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Perceived Hospital Preparedness Is Negatively Associated With Pandemic-Induced Psychological Vulnerability in Primary Care Employees: A Multicentre Cross-Sectional Observational Study

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ABSTRACT

Objective: The COVID-19 pandemic had a profound negative impact on the psychological wellbeing of healthcare providers (HPs), but little is known about the factors that positively predict mental health of primary care staff during these dire situations.
Methods: We conducted an online questionnaire survey among 702 emergency department workers across 10 hospitals in Switzerland and Belgium following the first COVID-19 wave in 2020, to explore their psychological vulnerability, perceived concerns, self-reported impact and level of pandemic workplace preparedness. Participants included physicians, nurses, psychologists and nondirect care employees (administrative staff). We tested for predictors of psychological vulnerability through both an exploratory cross-correlation with rigorous correction for multiple comparisons and model-based path modelling.
Results: Findings showed that the self-reported impact of COVID-19 at work, concerns about contracting COVID-19 at work, and a lack of personal protective equipment were strong positive predictors of Depression, Anxiety, and Stress, and low Resilience. Instead, knowledge of the degree of preparedness of the hospital/department, especially in the presence of a predetermined contingency plan for an epidemic and training sessions about protective measures, showed the opposite effect, and were associated with lower psychological vulnerability. All effects were confirmed after accounting for confounding factors related to gender, age, geographical location and the role played by HPs in the hospital/department.
Conclusions: Difficult working conditions during the pandemic had a major impact on the psychological wellbeing of emergency department HPs, but this effect might have been lessened if they had been informed about adequate measures for minimizing the risk of exposure.

Summary

- During COVID, medical personnel who faced increased workload and assignment to new duties (work impact) also displayed pronounced psychological vulnerability (high anxiety, stress, depression and low resilience).

- Hospital preparedness (especially information about pre-established contingency plans in case of a pandemic) appeared to exert a positive influence on personnel's vulnerability, as it was associated with low anxiety, stress, depression, and high resilience.

- Our data are best interpreted in terms of an 'indirect' effect of hospital pandemic preparedness on psychological vulnerability, whereby personnel who reported participating in informative or training sessions experienced reduced work impact and in turn exhibited improved mental health.

1 | Introduction

In December 2019, a new disease (COVID-19) caused by the highly contagious severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) emerged in the city of Wuhan (China). Due to its worldwide dissemination, the World Health Organization announced a global emergency in March 2020 (Sohrabi et al. 2020). To contain this pandemic, many countries put in place restrictive measures such as lockdown, curfew, social distancing and quarantine, which had negative social and psychological consequences. Distress, anxiety or, more generally, psychological vulnerability affected more young individuals, women or people living alone, although with a significant geographical variability (Kunzler et al. 2021; Lima et al. 2020; Nochaiwong et al. 2021; Santomauro et al. 2021; Wu et al. 2021).

Most worryingly, the pandemic affected the psychological wellbeing of frontline professional healthcare providers (HPs), who were exposed to overwhelming work schedules, high contagion risk, inadequate protection measures and constant psychological pressure. Even before the outbreak, the literature on work-related stress had reported a high risk of burnout in the healthcare sector (National Academies of Sciences, Engineering, and Medicine et al. 2019). This risk was worsened by the pandemic where HPs exhibited a high susceptibility to burnout and psychological vulnerability (De Brier et al. 2020; Lluch et al. 2022; Norhayati, Che Yusof, and Azman 2021; Pan, Zhang, and Pan 2020; Pappa et al. 2020; Salazar de Pablo et al. 2020; Sexton et al. 2022; Wu et al. 2021). Notably, the prevalence of psychological harm was greater than that observed in the lay population (Pan, Zhang, and Pan 2020; Weibelzahl, Reiter, and Duden 2021; Wu et al. 2021), in HPs before the outbreak (Weibelzahl, Reiter, and Duden 2021), or even in HPs working in regions/conditions with a lower risk of exposure (De Brier et al. 2020; Lai et al. 2020; Pisanu et al. 2022). In general, the most affected categories were nurses (compared with physicians), younger people or women (Lai et al. 2020; Lluch et al. 2022; Pappa et al. 2020; Pisanu et al. 2022; Sexton et al. 2022). Importantly, these findings were not specific to COVID-19 and had also been reported in previous outbreaks such as SARS, Middle East respiratory syndrome coronavirus and Ebola virus (Busch et al. 2021; De Brier et al. 2020; Salazar de Pablo et al. 2020).

Although many studies have documented psychological vulnerability in HPs worldwide, less is known about the factors that are negatively associated with this phenomenon, and which could offer insights on how to improve HPs' psychological health during care activities. Recent reviews have reported a key role played by social support, coping strategies and appropriate and timely communication from the organization (De Brier et al. 2020; Dehon et al. 2021; Elbay et al. 2020; Labrague 2021). Unfortunately, previous research differed in terms of measures employed and provided only a limited coverage of potential factors of interest. Hence, the present study aimed to fill this knowledge gap by devising a comprehensive survey using validated questionnaires exploring a large panel of potential predictors of psychological vulnerability among HPs and employees in 10 European hospitals. These ranged from regions with a high incidence/mortality of COVID-19 to those less affected by the pandemic (Ritchie et al. 2020; Scire et al. 2020; Tiete et al. 2021).

2 | Methods

2.1 | Sample

The study included employees of the emergency departments (EDs) of eight hospitals in Switzerland (University Hospital of Lausanne, Hospital of Sion, Hospital of Neuchâtel–Pourtalès, Cantonal Hospital of Luzern, Hospital San Giovanni of Bellinzona, Civic Hospital of Lugano, Italian Hospital of Lugano and Hospital 'La Carità' of Mendrisio) and two in Belgium (University Hospital of Saint Pierre and the University Clinic 'Saint Luc', Brussels). In each ED, a local 'champion' promoted the study during meetings and then sent an information email to the target population. Physicians (from any specialty), nurses, nursing assistants, psychologists, administrative staff, and support and logistics staff were invited to participate in the online survey, as long as they had worked in the ED during the first COVID-19 wave (between March and May 2022). Not all professional groups participated in each ED. Participation was voluntary and not compensated. Data collection was conducted between 22 June 2020 and 27 October 2020, just after the first COVID wave.

2.2 | Ethical Approval

Ethical approval was granted by the cantonal ethics commissions of Vaud, Lucerne and Ticino (CER-VD N. 2020-01200) and the ethics committee of the University Hospital of Saint Pierre (Belgium).

2.3 | Survey

The online questionnaire was developed using LimeSurvey® (LimeSurvey GmbH, Hamburg, Germany) and hosted on a dedicated server of the University Hospital of Lausanne. Participants received an email containing a unique personal web-link identifier allowing a one-time anonymous connection to the questionnaires. As a first step, participants accessed an informed consent page. By selecting the key 'I accept', they were then directed to the main survey where their responses were captured automatically. Data collection was anonymous. Adaptive questioning

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was used to reduce the number and complexity of the questions. Overall, there were 10 pages, each containing between 10 and 20 questions. The items' order within and across pages was fixed. Consistency or completeness checks were automatically performed after each page of the questionnaire had been submitted, and missing items were highlighted. Respondents were able to review and change their answers through a 'back' button. Once completed, the questionnaire could not be accessed again. Table S1 provides a full listing of all measures collected during the survey.

Briefly, we first collected demographic and professional information. Subsequently, we acquired COVID-19–related information, including access to alcohol-based hand rub and personal protective equipment. A psychological assessment was then conducted, which included the Connor–Davidson Resilience Scale (CD-RISC) questionnaire for psychological resilience (Campbell-Sills and Stein 2007; Connor and Davidson 2003) and the 21-item Depression, Anxiety and Stress Scale (DASS-21) (Lovibond and Lovibond 1995). Finally, an ad hoc questionnaire assessed pandemic-related concerns at work and outside work, the pandemic impact on participants' life and the perceived degree of hospital preparedness for pandemics (Wong et al. 2008). The survey was administered in French, German and Italian, based on validated translations of the CD-RISC and DASS-21, and of the translation by bilingual healthcare professionals for the other questionnaires.

The data collection process respected Swiss regulations and the General Data Protection Regulation, that is, the European Union comprehensive data protection law. The study was reported according to the Checklist for Reporting Results of Internet E-Surveys (CHERRIES) statement for web-based surveys (see Table S13) (Eysenbach 2004).

2.4 | Data Processing and Statistical Analyses

For the purpose of the study, we divided participants working in the ED during the pandemic into three groups of interest: medical doctors (MDs); non-MD HPs (other HPs), such as nurses, psychologists and nursing assistants; and non-HP individuals, such as administrative, support and logistic staff. Similarly, the geographical location was organized across four areas, that is, the French ($n = 4$), German ($n = 1$) and Italian ($n = 4$) regions of Switzerland, and Belgium ($n = 2$). Fifty-eight variables of interest were considered (Table S1), which included geographical/demographic information and personal experience of the COVID-19 pandemic, modelled as either categorical factors or continuous predictors. Scores from the CD-RISC and DASS-21 questionnaires were computed as scalars, based on the scoring instructions associated with the tests (Campbell-Sills and Stein 2007; Connor and Davidson 2003; Lovibond and Lovibond 1995). The items adapted from the questionnaire of Wong et al. (2008) have never been subjected to a systematic validation and do not generate a score. Thus, each item was analysed individually as a rating value using a 6-point Likert scale ranging from *totally disagree* to *totally agree*. Finally, to improve compliance with normal distribution and parametric tests assumptions, all measures arising from Likert scales (DASS-21, CD-RISC global scores and items from Wong et al. 2008) were recoded into proportions

p (ranging from 0.025 [lowest possible score] to 0.975 [highest possible score]) and logit-transformed: $logit(p) = ln(p/1 - p)$. Statistical analysis was carried out using R 4.2.1 (http://cran.r-project.org/) open source software.

First, as in previous studies, the associations between gender, professional groups, age and the CD-RISC and DASS-21 scores were tested through a linear mixed model (LMM) in which each score of interest was modelled as a function of the three predictors. The geographical location (four areas in which the 10 hospitals were located) was modelled as a random factor. The LMM parameter significance was calculated using the Satterthwaite approximation of the degrees of freedom. For completeness, the analysis of the DASS-21 data was repeated by modelling the likelihood of obtaining severe scores of depression, anxiety or stress (as established by normative cut-offs of depression ≥ 21, anxiety ≥ 15 and stress ≥ 26; Lovibond and Lovibond 1995) through a generalized LMM with a binomial distribution and Laplace approximation. The generalized LMM was carried out with the same factor structure used in the analysis of raw scores using the *lmerTest* package of R (Kuznetsova, Brockhoff, and Christensen 2015).

Subsequently, the remaining 50 potential predictors of DASS-21 and CD-RISC scores were analysed using the same LMM described above to account for the effects of age, gender, professional group and geographical location. From each of these mixed models, residual scores were extracted and fed to an exploratory analysis testing the correlation of each of the 50 variables against each DASS-21/CD-RISC residual score, resulting in 200 (4*50) Pearson correlation coefficients (r). As these correlations were calculated on residuals, the effects described are independent of geographical/demographic confounders that usually influence vulnerability. To account for a risk of inflation of the alpha error, we considered as significant those r coefficients with a $p < 0.00025$, corresponding to a Bonferroni correction for multiple comparisons at $p < 0.05$.

Finally, we took a model-based approach and exploited partial least squares path modelling (PLS-PM) (Tenenhaus et al. 2005; Wold 1982) to further assess the relationship between pandemic-related information, concerns, impact and preparation with regard to individuals' susceptibility to vulnerability (as tested by DASS-21 and CD-RISC). PLS-PM usually involves latent variables (LVs) and manifest variables (MVs). LVs are those among which relations are being assessed in a given model (e.g., pandemic concerns → psychological vulnerability). These are not measured directly but were estimated using the many MVs collected in the present study (Table S1). Consistent with recent research (Silveira et al. 2022a; Silveira et al. 2022b), we specified *vulnerability* as an LV described by the three subscores of the DASS-21 and the inverse score of the CD-RISC as MVs (residual values from the prior LMM). As for the other LVs, we obtained an estimate of the underlying structure of our dataset by feeding all 50 variables of interest (residual values) into an exploratory factor analysis (EFA) (see the supporting information for full details). The outlined factor structure was subsequently adopted to build our PLS-PM model, with each identified factor from the EFA specified as an LV, associated with contributing MVs. For each LV, we verified whether all MVs were reliable and unidimensional expressions of the same latent construct, by

assessing whether Dillon–Goldstein's ρ for composite reliability was ≥0.70 (Chin 1998; Tenenhaus et al. 2005). PLS-PM is an iterative process in which two approximations for the LVs are alternated until convergence: (a) an outer approximation in which LVs are modelled through linear combinations of their corresponding MVs ('reflective' method) and (b) an inner

TABLE 1 | Demographic characteristics, DASS-21 and CD-RISC scores of study participants by geographic location and professional role.

	Total (N = 702)	Belgium (N = 141)	Swiss FR (N = 346)	Swiss IT (N = 161)	Swiss GER (N = 54)
Sample size, *n* (%)					
MDs	272 (39)	57 (40)	138 (40)	63 (39)	14 (25)
Other HPs	375 (53)	65 (46)	172 (50)	98 (60)	40 (70)
Non-HPs	55 (8)	19 (13)	36 (10)	0 (0)	0 (0)
Female, *n* (%)[a]					
MDs	136 (50)	34 (60)	63 (46)	31 (49)	8 (57)
Other HPs	246 (66)	37 (58)	118 (69)	57 (58)	34 (85)
Non-HPs	45 (82)	14 (74)	31 (86)	—	—
Age, years (95% CI)					
MDs	36.2 (35.2, 37.3)	36.6 (34.1, 39.5)	35.8 (34.5, 37.3)	36.9 (35.1, 38.8)	35.1 (31.8, 39.4)
Other HPs	38.5 (37.5, 39.5)	36.0 (34.0, 38.0)	37.8 (36.3, 39.2)	42.6 (40.6, 44.7)	35.8 (33.4, 38.2)
Non-HPs	46.8 (43.8, 49.7)	46.8 (40.8, 52.1)	46.7 (43.3, 49.9)	—	—
DASS depression *[Dep]*, score (95% CI)					
MDs	5.9 (5.1, 6.8)	8.1 (6.1, 10.4)	5.6 (4.4, 6.8)	5.8 (4.2, 7.6)	0.9 (0.3, 1.6)
Other HPs	7.5 (6.6, 8.3)	11.8 (9.6, 14.2)	7.7 (6.5, 9.0)	6.0 (4.7, 7.4)	3.1 (1.8, 4.7)
Non-HPs	8.1 (5.6, 10.8)	10.5 (5.9, 15.5)	6.8 (4.1, 10.0)	—	—
DASS severe depression cases, *n* (%)[a]					
MDs	17 (6)	4 (7)	8 (6)	5 (8)	0 (0)
Other HPs	33 (9)	13 (20)	15 (9)	5 (5)	0 (0)
Non-HPs	8 (15)	5 (26)	3 (8)	—	—
DASS anxiety *[Anx]*, score (95% CI)					
MDs	3.8 (3.2, 4.5)	5.0 (3.5, 6.6)	4.2 (3.3, 5.1)	2.9 (2.0, 3.8)	0.4 (0.0, 1.1)
Other HPs	5.8 (5.2, 6.4)	7.7 (6.1, 9.3)	6.0 (5.1, 7.1)	4.9 (3.8, 6.1)	3.8 (2.4, 5.2)
Non-HPs	6.6 (4.9, 8.4)	6.1 (3.5, 8.6)	6.9 (4.7, 9.3)	—	—
DASS severe anxiety cases, *n* (%)[a]					
MDs	14 (5)	5 (9)	8 (6)	1 (2)	0 (0)
Other HPs	37 (10)	9 (14)	21 (12)	6 (6)	1 (2)
Non-HPs	5 (9)	1 (5)	4 (11)	—	—
DASS stress *[Stress]*, score (95% CI)					
MDs	10.2 (9.1, 11.2)	14.4 (11.8, 17.1)	8.4 (7.1, 9.9)	11.3 (9.3, 13.5)	4.7 (2.1, 7.6)
Other HPs	11.8 (10.9, 12.8)	16.0 (13.8, 18.2)	10.7 (9.3, 12.2)	12.4 (10.6, 14.3)	8.1 (6.0, 10.5)
Non-HPs	10.5 (7.9, 13.4)	12.7 (8.0, 18.1)	9.4 (6.4, 12.9)	—	—
DASS severe stress cases, *n* (%)[a]					
MDs	21 (8)	8 (14)	8 (6)	5 (8)	0 (0)
Other HPs	34 (9)	9 (14)	14 (8)	9 (9)	2 (5)
Non-HPs	5 (9)	2 (11)	3 (8)	—	—
CD-RISC *[Res]*, score (95% CI)					
MDs	28.1 (27.4, 28.8)	27.6 (25.9, 29.1)	29.2 (28.3, 30.0)	25.3 (23.8, 26.8)	31.5 (28.9, 34.0)
Other HPs	28.2 (27.6, 28.8)	28.7 (27.3, 30.1)	28.6 (27.9, 29.3)	26.8 (25.3, 28.3)	29.4 (28.2, 30.5)
Non-HPs	30.4 (28.9, 31.8)	29.1 (26.5, 31.6)	31.1 (29.4, 32.7)	—	—

Abbreviations: CD-RISC, Connor–Davidson Resilience Scale; CI, bootstrap-based confidence intervals; DASS-21, Depression, Anxiety or Stress Score; HP, healthcare provider; MD, medical doctor; Non-HPs, non-HP employees; other HPs, non-MD HPs; Swiss FR, Swiss French-speaking region; Swiss GER, Swiss German-speaking region; Swiss IT, Swiss Italian-speaking region.

[a]Normative cut-off scores were depression ≥21, anxiety ≥15 and stress ≥26; Lovibond and Lovibond 1995. Percentages are relative to the size of the individuals in the same site and with the same professional category. Values within each column do not add up to 100%.

approximation that reflects the putative relations between the LVs in the selected model (centroid scheme) (Tenenhaus et al. 2005). For the purpose of our analysis, each of the EFA latent factors were modelled as exogenous predictors, which could explain *vulnerability*. In addition, we also modelled direct relationships between the EFA latent factors by exploiting the information available from the significant factor cross-correlation in the previous EFA.

PLS-PM was carried out in the overall population. The path coefficients' reliability was established through 5000 bootstrap resamplings (with replacement) of the original dataset. In this perspective, hypothesis testing was achieved by inspecting the distribution of the resampled parameters, establishing whether the 2.5% and 97.5% confidence intervals did not overlap zero. Furthermore, path differences between different groups (e.g., MDs vs. other HPs) were assessed through permutation techniques, where the null hypothesis was estimated nonparametrically by randomly assigning group labels to the data (5000 data shufflings). Group differences were considered significant if they exceeded the 2.5% and 97.5% percentiles of this null distribution on either side. This approach allows rigorous rejection of the null hypothesis under two-tailed $\alpha = 0.05$, with a little reliance on the assumptions of parametric testing. PLS-PM analysis was carried out using the *plspm* package implemented in R (Sanchez, Trinchera, and Russolillo 2017).

3 | Results

Overall, 272 MDs, 375 other HPs and 55 non-HPs completed our measures of interests. The average response rate was 47.5%, but highly variable between locations and ranged from 27.4% (Belgium) to 64.9% (French-speaking region of Switzerland). Table 1 provides key demographic information about the cohort and scores of psychological vulnerability, with cases of severe depression, anxiety or stress representing approximately 8% of the overall population (see Tables S2–S8 for full descriptive statistics).

The subscores of depression and anxiety derived from the DASS-21 questionnaire were lower in older participants ($t \leq -2.46$; $p \leq 0.014$), whereas resilience derived from the CD-RISC displayed the opposite direction ($t_{(693.78)} = 3.52$; $p < 0.001$). A significant effect of gender ($|t| \geq 1.98$; $p \leq 0.048$) was also found with higher depression, anxiety and stress scores and lower resilience in women compared with men (Figure 1A,B). Finally, a professional group effect was observed for all DASS-21 subscores, revealing a lower vulnerability in MDs compared with other HPs ($t \geq 3.10$; $p \leq 0.002$) and, in the case of anxiety, also non-HPs ($t_{(694.37)} = 3.21$; $p < 0.001$; Figure 1C). When modelling the likelihood of obtaining severe scores of depression, anxiety or stress through a binomial mixed model (see Section 2), we confirmed that the probability of severe scores increased with age in all three subtests ($z \leq -2.20$; $p \leq 0.028$). Furthermore, we confirmed a higher probability of severe depression in women ($z = 2.05$; $p = 0.040$) and in non-HPs versus MDs ($z = 2.46$; $p = 0.014$). In addition, severe anxiety was more likely in other HPs versus MDs ($z = 2.41$; $p = 0.016$).

Subsequently, in a massive exploratory analysis, each DASS-21 and CD-RISC score was correlated with each remaining variable (residual values, see Section 2). After rigorous correction for multiple comparisons, we found that all DASS-21 scores positively correlated with several items relating to COVID-19 concerns and impact, such as increased workload, off-time shifts, conflicts at the workplace and concerns about people outside work. In a similar manner, parts of these items were negatively correlated with individual resilience from the CD-RISC scores (Figure 2). Several aspects of personal and hospital preparedness to the pandemic were negatively coupled with DASS-21 scores and positively coupled with CD-RISC ones (Figure 3). Participants with limited access to face masks or who purchased personal protective equipment displayed increased vulnerability, but those who had undergone specific outbreak response training reported lower degrees of stress, anxiety and depression and higher resilience.

An EFA analysis was then conducted on 50 potential predictors of DASS-21/CD-RISC (Table S9), which revealed that 28 variables could be efficiently described in terms of eight LVs: concern about contracting COVID-19 at work (*work concerns*) and to transmit it to family members/friends outside (*outside work concerns*); the pandemic's impact on one's work (*work impact*) and outside (*nonwork impact*); the degree of preparedness of the hospital/department in terms of a *contingency plan* for the pandemic; training on safety procedures (*distance & protection*); *equipment* (participants purchasing masks or alcohol-based hand rub); and participants' *family duties* outside work. We then ran PLS-PM to assess whether each of these LVs could predict psychological *vulnerability* (see Section 2). We found that the variance explained on psychological *vulnerability* by the combined eight LVs was $R^2 = 0.30$ (bootstrap-based 95% CI, 0.25–0.37). For all LVs, Dillon–Goldstein's ρ was ≥ 0.78. The supporting information contain further information on path coefficients estimation, including testing of the statistical assumptions that underlie linear regressions. Figures 4 and 5 depict the most relevant path coefficients, whereas detailed statistical information is provided in Tables S11 and S12. Specifically, we found a direct positive modulation by *work impact*, *work concerns* and *outside work concerns* on estimates of *vulnerability*. Regarding the variables describing the hospital/department preparedness to the pandemic, we found no direct influence on *vulnerability*. Importantly, however, Figure 4 (lower half) displays also those LVs exerting indirect effects on vulnerability. These include *contingency plan* and *distance & preparation*, who influence negatively *work concerns*/*work impact*, which, in turn, influence *vulnerability*. Hence, although the cross-correlation analysis points to a linear dependence between variables related to hospital preparedness and vulnerability, the current PLS path modelling suggest that this effect is best interpretable in terms of an indirect influence.

Finally, we tested for differences between professional groups in path modelling. The supporting information report analysis of compositional invariance, showing no difference in the relationship between each LV and the corresponding MVs. Instead, we found differences in the estimated path coefficients. The direct link *work concerns → vulnerability* was stronger in HPs when compared with both MDs and non-HPs (Figure 5A). Interestingly, although *contingency plan* exerts a negative indirect effect on *vulnerability*, which appears to be comparable across the three groups, non-HPs show also a direct negative modulation between these two variables that differs from the one observed for other HPs (Figure 5B,C). By contrast, the
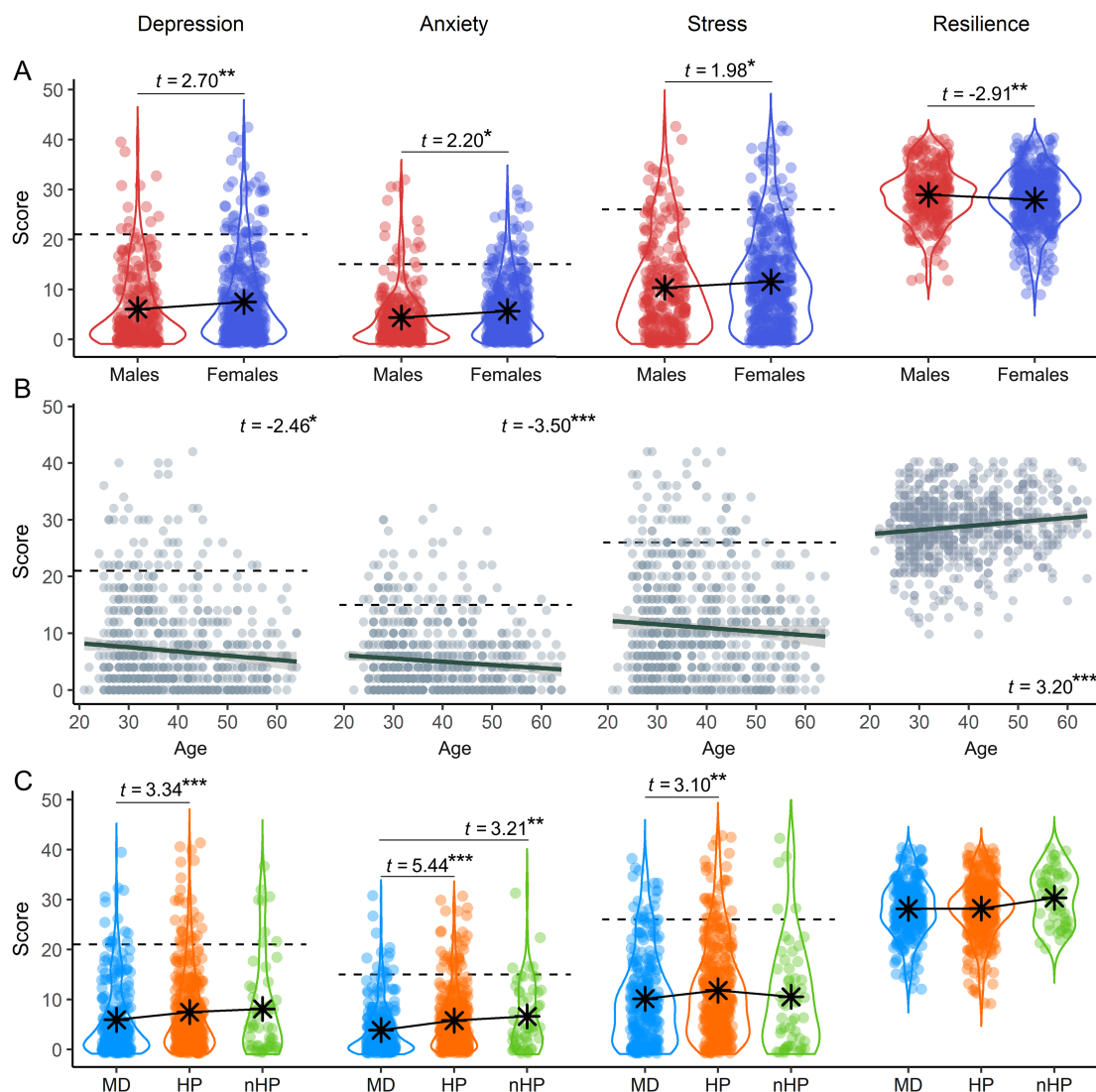
FIGURE 1 | Individual scores of depression, anxiety, stress (from DASS-21) and resilience (from CD-RISC) plot against (A) gender, (B) age and (C) group. For gender and group effects (A, C), violin plots display the data distribution within each subgroup. For age effects (B), scatter plots are displayed with a linear regression line (with a grey area describing the 95% confidence interval). Colour-coded individual data points are also displayed. For DASS-21 scores, a horizontal dashed line highlights the cut-off threshold for severe symptoms. Within each plot, the significance of effects is also highlighted, with the t-scores from linear mixed models (see Section 3) associated with the following coding: ***$p < 0.001$, **$p < 0.01$, *$p < 0.05$. Although statistical analysis was run on logit-transformed data (see Section 2), here, we display the original questionnaire scores to improve interpretability.

indirect effect *distance & preparation* on vulnerability appears to be driven by other HPs, whose parameters are different from those associated with MDs (Figure 5D).

4 | Discussion

We investigated key explanatory factors for the psychological vulnerability of ED personnel exposed to the COVID-19 pandemic during the first wave in 2020. Most importantly, our results provide compelling evidence that, on top of the detrimental role played by the pandemic, the level of hospital preparedness was associated with higher mental health. By running an extensive battery of questionnaires in a population of 702 ED employees across 10 hospitals in Switzerland and Belgium, we found converging evidence that the self-reported concerns about contracting COVID-19 and work-related

impact of COVID-19 were strong predictors of high depression, stress, anxiety and low resilience. Instead, the reported degree of preparation of the hospital or ED, especially in relation to the presence of a predetermined *contingency plan* for an epidemic, and training sessions about *distance and protection* measures, showed the opposite effect and were associated with lower psychological vulnerability. All these effects were confirmed after accounting for the confounding effects of gender, age, geographical location and employees' functions in the hospital or ED (MDs, other HPs and non-HPs). Interestingly, the effects of concern about contracting COVID-19 at work and *distance and protection* measures appeared more pronounced in nurses, psychologists and nursing assistants (other HPs) than for MDs or non-HP (Figure 5).

In our study, severe symptoms of psychological vulnerability occurred in approximately 8% of tested individuals,
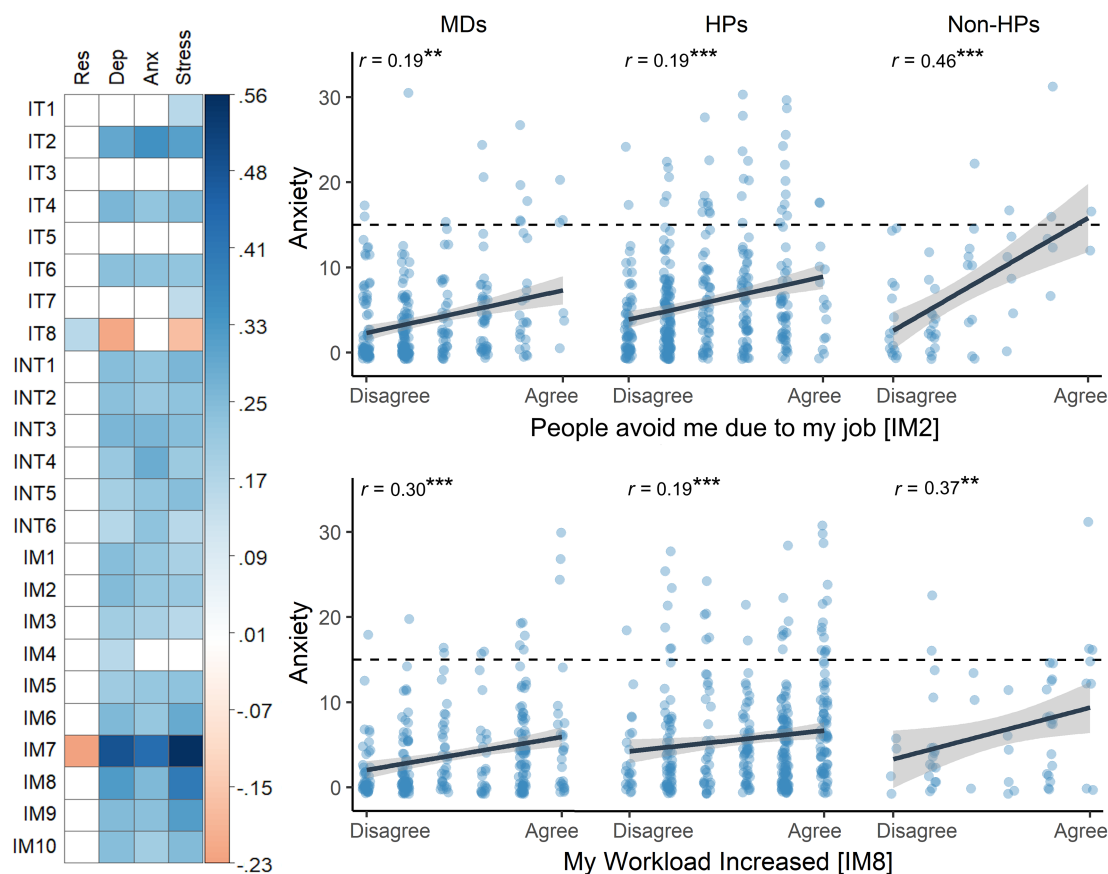
FIGURE 2 | Correlation analysis: Pandemic-related impact and concerns. (A) The scores from the CD-RISC and DASS questionnaires are correlated with all items enquiring about COVID-19 concerns and impact and displayed in matrix form. Correlation coefficients are obtained from residual scores after having accounted for confounding factors of group, gender, age and geographical location. Matrix cells are coloured if significant after Bonferroni correction for multiple comparisons; blue shades refer to positive correlations, and red shades refer to negative correlations. Note that although only part of the matrix is displayed here, correction for multiple comparisons took into account all 200 repeated measures (see Section 2). (B) Scatter plots describing the linear relation between the DASS anxiety score and two variables of interest in each group. Each plot shows a linear regression line (with a grey area describing the 95% confidence interval), plus the Pearson correlation coefficient. The significance of the correlation is highlighted as follows: ***$p < 0.001$, *$p < 0.05$. A horizontal dashed line highlights the cut-off threshold for severe anxiety symptoms. Although statistical analysis was run on residual, logit-transformed data (see Section 2), scatter plots display the original questionnaire scores to improve readability.

similar to previous reports and meta-analyses using the same psychological questionnaires (Alzueta et al. 2021; Chew et al. 2020; see also, Tiete et al. 2021). However, other studies showed an incidence of > 20% (Elbay et al. 2020; Giusti et al. 2020), whereas additional research using different measures and meta-analyses reported a heterogeneous prevalence of between 2% and 72% (Dehon et al. 2021; Lai et al. 2020; Norhayati, Che Yusof, and Azman 2021; Pappa et al. 2020; Pisanu et al. 2022; Salazar de Pablo et al. 2020; Weibelzahl, Reiter, and Duden 2021; Wu et al. 2021). This heterogeneous prevalence possibly reflects the disparity of opposing forces acting on ED personnel, ranging from variable adopted protection measures to a different pandemic impact on ED operation. In particular, one relevant source of variability is the geographical location as employees in regions with a high contagion risk generally displayed higher vulnerability (Lai et al. 2020; Pisanu et al. 2022). This potential confounder was accounted for in all our analyses through random factor modelling. It is interesting to note that in our cohort, individuals working in Belgium showed the highest

vulnerability (reaching ~20% in some subgroups; Table 1), possibly reflecting the high COVID-19–related mortality ratio in that country (Molenberghs et al. 2022). In addition to the role of geographical location, gender and age contributed to variability. This is consistent with abundant literature documenting how young individuals and women were more susceptible to psychological vulnerability during the pandemic (Lai et al. 2020; Lluch et al. 2022; Pappa et al. 2020; Pisanu et al. 2022). Regarding the professional role within the hospital/department, MDs displayed systematically less vulnerability than other HPs. This confirms previous studies that showed how members of this latter category (mainly nurses) reported higher scores of stress, anxiety, and emotional exhaustion, or even post-traumatic stress disorder (Kramer et al. 2021; Kunz, Strasser, and Hasan 2021; Lai et al. 2020; Lluch et al. 2022; Pappa et al. 2020; Sexton et al. 2022). This effect, observed also when accounting for gender imbalances across groups (Kramer et al. 2021), has been interpreted in the light of a high degree of exposure to patient care, which might have increased the likelihood of contagion in
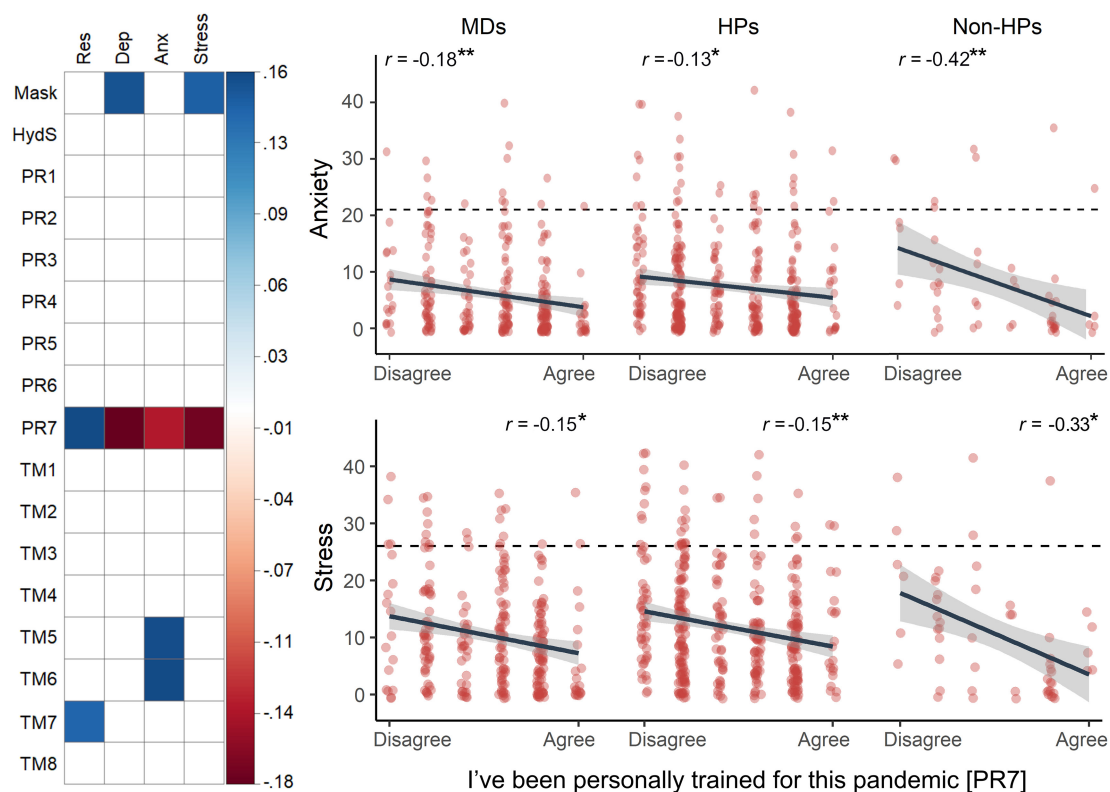
FIGURE 3 | Correlation analysis: Degree of preparation to the pandemic. (A) For each group, the four scores from CD-RISC and DASS questionnaires are correlated with all items enquiring about the perceived preparedness of the hospital/department to the pandemic (analysis on residual scores). (B) Scatter plots describing the effect played by self-reported preparation on DASS anxiety and stress scores. A horizontal dashed line highlights the cut-off threshold for severe stress symptoms. Each plot shows a Pearson correlation coefficient (scatter plot). The significance of the modulation is highlighted as follows: ***$p < 0.001$, **$p < 0.01$, *$p < 0.05$. Although statistical analysis was run on residual, logit-transformed data (see Section 2), scatter plots display the original questionnaire scores to improve readability.

the context of the pandemic and acted as a further stressor (Kramer et al. 2021; Kunz, Strasser, and Hasan 2021). Nevertheless, this interpretation does not entirely explain the group differences in our study as non-HPs also displayed higher anxiety (DASS-21 score) and depression (more severe cases) than MDs. However, as shown in Table S3, non-HPs had the least contact with infected patients or with the virus itself. Furthermore, the descriptive variables on personal exposure with the virus/patients did not predict significantly any psychological vulnerability score.

Our data offer further insights on the processes that might explain psychological vulnerability in healthcare workers, including the observed group differences. First, our analyses converge in identifying three main families of predictors describing (1) the pandemic's impact on participants' work (e.g., tighter working schedules, involvement in different duties), (2) concerns about contracting COVID-19 both at workplace (e.g., concerns about interacting with infected patients) or (3) outside (e.g., concerns about the health of parents and friends). Importantly, whereas effects of work-related impact and outside work concerns were observed independently of the group, work-related concerns influenced prevalently other HPs as MD and non-HPs' coefficients were approximately 0 (Figure 5). Hence, it is not the actual exposure to the COVID-19 virus or infected patients that was associated with higher degrees of psychological vulnerability in other HPs as previously suggested (Kramer et al. 2021;

Kunz, Strasser, and Hasan 2021) but rather subjective concerns about contagion.

In addition to direct effects, we also found that predictors describing the perceived presence of a contingency plan for the pandemic and training sessions about distance and protection measures were negatively associated with psychological vulnerability. This was observed in both the exploratory correlation (Figure 3) and in the path modelling, with the latter analysis suggesting that perceived hospital preparedness influenced vulnerability indirectly by decreasing the perceived work-related impact and concerns (Figure 4). Furthermore, the effect of training sessions about distance and protection measures appeared specific for other HPs (Figure 5). By contrast, no group differences in the indirect effect of contingency plan on psychological vulnerability, albeit, in the non-HP group specifically, the analysis suggested the presence of an additional direct negative influence (Figure 5). Previous studies have highlighted the beneficial role of factors like psychological/social support, counselling and the promotion of coping strategies (De Brier et al. 2020; Dehon et al. 2021; Elbay et al. 2020; Labrague 2021). Although relevant to address mental health issues, HPs rarely took advantage of these types of support, despite the high degree of distress reported, due in some cases to conflicts with the tight work schedule imposed by the public health emergency (Vera San Juan et al. 2020; Vicentini et al. 2022). One recent meta-analysis

Direct effects
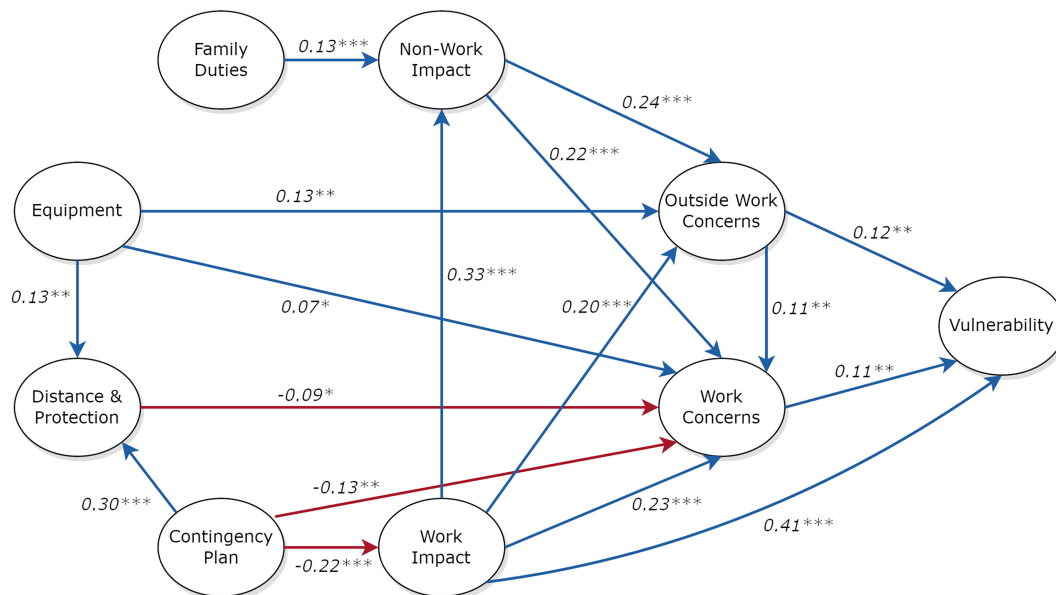
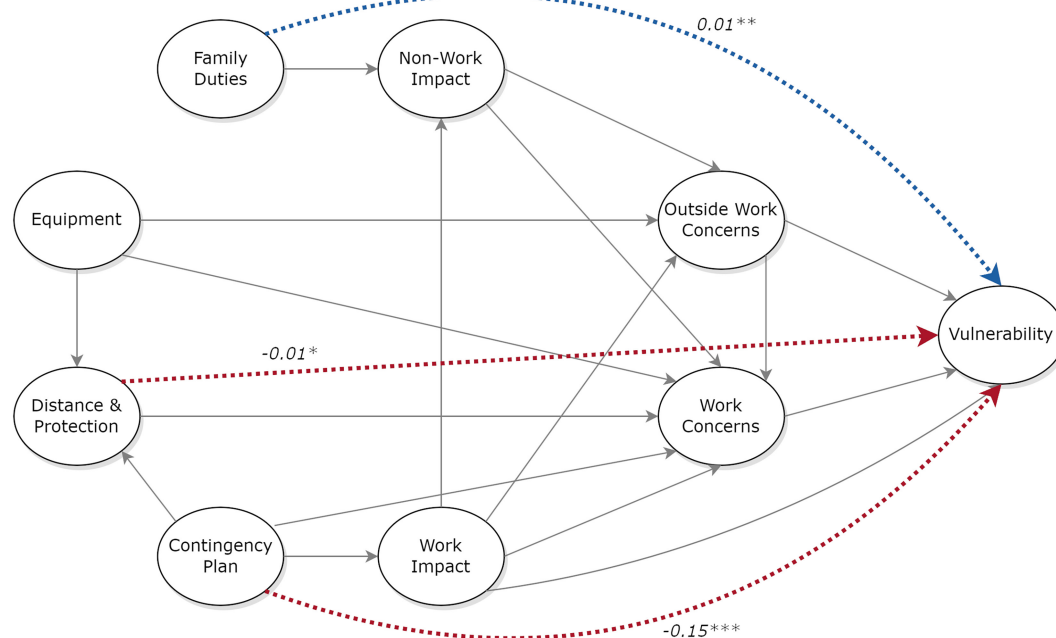## Indirect effects on Vulnerability

FIGURE 4 | Partial least squares path modelling (PLS-PM): Direct and indirect effects. Schematic representation of the relationships between latent constructs obtained from the combination of 32 variables (28 predictors of psychological vulnerability, plus DASS-21 and CD-RISC scores) from those employed in this study (Table 1). Standardized path coefficients (β) significantly different from 0 are displayed as colour-coded arrows: positive in blue and negative in red. Direct effects (upper half of the plot) are displayed as solid lines, whereas indirect effects (lower half) are displayed as dotted lines. Significance is established through a bootstrap resampling and is highlighted as follows: ***$p < 0.001$, **$p < 0.01$, *$p < 0.05$.

also argued that clear communication from the organization decreases the likelihood of developing severe symptoms (De Brier et al. 2020). Similarly, trust between the institution (hospital) and the employees was a key motivator to work during the 2009 H1N1 pandemic in Japan (Imai 2020). Our data confirm but also extend these findings, thus showing how the perception that the department/hospital is ready to face the pandemic can lead to improved psychological wellbeing.

Our study has some limitations that should be acknowledged. The size of the non-HP group is smaller than the other two groups and is restricted to only two of the four locations tested (Table 1). Second, as all our analyses were correlational in nature, the direction of the effects is often unclear. In particular, PLS-PM works under a directionality assumption, something that was a priori specified based on the most plausible interpretation of the effects (e.g., perception of being avoided due
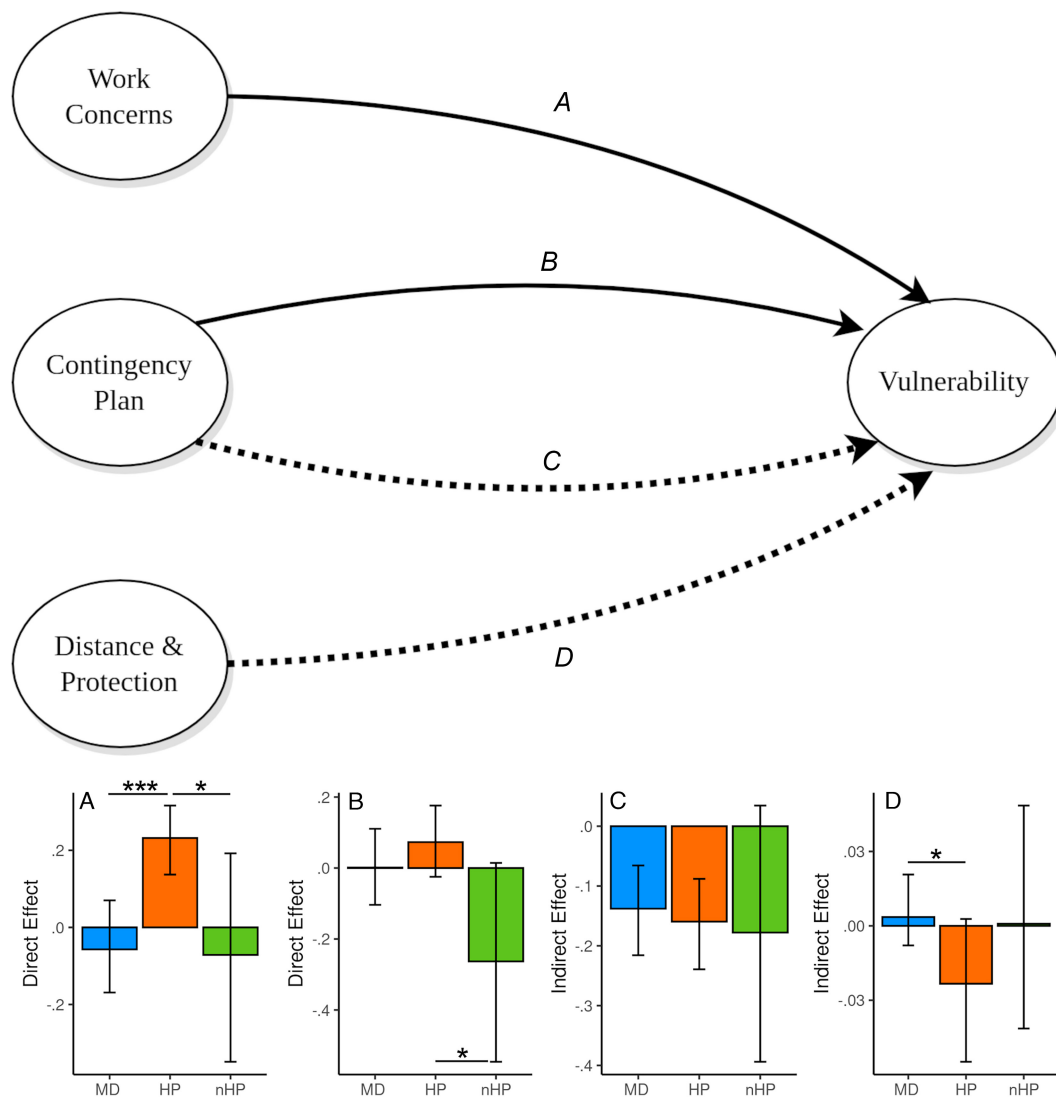
FIGURE 5 | Partial least squares path modelling (PLS-PM): Group differences. Schematic representation of two direct paths and one indirect path, each associated with bar plots describing the standardized path coefficients (β) together with bootstrap-based 95% confidence intervals as error bars. Direct effects are displayed as solid lines, whereas indirect effects are displayed as dotted lines. In all cases, group differences were assessed through permutation tests and are highlighted as follows: ***$p < 0.001$, *$p < 0.05$.

to work → high anxiety). However, alternative directions are also in principle possible (high anxiety → perception of being avoided due to work). Finally, as our results were derived from self-report questionnaires, it is unclear if they pertain to actual aspects of hospital conditions (e.g., increased workload) or to their subjective perception (people feel they are working more). Ideally, the variability in actual working conditions should be partly explained by geographical location, which are characterized by their own idiosyncratic regulations and by contagion severity. Hence, as random effects of locations were always accounted for in all our variables, we are inclined to interpret our results in terms of a subjective perception of working conditions.

Keeping these limitations in mind, our study provides compelling evidence that although dire working conditions during the recent pandemic impacted profoundly on the psychological well-being of emergency personnel, clear communication to staff regarding established contingency plans and protective measures to minimize the risk of exposure might have a beneficial effect on employees' mental health.

Author Contributions

Corrado Corradi-Dell'Acqua: Conceptualization; Methodology; Data curation; Formal analysis; Writing – original draft. **Garance Horisberger:** Conceptualization; Methodology; Data collection; Writing – review & editing. **Olivier Hugli:** Conceptualization; Methodology; Funding acquisition; Writing – review and editing. **David Caillet-Bois:** Methodology; Database management; Data curation; Writing – review and editing. **Alessio Toraldo:** Methodology; Writing – reviewing and editing. **Michael Christ:** Data collection; Writing – review & editing. **Vincent Della Santa:** Data collection; Writing – review & editing. **Vincent Frochaux:** Data collection; Writing – review & editing. **Pierre Mols:** Data collection; Writing – review & editing. **Andrea Penaloza:** Data collection; Writing – review & editing. **Sara Rezzonico:** Questionnaire translation; Data collection; Writing – review & editing. **Luca Tagliabue:** Questionnaire translation; Data collection; Writing – review & editing.

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Supporting Information

Additional supporting information can be found online in the Supporting Information section.