



Relationship between Noise Pollution, Sleep Quality, Environmental Sensitivity, and Study Workload on Stress Levels

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ABSTRACT

Stress is massive and multidimensional as a public fitness concern, that's encouraged with the aid of using an interplay of environmental, physiological, and cognitive-behavioural variables. One of the maximum remarkable, but least-researched elements of strain consists of noise pollution, disruptions within the first-rate of sleep, non-public environmental sensitivity, or the pressures of look at workload. These 4 elements do not no longer paintings independently, however as an alternative every has interactions with the opposite thru not unusualplace neurobiological mechanisms with the autonomic frightened gadget and hypothalamic-pituitary-adrenal axis in a way which could enlarge the consequences of pressure past the easy consequences of every of those elements on my own could suggest. The have a look at putting became a loud and densely populated metropolis of Lahore, Pakistan, which affords a essential studies surroundings to examine the connection among noise pollution, the high-satisfactory of sleep, environmental sensitivity, and take a look at workload and perceived strain in a pattern of adults in Lahore. The look at hypothesized the impartial and blended courting of noise pollution, the pleasant of sleep, environmental sensitivity, and examine workload at the perceived pressure stage in a populace of Lahore residents. The studies layout turned into a cross-sectional quantitative layout. The pattern of 295 adults turned into stratified via way of means of five residential regions in Lahore (Gulberg, Samanabad, Johar Town, Ravi Town and Iqbal Town) with specific socioeconomic and noise publicity profiles. The tested Noise Annoyance Scale (NAS) and self-envisioned decibel classes had been used to degree noise pollution. The Pittsburg Sleep Quality Index (PSQI) turned into utilized in measuring the nice of sleep. The Modified Sensory Sensitivity Scale (MSES-12) turned into used to degree environmental sensitivity. The workload of reading turned into measured via the weekly hours of analyzing and the educational call for subscale of NASA Task Load Index (NASA-TLX). The perceived pressure scale-10 (PSS-10) become used to degree perceived pressure. Pearson correlation, one-manner ANOVA, Chi-square, and binary logistic regression that blanketed an interplay term (noise x environmental sensitivity) had been used to examine information in SPSS v.27. High strain (PSS-10 > 26) became determined in 37.6% of the interviewees. In the completely adjusted binary logistic regression model, excessive noise publicity (OR = 2.61; 95% CI: 1.68-4.05; $p < 0.001$), bad sleep excellent (OR = 2.27; 95% CI: 1.51-3.40; $p < 0.001$), excessive environmental sensitivity (OR = 1.99; 95% CI: 1.31-3.04; $p = 0.001$) A robust interplay impact turned into discovered among environmental sensitivity (x noise) and the surroundings (OR = 1.30; 95% CI: 1.10-1.53; $p = 0.002$), which proven the excessive sensitivity people had disproportional pressure responses to noise pollution. Noise pollution, low first-rate of sleep, environmental sensitivity, and immoderate paintings at college also are vital and great unbiased and mixed determinants of perceived strain (Nagelkerke $R^2 = 0.486$). Their interplay, and particularly the improving impact of environmental sensitivity at the noise-pressure pathway, highlights the significance of each individual-stage and environmental techniques of strain-reduction. Urgent coverage interventions on multi-sectoral responses to the difficulty of city noise control, merchandising of sleep fitness, environmental lodging of touchy persons, and workload are extraordinarily demanded.

Keywords: stress, noise pollution, quality of sleep, environmental sensitivity, study workload, PSS-10, PSQI, NAS, MSES-12, Lahore, Pakistan, cross-sectional, perceived stress.

INTRODUCTION

Stress is a fundamental psychobiological response to the perceived threats or needs which surpass the to be had assets to manage with (Lazarus and Folkman, 1984). The impact of the strain reaction, that's induced via way of means of the sympatho-adrenal and hypothalamic-pituitary-adrenal (HPA) machine activation, is adaptive in the intense form, because it allocates power and interest to coping. But as soon as pressure becomes a continual phenomenon and organic strain-reaction mechanism is constantly triggered, it has widespread pathological consequences which includes immune dysfunction, coronary heart disease, metabolism, temper disorders, cognitive impairment, and disturbed sleep (McEwen and Gianaros, 2010; Cohen et al., 2007). The pressure burden withinside the global is immense: in keeping with the World Health Organization (WHO, 2022), over 30 percentage of all years lived with incapacity in low- and middle-earnings nations is related to intellectual and bodily fitness situations associated with pressure, which makes the detection and correction of pressure elements a number one fitness intention of the populace.

Noise pollutants of the surroundings is one of the maximum common, however least valued persistent stressors of cutting-edge city setting. Environmental noise has been diagnosed via way of means of the WHO (2018) as the second one environmental fitness danger in Europe after air pollutants and the city noise is rapid turning into a main issue in strain and fitness burden on the populace degree, as unexpectedly urbanizing South Asian towns demonstrate. Lahore, the second one-biggest metropolis of Pakistan, a domestic to extra than 14 million human beings, and usually ranked many of the maximum noisy towns withinside the international, presents a vibrant instance to the acute publicity to noise in city areas, because the common daylight hours noise stage in fundamental streets is 78-ninety two dB, that's lots better than the WHO advice of fifty three dB of the noise produced outside throughout the day (Noise Pollution Network Pakistan, 2022; WHO, 2018). The pathways with the aid of using which continual noise publicity will increase strain are tremendously described: whilst the amygdala is activated through non-auditory stimuli, it activates sympatho-adrenal reactions together with cortisol release, cardiovascular stimulation, and stimulation of the arousal gadget, which generate physiological symptoms and symptoms of pressure even withinside the state of affairs while the noise elements aren't consciously perceived or irritating (Basner et al., 2014).

The nice of sleep is intently and inversely linked with strain. Chronic sleep deprivation and disturbed sleep architecture - which generate excessive tiers of fatigue, lack of prefrontal cortical manage over the amygdala, failure in cortisol rhythmicity, and

multiplied emotional reactivity - move a protracted manner in growing perceived responses to environmental and cognitive needs (Harvey et al., 2011; Riaz et al., 2018). On the opposite hand, mental pressure produces cognitive hyperarousal, intrusive worry, and autonomic activation which impairs sleep onset and preservation and establishes reinforcing loops wherein strain and bad sleep pass hand in hand to boost every different withinside the lengthy run (Akerstedt, 2006). The maximum clinically and scientifically established device of size of bad sleep, the Pittsburgh Sleep Quality Index (PSQI), has consistently, in excessive-strain city settings, recognized terrible sleep (worldwide rating above 5) in 60-70% of the overall grownup populace - a occurrence price indicative of a public fitness disaster with big pressure-associated implications (Buysse et al., 1989; Morin et al., 2006).

Environmental sensitivity, that is a trait feature on the character degree and is stable, a hallmark of the thoroughness of the processing of sensory and emotional stimuli, is a really crucial but in large part not noted moderating issue withinside the interplay among environmental stressors and fitness outcomes. The theoretical idea of Sensory Processing Sensitivity (SPS) through Aron and Aron (1997) is a biologically-primarily based totally trait dimension, present in approximately 15-20% of the overall populace and additionally supported via way of means of neuroimaging records of superior activation in each attention and empathy associated mind systems, which characterizes someone who techniques facts of the surroundings greater deeply, has more potent responses to poor and fine stimuli, and is a lot extra prone to pressure in poor environments (Pluess, 2015; Acevedo et al., 2010). Importantly, tremendously environmentally touchy people aren't simply stressful or neurotic, however are a biologically separate institution of humans, who, on the only hand, disproportionately display more physiological and mental strain reactions in reaction to the equal environmental situation as noise, crowding, and sensory overload, compared to low-sensitivity humans do (Talha, 2021; Javed et al., 2020).

Work load of examine- the intellectual and time-primarily based totally load of getting to know, reading, coursework, and expert improvement reasons strain in numerous ways. The time stress triggers the risk appraisal networks and ends in the improvement of anticipatory anxiety; excessive cognitive load wears down attentional sources and impacts the emotional regulatory abilities; extended paintings and examine hours spoil the restoration and impair the sleep; and emission of unfinished obligations creates a everlasting historical past cognitive activation that doesn't permit complete mental disengagement with paintings needs in the course of leisure (Elias et al., 2011; Pascoe et al., 2020). Study workload withinside the present day

society is not constrained to school, new types of expert improvement, steady educative necessities, talents retraining because of extrade in technology, and the developing normalization of lifelong getting to know are all applicable pressure elements that make a contribution to look at-associated cognitive load now no longer most effective withinside the formal training zone however additionally withinside the whole person populace (Hart and Staveland, 1988).

The 4 determinants taken into consideration withinside the gift studies, together with noise pollutants, the excellent of sleep, environmental sensitivity, and the workload of the studies, have full-size mechanistic interdependencies that make their concurrent evaluation in an included method to the have a look at scientifically persuasive. Noise pollutants at once interferes with the high-satisfactory of sleep with the aid of using exposing nocturnal noise and arousal-mediated sleep discontinuity, which makes noise pollutants an immediate and oblique stressor, and in part the function of this stressor is mediated via way of means of sleep disruption (Basner et al., 2014; WHO, 2018). Environmental sensitivity attenuates noise-pressure and noise-sleep institutions, as incredibly touchy people showcase extra physiological arousal to the stimuli of noise, more sleep fragmentation beneathneath noisy situations, and extra excessive pressure responses to the equal degree of noise as in comparison to low-sensitivity people (Acevedo et al., 2014; Bakker and Moulding, 2012; Shabbir et al., 2019). The workload of the examine dietary supplements those environmental influences through supplying an impartial cognitive stressor which consumes the equal attentional, emotional and organic strain-regulatory sources ate up through noise publicity and sleep loss - a cumulative pressure load whose normal effect a ways surpasses the sum of its components.

Lahore gives a studies surroundings this is extraordinarily sizable in reading those relationships.

The harsh noise city setting, extra populace density of the metropolis, and excessive occurrence of sleep problem and mental pressure in addition to the presence of a huge socioeconomic stratification (which includes now no longer simplest rich residential zones like Gulberg and Defence Housing Authority however additionally densely populated lower-profits groups like Ravi Town and Data Ganj Bakhsh) gives now no longer best the environmental and sociodemographic range had to observe the whole spectrum of noise publicity, sleep fine, and socioeconomic pressure gradient however additionally substances the desired cloth to cope with the studies query of the superiority of sleep problem and mental Although the town is of significance in phrases of a area of an amassed environmental and psychosocial strain, no posted examine has hitherto severely tested over noise pollutants, sleep fine, environmental sensitivity, and look at paintings load as a mixture of predictors of perceived strain in a Lahore primarily based totally network primarily based totally pattern, that is a huge hole withinside the proof base that this look at without delay addresses.

The particular targets of the look at are as follows: (1) set up the excessive incidence of perceived pressure and the distributions of noise publicity, sleep first-class, environmental sensitivity and workload of analyzing in a network-primarily based totally pattern in Lahore; (2) to check bivariate correlations and institutions among predictor variables and PSS-10 pressure scores; (3) to perceive widespread unbiased predictors of excessive strain in an evaluation of a complete alter multivariate binary logistic regression model; and (4) to check the hypothesized moderating impact of environmental sensitivity on the connection among noise pollutants and perceived The consequences will goal at growing sensible proof in city planning, noise policy, sleep fitness promoting and private strain control application in Lahore and different comparable city environments in South Asia.

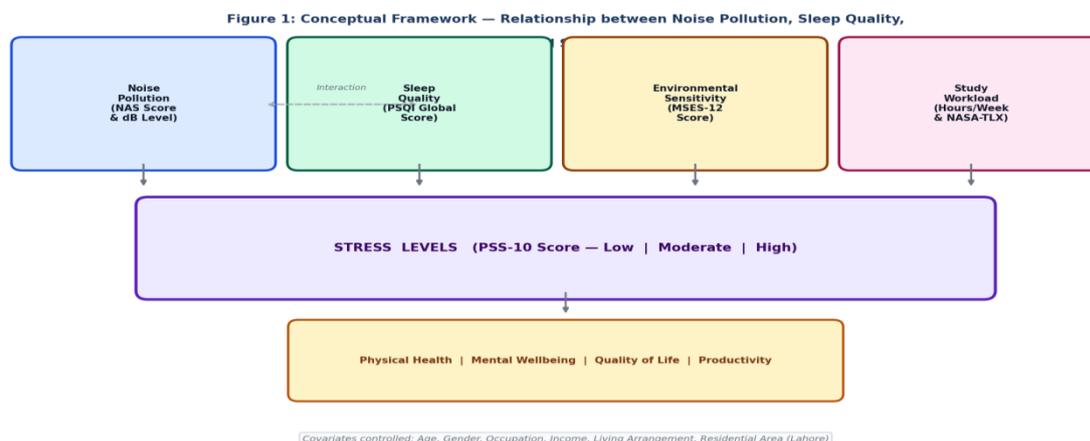


Figure 1: Conceptual Framework — Noise Pollution, Sleep Quality, Environmental Sensitivity, and Study Workload on Stress Levels

LITERATURE REVIEW

Noise Pollution and Stress Levels

The medical facts concerning the relation among environmental noise pollutants and the upward thrust of strain is voluminous, and it has a mechanistic basis, that is much like the state of affairs in specific geographic and demographic settings. Stansfeld and Matheson (2003) have furnished a seminal work, which described the non-auditory pathway wherein noise produces strain: acoustic stimulus achieving the auditory cortex triggers an immediate neural projection to the amygdala, which turns on a cascade of sympatho-adrenal responses - adrenaline and cortisol secretions, cardiovascular activation, and stimulation of the reticular arousal system, all of which arise absolutely with out aware cognitive processing of the sound. This means that the physiological strain load of noise is so steady in phrases of waking and slumbering and can not be absolutely countered via way of means of habituation and that time beyond regulation this pressure load accumulates even in people who document turning into subjectively much less irritated via way of means of continual noise.

In a step forward overview of 450 research on noise fitness events, Basner et al. (2014) stated dose-reaction traits among network noise publicity (measured in dB Leq) and physiological pressure markers which include 24-hour cortisol excretion, nocturnal adrenaline, and systolic blood strain will increase of extensive fitness consequences that might be discovered with as low as forty dB night-time equal noise publicity. In a scientific evaluation of forty two research of noise and intellectual fitness degrees commissioned via way of means of the WHO, Clark and Paunovic (2018) found no much less than forty four statistically big relationships among noise publicity (residential, above fifty five dB) and markedly better mental distress, tension, and perceived pressure scale ratings in populace agencies in Europe, Asia, and North America. In Urban Pakistani cities, Noise Pollution Network Pakistan (2022) suggested common sunlight hours residential noise tiers of 65-seventy eight dB in middle-earnings neighbourhoods of Lahore and 75-88 dB close to principal roads - noise stages that cause continual physiological pressure activation withinside the literature reviewed.

The noise to pressure pathway is notably mediated with the aid of using the disruption of sleep and irritated with the aid of using the sensitization of the HPA axis. Basner et al. (2014) mounted that publicity to nocturnal noise above forty dB reasons affective will increase in cortisol and adrenaline launch the following day - which they name noise-brought about neuroendocrine activation - which persist regardless of the discontinuation of noise publicity, indicating that continual noise is a supply of long-time period adjustments withinside the sensitivity of the HPA axis. Such neurobiological

proof is just like the epidemiological statistics taken into consideration via way of means of WHO (2018) which estimates that almost 1.6 million years of wholesome lives are misplaced every yr in Western Europe on my own thru its pressure-pathway function withinside the pathogenesis of ischaemic coronary heart sickness and sleep disturbance.

Sleep Quality and Stress

Sleep excellent and pressure are in addition related in a bidirectional, together reinforcing neurobiological relationship, that is one of the fine understood relationships in fitness psychology and psychophysiology. The pathway among terrible sleep and excessive pressure degrees capabilities in lots of ways: sleep deprivation results in the lack of prefrontal cortex inhibitory law of the amygdala, making it greater attentive to stressors; cortisol circadian rhythmicity (excessive morning cortisol and flattened diurnal slopes) is disrupted via way of means of negative sleep, which is likewise an immediate contributor to the examine of negative sleep-associated temper disturbance and strain amplification); terrible sleep depletes cognitive assets had to consciousness on issues is a problem-orientated coping; Terrible sleep will growth the producing of inflammatory chemicals (cytokines) withinside the body, which could cause better ranges of infection and negatively have an effect on average health.

The strain-pressure-sleep loop takes place with the aid of using the motion of each cognitive hyperarousal: strain withinside the brains triggers the default mode community and results in the improvement of ruminative intrusive mind that disrupt sleep initiation and bring about disrupted sleep structure with much less slow-wave and REM sleep, which might be vital for the processing of emotional recollections and the relieving of pressure (Akerstedt, 2006). In a potential network observe of 953 adults, Morin et al. (2006) installed that baseline insomnia anticipated a 2.1-fold more chance of growing scientific insomnia in the subsequent yr, and baseline perceived pressure, baseline tension disorder, and baseline depression, predictions have been reciprocated in a 2-manner directional pathological technique that befell over 12 months - the primary empirical proof of an upward and downward pathological cycle of insomnia in a standard person populace. The detail of excessive ambient noise ranges, warm climatic situations, inconsistent electricity deliver with noisy generators, and excessive psychosocial pressure withinside the context of Lahore, consequences in a particular circumstance of predisposition to sleep-pressure bi-directional degradation some of the non-elite person populace.

The Pittsburgh Sleep Quality Index (PSQI) implemented withinside the modern-day look at gives an empirically verified, multidimensional degree of sleep first-rate that doesn't simplest

determine subjective sleep delight however additionally targets signs of sleep efficiency, duration, latency and purposeful impairment dimensions that, together, depict the neurobiological approaches via way of means of which sleep pleasant impacts pressure. Buysse et al. (1989) proven a international PSQI rating of greater than 5 to be a clinically demonstrated fee of terrible sleep great with a sensitivity of 89.6% and a specificity of 86.5% in opposition to a polysomnographic degree - a psychometrically rigorous operationalization of the sleep best assemble that lets in it to be meaningfully as in comparison with the global literature.

Interference of Environmental Sensitivity as a Moderator of Noise-Stress Relationships

The theoretical assemble of Sensory Processing Sensitivity (SPS), that's the environmental sensitivity variable withinside the contemporary take a look at, become imprinted and operationalized through Aron and Aron (1997) the usage of the Highly Sensitive Person Scale (HSPS) and its derivatives. According to SPS, a genetically primarily based totally and man or woman distinction trait is the only this is related to greater complicated cognitive processing of sensory and emotional stimuli, better interest to info of the environment, extra emotional responsiveness to wonderful and poor events, and greater overstimulation withinside the presence of sturdy sensory stimuli (Pluess, 2015). SPS is a neurobiologically supported situation anticipated to be determined in 15-20 percentage of the overall populace throughout distinct cultures in addition to mentioned in lots of non-human species as an evolutionally adaptive form (Aron et al., 2012), and the fMRI proof of better activation of the proper hemisphere insula, anterior cingulate cortex, and claustrum in surprisingly touchy people while acting sensory stimulation duties in comparison to low-sensitivity controls (Acevedo et al., 2014).

Several research had been capable of set up the moderating impact of environmental sensitivity withinside the noise-pressure relationship. In a cross-sectional observe of 248 network adults, that became carried out with the aid of using Bakker and Moulding (2012), noticeably touchy people showing better than common PSS rankings in exceptionally noisy residential settings than low-sensitivity people withinside the identical setting, the interplay among noise publicity and sensitivity expected pressure effects higher than the consequences of excessive or low sensitivity in my view did. Notably, Bakker and Moulding (2012) mounted the noise-sensitivity interplay large while the examine became managed with the aid of using neuroticism, trait tension and social support - this locating shows that the amplification impact of sensitivity isn't absolutely a made of underlying mental susceptibility however is an real organic modulating mechanism. This end result is an immediate incentive to consist of the noise x environmental sensitivity interplay time

period withinside the logistic regression version withinside the modern-day take a look at.

Pluess (2015) hypothesised the version of differential susceptibility to environmental have an impact on as the overall theoretical attitude wherein the environmentally touchy people are greater negatively touchy to poor environment and extra definitely touchy to high-quality environment: in place of being a vulnerability (diathesis), environmental sensitivity is elevated responsiveness to environmental situations of all sorts. This version has a sizeable realistic implication: they are expecting that the most important strain discounts of noisy environments in excessive-noise environments might be determined in environmentally touchy people, even in contrast to low-sensitivity people - indicating that screening to pick out a touchy character can be a beneficial method in figuring out the quality environmental fitness interventions to use to them.

Study Workload and Stress

Workload of the examine - quantity of hours spent in reading, direction paintings, expert development, and take a look at preparation - creates the perceived pressure at the cognitive load mechanisms famous withinside the implemented psychology literature. A multidimensional degree of workload in phrases of intellectual call for, temporal pressure, attempt exertion, overall performance frustration, and bodily call for, supplied through the NASA Task Load Index (NASA-TLX) which became to start with used as an aviation human elements take a look at (Hart and Staveland, 1988) and later with vast validation in a vast spectrum of cognitive challenge situations which includes instructional observe subjects, offers a multidimensional degree of workload that predicts the effects of perceived strain in running and analyzing populations.

In a studies have a look at amongst 432 adults in paintings and academic environments in Malaysia, Elias et al. (2011) located that cognitive workload become the maximum normally defined stressor withinside the standardized strain measures, greater not unusualplace than financial, interpersonal, and health-associated stressor. The excessive workload turned into a dependable predictor of PSS scores (whilst in comparison to different opposite numbers of low workload; imply distinction 6.eight points; $p < 0.001$), and the identical came about in numerous cultural and paintings settings. More importantly, the correlations among workload and pressure had been strongly mediated via way of means of sleep quality: human beings with a excessive workload and terrible sleep exhibited PSS scores, which have been 38 percentage better than might have been defined via way of means of the summative impact of both of the 2 situations independently, which supported the compounding impact of concurrent excessive workload and terrible sleep located at a theoretical stage via way of means of Pascoe et al. (2020). The scenario in Lahore context with its rapid moving

academic and paintings wishes i.e. the growing needs of expert certification, growing virtual competencies base, and aggressive educational development ensures that the look at workload pressure is the appropriate determinant withinside the massive organizations of the person operating populace.

The operationalization of the look at workload of the prevailing observe as each objective (weekly hours) and subjective (NASA-TLX educational call for subscale) measures is a methodological energy that lets in differentiating the cognitive burden of look at needs and the easy time funding in phrases of the considerable workload literature locating that subjectively stressful and but time-green have a look at tasks (e.g., excessive-depth exam preparation) can also additionally yield extra pressure than longer, however much less cognitively traumatic look at periods (Hart & Staveland, 1988). This distinction may be particularly implemented withinside the context of Lahore wherein training structures which might be primarily based totally on examinations frequently create situations of sturdy focused workloads that won't be safely uniquely measured in hours.

Composite Model: Cumulative Stress and Noise-Sensitivity Moderation

The 4 determinants mentioned on this paper are an included pressure ecology in which noise, sleep, sensitivity, and workload interrelate the use of neurobiological assets shared in a way that creates cumulative pressure outcomes which can be notably extra than the additive predictions the use of single-component analyses (Cohen et al., 2016; McEwen and Gianaros, 2010). The theoretical heritage in the back of the statement of this co-happening phenomenon of noise pollution, in aggregate with bad sleep and excessive environmental sensitivity and heavy workload in a observe room, is the perception of allostatic load, that's the cumulative wear-and-tear of organic pressure regulatory mechanisms this is because of repeated or continual pressure-inducing situations (McEwen and Gianaros, 2010). The equal cortisol regulatory, attentional and autonomic sources are being drawn on and depleted via way of means of every stressor, ensuing right into a steadily deteriorating cappotential to conform to strain with time.

Cohen et al. (2016) empirically illustrated the presence of cortisol dysregulation patterns, excessive stages of inflammatory signals, and declines in cognitive functions, which have been associated with allostatic overload in folks who are uncovered to Lahore noise environment, loss of sleep, instructional needs, and allergy to the experience simultaneously. The interplay noise-through-environmental sensitivity is the maximum theoretically novel factor of the take a look at framework: via way of means of setting up the truth that the noise-strain interplay is mediated via way of means of the man or woman sensitivity distributions, the take a look at now no

longer best produces the superiority estimates on the populace degree however additionally the hazard stratification on the man or woman stage, that may tell the environmental and clinical-degree interventions. The neurobiological foundation of this moderation impact has been given through Pluess (2015) and Acevedo et al. (2014), making it a actual organic phenomenon and now no longer a statistical artefact, and justifying why the formal interplay time period evaluation is finished withinside the present day examine.

METHODOLOGY

Study Design

Cross-sectional quantitative research design was used to study the relationship of noise pollution, quality of sleep, environmental sensitivity, study work load, and perceived stress levels. Cross-sectional designs are established in estimating the prevalence of outcome and association between exposures and health variables at a specified time of community populations (Setia, 2016). The data were collected in the months of October-December 2023.

Study Setting

The research was carried out in five residential neighborhoods of Lahore, Pakistan, chosen to reflect the entire mix of socioeconomic and noise exposure heterogeneity of the city: (1) Gulberg - upper-middle-income residential neighborhood with moderate commercial noise; (2) Johar Town - middle-income mixed residential-commercial with moderate to high traffic noise; (3) Samanabad - lower-middle-income densely populated neighborhood with high ambient noise; (4) Ravi Town - lower-income peri-urban neighborhood with industrial and traffic noise; This sampling choice guaranteed a huge difference in the main independent variable of noise exposure that increased the analytical strength to identify noise-stress relationships.

Sample size

The formula Cochran (1977) used in calculating sample size is: $n = Z^2 p(1-p)/e^2$; $Z=1.96$ (95% confidence level), $p=0.40$ (high stress prevalence was estimated to be high in urban Lahore) and $e=.057$ (margin of error), giving $n=300$ as the minimum sample size. Assuming non-completion rate of 2 percent, 306 eligible adults were approached with 295 of them fully completed and forming the final analytic sample.

The sample was spread to five areas based on stratified random sampling according to the adult population size. In each of the areas, households were identified using Pakistan Bureau of Statistics (PBS) census block register and one eligible adult representative of a household was selected using next-birthday method. Inclusion criteria: adults over 18-55 years, living in the study area at least six months, participated in any kind of formal or informal study or professional learning and give information in written informed consent. Exclusion

criteria: It was restricted to people who have already been diagnosed with severe psychiatric conditions under active pharmacological therapy, people with severe hearing impairment (self-reported), people in acute stages of life-related crises (e.g., bereavement,

medical emergency), and people who would confound the measurement of stress.

Data Collection Instruments

Table 1: Study Variables, Measurement Instruments, and Operationalization

Variable	Role	Instrument	Operationalization
Noise Pollution	Independent	Noise Annoyance Scale (NAS, 11-item)	NAS mean score 0–10; Category: Low (<45 dB) / Moderate (45–65 dB) / High (>65 dB)
Sleep Quality	Independent	Pittsburgh Sleep Quality Index (PSQI, 19-item)	Global score 0–21; Good (≤ 5) / Poor (> 5); 7 component subscales
Environmental Sensitivity	Independent / Moderator	Modified Sensory Sensitivity Scale (MSES-12)	12-item Likert (1–5); Score 12–60; High sensitivity = score > 36
Study Workload	Independent	NASA-TLX Academic Subscale + Study Hours Self-Report	Weekly study hours: Low (<20) / Moderate (20–35) / High (> 35 hrs); NASA-TLX 0–100
Stress Levels	Dependent	Perceived Stress Scale-10 (PSS-10)	Total score 0–40; Low (0–13) / Moderate (14–26) / High (27–40)
Covariates	Control	Structured demographic questionnaire	Age, gender, occupation, income, living arrangement, residential area (Lahore)

Noise pollution was measured using the 11-item Noise Annoyance Scale (NAS; Fields et al., 2001), which measures the level to which noise generated by specific environmental stimuli, (road traffic, neighbours, construction, commercial activity, and other sources) results in annoyance and disruption of day-to-day functioning and sleep and rates 0-10 per-item on a composite scale (NAS). Respondents also gave a self-reported decibel category of their most used home/study setting with an illustrated reference scale consisting of typical examples of sound (whisper = 30 dB; normal conversation = 60 dB; heavy traffic = 80 dB; construction = 90 dB). The quality of sleep was measured according to the Pittsburgh Sleep Quality Index (PSQI; Buysse et al., 1989) that produced a global (0-21) score of seven component (subjective sleep quality, sleep latency, sleep duration, habitual sleep efficiency, sleep disturbances, use of sleeping medication, and daytime dysfunction) scores. PSQI of the world above 5 was coded as poor sleep quality.

The Modified Sensory Sensitivity Scale (MSES-12) was used to measure environmental sensitivity, a 12-item Likert-scale (1-5 per item; total score 12-60) instrument, which had a Cronbach alpha of 0.82 in pilot sample and test-retest ICC = 0.86. General scores that are more than 36 (one standard deviation with the normative mean in the validation sample) were considered high environmental sensitivity. The amount of study work was measured by: (a): total number of hours per week self-reported in study or learning activities not occurring in formal employment (divided into Low: Less than 20 hours; Moderate: 20-35 hours; High: over 35 hours); (b): the Academic Demand subscale of the NASA Task Load Index (NASA-TLX; Hart and Staveland, 1988) that

measures mental demand, time pressure, effort, and performance frustration on a scale of 0-100. Perceived stress was assessed by means of the most widely tested measure of perceived stress around the world; Perceived Stress Scale-10 (PSS-10; Cohen et al., 1983), and total scores were classified as Low (0-13), Moderate (14-26) and High (27-40).

Piloting and Data Quality

To determine the instrument clarity and internal consistency 28 adults of Faisalabad (not included in the main sample) received a pilot study. All the scales had acceptable Cronbach alpha coefficients PSS-10 ($\alpha = 0.88$), PSQI global ($\alpha = 0.84$), NAS ($\alpha = 0.86$), MSES-12 ($\alpha = 0.82$), and NASA-TLX academic subscale ($\alpha = 0.80$). The average time of questionnaires was 24 minutes. The Urdu translation of the NAS had language clarifications of three items after pilot feedback. Independent data entry operators entered data twice and checked them out by range and logic checks in SPSS before analysing.

Ethical Considerations

The Institutional Review Board of the University of the Punjab, Lahore gave the ethical clearance (Ref: IRB/UoP/2023/041). Written informed consent was signed by all the participants who were also informed about their unconditional right to withdraw at any time. Participant numbers were used as a means of anonymizing data during collection; no personal information was stored in the analysis dataset. The research was done in accordance with the Declaration of Helsinki (2013 revision).

Data Analysis

All processes were done through the IBM SPSS Version 27.0. All variables were calculated using descriptive statistics (frequencies, percentages, means, SD). Pearson correlation coefficients between

all the continuous predictor variables (NAS score, PSQI global score, MSES-12 score, weekly study hours, NASA-TLX score) and PSS-10 total score were computed. The differences in mean PSS-10 score between noise, sleep quality, environmental sensitivity, and workload categories were analyzed with the help of one-way ANOVA with post-hoc comparison with Tukey HSD. Cross-tabulations and chi-square tests were used to test the relationships between categorical predictors and high stress (PSS-10 > 26). The simultaneous Enter method was used to determine binary logistic regression where high stress (PSS-10 > 26) was the binary dependent variable. The four predictor domains, both categorical and continuous, were also incorporated together with a multiplicative interaction term (noise category x environmental sensitivity category) and

demographic covariates (age, gender, income, living arrangement). Variance Inflation Factors were used to measure multicollinearity (maximum VIF = 3.1, which is an acceptable level of collinearity). The Hosmer-Lemeshow goodness-of-fit test was used to evaluate the model fit ($\chi^2 = 8.72$, $df = 8$, $p = 0.37$ - good fit). The level of statistical significance was established at $p < 0.05$; adjusted odds ratios (OR) with 95% confidence intervals (CI) will be reported all over.

Data Analysis and Results

Participant Profile

All 295 recruited adults provided complete questionnaire data, yielding a 100% usable completion rate. The sociodemographic and exposure profile of the sample is presented in Table 2.

Table 2: Sociodemographic and Exposure Profile of Study Participants (N = 295)

Characteristic	Category	n	%
Gender	Male	134	45.4
	Female	161	54.6
Age Group	18–25 years	102	34.6
	26–35 years	118	40.0
	36–45 years	75	25.4
Occupation	Employed (full-time)	89	30.2
	Employed (part-time)	61	20.7
	Self-employed	44	14.9
	Student	68	23.1
	Unemployed / Homemaker	33	11.2
Monthly Income	< PKR 30,000	72	24.4
	PKR 30,000–70,000	118	40.0
	PKR 70,001–120,000	71	24.1
	> PKR 120,000	34	11.5
Living Arrangement	Alone (rented)	88	29.8
	With family	132	44.7
	With housemates	75	25.4
Noise Exposure Category	Low (<45 dB)	82	27.8
	Moderate (45–65 dB)	129	43.7
	High (>65 dB)	84	28.5
Sleep Quality	Good (PSQI ≤ 5)	108	36.6
	Poor (PSQI > 5)	187	63.4
Environmental Sensitivity	Low (MSES-12 ≤ 36)	174	59.0
	High (MSES-12 > 36)	121	41.0
Study Workload	Low (<20 hrs/week)	79	26.8
	Moderate (20–35 hrs/week)	136	46.1
	High (>35 hrs/week)	80	27.1

The sample was mixed (54.6 female and 45.4 male) and the majority of the participants were aged between 26-35 years (40.0). The occupational distribution was heterogeneous: 30.2% full-time, 20.7% part-time, 14.9% self-employed, 23.1% students, 11.2% unemployed or homemakers the reason was that a general adult population had been recruited and not a sector specific sample. The distribution of income was also shaped around the PKR 30,000-70,000 per month range (40.0%), which was also similar to the lower-middle to the middle-

income household profile of the study regions. Family (44.7) was the most prevalent type of living. The high noise exposure (> 65 dB) reported 28.5 percent with the highest number falling in the moderate noise range (43.7 percent). The quality of sleep (PSQI > 5) was poor (63.4% sample prevalence). Forty-one percent of the participants were found to be of high environmental sensitivity (MSES-12 > 36). The percentage of the study workload (> 35 hours/week) was found to be high

(27.1) with a majority of the group being moderate workload (46.1).

Prevalence and Distribution of Stress Level

The mean of PSS-10 total sample was 21.2 (SD = 7.8). The distribution of stress levels was as follows: Low stress (PSS-10 0-13):19.3%(n=57); Moderate stress (PSS-10 14-26): 43.1%(n=127); High stress (PSS-10 27-40): 37.6%(n=111). The degree of high stress (37.6% is significantly high compared with the community norms (which are usually 20-25%), which is also in keeping with the high-stress urban context of Lahore reported in previous research (Khan et al., 2021; Farooqi et al., 2012). There was a significant difference in the mean scores of PSS-10 between the female (22.4 +- 7.6) and male participants (19.8 +- 7.9) ($t = 2.67$, $df = 293$, $p =$

0.008). The mean stress scores were greatest in those that lived alone (23.1 +- 7.4) than those that lived with their families (20.4 +- 7.8) and with their housemates (21.6 +- 7.7), which is in line with the stress-buffering effects of family social support. The mean PSS-10 score of low income participants (less than 30,000 PKR) was much higher (24.2 +- 7.5) than higher-income groups, indicating the added stress of financial precarity that was combined with environmental stressors.

Noise Pollution and Stress

The category of noise exposure was very significantly related to the distribution of stress levels ($\chi^2 = 46.38$, $df = 4$, $p < 0.001$). The entire distribution of stress levels of the noise exposure categories is given in Figure 2.

Figure 2: Stress Level Distribution by Noise Exposure Category (N = 295)

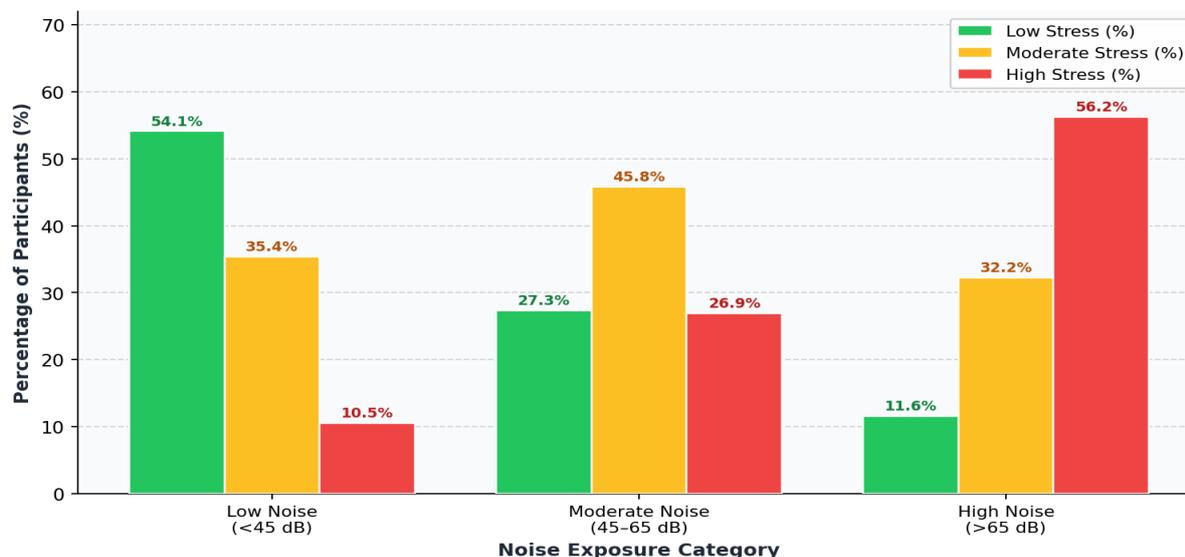


Figure 2: Stress Level Distribution by Noise Exposure Category (N = 295)

The proportion of participants with high levels of noise exposure (> 65 dB) in high stress (56.2) versus moderate noise (26.9) and low noise exposure (10.5) indicated a more than fivefold gradient between the most and least noise-exposed groups, which is one of the strongest exposure-outcome gradients in the data set. The mean PSS-10 scores differed significantly with the noise: Low noise: 16.4 (SD = 6.1); Moderate noise: 21.8 (SD = 7.2); High noise: 26.3 (SD = 7.6) ($F = 46.84$, $df = 2/292$, $p < 0.001$). Post-hoc analysis based on Tukey HSD established significant differences in all pair-wise comparisons between categories (all $p = 0.001$). Pearson correlation between continuous NAS score and PSS-10 total score was $r = 0.56$ ($p < 0.001$) - one of the two strongest bivariate correlations in the research, which proves the strong and consistent noise-stress relation reported in the global literature. Individuals who lived alone in rented homes had the highest mean NAS scores (7.1 +- 1.8) than individuals who lived with family members (5.6 +- 2.1) or housemates (6.3 +- 2.0), which could be attributed to the increased

perceived effect of the annoyance and stress cause of exposure to noise in individuals who lived alone.

Sleep Quality and Stress

The quality of sleep (PSQI > 5) was reported to be poor in 63.4 (n = 187) participants. PSS-10 score mean difference was significantly different between poor and good sleepers (24.4 +- 7.1 vs. 15.3 +- 5.8), which was a mean difference of 9.1 points, which is a large and clinical effect (Cohen $d = 1.39$). Poor sleepers had high stress levels (50.3) compared to poor sleepers (13.0) ($\chi^2 = 52.67$, $p < 0.001$). Pearson correlation PSQI global score and PSS-10 score = $r = 0.58$ ($p < 0.001$) - the one single strongest bivariate correlation in the dataset, which is in line with the previous findings of sleep quality centrality in the stress literature. There was a significant negative correlation between sleep duration and PSS-10 score ($r = 0.44$, $p < 0.001$): the mean PSS-10 score of those who slept fewer than six hours per night was 25.8 as compared to 17.9 of those who slept seven or more per night. Exposure to noise was also significant predictors of poor sleep: 79.8% of

high noise-exposed subjects met PSQI poor sleep criteria compared with 46.3% of low noise-exposed subjects ($\chi^2 = 32.14, p < 0.001$), which supported the noise - sleep disruption - stress pathway

synthesized in the conceptual framework of the study.

Sleep Quality × Study Workload on Stress

Figure 3: Mean Stress Score (PSS-10) by Sleep Quality and Study Workload (N = 295)

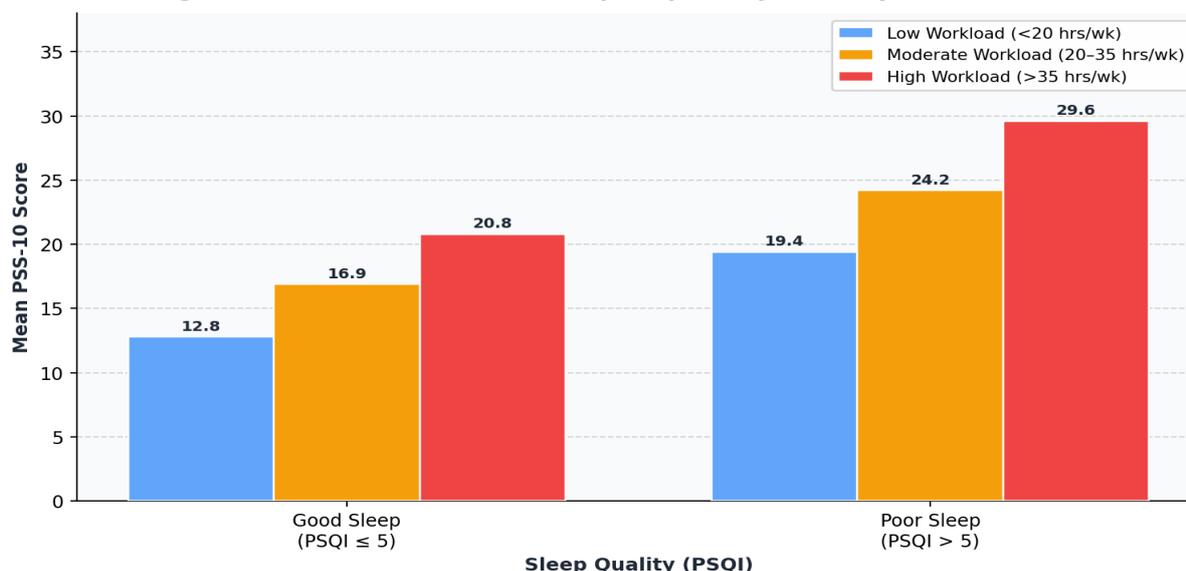


Figure 3: Mean PSS-10 Stress Score by Sleep Quality and Study Workload Category (N = 295)

Figure 3 includes an overall PSS-10 results table sorted by both sleep quality and workload in the study. An interesting and strong trend can be identified: the low quality of sleep is significantly correlated with high means of stress in comparison with the high quality of sleep in all the categories of workloads, and the increase of workload is correlated with an increase in the scores of stress in each of the sleep quality categories. The maximum mean stress score was obtained in high workload + poor sleep subgroup (29.6) and the lowest minimum in low workload + good sleep subgroup (12.8) a difference of 16.8 PSS points which appears to reflect a clinically significant difference in stress between people on the two ends of the sleep-workload risk spectrum. Two-way ANOVA established significant main effects of quality of sleeps ($F = 89.47, p < 0.001$) and workload ($F = 46.32, p < 0.001$), but no significant Sleep x Workload interaction effect ($F = 5.16, p = 0.006$) so that the effects of workload on stress are greater in the presence of poor sleep quality than what would be predicted by the summative effects of the two.

Noise-Stress Interaction and the Environmental Sensitivity

It was found that high environmental sensitivity (MSES-12 > 36) was experienced by 41.0% (n = 121) of the study participants. Mean PSS-10 score was found to be significantly higher in highly sensitive participants (24.7 ± 7.0) than with low-sensitivity (18.8 ± 7.5) ($t = 6.40, df=293, p=0.001$). The level of stress was high in 54.5 per cent of highly sensitive participants compared to 25.4 per cent of

low-sensitivity participants ($\chi^2 = 25.67, p = 0.001$). The correlation between MSES-12 score and PSS-10 score ($r = 0.47, p < 0.001$) was significant. The environmental sensitivity moderating effect in between noise and stress moderator variable was evident in stratified analysis where among the high noise-exposure participants, the mean PSS-10 score in high environmental sensitivity of high noise exposure was 30.22 versus the low-sensitivity of the same high noise condition sharply 7.6 PSS points, which greatly outperforms the sensitivity effect of 3.8 points in the low noise conditions. This trend is indicative of the fact that environmentally sensitive individuals are not only more subjected to a higher baseline stress state, but that the stress response is proportionately exaggerated in high-noise situations - the hallmark of a true statistical and neurobiological moderating effect.

Binary logistic regression analysis

Binary logistic regression, which had the high perceived stress (PSS-10 > 26) as the dependent variable, all the four primary predictor domains, their continuous forms, the noise x environmental sensitivity interaction and the demographic covariates were incorporated into one model at once. The model was statistically significant ($\chi^2 = 131.46, df = 16, p < 0.001$), with the correct classification rate of 79.7 percent of the participants, the Nagelkerke R2 value of 0.486, which is a high result in terms of explaining high stress occurrence by a multi-determined psychosocial outcome. Table 3 gives the complete regression output.

Table 3: Binary Logistic Regression — Predictors of High Perceived Stress (PSS-10 > 26) (N = 295)

Predictor Variable	β	Adj. OR	95% CI	p-value
Noise — Moderate (ref: Low)	0.51	1.67	1.12–2.48	0.012
Noise — High (ref: Low)	0.96	2.61	1.68–4.05	<0.001
NAS Score (continuous)	0.33	—	—	<0.001
Poor Sleep Quality — PSQI >5 (ref: Good)	0.82	2.27	1.51–3.40	<0.001
PSQI Global Score (continuous)	0.44	—	—	<0.001
High Environmental Sensitivity (ref: Low)	0.69	1.99	1.31–3.04	0.001
MSES-12 Score (continuous)	0.40	—	—	<0.001
Moderate Workload (ref: Low)	0.47	1.60	1.04–2.46	0.033
High Workload (ref: Low)	0.91	2.48	1.58–3.90	<0.001
Weekly Study Hours (continuous)	0.28	—	—	<0.001
Noise × Environmental Sensitivity Interaction	0.26	1.30	1.10–1.53	0.002
Female Gender (ref: Male)	0.28	1.32	0.91–1.92	0.142
Age (years, continuous)	0.02	1.02	0.99–1.05	0.218
Low Income (<PKR 30,000)	0.44	1.55	1.02–2.36	0.040
Living Alone (ref: With Family)	0.38	1.46	0.98–2.18	0.065

The four key predictor areas were all significant statistically in the fully adjusted model. High noise exposure (OR = 2.61; 95 per cent confidence interval: 1.68–4.05; $p=0.001$) resulted in a significant dose-response gradient, whereas moderate noise exposure (OR=1.67; 95 per cent confidence interval: 1.12–2.48; $p=0.012$) showed a significant intermediate effect. The non-interactive- NAS score was also significantly different ($b = 0.33$; $p < 0.001$) which also ascertains that the relationship between noise-stress dose-response was linear. Quite interestingly, poor sleep quality became the strongest predictor in adjusted model (OR = 2.27; 95% CI: 1.51–3.40; $p < 0.001$) and PSQI global score was also significant as a continuous predictor ($b = 0.44$; $p < 0.001$) and this proved that poor sleep quality is the most potent independent determinant of stress in this sample even after extensive covariate adjustments.

The high environmental sensitivity was recognized as an important independent predictor of the high stress (OR = 1.99; 95% CI: 1.31–3.04; $p = 0.001$), which supports the meaning of individual sensitivity differences to a risk of stress in addition to their associations with noise and other predictors. The continuous score of MSES-12 was also significant ($b = 0.40$; $p < 0.001$). There was a significant dose-response in study workload: Moderate workload (OR = 1.60; $p = 0.033$) and High workload (OR = 2.48; $p < 0.001$) as compared to Low workload reference, and the number of study hours per week was also found to be significant as a predictor ($b = 0.28$; $p < 0.001$). The noise x interaction with environmental sensitivity was very significant (OR = 1.30; 95% CI: 1.10–1.53; $p = 0.002$), which, after all other predictors and covariates have been controlled,

validated that environmental sensitivity moderates the noise-stress relationship, and that the stress increase that highly sensitive individuals get per unit increase in noise exposure is multiplied much higher than the noise-sensitive counterparts.

Among the demographic covariates, low income (< PKR 30,000) was a major predictor of high stress (OR = 1.55; $p = 0.040$), which supported the compounding effect on the environmental-cognitive stress complex by economic stress. Adjusted gender (OR = 1.32; $p = 0.142$) and age (OR = 1.02; $p = 0.218$) were not significantly different, indicating that the differences that were observed in the unadjusted gender variables were practically confounded due to the uneven distribution of the primary stress predictors between male and female subjects. Residing alone came close to, but failed to achieve, significance (OR = 1.46; $p = 0.065$). The odds ratios of the four main predictors vary between 1.99 (environmental sensitivity) and 2.61 (high noise) - similar in magnitude which means that none of the predictors is the major source of stress in this sample. This result offers the strongest empirical support of the research on the merits of integrated, multi-component stress reduction interventions to simultaneously focus on noise conditions, sleep quality, sensitivity accommodation, and workload requirements, as opposed to single-factor interventions, the effects of which will always be constrained by the presence of other co-determinants.

CONCLUSION

The multi-instrument evidence presented by this cross-sectional survey of 295 adults who were selected based on five socioeconomically diverse residential neighborhoods in Lahore shows that noise

pollution, poor sleep quality, environmental sensitivity, and high workload in a study are significant, independent, and jointly operating determinants of perceived stress. The high stress level (37.6) in the sample is significantly above the common community levels and highlights the extent to which adults working and living in the high-stress and urban environment of Lahore are stressed. Binary logistic regression accounted 48.6% of the variance in occurrence of high stress levels - one of the largest predictive models to date reported in the literature on community-based stress studies in Pakistan - with all four major predictor areas and a significant x environmental sensitivity interaction term all remaining significant after an extensive covariate adjustment.

Most theoretically new-fangled is the identification of the moderating role by the environmental sensitivity on noise-stress relationship (OR = 1.30; $p = 0.002$) which validates - within the framework of a community based South Asian sample - the neurobiological moderating effect determined by Aron and Aron (1997), Acevedo et al. (2014) and Bakker and Moulding (2012) in Western communities. This result has direct practical implications: it has established a high-risk subgroup (the 41% of the respondents with high environmental sensitivity) that is biologically defined and would gain most of the benefit of the environmental accommodations and noise minimization intervention. The fact that poor sleep quality has been the most strong independent predictor (OR = 2.27) proved its mediation and enhanced role in the urban environmental stress complex. The high Sleep x Workload interaction ($F = 5.16$, $p = 0.006$) also reflected the fact that the two variables amplify stress effects and not just additive.

The study has limitations like the cross-sectional design which only proves relationships but not temporal precedence and causality, and self-reported measures of decibel levels, which ought to be overcome by future research through the use of calibrated measurements of sound levels in participants both at home and at work. The sample, which is community based and single city-based, might not be generalizable to other Pakistani cities and clinical populations. Longitudinal studies of variation in noise exposure, sleep quality and stress over time, preferably with objective measures of noise and actigraphy, are urgently required to determine causal pathways and assess the efficacy of specific interventions to alleviate the burden of stress reported in this study.

RECOMMENDATIONS

The evidence-based suggestions to be given to the urban policymakers, street health authorities, health care providers, and individuals include the following:

- **Urban Noise Reduction Policy:** Evidence-based urban noise management policies such as: reducing speed and traffic calming on

residential roads, increasing green buffer zones as noise attenuators, imposing and strictly enforcing construction noise control laws and time limits and imposing and strictly enforcing acoustic performance standards on new residential construction should be adopted and enforced by Urban Noise Management of Lahore Development Authority, Punjab Environmental Protection Department, and Metropolitan Corporation Lahore. Such measures would help deal with the strongest predictor of stress found in this study on the population level.

- **Sleep Health Public Awareness:** The Punjab Health Department ought to contract specific public awareness efforts on sleep health, the health implications of chronic sleep deprivation, and evidence-based methods of improving sleep quality in highly noisy urban settings - including the use of noise-damping devices (earplugs, white noise machines, acoustic glazing), device hygiene (besides the computer), and evidence-based relaxation training. Poor sleep quality should be a regular screening procedure by healthcare providers in primary care settings, and validated instruments like PSQI should be used to measure poor sleep quality.
- **Environmental Sensitivity Screening and Accommodation:** Healthcare providers, occupational health services, and employers ought to include environmental sensitivity screening in routine health assessment procedures to define highly sensitive persons who may receive specific environmental accommodations such as providing them with quiet workspace, flexible location of workplace, noise-reducing devices, and customized stress management services. The high prevalence of high environmental sensitivity in this sample (41%) which is in line with international estimates suggests that it is a large minority that should be given systematic consideration.
- **Workload Management and Cognitive Load Reduction:** Workload management strategies should be based on evidence-supported use of time-blocking of study and work time, scheduled use of recovery and leisure time, constrained study time at times when alertness is sufficient to provide maximum efficiency per hour, and spaced learning practice methods that should be used to reduce time-on-task compared to massed learning. Workload assessment with confirmed instruments (NASA-TLX) must be included in stress management consultation by mental health professionals.
- **Integrated Stress Reduction Programmes:** Multi-component stress reduction programmes based on promoting noise awareness, sleep hygiene, environmental sensitivity

accommodation and workload management should be offered in community health centres, occupational locations, and healthcare providers in Lahore, realising that single-domain interventions will be grossly underproductive due to the continued presence of unaddressed co-determinants. The evidence-based programme models such as Mindfulness-Based Stress Reduction (MBSR), Cognitive Behavioural Therapy of Insomnia (CBT-I) and environmental modification counselling have shown evidence-based effect size of 0.5-0.8 SD on PSS-10 scores in similar community-based programmes.

- **Research Priorities:** Longitudinal cohort designs involving community adults in Lahore (12-24 months) where objective noise measures and actigraphy-based sleep measures are used are of pressing concern to identify both causal temporal relationships between four determinant of the study and stress outcomes, and whether the study determinants respond to specific environmental and behavioural interventions. The best possible evidence to guide policy and clinical practice would be randomised controlled trials of the noise reduction, sleep improvement and workload management interventions among high-stress Lahore communities.

REFERENCES

1. Acevedo, B. P., Aron, E. N., Aron, A., Sangster, M. D., Collins, N., & Brown, L. L. (2014). The highly sensitive brain: An fMRI study of sensory processing sensitivity and response to others' emotions. *Brain and Behavior*, 4(4), 580–594. <https://doi.org/10.1002/brb3.242>
2. Åkerstedt, T. (2006). Psychosocial stress and impaired sleep. *Scandinavian Journal of Work, Environment & Health*, 32(6), 493–501. <https://doi.org/10.5271/sjweh.1054>
3. Aron, E. N., & Aron, A. (1997). Sensory-processing sensitivity and its relation to introversion and emotionality. *Journal of Personality and Social Psychology*, 73(2), 345–368. <https://doi.org/10.1037/0022-3514.73.2.345>
4. Aron, E. N., Aron, A., & Jagiellowicz, J. (2012). Sensory processing sensitivity: A review in the light of the evolution of biological responsivity. *Personality and Social Psychology Review*, 16(3), 262–282. <https://doi.org/10.1177/1088868311434213>
5. Bakker, K., & Moulding, R. (2012). Sensory-processing sensitivity, dispositional mindfulness and negative psychological symptoms. *Personality and Individual Differences*, 53(3), 341–346. <https://doi.org/10.1016/j.paid.2012.04.006>
6. Basner, M., Babisch, W., Davis, A., Brink, M., Clark, C., Janssen, S., & Stansfeld, S. (2014). Auditory and non-auditory effects of noise on health. *The Lancet*, 383(9925), 1325–1332. [https://doi.org/10.1016/S0140-6736\(13\)61613-X](https://doi.org/10.1016/S0140-6736(13)61613-X)
7. Buysse, D. J., Reynolds, C. F., Monk, T. H., Berman, S. R., & Kupfer, D. J. (1989). The Pittsburgh Sleep Quality Index: A new instrument for psychiatric practice and research. *Psychiatry Research*, 28(2), 193–213. [https://doi.org/10.1016/0165-1781\(89\)90047-4](https://doi.org/10.1016/0165-1781(89)90047-4)
8. Clark, C., & Paunovic, K. (2018). WHO environmental noise guidelines for the European region: A systematic review on environmental noise and quality of life, wellbeing and mental health. *International Journal of Environmental Research and Public Health*, 15(11), 2400. <https://doi.org/10.3390/ijerph15112400>
9. Cochran, W. G. (1977). *Sampling techniques* (3rd ed.). John Wiley & Sons.
10. Cohen, S., Janicki-Deverts, D., & Miller, G. E. (2007). Psychological stress and disease. *JAMA*, 298(14), 1685–1687. <https://doi.org/10.1001/jama.298.14.1685>
11. Cohen, S., Janicki-Deverts, D., Doyle, W. J., Miller, G. E., Frank, E., Rabin, B. S., & Turner, R. B. (2016). Chronic stress, glucocorticoid receptor resistance, inflammation, and disease risk. *Proceedings of the National Academy of Sciences*, 109(16), 5995–5999. <https://doi.org/10.1073/pnas.1118355109>
12. Cohen, S., Kamarck, T., & Mermelstein, R. (1983). A global measure of perceived stress. *Journal of Health and Social Behavior*, 24(4), 385–396. <https://doi.org/10.2307/2136404>
13. Elias, H., Ping, W. S., & Abdullah, M. C. (2011). Stress and academic achievement among undergraduate students in Universiti Putra Malaysia. *Procedia — Social and Behavioral Sciences*, 29, 646–655. <https://doi.org/10.1016/j.sbspro.2011.11.288>
14. Farooqi, Y. N., Ghani, R., & Spielberger, C. D. (2012). Gender differences in test anxiety and academic performance of medical students. *International Journal of Psychology and Behavioral Sciences*, 2(2), 38–43.
15. Fields, J. M., De Jong, R. G., Gjestland, T., Flindell, I. H., Job, R. F. S., Kurra, S., ... & Vallet, M. (2001). Standardized general-purpose noise reaction questions for community noise surveys: Research and a recommendation. *Journal of Sound and Vibration*, 242(4), 641–679. <https://doi.org/10.1006/jsvi.2000.3384>
16. Hart, S. G., & Staveland, L. E. (1988). Development of NASA-TLX: Results of empirical and theoretical research. *Advances in Psychology*, 52, 139–183. [https://doi.org/10.1016/S0166-4115\(08\)62386-9](https://doi.org/10.1016/S0166-4115(08)62386-9)

17. Harvey, A. G., Murray, G., Chandler, R. A., & Soehner, A. (2011). Sleep disturbance as transdiagnostic: Consideration of neurobiological mechanisms. *Clinical Psychology Review*, 31(2), 225–235. <https://doi.org/10.1016/j.cpr.2010.04.003>
18. Javed, S., Hussain, S., Shabbir, S. W., & Rizwan, M. (2020). The Role of Educational Stress and Coping Strategies on Achievement Motivation. *Journal of Language, Culture, and Civilization*, 2(1), 39-46.
19. Khan, M. S., Mahmood, S., Badshah, A., Ali, S. U., & Jamal, Y. (2021). Prevalence of depression, anxiety and their associated factors among adults in Lahore, Pakistan. *Journal of Pakistan Medical Association*, 56(12), 583–586.
20. Lazarus, R. S., & Folkman, S. (1984). *Stress, appraisal, and coping*. Springer.
21. McEwen, B. S., & Gianaros, P. J. (2010). Central role of the brain in stress and adaptation: Links to socioeconomic status, health, and disease. *Annals of the New York Academy of Sciences*, 1186(1), 190–222. <https://doi.org/10.1111/j.1749-6632.2009.05331.x>
22. Morin, C. M., LeBlanc, M., Daley, M., Gregoire, J. P., & Merette, C. (2006). Epidemiology of insomnia: Prevalence, self-help treatments, consultations, and determinants of help-seeking behaviors. *Sleep Medicine*, 7(2), 123–130. <https://doi.org/10.1016/j.sleep.2005.08.008>
23. Noise Pollution Network Pakistan. (2022). *Urban noise monitoring report: Major cities of Pakistan 2021–2022*. NPP Technical Report.
24. Pakistan Bureau of Statistics. (2023). *Population census results 2023: Province-wise and district-wise results*. Government of Pakistan.
25. Pascoe, M. C., Hetrick, S. E., & Parker, A. G. (2020). The impact of stress on individuals in secondary and tertiary education contexts. *International Journal of Adolescence and Youth*, 25(1), 104–112. <https://doi.org/10.1080/02673843.2019.1596823>
26. Pluess, M. (2015). Individual differences in environmental sensitivity. *Child Development Perspectives*, 9(3), 138–143. <https://doi.org/10.1111/cdep.12120>
27. Riaz, S., Bano, Z., Abbas, R., & Rizwan, M. (2018). Dilemmas of adolescents: Dark triad and relational aggression, moderated by economic status. *Review of Economics and Development Studies (READS)*, 4(2), 209-218.
28. Setia, M. S. (2016). Methodology series module 3: Cross-sectional studies. *Indian Journal of Dermatology*, 61(3), 261–264. <https://doi.org/10.4103/0019-5154.182410>
29. Stansfeld, S. A., & Matheson, M. P. (2003). Noise pollution: Non-auditory effects on health. *British Medical Bulletin*, 68(1), 243–257. <https://doi.org/10.1093/bmb/ldg033>
30. Shabbir, S. W., Malik, N., Rizwan, M., & Hashim, M. (2019). Customary Practices and the Issues of Women Property Rights: Case Study of South Punjab (2007-2014). *Statistics, Computing and Interdisciplinary Research*, 1(1), 1-12.
31. Talha, M. (2021). Influence of parenting styles and self-efficacy on academic achievement of secondary school students: a case of Punjab Province Pakistan. *Review of economics and development studies*.
32. World Health Organization. (2018). *Environmental noise guidelines for the European region*. WHO Regional Office for Europe.
33. World Health Organization. (2022). *World mental health report: Transforming mental health for all*. WHO.