandemic [9], (h) history of COVID-19 infection in the respondents [10,11], and (i) vaccination against COVID-19. To incorporate the variable of (d) whether an endemic area of COVID-19 into the analysis, we categorized the location of the facility into two groups (endemic area or non-endemic area) according to the total number of COVID-19-positive cases per population in each prefecture as of December 28, 2021, which is one day prior to starting the survey (Supplementary Fig. S2). Regarding the risk factors for COVID-19 infection or stress related to the COVID-19 pandemic in (e), we defined the risk factors as pregnant [6,8], breastfeeding [8], living alone [9], over 65 years old [8], medically dependent state [8], smoking [8], obesity (BMI ≥ 30) [8], medical history of diabetes mellitus [8], hypertension [8], chronic heart disease [8], chronic pulmonary disease [8], chronic kidney disease [8], or immunocompromised state [8]. Regarding the risk factors in (f), we added the factor cohabitants under 17 years old [12–14] into the same cohabitant’s risk factors as in (e).

2.4. Work-associated factors

We examined the work-associated factors of the participants; these factors included the following variables: (j) duration per study [7,15], (k) examination frequency in the last two weeks [15], (l) presence of unscheduled examination [15,16], (m) type of examination performed (EEG with hyperventilation [7], EEG without hyperventilation [7], EEG monitoring [5,7,15]), (n) testing performed on outpatients, inpatients, or both [5,15], (o) examination for patients with COVID-19 or suspected with COVID-19 within two weeks [15,17], (p) presence of infection prevention protocols, screening interviews/examinations, guidelines, or agreements regarding examination during the pandemic at the respondent’s facility [5,7,15], (q) presence of a counseling/consultation office to talk about mental stress related to the pandemic in the facility [5], (r) availability of personal protective equipment (PPE) [5,7,15,18], (s) change in salary/bonus (decrease, no change, or increase) during the pandemic, including benefits due to work related to COVID-19 [19].

2.5. Outcome measurements of psychological distress

We surveyed the following two outcome measures of psychological distress: the K-6 and Tokyo Metropolitan Distress Scale for Pandemic (TMDP) in the Japanese version [20,21]. K-6 is an international score used worldwide [20]. K-6 includes a total of six questions regarding personal experiences and feelings within 30 days. The scores range from 0 to 24, with higher scores indicating higher stress [20]. K-6 is not specific to the COVID-19 pandemic; however, many studies have investigated psychological distress during the COVID-19 pandemic using K-6 [22–25]. On the other hand, TMDP is a scale developed in Japan to assess mental and social stress in medical personnel during the COVID-19 pandemic [21]. The TMDP includes a total of nine questions regarding personal experiences and feelings within two weeks. The TMDP is validated as being correlated with PHQ-9 and GAD-7, which are international scores for assessing psychological distress [21]. Both K-6 and TMDP have validated Japanese versions [21,26].

2.6. Statistical analysis

Statistical analysis was performed using IBM SPSS statistical software version 27 (IBM Corp., Armonk, NY). Multivariate linear regression analysis was used to determine which variables were independent associated factor with each outcome measure of psychological distress. Variables that were associated (p < 0.10) with each psychological distress scale using univariate linear regression analysis were incorporated into the multivariate linear regression analysis. A two-sided p-value of 0.05 was considered to be significant in the multivariate linear regression analysis.

2.7. Sensitivity analysis

We conducted a sensitivity analysis to assess the robustness of the results. In the sensitivity analysis, binary logistic regression analysis was used for each psychological distress outcome. The cutoff value of the binary classification in both outcome measurement scales was 5 for K-6 and 14 for TMDP, based on previous reports [21,26]. Multivariate binary logistic regression analysis was used to determine which variables were independent associated factor with each outcome measure of psychological distress. Variables that were associated (p < 0.10) with each psychological distress scale using univariate binary logistic regression analysis were incorporated into the multivariate binary logistic regression analysis. A two-sided p-value of 0.05 was considered to be significant in the multivariate binary logistic regression analysis.
3. Results

3.1. Total number of respondents and descriptive analysis

Responses were collected from 142 technicians, giving a response rate of 82% (142/173). Among the 142 respondents, 14 were excluded because they had not engaged in EEG within two weeks before answering. Of the remaining respondents, we included respondents who completed the survey. Finally, 128 responses were used for the analysis (Fig. 1).

We show the participants’ profiles and the proportion of each answer to every question in Table 1. The proportion of female patients was 71.1% (91/128). The age group with the highest number of respondents was 25–34 years (52/128: 40.6%). The majority of the participants were working at a hospital (117/128, 91.4%). The number of participants who worked in the endemic area was 99 (77.3%). Importantly, 35.2% of EEG technicians have been under psychological distress based on K-6 and TMDP scores. Then the linear regression analysis was conducted with the association of these scores.

3.2. Univariate and multivariate linear regression analyses for K-6

Table 2 shows the results of the univariate and multivariate linear regression analyses for K-6. The associated factors (p < 0.10) in univariate linear regression analysis with K-6 were female sex (p = 0.014), test for outpatients (p = 0.093), examination for patients (suspected) with COVID-19 (p = 0.036), and change in salary or bonus (p = 0.076). Based on the results of the univariate analysis, multivariate linear regression analysis incorporated the aforementioned variables. Multivariate linear regression analysis identified independent risk factors for high K-6 scores as female (estimate = 2.48; p < 0.001), presence of cohabitants who had to be separated from the respondent due to this pandemic (estimate = 4.28; p = 0.041), and change in salary or bonus (estimate = 1.69; p < 0.001).

3.3. Univariate and multivariate linear regression analyses for TMDP

Table 3 shows the results of the univariate and multivariate linear regression analyses for TMDP. The associated factors (p < 0.10) in the univariate linear regression analysis with TMDP were female sex (p = 0.002), presence of cohabitants who had to be separated from the respondent due to this pandemic (p = 0.088), and changes in salary or bonuses (p < 0.001). Based on the results of the univariate analysis, multivariate linear regression analysis incorporated the aforementioned variables. Multivariate linear regression analysis identified independent risk factors for high TMDP scores as female (estimate = 2.48; p < 0.001), presence of cohabitants who had to be separated from the respondent due to this pandemic (estimate = 4.28; p = 0.041), and change in salary or bonus (estimate = 1.69; p < 0.001).

3.4. Sensitivity analysis for K-6 using univariate and multivariate binary logistic regression analyses

Supplementary Table S1 shows the results of univariate and multivariate binary logistic regression analyses for K-6. The associated factors (p < 0.10) in the univariate binary logistic regression analysis with K-6 were female (p = 0.017), at least 1st dose of vaccination against COVID-19 (p = 0.048), and test for outpatients (p = 0.092). Based on the results of the univariate analysis, multivariate binary logistic regression analysis incorporated the aforementioned variables. Multivariate binary logistic regression analysis identified an independent risk factor for K-6 ≥ 5 as an examination for patients suspected of having COVID-19 (odds ratio = 5.91; p = 0.014).

3.5. Sensitivity analysis for TMDP using univariate and multivariate binary logistic regression analyses

Supplementary Table S2 shows the results of the univariate and multivariate binary logistic regression analyses for TMDP. The associated factors (p < 0.10) in the univariate binary logistic regression analysis with TMDP were the presence of cohabitants who had to be separated from the respondent due to this pandemic (p = 0.093), engaging in EEG monitoring (p = 0.061), and changes in salary or bonuses (p = 0.004). Based on the results of the univariate analysis, multivariate binary logistic regression analysis incorporated the aforementioned variables. Multivariate binary logistic regression analysis identified an independent risk factor for TMDP ≥ 14 as a change in salary or bonus (odds ratio = 0.46; p = 0.008).

Fig. 1. A flowchart showing the participant selection process. After the initial screening of applications from epilepsy centers/clinics throughout Japan according to the official email list of the Japanese Epilepsy Society, 19 hospitals and 4 clinics were nominated. We sent our questionnaire to 173 candidates, of which 142 responded. Among the 142 respondents, 4 were excluded because they had not engaged in any clinical neurophysiology test within 2 weeks. Another 10 respondents were excluded for not engaging in any EEG study. Finally, 128 responses were analyzed of this study. EEG: electroencephalography.
Although various measures of mental stress during the COVID-19 pandemic have been reported [33], we measured K-6 and TMDP in this study. K-6 is simple and has been reported to be useful in various studies worldwide. It has been used in studies assessing mental stress during the COVID-19 pandemic [22–25]. Another study reported the psychological stress of providing medical care to patients with COVID-19 or suspected COVID-19, which also supports the findings of this study [17,31]. This can be interpreted in two ways: (1) the increased risk of COVID-19 infection and (2) stigma due to COVID-19 exposure [32].

In addition, we found that changes in salary/bonus during the pandemic and the presence of cohabitants who had to be separated from respondents due to this pandemic are also independent risk factors for psychological stress. These factors are not specified by the clinical neurophysiology staff. Economic difficulty has been reported as a risk factor for psychological distress in a previous study [9].

Under the COVID-19 pandemic, the guideline recommends that EEG testing with hyperventilation activation should be avoided as much as possible [7]. This is because hyperventilation could expose the EEG technician to SARS-CoV-2 from an infected patient. Based on this recommendation, we hypothesized that EEG with hyperventilation is a risk factor for psychological distress in technicians. However, engaging in EEG tests with hyperventilation was not significantly associated with psychological distress among technologists. The reasons for this were considered to be as follows: (1) hyperventilation activation in EEG testing is performed only for patients with hyperventilation was not assessed in this study. Until the risk is investigated, clinicians still need to consider not ordering unnecessary hyperventilation activation tests, as warnings have been issued [7].

Table 1
Summary of participants’ profiles.

| Participants (n = 128) | Male: 37 (28.9), Female: 91 (71.1) |
|-----------------------|-----------------------------------|
| Category of age (years), No. (%) | ≤24, 12 (9.4), 25–34, 52 (40.6), 35–44, 27 (21.1), 45–54, 20 (15.6), 55–64, 13 (10.2), ≥65, 4 (3.1) |
| Type of facility, No. (%) | Hospital: 117 (91.4), Clinic: 11 (8.6) |
| Location of facility, No. (%) | Endemic area: 99 (77.3), Non-endemic area: 29 (22.7) |
| Risk factors for COVID-19 in the participants, No. (%) | At least one risk factor: 63 (49.2), none: 65 (50.8) |
| Risk factors for COVID-19 in the participants’ cohabitants, No. (%) | At least one risk factor: 61 (47.7), none: 67 (52.3) |
| Presence of cohabitants who had to be separated from respondents due to this pandemic, No. (%) | 3 (2.3) |
| History of COVID-19 infection in the respondent, No. (%) | 1 (0.8) |
| Vaccination against COVID-19, No. (%) | Not planned: 30 (23.4), Planned: 71 (55.5), 1st dose: 24 (18.8), 2nd dose: 3 (2.3) |
| Factors related to work | |
| Examination frequency in the last two weeks, median [IQR] | 60 [40–60] min |
| Experience of unexpected tests in two weeks, No. (%) | 87 (68.0) |
| Experience of EEG with hyperventilation in two weeks, No. (%) | 47 (36.7) |
| Experience of EEG monitoring in two weeks, No. (%) | 60 (46.9) |
| Test for outpatient, inpatients, or both, No. (%) | Outpatient: 14 (10.9), inpatient: 11 (8.6), both 103 (80.5) |
| Examination for patients with COVID-19 or suspected of having COVID-19, No. (%) | 12 (9.4) |
| Infection prevention protocols, screening interviews/examinations, guidelines, or agreements regarding examination, No. (%) | 121 (94.5) |
| Counseling/consultation office to talk about mental stress related to the pandemic, No. (%) | 89 (69.5) |
| Availability of N95 mask, No. (%) | 35 (27.3) |
| Change in salary/bonus due to the COVID-19 pandemic, No. (%) | Down: 57 (45.4), Up: 57 (44.5) |
| Outcome measurements | |
| K-6 ≥ 5, No. (%) | 45 (35.2) |
| TMDP ≥ 14, No. (%) | 45 (35.2) |

As many as 35.2 % of EEG technicians have been under psychological distress. Furthermore, female sex, examination for patients (suspected) with COVID-19, and change in salary or bonus were risk factors for higher K-6 score in our study. Regarding the examination of patients suspected of having COVID-19, its robustness was confirmed by sensitivity analysis. On the other hand, the analysis for higher TMDP identified factors associated with the presence of cohabitants who had to be separated from respondents due to this pandemic, and changes in salaries or bonuses, as well as females. In addition, the robustness of the change in salary or bonus was confirmed by sensitivity analysis.

The results of this study can help in understanding the psychological stress in EEG technicians during the COVID-19 pandemic. In our study, a decrease in bonus or salary was significantly related to psychological stress. This is an intervenable factor, and it is possible that increasing bonuses and salaries can reduce mental stress. However, the actual effects should be examined by conducting further interventional studies.

4. Discussion

4.1. Summary and interpretation of our findings

Performing a national-level cross-sectional survey with a high response rate (82%), we identified risk factors for mental distress in EEG technicians during the COVID-19 pandemic in Japan. Although there have been papers discussing the need for guidelines and staff considerations for clinical neurophysiology testing during the COVID-19 pandemic [5,7,15,16], few research papers have addressed this issue. In this regard, we conducted a study of mental stress specifically among clinical neurophysiology staff on a nationwide scale in Japan, and succeeded in identifying risk factors.
opened in 2020 [21], and it is not widely used around the world at this time. However, one of the strengths of the TMDP, as opposed to the K-6, is that it is a scale specifically designed to measure stress in medical personnel during the COVID-19 pandemic. Another strength of the TMDP is that this scale was developed in Japan. Considering these two strengths, the TMDP was considered to be the most specific and appropriate scale for measuring psychological stress among medical professionals in Japan during the COVID-19 pandemic.

Our study has some limitations. First, this cross-sectional questionnaire survey retrospectively captured subjects’ experiences and perceptions at only one point in time. Thus, recall bias was unavoidable. Second, there was no control or baseline psychological status. Ideally, similar outcome measurements should be taken before and during the COVID-19 pandemic to compare psychological stress. Finally, there was no control during the COVID-19 pandemic. Ideally, similar outcome measurements should be taken before and during the COVID-19 pandemic to compare psychological stress.

Table 2
Results of univariate and multivariate linear regression analyses based on the outcome of K-6.

|                          | Univariate | Multivariate |
|--------------------------|------------|--------------|
|                          | P-value    | Unstandardized Coefficients | 95% C.I. | P-value | Unstandardized Coefficients | 95% C.I. |
| Sex (male: 0, female: 1) | 0.014      | 1.80          | 0.37 to 3.24 | 0.031   | 1.55          | 0.14 to 2.95 |
| Age: category            | 0.148      | –0.38         | –0.90 to 0.14 |
| Type of facility (Hospital: 0, Clinic: 1) | 0.669      | –0.51         | –2.89 to 1.86 |
| Endemic area             | 0.679      | –0.33         | –1.92 to 1.26 |
| At least one risk factor in the participant | 0.862      | –0.12         | –1.45 to 1.21 |
| At least one risk factor in the cohabitant | 0.534      | 0.40          | –0.93 to 1.73 |
| Living apart due to the pandemic | 0.177      | 3.00          | –1.37 to 7.76 |
| COVID-19 infectious      | 0.845      | –0.75         | –8.30 to 6.81 |
| Vaccine (None: 0, At least 1st dose: 1) | 0.209      | –1.03         | –2.66 to 0.59 |
| Duration per test (min)  | 0.426      | –0.01         | –0.01 to 0.01 |
| Test frequency (2 weeks) | 0.354      | 0.01          | –0.01 to 0.03 |
| Unexpected test          | 0.043      | 0.05          | –1.37 to 1.48 |
| EEG with hyperventilation | 0.919      | 0.07          | –1.31 to 1.45 |
| EEG monitoring           | 0.443      | 0.52          | –0.81 to 1.85 |
| Test for outpatients     | 0.093      | 2.01          | –0.34 to 4.35 |
| Examination for patients (suspected) with COVID-19 | 0.036      | 2.40          | 0.16 to 4.64 |
| Protocol or screening    | 0.823      | 0.33          | –2.59 to 1.26 |
| Counseling/Consultation office | 0.224      | –0.89         | –2.32 to 0.55 |
| Availability of N95 mask | 0.639      | 0.36          | –1.14 to 1.85 |
| Change in salary or bonus during the COVID-19 pandemic (Down: 0, No change: 1, Up: 2) | 0.076      | –0.86         | –1.80 to 0.09 |

C.I.: confidence interval; EEG: electroencephalography.
P < 0.10 in Univariate analysis and P < 0.05 in multivariate analysis indicated significance (in bold).

Table 3
Results of univariate and multivariate linear regression analyses based on the outcome of TMDP.

|                          | Univariate | Multivariate |
|--------------------------|------------|--------------|
|                          | P-value    | Unstandardized Coefficients | 95% C.I. | P-value | Unstandardized Coefficients | 95% C.I. |
| Sex (male: 0, female: 1) | 0.002      | 2.33          | 0.88 to 3.77 | <0.001  | 2.48          | 1.12 to 3.85 |
| Age: category            | 0.126      | 0.42          | –0.12 to 0.95 |
| Type of facility (Hospital: 0, Clinic: 1) | 0.252      | 1.40          | –1.10 to 3.82 |
| Endemic area             | 0.279      | –0.89         | –2.51 to 0.73 |
| At least one risk factor in the participant | 0.670      | 0.29          | –1.07 to 1.65 |
| At least one risk factor in the cohabitant | 0.108      | 1.10          | –0.25 to 2.45 |
| Living apart due to the pandemic | 0.089      | 3.86          | –0.59 to 8.31 |
| COVID-19 infectious      | 0.979      | 0.10          | –7.63 to 7.83 |
| Vaccine (None: 0, At least 1st dose: 1) | 0.792      | 0.22          | –1.45 to 1.89 |
| Duration per test (min)  | 0.688      | –0.001        | –0.01 to 0.01 |
| Test frequency (2 weeks) | 0.192      | –0.01         | –0.04 to 0.01 |
| Unexpected test          | 0.703      | 0.28          | –1.18 to 1.74 |
| EEG with hyperventilation | 0.646      | 0.33          | –1.08 to 1.74 |
| EEG monitoring           | 0.276      | –0.75         | –2.11 to 0.61 |
| Test for outpatients     | 0.577      | 0.69          | –1.74 to 3.11 |
| Examination for patients (suspected) with COVID-19 | 0.359      | –1.08         | –3.41 to 1.24 |
| Protocol or screening    | 0.977      | 0.04          | –2.95 to 3.04 |
| Counseling/Consultation office | 0.114      | –1.18         | –2.64 to 0.29 |
| Availability of N95 mask | 0.177      | –1.04         | –2.56 to 0.48 |
| Change in salary or bonus during the COVID-19 pandemic (Down: 0, No change: 1, Up: 2) | <0.001     | –1.77         | –2.70 to –0.84 |

C.I.: confidence interval; EEG: electroencephalography.
P < 0.10 in Univariate analysis and P < 0.05 in multivariate analysis indicated significance (in bold).
not be made before the COVID-19 pandemic. For this reason, our study design had to be a cross-sectional survey, which could not determine the causality between associated factors and outcomes. The third limitation is that we did not collect the variables such as pre-existing psychological comorbidities or psychotropic medications, which would affect the outcomes of this study. The last limitation is the generalizability. In this study, we focused on clinical neurophysiology staff engaged in EEG in Japan. The impact of COVID-19 and its effects on mental health varies across countries. Future research should consider the applicability of these results to other countries. Although our primary aim was to investigate the potential risk factors in EEG technicians who play an essential role in epilepsy clinics, another applicability should be considered for clinical neurophysiology staff not limited to EEG in further studies.

5. Conclusions

We successfully identified the risk factors associated with psychological distress in EEG technicians during the COVID-19 pandemic by performing a national-level cross-sectional survey in Japan with a high response rate. The results of this study may help understanding the psychological stress in EEG technicians during the COVID-19 pandemic. Our results would also help in improving the work environment, which is necessary to maintain the mental health of EEG technicians.

Declarations of competing interests

None.

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Conflict of interest statement

None.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.yebeh.2021.108361.

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