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Effort-reward and overcommitment at work and psychiatric symptoms in healthcare professionals: The mediation role of allostatic load

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ABSTRACT

Background: Despite decades of advancement to support interventions for managing work-related stress, mental health issues have significantly escalated among healthcare professionals. Effort-reward imbalance (ERI) and overcommitment in the workplace are linked to several psychiatric disorders. However, the underlying biological mechanisms remain unclear. This study investigated whether ERI and overcommitment among healthcare professionals were linked to Allostatic Load (AL) and whether AL mediates the relationship between ERI, overcommitment and mental health issues.

Methods: One hundred forty-two nursing workers (n = 142; 90.1 % female, mean age: 39.5 ± 9.6) were randomly recruited from a university hospital in Sao Paulo, Brazil, and applied the ERI scale that assesses work effort, reward, and overcommitment. The Perceived Stress Scale (PSS), The Beck Depression Inventory (BDI), and the Self-Report Questionnaire for psychiatric symptoms (SRQ-20) evaluated the mental health outcomes. Ten neuroendocrine, metabolic, immunologic and cardiovascular biomarkers were analyzed, and values were transformed into an AL index using clinical reference cutoffs.

Results: Linear regression adjusted for covariates showed that higher scores for overcommitment were associated with higher AL indexes, which in turn were associated with higher SRQ-20, but not with PSS and DBI scores. As expected, higher scores for effort, lower for reward, and higher ERI were associated with higher scores for PSS, SRQ-20, and DBI, but not with AL index. Direct effect estimates showed that overcommitment was directly associated with higher SRQ-20 scores, and indirectly via AL.

Conclusion: Our study reveals that overcommitment, rather than ERI, was linked to increased AL in healthcare workers. Additionally, AL mediates the relationship between overcommitment and higher psychiatric symptoms, highlighting a key mechanism by which work stress can lead to mental health problems. Individual's responses to high work demands need to be considered when designing predictive models and interventions for mental health issues.

1. Introduction

Extensive evidence advanced the stress science to support interventions to manage work-related stress. Despite such efforts, mental health issues among workers have significantly escalated and emerged as the leading cause of work disability [1]. This escalating trend of mental health issues in the workplace presents a considerable economic burden, as work-related stress is estimated to cost the global economy US$ 1 trillion annually. These costs are primarily associated with absenteeism, decreased productivity, and accidents [2].

In this context, healthcare workers consistently top the ranks in terms of sickness absence attributed to mental health issues. The ongoing global pandemic has further exacerbated this situation, with significant increases in mental health issues, primarily depression, anxiety and sleep disturbances, among healthcare professionals [3,4]; . Psychosocial stress among this workers is often a byproduct of the demanding work environment and the fear of failure, which can trigger intense negative emotions and physiological responses [5,6]. However, identifying vulnerable individuals in work settings remains a significant challenge due to the multifaceted nature of individual responses to environmental risk factors.

The Effort-Reward Imbalance (ERI) model developed by Siegrist [7]

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is a widely accepted theoretical framework connecting occupational stress to mental health outcomes. It delineates stress burden in work environments by analyzing the interplay between perceived work stressors (i.e., demands – quantitative and qualitative load) and rewards, including esteem, job promotion, and job security. According to the model, imbalances between the employees' effort and their rewards, can result in failed reciprocity, causing strain and adversely affecting workers' health. Multiple studies have demonstrated ERI as a significant contributor to mental health disorders like depression and anxiety, notably among healthcare workers [8–12]. Longitudinal findings showed that higher ERI was associated with increased risk for depression symptoms during a 2-year follow up [13,14].

Overcommitment is another component of the ERI model that enables analyzing the interaction of situational (e.g., job demands) and the personal behavioral response to them [10,15] that ultimately lead to work-related mental health issues [10,15]. Overcommitment is characterized by excessive striving and the inability to withdraw from work with a profound need for approval and esteem—attributes with noteworthy bearings on workers' mental health disorders [10,15]. This intrinsic behavioral response can intensify the perception of effort and decrease the perception of rewards, potentially exacerbating the ERI [10,15]. Overcommittement can be interpreted as a maladaptive response to high job demands that may exert workers excessively, often beyond what is required, leading to higher perceived effort and possible health risks, especially if the rewards received do not sufficiently compensate for these extraordinary efforts [10,15].

However, evidence showing the biological pathways that connect ERI and overcommitment to mental health issues is limited and findings are not consistent [10]. Synthesis of findings showed that higher ERI and overcommitment has been linked to altered hypothalamic-pituitary-adrenal (HPA) axis (e.g., cortisol), sympathetic-adrenal-medullary (SMA) axis (e.g., heart rate and adrenaline), and immunological biomarkers (e.g., C-Reactive Protein – CRP, fibrinogen and cytokines), but results are not consistent among studies (for review [16]). The biological cascade that links stress to health outcomes is multifaceted and entails the interconnection of multiple stress-target systems (i.e., neuroendocrine, immunological, cardiovascular, and metabolic). Therefore, integrated approaches might better capture the underlying biological mechanisms.

The Allostatic Load (AL) model links the cumulative physiological burden of chronic stress exposure to physical and psychological outcomes that increase illness risk [17,18]. Primary stress mediators, such as glucocorticoids and catecholamines, trigger acute cellular and systemic changes to mobilize energy resources (*allostasis*). This process is crucial for short-term adaptive response, yet their prolonged elevation disrupts homeostasis and can lead to systemic dysregulation [17,18]. Prolonged stress exposure disrupts glucocorticoid signaling and increases insulin resistance and glucose levels, leading to mitochondrial dysfunction, oxidative stress, methylation-related DNA damage, altered energy metabolism, and susceptibility to cell death, a process named *mitochondria allostatic load* [19]. At the system level, the sustained cellular dysfunction produces secondary outcomes such as increased inflammation and altered cardiovascular, metabolic, and neuroendocrine functioning, signaling an increased risk for illness - the *allostatic load* [17–19]. Over time and without adequate recovery, AL precipitates tertiary outcomes (*allostatic overload*) such as sleep issues, lack of energy, dizziness, generalized anxiety, and sadness with significant impact on social and occupational functioning [20,21]. That cumulative outcomes seed the vulnerability to stress-related disorders such as cardiovascular diseases, diabetes, neurodegeneration, and physical and cognitive decline [17–19].

The biological piece of the AL model is particularly beneficial in detecting pathophysiological changes that signal preclinical stages associated with increased illness risk and promoting an opportunity for timely intervention [17]. A cumulative index (AL index) that encompasses biomarkers from several stress-target systems, such as neuroendocrine, immunological, metabolic, and cardiovascular, assesses one's cumulative biological risk [22]. AL index has linked to increased mortality, physical and cognitive decline, and mental health disorders in several studies (for review, [20,23]).

By combining biological changes with physical and psychological symptoms linked to cumulative effects of chronic stress (exposure and response), the AL model emerges as a plausible framework to identify underlying mechanisms that link ERI to mental health issues. However, evidence linking ERI to AL is scarce in healthcare settings.

An association between ERI and high AL index has been documented in public and industrial labor forces and individuals nearing career termination [24–26], but not in healthcare workers. Moreover, the relationship between overcommitment and AL index has been overlooked, limiting our understanding of the connection between one's perception of job demands, behavioral responses, and the underlying biological process that cumulatively leads to psychological symptoms and psychiatric disorders. Comprehending the interlinkages among ERI, overcommitment, AL, and mental health outcomes is essential to design tailored interventions.

This study investigated whether ERI and overcommitment among healthcare professionals were linked to Allostatic Load (AL) and whether AL mediates the relationship between ERI, overcommitment and mental health outcomes. Based on current evidence linking both ERI and AL to mental health issues [16,20,23], our hypotheses were: (i) greater ERI and overcommitment were linked to increased AL, (ii) increased AL was correlated with poor mental health outcomes in healthcare workers, and (iii) AL mediated the relationship between high ERI/overcommitment and deleterious mental health.

2. Methods

2.1. Study setting, recruitment and sampling

We randomly selected 222 nursing staff from a University Hospital at the University of Sao Paulo (HU-USP), Brazil's active worker's registry, for potential inclusion in the study. We limited the eligibility to active nursing staff from the day shift, without restrictions on gender. Several exclusion criteria were set, such as recent leaves due to sickness or vacation in the past month, concurrent night shift employment at another institution, presence of neurological or psychiatric disorders like dementia, depression, anxiety, bipolar disorder, schizophrenia, or post-traumatic stress disorder, history of substance abuse, smoking in the past decade, use of psychoactive drugs, synthetic glucocorticoids or steroids, and undergoing dental treatment at the time of assessment. A telephonic screening interview performed by a trained research assistant determined eligibility, resulting in 160 individuals recruited for the study. A total of 18 of these participants could not meet the biological sampling schedule and excluded themselves from the project during data collection. The final study sample comprised 142 nursing staff (90.1 % female; age range: 23–67 years) who successfully completed the protocol. This cross-sectional study secured approval from the Ethical Committees of the University of Sao Paulo (# 403.390 and # 415.986). All participants gave their voluntary participation in the study via written, informed consent.

2.2. Measurements

2.2.1. Allostatic load index

AL index was measured using ten biomarkers across four stress-response systems: neuroendocrine (cortisol, DHEA-S), immunologic (fibrinogen, CRP), metabolic (HbA1c, total cholesterol, HDL cholesterol), cardiovascular (systolic blood pressure - SBP, diastolic blood pressure DBP) and anthropometric (waist/hip ratio). As traditionally done, values of each participant's biomarkers were aggregated into a count-based AL index [17,22]. Using clinical reference ranges distribution, quartile ranges determined the risk cut-off for each biomarker. The

AL index was computed by adding the number of biomarkers that surpassed the standard risk threshold (75th percentile), except for HDL and DHEA-S where values below the 25th percentile indicated risk. The index ranged from 0 to 10, indicating low to high risk respectively.

2.2.2. Effort-reward imbalance and overcommitment at work

The Effort-Reward Imbalance Scale assesses three dimensions: work effort (6 items related to demanding aspects of the work), reward (10 items related to esteem, job promotion and security at work), and overcommitment (6 items). A total score based on the sum of the four-point Likert scale (0–4) varies between 0 and 24 for effort, 0 and 40 for reward and 0 to 24 for overcommitment [15]. Higher scores mean higher work effort, reward, and overcommitment [15]. To assess the degree of imbalance between high effort and low reward at work, an ER ratio (ERI) was calculated as E/(R*C), where E was the total score of the effort dimension, R was the total score of the reward dimension, and C was the correction coefficient based on the difference in the number of numerators and denominators [15,27]. Cronbach's alpha coefficient of the scale in this study was 0.861 for effort; 0.857 for reward and 0.771 for overcommitment.

2.2.3. Mental health assessment

a) Perceived stress

Participants were applied the 14-item Perceived Stress Scale - PSS [28], a validated measure of stress appraisal that evaluates the degree to which respondents perceive their daily live as unpredictable, uncontrollable, and overwhelming in the last month. Each item is scored on a five-point Likert scale (0 = never, 4 very often). A total score based on the sum of Likert points varies between 0 and 56 and the higher the score, the more perceived stress [28]. Cronbach's alpha coefficient of the scale in this study was 0.818.

b) Psychiatric symptoms

The self-reported questionnaire (SRQ-20), developed by the World Health Organization and validated in several low and middle-income countries, consists of 20 questions designed on a yes/no answer format to detect non-specific psychiatric disturbances, including suicidality. Each yes answer scores 1 point and the higher the score, the more psychological distress [29]. Cronbach's alpha coefficient of the scale in this study was 0.865.

c) Depressive symptoms

The Beck Depression Inventory (BDI), a 21-item, self-report rating inventory, was applied to evaluate attitudes and symptoms of depression [30]. Participants responded on a three-point Likert scale to rate feelings of sadness, pessimism, failure, guilt and punishment, unsatisfaction, self-depreciation and psychosomatic symptoms related to depression. The total score obtained by the sum of each item varies between 0 and 63 points and the higher the score, the more likely the depression [30]. Cronbach's alpha coefficient of the scale in this study was 0.864.

2.2.4. Potential confounders

Possible confounding variables of the association between effort-demand at work, allostatic load index and psychological distress included age, sex, education (years attending school), chronic conditions (self-report diagnosis of hypertension, diabetes, stroke, coronary artery disease) and weekly work load (hours).

2.3. Procedures

After eligibility screening, selected participants attended an individual morning appointment in the Research Center at the HU-USP for questionnaire application and blood sampling. Participants were instructed to fast for 8 h, stay hydrated, and avoid exercise, alcohol, and caffeine before the morning blood sampling. Morning fasting venous blood samples (30 mL) were drawn from the antecubital vein in vacuum tubes (Vacutainer®) for AL biomarkers. They were briefed on the procedure and post-sampling care, including pressure application and arm elevation, and given contact info for complications. Assays were performed in the HU-USP laboratory facilities.

2.4. Statistical analysis

Quantitative variables were characterized using means and standard deviations, while categorical variables were presented via relative frequencies. All dependent variables were checked for assumptions of normality. Multiple regression analyses were performed following the recommended prerequisites regarding sample size ($N > 100$), number of predictors in the model (n. predictors x 10 < N), independent residuals of the predictors, and variances inflation factors (VIF) were between 1.02 and 1.5 [31]. Individual linear regression models (one for each independent variable), adjusted for the listed covariates, were performed to examine the (i) association between effort, reward, ERI, overcommitment (i.e., independent variables), and AL index, and (ii) association between AL (i.e., independent variable) and mental health outcomes (i.e., PSS, SRQ-20, and DBI). Linear regression models were adjusted for multiple comparisons using Bonferroni correct. Assuming a significant relationship between ERI/overcommitment and mental health outcomes [8–12], mediation analysis was performed using the PROCESS macro in SPSS [32], which generated estimates for the direct effect of the predictor (X) on the outcome (Y) (path c Fig. 1) and the indirect effects via AL index load (M) (path a and b; Fig. 1), adjusted for covariates. Statistical analyses were conducted using SPSS®, version 29.0 (IBM Corporation, Armonk NY; USA) for Apple Mac®. The level of statistical significance was set at 0.05 level and 95 % confidence interval.

3. Results

3.1. Sociodemographic, chronic conditions, effort-reward and mental health characteristics

Participants were predominately mid-age women, with high education level, married, with a low prevalence of chronic diseases, and working for several years in the healthcare system (Table 1).

3.2. Allostatic load

AL index mean was 4.2 (SD ± 7.0), ranging from 0 to 9 points. The most commonly encountered high-risk biomarker was DHEA-S, followed by cholesterol and waist/hip ratio (Table 2).

3.3. Association between effort, reward, over-commitment, and allostatic load

Linear regression adjusted for adjusted for age, sex, education, weekly workload, and chronic conditions showed that higher scores for overcommitment were associated with a higher AL index ($\beta = .271$; 95 % CI [0.037, 0.242]; $p = 0.008$). Effort, reward, and ERI were not associated with the AL index (Table 3).

3.4. Association between AL and mental health outcomes

Linear regression adjusted for age, sex, education, weekly workload, and chronic conditions showed that higher AL indexes were associated with higher SRQ-20 scores ($\beta = 0.287$; 95 % CI [2.389, 11.267]; $p = 0.003$). No significant association was observed between AL PSS and DBI scores (Table 4). As expected, higher scores for effort, lower for reward,

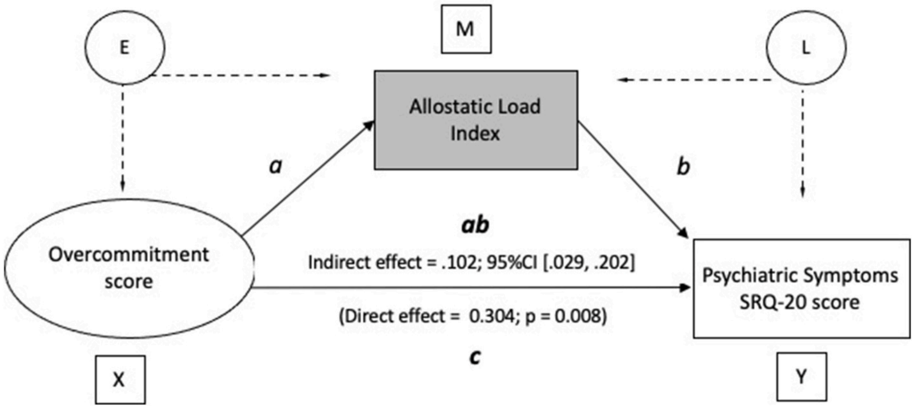

Fig. 1. Schematic representation and regression coefficients for the relationship between predictors (X), outcomes (Y) and mediator (M). The E and L represents the covariates for predictor–outcome and mediator–outcome. Letters a and b represent the paths for indirect effect of mediation, whereas letter c represents the direct effect. The arrows represent the possible direction of the relationship between overcommitment, allostatic load, and psychiatric symptoms (SRQ-20 scores).

Table 1
Sample characteristics.

	Mean (±SD) OR n (%)	Minimum	Maximum
Age (years)	39.5 (9.6)	23	67
Education (years)	15.9 (2.9)	11	27
Sex (% female)	90.1	–	–
Marital status (%)			
single	36 (25.4)	–	–
married	94 (66.2)	–	–
divorced	12 (8.5)	–	–
Hypertension (% yes)	25 (17.6)	–	–
Diabetes (% yes)	20 (14.1)	–	–
Stroke (% yes)	6 (4.2)	–	–
Coronary artery disease (% yes)	3 (2.1)	–	–
Shift work (%)			
6 h morning	65 (46.1)	–	–
6 h afternoon	76 (53.9)	–	–
Work load (mean hours per week)	36.0 (0.34)	36	40
Time in the workforce (mean years)	15.3 (8.9)	2	44
Effort (mean)	13.2 (5.5)	1	28
Reward (mean)	22.7 (5.4)	6	34
Effort-reward imbalance (mean)	1.2 (0.3)	.02	1.80
Overcommitment (mean)	10.8 (3.9)	1	20
Perceived Stress Scale (mean)	25.6 (7.8)	5	52
SRQ-20 (mean)	6.6 (4.7)	0	15
Beck Depression Inventory (mean)	9.9 (7.0)	0	30

SRQ-20 = self-report questionnaire.

Table 2
Biomarker levels, criteria for clinical allostatic load index and high-risk for each biomarker.

Biomarker	Mean (±SD)	Clinical Reference	25° percentile	75° percentile	High-risk n (%)
DHEA-S mmol/L	3.322	male: 0.94-15.36 female: 0.70-12.42	male: 4.54* female: 3.63*	male: 11.76 female: 8.79	89 (64.5)
Waist/hip	0.8281	0.8–1	0.85	.095*	74 (59.7)
Cholesterol mmol/L	4.913	<5.17	1.552	4.65*	78 (56.1)
Fibrinogen g/L	3.4	1.8 - 4.0	2.35	3.45*	64 (46.4)
DBP mmHg	81.92	60–90	67.5	82.50*	55 (41.7)
SBP mmHg	123.47	90–140	102.5	127.50*	44 (33.3)
HbA1c (%)	5.411	4.0–5.6	1.625	4.875*	35 (26.1)
Cortisol nmol/L	375.091	118.63–618.01	243.48	491.17*	28 (20.4)
CRP nmol/L	33.641	28.57	7.14	21.43*	28 (20.4)
HDL mmol/L	1.456	>1.55	0.2575*	0.7725	0 (0)

DHEA-S = dehydroepiandrosterone-sulfate; Cholesterol = total cholesterol; HDL = high-density lipoprotein cholesterol; DBP = diastolic blood pressure; SBP = systolic blood pressure; CPR═C-Reactive Protein; 25th and 75th percentiles derived from the clinical reference range, and high-risk frequency is the rate of participants who attained scores within the high-risk cut-off (*) for each biomarker.

and higher ERI were associated with higher scores for PSS, SRQ-20, and DBI (Table 4).

3.5. *Direct and indirect effects of overcommitment and psychiatric symptoms*

Direct effect estimates showed that overcommitment was directly associated with higher SRQ-20 scores (direct effect = 0.304; 95 %CI [0.083, 0.524]; p = 0.008) (path c in Fig. 1) and indirectly via AL (Indirect effect = 0.102; [95 %CI [0.029, 0.202]) (path ab in Fig. 1). Specifically, higher scores for overcommitment were significantly associated with higher AL index (path a in Fig. 1; B = 0.166; 95 % CI [0.069, 0.263]; p = 0.001), and an AL index in turn.

4. Discussion

Our investigation into work-related stress among healthcare professionals has elucidated that overcommitment, as opposed to ERI, is significantly associated with higher AL. Moreover, we found that AL serves as a mediating factor between overcommitment and heightened psychiatric symptoms. This finding augments the scientific understanding of the potential pathways through which work-related stress in healthcare settings might precipitate mental health issues.

Our study has brought to light the crucial and overlooked connection between overcommitment and AL in healthcare professionals [16]. Examining individual biomarkers of stress, a pattern emerges wherein elevated overcommitment has been associated with altered cortisol levels [33–35, 45], increased CRP [36], and abnormal lipid profiles [37]. Nevertheless, this connection has not been uniformly established across studies [38,39]. Methodological differences, such as various biological specimens to determine cortisol and sex differences, might

Table 3
Association between effort-reward, overcommitment, and AL index (n = 142).

	AL index				AL index			
	Model 1[a]				Model 2[b]			
	B	β [95 % CI]	Adj.*p*[c]	R^2	B	β [95 % CI]	Adj.*p*[c]	R^2
Effort	−.037	−.101 [-.107, .033]	.298	.111	−.014	−0.37 [-.086, .058]	.704	.183
Reward	−.053	−.132 [-.131, .024]	.177	.129	−.063	−.155 [-.141, .016]	.115	.190
ERI	.237	.026 [-1.576, 2.050]	.796	.106	.966	.104 [-.856, 2.787]	.295	.202
Overcommitment	.147	.288 [.051, .244]	**.003**	.195	.139	.271 [.037, .242]	**.008**	.210

Abbreviations: ERI: Effort-reward imbalance; B = Unstandardized coefficients; β: standardized coefficients.
[a] Model 1: Linear regression model adjusted for age and sex.
[b] Model 2: Linear regression model adjusted for age, sex, education, weekly work load, hypertension, diabetes.
[c] p-values after Bonferroni correction; bold p-values: <.005.

Table 4
Association between effort-reward, overcommitment, AL index and mental health outcomes (n = 142).

	PSS				SRQ20				BDI			
	B	β [95 % CI]	Adj.*p*[c]	R^2	B	β (95 % CI)	Adj.*p*[c]	R^2	B	β (95 % CI)	Adj.*p*[c]	R^2
AL index												
Model 1[a]	2.753	.069 [-4.819, 10.325]	.473	.068	6.729	.281 [2.481, 10.977]	**.002**	.132	3.044	.086 [-3.448, 9.537]	.355	.042
Model 2[b]	1.384	.035 [-6.613, 9.381]	.732	.078	6.828	.287 [2.389, 11.267]	**.003**	.165	2.713	.077 [-4.212, 9.638]	.439	.048
Effort												
Model 1[a]	−.409	−.284 [-.664, −.154]	**.002**	.141	−.292	−.346 [-.433, −.151]	<**.001**	.182	−.399	−.313 [-.617, −.182]	<**.001**	.125
Model 2[b]	.393	.275 [.137, .650]	**.003**	.146	.182	.217 [.038, 326]	**.014**	.167	.409	.318 [.189, .630]	<**.001**	.145
Reward												
Model 1[a]	−.409	−.284 [-.664, −.154]	**.002**	.141	−.292	−.346 [-.433, −.151]	<**.001**	.182	−.399	−.313 [-.617, −.182]	<**.001**	.125
Model 2[b]	−.433	−.301 [-.693, −.173]	**.001**	.163	−.291	−.346 [-.433, −.149]	<**.001**	.210	−.406	−.318 [-.629, −.183]	<**.001**	.132
ERI												
Model 1[a]	7.485	.254 [2.186, 12.784]	**.006**	.124	5.503	.316 [2.56, 8.444]	<**.001**	.170	9.965	.378 [5.589, 14.342]	<**.001**	.171
Model 2[b]	8.666	.293 [3.209, 14.123]	**.002**	.154	.349	.089 [3.162, 8.967]	<**.001**	.237	10.748	.407 [6.262, 15.233]	<**.001**	.197
Overcommitment												
Model 1[a]	.144	.071 [-.237, .524]	.456	.069	.452	.394 [.258, .647]	<**.001**	.208	.145	.080 [-.186, .476]	.387	.042
Model 2[b]	.067	.033 [-.338, .472]	.743	.086	.431	.376 [.224, .638]	<**.001**	.223	.126	.486 [-.231, .483]	.486	.048

Abbreviations: PSS: Perceived Stress Scale; SRQ-20: Self-Report Questionnaire – 20 items; Beck: Beck Depression Inventory; ERI: Effort-reward imbalance; B = Unstandardized coefficients; β: standardized coefficients.
[a] Model 1: Linear regression model adjusted for age and sex.
[b] Model 2: Linear regression model adjusted for age, sex, education, weekly work load, hypertension, diabetes.
[c] p-values after Bonferroni correction; bold p-values: <.005.

explain this inconsistency [10]. A distinct aspect of our study is the demonstration of AL as a mediator in the relationship between overcommitment and heightened symptoms of anxiety and depression—a finding not previously reported. This highlights the detrimental role of overcommitment in contexts characterized by high effort and low reward, underlining its adverse impact on the mental well-being of healthcare professionals [10,15].

The role of AL as a mediating factor suggests a physiological response ensuing from the psychological adaptation to occupational stressors, offering insights into the multilevel processes involved. In essence, prolonged exposure to excessive work strain and overcommitment response appears to trigger a chain reaction between stress-target systems, exacerbating perceived occupational stress and consequently impacting mental health [40].

These findings raise relevant insights regarding how employees and employers perceive the interactive relationship between productivity, success, and individual exhaustibility. The concept of overcommitment viewed as a coping strategy highlights the tendency of individuals to accept more responsibilities or tasks than they can feasibility manage [10,15]. This is often due to a bias about one's capacities, need for approval or underestimation of task demands, which may eventually lead to acute stress, burnout, low productivity and employee dissatisfaction [10,15]. A more sustainable and mindful approach, where individuals and organizations are encouraged to recognize and respect their limits, is a critical piece to consider when designing interventions to lessen the impact of work-related stress and its consequences on professional well-being.

In comparing our study with existing research, our findings corroborate with previous studies that have found a negative relationship between overcommitment at work and mental health outcomes [10–12]. Extending our understanding of biological mechanisms linking work-related stress to mental disorders [16, 46], our findings positioned AL as a critical underlying and multi-system pathophysiological pathway in this relationship.

However, contradicting existing evidence [11,24,25], our study did not observe a significant association between ERI and either psychiatric symptoms or the AL index. Coronado et al. [24] study examined repeated reports of ERI over time, revealing that higher levels of AL were associated with more reported instances of ERI [24]. Additionally, the lack of correlation does not rule out the possible existence of other mediators or moderators in this relationship[26]. Individual attributes such as coping strategies, social support, or personal resilience could potentially moderate the impact of ERI on mental health and AL index—factors [41] that were not explored in our study. Moreover, the role of contextual factors like organizational culture, job demands, and workplace social support cannot be ignored. They could either intensify or mitigate the effects of ERI on mental health and AL index [42]. Hence, despite the non-significant findings in our study, the relationship between ERI and health outcomes remains a complex interplay of various factors that need further exploration in future studies.

Furthermore, our findings highlighted the relationship between increased job efforts, decreased rewards, and mental health outcomes among healthcare professionals. These outcomes manifest as heightened perceived stress levels, anxiety and depressive symptoms, which stand in line with our initial hypothesis. This observation resonates with the ERI model whereby increased effort allied with diminished recognition at work can produce negative psychiatric consequences [10,15]. Previous synthesis of evidence showed that ERI was associated with a 1.5-fold increased risk of depressive disorders in a meta-analysis of eight prospective cohort studies from Europe, Canada, and the US [9]. Similar findings were also observed in healthcare employees [8,11,43].

Despite the robustness of our data, this study has certain limitations. First, the predominance of female participants in our cross-sectional data. Given that gender differences can impact the dynamics of work-related stress on health via underlying biological mechanisms, the results may not be universally applicable [44]. Moreover, using clinical cutoffs identify those at health risk accurately, preferable to sample-based quartile methods. Yet, skewed results for certain health markers suggest potential sample biases or outdated thresholds, emphasizing the need for updated, population-relevant cutoffs to ensure precision [40]. Furthermore, various external and internal factors such as work-based social support, lifestyle habits, and coping mechanisms play essential moderator roles in the link between work stress and mental health [26,41]. Hypertension and diabetes were also factors that could influence AL findings. Although these conditions were included as covariates and the rate of hypertension and diabetes were relatively low in the sample, these factors must be considered when interpreting findings. Future research stands to gain from implementing more inclusive, encompassing different gender groups, examining interpersonal relationships at work, exploring task dynamics, and potential physiological intermediaries. Such an inclusive approach can pave the way for a comprehensive understanding of the ERI model in diverse workplace settings, and its implications on mental health. Finally, the study's reliance on cross-sectional data limits the ability to establish causation. Longitudinal studies are necessary to demonstrate the progression of mental health issues under chronic exposure to work-related stressors.

Notwithstanding these limitations, our study's strengths lie in the randomized sampling, a broad panel of AL biomarkers indicating critical stress-target systems, and a diverse, mixed-race sample from middle to low-income countries. These strengths inform and diversify the macro scenario from which our current understanding of the ERI model has primarily built.

5. Conclusion

Our study reveals that overcommitment, rather than ERI, was linked to increased AL in healthcare workers. Additionally, AL mediates the relationship between overcommitment and higher psychiatric symptoms, highlighting a key mechanism by which work stress can lead to mental health problems. Longitudinal studies conducted in diverse participant samples are necessary to establish causation and guide tailored interventions.

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CRediT authorship contribution statement

Daniela Coelho: Data curation, Formal analysis, Methodology, Writing – original draft, Writing – review & editing. **Siomara Yamaguchi:** Data curation, Formal analysis, Methodology, Writing – original draft, Writing – review & editing. **Alaa Harb:** Methodology, Writing – original draft, Writing – review & editing. **Juliana N. Souza-Talarico:** Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Project administration, Resources, Supervision, Writing – original draft, Writing – review & editing.

Declaration of generative AI and AI-assisted technologies in the writing process

During the preparation of this work the author(s) used Grammarly in order to correct grammar mistakes and align with appropriate academic language. After using this tool, the author(s) reviewed and edited the content as needed and take(s) full responsibility for the content of the publication.

Declaration of competing interest

None

References

[1] P.K. Maulik, Workplace stress: a neglected aspect of mental health wellbeing. Indian J, Med. Res. 146 (2017) 441–444, https://doi.org/10.4103/ijmr.IJMR_1298_17.

[2] World Health Organization, Mental health in the workplace. https://www.who.int/teams/mental-health-and-substance-use/promotion-prevention/mental-health-in-the-workplace, 2023. (Accessed 7 September 2023).

[3] N. Abdoli, V. Farnia, S. Jahangiri, F. Radmehr, M. Alikhani, P. Abdoli, O. Davarinejad, K.M. Dürsteler, A.B. Brühl, D. Sadeghi-Bahmani, S. Brand, Sources of sleep disturbances and psychological strain for hospital staff working during the COVID-19 pandemic, Int. J. Environ. Res. Publ. Health 18 (6289) (2021), https://doi.org/10.3390/ijerph18126289.

[4] O. Bouaddi, N.M. Abdallahi, C.M. Fadel Abdi, K. Hassouni, M. Jallal, R. Benjelloun, Z. Belrhiti, C. Nejjari, M. Khalis, Anxiety, stress, and depression among healthcare professionals during the COVID-19 pandemic: a cross-sectional study in Morocco, Inquiry 60 (469580221147377) (2023), https://doi.org/10.1177/00469580221147377.

[5] R. Bardhan, K. Heaton, M. Davis, P. Chen, D.A. Dickinson, C.T. Lungu, A cross-sectional study evaluating psychosocial job stress and health risk in emergency department nurses. Int, J. Environ. Res. Public Health 16 (3243) (2019), https://doi.org/10.3390/ijerph16183243.

[6] Centers for Disease Control and Prevention, Healthcare workers. Work-related stress. https://www.cdc.gov/niosh/topics/healthcare/workstress.html, 2023. (Accessed 7 September 2023).

[7] J. Siegrist, Adverse health effects of high-effort/low-reward conditions, J. Occup. Health Psychol. 1 (1996) 27–41, https://doi.org/10.1037//1076-8998.1.1.27.

[8] P. Beschoner, J. von Wietersheim, M.N. Jarczok, M. Braun, C. Schönfeldt-Lecuona, R. Viviani, L. Jerg-Bretzke, M. Kempf, A. Brück, Effort-reward-imbalance, burnout, and depression among psychiatrists 2006 and 2016-Changes after a legislative intervention, Front. Psychiatr. 12 (641912) (2021), https://doi.org/10.3389/fpsyt.2021.641912.

[9] R. Rugulies, B. Aust, I.E.H. Madsen, ERI at work and risk of depressive disorders: a systematic review and meta-analysis of prospective cohort studies. Scand, J. Work. Environ. Health 43 (2017) 294–306, https://doi.org/10.5271/sjweh.3632.

[10] J. Siegrist, J. Li, Associations of extrinsic and intrinsic components of work stress with health: a systematic review of evidence on the ERI model, Int. J. Environ. Res. Publ. Health 13 (432) (2016), https://doi.org/10.3390/ijerph13040432.

[11] T.M. de Araújo, J. Siegrist, A.B. Moreno, M. de Jesus Mendes da Fonseca, S. M. Barreto, D. Chor, R.H. Griep, ERI, over-commitment, and depressive episodes at work: evidence from the ELSA-brasil cohort study, Int. J. Environ. Res. Publ. Health 16 (3025) (2019), https://doi.org/10.3390/ijerph16173025.

[12] J. Zhang, Y. Wang, J. Xu, H. You, Y. Li, Y. Liang, S. Li, L. Ma, J.T. Lau, Y. Hao, S. Chen, J. Zeng, J. Li, J. Gu, Prevalence of mental health problems and associated factors among front-line public health workers during the COVID-19 pandemic in China: an ERI model-informed study, BMC Psychol 9 (55) (2021), https://doi.org/10.1186/s40359-021-00563-0.

[13] N. Wege, J. Li, J. Siegrist, Are there gender differences in associations of effort-reward imbalance at work with self-reported doctor-diagnosed depression? Prospective evidence from the German Socio-Economic Panel, Int. Arch. Occup. Environ. Health 91 (4) (2018) 435–443, https://doi.org/10.1007/s00420-018-1293-8.

[14] J.K. Ahlin, A.D. LaMontagne, L.L.Magnusson. Hanson, Are there bidirectional relationships between psychosocial work characteristics and depressive symptoms? A fixed effects analysis of Swedish national panel survey data, Occup. Environ. Med. 76 (2019) 455–461, https://doi.org/10.1136/oemed-2018-105450.

[15] J. Siegrist, D. Starke, T. Chandola, I. Godin, M. Marmot, I. Niedhammer, et al., The measurement of effort-reward imbalance at work: European comparisons, Soc. Sci. Med. 58 (2004) 1483–1499, https://doi.org/10.1016/s0277-9536(03)00351-4.

[16] J. Siegrist, J. Li, Work stress and altered biomarkers: a synthesis of findings based on the effort–reward imbalance model. Int, J. Environ. Res. Public Health 14 (1373) (2017), https://doi.org/10.3390/ijerph14111373.

[17] R.-P. Juster, B.S. McEwen, S.J. Lupien, Allostatic load biomarkers of chronic stress and impact on health and cognition, Neurosci. Biobehav. Rev. 35 (2010) 2–16, https://doi.org/10.1016/j.neubiorev.2009.10.002.

[18] B.S. McEwen, Protective and damaging effects of stress mediators. N. Engl, J. Med. 338 (1998) 171–179, https://doi.org/10.1056/NEJM199801153380307.
[19] M. Picard, R.P. Juster, B.S McEwen, Mitochondrial allostatic load puts the 'gluc' back in glucocorticoids, Nat. Rev. Endocrinol. 10 (5) (2014 May), https://doi.org/10.1038/nrendo.2014.22, 303–10.
[20] J. Guidi, M. Lucente, N. Sonino, G.A. Fava, Allostatic load and its impact on health: a systematic review, Psychother. Psychosom. 90 (2021) 11–27, https://doi.org/10.1159/000510696.
[21] G.A. Fava, B.S. McEwen, J. Guidi, S. Gostoli, E. Offidani, N. Sonino, Clinical characterization of allostatic overload, Psychoneuroendocrinology 108 (2019 Oct) 94–101, https://doi.org/10.1016/j.psyneuen.2019.05.028.
[22] T.E. Seeman, B.S. McEwen, J.W. Rowe, B.H. Singer, Allostatic load as a marker of cumulative biological risk: MacArthur studies of successful aging. Proc. Natl. Acad. Sci. U, S. A 98 (2001) 4770–4775, https://doi.org/10.1073/pnas.081072698.
[23] H.W. Parker, A.M. Abreu, M.C. Sullivan, M.K. Vadiveloo, Allostatic load and mortality: a systematic review and meta-analysis, Am. J. Prev. Med. 63 (2022) 131–140, https://doi.org/10.1016/j.amepre.2022.02.003.
[24] J.I.C. Coronado, T. Chandola, A. Steptoe, Allostatic load and ERI: associations over the working-career, Int. J. Environ. Res. Publ. Health 15 (191) (2018), https://doi.org/10.3390/ijerph15020191.
[25] R.H. Carlsson, Å.M. Hansen, M.L. Nielsen, M. Blønd, B. Netterstrøm, Changes in allostatic load during workplace reorganization, J. Psychosom. Res. 103 (2017) 34–41, https://doi.org/10.1016/j.jpsychores.2017.09.015.
[26] D. Mauss, M.N. Jarczok, J.E. Fischer, The streamlined allostatic load index: a replication of study results, Stress 19 (2016) 553–558, https://doi.org/10.1080/10253890.2016.1219718.
[27] I. Niedhammer, M.L. Tek, D. Starke, J. Siegrist, Effort–reward imbalance model and self-reported health: cross-sectional and prospective findings from the GAZEL cohort, Soc. Sci. Med. 58 (2004) 1531–1541, https://doi.org/10.1016/s0277-9536(03)00346-0.
[28] S. Cohen, T. Kamarck, R. Mermelstein, A global measure of perceived stress, J. Health Soc. Behav. 24 (1983) 385–396.
[29] E. Iacoponi, J. de Jesus Mari, Reliability and factor structure of the Portuguese version of Self-Reporting Questionnaire, Int. J. Soc. Psychiatr. 35 (1989) 213–222, https://doi.org/10.1177/002076408903500301.
[30] A.T. Beck, R.A. Steer, M.G. Garbin, Psychometric properties of the Beck depression inventory: twenty-five years of evaluation, Clin. Psychol. Rev. 8 (1988) 77–100, https://doi.org/10.1016/0272-7358(88)90050-5.
[31] J.F. Hair, C.W. Black, B.J. Babin, R.E. Anderson, *Multivariate Data Analysis.* 7th, 2014. Pearson Education Limited; London, UK.
[32] A.F. Hayes, Introduction to mediation, moderation, and conditional process analysis: a regression-based approach, Guilford Press (2013).
[33] A. Steptoe, J. Siegrist, C. Kirschbaum, M. Marmot, Effort-reward imbalance, overcommitment, and measures of Cortisol and blood pressure over the working day, Psychosom. Med. 66 (2004) 323–329, https://doi.org/10.1097/01.psy.0000126198.67070.72.
[34] M. Wolfram, S. Bellingrath, N. Feuerhahn, B.M. Kudielka, Emotional exhaustion and overcommitment to work are differentially associated with hypothalamus-pituitary-adrenal (HPA) axis responses to a low-dose ACTH1-24 (Synacthen) and dexamethasone-CRH test in healthy school teachers, Stress 16 (1) (2013 Jan) 54–64, https://doi.org/10.3109/10253890.2012.683465.
[35] A. Marchand, R.P. Juster, P. Durand, S.J. Lupien, Work stress models and diurnal cortisol variations: the SALVEO study, J. Occup. Health Psychol. 21 (2016) 182–193, https://doi.org/10.1037/a0039674.
[36] W. Xu, B. Chen, L. Guo, Z. Li, Y. Zhao, H. Zeng, High-sensitivity CRP: possible link between job stress and atherosclerosis, Am. J. Ind. Med. 58 (2015) 773–779, https://doi.org/10.1002/ajim.22470.
[37] R. Peter, L. Alfredsson, N. Hammar, J. Siegrist, T. Theorell, P. Westerholm, High effort, low reward, and cardiovascular risk factors in employed Swedish men and women: baseline results from the WOLF Study, J. Epidemiol. Community Health 52 (1998) 540–547, https://doi.org/10.1136/jech.52.9.540.
[38] A. Ota, J. Mase, N. Howteerakul, T. Rajatanun, N. Suwannapong, H. Yatsuya, Y. Ono, The effort-reward imbalance work-stress model and daytime salivary cortisol and dehydroepiandrosterone (DHEA) among Japanese women, Sci. Rep. 17 (4) (2014), https://doi.org/10.1038/srep06402, 6402.
[39] C.J. Gidlow, J. Randall, J. Gillman, S. Silk, M.V. Jones, Hair cortisol and self-reported stress in healthy, working adults, Psychoneuroendocrinology 63 (2016) 163–169, https://doi.org/10.1016/j.psyneuen.2015.09.022.
[40] R.-P. Juster, S. Sindi, M.F. Marin, A. Perna, A. Hashemi, J.C. Pruessner, S.J. Lupien, A clinical allostatic load index is associated with burnout symptoms and hypocortisolemic profiles in healthy workers, Psychoneuroendocrinology 36 (2011) 797–805, https://doi.org/10.1016/j.psyneuen.2010.11.001.
[41] L. Shi, R.H. Xu, Y. Xia, D. Chen, D. Wang, The impact of COVID-19-related work stress on the mental health of primary healthcare workers: the mediating effects of social support and resilience. Front, Psychol. 12 (800183) (2022), https://doi.org/10.3389/fpsyg.2021.800183.
[42] E. Lopez-Martin, G. Topa, Organizational culture and job demands and resources: their impact on employees' wellbeing in a multivariate multilevel model, Int. J. Environ. Res. Publ. Health 16 (2019), https://doi.org/10.3390/ijerph16173006.
[43] M. Kivimäki, J. Vahtera, M. Elovainio, M. Virtanen, J. Siegrist, Effort-reward imbalance, procedural injustice and relational injustice as psychosocial predictors of health: complementary or redundant models? Occup. Environ. Med. 64 (2007) 659–665, https://doi.org/10.1136/oem.2006.031310.
[44] P. Kerr, S. Kheloui, M. Rossi, M. Désilets, R.-P. Juster, Allostatic load and women's brain health: a systematic review. Front, Neuroendocrinology 59 (2020) 100858, https://doi.org/10.1016/j.yfrne.2020.100858.
[45] X. Qi, J. Zhang, Y. Liu, S. Ji, Z. Chen, J.K. Sluiter, H. Deng, Relationship between effort-reward imbalance and hair cortisol concentration in female kindergarten teachers, J. Psychosom. Res. 76 (2014) 329–332, https://doi.org/10.1016/j.jpsychores.2014.01.008.
[46] S. Bellingrath, B.M. Kudielka, Psychobiological pathways from work stress to reduced health: Naturalistic and experimental studies on the ERI mode, in: J. Siegrist, M. Wahrendorf (Eds.), Work stress and health in a globalized economy: The model of effort-reward imbalance, Springer International Publishing/Springer Nature, 2016, pp. 145–170. https://doi.org/10.1007/978-3-319-32937-6_7.