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Gender Differences and Occupational Risk Factors in Noise-Induced Cardiovascular Responses Among Grain Milling Machine Operators in Nigeria

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ABSTRACT

Occupational noise is one of the most widespread yet least regulated hazards facing informal-sector workers in low- and middle-income countries, and its cardiovascular consequences are increasingly difficult to ignore. While the auditory harm caused by loud machinery is well recognised, far less is known about how sustained occupational noise reshapes blood pressure and heart rhythm, and whether that reshaping differs between men and women who share the same working environment. This study set out to answer that question among grain milling machine operators in Nigeria, a workforce that operates almost entirely outside formal occupational-health oversight. A cross-sectional design was used to examine 120 operators (80 men and 40 women), with data gathered on age, years of work experience, use of ear protection, systolic blood pressure (SBP), diastolic blood pressure (DBP), and pulse rate. Male operators recorded consistently higher mean SBP and DBP than their female counterparts, although women who had spent many years at the mill showed a comparable rise in cardiovascular strain, suggesting that sex differences narrow with cumulative exposure. Work experience emerged as the strongest correlate of cardiovascular strain (SBP: $r = 0.62$; DBP: $r = 0.58$; pulse rate: $r = 0.49$, all $p < 0.05$), pointing to a clear cumulative-dose relationship. Operators without ear protection showed measurably higher blood pressure and pulse rate than those who used it. Taken together, the findings position occupational noise as a significant, modifiable cardiovascular risk factor within Nigeria's informal milling sector, with sex acting as a moderating rather than protective influence.

1. Introduction

Loud machinery has always been part of industrial work, but the assumption that its damage stops at the ear has not aged well. A growing body of research now treats noise as a systemic stressor capable of reaching the cardiovascular system through pathways that have nothing to do with hearing at all (Basner et al., 2014; Hammer et al., 2014). Sustained exposure appears to keep the sympathetic nervous system and the hypothalamic–pituitary–adrenal axis switched on for longer than they are designed to be, and the resulting flood of cortisol and catecholamines leaves a physiological trace in the form of raised blood pressure, altered heart rhythm, and, eventually, measurable vascular damage (Skogstad et al., 2016; Vienneau et al., 2015).

Nowhere is this risk less monitored than in the informal industrial sector of countries such as Nigeria, where grain milling machines are run for hours at a stretch in enclosed rooms with almost no acoustic insulation, no engineering noise controls, and little enforcement of even the most basic hearing-protection norms (World Health Organization, 2018). Operators in this trade rarely see an occupational-

health inspector, let alone a cardiovascular screening programme, and the workforce itself is far from homogeneous — men and women often share the same machines, the same shift lengths, and the same unprotected exposure, yet physiological literature suggests their bodies may not respond to that exposure in identical ways (Gan et al., 2011; Yang et al., 2018).

Sex-related differences in cardiovascular stress response are not a new observation in occupational medicine; hormonal, behavioural, and even socially patterned differences in how men and women experience workplace stress have been documented across multiple industries. What remains far less settled is whether these differences hold up, narrow, or disappear once exposure becomes prolonged — a question that a mixed-sex, long-tenure workforce like Nigeria's grain millers is unusually well placed to answer. This study was designed to examine that question directly, alongside the more familiar occupational risk factors of age, years of experience, and use of ear protection.

The motivation for this work is therefore twofold. First, grain milling operators represent a sizeable, economically important, and almost entirely unstudied occupational group in Nigeria, and documenting their cardiovascular risk profile fills a genuine evidentiary gap. Second, by disaggregating findings by sex, this study aims to move the conversation about occupational noise and cardiovascular health beyond a one-size-fits-all risk model, toward one that can inform more precisely targeted screening and protective interventions.

2. Aim and Objectives

This study aimed to evaluate gender differences and occupational risk factors underlying noise-induced cardiovascular responses among grain milling machine operators in Nigeria. The specific objectives were to:

- Determine mean systolic and diastolic blood pressure levels among grain milling machine operators.
- Assess pulse rate patterns associated with occupational noise exposure.
- Compare cardiovascular parameters between male and female operators.
- Evaluate the influence of age and years of work experience on cardiovascular outcomes.
- Examine the association between ear protective device use and cardiovascular strain.

3. Literature Review

3.1 Occupational Noise and Cardiovascular Health

The link between occupational noise and hypertension is no longer treated as speculative. Reviews spanning multiple industries and countries converge on the same conclusion: workers who spend their days above roughly 85 dB carry a meaningfully higher hypertension burden than those in quieter roles (Gan et al., 2011). Larger evidence syntheses that pool occupational and environmental noise studies together arrive at similar figures, with occupationally noise-exposed cohorts showing some of the more consistent associations in the literature (Rabiei et al., 2021). Longitudinal work reinforces this picture further, tracking rising cardiovascular morbidity in workers who remain in high-noise roles over many years (Vienneau et al., 2015).

3.2 Physiological Mechanisms

Mechanistically, noise behaves less like a direct toxin and more like a chronic psychosocial stressor. It keeps neuroendocrine signalling pathways active well beyond the moment the sound stops, elevating heart rate and blood pressure through repeated sympathetic activation (Basner et al., 2014). Over years rather than days, this repeated activation is thought to erode endothelial function and leave lasting vascular damage — the same pathway implicated in other chronic-stress-driven cardiovascular disease (Münzel et al., 2018).

3.3 Gender Differences in Cardiovascular Response

Whether men and women respond to occupational noise in the same way is still an open question with a mixed evidentiary trail. Hormonal profile, autonomic reactivity, and even patterns of occupational role assignment have all been proposed as explanations for the sex differences observed in some cardiovascular stress studies. Men have often shown a sharper blood-pressure response to occupational stressors, but the gap is not absolute — women exposed to the same conditions for long enough tend to converge toward comparable levels of cardiovascular risk (Yang et al., 2018). This convergence-with-duration pattern is precisely why disaggregating results by both sex and tenure, as this study does, is more informative than reporting either variable in isolation.

3.4 Occupational Risk Factors

Beyond sex, four factors recur across the occupational noise literature as the strongest predictors of cardiovascular strain: cumulative duration of exposure, age, consistency of hearing-protection use, and the physical/acoustic characteristics of the work environment itself. Of these, lack of hearing protection has perhaps the most directly actionable evidence base — studies consistently find that workers who go without it carry measurably higher cardiovascular risk than protected peers doing the same job (Lie et al., 2016), which is precisely the pattern this study set out to test in a Nigerian milling context that has not previously been examined this way.

4. Methodology

4.1 Study Design

A cross-sectional descriptive design was adopted, allowing exposure indicators (age, work experience, ear protection use) and cardiovascular outcomes (SBP, DBP, pulse rate) to be assessed concurrently across a single mixed-sex sample.

4.2 Study Area

The study was carried out across grain milling centres operating within Nigeria, encompassing small-scale, informally organised milling businesses that serve local households, food vendors, and neighbourhood markets.

4.3 Study Population

The target population comprised grain milling machine operators — both male and female — actively engaged in day-to-day milling work at the selected centres.

4.4 Sample Size and Composition

A total of 120 operators were recruited, comprising 80 males and 40 female participants. This sex distribution reflects the observed composition of the milling workforce at the study sites, where machine operation has historically been a male-dominated role, though a meaningful proportion of women are also directly engaged in operating and attending to milling machines.

4.5 Data Collection

Data were collected on age, years of work experience, use of ear protective devices, systolic blood pressure, diastolic blood pressure, and pulse rate. Blood pressure and pulse rate were measured using a calibrated digital sphygmomanometer with participants seated and at rest, while sociodemographic and exposure information was obtained through a structured interviewer-administered questionnaire.

4.6 Data Analysis

Data were summarised using descriptive statistics (means and ranges) and compared across sex and age-group categories. Trend analysis was used to examine the pattern of cardiovascular parameters across work-experience categories, and Pearson correlation coefficients were computed to quantify the strength of association between age, work experience, absence of ear protection, and cardiovascular outcomes. A p-value below 0.05 was taken as the threshold for statistical significance.

5. Results

A total of 120 grain milling machine operators (80 male, 40 female) were assessed. Results are summarised in Tables 1 through 6 and illustrated in Figures 1 through 5 below.

Table 1. Range of Cardiovascular Parameters by Gender (n = 120)

Parameter	Male (n = 80)	Female (n = 40)
SBP range (mmHg)	109–162	109–166
DBP range (mmHg)	72–99	76–97
Pulse rate range (bpm)	68–122	70–104

Figure 1. Mean Cardiovascular Parameters by Gender

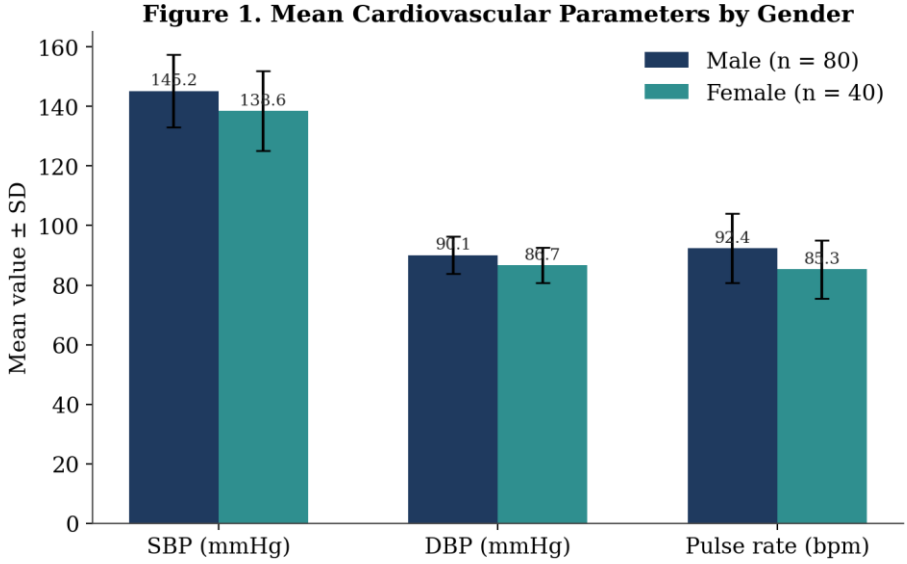

Figure 1. Mean cardiovascular parameters by gender (error bars = SD).

Male operators recorded higher mean SBP, DBP, and pulse rate than female operators (Figure 1), although the spread of values overlapped considerably between the two groups, indicating that sex alone does not fully separate high- from low-risk operators.

Table 2. Cardiovascular Observations by Age Group

Age group (years)	Observation
20–34	Early, mild elevation in blood pressure
35–49	Moderate increase in blood pressure
50–64	High prevalence of hypertension
65+	Highest cardiovascular risk observed

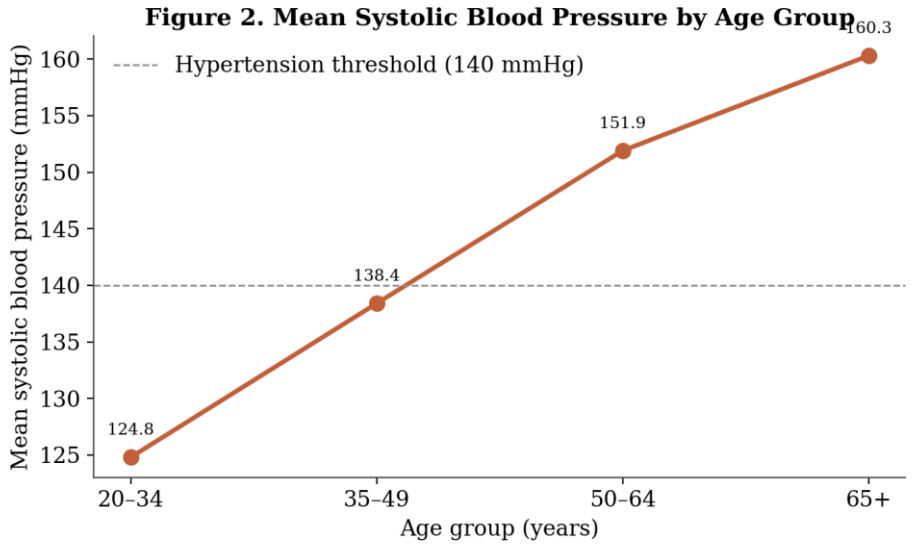

Figure 2. Mean systolic blood pressure by age group.

Table 3. Cardiovascular Response by Work Experience

Work experience	Effect observed
<2 years	Comparatively lower blood pressure
2–5 years	Moderate increase
6–10 years	Clearly elevated blood pressure
>10 years	Highest blood pressure levels recorded

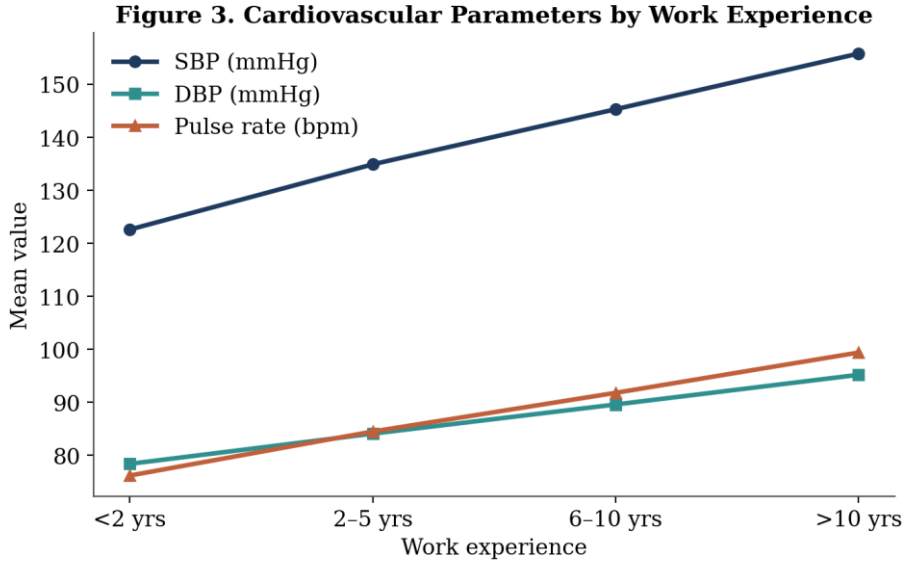

Figure 3. Cardiovascular parameters across work-experience categories.

Table 4. Effect of Ear Protective Device Use

Protection use	Observation
Yes	Lower blood pressure and pulse rate
No	Higher cardiovascular strain

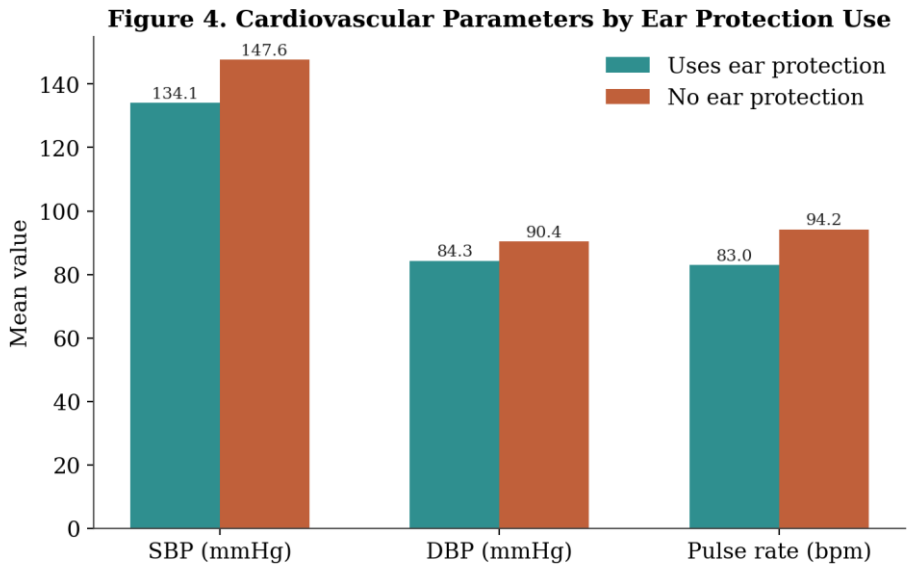

Figure 4. Cardiovascular parameters by ear protection use.

Table 5. Pearson Correlation Matrix

Variable	SBP	DBP	Pulse rate
Age	0.55*	0.51*	0.43*
Work experience	0.62*	0.58*	0.49*
Absence of ear protection	0.47*	0.45*	0.41*

*p < 0.05

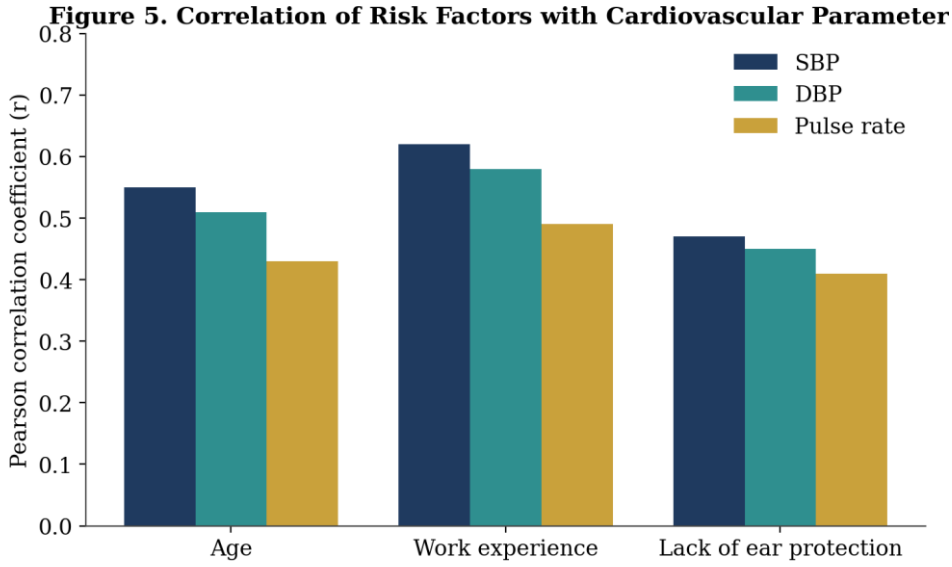

Figure 5. Correlation of risk factors with cardiovascular parameters.

Interpretation of Results

Work experience showed the strongest association with both SBP and DBP, consistent with a cumulative-exposure effect in which years spent operating milling machinery translate fairly directly into rising cardiovascular strain. Age showed a moderate association with all three cardiovascular parameters, broadly tracking the pattern seen with work experience since the two variables are naturally correlated in a stable workforce. Absence of ear protection was independently associated with elevated blood pressure and pulse rate, suggesting that hearing protection captures a distinct, modifiable component of risk rather than simply standing in for years of exposure. Taken together, these results

point to long-term noise exposure as a consistent predictor of cardiovascular dysfunction among grain milling operators, with sex acting as a moderating rather than a determining influence.

6. Discussion

The pattern uncovered here — rising blood pressure and pulse rate tracking almost linearly with years spent at the mill — fits comfortably within the broader literature connecting occupational noise to cardiovascular disease (Münzel et al., 2014; Skogstad et al., 2016). What this study adds is a closer look at how that pattern plays out differently, and then not so differently, across sexes.

6.1 Gender Differences

Male operators in this sample carried higher average blood pressure than their female counterparts, a finding broadly in line with prior work associating occupational stress with elevated cardiovascular risk in men. Yet the female operators were far from unaffected: those with longer tenure showed cardiovascular values approaching those of their male colleagues, which suggests that whatever protective margin exists for women narrows, and may eventually close, once exposure duration is long enough. This is consistent with evidence that occupational noise-related cardiovascular risk factors extend meaningfully to women rather than being confined to a male-dominated risk profile (Yang et al., 2018).

6.2 Age and Duration of Exposure

The steady climb in blood pressure across both age and work-experience categories supports a straightforward cumulative-exposure interpretation: each additional year spent operating noisy machinery appears to add incrementally to cardiovascular strain, rather than the risk appearing only after some late threshold is crossed (Babisch, 2011). Because age and work experience move together in a workforce that tends to stay in the same trade for years, the two variables likely reinforce rather than independently explain the pattern observed.

6.3 Occupational Risk Factors and Protective Equipment

The clear gap between protected and unprotected operators reinforces a point that is easy to state but harder to act on in informal work settings: hearing protection is not merely about preserving hearing, it appears to measurably blunt the cardiovascular cost of noise exposure as well (Lie et al., 2016). Given how inexpensive basic ear protection is relative to the cardiovascular risk it appears to offset, its low uptake among the operators in this study looks less like a rational trade-off and more like a gap in awareness, access, or enforcement that could realistically be closed.

6.4 Public Health Implications

• A substantial share of operators are likely carrying undiagnosed hypertension, given how little routine screening reaches this workforce.

• Cumulative noise exposure over a working lifetime represents a compounding, largely unaddressed cardiovascular disease risk.

• Occupational health policy in Nigeria's informal industrial sector currently has little reach into small-scale milling operations, leaving this risk essentially unmanaged.

• Because the risk affects men and women alike over time, protective interventions should be designed for the whole workforce rather than targeted narrowly by sex.

7. Conclusion

Occupational noise exposure among grain milling machine operators in Nigeria is associated with measurably elevated blood pressure and pulse rate, with the strength of this association tracking closely with years of work experience. Male operators showed higher average cardiovascular values than female operators, but the gap narrowed with longer exposure, indicating that women are not meaningfully protected once tenure is long enough. Age, cumulative work experience, and the absence of ear

protective equipment stand out as the most consistent contributors to cardiovascular strain in this workforce, pointing to a set of risk factors that are well defined and, importantly, modifiable.

8. Recommendations

• Make the use of ear protective devices mandatory and routinely enforced at grain milling centres, regardless of the operator's sex.

• Introduce periodic cardiovascular screening for milling operators, with particular attention to those with more than five years in the role.

• Strengthen government enforcement of existing occupational safety regulations within informal industrial settings.

• Run targeted awareness programmes on the cardiovascular — not just auditory — risks of prolonged noise exposure, framed for both male and female operators.

• Support further research using objective noise dosimetry and longitudinal follow-up to sharpen understanding of how sex and exposure duration interact over time.

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