RESEARCH ARTICLE

The major worldwide stress of healthcare professionals during the first wave of the COVID-19 pandemic – the international COVISTRESS survey

Sébastien Couarraze, Louis Delamarre, Fouad Marhar, Bing Quach, Jiao Jiao, Raimundo Avilés Dorliac, Foued Saadaoui, Andy Su-I Liu, Benoit Dubuis, Samuel Antunes, Nicolas Andant, Bruno Pereira, Ukadike C. Ugbolue, Julien S. Baker, The COVISTRESS network, Maélys Clinchamps, Frédéric Dutheil

1 Department of Anesthesiology and Critical Care, University Hospital of Toulouse, University Toulouse 3-Paul Sabatier, Toulouse, France, 2 UMR EFTS, Université Toulouse 2–Jean Jaurès, Toulouse, France, 3 Université Clermont Auvergne, CNRS, LaPSCo, Physiological and Psychosocial Stress, University Hospital of Toulouse, CHU Toulouse, France, 4 Hong Kong Baptist University, Physical Education and Health, Centre for Health and Exercise Science Research, Kowloon Tong, Hong Kong, 5 Universidad Finis-Terrae, Hospital Dr. Luis-Valentín-Ferrada, El-Carmen, Maipú, Chile, 6 King Abdulaziz University, Saudi Arabia, College of Sciences and Theoretical Studies, Riyadh, Saudi Arabia, 7 University of Taipei, Exercise and Health Science, Taipei, Taiwan, 8 Université de Genève, UNIGE, Fondation INARTIS, Genève, Switzerland, 9 ISPA—Instituto Universitário, Ordem dos Psicólogos Portugueses, APPsyCI—Applied Psychology Research Center Capabilities & Inclusion, Lisboa, Portugal, 10 University Hospital of Clermont Ferrand, CHU Clermont-Ferrand, Clinical Research and Innovation Direction—Biostatistics, Clermont-Ferrand, France, 11 University of the West of Scotland, Institute for Clinical Exercise & Health Sciences, School of Health and Life Sciences, South Lanarkshire, Scotland, UK, 12 University Hospital of Clermont-Ferrand, CHU Clermont-Ferrand, Preventive and Occupational Medicine, Clermont-Ferrand, France, 13 Université Clermont Auvergne, CNRS, LaPSCo, Physiological and Psychosocial Stress, University Hospital of Clermont-Ferrand, CHU Clermont-Ferrand, Preventive and Occupational Medicine, WittyFit, Clermont-Ferrand, France

¶ Members of the COVISTRESS network are provided in the Acknowledgments.

* couarraze.s@chu-toulouse.fr

Abstract

Introduction

The COVID-19 pandemic has initiated an upheaval in society and has been the cause of considerable stress during this period. Healthcare professionals have been on the front line during this health crisis, particularly paramedical staff. The aim of this study was to assess the high level of stress of healthcare workers during the first wave of the pandemic.

Materials and methods

The COVISTRESS international study is a questionnaire disseminated online collecting demographic and stress-related data over the globe, during the pandemic. Stress levels were evaluated using non-calibrated visual analog scale, from 0 (no stress) to 100 (maximal stress).
Results
Among the 13,537 individuals from 44 countries who completed the survey from January to June 2020, we included 10,051 workers (including 1379 healthcare workers, 631 medical doctors and 748 paramedical staff). The stress levels during the first wave of the pandemic were 57.8 ± 33 in the whole cohort, 65.3 ± 29.1 in medical doctors, and 73.6 ± 27.7 in paramedical staff. Healthcare professionals and especially paramedical staff had the highest levels of stress (p < 0.001 vs non-healthcare workers). Across all occupational categories, women had systematically significantly higher levels of work-related stress than men (p < 0.001). There was a negative correlation between age and stress level (r = -0.098, p < 0.001). Healthcare professionals demonstrated an increased risk of very-high stress levels (>80) compared to other workers (OR = 2.13, 95% CI 1.87–2.41). Paramedical staff risk for very-high levels of stress was higher than doctors’ (1.88, 1.50–2.34). The risk of high levels of stress also increased in women (1.83, 1.61–2.09; p < 0.001 vs. men) and in people aged <50 (1.45, 1.26–1.66; p < 0.001 vs. aged >50).

Conclusions
The first wave of the pandemic was a major stressful event for healthcare workers, especially paramedical staff. Among individuals, women were the most at risk while age was a protective factor.

Introduction
The COVID-19 pandemic commenced at the end of 2019 and has been exponential since inception [1]. It is the biggest global health crisis ever experienced in the modern world [2]. The health crisis clearly has an impact on the stress levels of individuals, that can lead to forthcoming public health crisis [3]. Many studies have focused on the stress and concern of healthcare professionals [4–7]. However, studies that compared the stress of physicians to paramedical staff are sparse. The characteristics of pandemic-related stress in a context of such magnitude are new and may present some specific features, such as concerns for the future [8, 9]. Some consequences of this pandemic seem to influence people’s stress levels, such as isolation due to lockdowns and the fear of contagion, which can induce chronic stress [10]. The disruption of professional environments secondary to containment measures has been heterogeneous, [11] forcing workers to interrupt their professional activity while some others maintained regular working routines [11]. This was the case for healthcare professionals who had to continue their work despite the risks inherent to the pandemic [12, 13]. Work is already known as a major source of stress for individuals [14]. Nevertheless, the pandemic-related dimension of occupational stress in healthcare professionals, and particularly between medical doctors and paramedical staff, were not reported to our knowledge. Because of their profession, healthcare professionals have had to maintain or even increase their professional workload [13]. At the onset of the crisis, the lack of known treatment forced healthcare professionals to optimize only symptomatic treatments, isolate patients and provide supportive care [15]. Paramedical staff played a pivotal role in this part of patient care [15]. In the absence of a clearly established "cure", "care" predominated [16]. Certain socio-demographic factors such as gender or age can also influence the level of stress at work and thus represent a risk.
factor. This is the case among nurses, where women are more stressed than men [17]. Age appears to be a protective factor for all workers during the pandemic and older people have developed specific coping strategies that preserve them from high levels of stress [18]. Showing whether the occupation had an influence on the level of work-related stress could make it possible to better identify the populations at risk to implement targeted actions.

Therefore, the main objective of this study was to assess the work-related stress of health-care professionals during the covid-19 pandemic. Secondary objectives were to compare the stress of medical doctors with that of paramedical staff, and to evaluate the consequences of personal risk factors such as gender, age etc.

**Methods**

**Study design**

We conducted an international prospective observational study on the general population during the pandemic period of COVID-19 from March to October 2020. We used a computerized anonymous online questionnaire, accessible through the website COVISTRESS.ORG. The questionnaire was translated into ten languages. The questionnaire was hosted by the University Hospital of Clermont-Ferrand, using the REDCap® software. To facilitate its diffusion, the questionnaire was disseminated by any mean (social media, radio, television, internet, mailing lists, etc.). Respondents were informed of the objective of the survey prior to answering the questionnaire. They were also informed that their data would be used anonymously for research purposes. This study was approved by the South-East VI Ethical Committee of France (Clinicaltrials.gov NCT04538586). The ethics committee waived the need for written consent considering that respondents gave their consent by answering to the questionnaire, and that they could also withdraw at any time.

**Participants**

The questionnaire was distributed using the international COVISTRESS network. It was disseminated to the general population without distinction of country, gender, occupation or disease (Fig 1).

**Outcomes: Instrument survey**

The main outcome was work-related stress, measured with the use of a visual analog scale i.e. a non-calibrated horizontal line ranging from minimum (0) to maximum (100) [19]. Visual analog scale of stress is a validated tool commonly used in daily practice [20, 21]. With this type of tool, participants can self-assess in a simple way the range of their possible feelings [22]. Secondary outcomes were sociodemographic (age, sex), occupations (non-healthcare workers, medical doctors, paramedical staff), and working conditions (working in usual conditions, working in unusual conditions, interruption of work). This was a computerized questionnaire hosted on the secure REDCAP® platform. It consisted of about 100 questions. The study presented here reports on the answers related to work-related stress. Depending on the answers given, individuals had access to all or part of the questionnaire. The questions used for this study are available in S2 Appendix.

**Statistical analysis**

Data were expressed in number and percentage for categorical variables and mean ± standard deviation (SD) for quantitative variables. Statistics were computed using Stata software (v16, StataCorp, College station, USA). Comparisons between categorical variables were
accomplished using Chi2 ($\chi^2$) and contingency tables. Comparisons between quantitative variables, such as the levels of stress at work according to professional practice during the pandemic, were executed using ANOVA (Fig 2). A Pearson’s r test was carried out to study the correlation between numerical values such as stress levels and age. Logistic regressions were performed to evaluate the risk factors of stress in the workplace (Fig 3). Results were expressed as odds ratio (OR) and 95% confidence intervals (95% CI). Close attention was paid to examining multicollinearity and interactions between covariates: 1) studying the relationships between the covariates, 2) estimating the variance inflation factor and 3) measuring the impact of adding or removing variables in the multivariable model [23, 24]. We first performed univariate regressions for each explanatory factor and then performed a stepwise approach on the status of healthcare worker and on the fact of being a doctor or paramedical staff by adding one by one the other potential explanatory factors (work or not, age and gender).

Regression’s analysis were performed to evaluate the risk factors of stress at the workplace. When stress was expressed as a quantitative variable, results were expressed as coefficient and its 95% confidence intervals (95CI) (Fig 4). Close attention was paid to examining multicollinearity and interactions between covariates: 1) studying the relationships between the covariates, 2) estimating the variance inflation factor and 3) measuring the impact of adding or removing variables in the multivariable model. We first performed univariate regressions for each explanatory factor and then performed a stepwise approach on the status of healthcare worker and on the fact of being a doctor or paramedical staff by adding one by one the other potential explanatory factors (work or not, age and gender) (S1 Table). Finally, we ran logistic regressions to quantify the influence of risk factors on « at-risk » stress levels (i.e. in range 50–79 out of 100) and on « intervention » stress levels (i.e. in range 80–100 out of 100). When stress was expressed as a qualitative variable (« at-risk » and « intervention » thresholds),
results were expressed as odds ratio (OR) and 95CI (Fig 5). Sensitivity analyses were also conducted for OR (S2 Table). A value of p ≤ 0.05 was needed for statistical significance.

**Results**

**Participants**

We received 13,547 responses to the questionnaire from 44 countries. The distribution of responses by continent was as follows: Europe 82.8% (n = 9757), America 8.5% (n = 1002), Africa 5.2% (n = 617), Asia 3.4% (n = 404). Due to missing data precluding statistical analysis, 3496 participants were excluded, resulting in a final sample of 10,051 (Fig 1). Respondents were 41.0 ± 14.0 years old; 31.8% were men. There were 8,644 non-healthcare workers, and 1,379 healthcare professionals (631 medical doctors and 748 paramedical staff). Women were relatively more frequent in healthcare professions than in the general population (χ² = 112, n = 10018; p < 0.001). While lockdown and staying at home was recommended, 90.3%
(n = 6,639) of our cohort maintained occupational activity. 96.6% (n = 1,264) of healthcare professionals maintained their professional activity, more than other workers ($\chi^2 = 73.7$, n = 7,356; p < 0.001). Despite their equality in maintaining their professional activity,

Fig 3. Correlation of age and stress at work.

https://doi.org/10.1371/journal.pone.0257840.g003

| Variables | Stress at work - continuous data | Standard. estimate (95% CI) | p-value |
|-----------|---------------------------------|-----------------------------|---------|
| **Internal factors** | | | |
| Age, <50 (vs >50 as REF) | | 0.12 (0.07, 0.18) | < 0.001 |
| Sex, female (vs male as REF) | | 0.23 (0.18, 0.28) | < 0.001 |
| **Profession factors** | | | |
| Occupation, caregivers (vs not caregivers as REF) | | 0.39 (0.30, 0.47) | < 0.001 |
| Healthcare worker, paramedics (vs MD as REF) | | 0.29 (0.17, 0.41) | < 0.001 |
| **Working status** | | | |
| Working conditions, work (vs stop working as REF) | | 0.37 (0.29, 0.45) | < 0.001 |

Fig 4. Multivariate analysis of work-related stress. Abbreviations: REF: reference variable, MD: Medical doctors, CI: confidence intervals.

https://doi.org/10.1371/journal.pone.0257840.g004
physicians were more prone to declare working in unusual conditions than paramedical staff (working conditions, usual vs unusual, p < 0.001, respectively) (Table 1).

### Main outcome: Work-related stress

The level of work-related stress during the pandemic was influenced by profession (Fig 2). Healthcare professionals had levels of stress 25.8% higher than the general population.

#### Table 1. Characteristics of the individuals.

|               | Non Healthcare Workers | Medical Doctors | Paramedical Professions |
|---------------|------------------------|-----------------|-------------------------|
|               | n = 8 644              | n = 631         | n = 748                 |
| Stress at work (mean ± SD) | 55.5 ± 33.2            | 65.3 ± 29.1     | 73.6 ± 27.7             |
| p-value       | < 0.001                | 0.027           | 0.09                    |
| Gender (n = 10 018) |                        |                 |                         |
| Female        | 5 713                  | 426             | 679                     |
| Male          | 2 931                  | 200             | 69                      |
| Stress at work (mean ± SD) | 57.5 ± 33.2            | 61.4 ± 29.8     | 68.1 ± 28               |
| p-value       | < 0.001                | 0.001           | 0.48                    |
| Age (n = 9 968) |                        |                 |                         |
| < 30 years    | 1 932                  | 124             | 160                     |
| 30–50 years   | 3 721                  | 376             | 450                     |
| > 50 years    | 1 894                  | 126             | 135                     |
| Stress at work (mean ± SD) | 56.9 ± 33.9            | 62.1 ± 31.7     | 73.3 ± 27.4             |
| p-value       | < 0.001                | 0.001           | 0.48                    |
| Working conditions (n = 7 356) |            |                 |                         |
| Usual conditions | 1 765                  | 273             | 392                     |
| Stress at work (mean ± SD) | 60.4 ± 31.7            | 66.7 ± 27.7     | 75.8 ± 26.7             |
| p-value       | < 0.001                | 0.003           | 0.001                   |
| Unusual conditions | 3 205                  | 292             | 264                     |
| Stress at work (mean ± SD) | 56 ± 31.9              | 65.5 ± 29.5     | 73.4 ± 26.5             |
| p-value       | < 0.001                | 0.003           | 0.001                   |
| Stop working  | 553                    | 27              | 21                      |
| Stress at work (mean ± SD) | 46.7 ± 37              | 42.1 ± 39.2     | 53 ± 42.8               |
| p-value       | < 0.001                | 0.003           | 0.001                   |

https://doi.org/10.1371/journal.pone.0257840.t001
Among healthcare workers, paramedical staff had levels of stress 12.7% higher than medical doctors (p < 0.001). Regardless of occupational category, women were systematically more stressed than men (between 12.2% and 20.7% depending on occupational category, p < 0.001) (Fig 2). Working under unusual conditions did not have an impact on healthcare professionals’ job stress.

**Correlation**

Workers’ age was inversely correlated with stress scores (Pearson r = -0.098; p < 0.001), as presented in (Fig 3).

**Univariate and multivariate analyses**

Using work-related stress as a continuous variable, being a health professional or paramedical staff, continuing to work, gender, and age were linked with stress scores (p < 0.001). Univariate analyses demonstrated higher scores of work-related stresses in healthcare professionals (Standardized estimate 0.43, 95% CI 0.37 to 0.49). Among healthcare professionals, paramedical staff presented higher stress scores (0.29, 0.18 to 0.39 vs medical doctors). Continuing professional activity (vs. interrupted work), female gender and age < 50 were significantly associated with higher stress scores both in univariate and multivariate analysis, as expressed in (Fig 4). Sensitivity analyses demonstrated that the status of healthcare worker and the fact of being a doctor or paramedical staff was a risk factor of stress whatever the covariates (S1 Table).

**Quantification of risk**

Using work-related stress as a qualitative variable, multivariate analyses showed that the risk of very-high level of stress (intervention threshold, >80) was twice the magnitude in healthcare professionals compared to other workers (OR = 2.13, 95% CI 1.87–2.41). Within healthcare professionals, the risk of very-high level of stress (>80) increased by 88% for paramedical staff compared to medical doctors (OR = 1.88, 95%CI 1.50–2.34). The risk of very-high levels of stress (>80) increased in those who continued to work (OR = 1.22, 95%CI 1.01–1.49 compared to those who stopped working), by 83% in women (OR = 1.83, 95%CI 1.61–2.09) compared to men and by 45% in people under 50 years of age (OR = 1.45, 95%CI 1.26–1.66) compared to those who are older). Quantification of risk for those factors was similar for levels of stress above the at-risk threshold (>50) (Fig 5). Sensitivity analyses demonstrated similar findings (S2 Table).

**Discussion**

The main findings were that healthcare professionals were the most at risk of stress during the pandemic, globally. Among this population, paramedical staff were more at-risk than physicians. Age and gender also appear to mitigate the experience of work-related stress. Our results are comparable to the literature on the subject [25–27]. Thus, we found higher levels of stress among healthcare professionals compared to other workers. Among healthcare workers, nurses are more stressed than doctors. Women were more affected than men. Young people are a population more at risk of high stress.

**A major stress of healthcare professionals during the first wave**

Given the sanitary nature of the COVID-19 global crisis, healthcare professionals have been on the front line dealing with the pandemic [28–30]. Despite their professionalism, overburdened, overworked and under-equipped [31] healthcare systems may account for higher stress...
among these individuals [32, 33]. It is already known that the pandemic may have led to an increase in burnout among these workers [34, 35]. The chronic stress observed is itself a risk factor for mental [36] and physical [37–39] health issues. The duration and intensity of the pandemic, which was a major source of stress, was the cause of depression among healthcare professionals [40]. Longer lasting and more profound consequences such as post-traumatic stress, suicides, depression have been observed, but as the pandemic is still ongoing, these consequences may be even more important [41, 42]. We were interested here in work-related stress and thus in the short term. However, the consequences of this stress for healthcare workers will persist in the medium and long term [43].

An even greater stress for paramedical staff

Even if patient care is necessarily multidisciplinary, being a paramedic is an additional risk factor for stress [44]. Paramedical staff appear to have been more exposed than physicians. In the absence of specific COVID-19 treatment, healthcare professionals must provide basic, comfort and symptomatic care. This type of care preferentially involves paramedical staff in contact with the patient and therefore potential contamination [45]. Paramedical staff were more exposed to the lack of material and human resources than physicians [5]. Nurse-to-patient ratio standards in critical care services required new resources during the pandemic. This meant that some paramedical staff were reallocated to understaffed units to provide help and increase manpower [46]. This was also not a trivial issue in terms of work-related stress and was much less the case for physicians who, because of their specialties, remained within their areas of expertise. The sources of stress were thus more important for paramedical staff, including nurses [5]. The high levels of work-related stress among nurses during the pandemic are leading to increased burnout among these health professionals [47]. The effects of the pandemic on COVID are major as they increase psychological distress and the desire of nurses to leave the profession [48]. This is an important point because the period requires maximum nursing resources and their departure generates recruitment problems which may lead to the closure of certain beds or even units as may be the case with critical care beds. Another problem resulting from the stress and burnout of nurses is the decline in the quality of care when nurses are affected [49]. This phenomenon could increase in the weeks and months to come, according to the results of the survey carried out by the National Order of Nurses of France [50].

Women workers might be more affected

In our study, whatever their profession, women had the highest levels of work-related stress during the first global lockdown. Our results concord with the literature revealing that women are more prone to stress [51–53], and may also suffer more from the negative psychological impact of the COVID-19 outbreak [39, 54]. Women often have a double life combining work and family life [55, 56]. This is even less reconcilable when both professional and family constraints increase. Indeed, families had to adapt to the closure of schools. Even in couples that shared the involvement in the education and care of children, women are still mostly implicated [55]. Given these elements and the predominance of women in healthcare professionals, the WHO advised to study gender-specific consequences of the pandemic [57]. Even if women have less severe forms of COVID [58], they were frightened of contracting COVID-19 [54]. They may also have been more impacted by the higher number of deaths and difficulties during the crisis. Women show greater psychophysiological concordance and consistency than men [59], and may therefore present more psychological vulnerability [60, 61].
Youth are also at risk

The average age of our cohort corresponds to the average age of the population of developed countries [62]. Indeed, age seems to have had a significant impact on the level of stress at work. According to the literature [63], older staff seemed less stressed, despite facing a higher risk of mortality and morbidity from COVID-19 [64]. Our results on a much larger population confirm these findings. A possible explanation may be that younger healthcare professionals are less experienced, which may contribute to an increased work-related stress, especially in complex and/or difficult work situations, such as during the pandemic [65]. The lack of human resources was such that people with little (young graduates . . . ) or no experience (students . . . ) were solicited to come and work in sectors where fully qualified professionals were absent [66]. It was demonstrated that healthy students who were involved during the pandemic had high levels of job stress and indications of mental distress [66]. Individuals in our cohort under 50 years of age were predominantly female, which may explain their high level of work stress, which is more prevalent among younger individuals. The greater feminization of paramedical staff compared to physicians [67] may partly explain this difference, but is not exclusive.

Limitations

Our study has limitations. We have collected data through a cross-sectional study, a methodology which has its own limitations but allows for a large number of responses [68]. Collecting only declarative data, each individual was able to answer anonymously without any possible control. As a result, the study may be subject to self-reporting bias, especially when questions were omitted by the participants, as well as non-disclosure and uncertainty regarding timing of the questionnaire. Nevertheless, the anonymous nature of the survey may limit biases in the answers. To limit this bias, we have eliminated all incomplete or questionable answers.

Second, some countries and continents are more represented than others, which may limit the generalizability of the data collected. However, this project may be one of the largest studies on this topic due to the number of responses (13,537), and the variety of covered geographic areas, making it more relevant than monocentric studies [69–71]. There could also be measurement bias occurring from the scales used, but this method is scientifically sound [19]. The number of respondents in our study is consistent with the recommendations for this type of analysis [72]. Self-assessed stress levels can be complex because the question may seem vague. However, in a transactional approach, this personal and individual evaluation remains relevant.

This study also presents strengths. Our cohort was representative in terms of age and gender for health professionals even if we did not exhaustively profile these workers (job tenure. . . ) [73]. The international nature of this study may increase the generalizability of our results even if the inhomogeneous distribution of response across the globe generates limits to this external validity. Besides, this study compares stress across professions, which is often a missing element of research regarding stress in healthcare workers. Due to the cross-sectional design of this study, the causal relationship between the risk of work-related stress and mental health needs to be investigated through longitudinal studies.

Conclusions

The COVID-19 pandemic has and will have consequences for every population. Nevertheless, healthcare professionals were more impacted than other workers by work-related stress. Para-medical staff were more impacted on than physicians. Across all occupational categories, age appears to mitigate work-related stress, and maybe due to the effects of experience. We were
able to identify risk factors for high levels of work-related stress such as youth, female gender, paramedical professions and having maintained one’s professional activity. The impact of such a surge in work-related stress may inflict a second blow to already fragile healthcare systems. Adequately monitoring work-related stress and its effects on healthcare workers may be crucial to plan for post-pandemic adjustments.

Supporting information
S1 Appendix. Crude data used and analyzed in the study.
(XLSX)
S2 Appendix. English version of the questionnaire (questions used for this study).
(DOCX)
S1 Table. Sensitivity analyses of factors increasing work-related stress.
(DOCX)
S2 Table. Sensitivity analyses of risk factors for high score of work-related stress: Stepwise approach to the status of healthcare worker.
(DOCX)

Acknowledgments
The COVISTRESS network is headed by Pr. Frédéric Dutheil (frederic.dutheil@uca.fr) – CHU Clermont-Ferrand, Occupational and Environmental Medicine, 58 rue Montalembert, 63000 Clermont-Ferrand, France. Members of the research group are Nicolas Andant, Maëlys Clinchamps, Stéphanie Mestres, Cécile Miele, Valentin Navel, Bruno Pereira, Karine Rouffiac – CHU Clermont-Ferrand, France; Yves Boirie, Jean-Baptiste Bouillon-Minois, Martine Duclos, Maria Livia Fantini, Jeannot Schmidt, Stéphanie Tubert-Jeannin – Université Clermont Auvergne / CHU Clermont-Ferrand, France; Mickael Berthon, Pierre Chausse, Michael Dambrun, Sylvie Droit-Volet, Julien Guegan, Serge Guimond, Laurie Mondillon, Armelle Nugier, Pascal Huguet – Université Clermont Auvergne, CNRS, LAPSCO, France; Samuel Dewarvin – WittyFit, France; Sébastien Courraze, Louis Delamarre, Fouad Marhar – CHU Toulouse, France; Geraldine Naughton, Amanda Benson – Swinburne University, Australia; Claus Lamm – University of Vienna, Austria; Karen Gbaglo, Ministry of Health; Vicky Drapeau – Université de Laval, Canada; Raimundo Avilés Dorlhiac – Universidad Finis Terrae, Chile; Benjamin Bustos – Universidad de Los Andes, Chile; Gu Yaodong – Ningbo University, China; Haifeng Zhang – Hebei Normal University, China; Peter Dieckmann – Copenhagen Academy for Medical Education and Simulation (CAMES), Denmark; Julien Baker, Yanping Duan, Yang Gemma Gao, Yajun Wendy Huang, Jiao Jiao, Binh Quach, Chunqing Zhang, Hong Kong Baptist University, China; Hijrah Nasir, Indonesia; Perugi Cocco, Rosamaria Lecca, Monica Puligheddu, Michela Figorilli, Università di Cagliari, Italy; Morteza Charkhabi, Reza Bagheri – University of Isfahan, Iran; Daniela Pfabigan – University of Oslo, Norway; Peter Dieckmann, University of Stavanger, Norway; Samuel Antunes, David Neto, Pedro Almeida – Ordem dos Psicólogos Portugueses, ISPA-Instituto Universitário, Portugal; Maria João Gouveia – ISPA-Instituto Universitário, Portugal; Pedro Quinteiro – William James Center for Research, ISPA-Instituto Universitário; Constanta Urzeala – UNEFS, Romania; Benoit Dubuis – UNIGE, Switzerland; Juliette Lemaignen – Fondation INARTIS, Switzerland; Kuan-Chou Chen, National Taiwan University of Sport, Taiwan; Andy Su-I Liu – University of Taipei, Taiwan; Foued Saadaoui, King Abdulaziz University, Tunisia;
Ukadike C Ugbolue, University of the West of Scotland, United Kingdom; Keri Kulik – Indiana University of Pennsylvania, USA.

Author Contributions
Conceptualization: Maëlys Clinchamps, Frédéric Dutheil.
Data curation: Nicolas Andant, Bruno Pereira, Frédéric Dutheil.
Formal analysis: Nicolas Andant, Bruno Pereira, Frédéric Dutheil.
Investigation: Jiao Jiao, Raimundo Avilés Dorlhiac, Foued Saadaoui, Andy Su-I Liu, Benoît Dubuis, Samuel Antunes, Ukadike C. Ugbolue, Julien S. Baker, Frédéric Dutheil.
Methodology: Nicolas Andant, Bruno Pereira, Maëlys Clinchamps, Frédéric Dutheil.
Project administration: Maëlys Clinchamps, Frédéric Dutheil.
Resources: Binh Quach, Maëlys Clinchamps, Frédéric Dutheil.
Supervision: Maëlys Clinchamps, Frédéric Dutheil.
Validation: Frédéric Dutheil.
Visualization: Frédéric Dutheil.
Writing – original draft: Sébastien Couarraze, Frédéric Dutheil.
Writing – review & editing: Sébastien Couarraze, Louis Delamarre, Fouad Marhar, Frédéric Dutheil.

References
1. Wynants L, Van Calster B, Collins GS, Riley RD, Heinzé G, Schuit E, et al. Prediction models for diagnosis and prognosis of covid-19: systematic review and critical appraisal. BMJ. 2020; m1328. https://doi.org/10.1136/bmj.m1328 PMID: 32265220
2. Arabi YM, Murthy S, Webb S. COVID-19: a novel coronavirus and a novel challenge for critical care. Intensive Care Med. 2020; 46: 833–836. https://doi.org/10.1007/s00134-020-05955-1 PMID: 32125458
3. Torales J, O’Higgins M, Castaldelli-Maia JM, Ventriglio A. The outbreak of COVID-19 coronavirus and its impact on global mental health. Int J Soc Psychiatry. 2020; 66: 317–320. https://doi.org/10.1177/0020764020915212 PMID: 32233719
4. Mo Y, Deng L, Zhang L, Lang Q, Liao C, Wang N, et al. Work stress among Chinese nurses to support Wuhan in fighting against COVID-19 epidemic. J Nurs Manag. 2020 [cited 27 Jun 2020]. https://doi.org/10.1111/jonm.13014 PMID: 32255222
5. Shen X, Zou X, Zhong X, Yan J, Li L. Psychological stress of ICU nurses in the time of COVID-19. Crit Care. 2020;24. https://doi.org/10.1186/s13054-019-2723-z PMID: 31980028
6. Wu W, Zhang Y, Wang P, Zhang L, Wang G, Lei G, et al. Psychological stress of medical staffs during outbreak of COVID-19 and adjustment strategy. J Med Virol. 2020 [cited 27 Jun 2020]. https://doi.org/10.1002/jmv.25914 PMID: 32314806
7. Tsamakis K, Rizos E, Manolis A, Chaidou S, Kympouroupolos S, Spartalis E, et al. [Comment] COVID-19 pandemic and its impact on mental health of healthcare professionals. Exp Ther Med. 2020 [cited 28 Jun 2020]. https://doi.org/10.3892/etm.2020.8646 PMID: 32348406
8. Biondli Massimo, Iannitelli Angela. CoVID-19 and stress in the pandemic: “sanity is not statistical.” Riv Psichiatr. 2020 [cited 28 Jun 2020]. https://doi.org/10.1708/3382.33568 PMID: 32489189
9. Preti E, Di Mattei V, Perego G, Ferrari F, Mazzetti M, Taranto P, et al. The Psychological Impact of Epidemic and Pandemic Outbreaks on Healthcare Workers: Rapid Review of the Evidence. Curr Psychiatry Rep. 2020;22. https://doi.org/10.1007/s11920-020-01146-3 PMID: 32285306
10. Burttscher J, Burttscher M, Millet GP. (Indoor) isolation, stress and physical inactivity: vicious circles accelerated by Covid-19? Scand J Med Sci Sports. 2020 [cited 28 Jun 2020]. https://doi.org/10.1111/smss.13706 PMID: 32374894
11. Rind E, Kimpel K, Preiser C, Papenfuss F, Wagner A, Alsyte K, et al. Adjusting working conditions and evaluating the risk of infection due to the COVID-19 pandemic in different workplace settings in Germany: a study protocol for an explorative modular mixed methods approach. BMJ Open. 2020; 10: e043908. https://doi.org/10.1136/bmjopen-2020-043908 PMID: 32308339

12. Boluarte Carbajal A, Sánchez Boluarte A, Rodríguez Boluarte A, Merino Soto C. Working conditions and emotional impact in healthcare workers during COVID-19 pandemic. J Healthc Qual Res. 2020; 35: 401–402. https://doi.org/10.1016/j.jhrq.2020.08.002 PMID: 33008794

13. Theorell T. COVID-19 and Working Conditions in Health Care. Psychother Psychosom. 2020; 89: 193–194. https://doi.org/10.1159/000507765 PMID: 32299083

14. Chudziacka-Czupala A, Stasila-Sieradzka M, Rachwaniac-Szczezcińska Z, Grabowski D. The severity of work-related stress and an assessment of the areas of worklife in the service sector. Int J Occup Med Environ Health. 2019; 32: 569–584. https://doi.org/10.1037/ijomh.1896.01406 PMID: 31241050

15. Sharma SK, Nuttall C, Kalyani V, Hemlata. Clinical nursing care guidance for management of patient with COVID-19. JPMA J Pak Med Assoc. 2020; 70(Suppl 3): S118–S123. https://doi.org/10.5455/JPMA.29 PMID: 30653094

16. Lucchini A, Iozzo P, Bambi S. Nursing workload in the COVID-19 era. Intensive Crit Care Nurs. 2020; 61: 102929. https://doi.org/10.1016/j.iccn.2020.102929 PMID: 32893048

17. Ezenwaji IO, Eseadi C, Okide CC, Nwosu NC, Ugwoke SC, Ololo KO, et al. Work-related stress, burnout, and related sociodemographic factors among nurses: Implications for administrators, research, and policy. Medicine (Baltimore). 2019; 98: e13889. https://doi.org/10.1097/MD.0000000000013889 PMID: 30653094

18. Minahan J, Falzarano F, Yazdani N, Siedlecki KL. The COVID-19 Pandemic and Psychosocial Outcomes across Age through the Stress and Coping Framework. The Gerontologist. 2020 [cited 17 Dec 2020]. https://doi.org/10.1093/geront/gnaa205 PMID: 33230191

19. Dutheil F, Pereira B, Moustafa F, Naughton G, Lesage F-X, Lambert C. At-risk and intervention thresholds of occupational stress using a visual analogue scale. PLoS One. 2017; 12: e0178948. https://doi.org/10.1371/journal.pone.0178948 PMID: 28586383

20. Lesage FX, Berjot S. Validity of occupational stress assessment using a visual analogue scale. Occup Med Engl. 2011; 61: 434–436. https://doi.org/10.1093/occmed/kqr037 PMID: 21505089

21. Lesage F-X, Berjot S, Deschamps F. Clinical stress assessment using a visual analogue scale. Occup Med. 2012; 62: 600–605. https://doi.org/10.1093/occmed/kqs140 PMID: 22965867

22. Dutheil F, Duclos M, Naughton G, Dewarvin S, Cornel T, Huguet P, et al. WittyFit—Live Your Work Differently: Study Protocol for a Workplace-Delivered Health Promotion. JMIR Res Protoc. 2017; 6: e58. https://doi.org/10.2196/resprot.6267 PMID: 28408363

23. Mickey RM, Greenland S. The impact of confounder selection criteria on effect estimation. Am J Epidemiol. 1989; 129: 125–137. https://doi.org/10.1093/oxfordjournals.aje.a115101 PMID: 2910056

24. Harrell FE Jr, Lee KL, Mark DB. Multivariable prognostic models: issues in developing models, evaluating assumptions and adequacy, and measuring and reducing errors. Stat Med. 1996; 15: 361–387. https://doi.org/10.1002/(SICI)1097-0258(19960229)15:4<361::AID-SIM368>3.0.CO;2-4 PMID: 8668867

25. Ceri V, Ciciek I. Psychological Well-Being, Depression and Stress During COVID-19 Pandemic in Turkey: A Comparative Study of Healthcare Professionals and Non-Healthcare Professionals. Psychol Health Med. 2021; 26: 85–97. https://doi.org/10.1080/13548506.2020.1859566 PMID: 33320723

26. Kuo F, Yang P, Hsu H, Su C, Chen C, Yeh I, et al. Survey on perceived work stress and its influencing factors among hospital staff during the COVID-19 pandemic in Taiwan. Kaohsiung J Med Sci. 2020; 36: 944–952. https://doi.org/10.1002/(SICI)1097-0258(19960229)15:4<944::AID-SIM168>3.0.CO;2-Y PMID: 8668867

27. Schechter A, Diaz F, Moise N, Anstey DE, Ye S, Aganwal S, et al. Psychological distress, coping behaviors, and preferences for support among New York healthcare workers during the COVID-19 pandemic. Gen Hosp Psychiatry. 2020; 66: 1–8. https://doi.org/10.1016/j.genhosppsych.2020.06.007 PMID: 32590254

28. Santarone K, McKenney M, Elkiubi A. Preserving mental health and resilience in frontline healthcare workers during COVID-19. Am J Emerg Med. 2020; 38: 1530–1531. https://doi.org/10.1016/j.ajem.2020.04.030 PMID: 32336584

29. Tracy DK, Tarn M, Eldridge R, Cooke J, Calder JDF, Greenberg N. What should be done to support the mental health of healthcare staff treating COVID-19 patients? Br J Psychiatry J Ment Sci. 2020; 217: 537–539. https://doi.org/10.1192/bjp.2020.109 PMID: 32423523

30. Sallowá-Žiha D, Hlavati M, Gvozdanović Z, Gašić M, Placento H, Jakić H, et al. Differences in Distress and Coping with the COVID-19 Stressor in Nurses and Physicians. Psychiatr Danub. 2020; 32: 287–293. https://doi.org/10.24869/psyd.2020.287 PMID: 32796800
The major worldwide stress of healthcare professionals during the first wave of the COVID-19 pandemic

31. Shammi M, Bodrud-Doza Md, Towfiqul Islam ARMd, Rahman MdM. COVID-19 pandemic, socioeconomic crisis and human stress in resource-limited settings: A case from Bangladesh. Heliyon. 2020; 6: e04063. https://doi.org/10.1016/j.heliyon.2020.e04063 PMID: 32462098

32. El-Hage W, Hingray C, Lemogne C, Yrondi A, Brunault P, Bienvenu T, et al. Les professionnels de santé face à la pandémie de la maladie à coronavirus (COVID-19): quels risques pour leur santé mentale? L’Encéphale. 2020; 46: S73–S80. https://doi.org/10.1016/j.encep.2020.04.008 PMID: 32370984

33. Evanoff BA, Strickland JR, Dale AM, Hayibor L, Page E, Duncan JG, et al. Work-Related and Personal Factors Associated With Mental Well-Being During the COVID-19 Response: Survey of Health Care and Other Workers. J Med Internet Res. 2020; 22: e21366. https://doi.org/10.2196/21366 PMID: 32763891

34. Kulkarni A, Khasne RW, Dhakulkar BS, Mahajan HC. Burnout among Healthcare Workers during COVID-19 Pandemic in India: Results of a Questionnaire-based Survey. Indian J Crit Care Med. 2020; 24: 664–671. https://doi.org/10.10505/icjccm.2020.24.11 PMID: 33024372

35. Raudenska J, Steinerova V, Javurková A, Urits I, Kaye AD, Viswanath O, et al. Occupational burnout syndrome and post-traumatic stress among healthcare professionals during the novel coronavirus disease 2019 (COVID-19) pandemic. Best Pract Res Clin Anaesthesiol. 2020; 34: 553–560. https://doi.org/10.1016/j.bpa.2020.07.008 PMID: 33004166

36. Virtanen M. Stress at work—a risk factor for depression? Scand J Work Environ Health. 2010; 36: 433–434. https://doi.org/10.5271/sjweh.3125 PMID: 20927487

37. Kivimäki M, Steptoe A. Effects of stress on the development and progression of cardiovascular disease. Nat Rev Cardiol. 2018; 15: 215–229. https://doi.org/10.1038/nrcardio.2017.189 PMID: 29213140

38. Gafarov VV, Gromova EA, Panov DO, Gagulin IV, Gafarova AV. Effect of stress at work on the risk of cardiovascular diseases among the population of 25–64 years in Russia/Siberia (WHO program “MONICA-psychosocial”). Ter Arkh. 2019; 91: 13–18. https://doi.org/10.26442/00403660.2019.01.00022 PMID: 31090365

39. Wang C, Pan R, Wan X, Tan Y, Xu L, Ho CS, et al. Immediate Psychological Responses and Associated Factors during the Initial Stage of the 2019 Coronavirus Disease (COVID-19) Epidemic among the General Population in China. Int J Environ Res Public Health. 2020; 17: 1729. https://doi.org/10.3390/ijerph17051729 PMID: 32155789

40. Magnavita N, Soave PM, Antonelli M. Prolonged Stress Causes Depression in Frontline Workers Facing the COVID-19 Pandemic-A Repeated Cross-Sectional Study in a COVID-19 Hub-Hospital in Central Italy. Int J Environ Res Public Health. 2021; 18: 7316. https://doi.org/10.3390/ijerph18147316 PMID: 34298767

41. Bryant-Genevier J, Rao CY, Lopes-Cardozo B, Kone A, Rose C, Thomas I, et al. Symptoms of Depression, Anxiety, Post-Traumatic Stress Disorder, and Suicidal Ideation Among State, Tribal, Local, and Territorial Public Health Workers During the COVID-19 Pandemic—United States, March-April 2021. MMWR Morb Mortal Wkly Rep. 2021; 70: 947–952. https://doi.org/10.15585/mmwr.mm7026e1 PMID: 34197362

42. Dutheil F, Mondillon L, Navel V. PTSD as the second tsunami of the SARS-Cov-2 pandemic. Psychol Med. 2020; 1–2. https://doi.org/10.1017/S0033291720001336 PMID: 32326997

43. Hall H. The effect of the COVID-19 pandemic on healthcare workers’ mental health. J Am Acad PAs. 2020; 33: 45–48. https://doi.org/10.1097/JOA.0000669772.78848.8c PMID: 32590533

44. Cabarkapa S, Nadijdai SE, Murjig J, Ng CH. The psychological impact of COVID-19 and other viral epidemics on frontline healthcare workers and ways to address it: A rapid systematic review. Brain Behav Immun-Health. 2020; 100144. https://doi.org/10.1016/j.bbih.2020.100144 PMID: 32959031

45. Wang H, Liu Y, Hu K, Zhang M, Du M, Huang H, et al. Healthcare workers’ stress when caring for COVID-19 patients: An altruistic perspective. Nurs Ethics. 2020; 27: 1490–1500. https://doi.org/10.1177/0969733020934146 PMID: 33024372

46. Liu Y, Wang H, Chen J, Zhang X, Yue X, Ke J, et al. Emergency management of nursing human resources and supplies to respond to coronavirus disease 2019 epidemic. Int J Nurs Sci. 2020; 7: 135–138. https://doi.org/10.1016/j.ijnss.2020.03.011 PMID: 32292632

47. Ross J. The Exacerbation of Burnout During COVID-19: A Major Concern for Nurse Safety. J PeriAnesthesia Nurs. 2020; 35: 439–440. https://doi.org/10.1016/j.jpan.2020.04.001 PMID: 32741522

48. Labrague LJ, de Los Santos JAA. Fear of COVID-19, psychological distress, work satisfaction and turnover intention among frontline nurses. J Nurs Manag. 2021; 29: 395–403. https://doi.org/10.1111/jonm.13168 PMID: 32985046

49. Humphries N, Morgan K, Conny MC, McGowan Y, Montgomery A, McGee H. Quality of care and health professional burnout: narrative literature review. Int J Health Care Qual Assur. 2014. https://doi.org/10.1108/IJHCQA-08-2012-0087 PMID: 25076604
50. Debout C. Pandémie de Covid-19 et pénurie infirmière en France: un phénomène prévisible. Rev Fr
Arch Int Rech Infirm. 2020; 6: 100200. https://doi.org/10.1016/j.refiri.2020.100200

51. Bangasser DA, Eck SR, Ordoñez Sanchez E. Sex differences in stress reactivity in arousal and atten-
tion systems. Neuropsychopharmacology, 2019; 44: 129–139. https://doi.org/10.1038/s41386-018-
0137-2 PMID: 30022063

52. Bangasser DA, Eck SR, Telenson AM, Salvatore M. Sex differences in stress regulation of arousal and
cognition. Physiol Behav. 2018; 187: 42–50. https://doi.org/10.1016/j.physbeh.2017.09.025 PMID:
28974457

53. Sandanger I, Nygård JF, Særensen T, Moum T. Is women’s mental health more susceptible than men’s
to the influence of surrounding stress? Soc Psychiatry Psychiatr Epidemiol. 2004; 39: 177–184. https://
doi.org/10.1007/s00127-004-0728-6 PMID: 14999449

54. Broche-Pérez Y, Fernández-Fleites Z, Jiménez-Puig E, Fernández-Castillo E, Rodríguez-Martín BC.
Gender and Fear of COVID-19 in a Cuban Population Sample. Int J Ment Health Addict. 2020; 1–9.
https://doi.org/10.1007/s11469-020-00343-8 PMID: 32837428

55. Notman MT, Nadelson CC. Medicine: A Career Conflict for Women. Am J Psychiatry. 1973; 130:
1123–1127. https://doi.org/10.1176/ajp.130.10.1123 PMID: 4728905

56. Dutheil F, Aubert C, Pereira B, Dambrun M, Moustafa F, Mermillod M, et al. Suicide among physicians
and healthcare workers: A systematic review and meta-analysis. PloS One. 2019; 14: e0226361.
https://doi.org/10.1371/journal.pone.0226361 PMID: 31830138

57. WHO. Gender and COVID-19. 14 May 2020 [cited 15 Feb 2021]. Available: https://apps.who.int/iris/
bitstream/handle/10665/332080/WHO-2019-nCoV-Advocacy_brief-Gender-2020.1-eng.pdf

58. Gebhard C, Regitz-Zagrosek V, Neuhausker HK, Morgan R, Klein SL. Impact of sex and gender on
COVID-19 outcomes in Europe. Biol Sex Differ. 2020;11 . https://doi.org/10.1186/s13293-020-00289-5
PMID: 32188512

59. Rattel JA, Mauss IB, Liedlgruber M, Wilhelm FH. Sex differences in emotional concordance. Biol Psy-
chol. 2020; 151: 107845. https://doi.org/10.1016/j.biopsycho.2020.107845 PMID: 31958549

60. Liu N, Zhang F, Wei C, Jia Y, Shang Z, Sun L, et al. Prevalence and predictors of PTSS during COVID-
19 outbreak in China hardest-hit areas: Gender differences matter. Psychiatry Res. 2020; 287: 112921.
https://doi.org/10.1016/j.psychres.2020.112921 PMID: 32240896

61. Rossi R, Socci V, Talevi D, Mensi S, Niolu C, Pacitti F, et al. COVID-19 pandemic and lockdown mea-
sures impact on mental health among the general population in Italy. An N = 18147 web-based survey.
Psychiatry and Clinical Psychology ; 2020 Apr. https://doi.org/10.1101/2020.04.09.20057802

62. Ritchie H, Roser M. Age structure. Our World Data. 2019.

63. Kang S-J, Jung SI. Age-Related Morbidity and Mortality among Patients with COVID-19. Infect Che-
mother. 2020; 52: 154. https://doi.org/10.3947/ic.2020.52.2.154 PMID: 32537961

64. Kühlmeyer K, Kuhn E, Knochel K, Hildesheim H, Witt VD, Friedrich O, et al. [Moral distress in medical
students and young professionals: research desiderata in the context of the COVID-19 pandemic]. Bun-
desgesundheitsblatt Gesundheitsforschung Gesundheitsschutz. 2020; 63: 1483–1490. https://
doi.org/10.1007/s10010-020-03244-2 PMID: 33180160

65. Wang Y, Li Y, Jiang J, Feng Y, Lu D, Zhang W, et al. COVID-19 outbreak-related psychological distress
among healthcare trainees: a cross-sectional study in China. BMJ Open. 2020; 10: e041671. https://
doi.org/10.1136/bmjopen-2020-041671 PMID: 33082197

66. Rosas VGSY, Moscoso-Perras M, Ormeño R, Artica F, Bayes CL, Miranda JJ. Gender income gap
among physicians and nurses in Peru: a nationwide assessment. Lancet Glob Health. 2019; 7: e412–
e413. https://doi.org/10.1016/S2214-109X(19)30034-8 PMID: 30745027

67. Levin KA. Study design III: Cross-sectional studies. Evid Based Dent. 2006; 7: 24–25. https://doi.org/
10.1038/sj.ebd.6400375 PMID: 16557257

68. Chersich MF, Gray G, Fairlie L, Eichbaum Q, Mayhew S, Allwood B, et al. COVID-19 in Africa: care and
protection for frontline healthcare workers. Glob Health. 2020; 16: 46. https://doi.org/10.1186/s12992-
020-00574-3 PMID: 32414379

69. Chen Q, Liang M, Li Y, Guo J, Fei D, Wang L, et al. Mental health care for medical staff in China during
the COVID-19 outbreak. Lancet Psychiatry. 2020; 7: e15–e16. https://doi.org/10.1016/S2215-0366(20)
30078-X PMID: 32086839

70. Romero CS, Delgado C, Catalá J, Ferrer C, Errando C, Iftimi A, et al. COVID-19 psychological impact in
3109 healthcare workers in Spain: The PSIMOCEV group. Psychol Med. 2020; 1–7. https://doi.org/
10.1017/S0033291720001671 PMID: 32404217
72. Terwee CB, Bot SDM, de Boer MR, van der Windt DAWM, Knol DL, Dekker J, et al. Quality criteria were proposed for measurement properties of health status questionnaires. J Clin Epidemiol. 2007; 60: 34–42. https://doi.org/10.1016/j.jclinepi.2006.03.012 PMID: 17161752

73. Women in Healthcare: Quick Take. In: Catalyst [Internet]. [cited 2 Jan 2021]. Available: https://www.catalyst.org/research/women-in-healthcare/