



Article

# Longitudinal Study Comparing Mental Health Outcomes in Frontline Emergency Department Healthcare Workers through the Different Waves of the COVID-19 Pandemic

Francesca Th'ng <sup>1,\*</sup>, Kailing Adriel Rao <sup>1</sup>, Lixia Ge <sup>2</sup> , Hwee Nah Neo <sup>1</sup>, Joseph Antonio De Molina <sup>2</sup>, Wei Yang Lim <sup>3</sup> and Desmond Mao <sup>1</sup>

<sup>1</sup> Acute & Emergency Care Department, Khoo Teck Puat Hospital, 90 Yishun Central, Singapore 768828, Singapore

<sup>2</sup> Health Services and Outcomes Research, National Healthcare Group, 3 Fusionopolis Link, Singapore 138543, Singapore

<sup>3</sup> School of Medicine, University of Galway, University Road, Galway H91TK33, Ireland

\* Correspondence: thng.francesca.cs@ktph.com.sg; Tel.: +65-98821657

**Abstract:** As countries transition from the COVID-19 pandemic to endemic status, healthcare systems continue to be under pressure. We aimed to quantify changes in depression, anxiety, stress and post-traumatic stress disorder (PTSD) between 3 cohorts (2020, 2021 and 2022) of our Emergency Department (ED) healthcare workers (HCWs) and those who had worked through all 3 phases of the pandemic; and identify factors associated with poorer mental health outcomes (MHOs). In this longitudinal single-centre study in Singapore, three surveys were carried out yearly (2020, 2021 and 2022) since the COVID-19 outbreak. Depression, anxiety and stress were measured using DASS-21, and PTSD was measured using IES-R. A total of 327 HCWs (90.1%) participated in 2020, 279 (71.5%) in 2021 and 397 (92.8%) in 2022. In 2022, ED HCWs had greater concerns about workload (Mean score  $\pm$  SD: 2022:  $4.81 \pm 0.86$ , vs. 2021:  $4.37 \pm 0.89$ , vs. 2020:  $4.04 \pm 0.97$ ) and perceived to have less workplace support (2022:  $4.48 \pm 0.76$ , vs. 2021:  $4.66 \pm 0.70$ , vs. 2020:  $4.80 \pm 0.69$ ). There was overall worsening depression (27.5% in 2020, 29.7% in 2021 and 32.2% in 2022) and stress (12.2% in 2020, 14.0% in 2021 and 17.4% in 2022). Healthcare assistants as a subgroup had improving MHOs. ED HCWs who were female and had psychiatric history, were living with the elderly, and had concerns about their working environment, workload and infection had poorer MHOs. This study will guide us in refining existing and devising more focused interventions to further support our ED HCWs' wellbeing.

**Keywords:** COVID-19; depression; anxiety; stress; post-traumatic stress disorder; healthcare workers; emergency department; mental health



**Citation:** Th'ng, F.; Rao, K.A.; Ge, L.; Neo, H.N.; Molina, J.A.D.; Lim, W.Y.; Mao, D. Longitudinal Study Comparing Mental Health Outcomes in Frontline Emergency Department Healthcare Workers through the Different Waves of the COVID-19 Pandemic. *Int. J. Environ. Res. Public Health* **2022**, *19*, 16878. <https://doi.org/10.3390/ijerph192416878>

Academic Editor: Claudio Barbaranelli

Received: 27 October 2022

Accepted: 11 December 2022

Published: 15 December 2022

**Publisher's Note:** MDPI stays neutral with regard to jurisdictional claims in published maps and institutional affiliations.



**Copyright:** © 2022 by the authors. Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (<https://creativecommons.org/licenses/by/4.0/>).

## 1. Introduction

After about a 3.5-year long battle with the COVID-19 outbreak, many countries are taking a new approach: learning to live with COVID-19 rather than eradicating it. Similarly, Singapore is moving towards endemicity and is scaling back on infection control restrictions [1]. As we transition into the endemic phase of COVID-19, our healthcare system continues to be under pressure, and the wellbeing of our healthcare workers (HCWs) is more important than ever before [2].

Currently, there are limited longitudinal studies monitoring mental health changes in HCWs as we transition from the COVID-19 pandemic to an endemic state. A study amongst six Southeast Asian countries (Indonesia, Malaysia, Philippines, Singapore, Thailand and Vietnam) in 2021 found that job burnout rates were highest across the countries, followed by anxiety and depression [3]. Anxiety was found to be higher (10%) than pre-COVID-19 (2.2–4.9%). In their study, longer-than-usual working hours, the perception of high risk from COVID-19 infection and the inadequacy of personal protective equipment (PPE) were

associated with higher odds of burnout and anxiety. Protective factors like good teamwork were associated with lower odds of burnout, anxiety and depression.

We had previously conducted two studies amongst our Emergency Department (ED) HCWs in 2020 [4] and 2021 [5]. The 2021 results showed improvement in anxiety amongst ED HCWs and worsening depression amongst ED doctors over one year. Age, living with the elderly and concerns about workload and infection risk were associated with higher odds of depression and anxiety. Following our second survey in 2021, efforts have been made by our ED and the hospital to improve HCWs' wellbeing. These included the creation of a departmental wellbeing committee to provide support for our HCWs; HCWs with families overseas being granted leave to see their loved ones; and the hospital's initiation of Staff Wellness Passes for extra protected time off from work. As Singapore transitioned towards an endemic status at the beginning of 2022, there have been significant national changes in COVID-19 safety measures, including no restrictions on dining out and the opening up of travel borders (Table A1).

Leveraging on the prior studies conducted, our 3rd survey aimed to (1) quantify changes in MHOs (depression, anxiety, stress and post-traumatic stress disorder (PTSD) symptoms) between 3 cohorts of our frontline ED HCWs in 2020, 2021 and 2022; (2) quantify changes in MHOs between our ED HCWs who were working through all 3 phases of the pandemic; and (3) identify the factors longitudinally associated with poorer MHOs. We hypothesised that MHOs would generally improve amongst our ED HCWs, as they would have adapted to the changes that have occurred over the past 3.5 years and as the nation eased infection control measures.

## 2. Materials and Methods

### 2.1. Study Design and Participants

This is a prospective longitudinal study carried out amongst frontline ED HCWs in Khoo Teck Puat Hospital, Singapore. The study hospital is a 795-bed acute hospital that serves more than 550,000 people living in the north of Singapore. The average number of ED patients seen, including the number of P1 (triage acuity level 1) and P2 (triage acuity level 2) patients per month, the average waiting time for ED patients to be seen by a doctor and the average waiting time for admitted patients to obtain a ward bed in 2019 to 2022 are illustrated in Table A2.

Three rounds of surveys had been carried out annually since the outbreak of COVID-19 in Singapore in 2020. The first survey was conducted in June 2020 [4] during the first wave of the pandemic; the second one was conducted one year later in June 2021 [5] when there was an emergence of COVID-19 variants, including Omicron; and the third survey was carried out in June 2022 as Singapore transitioned from a COVID-19 pandemic to endemic status. The methodologies for the first two surveys have been described previously [4,5]. In this third survey, all ED HCWs of KTPH were invited to complete a paper-based survey questionnaire (Figure A1). Participation was voluntary, and written consent was obtained. Participants returned the completed questionnaires to the investigators either at the end of their work shifts in person or dropped them off directly into a collection box at the ED office. The three surveys were reviewed and approved independently by the National Healthcare Group Domain Specific Review Board (DSRB 2020/00653, 2021/00336, and 2022/00290). Data of participants who participated in the three surveys were matched based on their reference numbers (last four digits of handphone number) with reference to the demographics (e.g., age, gender and ethnicity) and occupation to ensure accuracy.

### 2.2. Outcome Measures

Data for depression, anxiety and stress were collected using 21-item validated Depression, Anxiety and Stress Scale (DASS-21) [6], similar to our previous 2 studies. The sum score for each MHO was calculated and multiplied by two, which was then used to categorise individual MHO into two groups (normal vs. positive for each MHO). A positive score for depression, anxiety and stress was defined as >9, >7 and >14, respectively. PTSD

was measured using 22-item Impact of Events Scale-Revised (IES-R) scale [7]. A cut-off score of  $\geq 24$  was used to define PTSD symptoms of clinical concern.

All HCWs' demographic information, including age group, gender, ethnicity, occupation and living arrangement were collected in all three surveys. HCWs' concerns and perceptions were collected using a questionnaire containing a list of statements based on a Likert scale where 1 = Strongly Disagree and 6 = Strongly Agree. This questionnaire was developed based on experts' opinions (study team's ED consultants, senior nurse and biostatisticians). These concerns and perception statements were categorised into five domains based on their content relevance and inter-item correlations (Figure A2), namely concerns about COVID-19 infection risk, perceptions about workplace support, concerns about workload, concerns about working environment and perception about how socially connected they were. The responses for perception about religion and exercise as a way of coping with stress and whether they felt respected were re-categorised into binary variables: "Yes" for responses of "Not sure but probably agree", "Agree", and "Strongly agree", and "No" for responses of "Not sure but probably disagree", "Disagree", and "Strongly disagree". The word 'trend' is used in the manuscript to describe the direction of change a variable is moving towards and does not equate to statistical significance.

### 2.3. Statistical Analysis

We performed analysis on three cohorts as well as on matched HCWs. The three cohorts referred to the HCWs who had responded to the respective year's survey. The matched HCWs referred to the 160 HCWs who had responded to all 3 surveys. Categorical variables were described using frequencies and percentages, and continuous variables were expressed in means and standard deviations (SD), and medians and 1st and 3rd quartiles (Q1-Q3). The distribution of the severity and status of each MHO, as well as MHOs and concerns and perception scores for the three cohorts, were visually compared without using statistical tests, as the data were partially dependent. For the matched HCWs, Repeated Measure ANOVA was conducted to compare scores of concerns and perception since they were normally distributed. An unadjusted Generalized Estimating Equation (GEE) [8,9] by specifying binominal family and logit link function was performed for each MHO status to test whether survey year was associated with any MHO status. GEE approach facilitates analysis of longitudinal data or repeated measures designs and produces more efficient and unbiased regression estimates, as it takes into account the correlation of within-subject data.

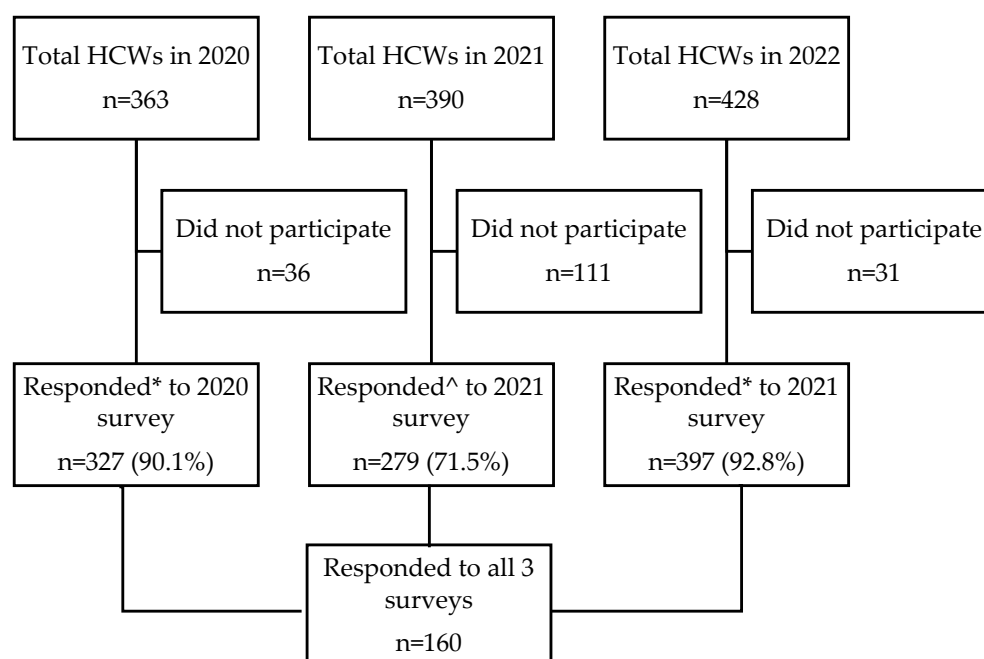
GEE employing binominal family and logit link function was also performed to identify potential factors that were associated with risk of individual MHO for the three cohorts. In each model, status of one MHO (binary variable) was the dependent variable. The survey year, characteristics, domain scores of concerns about COVID-19 infection, working environment and workload, perceptions about workplace support and social connectedness, two coping items (binary) and feeling respected (binary), which were identified to be associated with any MHO ( $p < 0.1$ ) in univariate GEE analyses, were included as independent variables in the final model.

Odds ratios (OR) when outcome variable is binary or beta coefficients when outcome variable is continuous 95% confidence intervals (CIs) and  $p$ -values were reported. All analyses were performed using Stata/SE 16.1.  $p < 0.05$  was set as the level of significance.

## 3. Results

### 3.1. Demographics of the Cohorts

The response rate for each round of the survey was: 90.1% in 2020, 71.5% in 2021 and 92.8% in 2022. A total of 160 ED HCWs participated in all three rounds (Figure 1). Table 1 shows the demographic characteristics of all ED HCWs in 2020, 2021 and 2022, respectively, and Table A3 shows the demographic characteristics of the 160 matched HCWs. In comparison to 2020 and 2021, the cohort in 2022 was generally younger and had a higher proportion of HCAs, a lower proportion of married HCWs and a higher proportion of HCWs with a family member(s) or friend(s) who had contracted COVID-19 (Table 1).



**Figure 1.** Flow diagram of the COVID-19 studies carried out in June 2020 (1st survey), June 2021 (2nd survey) and June 2022 (3rd survey). \* All ED HCWs at the time of the study's recruitment period were approached for recruitment. ^ Only ED HCWs who had participated in the first survey in 2020 were approached.

**Table 1.** Characteristics of all ED HCWs in the 2020 (n = 327), 2021 (n = 279) and 2022 (n = 397) cohorts.

Characteristics	2020 (n = 327)	2021 (n = 279)	2022 (n = 397)
<b>Age group in years (n,%)</b>			
21–30	154 (47.1)	110 (39.4)	210 (52.9)
31–40	121 (37.0)	124 (44.4)	141 (35.5)
41+	52 (15.9)	45 (16.1)	46 (11.6)
<b>Gender (n,%)</b>			
Female	236 (72.2)	204 (73.1)	281 (70.8)
Male	91 (27.8)	75 (26.9)	116 (29.2)
<b>Ethnicity (n,%)</b>			
Chinese	128 (39.1)	110 (39.4)	175 (44.1)
Filipino	92 (28.1)	88 (31.5)	95 (23.9)
Others	107 (32.7)	81 (29.0)	127 (32.0)
<b>Marital status (n,%)</b>			
Single/Separated/Divorced/Widowed	180 (55.1)	142 (50.9)	263 (66.3)
Married	147 (45.0)	137 (49.1)	134 (33.8)
<b>Occupation (n,%)</b>			
Senior doctor	25 (7.7)	23 (8.2)	25 (6.3)
Junior doctor	64 (19.6)	38 (13.6)	70 (17.6)
Nurse	217 (66.4)	206 (73.8)	249 (62.7)
Healthcare Assistant	21 (6.4)	12 (4.3)	53 (13.4)

**Table 1.** *Cont.*

Characteristics	2020 (n = 327)	2021 (n = 279)	2022 (n = 397)
<b>Past medical history (n,%)</b>			
Yes	14 (4.3)	15 (5.4)	22 (5.5)
No	313 (95.7)	264 (94.6)	375 (94.5)
<b>Living with young children (&lt;12 years) (n,%)</b>			
Yes	50 (15.3)	60 (21.5)	70 (17.6)
No	277 (84.7)	219 (78.5)	327 (82.4)
<b>Living with elderly (&gt;65 years) (n,%)</b>			
Yes	51 (15.6)	45 (16.1)	65 (16.4)
No	276 (84.4)	234 (83.9)	332 (83.6)
<b>Lives alone (n,%)</b>			
Yes	44 (13.5)	47 (16.9)	49 (12.3)
No	283 (86.5)	232 (83.1)	348 (87.7)
<b>Practices a religion (n,%)</b>			
Yes	251 (76.8)	213 (76.3)	304 (76.6)
No	76 (23.3)	66 (23.7)	93 (23.4)
<b>Has family/close friend with COVID-19 (n,%)</b>			
Yes	25 (7.7)	48 (17.2)	330 (83.1)
No	302 (92.3)	231 (82.8)	67 (16.9)

### 3.2. Concerns and Perceptions of the Cohorts

Overall, ED HCWs in 2022 had greater concerns about their workload (mean score  $\pm$  SD: 2022:  $4.81 \pm 0.86$ , vs. 2021:  $4.37 \pm 0.89$ , vs. 2020:  $4.04 \pm 0.97$ ) and perceived to have less workplace support (2022:  $4.48 \pm 0.76$ , vs. 2021:  $4.66 \pm 0.70$ , vs. 2020:  $4.80 \pm 0.69$ ) (Table 2). In 2022, the ED HCWs had fewer concerns about COVID-19 infection risk (2022:  $3.90 \pm 0.92$ , vs. 2021:  $3.93 \pm 0.83$ , vs. 2020:  $4.19 \pm 0.82$ ) and their working environment (2022:  $3.90 \pm 1.03$ , vs. 2021:  $3.96 \pm 0.98$ , vs. 2020:  $4.09 \pm 0.85$ ). Similarly, the 160 matched ED HCWs followed parallel trends in these categories (Table A4).

**Table 2.** The mean scores for the different categories of ED HCWs' concerns and perceptions for the three cohorts. Comparison of mean scores of ED HCWs' concerns and perceptions within the subgroups for the three cohorts.

Concerns and Perceptions	2020 (Mean $\pm$ SD)	2021 (Mean $\pm$ SD)	2022 (Mean $\pm$ SD)
Concerns about infection risk	$4.19 \pm 0.82$	$3.93 \pm 0.83$	$3.90 \pm 0.92$
Concerns about working environment	$4.09 \pm 0.85$	$3.96 \pm 0.98$	$3.90 \pm 1.03$
Concerns about workload	$4.04 \pm 0.97$	$4.37 \pm 0.89$	$4.81 \pm 0.86$
Social connectedness	$4.53 \pm 0.64$	$4.43 \pm 0.67$	$4.57 \pm 0.70$
Workplace support	$4.80 \pm 0.69$	$4.66 \pm 0.70$	$4.48 \pm 0.76$

Table 2. Cont.

Concerns and Perceptions	2020 (Mean $\pm$ SD)	2021 (Mean $\pm$ SD)	2022 (Mean $\pm$ SD)			
	Senior doctors			Junior doctors		
Concerns & perceptions	2020 (n = 25)	2021 (n = 23)	2022 (n = 25)	2020 (n = 64)	2021 (n = 38)	2022 (n = 70)
Concerns about infection	3.83 $\pm$ 0.70	3.61 $\pm$ 0.74	3.59 $\pm$ 1.10	3.94 $\pm$ 0.76	3.85 $\pm$ 0.85	3.86 $\pm$ 0.85
Concerns about working environment	4.37 $\pm$ 0.60	4.37 $\pm$ 0.81	4.12 $\pm$ 1.11	3.91 $\pm$ 0.70	4.10 $\pm$ 0.81	4.28 $\pm$ 0.87
Concerns about workload	3.25 $\pm$ 0.79	3.95 $\pm$ 1.00	4.76 $\pm$ 0.92	3.45 $\pm$ 0.88	4.29 $\pm$ 0.82	4.86 $\pm$ 0.87
Social connectedness	4.79 $\pm$ 0.78	4.43 $\pm$ 0.79	4.47 $\pm$ 0.71	4.71 $\pm$ 0.65	4.52 $\pm$ 0.66	4.62 $\pm$ 0.87
Workplace support	4.83 $\pm$ 0.62	4.43 $\pm$ 0.88	4.40 $\pm$ 0.98	4.81 $\pm$ 0.60	4.71 $\pm$ 0.61	4.36 $\pm$ 0.63
	Nurses			HCAs		
Concerns & perceptions	2020 (n = 217)	2021 (n = 206)	2022 (n = 248)	2020 (n = 21)	2021 (n = 12)	2022 (n = 53)
Concerns about infection	4.33 $\pm$ 0.80	3.99 $\pm$ 0.83	3.94 $\pm$ 0.92	3.93 $\pm$ 1.00	3.72 $\pm$ 0.70	3.87 $\pm$ 0.89
Concerns about working environment	4.11 $\pm$ 0.89	3.88 $\pm$ 1.03	3.79 $\pm$ 1.05	4.15 $\pm$ 0.99	4.02 $\pm$ 0.90	3.81 $\pm$ 0.99
Concerns about workload	4.34 $\pm$ 0.86	4.48 $\pm$ 0.87	4.92 $\pm$ 0.79	3.69 $\pm$ 0.99	3.69 $\pm$ 0.78	4.21 $\pm$ 0.89
Social connectedness	4.48 $\pm$ 0.60	4.39 $\pm$ 0.67	4.54 $\pm$ 0.67	4.12 $\pm$ 0.65	4.69 $\pm$ 0.52	4.67 $\pm$ 0.59
Workplace support	4.80 $\pm$ 0.69	4.66 $\pm$ 0.70	4.46 $\pm$ 0.75	4.69 $\pm$ 1.05	5.05 $\pm$ 0.50	4.80 $\pm$ 0.77

### 3.3. Mental Health Outcomes

#### 3.3.1. Depression

A total of 27.5% of ED HCWs screened positive for depression in 2020, 29.7% in 2021 and 32.2% in 2022 (Table 3), reflecting an increasing trend. The score distribution for each MHO in each cohort is shown in Figure A3. In the HCA group, however, the trend was reversed (2020: 52.4%, vs. 2021: 33.3%, vs. 2022: 30.2%). The score distribution for each MHO in each cohort is shown in Figure A3. The unadjusted GEE with each MHO score as the outcome showed that amongst the matched HCWs, the proportion who screened positive for depression (Table A5) and their depression scores (Table A5) remained similar.

The GEE results (Table 4) showed that junior doctors (OR [95%CI]: 0.43 [0.19,0.99],  $p = 0.048$ ), those with a greater number of years in their occupation (OR 0.94 [0.90,0.98],  $p = 0.005$ ), those who perceived that they had better workplace support (OR 0.74 [0.57,0.96],  $p = 0.021$ ), those who were socially connected (OR 0.50 [0.38,0.64],  $p < 0.001$ ) and those who felt respected (OR 0.63 [0.42,0.95],  $p = 0.026$ ) had lower odds of developing depression (Table 4). ED HCWs with a psychiatric history (OR 3.75 [1.41,9.96],  $p = 0.008$ ), those who were living with the elderly (OR 1.82 [1.20,2.77],  $p = 0.005$ ) and those with concerns about their working environment (OR 1.21 [1.03,1.44],  $p = 0.024$ ) and workload (OR 1.46 [1.19,1.79],  $p < 0.001$ ) had higher odds of developing depression. Compared to the 2020 cohort, the odds of developing depression in the 2021 and 2022 cohorts were lower but not significant.

**Table 3.** Distribution of the different severities of depression, anxiety, stress and PTSD of clinical concern amongst all ED HCWs in the three cohorts. Depression, anxiety, stress and PTSD scores amongst all the ED HCWs and its subgroups in the three cohorts.

	All HCWs			Senior Doctors			Junior Doctors			Nurses			HCAs		
MHOs	2020 n = 327	2021 n = 279	2022 n = 397	2020 n = 25	2021 n = 23	2022 n = 25	2020 n = 64	2021 n = 38	2022 n = 70	2020 n = 217	2021 n = 206	2022 n = 249	2020 n = 21	2021 n = 12	2022 n = 53
<b>Depression</b>															
No	237 (72.5)	196 (70.3)	269 (67.8)	18 (72.0)	16 (69.6)	16 (64.0)	52 (81.3)	28 (73.7)	50 (71.4)	157 (72.4)	144 (69.9)	166 (66.7)	10 (47.6)	8 (66.7)	37 (69.8)
Yes	90 (27.5)	83 (29.7)	128 (32.2)	7 (28.0)	7 (30.4)	9 (36.0)	12 (18.7)	10 (26.3)	20 (28.6)	60 (27.6)	62 (30.1)	83 (33.3)	11 (52.4)	4 (33.3)	16 (30.2)
Mild	38 (11.6)	34 (12.2)	52 (13.1)	2 (8.0)	2 (8.7)	5 (20.0)	5 (7.8)	4 (10.5)	8 (11.4)	28 (12.9)	24 (11.7)	34 (13.7)	3 (14.3)	4 (33.3)	5 (9.4)
Moderate	36 (11)	34 (12.2)	50 (12.6)	2 (8.0)	2 (8.7)	3 (12.0)	4 (6.3)	4 (10.5)	5 (7.1)	24 (11.1)	28 (13.6)	34 (13.7)	6 (28.6)	0 (0)	8 (15.1)
Severe	10 (3.1)	4 (1.4)	11 (2.8)	2 (8.0)	1 (4.4)	1 (4.0)	1 (1.6)	0 (0)	5 (7.1)	5 (2.3)	3 (1.5)	4 (1.6)	2 (9.5)	0 (0)	1 (1.9)
Extremely severe	6 (1.8)	11 (3.9)	15 (3.8)	1 (4.0)	2 (8.7)	0 (0)	2 (3.1)	2 (5.3)	2 (2.9)	3 (1.4)	7 (3.4)	11 (4.4)	0 (0)	0 (0)	2 (3.8)
<b>Anxiety</b>															
No	215 (65.8)	199 (71.3)	244 (61.5)	22 (88.0)	19 (82.6)	18 (72.0)	47 (73.4)	31 (81.6)	52 (74.3)	140 (64.5)	145 (70.4)	147 (59.0)	6 (28.6)	4 (33.3)	27 (50.9)
Yes	112 (34.2)	80 (28.7)	153 (38.5)	3 (12.0)	4 (17.4)	7 (28.0)	17 (26.6)	7 (18.4)	18 (25.7)	77 (35.5)	61 (29.6)	102 (41.0)	15 (71.4)	8 (66.7)	26 (49.1)
Mild	33 (10.1)	17 (6.1)	33 (8.3)	1 (4.0)	2 (8.7)	1 (4.0)	9 (14.1)	2 (5.3)	4 (5.7)	20 (9.2)	13 (6.3)	20 (8.0)	3 (14.3)	0 (0)	8 (15.1)
Moderate	49 (15)	37 (13.3)	71 (17.9)	2 (8.0)	2 (8.7)	5 (20.0)	5 (7.8)	3 (7.9)	10 (14.3)	36 (16.6)	25 (12.1)	43 (17.3)	6 (28.6)	7 (58.3)	13 (24.5)
Severe	10 (3.1)	12 (4.3)	26 (6.6)	0 (0)	0 (0)	1 (4.0)	2 (3.1)	1 (2.6)	4 (5.7)	8 (3.7)	10 (4.9)	20 (8.0)	0 (0)	1 (8.3)	2 (3.8)
Extremely severe	20 (6.1)	14 (5)	23 (5.8)	0 (0)	0 (0)	0 (0)	1 (1.6)	1 (2.6)	0 (0)	13 (6.0)	13 (6.3)	19 (7.6)	6 (28.6)	0 (0)	3 (5.7)
<b>Stress</b>															
No	287 (87.8)	240 (86.0)	328 (82.6)	22 (88.0)	20 (87.0)	23 (92.0)	61 (95.3)	33 (86.8)	59 (84.3)	191 (88.0)	176 (85.4)	200 (80.3)	13 (61.9)	11 (91.7)	46 (86.8)
Yes	40 (12.2)	39 (14.0)	69 (17.4)	3 (12.0)	3 (13.0)	2 (8.0)	3 (4.7)	5 (13.2)	11 (15.7)	26 (12.0)	30 (14.6)	49 (19.7)	8 (38.1)	1 (8.3)	7 (13.2)
Mild	15 (4.6)	18 (6.5)	27 (6.8)	1 (4)	2 (8.7)	0 (0)	1 (1.6)	3 (7.9)	3 (4.3)	9 (4.2)	12 (5.8)	22 (8.8)	4 (19.1)	1 (8.3)	2 (3.8)
Moderate	16 (4.9)	15 (5.4)	25 (6.3)	2 (8)	1 (4.4)	1 (4.0)	1 (1.6)	1 (2.6)	5 (7.1)	11 (5.1)	13 (6.3)	17 (6.8)	2 (9.5)	0 (0)	2 (3.8)
Severe	8 (2.5)	3 (1.1)	12 (3)	0 (0)	0 (0)	1 (4.0)	0 (0)	0 (0)	3 (4.3)	6 (2.8)	3 (1.5)	7 (2.8)	2 (9.5)	0 (0)	1 (1.9)
Extremely severe	1 (0.3)	3 (1.1)	5 (1.3)	0 (0)	0 (0)	0 (0)	1 (1.6)	1 (2.6)	0 (0)	0 (0)	2 (1.0)	3 (1.2)	0 (0)	0 (0)	2 (3.8)
<b>PTSD of Clinical Concern</b>															
No	274 (83.8)	241 (86.4)	333 (83.9)	22 (88)	21 (91.3)	23 (92.0)	59 (92.2)	35 (92.1)	63 (90.0)	181 (83.4)	176 (85.4)	203 (81.5)	12 (57.1)	9 (75.0)	43 (81.1)
Yes	53 (16.2)	38 (13.6)	64 (16.1)	3 (12)	2 (8.7)	2 (8.0)	5 (7.8)	3 (7.9)	7 (10.0)	36 (16.6)	30 (14.6)	46 (18.5)	9 (42.9)	3 (25.0)	10 (18.9)

Table 3. Cont.

	All HCWs			Senior Doctors			Junior Doctors			Nurses			HCAs		
MHOs	2020 n = 327	2021 n = 279	2022 n = 397	2020 n = 25	2021 n = 23	2022 n = 25	2020 n = 64	2021 n = 38	2022 n = 70	2020 n = 217	2021 n = 206	2022 n = 249	2020 n = 21	2021 n = 12	2022 n = 53
MHOs	2020 Median (Q1–Q3)	2021 Median (Q1–Q3)	2022 Median (Q1–Q3)	2020 Median (Q1–Q3)	2021 Median (Q1–Q3)	2022 Median (Q1–Q3)	2020 Mean (±SD)	2021 Mean (±SD)	2022 Mean (±SD)	2020 Mean (±SD)	2021 Mean (±SD)	2022 Mean (±SD)	2020 Mean (±SD)	2021 Mean (±SD)	2022 Mean (±SD)
All HCWs	n = 327	n = 279	n = 397	n = 25	n = 23	n = 25	n = 327	n = 279	n = 397	n = 327	n = 279	n = 397	n = 327	n = 279	n = 397
Depression	2 (0–5)	2 (0–5)	2 (1–5)	2 (0–5)	2 (0–5)	2 (1–5)	3.3 ± 3.6	3.5 ± 4	3.7 ± 3.9	3.3 ± 3.6	3.5 ± 4	3.7 ± 3.9	3.3 ± 3.6	3.5 ± 4	3.7 ± 3.9
Anxiety	2 (1–4)	2 (0–4)	2 (1–5)	2 (0–4)	2 (0–4)	2 (1–5)	3.1 ± 3.3	2.7 ± 3.3	3.4 ± 3.6	3.1 ± 3.3	2.7 ± 3.3	3.4 ± 3.6	3.1 ± 3.3	2.7 ± 3.3	3.4 ± 3.6
Stress	3 (1–6)	3 (1–6)	4 (2–7)	3 (1–6)	3 (1–6)	4 (2–7)	3.8 ± 3.5	3.8 ± 3.6	4.6 ± 3.8	3.8 ± 3.5	3.8 ± 3.6	4.6 ± 3.8	3.8 ± 3.5	3.8 ± 3.6	4.6 ± 3.8
PTSD	7 (2–18)	7 (2–16)	9 (2–20)	7 (2–16)	7 (2–16)	9 (2–20)	12.3 ± 14.5	11.1 ± 12.8	12.7 ± 12.8	12.3 ± 14.5	11.1 ± 12.8	12.7 ± 12.8	12.3 ± 14.5	11.1 ± 12.8	12.7 ± 12.8
Senior doctors	n = 25	n = 23	n = 25	n = 25	n = 23	n = 25	n = 25	n = 23	n = 25	n = 25	n = 23	n = 25	n = 25	n = 23	n = 25
Depression	1 (0–5)	2 (0–6)	2 (1–5)	1 (0–5)	2 (0–6)	2 (1–5)	3.0 ± 4.4	4.2 ± 5.5	3.5 ± 3.4	3.0 ± 4.4	4.2 ± 5.5	3.5 ± 3.4	3.0 ± 4.4	4.2 ± 5.5	3.5 ± 3.4
Anxiety	1 (0–2)	1 (0–3)	1 (0–4)	1 (0–2)	1 (0–3)	1 (0–4)	1.4 ± 1.8	1.4 ± 1.8	2.2 ± 3.0	1.4 ± 1.8	1.4 ± 1.8	2.2 ± 3.0	1.4 ± 1.8	1.4 ± 1.8	2.2 ± 3.0
Stress	2 (1–5)	3 (1–6)	4 (1–6)	2 (1–5)	3 (1–6)	4 (1–6)	3.7 ± 3.4	3.5 ± 3.4	4.2 ± 3.5	3.7 ± 3.4	3.5 ± 3.4	4.2 ± 3.5	3.7 ± 3.4	3.5 ± 3.4	4.2 ± 3.5
PTSD	6 (1–9)	3 (0–10)	3 (0–11)	6 (1–9)	3 (0–10)	3 (0–11)	8.7 ± 10.4	6.5 ± 8.4	7.5 ± 9.1	8.7 ± 10.4	6.5 ± 8.4	7.5 ± 9.1	8.7 ± 10.4	6.5 ± 8.4	7.5 ± 9.1
Junior doctors	n = 64	n = 38	n = 70	n = 64	n = 38	n = 70	n = 64	n = 38	n = 70	n = 64	n = 38	n = 70	n = 64	n = 38	n = 70
Depression	1.5 (0–4)	3 (1–5)	2 (0–5)	1.5 (0–4)	3 (1–5)	2 (0–5)	2.7 ± 4.0	3.6 ± 4.0	3.3 ± 4.1	2.7 ± 4.0	3.6 ± 4.0	3.3 ± 4.1	2.7 ± 4.0	3.6 ± 4.0	3.3 ± 4.1
Anxiety	2 (1–4)	1 (0–3)	2 (0–4)	2 (1–4)	1 (0–3)	2 (0–4)	2.5 ± 3.0	2.0 ± 2.9	2.4 ± 2.5	2.5 ± 3.0	2.0 ± 2.9	2.4 ± 2.5	2.5 ± 3.0	2.0 ± 2.9	2.4 ± 2.5
Stress	3 (1–5.5)	4 (1–6)	3.5 (1–6)	3 (1–5.5)	4 (1–6)	3.5 (1–6)	3.5 ± 3.4	4.2 ± 3.6	4.3 ± 3.8	3.5 ± 3.4	4.2 ± 3.6	4.3 ± 3.8	3.5 ± 3.4	4.2 ± 3.6	4.3 ± 3.8
PTSD	5 (1–9.5)	4 (1–10)	4.5 (0–16)	5 (1–9.5)	4 (1–10)	4.5 (0–16)	8.6 ± 13.7	9.0 ± 13.9	9.5 ± 11.7	8.6 ± 13.7	9.0 ± 13.9	9.5 ± 11.7	8.6 ± 13.7	9.0 ± 13.9	9.5 ± 11.7
Nurses	n = 217	n = 206	n = 249	n = 217	n = 206	n = 249	n = 217	n = 206	n = 249	n = 217	n = 206	n = 249	n = 217	n = 206	n = 249
Depression	3 (1–5)	2 (0–5)	3 (1–6)	3 (1–5)	2 (0–5)	3 (1–6)	3.3 ± 3.3	3.5 ± 3.9	3.8 ± 3.9	3.3 ± 3.3	3.5 ± 3.9	3.8 ± 3.9	3.3 ± 3.3	3.5 ± 3.9	3.8 ± 3.9
Anxiety	2 (1–5)	2 (0–4)	3 (1–6)	2 (1–5)	2 (0–4)	3 (1–6)	3.2 ± 3.2	2.9 ± 3.5	3.8 ± 3.9	3.2 ± 3.2	2.9 ± 3.5	3.8 ± 3.9	3.2 ± 3.2	2.9 ± 3.5	3.8 ± 3.9
Stress	2 (1–6)	3 (1–5)	4 (2–7)	2 (1–6)	3 (1–5)	4 (2–7)	3.6 ± 3.4	3.7 ± 3.7	4.7 ± 3.8	3.6 ± 3.4	3.7 ± 3.7	4.7 ± 3.8	3.6 ± 3.4	3.7 ± 3.7	4.7 ± 3.8
PTSD	7 (2–19)	8 (2–18)	10 (3–21)	7 (2–19)	8 (2–18)	10 (3–21)	12.5 ± 14.1	11.6 ± 13	13.6 ± 13.1	12.5 ± 14.1	11.6 ± 13	13.6 ± 13.1	12.5 ± 14.1	11.6 ± 13	13.6 ± 13.1
HCAs	n = 21	n = 12	n = 53	n = 21	n = 12	n = 53	n = 21	n = 12	n = 53	n = 21	n = 12	n = 53	n = 21	n = 12	n = 53
Depression	5 (2–10)	2 (1–5)	2 (1–5)	5 (2–10)	2 (1–5)	2 (1–5)	5.8 ± 4.0	2.9 ± 2.0	3.6 ± 3.7	5.8 ± 4.0	2.9 ± 2.0	3.6 ± 3.7	5.8 ± 4.0	2.9 ± 2.0	3.6 ± 3.7
Anxiety	6 (3–10)	5 (2.5–6)	3 (1–5)	6 (3–10)	5 (2.5–6)	3 (1–5)	6.0 ± 4.1	4.6 ± 2.3	3.9 ± 3.5	6.0 ± 4.1	4.6 ± 2.3	3.9 ± 3.5	6.0 ± 4.1	4.6 ± 2.3	3.9 ± 3.5
Stress	7 (4–9)	4.5 (4–6)	3 (2–6)	7 (4–9)	4.5 (4–6)	3 (2–6)	6.7 ± 4.0	4.8 ± 1.9	4.4 ± 3.9	6.7 ± 4.0	4.8 ± 1.9	4.4 ± 3.9	6.7 ± 4.0	4.8 ± 1.9	4.4 ± 3.9
PTSD	22 (13–45)	15 (11–23.5)	14 (6–20)	22 (13–45)	15 (11–23.5)	14 (6–20)	25.1 ± 17.5	17.3 ± 9.7	15.5 ± 13.1	25.1 ± 17.5	17.3 ± 9.7	15.5 ± 13.1	25.1 ± 17.5	17.3 ± 9.7	15.5 ± 13.1



**Table 4.** The association between individual factors and each MHO status using GEE.

	Depression		Anxiety		Stress		PTSD of Clinical Concern	
	OR (95% CI)	<i>p</i> -Value	OR (95% CI)	<i>p</i> -Value	OR (95% CI)	<i>p</i> -Value	OR (95% CI)	<i>p</i> -Value
<b>Survey Year (Ref: 2020)</b>								
2021	0.88 (0.62, 1.24)	0.461	0.76 (0.56, 1.02)	0.071	0.84 (0.55, 1.28)	0.412	0.70 (0.44, 1.11)	0.130
2022	0.62 (0.38, 1.01)	0.055	0.78 (0.49, 1.24)	0.289	0.75 (0.37, 1.52)	0.426	0.70 (0.35, 1.38)	0.301
<b>Gender (Ref: Male)</b>								
Female	1.04 (0.68, 1.59)	0.876	1.86 (1.20, 2.89)	0.005	1.30 (0.77, 2.20)	0.330	1.56 (0.84, 2.89)	0.162
<b>Age group (Ref: 21–30)</b>								
31–40	1.21 (0.79, 1.84)	0.382	0.66 (0.45, 0.97)	0.036	0.90 (0.54, 1.51)	0.692	0.68 (0.4, 1.15)	0.147
≥41	1.76 (0.84, 3.71)	0.135	0.93 (0.44, 1.95)	0.847	0.62 (0.25, 1.55)	0.306	1.00 (0.43, 2.29)	0.990
<b>Ethnicity (Ref: Chinese)</b>								
Filipino	0.72 (0.42, 1.21)	0.212	0.69 (0.41, 1.16)	0.165	0.51 (0.25, 1.02)	0.058	0.97 (0.49, 1.92)	0.925
Others	1.11 (0.72, 1.72)	0.641	1.24 (0.82, 1.87)	0.306	1.08 (0.64, 1.82)	0.779	1.69 (0.96, 2.96)	0.069
<b>Marital status (Ref: Single/divorced/widowed)</b>								
Married	0.70 (0.49, 1.02)	0.060	0.92 (0.64, 1.32)	0.648	1.16 (0.72, 1.87)	0.538	1.45 (0.91, 2.30)	0.117
<b>Occupation (Ref: Senior doctors)</b>								
Junior doctors	0.43 (0.19, 0.99)	0.048	0.67 (0.31, 1.46)	0.312	0.65 (0.2, 2.14)	0.475	0.68 (0.22, 2.10)	0.503
Nurses	0.63 (0.29, 1.38)	0.246	1.00 (0.48, 2.10)	0.999	0.86 (0.27, 2.75)	0.804	0.98 (0.34, 2.87)	0.976
HCAAs	1.07 (0.42, 2.73)	0.886	2.29 (0.97, 5.40)	0.058	1.60 (0.43, 5.90)	0.482	2.33 (0.72, 7.60)	0.159
<b>Number of years in occupation</b>	0.94 (0.90, 0.98)	0.005	0.97 (0.93, 1.01)	0.100	0.95 (0.9, 1.01)	0.098	0.96 (0.91, 1.00)	0.06
<b>Psychiatric history</b>	3.75 (1.41, 9.96)	0.008	1.56 (0.48, 5.08)	0.460	3.20 (1.15, 8.92)	0.027	0.91 (0.24, 3.48)	0.895
<b>Living with elderly</b>	1.82 (1.20, 2.77)	0.005	1.44 (0.95, 2.19)	0.090	1.71 (1.08, 2.70)	0.022	2.12 (1.32, 3.40)	0.002
<b>Family infected by Covid</b>	1.28 (0.82, 1.98)	0.275	1.23 (0.80, 1.89)	0.349	1.01 (0.59, 1.73)	0.978	0.96 (0.53, 1.74)	0.897
<b>Workplace support</b>	0.74 (0.57, 0.96)	0.021	1.09 (0.85, 1.40)	0.496	1.13 (0.81, 1.57)	0.479	1.02 (0.74, 1.40)	0.925
<b>Social connected</b>	0.5 (0.38, 0.64)	<0.001	0.67 (0.52, 0.85)	0.001	0.57 (0.44, 0.75)	<0.001	0.52 (0.39, 0.7)	<0.001
<b>Concerns about infection</b>	1.15 (0.93, 1.41)	0.200	1.31 (1.06, 1.62)	0.011	0.91 (0.71, 1.17)	0.455	1.48 (1.15, 1.92)	0.003
<b>Concerns about working environment</b>	1.21 (1.03, 1.44)	0.024	1.28 (1.08, 1.51)	0.004	1.14 (0.93, 1.41)	0.204	1.16 (0.92, 1.47)	0.213
<b>Concerns about workload</b>	1.46 (1.19, 1.79)	<0.001	1.22 (1.00, 1.48)	0.050	1.9 (1.41, 2.55)	<0.001	1.64 (1.25, 2.15)	<0.001
<b>Agreed religion help cope with stress</b>	0.84 (0.53, 1.32)	0.448	1.18 (0.76, 1.82)	0.466	0.59 (0.34, 1.03)	0.063	0.70 (0.37, 1.30)	0.259
<b>Agreed exercise help cope with stress</b>	0.91 (0.57, 1.44)	0.678	0.99 (0.64, 1.54)	0.972	0.99 (0.52, 1.88)	0.965	0.65 (0.38, 1.13)	0.127
<b>Feel respected</b>	0.63 (0.42, 0.95)	0.026	0.56 (0.38, 0.84)	0.005	0.56 (0.34, 0.93)	0.026	0.69 (0.41, 1.18)	0.173

Note: Only individuals who completed at least two measurements in any two survey years were included in the model. HCA: Healthcare Assistants; PTSD: Post-traumatic stress disorder; OR: odds ratio; 95% CI: 95% confidence interval.

### 3.3.2. Anxiety

A total of 34.2% of ED HCWs screened positive for anxiety in 2020, 28.7% in 2021 and 38.5% in 2022 (Table 3). There was a reduction in the proportion of HCAs who screened positive for anxiety (2020: 71.4%, vs. 2021: 66.7%, vs. 2022: 49.1%) and a reduction in the HCAs' anxiety scores (2020:  $6.0 \pm 4.1$ , vs. 2021:  $4.6 \pm 2.3$ , vs. 2022:  $3.9 \pm 3.5$ ) (Table 3). Improvement in anxiety was also observed amongst the matched HCAs (2020: 71.4%, vs. 2021: 57.1%, vs. 2022: 42.9%) (Table A5). Amongst the 121 nursing staff who participated in all three surveys, there was a reduction in the risk of developing anxiety in 2021 and 2022 compared to 2020 (Table A6).

The GEE results showed that ED HCWs who were 31–40 years old (OR 0.66 [0.45,0.97],  $p = 0.036$ ), who perceived themselves to be socially connected (OR 0.67 [0.52,0.85],  $p = 0.001$ ) and felt respected (OR 0.56 [0.38,0.84],  $p = 0.005$ ) had lower odds of developing anxiety (Table 4). ED HCWs who were female (OR 1.86 [1.20,2.89],  $p = 0.005$ ), with concerns about infection risk (OR 1.31 [1.06,1.62],  $p = 0.011$ ) and working environment (OR 1.28 [1.08,1.51],

$p = 0.004$ ) had higher odds of developing anxiety. Compared to the 2020 cohort, the odds of developing anxiety in the 2021 and 2022 cohorts were lower but not significant.

### 3.3.3. Stress

A total of 12.2% of ED HCWs screened positive for stress in 2020, which increased to 14% in 2021 and 17.4% in 2022 (Table 3). The proportion of junior doctors (2020: 4.7%, vs. 2021: 13.2%, vs. 2022: 15.7%) and nurses (2020: 12.0%, vs. 2021: 14.6%, vs. 2022: 19.7%) who screened positive for stress was increasing. The stress scores amongst senior doctors, junior doctors and nurses were also increasing. In contrast, there was a reduction in stress scores amongst HCAs (Mean  $\pm$  SD: 2020:  $6.7 \pm 4.0$ , vs. 2021:  $4.8 \pm 1.9$ , vs. 2022:  $4.4 \pm 3.9$ ) (Table 3).

GEE results showed that ED HCWs with better social connections (OR 0.57 [0.44,0.75],  $p < 0.001$ ) and who felt respected (OR 0.56 [0.34,0.93],  $p = 0.026$ ) had lower odds of developing stress (Table 4). ED HCWs who had a psychiatric history (OR 3.20 [1.15,8.92],  $p = 0.027$ ), those who were living with elderly (OR 1.71 [1.08,2.70],  $p = 0.022$ ) and had concerns about workload (OR 1.90 [1.41,2.55],  $p < 0.001$ ) had higher odds of developing stress. Compared to the 2020 cohort, the odds of developing stress in the 2021 and 2022 cohorts were lower but not significant.

### 3.3.4. PTSD of Clinical Concern

A total of 16.2% of ED HCWs screened positive for PTSD in 2020, 13.6% in 2021 and 16.1% in 2022 (Table 3). There was a downward trend in PTSD scores among HCAs (mean  $\pm$  SD: 2020:  $25.1 \pm 17.5$ , vs. 2021:  $17.3 \pm 9.7$ , vs. 2022:  $15.5 \pm 13.1$ ) (Table 3).

The GEE results showed that ED HCWs who perceived themselves to have better social connections (OR 0.52 [0.39,0.70],  $p < 0.001$ ) had lower odds of developing PTSD (Table 4). ED HCWs who were living with the elderly (OR 2.12 [1.32,3.40],  $p = 0.002$ ) and had concerns about infection risk (OR 1.48 [1.15,1.92],  $p = 0.003$ ) and workload (OR 1.64 [1.25,2.15],  $p < 0.001$ ) had higher odds of developing PTSD. Compared to the 2020 cohort, the odds of developing PTSD of clinical concern in the 2021 and 2022 cohorts were lower but not significant.

## 4. Discussion

Our 3-year prospective cohort study found (1) worsening depression and stress in the overall cohort, (2) improving anxiety, stress and PTSD scores amongst HCAs as a subgroup, (3) increased concerns about workload, (4) an overall perception of receiving less workplace support and (5) reduced concerns about COVID-19 infection risk and working environment. ED HCWs who were female, had a psychiatric history, were living with the elderly and had concerns about the working environment, workload and infection risk had poorer MHOs.

### 4.1. Overall Worsening Depression and Stress

Overall, there was an increasing proportion of ED HCWs who screened positive for depression and stress, and their scores were increasing over the years; these were not statistically significant when adjusted for (Table 4). Nevertheless, these are interesting findings, as we had expected ED HCWs to have received care for their mental health concerns or to have psychologically adapted to the changes within the healthcare system and community over the past 3.5 years. These were also in spite of the easing of infection-control measures nationally since the beginning of 2022 and efforts by the hospital and department to improve HCWs' wellbeing. The prevalence of depression (27.5–32.3%) amongst our cohorts of ED HCWs is much higher than that demonstrated by Teo et. al.'s study [3], which was carried out across 6 Southeast Asian countries (an average of 4%). This could be due to the cohort sampling differences, as Teo et. al.'s study included other non-frontline HCWs - EMTs and hospital administrative staff, and had used different measurement tools for depression. Nevertheless, their study showed that Singapore HCWs

reported the highest levels of burnout (39%), anxiety (21%) and depression (9%) compared to the 5 other countries.

In line with our study's findings, a cross-sectional study [10] amongst Taiwanese front-line HCWs showed persistently poor MHOs (anxiety, depression and insomnia) irrespective of the wave of the pandemic. This was partly explained by the changes in workload, work schedules, working overtime and concerns over the risk of infection [10,11]. Similarly, a Chinese study that was carried out about 3 years after the 2003 severe acute respiratory syndrome (SARS) outbreak showed persistently high levels of psychological stress, which was thought to be attributed to working in a high-risk environment and having a fear of being a source of infection to a family member(s) [12]. These factors, specifically concerns about workload and the working environment, could likely explain the persistently poor levels of depression and stress amongst our ED HCWs.

However, our subgroup of HCAs bucked this trend and had improved MHOs over the years; there was a reduction in the proportion of HCAs with depression, anxiety and PTSD and an improvement in anxiety, stress and PTSD scores. From 2020 to 2022, there was a considerable increase in the number of HCAs recruited by the department (Table 1). We postulate several reasons for HCAs' improved MHOs: Firstly, new HCAs voluntarily joined the department during the pandemic and hence would have likely been adequately self-educated on COVID-19 and psychologically prepared for the type of work they would carry out and the working environment they would be in. Secondly, with the increase in workforce numbers, patient care and workload could be distributed appropriately and thus easing the burden off each other. They would also be able to provide more camaraderie and social support to one another, helping to alleviate uncertainties and their concerns about infection risk and the working environment. The job description of HCAs includes taking patients' vital signs, doing point-of-care tests and tending to patients' hygiene and personal care. The work is generally less intense compared to nurses.

#### *4.2. Concerns about Workload and Workplace Support*

Workload-related concerns have grown from 2020 to 2022 across our subgroups of HCWs. The pandemic has placed great pressure on the healthcare system, and many studies have attributed that to a combination of an increase in workload and the attrition of HCWs [13]. HCWs suffer from stress and burnout when overworked, and that compromises their ability to deliver good care [14]. Despite being in an endemic phase, there will be intermittent surges in COVID-19 patients attending healthcare services with the ongoing emergence of different COVID-19 variants and the resuming of normal social activities [15,16]. Interestingly, in spite of the lower ED attendances when compared to pre-COVID-19 numbers, there had been an increasing number of sicker patients requiring higher acuity care (Table A2). Waiting time to see a doctor stayed fairly constant, yet the average waiting time to obtain a ward bed has increased drastically. This access block issue has caused the ED to be overcrowded, and the issue is also evident in other public hospitals nationally [17,18]. ED HCWs do not just have to tend to new incoming patients but also patients who are boarding in the ED. Furthermore, the COVID-19 pandemic has affected the processes of routine comprehensive care for chronic patients due to the repurposing of healthcare facilities and reduction in services [19]. This in turn has resulted in a possible "rebound effect" of non-COVID-19 patients presenting to the ED. Judging from the increase in higher-acuity patients received in our ED, we should perhaps give some thought to the impact on the healthcare system as we deal with the aftermath of suboptimally managed chronic diseases after the pandemic phase is over [20]. Overall, even though the staff numbers in our department have grown these 3 years, which was largely caused by the increased hire of HCAs, the more experienced workforce at the start of the pandemic was replaced by new hires (evidenced by changes in staff demographics in Table 1), further contributing to the persistent high scores on workload concerns.

There was also the perception of less support from supervisors and colleagues in spite of measures being put in place by the hospital to provide mental support to HCWs in the

form of wellness programs and the provision of a care hotline. We believe this perception has much to do with the factors outlined above, and it goes beyond just increasing the healthcare workforce numbers. The new hires may consist of redeployed staff, who would have to match the skillsets of what needs to be done. Recent publications on staff redeployment during the pandemic have highlighted the importance of carrying out detailed skills assessment to ensure patients' needs are met [21]. In addition, access blocks and ED overcrowding erode staff resilience and contribute to staff feeling unsafe and unsupported [22]. Solving such operational issues will likely have a greater impact on staff wellbeing than just the provision of wellness programs.

#### *4.3. Whole Sampled Cohort vs. Matched Cohort*

When we delved into the differences between the 2 groups, we realised that there were slight differences. MHOs in the 160 matched cohort showed similar trends from 2020 to 2022 in both severity and scores (Table A5). This was in comparison to the overall worsening of depression and stress when we looked at the entire sampled population. Another interesting finding in the matched cohort (Table A6) is that the odds of having anxiety in 2021 and 2022 were lower compared to 2020 (2021: OR 0.67 [0.46–0.99] vs. 2022: OR 0.63 [0.42–0.93]) and is most evident amongst the nursing staff. We were not surprised that this finding occurred in the matched cohort, who had been through all 3.5 years of the pandemic. Anxiety in this group would have improved from 2020 when information and knowledge of the pandemic became more available through the subsequent years.

#### *4.4. Strengths and Limitations*

To our knowledge, this is one of the few studies to assess MHOs amongst ED HCWs over different waves of COVID-19. Validated assessment tools were used to measure MHOs. Our study analysed the ED cohort as a whole and those who had completed 3 surveys (matched). Most similar longitudinal studies just compared cohorts from the same place of interest [23,24]. With this information, we can target more focused interventions and prevention measures for the HCWs who have been with the department for the last 3.5 years, as well as new hires.

The limitations of this study include it being a single-centre study, which may limit the study's generalisability to other healthcare settings. Voluntary participation and the lower response rate in 2021 could potentially have introduced selection bias. Only known confounders were corrected for. Socioeconomic factors, for example, housing conditions, which could have been confounders, were not included. The self-reporting nature of DASS-21 and IES-R, rather than clinician-facilitated assessments, could have also introduced bias.

### **5. Conclusions**

In summary, our study showed that our frontline ED HCWs continue to have overall poor levels of depression, anxiety, stress and PTSD, irrespective of the wave of the pandemic. There was worsening depression and stress in the entire cohort, with the exception of the HCAs, for the various reasons mentioned above. ED HCWs who were female, had a psychiatric history, who were living with the elderly and had concerns about the working environment, workload and infection risk had poorer MHOs.

This study is crucial in aiding healthcare systems to identify potentially modifiable workplace factors associated with poorer MHOs. These will guide us in refining existing and in devising more focused interventions to further support our ED HCWs' wellbeing. Furthermore, the insights gleaned from this study about HCWs' concerns about workload and workplace support will aid us in optimising workflow processes with regards to the access block problems of staff attrition and staff redeployment in order to build a more resilient frontline workforce. It will be interesting and beneficial to our ED HCWs and to the wider national healthcare system to further reassess the changes in their MHOs over the next few years as the pandemic settles into endemicity.

**Author Contributions:** F.T., K.A.R. and D.M. were involved in the concept and design of the study. F.T. obtained research funding. F.T., K.A.R., W.Y.L., D.M. and H.N.N. supervised the conduct of the study and data collection. L.G. and J.A.D.M. managed the data, including quality control. F.T., K.A.R., L.G., D.M. and J.A.D.M. provided advice on study design, methodology and statistical support. L.G. and J.A.D.M. analysed the data. F.T., K.A.R., L.G. and W.Y.L. drafted the manuscript, and all authors contributed substantially to its revision. F.T. takes overall responsibility for the paper. All authors have read and agreed to the published version of the manuscript.

**Funding:** This study is supported by the Alexandra Health Fund Ltd. through the Alexandra Health Enabling Grant (AHEG), grant number AHEG2201.

**Institutional Review Board Statement:** The study was conducted according to the guidelines of the Declaration of Helsinki and approved by the Institutional Review Board (or Ethics Committee) of National Healthcare Group (DSRB 2020/00653, 2021/00336 and 2022/00290; and date of approval on 27 May 2020, 12 May 2021 and 8 June 2022, respectively).

**Informed Consent Statement:** Written consent was obtained from all subjects involved in the study.

**Data Availability Statement:** The individual datasets collected and analysed will not be publicly made available due to privacy and confidentiality reasons. Data presented in this study is available upon request from the corresponding author.

**Acknowledgments:** This 3rd study uses data from our previous 1st and 2nd COVID-19 studies carried out in 2020 [4] and 2021 [5], respectively.

**Conflicts of Interest:** The authors declare no conflict of interest. The funders had no role in the design of the study; in the collection, analyses, or interpretation of data; in the writing of the manuscript, or in the decision to publish the results.

## Appendix A

**Table A1.** Timeline of main changes in Singapore through the 1-year period between the 2nd and 3rd surveys (1–28 June 2022).

21 June 2021	Phase 3 (heightened alert): Food and beverages (F&B) dine-in to resume (max 2 pax per group), sports/exercise activities to resume (max 5 per group)
21 July 2021	Vaccination programme open to all in Singapore aged 12–39 years
5 July 2021	Ministry of Health (MOH) announced on the small risk of myocarditis and pericarditis with after vaccination with mRNA COVID-19 vaccines
12 July 2021	Phase 3 update: F&B (dine-in max 5 pax per group all fully vaccinated/recovered from COVID-19/have negative COVID-19 test result, wedding receptions to resume, working from home remains default
22 July 2021	Reverted to Phase 2 till 10 August 2021: No dine-ins (only takeaways), social gatherings of max 2 pax, max 2 unique visitors per household per day, No indoor sports/exercise activities
20 August 2021	Vaccination-differentiated measures: If vaccinated, max 5 pax per social gathering and at F&B outlets, otherwise max 2 pax for unvaccinated
30 August 2021	Home isolation pilot started for those vaccinated with mild or no symptoms
8 September 2021	Vaccinated Travel Lanes (VTL) with Brunei and Germany
15 September 2021	COVID-19 booster vaccine offered to persons aged 60 years and above
18 September 2021	Home Recovery to be default care management model for suitable individuals
27 September 2021	Tightening community measures to stabilise situation: Social gatherings of max 2 pax per group, 1 gathering a day, dine-in with max 2 pax, sports activities max 2 pax per group
4 October 2021	COVID-19 booster vaccine offered to persons aged 50 years and above
19 October 2021	VTL for Canada, Denmark, France, Italy, Netherlands, Spain, UK and US
10 November 2021	Dine-in with max 5 pax, team sports to max 10 pax
29 November 2021	VTL with Malaysia, Finland, Sweden, India and Indonesia
2 December 2021	2 Omicron cases first detected in Singapore
3 December 2021	No home recovery for Omicron variant cases; to be isolated at National Centre for Infectious Diseases
6 December 2021	VTL with Qatar, Saudi Arabia and United Arab Emirates



**Table A1.** *Cont.*

16 December 2021	COVID-19 booster vaccine offered to persons aged 18 and above
22 December 2021	COVID-19 vaccination offered to persons aged 5 to 11 years old
27 December 2021	Adjustment in approach to manage Omicron variant: Isolation in dedicated facilities not needed, able to self-isolate at home for 10 days
1 January 2022	50% of employees who can work from home can return to office
15 January 2022	Unvaccinated individuals cannot return to work place even with negative swab tests
22 January 2022	Home isolation reduced from 10 to 7 days
22 January 2022	COVID-19 booster vaccine offered to persons aged 12 to 17
9 February 2022	Home isolation for at least 72 h and to carry out self-administered Antigen Rapid Test (ART) after 72 h. To resume normal activities if ART is negative
14 February 2022	COVID-19 booster vaccinations required to maintain 'fully vaccinated' status
25 February 2022	Measures to live with Omicron variant & introduction of Safe Management Measures (SMMs) framework: group size & household visitors up to 5 pax at one time, safe distancing not required in mask on settings, up to 50% employees can return to office, capacity limits for events with >1000 pax and no safe distancing
29 March 2022	Easing of SMMs: Group size & household visitors max 10 pax for mask-off settings, up to 75% of workforce can return to office, mask wearing outdoors is optional but required in indoor settings, 1 m safe distancing required for mask-off settings
1 April 2022	Fully vaccinated travellers and children under 12 years old can enter Singapore quarantine-free
22 April 2022	Step down to Disease Outbreak Response System Condition (DORSCON) Yellow (from Orange since Feb 2020)
26 April 2022	No limit to group sizes/visitors per household, Capacity limits for events removed, Safe distancing not required, check-in using TraceTogether & SafeEntry not required except for events >500 pax & nightlife establishments with dancing, All workers can return to office,
15 May 2022	First local cases BA.4 and BA.5 variant infections
3 June 2022	Pre-departure tests not required before departure to Singapore and no quarantine/COVID-19 tests required upon arrival
10 June 2022	Second COVID-19 booster vaccine offered to those 50 years and older
21 June 2022	23% week-on-week increased in COVID-19 community infections largely by increased spread of newer Omicron subvariants BA.4 and BA.5
Reference: Ministry of Health Singapore. Available on: <a href="https://www.moh.gov.sg/covid-19">https://www.moh.gov.sg/covid-19</a> , accessed on 26 October 2022.	

**Appendix B****Table A2.** Average number of ED patients seen per month, average waiting time to see a doctor in ED (in minutes) and average waiting time to obtain a ward bed (in hours) from 2019 to 2022.

	2019 [Pre COVID-19]	2020 [Beginning of COVID-19]	2021 [Mid COVID-19]	2022 [Early Post COVID-19]
Average no. of patients seen in ED per month (n)	11,124	9758	9339	9618
Average no. of P1 */P2 ^ patients seen per month (n,%)	4297 (38.6%)	4451 (45.6%)	4666 (50.0%)	5052 (52.5%)
Average waiting time to be seen by a doctor (mins)	31	28	26	34
Average waiting time to obtain a ward bed (hours)	1.1	3.4	5.8	11.2

\* Triage acuity level 1 (resuscitation) patients needing immediate, life-saving intervention; ^ Triage acuity level 2 (emergent) patients needing immediate assessment and rapid treatment.

## Appendix C

**Study Protocol: Changes in Mental Health Among Frontline Emergency Department Healthcare Workers as Singapore Transitions from COVID-19 Pandemic to Endemic**

Date: \_\_\_\_\_

Last 4 digits of mobile number:

--	--	--	--

**A. Demographic information**

A1 Gender	1. Female    2. Male		
A2 Age (in years)	1. 21-30    4. 51-60 2. 31-40    5. 61 and older 3. 41-50		
A3 Ethnicity	1. Chinese 2. Malay 3. Indian 4. Filipino 5. Caucasian 6. Others (specify) _____		
A4 Marital status	1. Single 2. Married 3. Separated/Divorced 4. Widow		
A5a Occupation	1. Senior Doctor – defined as Dr on Senior roster 2. Junior Doctor – defined as Dr on the Junior roster 3. Nurse 4. Healthcare Assistant (HCA)		
A5b Total number of years in current occupation (as Doctor, Nurse or HCA)	<table border="1"><tr><td></td><td></td></tr></table>		
A6 Past medical history of chronic diseases (e.g., Hypertension, Diabetes)	1. Yes    2. No		
A7 Past psychiatric history (e.g., depression, anxiety and panic disorders)	1. Yes    2. No		
A8 I live with young children (<12 y.o.) at home	1. Yes    2. No		
A9 I live with elderly (>65 y.o.) at home	1. Yes    2. No		
A10 I live alone	1. Yes    2. No		
A11 I practice a religion	1. Yes    2. No		
A12 I have a family member or close friend who has contracted COVID-19 during this outbreak	1. Yes    2. No		
A13 I have received the COVID-19 vaccine (includes one or two doses of vaccine)	1. Yes    2. No		

Figure A1. Cont.

**B.** Please read each statement and circle a number 0, 1, 2 or 3 which indicates how much the statement applied to you *over the past week*. There are no right or wrong answers. Do not spend too much time on any statement.

*The rating scale is as follows:*

- 0 Did not apply to me at all
- 1 Applied to me to some degree, or some of the time
- 2 Applied to me to a considerable degree, or a good part of time
- 3 Applied to me very much, or most of the time

B1	I found it hard to wind down	0	1	2	3
B2	I was aware of dryness of my mouth	0	1	2	3
B3	I couldn't seem to experience any positive feeling at all	0	1	2	3
B4	I experienced breathing difficulty (e.g., excessively rapid breathing, breathlessness in the absence of physical exertion)	0	1	2	3
B5	I found it difficult to work up the initiative to do things	0	1	2	3
B6	I tended to over-react to situations	0	1	2	3
B7	I experienced trembling (e.g., in the hands)	0	1	2	3
B8	I felt that I was using a lot of nervous energy	0	1	2	3
B9	I was worried about situations in which I might panic and make a fool of myself	0	1	2	3
B10	I felt that I had nothing to look forward to	0	1	2	3
B11	I found myself getting agitated	0	1	2	3
B12	I found it difficult to relax	0	1	2	3
B13	I felt down-hearted and blue	0	1	2	3
B14	I was intolerant of anything that kept me from getting on with what I was doing	0	1	2	3
B15	I felt I was close to panic	0	1	2	3
B16	I was unable to become enthusiastic about anything	0	1	2	3
B17	I felt I wasn't worth much as a person	0	1	2	3
B18	I felt that I was rather touchy	0	1	2	3
B19	I was aware of the action of my heart in the absence of physical exertion (e.g., sense of heart rate increase, heart missing a beat)	0	1	2	3
B20	I felt scared without any good reason	0	1	2	3
B21	I felt that life was meaningless	0	1	2	3

**Figure A1.** *Cont.*



**C.** Below is a list of difficulties people sometimes have after stressful life events. Please read each item, and then indicate how distressing each difficulty has been for you for the *past 7 days* with respect to COVID-19. How much have you been distressed or bothered by these difficulties?

	Not At All	A Little Bit	Moderately	Quite A Bit	Extremely
C1 Any reminder brought back feelings about it	0	1	2	3	4
C2 I had trouble staying asleep	0	1	2	3	4
C3 Other things kept making me think about it	0	1	2	3	4
C4 I felt irritable and angry	0	1	2	3	4
C5 I avoided letting myself get upset when I thought about it or was reminded of it	0	1	2	3	4
C6 I thought about it when I didn't mean to	0	1	2	3	4
C7 I felt as if it hadn't happened or wasn't real	0	1	2	3	4
C8 I stayed away from reminders of it	0	1	2	3	4
C9 Pictures about it popped into my mind	0	1	2	3	4
C10 I was jumpy and easily startled	0	1	2	3	4
C11 I tried not to think about it	0	1	2	3	4
C12 I was aware that I still had a lot of feelings about it, but I didn't deal with them	0	1	2	3	4
C13 My feelings about it were kind of numb	0	1	2	3	4
C14 I found myself acting or feeling like I was back at that time	0	1	2	3	4
C15 I had trouble falling asleep	0	1	2	3	4
C16 I had waves of strong feelings about it	0	1	2	3	4
C17 I tried to remove it from my memory	0	1	2	3	4
C18 I had trouble concentrating	0	1	2	3	4
C19 Reminders of it caused me to have physical reactions such as sweating, trouble breathing, nausea, or a pounding heart	0	1	2	3	4
C20 I had dreams about it	0	1	2	3	4
C21 I felt watchful and on-guard	0	1	2	3	4
C22 I tried not to talk about it	0	1	2	3	4

Figure A1. Cont.

**D. Concerns regarding COVID-19**

Please indicate how much you agree or disagree with the following statements based on your experience *over the past year*.

	Strongly Disagree	Disagree	Not Sure But Probably Disagree	Not Sure But Probably Agree	Agree	Strongly Agree
D1 I find the following components of PPE uncomfortable to wear: (Circle for those components you wear at work)						
Mask (N95)	1	2	3	4	5	6
Goggles / Face shield	1	2	3	4	5	6
Gloves	1	2	3	4	5	6
Gown	1	2	3	4	5	6
PAPR	1	2	3	4	5	6
D2 Wearing PPE prevents me from doing certain procedures properly	1	2	3	4	5	6
D3 It is difficult to communicate properly with patients while wearing PPE	1	2	3	4	5	6
D4 The fever area is too hot to work in	1	2	3	4	5	6
D5 There is a lack of manpower in the fever area	1	2	3	4	5	6
D6 I feel there is an increased risk of contracting COVID-19 by working in the fever area	1	2	3	4	5	6
D7 There is an increase in workload since the outbreak started	1	2	3	4	5	6
D8 I spend longer hours at work since the outbreak started	1	2	3	4	5	6
D9 I am afraid of being infected with COVID-19 while at work	1	2	3	4	5	6
D10 My job puts me at high risk of exposure to COVID-19	1	2	3	4	5	6
D11 The risk I am exposed to at work is acceptable	1	2	3	4	5	6
D12 Work has been more tiring since the outbreak started	1	2	3	4	5	6
D13 I have managed to get enough breaks whilst on my shifts	1	2	3	4	5	6
D14 I am confident my employer would look after my needs if I fall ill with COVID-19	1	2	3	4	5	6

Figure A1. Cont.

D15	I am satisfied with the hospital response to the outbreak	1	2	3	4	5	6
D16	I receive clear communication of outbreak directives from my superiors	1	2	3	4	5	6
D17	People respect the work that I do	1	2	3	4	5	6
D18	People close to me are worried about getting infected by me	1	2	3	4	5	6
D19	I am worried about infecting my loved ones because of my job (Circle only if you live or interact with loved ones locally)	1	2	3	4	5	6
D20	I take additional precautions when interacting with my loved ones during this period (Circle only if applicable)	1	2	3	4	5	6
D21	I am frustrated about not being able to visit my family living abroad (Circle only if applicable)	1	2	3	4	5	6

### **E. Coping strategies**

Please indicate how much you agree or disagree with the following statements based on your experience *over the past year*.

	Strongly Disagree	Disagree	Not Sure But Probably Disagree	Not Sure But Probably Agree	Agree	Strongly Agree
E1						
I get adequate support from my:						
Family	1	2	3	4	5	6
Friends	1	2	3	4	5	6
Supervisors	1	2	3	4	5	6
Colleagues	1	2	3	4	5	6
E2						
My religion helps me cope with stress	1	2	3	4	5	6
E3						
Being able to see my colleagues at work helps to decrease feelings of social isolation	1	2	3	4	5	6
E4						
Exercise helps me cope with stress	1	2	3	4	5	6

Do you have any other feedback or comments you'd like to share with the study team?

---



---

Thank you very much.

**Figure A1.** COVID-19 survey questionnaire for 2022.

## Appendix D

<b>Infection Risk</b> $\alpha = 0.70$ (2020), $0.74$ (2021), $0.73$ (2022)	<b>Working Environment</b> $\alpha = 0.70$ (2020), $0.83$ (2021), $0.84$ (2022)	<b>Workload</b> $\alpha = 0.75$ (2020), $0.75$ (2021), $0.75$ (2022)	<b>Workplace Support</b> $\alpha = 0.78$ (2020), $0.82$ (2021), $0.80$ (2022)	<b>Social Connectedness</b> $\alpha = 0.61$ (2020), $0.58$ (2021), $0.48$ (2022)	<b>Stand Alone Questions</b>
<ul style="list-style-type: none"> <li>• D6: I feel there is an increased risk of contracting COVID-19 by working in the fever area</li> <li>• D9: I am afraid of being infected with COVID- 19 while at work</li> <li>• D10: My job puts me at high risk of exposure to COVID-19</li> <li>• D11: The risk I am exposed to at work is acceptable</li> <li>• D18: People close to me are worried about getting infected by me</li> <li>• D19: I am worried about infecting my loved ones because of my job</li> </ul>	<ul style="list-style-type: none"> <li>• D1: I find the following components of PPE uncomfortable to wear: <ul style="list-style-type: none"> <li>• (a) Mask (N95)</li> <li>• (b) Goggles / Face shield</li> <li>• (c) Gloves</li> <li>• (d) Gown</li> <li>• (e) PAPR</li> </ul> </li> <li>• D2: Wearing PPE prevents me from doing certain procedures properly</li> <li>• D3: It is difficult to communicate properly with patients while wearing PPE</li> <li>• D4: The fever area is too hot to work in</li> </ul>	<ul style="list-style-type: none"> <li>• D5: There is a lack of manpower in the fever area</li> <li>• D7: There is an increase in workload since the outbreak started</li> <li>• D8: I spend longer hours at work since the outbreak started</li> <li>• D12: Work has been more tiring since the outbreak started</li> </ul>	<ul style="list-style-type: none"> <li>• D14: I am confident my employer would look after my needs if I fall ill with COVID-19</li> <li>• D15: I am satisfied with the hospital response to the outbreak</li> <li>• D16: I receive clear communication of outbreak directives from my superiors</li> <li>• E1: I get adequate support from my: <ul style="list-style-type: none"> <li>• (c) Supervisors</li> <li>• (d) Colleagues</li> </ul> </li> </ul>	<ul style="list-style-type: none"> <li>• D21: I am frustrated about not being able to visit my family living abroad</li> <li>• E1: I get adequate support from my: <ul style="list-style-type: none"> <li>• (a) Family</li> <li>• (b) Friends</li> </ul> </li> <li>• E3: Being able to see my colleagues at work helps to decrease feelings of social isolation</li> </ul>	<ul style="list-style-type: none"> <li>• D13: I have managed to get enough breaks whilst on my shifts</li> <li>• D17: People respect the work that I do</li> <li>• D20: I take additional precautions when interacting with my loved ones during this period</li> <li>• E2: My religion helps me cope with stress</li> <li>• E4: Exercise helps me cope with stress</li> </ul>

**Figure A2.** Questions on ED HCWs' concerns and perceptions were categorised based on content relevance shown below for data analysis with listed factor analysis (Cronbach's alpha,  $\alpha$ ).

## Appendix E

**Table A3.** Demographic characteristics of 160 ED HCWs who participated in all 3 surveys. There were 39 doctors (24%) and 121 nursing staff (76%).

Characteristics	2020	2021	2022
<b>Age group in years (n,%)</b>			
21–30	70 (43.8)	60 (37.5)	47 (29.4)
31–40	65 (40.6)	71 (44.4)	81 (50.6)
41+	25 (15.6)	29 (18.1)	32 (20.0)
<b>Gender (n,%)</b>			
Female	115 (71.9)	115 (71.9)	115 (71.9)
Male	45 (28.1)	45 (28.1)	45 (28.1)
<b>Ethnicity (n,%)</b>			
Chinese	61 (38.1)	61 (38.1)	61 (38.1)
Filipino	54 (33.8)	54 (33.8)	54 (33.8)
Others	45 (28.1)	45 (28.1)	45 (28.1)
<b>Marital status (n,%)</b>			
Single/Separated/Divorced/Widowed	88 (55.0)	84 (52.5)	80 (50.0)
Married	72 (45.0)	76 (47.5)	80 (50.0)
<b>Occupation (n,%)</b>			
Junior doctor	15 (9.4)	15 (9.4)	16 (10.0)
Senior doctor	24 (15)	24 (15)	23 (14.4)
Nurse	114 (71.3)	114 (71.3)	114 (71.3)
Healthcare Assistant	7 (4.4)	7 (4.4)	7 (4.4)
<b>Past medical history (n,%)</b>			
Yes	7 (4.4)	9 (5.6)	12 (7.5)
No	153 (95.6)	151 (94.4)	148 (92.5)
<b>Living with young children (&lt;12 years) (n,%)</b>			
Yes	22 (13.8)	32 (20)	37 (23.1)
No	138 (86.2)	128 (80.0)	123 (76.9)
<b>Living with elderly (&gt;65 years) (n,%)</b>			
Yes	22 (13.8)	25 (15.6)	22 (13.8)
No	138 (86.2)	135 (84.4)	138 (86.2)
<b>Lives alone (n,%)</b>			
Yes	27 (16.9)	29 (18.1)	22 (13.8)
No	133 (83.1)	131 (81.9)	138 (86.2)
<b>Practices a religion (n,%)</b>			
Yes	118 (73.8)	121 (75.6)	127 (79.4)
No	42 (26.2)	39 (24.4)	33 (20.6)
<b>Has family or close friend with COVID-19 (n,%)</b>			
Yes	16 (10.0)	26 (16.3)	135 (84.4)
No	144 (90.0)	134 (83.7)	25 (15.6)

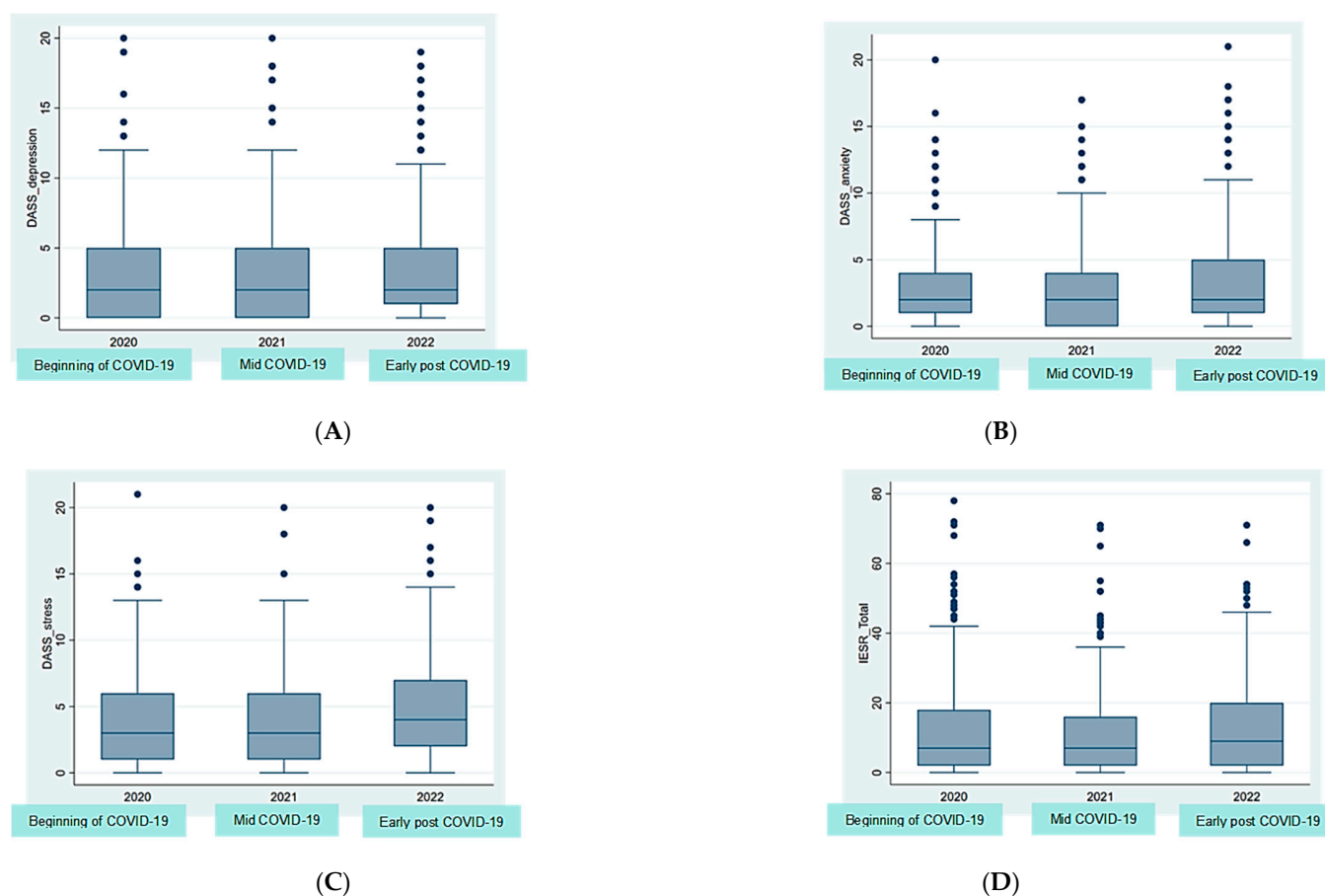
## Appendix F

**Table A4.** The mean scores for the different categories of ED HCWs' concerns and perceptions amongst the 160 matched HCWs.

Concerns and Perceptions	2020 (Mean $\pm$ SD)	2021 (Mean $\pm$ SD)	2022 (Mean $\pm$ SD)	<i>p</i> -Value *
Concerns about infection risk	4.16 $\pm$ 0.83	3.88 $\pm$ 0.88	3.82 $\pm$ 0.96	0.001
Concerns about working environment	4.14 $\pm$ 0.87	3.95 $\pm$ 0.97	3.93 $\pm$ 1.00	0.104
Concerns about workload	4.09 $\pm$ 0.91	4.37 $\pm$ 0.89	4.97 $\pm$ 0.81	<0.001
Social connectedness	4.55 $\pm$ 0.62	4.34 $\pm$ 0.66	4.52 $\pm$ 0.64	0.039
Workplace support	4.87 $\pm$ 0.67	4.67 $\pm$ 0.71	4.43 $\pm$ 0.77	0.007

\* *p*-values were generated using Repeated Measure ANOVA.

## Appendix G



**Figure A3.** MHO scores ((A) Depression, (B) Anxiety, (C) Stress and (D) PTSD of clinical concern) in all ED HCWs in each cohort.

## Appendix H

**Table A5.** Distribution of the different severities of depression, anxiety, stress and PTSD of clinical concern amongst the 160 matched ED HCWs. Depression, Anxiety, Stress and PTSD scores amongst the matched HCWs (n = 160).

MHOs	All HCWs			Senior Doctors			Junior Doctors			Nurses			HCAs		
	2020 n = 160	2021 n = 160	2022 n = 160	2020 n = 15	2021 n = 15	2022 n = 15	2020 n = 24	2021 n = 24	2022 n = 24	2020 n = 114	2021 n = 114	2022 n = 114	2020 n = 7	2021 n = 7	2022 n = 7
<b>Depression</b>															
No	118 (73.8)	116 (72.5)	118 (73.8)	11 (73.3)	11 (73.3)	11 (73.3)	19 (79.2)	19 (79.2)	16 (66.7)	83 (72.8)	81 (71.1)	86 (75.4)	5 (71.4)	5 (71.4)	5 (71.4)
Yes	42 (26.2)	44 (27.5)	42 (26.2)	4 (26.7)	4 (26.7)	4 (26.7)	5 (20.8)	5 (20.8)	8 (33.3)	31 (27.2)	33 (28.9)	28 (24.6)	2 (28.6)	2 (28.6)	2 (28.6)
Mild	20 (12.5)	21 (13.1)	21 (13.1)	2 (13.3)	2 (13.3)	1 (6.7)	0	3 (12.5)	5 (20.8)	16 (14)	14 (12.3)	14 (12.3)	2 (28.6)	2 (28.6)	1 (14.3)
Moderate	14 (8.8)	16 (10)	11 (6.9)	1 (6.7)	1 (6.7)	2 (13.3)	3 (12.5)	1 (4.2)	1 (4.2)	10 (8.8)	14 (12.3)	7 (6.1)	0	0	1 (14.3)
Severe	4 (2.5)	2 (1.3)	6 (3.8)	0	0	1 (6.7)	1 (4.2)	0	2 (8.3)	3 (2.6)	2 (1.8)	3 (2.6)	0	0	0
Extremely severe	4 (2.5)	5 (3.1)	4 (2.5)	1 (6.7)	1 (6.7)	0	1 (4.2)	1 (4.2)	0	2 (1.8)	3 (2.6)	4 (3.5)	0	0	0
<b>Anxiety</b>															
No	107 (66.9)	120 (75.0)	122 (76.3)	13 (86.7)	12 (80.0)	14 (93.3)	16 (66.7)	18 (75.0)	17 (70.8)	76 (66.7)	87 (76.3)	87 (76.3)	2 (28.6)	3 (42.9)	4 (57.1)
Yes	53 (33.1)	40 (25.0)	38 (23.7)	2 (13.3)	3 (20.0)	1 (6.7)	8 (33.3)	6 (25.0)	7 (29.2)	38 (33.3)	27 (23.7)	27 (23.7)	5 (71.4)	4 (57.1)	3 (42.9)
Mild	21 (13.1)	12 (7.5)	8 (5)	1 (6.7)	1 (6.7)	0	4 (16.7)	2 (8.3)	2 (8.3)	13 (11.4)	9 (7.9)	6 (5.3)	3 (42.9)	0	0
Moderate	21 (13.1)	19 (11.9)	24 (15)	1 (6.7)	2 (13.3)	1 (6.7)	1 (4.2)	3 (12.5)	5 (20.8)	17 (14.9)	11 (9.7)	15 (13.2)	2 (28.6)	3 (42.9)	3 (42.9)
Severe	7 (4.4)	3 (1.9)	4 (2.5)	0	0	0	2 (8.3)	1 (4.2)	0	5 (4.4)	1 (0.9)	4 (3.5)	0	1 (14.3)	0
Extremely severe	4 (2.5)	6 (3.8)	2 (1.3)	0	0	0	1 (4.2)	0	0	3 (2.6)	6 (5.3)	2 (1.8)	0	0	0
<b>Stress</b>															
No	147 (91.9)	139 (86.9)	146 (91.3)	13 (86.7)	12 (80.0)	14 (93.3)	21 (87.5)	20 (83.3)	22 (91.7)	106 (93.0)	101 (88.6)	104 (91.2)	7 (100)	6 (85.7)	6 (85.7)
Yes	13 (8.1)	21 (13.1)	14 (8.7)	2 (13.3)	3 (20.0)	1 (6.7)	3 (12.5)	4 (16.7)	2 (8.3)	8 (7.0)	13 (11.4)	10 (8.8)	0	1 (14.3)	1 (14.3)
Mild	3 (1.9)	13 (8.1)	3 (1.9)	0	2 (13.3)	0	1 (4.2)	3 (12.5)	0	2 (1.8)	7 (6.1)	3 (2.6)	0	1 (14.3)	0

Table A5. Cont.

	All HCWs			Senior Doctors			Junior Doctors			Nurses			HCAs		
MHOs	2020 n = 160	2021 n = 160	2022 n = 160	2020 n = 15	2021 n = 15	2022 n = 15	2020 n = 24	2021 n = 24	2022 n = 24	2020 n = 114	2021 n = 114	2022 n = 114	2020 n = 7	2021 n = 7	2022 n = 7
Moderate	7 (4.4)	6 (3.8)	6 (3.8)	2 (13.3)	1 (6.7)	0	1 (4.2)	1 (4.2)	1 (4.2)	4 (3.5)	4 (3.5)	4 (3.5)	0	0	1 (14.3)
Severe	2 (1.3)	1 (0.6)	4 (2.5)	0	0	1 (6.7)	0	0	1 (4.2)	2 (1.8)	1 (0.9)	2 (1.8)	0	0	0
Extremely severe	1 (0.6)	1 (0.6)	1 (0.6)	0	0	0	1 (4.2)	0	0	0	1 (0.9)	1 (0.9)	0	0	0
PTSD of clinical concern															
No	136 (85.0)	144 (90.0)	143 (89.4)	12 (80.0)	14 (93.3)	15 (100)	21 (87.5)	22 (91.7)	21 (87.5)	97 (85.1)	101 (88.6)	102 (89.5)	6 (85.7)	7 (100)	5 (71.4)
Yes	24 (15.0)	16 (10.0)	17 (10.6)	3 (20.0)	1 (6.7)	0	3 (12.5)	2 (8.3)	3 (12.5)	17 (14.9)	13 (11.4)	12 (10.5)	1 (14.3)	0	2 (28.6)
MHOs	2020 Median (Q1-Q3)			2021 Median (Q1-Q3)			2022 Median (Q1-Q3)			2020 Mean ( $\pm$ SD)			2021 Mean ( $\pm$ SD)		
All HCWs	n = 160			n = 160			n = 160			n = 160			n = 160		
Depression	2 (0–5)			2 (0–5)			2 (1–5)			3.0 $\pm$ 3.6			3.3 $\pm$ 3.7		
Anxiety	2 (0–4)			2 (0–3.5)			2 (0–3)			2.9 $\pm$ 3.2			2.3 $\pm$ 2.9		
Stress	3 (1–5)			3 (1–5)			3 (1–5)			3.5 $\pm$ 3.4			3.6 $\pm$ 3.4		
PTSD	7 (1.5–16.5)			6 (2–14)			7 (2–17.5)			11.6 $\pm$ 14.5			10.0 $\pm$ 12.3		
Senior doctors	n = 15			n = 15			n = 15			n = 15			n = 15		
Depression	1 (0–5)			3 (0–5)			2 (1–5)			2.7 $\pm$ 3.9			3.5 $\pm$ 4.7		
Anxiety	2 (0–2)			1 (0–3)			0 (0–2)			1.6 $\pm$ 1.8			1.7 $\pm$ 1.9		
Stress	5 (1–7)			3 (1–7)			4 (1–6)			4.3 $\pm$ 3.9			3.9 $\pm$ 3.8		
PTSD	7 (1–15)			4 (1–9)			4 (0–9)			10.3 $\pm$ 12.2			6.4 $\pm$ 7.8		
Junior doctors	n = 24			n = 24			n = 24			n = 24			n = 24		
Depression	1 (0–3.5)			3 (0–4)			2 (0–5)			3.0 $\pm$ 4.9			3.0 $\pm$ 3.5		
Anxiety	1.5 (0–4)			1 (0–3.5)			1 (0–4)			2.9 $\pm$ 4.4			2.0 $\pm$ 2.5		



Table A5. Cont.

	All HCWs			Senior Doctors			Junior Doctors			Nurses			HCAs			
MHOs	2020 n = 160	2021 n = 160	2022 n = 160	2020 n = 15	2021 n = 15	2022 n = 15	2020 n = 24	2021 n = 24	2022 n = 24	2020 n = 114	2021 n = 114	2022 n = 114	2020 n = 7	2021 n = 7	2022 n = 7	
Stress			3 (1–5)			4 (1–6.5)			5 (1–6)			3.8 ± 4.6			4.0 ± 3.2	4.1 ± 3.8
PTSD			4 (1–7)			4 (0.5–9.5)			9 (0–16)			10.5 ± 19.5			8.1 ± 12.2	11.4 ± 13.8
Nurses			n = 114			n = 114			n = 114			n = 114			n = 114	n = 114
Depression			2 (0–5)			2 (0–5)			2 (1–4)			3.0 ± 3.3			3.3 ± 3.7	3.3 ± 3.6
Anxiety			2 (1–4)			1.5 (0–3)			2 (0–3)			2.9 ± 3.1			2.4 ± 3.1	2.5 ± 2.9
Stress			2 (1–5)			3 (1–5)			3 (1–5)			3.2 ± 3.1			3.4 ± 3.4	3.9 ± 3.4
PTSD			7 (2–17)			6 (2–18)			7 (2–18)			11.9 ± 13.6			10.7 ± 13.0	11.2 ± 12.5
HCAs			n = 7			n = 7			n = 7			n = 7			n = 7	n = 7
Depression			3 (2–5)			2 (1–6)			3 (0–5)			3.4 ± 1.6			3.0 ± 2.2	2.9 ± 3.3
Anxiety			4 (2–7)			5 (2–5)			3 (1–5)			4.0 ± 2.5			4.1 ± 2.3	3.3 ± 2.5
Stress			4 (3–7)			5 (4–6)			3 (1–7)			4.7 ± 1.7			5.0 ± 1.9	4.0 ± 3.6
PTSD			15 (2–20)			12 (10–18)			12 (7–28)			13.3 ± 12.4			13.0 ± 5.5	15.3 ± 11.0

## Appendix I

Table A6. Prevalence of each MHO amongst ED HCWs who participants in all three surveys (n = 160).

All ED HCWs n = 160	Depression		Anxiety		Stress		PTSD Concern	
	n (%)	OR (95% CI)	n (%)	OR (95% CI)	n (%)	OR (95% CI)	n (%)	OR (95% CI)
2020	42 (26.3)	1.00	53 (33.1)	1.00	13 (8.1)	1.00	24 (15)	1.00
2021	44 (27.5)	1.07 (0.74–1.53)	40 (25.0)	0.67 (0.46–0.99)	21 (13.1)	1.71 (1.05–2.79)	16 (10)	0.63 (0.39–1.02)
2022	42 (26.3)	1.00 (0.66–1.51)	38 (23.8)	0.63 (0.42–0.93)	14 (8.8)	1.08 (0.56–2.09)	17 (10.6)	0.67 (0.42–1.09)
Doctors n = 39	Depression		Anxiety		Stress		PTSD concern	
	n (%)	OR (95% CI)	n (%)	OR (95% CI)	n (%)	OR (95% CI)	n (%)	OR (95% CI)
2020	9 (23.1)	1.00	10 (25.6)	1.00	5 (12.8)	1.00	6 (15.4)	1.00
2021	9 (23.1)	1.00 (0.56–1.77)	9 (23.1)	0.87 (0.38–1.99)	7 (18.0)	1.49 (0.68–3.26)	3 (7.7)	0.46 (0.14–1.46)
2022	12 (30.8)	1.48 (0.68–3.22)	8 (20.5)	0.75 (0.33–1.68)	3 (7.7)	0.57 (0.18–1.75)	3 (7.7)	0.46 (0.19–1.11)
Nursing staff n = 121	Depression		Anxiety		Stress		PTSD concern	
	n (%)	OR (95% CI)	n (%)	OR (95% CI)	n (%)	OR (95% CI)	n (%)	OR (95% CI)
2020	33 (27.3)	1.00	43 (35.5)	1.00	8 (6.6)	1.00	18 (14.9)	1.00
2021	35 (28.9)	1.09 (0.70–1.69)	31 (25.6)	0.62 (0.41–0.96)	14 (11.6)	1.85 (0.98–3.5)	13 (10.7)	0.69 (0.41–1.17)
2022	30 (24.8)	0.88 (0.54–1.43)	30 (24.8)	0.60 (0.38–0.94)	11 (9.1)	1.41 (0.62–3.2)	14 (11.6)	0.75 (0.42–1.32)

OR: Odds ratio. 95% CI: 95% confidence interval. The bolded OR (95% CI) values mean significant at  $p$ -value < 0.05.

## References

- Ministry of Health Singapore. Endemic COVID-19. Updated 5 July 2021. Available online: <https://www.moh.gov.sg/news-highlights/details/endemic-covid-190> (accessed on 15 September 2022).
- Ministry of Health Singapore. Updates on Singapore's COVID-19 Situation. Available online: <https://www.moh.gov.sg/covid-19> (accessed on 15 September 2022).
- Teo, I.; Nadarajan, G.D.; Ng, S.; Bhaskar, A.; Sung, S.C.; Cheung, Y.B.; Pan, F.T.; Haedar, A.; Gaerlan, F.J.; Ong, S.F.; et al. The Psychological Well-Being of Southeast Asian Frontline Healthcare Workers during COVID-19: A Multi-Country Study. *Int. J. Environ. Res. Public Health* **2022**, *19*, 6380. [\[CrossRef\]](#) [\[PubMed\]](#)
- Rao, K.; Th'Ng, F.; Mak, C.; Neo, H.; Ubeynarayana, C.; Kumar, R.N.; Mao, D. Factors associated with mental health outcomes in emergency department healthcare workers on the frontlines of the COVID-19 pandemic. *Singap. Med. J.* **2021**, *1*, 11. [\[CrossRef\]](#) [\[PubMed\]](#)
- Th'Ng, F.; Rao, K.A.; Ge, L.; Mao, D.; Neo, H.N.; De Molina, J.A.; Seow, E. A One-Year Longitudinal Study: Changes in Depression and Anxiety in Frontline Emergency Department Healthcare Workers in the COVID-19 Pandemic. *Int. J. Environ. Res. Public Health* **2021**, *18*, 11228. [\[CrossRef\]](#) [\[PubMed\]](#)
- Lovibond, S.H.; Lovibond, P.F. *Manual for the Depression Anxiety Stress Scales*, 2nd ed.; Psychology Foundation: Sydney, Australia, 1995; ISBN 7334-1423-7330.
- Asukai, N.; Kato, H.; Kawamura, N.; Kim, Y.; Yamamoto, K.; Kishimoto, J.; Miyake, Y.; Nishizono-Maher, A. Reliability and validity of the Japanese-language version of the impact of event scale-revised (Ies-RJ): Four studies of different traumatic events. *J. Nerv. Ment. Dis.* **2002**, *190*, 175–182. [\[CrossRef\]](#) [\[PubMed\]](#)
- Ballinger, G.A. Using Generalized Estimating Equations for Longitudinal Data Analysis. *Organ. Res. Methods* **2004**, *7*, 127–150. [\[CrossRef\]](#)
- Samur, A.A.; Coskunfirat, N.; Saka, O. Comparison of predictor approaches for longitudinal binary outcomes: Application to anesthesiology data. *PeerJ* **2014**, *2*, e648. [\[CrossRef\]](#)
- Sun, T.-K.; Chu, L.-C.; Hui, C. The Psychological Impact and Influencing Factors during Different Waves of COVID-19 Pandemic on Healthcare Workers in Central Taiwan. *Int. J. Environ. Res. Public Health* **2022**, *19*, 10542. [\[CrossRef\]](#)
- Sampaio, F.; Sequeira, C.; Teixeira, L. Nurses' mental health during the Covid-19 outbreak: A cross-sectional study. *J. Occup. Environ. Med.* **2020**, *62*, 783–787. [\[CrossRef\]](#) [\[PubMed\]](#)
- Wu, P.; Fang, Y.; Guan, Z.; Fan, B.; Kong, J.; Yao, Z.; Liu, X.; Fuller, C.J.; Susser, E.; Lu, J.; et al. The Psychological Impact of the SARS Epidemic on Hospital Employees in China: Exposure, Risk Perception, and Altruistic Acceptance of Risk. *Can. J. Psychiatry* **2009**, *54*, 302–311. [\[CrossRef\]](#) [\[PubMed\]](#)
- Poon, Y.-S.R.; Lin, Y.P.; Griffiths, P.; Yong, K.K.; Seah, B.; Liaw, S.Y. A global overview of healthcare workers' turnover intention amid COVID-19 pandemic: A systematic review with future directions. *Hum. Resour. Health* **2022**, *20*, 70. [\[CrossRef\]](#) [\[PubMed\]](#)

14. de Lima Garcia, C.; de Abreu, L.C.; Ramos, J.L.S.; de Castro, C.F.D.; Smiderle, F.R.N.; dos Santos, J.A.; Bezerra, I.M.P. Influence of Burnout on Patient Safety: Systematic Review and Meta-Analysis. *Medicina* **2019**, *55*, 553. [CrossRef] [PubMed]
15. Ching, N.M.C.; Low, D.W. Singapore Sees 25% Increase in Emergency Public Hospital Visits. Bloomberg Asia Edition. Updated 22 July 2022. Available online: <https://www.bloomberg.com/news/articles/2022-07-22/singapore-sees-25-increase-in-emergency-public-hospital-visits> (accessed on 5 October 2022).
16. Chew, M.H. Clinics in Singapore See Rise in COVID-19 Patients in New Wave of Infections. Chanel News Asia. Updated 1 July 2022. Available online: <https://www.channelnewsasia.com/singapore/omicron-5th-wave-covid19-coronavirus-infection-clinics-singapore-2784941> (accessed on 5 October 2022).
17. Ministry of Health Singapore. Waiting Time for Admission to Ward. Updated 30 September 2022. Available online: <https://www.moh.gov.sg/resources-statistics/healthcare-institution-statistics/waiting-time-for-admission-to-ward> (accessed on 5 October 2022).
18. Ministry of Health Singapore. Bed Occupancy Rate (BOR). Updated 30 September 2022. Available online: [https://www.moh.gov.sg/resources-statistics/healthcare-institution-statistics/beds-occupancy-rate-\(bor\)](https://www.moh.gov.sg/resources-statistics/healthcare-institution-statistics/beds-occupancy-rate-(bor)) (accessed on 5 October 2022).
19. Fekadu, G.; Bekele, F.; Tolossa, T.; Fetensa, G.; Turi, E.; Getachew, M.; Abdisa, E.; Assefa, L.; Afeta, M.; Demisew, W.; et al. Impact of COVID-19 pandemic on chronic diseases care follow-up and current perspectives in low resource settings: A narrative review. *Int. J. Physiol. Pathophysiol. Pharmacol.* **2021**, *13*, 86–93. [PubMed]
20. Singh, K.; Xin, Y.; Xiao, Y.; Quan, J.; Kim, D.; Nguyen, T.-P.; Kondal, D.; Yan, X.; Li, G.; Ng, C.S.; et al. Impact of the COVID-19 Pandemic on Chronic Disease Care in India, China, Hong Kong, Korea, and Vietnam. *Asia Pac. J. Public Health* **2022**, *34*, 392–400. [CrossRef] [PubMed]
21. Vindrola-Padros, C.; Andrews, L.; Dowrick, A.; Djellouli, N.; Fillmore, H.; Gonzalez, E.B.; Javadi, D.; Lewis-Jackson, S.; Manby, L.; Mitchinson, L.; et al. Perceptions and experiences of healthcare workers during the COVID-19 pandemic in the UK. *BMJ Open* **2020**, *10*, e040503. [CrossRef] [PubMed]
22. Dixon, E.; Murphy, M.; Wynne, R. A multidisciplinary, cross-sectional survey of burnout and wellbeing in emergency department staff during COVID-19. *Australas. Emerg. Care* **2021**, *25*, 247–252. [CrossRef] [PubMed]
23. Daly, M.; Sutin, A.R.; Robinson, E. Longitudinal changes in mental health and the COVID-19 pandemic: Evidence from the UK Household Longitudinal Study. *Psychol. Med.* **2020**, *52*, 2549–2558. [CrossRef] [PubMed]
24. Voltmer, E.; Kösllich-Strumann, S.; Walther, A.; Kasem, M.; Obst, K.; Kötter, T. The impact of the COVID-19 pandemic on stress, mental health and coping behavior in German University students—a longitudinal study before and after the onset of the pandemic. *BMC Public Health* **2021**, *21*, 1385. [CrossRef] [PubMed]