

Article

Unveiling Stress Vulnerability and Occupational Noise Perception as Burnout Predictors: Results of an Exploratory Study in Industrial Environments

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Abstract: Burnout is a complex phenomenon influenced by both environmental and individual factors. This pilot study explores the predictive role of occupational noise perception and stress vulnerability on burnout symptoms among industrial workers. A cross-sectional survey was conducted with 119 Portuguese workers exposed to occupational noise. Participants completed validated self-report measures assessing noise perception, stress vulnerability, and burnout. Path analysis revealed that both higher stress vulnerability and greater perceived occupational noise were significant predictors of elevated burnout levels. Furthermore, gender emerged as a relevant predictor, with women reporting significantly higher burnout symptoms than men. Age was inversely related to stress vulnerability, indicating greater resilience among older workers. These findings suggest that individual differences in stress vulnerability and noise perception contribute meaningfully to burnout risk, beyond traditional occupational hazard assessments. The study underscores the need for holistic occupational health strategies, integrating both environmental modifications and psychosocial interventions aimed at enhancing workers' coping capacities. This study contributes novel insights into the interplay between perceived noise and psychological vulnerability in industrial settings, supporting broader preventive measures for work-related mental health outcomes.

Keywords: burnout; occupational noise; stress; industrial workers; psychosocial risks



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Academic Editor: Gaetano Licitra

Received: 28 April 2025

Revised: 5 June 2025

Accepted: 13 June 2025

Published: 17 June 2025

Citation: Carvalhais, C.; Ribeiro, L.A.; Pereira, C.C. Unveiling Stress Vulnerability and Occupational Noise Perception as Burnout Predictors: Results of an Exploratory Study in Industrial Environments.

Environments **2025**, *12*, 208.

<https://doi.org/10.3390/environments12060208>

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1. Introduction

Occupational noise exposure is a well-established risk factor for hearing loss and other auditory impairments. However, emerging evidence suggests that its effects may extend beyond auditory damage, potentially contributing to psychological stress and burnout symptoms [1]. While most studies on workplace noise have focused on its impact on hearing, less attention has been given to its influence on other health outcomes such as mental health disorders [2]. Moreover, the experience of noise-related stress may be modulated by individual differences in stress vulnerability [1]. Some evidence indicates that

noise contributes to psychological strain among workers exposed to multiple occupational hazards, including both physical (e.g., noise) and chemical agents [3].

1.1. Noise and Noise Perception

Noise can be defined as an unwanted sound that acts as a psychosocial stressor adversely affecting the health and well-being of individuals through the activation of the sympathetic and endocrine systems [4–7]. Evidence shows that noise exposure increases systolic and diastolic blood pressure, changes heart rate, and causes the release of stress hormones (including catecholamines and glucocorticoids) [4,8]. The General Stress Model proposed by Babisch [5] explains the rationale behind these reactions (Figure 1). Potential mechanisms are emotional stress reactions due to perceived discomfort (indirect pathway) and non-conscious physiological stress from interactions between the central auditory system and other regions of the CNS (direct pathway) [5,6].

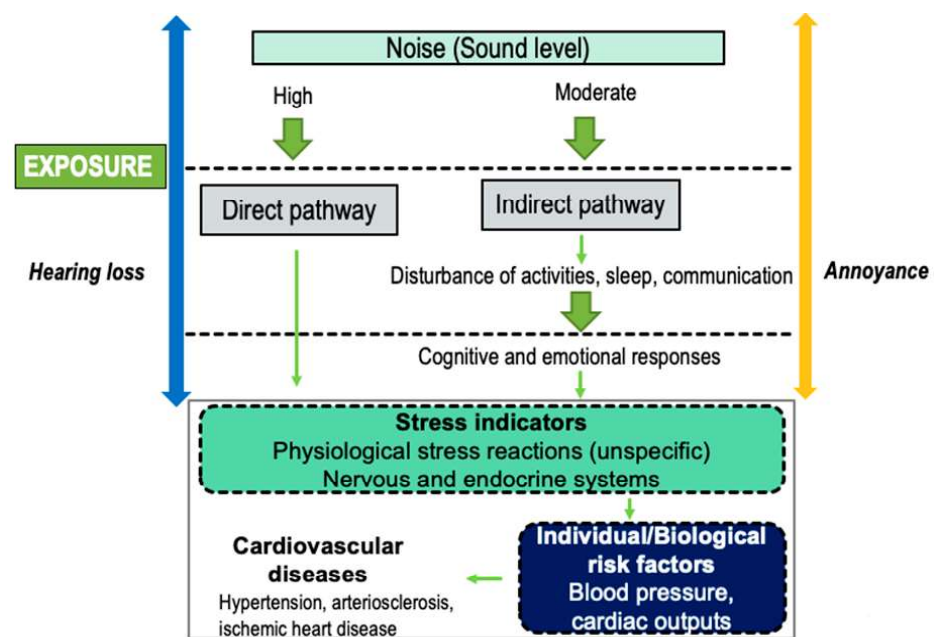


Figure 1. Noise reaction scheme (adapted from Babisch [5]).

High noise perception may contribute to increased stress levels [9]. Noise perception refers to how an individual interprets and responds to auditory stimuli in their environment. In fact, workers' noise perceptions have been studied in several occupational contexts, namely in relation to creating health and safety legislation, so that workers are not exposed to noise that they consider excessive (e.g., patient areas in hospital environments) [10,11].

Noise pollution has emerged as a significant, yet often underestimated, contributor to chronic stress [12]. The incessant exposure to noise—whether from urban traffic, construction, industrial machinery, or the omnipresence of electronic devices—not only affects the auditory system but also impacts cognitive and emotional functioning [13]. Research has increasingly highlighted the adverse effects of noise on human health, with prolonged exposure linked to heightened stress responses, disrupted sleep patterns, and reduced cognitive performance [9]. These effects are particularly relevant in occupational settings, where noise exposure during cognitive tasks can lead to elevated physiological and psychological stress, as well as other non-auditory disorders [3,6,13–17]. Additionally, chronic exposure to psychosocial stressors in the workplace—including noise—has been associated with an increased risk of cardiovascular disease, reinforcing the broader health implications of persistent stressors in the work environment [14].

1.2. Vulnerability to Stress

Vulnerability to stress refers to an individual's susceptibility or predisposition to experience negative effects in response to stressors [18]. Stressors are events, situations, or conditions that can elicit a stress response, which involves the body and mind's efforts to cope with challenges. It can be influenced by various factors, including biological, psychological, and environmental elements [19,20]. An individual's vulnerability to stress significantly shapes their response to environmental stressors. Factors such as sociocultural environment, personal resilience, coping mechanisms, and overall mental health are contributing factors to an individual's profile of stress response [21]. Those already pushing their stress tolerance limit due to work pressures, personal responsibilities, or existing mental health conditions are particularly susceptible to the detrimental effects of noise [21–24]. Recent research has also shown that noise exposure, when combined with high stress from other sources, can lead to severe outcomes such as cardiovascular strain, sleep disturbances, and increased anxiety [22,25,26]. When stress tolerance is already near its limit, the added burden of noise can significantly amplify its harmful effects [8,27].

1.3. Burnout

Burnout is a state of chronic physical and emotional exhaustion, often accompanied by feelings of cynicism and detachment from work [28]. Burnout syndrome is transversal across occupations, since the stressors that can instigate it may be present at any workplace [29]. Consequently, it is expected that burnout has a negative effect on workers' performance, inhibiting creativity and innovation and causing more work-related accidents and absenteeism [30,31]. Both noise perception and vulnerability to stress can be hypothesized as potential predictors of burnout, since, theoretically, individuals with prolonged exposure to noise stressors and higher vulnerability to stress may struggle to cope with yet another work-related challenge [20]. Over time, these heightened stress levels can contribute to burnout [32].

1.4. Rationale and Aim of the Study

Understanding the interaction between environmental stressors and individual psychological traits is essential for developing comprehensive frameworks to address occupational burnout. In particular, the theoretical link between perceived occupational noise (PON) and stress vulnerability (SV) offers valuable insight into the multifaceted nature of burnout. Despite increasing evidence of the impact of occupational stressors on mental health, few studies have integrated both environmental and dispositional variables into explanatory models of burnout.

Perceived occupational noise, a subjective and often underestimated stressor, may play a critical role in the development of burnout, particularly among individuals with high vulnerability to stress. Recognizing the interplay between environmental stimuli and psychological susceptibility underscores the need for holistic approaches to preventing and mitigating burnout. Such approaches should address not only environmental factors, such as noise exposure but also individual factors. This dual perspective may inform the design of more targeted interventions that combine environmental modifications with psychological strategies aimed at enhancing coping mechanisms and reducing vulnerability.

The main aim of this pilot study is to investigate whether noise perception and vulnerability to stress predict burnout symptoms among industrial workers. We also examine the moderating effects of demographic variables, specifically gender and age.

2. Materials and Methods

2.1. Participants

A total of 119 industrial manual workers exposed to occupational noise were recruited through a convenience sampling method from five different industrial settings (metal-working and chemical sectors). This non-probabilistic approach was chosen due to the exploratory nature of the study and the practical accessibility of participants within the selected workplaces. The sample comprised 64 men (54%) and 53 women (45%), while two participants (1%) did not report their gender. The overall response rate was 61.0%. Individuals were aged between 19 and 66 years ($M = 34.9$, $SD = 12.8$). Most participants were single (52.1%) or married/living with a partner (37.8%). Only 8 participants (6.7%) were separated/divorced and 4 widowed (3.4%). Regarding education, 59 (49.6%) participants completed 10 to 12 years of education, and 34 (28.6%) completed 9 years or less. Nearly all participants (96.7%) were Portuguese citizens, with the remaining workers originating from Brazil. Seventy-eight (78%) workers reported the need to raise their voice to be able to communicate with their colleagues at the workplace, but just 35 (29.4%) reported using hearing protection devices, at least sometimes. Permission was not obtained to access the noise exposure levels expressed in dB (A).

2.2. Measures

Perception of Occupational Noise (PON): In line with Abbasi et al. [33], who included two standardized items from ISO/TS 15666 [34] to assess noise annoyance in occupational settings, we used the equivalent adapted items from the Portuguese Standard NP 4476 [35], which is based on the first edition of ISO/TS 15666. The questions are as follows: PN1—“Considering the last 12 months, to what extent has the noise at your workplace bothered and disturbed you?”, with a 10-point response scale. Higher numbers on the 0–10 scale indicate greater agreement with the statement. PN2—“Considering the last 12 months, indicate from 0 to 10 the extent to which you feel harmed or disturbed by the noise at your workplace”. Higher numbers on the scale of 0–10 represent greater reported disturbance.

Stress Vulnerability Scale (23QVS [36]): The Stress Vulnerability Scale is a self-report questionnaire composed of 23 questions used to measure individual vulnerability to stress as a trait. Based on a sample of 368 individuals of the general Portuguese population, the original version had a good internal consistency (Cronbach’s $\alpha = 0.83$ for all items). The questionnaire assessed the following seven factors characterizing vulnerability to stress: (i) Perfectionism and Intolerance to Frustration; (ii) Inhibition and Functional Dependence; (iii) Lack of Social Support; (iv) Adverse Life Conditions; (v) Dramatization of Existence; (vi) Subjugation; and (vii) Deprivation of Affection and Rejection. A value of 43 is the cut-off point above which a person is considered to be vulnerable to stress. Appendix A presents an informative English translation of the items included in the 23-item Stress Vulnerability Scale (23QVS), originally validated in Portuguese. This translation is provided for illustrative purposes only.

Shirom-Melamed Burnout Measure (SMBM) [37]: We used the Portuguese version of the SMBM adapted and translated by Gomes [38] to measure Burnout (B). The scale is composed of 14 items assessing feelings of burnout, such as the following: “When I wake up, I feel no energy to go to work”; “I have trouble concentrating at work”; etc. The 14 items are divided into three subscales as follows: (a) Physical Fatigue (6 items), (b) Cognitive Fatigue (5 items), and (c) Emotional Exhaustion (3 items). Respondents rate each item from “never” (1) to “always” (7), with higher scores corresponding to higher levels of burnout. The instrument has shown good psychometric properties in Portuguese samples [38,39].

2.3. Procedure

Questionnaires were distributed at industry sites, mostly in paper format, to facilitate the participation of workers without computer access. Participation was voluntary, and workers were asked to give informed consent with regard to the use of their data for research purposes. All data were confidential and anonymized. The study was approved by the Institutional Ethical Board Committee and was conducted in accordance with the ethical principles of the Declaration of Helsinki. The questionnaire started with a demographic section, followed by the three measures described above. The workers took approximately 10 min to complete the questionnaire. Data were entered into an Excel spreadsheet and further analyzed using R software (version 4.2.3), R Studio Desktop (version 3.6.1), and the R packages “Lavaan” [40] and “semPlot” [41].

3. Results

3.1. Missing Data

There were, in total, five missing values in our data (only two of which were in the same case). The missing pattern was as follows: one missing value each on the variables Age, Stress Vulnerability, and Burnout; two missing values for the variable Sex. Missingness was therefore quite low. Nevertheless, we used both the default ML estimator and listwise deletion for handling missing data. The results of our prediction models were identical, so we present here the ML model only.

3.2. Descriptive Statistics

The means and standard deviations of the variables (by gender) used in the analysis can be seen in Table 1. There were no significant differences between men and women for the variables PN1 (Portuguese Standard item #1), PN2 (Portuguese Standard item #2), and Stress Vulnerability (SV). Men were significantly older than women ($t(114) = 3.18, p < 0.001$), and women had significantly higher levels of Burnout (B) ($t(114) = -4.42, p < 0.001$). Figure 2 shows the separate histograms for the dependent variable Burnout by gender.

Table 1. Means and standard deviations of the variables age, PN1, PN2, Stress Vulnerability (SV), and Burnout (B).

	Female ($n = 53$)	Male ($n = 64$)	Total ($n = 119$)
	M (SD)	M (SD)	M (SD)
Age	30.6 (11.12)	37.75 (12.78)	34.92 (12.76)
PN1	5.74 (2.31)	5.86 (2.65)	5.76 (2.53)
PN2	5.55 (2.44)	5.53 (2.57)	5.50 (2.53)
SV	2.42 (0.39)	2.35 (0.51)	2.38 (0.45)
B	3.73 (1.19)	2.68 (1.36)	3.18 (1.39)

Note: There were two individuals who did not indicate their gender.

By analyzing Figure 2, the histogram suggests a tendency for lower burnout levels among men, with a higher concentration of scores in the lower range of the scale. In contrast, women’s scores appear more evenly distributed, with a noticeable peak around the mid-range values and a greater proportion reporting moderate to high levels of burnout. This visual pattern may indicate gender-related differences in the experience or perception of occupational burnout within the sample.

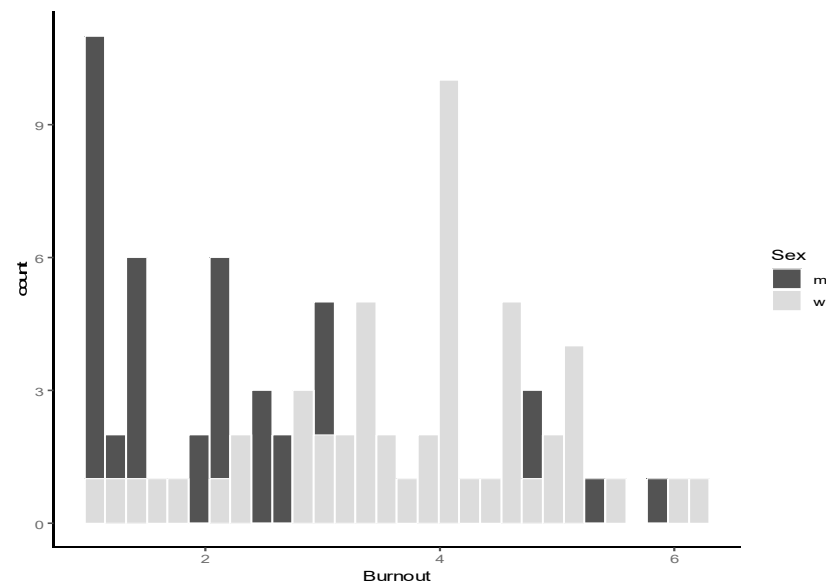


Figure 2. Distribution of burnout scores among male (dark bars) and female (light bars) participants ($n = 116$). Separate histograms are shown by sex to illustrate differences in the frequency of burnout levels.

3.3. Simple Correlation Analyses

Being male was significantly associated with older age and lower levels of Burnout. There was a significant negative correlation between age and Stress Vulnerability, with older individuals being less vulnerable. The same happened for the relation between age and Burnout: the older the individuals, the lower the burnout levels they reported. As expected, the variables PN1 (Portuguese Standard item #1) and PN2 (Portuguese Standard item #2) referring to the perception of occupational noise in the workplace showed significant positive correlations between them, and both were positively and significantly correlated with reported Burnout. Finally Stress Vulnerability was significantly associated with Burnout levels, with more vulnerable individuals reporting higher levels of Burnout. Table 2 shows the correlation matrix between all variables.

Table 2. Correlation matrix for the variable sex, age, PN1, PN2, Stress Vulnerability (SV), and Burnout (B).

	Sex	Age	PN1	PN2	SV	B
Sex	1					
Age	-0.29 **	1				
PN1	-0.03	0.12	1			
PN2	0.003	0.14	0.87 **	1		
SV	0.08	-0.21 *	0.14	0.16	1	
B	0.38 **	-0.18 *	0.24 **	0.29 **	0.40 **	1

* $p < 0.05$, ** $p < 0.01$ Sex: 0 = male; 1 = female.

3.4. Prediction Models

The main estimation models (displayed as path diagrams) are shown in Figure 3. A latent variable PON (Perception of Occupational Noise) was created with the indicators PN1 and PN2, which consider the two questions included in the Portuguese standard for noise perception, as described in the methods section. The variables SV (Stress Vulnerability) and B (Burnout) are manifest variables and correspond to the total scores obtained from the questionnaire measures 23QVS and SMBM, respectively.

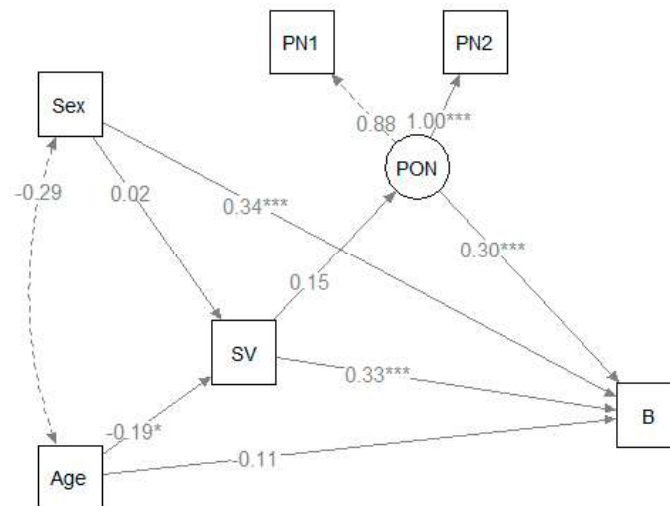


Figure 3. Path model illustrating regressions predicting B (Burnout) from PON (Perception of Occupational Noise) and SV (Stress Vulnerability). Standardized coefficients are depicted ($n = 119$). Men = 0; Women = 1. * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$.

Burnout was significantly and directly predicted by gender, Stress Vulnerability, and Perception of Occupational Noise. Being female ($B = 0.91$, $SE = 0.21$, $p < 0.001$) and having higher levels of both Stress Vulnerability ($B = 1.01$, $SE = 0.23$, $p < 0.001$) and Perception of Occupational Noise ($B = 0.19$, $SE = 0.05$, $p < 0.001$) were associated with higher Burnout scores. In addition, age significantly predicted Stress Vulnerability ($B = -0.007$, $SE = 0.003$, $p < 0.05$), with older workers showing lower levels on that scale.

4. Discussion

This exploratory study investigated the predicting role of the perception of occupational noise and stress vulnerability on burnout levels in a sample of Portuguese industrial workers. We have also investigated the moderating role of the variables age and gender. The results of the path analysis model revealed that being female, having higher levels of stress vulnerability, and greater levels of perceived occupational noise were significantly associated with increased burnout symptoms. The positive association between perceived occupational noise and burnout is consistent with previous research showing that noisy environments can impair concentration, disrupt communication, and lead to both physiological arousal and psychological strain [42]. These stress responses, if sustained over time, can contribute to emotional exhaustion and other components of burnout. While noise exposure has been more commonly studied in relation to auditory outcomes, our findings emphasize its broader psychosocial impact. The results align with studies in both educational [16] and industrial settings [43], where subjective noise perception was linked to irritation, fatigue, and stress-related outcomes. Stress vulnerability also emerged as a robust predictor of burnout, reinforcing the hypothesis that dispositional factors significantly influence how individuals respond to occupational stressors. As previously suggested [44], individuals with higher vulnerability may lack adequate coping strategies, making them more susceptible to emotional exhaustion and reduced psychological resilience in demanding work environments. This finding supports models of stress–burnout relationships that integrate both environmental and personal dimensions [22]. An interesting and theoretically grounded result concerns the inverse relationship between age and stress vulnerability. Older workers reported significantly lower vulnerability, which is consistent with the Strength and Vulnerability Integration (SAVI) model [45]. According to this framework, aging is associated with improved emotion regulation and more adaptive coping, which may buffer against the effects of chronic stressors in the workplace.

Gender differences in burnout were also observed, with women reporting significantly higher levels of burnout than men. This finding echoes the previous literature attributing higher burnout risk in women to increased emotional labor demands [46], work–family role conflict [47], and systemic gender-based inequities in the workplace [48]. It is also plausible that task assignment, support structures, and reporting patterns differ by gender, especially in male-dominated industrial contexts. Further studies should consider a more granular analysis of job roles, psychosocial hazards, and coping resources by gender. Taken together, these findings support a biopsychosocial model of occupational burnout, where both external stressors (e.g., noise exposure) and individual traits (e.g., stress vulnerability) interact to shape mental health outcomes. Importantly, this study highlights the relevance of subjective perception—how workers interpret and internalize environmental demands—as a key factor in understanding burnout.

5. Conclusions

To our knowledge, this is the first study on the role of noise perception and vulnerability to stress as predictors of burnout in an industrial environment. In these environments, occupational health and safety professionals are typically more focused on preventing professional hearing loss than on non-auditory effects, such as burnout. The assessment and prevention of non-auditory disorders, which can occur at exposure levels much lower than the recommended maximum levels for hearing loss prevention, represent a step forward in relation to the classic assessment of noise exposure at the workplace, typically focused on preventing hearing damage. The integration of occupational health psychologists in multidisciplinary teams could provide a valuable contribution to designing interventions against the detrimental psychological effects of noise exposure, namely, by focusing on coping mechanisms and stress management skills. While our exploratory study provides valuable insights that can guide future studies, it is essential to acknowledge some limitations. First, the cross-sectional design limits causal inferences. Future research should employ longitudinal designs to examine the temporal relations among these variables. Second, this study employed the self-report method, which is vulnerable to participants' reporting style, motivation, and social desirability. Third, our study focused on a specific population of industrial workers and a relatively small sample. Replicating these findings in other occupational settings would strengthen the generalizability of our results. Future studies on noise exposure (including objective measurements or eventually scales validated to quantify noise exposure) and other environmental factors, such as lightening, thermal environment, indoor air quality, and other variables, such as job demands, job control, and social support, could provide a more comprehensive understanding of burnout. In summary, this study highlights the importance of considering both environmental perceptions and psychological traits in understanding burnout among industrial workers. Perceived occupational noise and stress vulnerability emerged as significant predictors of burnout, reinforcing the need for integrated workplace interventions. These should include not only physical noise control measures, but also psychosocial support strategies tailored to individual profiles.

Author Contributions: Formal analysis, L.A.R., C.C. and C.C.P.; investigation, L.A.R. and C.C.P.; resources, L.A.R. and C.C.P.; data curation, L.A.R.; writing—original draft preparation, C.C.; writing—review and editing, C.C., L.A.R. and C.C.P. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Institutional Review Board Statement: The study was conducted in accordance with the Declaration of Helsinki, authorized by the National Data Protection Commission (CNPD) (protocol no.7087/2028,

24 May 2018) and approved by the Ethics Committee for Health of National Institute of Health (CES-INSA) (18 June 2019).

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

Data Availability Statement: The original contributions presented in this study are included in the article. Further inquiries can be directed to the corresponding author.

Acknowledgments: We would like to thank Adélia Monarca for her support in establishing contact with the industrial settings where the study took place and the students Joana Batista and Sara Reis for their collaboration in data collection.

Conflicts of Interest: The authors declare no conflicts of interest.

Appendix A

English translation of the Stress Vulnerability Scale (23QVS).

1. I am a determined person when it comes to solving my problems
2. I have difficulty relating to unfamiliar people
3. When I have problems that bother me, I can count on one or more friends who serve as confidants
4. I usually have enough money to meet my personal needs
5. I worry easily about everyday setbacks
6. When I have a problem to solve, I usually find someone who can help me
7. I regularly give and receive affection
8. It is rare for me to be overwhelmed by unpleasant events that happen to me
9. When faced with daily difficulties, I tend to complain more than make an effort to solve them
10. I am the kind of person who gets easily upset
11. In most cases, the solutions to the important problems in my life do not depend on me
12. When I am criticized, I tend to feel guilty
13. People only pay attention to me when they need something for their own benefit
14. I spend more time responding to other people's demands than attending to my own needs
15. I prefer to stay quiet rather than contradict someone, even when they are wrong
16. I get nervous and annoyed when I do not perform as well as I expected
17. There are unpleasant aspects of myself that cause others to distance themselves
18. At the right moments, I find it difficult to express what I truly feel
19. I get nervous and upset if I don't get what I want immediately
20. I am the kind of person who, due to my sense of humor, can laugh about unpleasant events that happen to me
21. The money I have barely covers my essential expenses
22. When faced with life's problems, I am more likely to run away than to fight
23. I feel bad when I am not perfect in what I do

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