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Article

Occupational Morbidity and Associated Determinants Among Automobile Service and Repair Workers in Enugu Metropolis, Nigeria: A Cross-Sectional Study

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Abstract

Automobile service and repair workers in Nigeria’s informal economy face chronic exposures to chemical, physical, ergonomic, and psychosocial hazards. Despite the large size of this workforce in Enugu State, South-Eastern Nigeria, their occupational health profile has remained undocumented, impeding evidence-based policy development. Objective: To assess the prevalence and pattern of occupational morbidity, personal protective equipment (PPE) usage, hazard awareness, and social security coverage, and to identify determinants of reduced pulmonary function and peripheral sensory impairment among automobile service and repair workers in Enugu metropolis. Methods: A cross-sectional observational study was conducted between January and April 2024. Of 150 workers approached from five major workshop clusters, 138 (92.0%) provided complete responses. A semi-structured bilingual interviewer-administered questionnaire collected data on sociodemographic characteristics, occupational exposures, symptoms, PPE use, and health awareness. Targeted clinical examinations included peripheral sensory assessment (2-gram Semmes-Weinstein monofilament; 10-site plantar protocol) and peak expiratory flow rate (PEFR) measurement. Chi-square tests and multivariable binary logistic regression with crude and adjusted odds ratios were used for analysis (IBM SPSS v.26.0; significance: $p < 0.05$). Results: Participants had a mean age of 32.4 ± 10.6 years and were predominantly male (95.7%). Petroleum product exposure was near-universal (91.3%). Only 8.7% used PPE regularly. Common morbidities included peripheral sensory impairment (47.8%), musculoskeletal complaints (46.4%), gastrointestinal symptoms (30.4%), and unintentional injuries (26.1%). Reduced PEFR (<300 L/min) was recorded in 17.4%. On multivariable regression, heavy metal exposure was the strongest predictor of both reduced PEFR (adjusted OR = 6.74, 95% CI: 2.18-20.85, $p = 0.001$) and peripheral sensory impairment (adjusted OR = 5.16, 95% CI: 1.62-16.42, $p = 0.005$). Years of service exceeding five years independently predicted peripheral sensory impairment (adjusted OR = 4.21, 95% CI: 1.88-9.43, $p = 0.001$). Conclusion: Automobile repair workers in Enugu carry a high and clinically significant burden of work-related morbidity compounded by critically low PPE use and near-universal absence of social security protection. Urgent priorities include occupational health surveillance programmes, mandatory PPE provision, and extension of National Health Insurance Authority coverage to informal sector workers.

Keywords: occupational morbidity; automobile repair workers; Enugu; Nigeria; personal protective equipment; peripheral sensory impairment; pulmonary function; informal economy; occupational hazards; cross-sectional study

1. Introduction

The global automobile repair and maintenance services industry has expanded substantially over the past two decades, driven by rising vehicle ownership, rapid urbanisation, and growing demand for aftermarket services. In sub-Saharan Africa and Nigeria in particular, this sector is dominated by small, unregistered informal workshops that collectively employ millions of workers. Nigeria's National Bureau of Statistics (NBS, 2020) estimated that the automotive repair trade accounts for over 2.3 million informal sector workers nationally, most of whom operate outside the coverage of formal occupational health and safety legislation, social security schemes, and labour regulations [1–3].

This study is situated within the WHO occupational health model, which conceptualises work-related disease as the product of workplace hazard exposures interacting with individual, organisational, and systemic vulnerabilities including low health literacy, absent regulatory protection, and poverty [4]. For informal automobile workers, this model predicts a high and largely invisible burden of occupational morbidity, compounded by the absence of the institutional safeguards that characterise formal employment.

Workers in the automobile service and repair sector are routinely exposed to a well-characterised constellation of occupational hazards. Chemical exposures include petroleum hydrocarbons, benzene, polycyclic aromatic hydrocarbons, battery acid, soldering flux, engine coolant, brake fluid, and heavy metals including lead, cadmium, and chromium [5–8]. Physical hazards encompass noise, heat stress, whole-body and hand-arm vibration, and ergonomic strain from prolonged awkward postures and heavy manual handling [9,10]. Psychosocial hazards include long working hours, poor remuneration, job insecurity, and the absence of social support [3]. These exposures generate a pattern of morbidity that includes respiratory disease, peripheral sensory impairment, musculoskeletal disorders, dermatological conditions, and psychosocial ill-health [11,12].

International evidence has established the health risks inherent in this occupation. A mortality follow-up study of automobile mechanics in the Netherlands demonstrated excess mortality from mesothelioma and urinary tract cancer [13]. A proportionate mortality ratio analysis in the United States showed elevated mortality from leukaemia and bladder cancers among automobile mechanics [5]. A cross-sectional study in Egypt documented contact dermatitis in 18.4% of automobile repair workers compared to 3.9% among controls [14]. Pulmonary function studies in India found obstructive impairment in 25.8% of automobile repair workers [12], and peripheral sensory impairment in 46.2% on monofilament testing [11]. Ethiopian studies have documented musculoskeletal disorder prevalences exceeding 73% and significant workplace stress among vehicle repair workers [3,9].

In Nigeria, studies addressing occupational morbidity among automobile mechanics are sparse, focusing primarily on ergonomic injury risk [10], occupational stress [15], and descriptive working condition surveys [16], without integrating clinical examination findings, objective pulmonary function testing, or neurological assessments. Enugu metropolis, the capital of Enugu State in South-Eastern Nigeria, hosts a dense and growing concentration of informal automobile repair workshops; yet their occupational health profile remains substantially undocumented in the peer-reviewed literature, impeding evidence-based policy advocacy.

This study was designed to address this evidence gap by assessing the prevalence and pattern of occupational morbidity among automobile service and repair workers in Enugu metropolis. Specifically, the study sought to: (i) characterise the sociodemographic and occupational profile of workers; (ii) determine the nature and prevalence of occupational hazard exposures; (iii) assess morbidity patterns through self-reported symptoms and targeted clinical examination; (iv) evaluate PPE availability and usage; and (v) identify occupational exposure and selected sociodemographic determinants of reduced pulmonary function and peripheral sensory impairment.

2. Literature Review

2.1. Occupational Hazards in Automobile Service and Repair Work

The automobile repair workshop constitutes one of the most hazardous environments in the informal economy. Chemical hazards are pervasive and encompass petroleum-derived products including engine oil, petrol, diesel, brake fluid, gear oil, engine coolant, and lubricating grease, many of which contain benzene (a Group 1 IARC human carcinogen) and aliphatic and aromatic hydrocarbons that are neurotoxic at chronic exposure levels [5,7]. Quantitative exposure assessments in comparable informal workshops in low- and middle-income countries have documented ambient benzene concentrations exceeding occupational exposure limits [17], and blood lead levels two to four times higher than population reference ranges in battery repair workers [6]. Battery servicing activities introduce exposure to sulphuric acid and lead; spray painting exposes workers to isocyanates, chromates, and solvent vapours; and welding tasks generate fumes containing iron oxide, manganese, and nickel [6,8].

Physical hazards include ambient noise levels from power tools and pneumatic equipment, which produce noise-induced hearing loss with chronic exposure; heat stress from vehicle engines and poorly ventilated workshops; ergonomic hazards from sustained awkward postures during under-vehicle work and heavy component handling [9]; and whole-body vibration from operating heavy equipment. Psychosocial hazards include high job demands, low decision latitude, financial insecurity, and limited access to occupational health services [3,18].

2.2. Morbidity Patterns in Automobile Repair Workers

Pulmonary morbidity is among the most consistently documented health outcomes in automobile repair workers. Chattopadhyay [12] found that 25.8% of automobile repair workers in Kolkata had obstructive impairment on spirometry. Philip et al. [11] documented that 16% of workers in Vellore, South India, had peak expiratory flow rates below 300 L/min, with reduced pulmonary function significantly associated with heavy metal exposure consistent with the fibrotic and inflammatory pulmonary effects of metal dust inhalation documented in experimental models.

Peripheral sensory impairment is the mechanistic product of cumulative neurotoxic exposure. Petroleum-derived n-hexane is metabolised to 2,5-hexanedione, which forms pyrrole adducts on neurofilament proteins, causing axonal swelling and degeneration of peripheral sensory and motor fibres [19]. Lead, even at blood concentrations below the occupational exposure limit, impairs peripheral nerve conduction velocity and myelin integrity through calcium channel dysregulation and oxidative stress [5,8]. Philip et al. [11] found peripheral sensory impairment in 46.2% of automobile workers, with significant associations with years of service and heavy metal exposure.

Musculoskeletal disorders are highly prevalent, with Tamene et al. [9] reporting a 12-month prevalence of 73.4% in Ethiopian vehicle repair workers, predominantly affecting the lower back, neck, and upper limbs. Contact dermatitis has been reported in 11-18% of automobile repair workers [14,20]. Workplace injuries affect approximately a quarter of workers in the six months preceding survey, reflecting the absence of formal safety management systems.

2.3. PPE Usage, Health Awareness, and Social Protection

PPE usage in the informal automobile repair sector in low- and middle-income countries is critically low. Philip et al. [11] found that while PPE was nominally available in 31.1% of workshops surveyed, only 9.4% of workers used it regularly. Barriers to PPE use include lack of employer provision, thermal discomfort, cost, and occupational health illiteracy [18,20]. In Nigeria, informal sector workers are largely excluded from the provisions of the Employees' Compensation Act (ECA) 2010 and the National Health Insurance Authority (NHIA) Act 2022, leaving them without financial protection in the event of work-related illness or injury [21,22].

2.4. Research Gap and Study Rationale

Existing literature documents the occupational morbidity burden of automobile repair workers primarily from South Asian [11,12], East African [3,9], and North African [14,20] settings. Nigerian-specific evidence is largely confined to descriptive surveys of working conditions and ergonomic risk, without integrating clinical examination, pulmonary function testing, or peripheral sensory assessment. No published study has provided a comprehensive multi-method occupational health characterisation of automobile repair workers in South-Eastern Nigeria. This study fills that gap, providing the first integrated clinical, symptomatic, and analytical evidence base for occupational health policy development in Enugu State and the broader Nigerian context.

3. Materials and Methods

3.1. Study Design

A cross-sectional observational study was conducted among automobile service and repair workers in Enugu metropolis, Enugu State, Nigeria. Cross-sectional designs are appropriate for estimating the prevalence of health conditions and identifying associated factors in occupational populations [23]. The study was conducted between January and April 2024.

3.2. Study Area

Enugu metropolis (Latitude 6.52°N, Longitude 7.49°E) is the capital of Enugu State, located in South-Eastern Nigeria. It is a major commercial hub with a large and growing informal automobile repair sector concentrated in identifiable workshop clusters at Ogbete, New Haven, Artisan Market, Independence Layout, and Coal Camp. The city's high volume of commercial and private vehicles generates sustained demand for repair and maintenance services, supporting an estimated workforce of several thousand informal mechanics.

3.3. Population and Sampling

The target population comprised all automobile service and repair workers in registered and identifiable workshop clusters in Enugu metropolis. A pilot survey of two randomly selected clusters revealed an estimated 420 mechanics operating across the five major clusters. Using a prevalence estimate of 47% for occupational stress [11] selected as it yields the largest required sample among the available outcome prevalence estimates, thus providing adequate power for all outcomes a precision of 8%, and a 95% confidence interval, the Cochran formula yielded a minimum sample size of: $n = [Z^2(1-\alpha/2) \times P(1-P)] / d^2 = [(1.96)^2 \times 0.47 \times 0.53] / (0.08)^2 \approx 150$. Proportionate systematic random sampling was employed from each cluster proportional to cluster size. Within each cluster, all workshops were enumerated and mechanics systematically selected at regular intervals.

Inclusion criteria: automobile service and repair workers aged ≥ 18 years; ≥ 1 year of occupational experience; currently employed in an Enugu metropolis workshop; and provision of written informed consent. Exclusion criteria: < 1 year experience; acutely unwell at data collection; and workshop owners not personally performing repair work. Of 150 workers approached, 138 (92.0%) provided complete responses and were included in analysis. Of the 12 non-included workers: 8 declined consent, 2 were acutely unwell, and 2 provided incomplete questionnaires.

3.4. Data Collection Instruments

3.4.1. Interviewer-Administered Questionnaire

A semi-structured questionnaire adapted from Philip et al. [11] and contextualised for the Nigerian setting was used to collect data on: sociodemographic characteristics; occupational profile (years of service, specialisation, working hours, job satisfaction); occupational hazard exposures (dust, heat, chemicals, petroleum products, heavy metals, noise, ergonomic strain) assessed by self-report; PPE availability and usage; occupational health awareness; social security coverage; and self-

reported symptoms in the preceding six months (respiratory, gastrointestinal, musculoskeletal, dermatological, unintentional injuries, headaches, and eye irritation). The questionnaire was translated into Igbo and back-translated by independent bilingual experts to ensure linguistic equivalence. Pilot testing (n = 20 mechanics, Artisan Market cluster, excluded from main study) confirmed comprehensibility and estimated administration time of 25-35 minutes.

3.4.2. Peripheral Sensory Assessment

Peripheral sensory function was assessed using a calibrated 2-gram Semmes-Weinstein monofilament applied bilaterally to ten standardised plantar sites on each foot: the hallux, first, third, and fifth metatarsal heads, the medial and lateral midfoot, and the heel consistent with the standard 10-site diabetic neuropathy screening protocol adapted by Philip et al. [11]. Inability to detect the monofilament at two or more sites on either foot was classified as peripheral sensory impairment. Two trained clinicians conducted all assessments; inter-rater agreement was assessed by duplicate testing on 20 participants (Cohen's Kappa = 0.81, indicating strong agreement).

3.4.3. Peak Expiratory Flow Rate (PEFR)

PEFR was measured using a calibrated mini-Wright peak flow meter. Three successive measurements were taken per participant in a standing position; the best of three readings was recorded. A PEFR below 300 L/min was classified as reduced, consistent with the threshold applied by Philip et al. [11] in a comparable South Indian occupational population, and approximating the lower limit of the predicted normal range for adult Nigerian males of mean height and age in this sample based on Quanjer et al. [24] reference equations for sub-Saharan African populations. All participants received standardised instruction in technique prior to measurement. Participants whose technique was assessed as suboptimal after instruction were excluded from PEFR analysis (n = 3).

3.5. Clinical Examination

A focused clinical examination was conducted by two trained clinicians at a designated area within each workshop cluster under standardised lighting using a portable examination kit. Examination included: assessment for pallor (conjunctival and palmar), features of contact dermatitis (erythema, scaling, vesiculation on hands and forearms), and chest auscultation for wheeze or crepitations.

3.6. Data Analysis

Data were entered into Microsoft Excel and transferred to IBM SPSS version 26.0. Descriptive statistics (frequencies, percentages, means, and standard deviations) were computed for all variables. Chi-square (χ^2) tests of association examined bivariate relationships between exposures and morbidity outcomes, with both chi-square statistics and p-values reported. Multivariable binary logistic regression was performed for outcomes significantly associated with two or more predictors in bivariate analysis, to identify independent predictors after confounding adjustment. Both crude odds ratios (OR) and adjusted odds ratios (aOR) with 95% confidence intervals (CI) are reported. Models were adjusted simultaneously for age, sex, years of service, educational level, smoking status, and all measured exposure variables. Model fit was assessed using the Nagelkerke R^2 statistic and the Hosmer-Lemeshow goodness-of-fit test. Statistical significance was set at $p < 0.05$.

3.7. Ethical Approval

Ethical approval was obtained from the Health Research Ethics Committee of the University of Nigeria Teaching Hospital (UNTH), Ituku-Ozalla, Enugu (Reference No.: UNTH/CSA/329/Vol.6). Institutional permission was obtained from the Enugu State Ministry of Health and the National Automotive Technicians Association (NATA), Enugu State Chapter. Written informed consent was obtained from all participants. Participation was voluntary and without financial remuneration.

Participants with significant clinical findings were referred with written documentation to the nearest public health facility.

4. Results

4.1. Response Rate and Sociodemographic Characteristics

Of 150 approached workers, 138 (92.0%) were included in analysis (8 declined consent; 2 acutely unwell; 2 incomplete questionnaires). Table 1 presents the sociodemographic and occupational characteristics. The mean age was 32.4 ± 10.6 years (range: 18-63 years). The sample was predominantly male (95.7%). Only 29.7% had completed secondary education; 93.5% had received no formal occupational safety training. The majority (67.4%) had more than five years of occupational experience. Most (83.3%) performed general repair and servicing; 16.7% performed specialised tasks including battery repair, spray painting, and gearbox overhaul. Over 90% worked more than 48 hours per week. The mean monthly income was ₦46,800 ± ₦14,200 (approximately USD 30-40 at prevailing exchange rates).

Table 1. Sociodemographic and Occupational Characteristics of Respondents (N = 138).

Variable	Category	n	Percentage (%)
Sex	Male	132	95.7
	Female	6	4.3
Age group (years)	18-25	38	27.5
	26-35	52	37.7
	36-45	31	22.5
	>45	17	12.3
Mean ± SD: 32.4 ± 10.6 years			
Education	No formal education	22	15.9
	Primary	39	28.3
	Secondary (completed)	41	29.7
	Vocational/technical	28	20.3
Years of experience	Tertiary	8	5.8
	<2 years	11	8.0
	2-5 years	34	24.6
	>5 years	93	67.4
Work type	General repair/servicing	115	83.3
	Specialised tasks	23	16.7
Weekly working hours	<48 hours	13	9.4
	48-60 hours	58	42.0
	>60 hours	67	48.6
Monthly income (₦)	<30,000	41	29.7
	30,000-60,000	73	52.9
	>60,000	24	17.4
Social security coverage	None	112	81.2
	NHIA/NHIS coverage	14	10.1
	Other scheme	12	8.7
Paid sick leave	Yes	11	8.0
	No	127	92.0

4.2. Job Satisfaction, Psychosocial Factors, and PPE Utilisation

Table 2 presents psychosocial and PPE data. Overall, 67 (48.6%) workers reported job dissatisfaction, citing low wages and physically demanding conditions. Seventy-one (51.4%) reported work-related stress; 36 (26.1%) reported that occupational stress adversely affected family and social

relationships. PPE was reportedly available in 46 (33.3%) workshops, but only 12 (8.7%) workers used PPE regularly. Barriers to PPE use included thermal discomfort (38.0%), unavailability (31.0%), cost (20.0%), and risk misperception (11.0%). Fifty-three per cent (53.6%) were unaware of any occupational health risks associated with their work; only 9 (6.5%) had ever received occupational safety training.

Table 2. Job Satisfaction, Psychosocial Factors, and PPE Utilisation (N = 138).

Variable	Yes n (%)	No n (%)
Satisfied with current job	71 (51.4%)	67 (48.6%)
Reported work-related stress	71 (51.4%)	67 (48.6%)
Stress adversely affects family life	36 (26.1%)	102 (73.9%)
PPE available at workshop	46 (33.3%)	92 (66.7%)
Uses PPE regularly	12 (8.7%)	126 (91.3%)
Has social security coverage	26 (18.8%)	112 (81.2%)
Has provision for paid sick leave	11 (8.0%)	127 (92.0%)
Aware of occupational health risks	64 (46.4%)	74 (53.6%)
Has received occupational safety training	9 (6.5%)	129 (93.5%)

4.3. Occupational Hazard Exposures

Table 3 presents occupational hazard exposures. Petroleum product exposure was near-universal (91.3%). Ergonomic exposure (86.2%), heat (78.3%), noise (74.6%), chemical exposure (52.2%), and dust (34.1%) were also widely prevalent. Eighteen workers (13.0%) were engaged in battery servicing, electroplating, and related activities involving potential heavy metal exposure—the subgroup carrying the highest predicted neurotoxic and pulmonary risk.

Table 3. Prevalence of Occupational Hazard Exposures (N = 138).

Hazard Category	Exposed n (%)	Not Exposed n (%)
Petroleum products (petrol, diesel, engine oil, lubricants)	126 (91.3%)	12 (8.7%)
Ergonomic (awkward postures, manual handling)	119 (86.2%)	19 (13.8%)
Heat (engine heat, ambient thermal exposure)	108 (78.3%)	30 (21.7%)
Noise (power tools, pneumatic equipment, engine testing)	103 (74.6%)	35 (25.4%)
Chemicals (battery acid, brake fluid, coolant, gear oil)	72 (52.2%)	66 (47.8%)
Dust (metal shavings, road grit, carbon deposits)	47 (34.1%)	91 (65.9%)
Heavy metals (lead, cadmium—battery/electroplating work)	18 (13.0%)	120 (87.0%)

4.4. Self-Reported Symptoms and Clinical Findings

Table 4 presents self-reported symptoms and clinical examination findings. Musculoskeletal complaints (46.4%) were the most prevalent self-reported symptom, followed by work-associated headaches (37.0%), eye irritation or visual disturbance (31.9%), gastrointestinal symptoms (30.4%), unintentional workplace injuries (26.1%), and respiratory symptoms lasting more than two weeks (21.0%). Clinically, peripheral sensory impairment on 2-gram monofilament testing was the most prevalent finding (47.8%), followed by contact dermatitis features (11.6%), pallor (9.4%), and wheeze/crepitations (6.5%). Reduced PEFr (<300 L/min) was recorded in 24 (17.4%) workers.

Table 4. Self-Reported Symptoms and Clinical Examination Findings (N = 138).

Health Outcome	n	%
SELF-REPORTED SYMPTOMS (preceding 6 months)		
Musculoskeletal complaints (muscle/joint pains)	64	46.4
Work-associated headaches	51	37.0
Eye irritation or visual disturbance	44	31.9

Gastrointestinal symptoms (dyspepsia/abdominal pain)	42	30.4
Unintentional workplace injuries	36	26.1
Respiratory symptoms (cough/breathlessness >2 weeks)	29	21.0
Skin rash or irritation	12	8.7
CLINICAL EXAMINATION FINDINGS		
Peripheral sensory impairment (2g monofilament)	66	47.8
Pallor (conjunctival/palmar)	13	9.4
Features of contact dermatitis	16	11.6
Wheeze or crepitations on auscultation	9	6.5
Reduced PEFR (<300 L/min)	24	17.4

4.5. Determinants of Reduced PEFR and Peripheral Sensory Impairment

Table 5 presents bivariate and multivariable regression analyses for the two primary clinical outcomes. On multivariable logistic regression, reduced PEFR was significantly and independently associated with age above 40 years (aOR = 3.82, 95% CI: 1.44-10.14, p = 0.007) and heavy metal exposure (aOR = 6.74, 95% CI: 2.18-20.85, p = 0.001; Nagelkerke R² = 0.38; Hosmer-Lemeshow p = 0.612). Peripheral sensory impairment was independently associated with age above 40 years (aOR = 2.89, 95% CI: 1.42-5.88, p = 0.003), years of service exceeding five years (aOR = 4.21, 95% CI: 1.88-9.43, p = 0.001), petroleum product exposure (aOR = 2.58, 95% CI: 1.10-6.07, p = 0.030), and heavy metal exposure (aOR = 5.16, 95% CI: 1.62-16.42, p = 0.005; Nagelkerke R² = 0.44; Hosmer-Lemeshow p = 0.541). Current smoking status was not a significant predictor in either model.

Table 5. Bivariate (Crude) and Multivariable (Adjusted) Logistic Regression Determinants of Reduced PEFR and Peripheral Sensory Impairment.

Predictor	Reduced PEFR cOR (95% CI)	P	aOR (95% CI)	P	Peripheral Impairment cOR (95% CI)	P	aOR (95% CI)	P
Age >40 years	3.41 [1.24-9.37]	0.017*	3.82 [1.44-10.14]	0.007*	2.64 [1.35-5.17]	0.005*	2.89 [1.42-5.88]	0.003*
Years of service >5	1.72 [0.67-4.42]	0.261	1.94 [0.74-5.11]	0.178	3.88 [1.79-8.39]	0.001*	4.21 [1.88-9.43]	0.001*
Petroleum product exposure	1.44 [0.47-4.37]	0.524	1.63 [0.52-5.12]	0.401	2.21 [0.96-5.07]	0.062	2.58 [1.10-6.07]	0.030*
Chemical exposure	1.97 [0.84-4.63]	0.119	2.11 [0.88-5.07]	0.095	1.58 [0.76-3.27]	0.221	1.74 [0.82-3.67]	0.149
Heavy metal exposure	6.02 [2.01-18.07]	0.001*	6.74 [2.18-20.85]	0.001*	4.71 [1.52-14.58]	0.007*	5.16 [1.62-16.42]	0.005*
Smoking (current)	1.88 [0.66-5.34]	0.237	2.04 [0.71-5.88]	0.187	1.38 [0.57-3.33]	0.476	1.48 [0.61-3.58]	0.388

Note. cOR = Crude (unadjusted) Odds Ratio; aOR = Adjusted Odds Ratio. Models adjusted simultaneously for age, sex, years of service, educational level, smoking status, and all listed exposure variables. *p < 0.05. Model fit—Reduced PEFR: Nagelkerke R² = 0.38, Hosmer-Lemeshow p = 0.612; Peripheral Sensory Impairment: Nagelkerke R² = 0.44, Hosmer-Lemeshow p = 0.541.

5. Discussion

This cross-sectional study provides, to the best of our knowledge, the first comprehensive multi-method occupational health assessment of automobile service and repair workers in South-Eastern Nigeria, combining self-reported symptom data, targeted clinical examination, PEFR measurement, and peripheral sensory assessment with multivariable regression analysis. The findings reveal a workforce characterised by near-universal multi-hazard exposure, a high and clinically significant burden of work-related morbidity, critically inadequate PPE usage, widespread occupational health unawareness, and near-complete absence of social security protection.

The mean age of participants (32.4 ± 10.6 years) reflects a predominantly young-to-middle-aged workforce, consistent with prior surveys of Nigerian informal sector artisans [10,15]. The very low educational attainment (only 29.7% completing secondary education) and near-universal absence of formal occupational safety training (93.5%) are important upstream determinants of occupational health risk, limiting workers' capacity to recognise hazards, seek health information, or advocate for safer working conditions.

The prevalence of work-related stress (51.4%) and job dissatisfaction (48.6%) is consistent with Philip et al. [11], who reported a stress prevalence of 47.2% among South Indian automobile workers, and with Hailemichael et al. [3], who documented significant workplace stress in Ethiopian vehicle repair workers. The 26.1% prevalence of stress-related family disruption has implications beyond the individual worker, reflecting a community-level burden that merits psychosocial support interventions.

PPE usage at 8.7% closely mirrors the 9.4% reported by Philip et al. [11] and aligns with the broader pattern of PPE non-use documented across informal sector automotive studies in Africa [3,20]. The barriers identified—thermal discomfort, unavailability, cost, and risk misperception—are consistent with the occupational health literature on informal sector PPE compliance [4,18]. Critically, 53.6% of workers were unaware of any health risks associated with their occupation, confirming that low PPE usage is driven by health illiteracy as much as by structural barriers.

Peripheral sensory impairment was detected in 47.8% of participants—a prevalence comparable to the 46.2% reported by Philip et al. [11] and substantially higher than the general population prevalence of peripheral sensory dysfunction in Nigerian adults. The significant independent associations with heavy metal exposure (aOR = 5.16), years of service (aOR = 4.21), and petroleum product exposure (aOR = 2.58) are biologically plausible given the established neurotoxic mechanisms of n-hexane and lead, as reviewed in Section 2.2. An important caveat must be acknowledged: diabetes mellitus, vitamin B12 deficiency, and chronic alcohol use—none of which were assessed in this study—are prevalent independent causes of peripheral sensory impairment in the Nigerian adult population (estimated diabetes prevalence 5-7%; Uloko et al. [25]). The 47.8% prevalence figure is therefore likely to represent a composite of occupationally-attributable and metabolic peripheral sensory dysfunction, and should be interpreted accordingly.

Reduced PEFR was documented in 17.4%, consistent with Philip et al.'s [11] 16% prevalence, and with heavy metal exposure emerging as the strongest predictor (aOR = 6.74). This association is mechanistically plausible given the well-documented fibrotic and inflammatory pulmonary effects of metal oxide inhalation in occupational cohorts [7,12]. The PEFR reduction prevalence in this Nigerian sample (17.4%) is lower than Chattopadhyay's [12] spirometric obstructive impairment prevalence (25.8%) but is methodologically more conservative, as PEFR underestimates the prevalence of mild obstructive disease relative to full spirometry.

Musculoskeletal complaints (46.4%) were substantially lower than Tamene et al.'s [9] Ethiopian prevalence of 73.4%, which may reflect differences in task specialisation, reporting thresholds, and survey instruments between studies rather than true population differences. The virtual absence of social security coverage (81.2% unprotected) and paid sick leave (92.0% without) exposes this workforce to compound vulnerability: high occupational risk with zero financial protection in the event of illness or injury.

5.1. Limitations

This study has five principal limitations. First, the cross-sectional design precludes causal inference between occupational exposures and morbidity outcomes. Second, all exposure assessments were self-reported; no objective environmental sampling or biological monitoring was conducted, limiting precision in exposure characterisation. Third, the 2-gram monofilament testing was conducted without diabetes screening, B12 assessment, or neurophysiological confirmation, potentially producing false-positive peripheral sensory impairment findings. Fourth, PEFR provides a limited measure of pulmonary function and is less sensitive than full spirometry for detecting mild

obstructive or restrictive disease. Fifth, the study was conducted in Enugu metropolis; findings may not be generalisable to peri-urban or rural automobile repair settings, or to other Nigerian states.

6. Conclusions

This study provides the first comprehensive, multi-method occupational health characterisation of automobile service and repair workers in South-Eastern Nigeria, contributing previously absent empirical evidence to a workforce that has remained substantially invisible in the peer-reviewed literature. Automobile repair workers in Enugu metropolis carry a high and clinically significant burden of work-related morbidity—including peripheral sensory impairment (47.8%), musculoskeletal complaints (46.4%), reduced pulmonary function (17.4%), gastrointestinal symptoms (30.4%), and unintentional injuries (26.1%)—compounded by critically low PPE use (8.7%), widespread occupational health unawareness (53.6%), and near-universal absence of social security protection (81.2%). Heavy metal exposure emerged as the strongest independent predictor of both pulmonary and neurological morbidity.

The following recommendations are made based on these findings:

(i) The Enugu State Ministry of Health, in collaboration with the Federal Ministry of Labour and Employment, should establish a dedicated occupational health surveillance programme for informal sector automobile workers in Enugu, incorporating periodic medical screening, spirometry, neurological assessment, audiometry, and blood lead level monitoring for workers involved in battery servicing and related heavy metal exposure tasks.

(ii) The National Automotive Technicians Association (NATA), Enugu State Chapter, should be engaged as the primary delivery channel for peer-led occupational health education programmes, leveraging the association's workshop network infrastructure to reach mechanics at scale with targeted PPE promotion and hazard awareness content.

(iii) The Enugu State Government and regulatory authorities should mandate and enforce minimum safety standards for automobile repair workshops, including compulsory provision of functional fire extinguishers, first aid kits, and basic PPE (gloves, eye protection, respiratory masks).

(iv) The National Health Insurance Authority (NHIA) should prioritise development of an implementation pathway for the 2022 NHIA Act's informal sector coverage mandate, ensuring automobile mechanics and similar artisan groups access subsidised healthcare and workers' compensation under the Employees' Compensation Act 2010.

(v) Future research should employ prospective cohort designs with objective biomarker assessments prioritising blood lead levels, urinary benzene metabolites, full spirometry, and nerve conduction studies to establish dose-response relationships between specific exposures and morbidity outcomes.

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