Permanent Hearing Loss among Professional Spice Grinders in an Urban Community in Southwest Nigeria

Bolajoko O. Olusanya, Babatunde A. Bamigboye,
and Abayomi O. Somefun

ABSTRACT *This study set out to determine the pattern and predictors of noise-induced hearing loss (NIHL) among small-scale and self-employed chili pepper grinders in Lagos, Southwest Nigeria. Audiological evaluation was conducted for all participants after noise level measurement. Of 136 studied, 85 (62.5%) were confirmed with slight-to-moderate NIHL. Mean age was 40.2 years, mean years spent as grinders was 9.3 years and mean hours spent daily at work was 13.3 hours. The mean age of those with NIHL was significantly higher than those without. Spending over 10 years in commercial grinding and working ≤ 12 hours daily were predictive of NIHL. Questionnaire-based screening using symptoms of NIHL was associated with a sensitivity of 44.7%, specificity of 62.7%, and positive predictive value of 66.7%. In conclusion, pepper grinding is associated with high/excessive noise levels and NIHL. Hearing conservation program incorporating engineering modification of locally fabricated grinders is warranted in this and similar populations in developing countries.*

KEYWORDS *Developing country, Informal sector, Noise-induced hearing loss, Occupational noise, Urbanization*

INTRODUCTION

Every month, at least 5 million people migrate mainly into the already overcrowded cities in developing countries.¹ The current urban population of 39% in Africa would hit 50% by 2030 at an estimated annual growth rate of 4.7%, the highest worldwide. In many resource-poor countries the informal sector, comprising self-controlled economic activities outside organized and regulated labor markets, is the ready recourse for the majority of the nation's economically active population due to the lack of social welfare systems.² The growth and scale of informal employment has also been attributed to the displacement of workers into insecure forms of labor market attachment as the only feasible alternative to unemployment.³ It is estimated that the share of the informal labor market varies from 4% to 6% in high-income countries to over 50% in low-income countries and assumes greatest prominence

Olusanya is with the Department of Community Health and Primary Care, College of Medicine, University of Lagos, Lagos, Nigeria; Bamigboye is with the Department of Otolaryngology, Lagos University Teaching Hospital, Lagos, Nigeria; Somefun is with the Department of Otolaryngology, College of Medicine, University of Lagos, Lagos University Teaching Hospital, Lagos, Nigeria.

Correspondence: Bolajoko O. Olusanya, Department of Community Health and Primary Care, College of Medicine, University of Lagos, Lagos, Nigeria. (E-mail: boolusanya@aol.com)

during periods of economic downturn.⁴ Although the activities in the informal sector particularly in the urban areas are numerous and widely diversified, many cottage industries such as spice grinding, grain milling, saw milling, printing, steel and metal fabrication, discotheques, and rental of power generators are frequently associated with excessive and prolonged noise and attention is rarely drawn to this vulnerable group. The damaging effects of occupational noise such as elevated blood pressure, sleeping difficulties, annoyance and stress, tinnitus, and permanent/sensorineural hearing loss have been extensively reported in the literature.⁵ Activities in the informal sector are non-structured and unregulated by government. Unique features of most workers in these industries are that they are predominantly self-employed, work longer hours than those in regular employment, and are hardly aware of or protected under occupational health and safety standards which predispose the affected individuals to higher risks of health hazards.

Chili pepper and paprika, which belong to the genus *Capsicum*, are a staple spice for most diet among populations of African and Asian descent. Pepper grinding is therefore a traditional and lucrative occupation in the informal sector. Besides the respiratory problems commonly associated with the irritant dusts from spice grinding, studies from South Asia have shown that this occupation is a major cause of noise-induced hearing loss (NIHL) in developing countries.⁶⁻⁹ However, limited data is currently available from sub-Saharan Africa on the risks of NIHL among professional spice grinders, which may forestall requisite intervention programs to curtail the burden of NIHL as recommended by the World Health Assembly.¹⁰ This study therefore set out to determine the prevalence and pattern of hearing loss among pepper grinders in a traditional market setting in a developing country.

METHODS

Setting

Nigeria (administratively made up of 6 geo-political regions, 36 states, and 774 local government areas) is the most populous African nation with an estimated population of 140 million people. The population is currently 48% urbanized and it is expected to grow by more than twofold to 289 million by 2050, with a majority of urban dwellers by 2020. The city of Lagos where this study was conducted was the capital of Nigeria until 1991 but remains the nation's commercial and financial hub. It is 94% urbanized and is reputed to have the best and highest number of healthcare facilities in the country.

Study Design

This prospective study was conducted between January and June 2005 in the largest single market for pepper and pepper grinding in Nigeria, commonly known as "Mile12/Ketu Market." All pepper grinders duly registered under the umbrella trade association in the market were enrolled after written informed consent. Enrollment was backed by a commitment that appropriate intervention services such as provision of noise protectors and medical referrals would be offered free to all participants. An overview of the survey procedure is presented in Figure 1. All participants requiring medical attention at any stage were referred to a nearby teaching hospital. Regardless of the final hearing status, participants were counseled on the health risks on excessive noise and provided with customized noise plugs at

FIGURE 1. Study protocol.

no charge. The project was approved by the Environmental and Occupational Health Division of the Federal Ministry of Health, Nigeria.

Pepper Species

There are four predominant species used as spices for local dishes in the southern parts of the country and these are commonly referred to as “tatashe,” “ata rodo,” “shombo,” and “ata wewe.” They are all in the category of chili peppers, mostly reddish in color and with varying degrees of pungency. The wet types are usually combined with tomatoes and onions during grinding to modify the flavor and reduce the pungency according to individual’s preferences. In northern Nigeria the dry pepper is used in powder form to spice barbecued meat and poultry (popularly known as “suya”). Attached to each grinder is a portable petrol generator for

supplying power to the equipment due to the lack of public electricity. Those engaged in dry pepper grinding also combine this with other food stuffs like millet, corn, and cassava, which generate substantial dust.

Noise Exposure Measurement

After the selection of the market, a noise survey was done to determine the noise exposure levels for the wet and dry pepper grinders with a duly calibrated (according to manufacturer's instructions) integrated sound level meter by Larson Davis, Provo, UT, USA (Model: Type I Precision 800 dB) set to the "A" weighting network/slow meter response. Measurements were taken at ear level of each subject and in accordance with ISO 9612 guidelines for occupational noise.¹¹ For each recording the instruments calculates five level measurements at intervals of 5 seconds, namely: minimum sound level (L_{MIN}), maximum sound level (L_{MAX}) and equivalent sound pressure level (L_{EQ}), for each interval measured in A-weighted decibel (dBA) as well as the unweighted peak sound level (L_{PEAK}) and single event sound level (L_{SIN}).

Screening Procedure

A meeting room located in a quiet section of the market used by the trade association was made available for hearing screening. The subjects to be screened on any given day were instructed a day previous to keep away from the grinders from 6:00 PM until end of the screening on the next day to forestall the incidence of temporary threshold shift. On a screening day, the subjects were taken to the quiet location for the administration of a structured questionnaire and the hearing tests between 9:00 AM and 12 noon. The ambient noise level at this location ranged from 51.52 to 57.2 dBA. Thereafter, sweep audiometry was conducted after otoscopic examination by a trained audiometrician. Frequencies 0.5–4.0 kHz were tested at 25 dBHL using a hand-held Audioscope 3 (Welch Allyn Inc, Skaneateles Falls, NY, USA). Middle ear status was assessed using a MicroTymp II (Welch Allyn Inc, Skaneateles Falls, NY, USA) and those with abnormal tympanograms (type B) were referred to a nearby University Teaching Hospital for appropriate medical attention. Diagnostic pure-tone audiometry was done at frequencies of 0.5, 1, 2, 3, 4, 6, and 8 kHz using a duly calibrated portable audiometer with insert phone (Model MA 41 by MAICO Diagnostic GmbH, Berlin, Germany) after daily biological calibration.

Statistical Analysis

Strength of association for categorical variables was estimated by odds ratios and the corresponding 95% confidence intervals. The difference between mean values of continuous variables with normal distribution was determined with Student's *t* test while Mann–Whitney test was used to compare differences in audiometric thresholds. Prevalence and classification of hearing loss was based on pure-tone average for the frequencies 0.5, 1, 2, and 4 kHz as recommended by WHO guidelines.¹² All tests of significance were two-sided. Factors with significance ($p < 0.05$) or borderline significance ($0.05 \leq p < 0.10$) in the univariable analyses were entered into multivariable logistic model to derive the adjusted odds ratios. Potential interactions between independent variables were evaluated with likelihood ratio test and goodness-of-fit was assessed with Hosmer–Lemeshow test. The predictive value of the final model was assessed by the *c* statistic (indexed by the area under the receiver operating characteristic [ROC] curve) and Nagelkerke Pseudo- R^2 statistic (a measure of

explained variation in the model). SPSS for Windows version 16.0 (SPSS Inc, Chicago, IL, USA) was used for all statistical analyses.

RESULTS

The noise levels associated with the two types of pepper grinders are presented in Table 1. Although the average sound levels were higher with dry pepper grinding, the difference was not statistically significant. The noise levels recorded from a sample of the grinders were identical regardless of the suppliers/local fabricators.

A total of 142 pepper grinders were recruited for this study, out of which 6 with abnormal tympanograms were excluded from the analysis. Female grinders ($n=95$) were more than double the number of male grinders ($n=41$). A total of 85 (62.5%) had hearing loss in the better ear, while 103 (75.7%) had hearing loss based on worse ear (Table 2). The degree of hearing loss was predominantly slight-to-moderate (26–60 dB). The mean hearing thresholds at all frequencies for all participants are shown in Figure 2, which typically are indicative of NIHL as depicted by the poorer thresholds at 3, 4, and 6 kHz. The mean hearing thresholds at frequencies 3, 4, and 6 kHz for all participants based on the type of grinding activities are also presented in Table 3. At each frequency, the right ears were worse than the left ears among those who were engaged in wet-only or wet-combined-with-dry pepper grinding, whereas the reverse was the case for those involved in dry pepper grinding only. The average hearing thresholds for the left ears were significantly higher among those in dry pepper grinding compared with those in wet pepper grinding ($p=0.045$) but not for the right ears ($p=0.448$).

The socio-demographic characteristics of the participants are shown in Table 4. The mean age (SD) was 40.2 (13.8) years and the average years spent as professional grinder was 9.3 (7.8) years. The mean hours spent daily was 13.3 (2.9) hours. The better ear was used for all analyses as recommended by WHO.¹² The mean age of those with hearing loss (42.9 years) was statistically higher ($p=0.003$) than those without hearing loss (35.8 years). Similarly, the mean years spent by those with hearing loss (10.4 years) was significantly higher ($p=0.017$) than those without hearing loss. In the univariate analyses, age, marital status, years spent as grinders, and hours spent daily at work were significantly associated with hearing loss. However, after adjusting for the confounding effects of covariates, only years spent as grinders and length of hours spent daily at work were predictive of hearing loss. Pepper grinders with hearing loss were significantly likely to have spent over 10 years in this trade ($p=0.017$) and were less likely to stay longer than 12 hours daily at work ($p=0.037$). These two factors accounted for 17.5% variation (Nagelkerke Pseudo- $R^2=0.174$) in hearing loss among pepper grinders. The model

TABLE 1 Noise levels at pepper grinding sections of Ketu Market, Lagos

Parameters	Wet grinding	Dry grinding
Equivalent sound pressure level (L_{EQ})	101.1	107.4
Lowest measured signal (L_{MIN})	92.5	97.3
Highest measured signal (L_{MAX})	107.3	111.0
Peak impulse signal (L_{PEAK})	126.0	124.8
Single event level (L_{SIN})	120.9	121.8

TABLE 2 Pattern of hearing loss among professional pepper grinders (*n*=142)

Grade of hearing impairment	Better ear			Worse ear		
	Male	Female	All	Male	Female	All
Normal (<26 dB)	15	36	51	11	22	33
Slight (26–40 dB)	24	49	73	18	53	71
Moderate (41–60 dB)	2	10	12	10	19	29
Severe (61–80 dB)	–	–	–	1	1	2
Profound (> 80 dB)	–	–	–	1	–	1
Total	41	95	136	41	95	136

has modest discriminatory powers (*c* statistic=0.705) and there was no evidence of poor model-fit (Hosmer–Lemeshow test: *p*=0.935). Only four (2.9%) persons reported previous hearing test, three of whom were confirmed with hearing loss in this study. Smoking was rarely reported among all participants, as only two persons gave this history.

The self-reported symptoms of hearing loss among all participants are summarized in Table 5. A screening questionnaire based on any one reported symptom was associated with a sensitivity of 44.7%, specificity of 62.7%, and positive predictive value of 66.7%.

DISCUSSION

The imminent urban transition in many developing countries without concomitant growth in economic opportunities in the formal sectors underscores the need to pay attention to the current structure and potentials of the informal sectors as major employers of labor. This study corroborates the substantial evidence in the literature that highlights the silent burden of occupational hazards with specific reference to essential but largely unregulated economic activities in the informal sectors in resource-poor countries. There is little evidence that even in the formal sectors in these countries occupational health and safety standards are enforced, perhaps with the exception of obviously life-threatening situations. While the overall industry or national data on the size of the labor market in this occupation is not available, the findings in this study mirror the health and safety challenges likely to be faced by a

FIGURE 2. Mean hearing levels participants with or without hearing loss.

TABLE 3 Mean (SE) hearing thresholds (3, 4, and 6 kHz) among professional pepper grinders (n=136)

Type of pepper grinding	Right ear				Left ear			
	3 kHz	4 kHz	6 kHz	Average	3 kHz	4 kHz	6 kHz	Average
Wet only (Standard error)	34.12 (1.76)	33.77 (1.82)	44.12 (2.18)	37.34 (1.82)	31.69 (1.65)	30.54 (1.67)	41.55 (1.96)	34.60 (1.64)
Dry only (Standard error)	38.38 (2.73)	37.35 (3.05)	43.09 (3.27)	39.61 (2.84)	38.53 (2.57)	38.09 (2.86)	45.74 (3.76)	40.78 (2.89)
Wet and dry (Standard error)	35.71 (3.77)	36.96 (4.13)	45.54 (4.13)	39.41 (3.83)	33.75 (3.21)	36.07 (3.64)	45.00 (3.47)	38.27 (3.26)

Difference between wet and dry: right ear: $p=0.448$; left ear: $p=0.045$

broader range of informal economic activities associated with work-place noise in Nigeria and many developing countries.^{13,14}

Noise-induced hearing loss is one of the most prominent occupational health hazards worldwide and is a significant contributor to the global burden of disease in adulthood.^{15,16} The slight-to-moderate degrees of hearing loss predominant in this study are characteristic of NIHL and the use of amplification devices may be ineffective for some of the affected individuals.¹⁷ But this should not suggest that they are less serious considering that as high frequency hearing losses they have deleterious effects on speech perception and discrimination essential for active daily functioning and participation.

Comparative studies among chili pepper grinders in informal settings are rare. Notwithstanding, noise levels above 90 dbA are considered high or excessive by international standards.⁷ One study among mill workers from Nigeria reported noise levels ranging from 88 to 105 dbA and NIHL prevalence of 71% consistent with the findings in the current study.¹⁸ In contrast, another study among spice grinders in factories in Singapore reported lower noise levels of between 87 dbA and 98 dbA as well as NIHL prevalence of 21% which appear to demonstrate the NIHL impact of traditional market settings in the Nigerian studies.⁸ Additionally, the grinders used in the Nigerian studies were fabricated locally without any acoustic considerations and were usually powered by petrol generators attached close to the units. Government-backed initiatives to promote hearing conservation program in this sector is therefore necessary. These may include technical support for local fabricators of grinders to reduce the associated noise levels as well as health promotion for personal protection devices. A publicly funded exchange program to replace the existing grinders with better engineered models may also be explored. Women are known to be over-represented in the informal sector worldwide and this is consistent with the significantly higher proportion of women found in this study. It is therefore essential for any intervention programs to be gender sensitive, particularly among women of child-bearing age, because of the potential risks of excessive noise during pregnancy for expectant mothers.¹⁹

Working longer than 10 years in this trade was a strong predictor of NIHL and is supported with the well-established evidence on the contribution of the years spent on noise-related occupation.^{5,20} The finding in this study could be interpreted as providing a window for introducing a hearing conservation program beyond which any intervention may be sub-optimal. However, because the degree of continuous

TABLE 4 Characteristics of professional pepper grinders in an informal sector in Lagos, Nigeria

Factors	Total (%) <i>n</i> =136	Confirmed with hearing loss (%) <i>n</i> =85	Unadjusted OR (95% CI)	Adjusted OR ^{a,b} (95% CI)
Age (years)				
<20	9 (6.7)	2 (2.4)	1.0	1.0
20–45	81 (60.0)	49 (58.3)	5.36 (1.05–27.45)	4.07 (0.45–36.64)
>45	45 (33.3)	33 (39.3)	9.63 (1.75–52.96)	5.50 (0.53–57.26)
Sex				
Female	95 (69.9)	59 (69.4)	1.0	
Male	41 (30.1)	26 (30.6)	1.06 (0.50–2.26)	
Marital status				
Single	17 (12.5)	7 (8.2)	1.0	1.0
Married	119 (87.5)	78 (91.8)	2.72 (0.96–7.67)	0.81 (0.17–3.92)
Education				
None	26 (19.1)	17 (20.0)	1.0	
Primary	60 (44.1)	38 (44.7)	0.91 (0.35–2.40)	
Secondary/Technical	50 (36.8)	30 (35.3)	0.79 (0.30–2.13)	
Type of grinding				
Wet	74 (54.4)	44 (51.8)	1.0	
Dry	34 (25.0)	22 (25.9)	1.25 (0.54–2.90)	
Wet and Dry	28 (20.6)	19 (22.4)	1.44 (0.57–3.61)	
Years spent at work				
<5	44 (32.4)	21 (24.7)	1.0	1.0
–10	52 (38.2)	33 (38.8)	1.90 (0.84–4.30)	1.54 (0.63–3.77)
>10	40 (29.4)	31 (36.5)	3.77 (1.46–9.75)	3.77 (1.27–11.23) ^c
Time spent at work daily				
≤12 hours	45 (33.8)	34 (40.5)	1.0	1.0
>12 hours	88 (28.6)	50 (59.5)	0.43 (0.19–0.95)	0.41 (0.17–0.95) ^d
Family history of hearing loss				
No	126 (92.6)	78 (91.8)	1.0	
Yes	10 (7.4)	7 (8.2)	1.44 (0.35–5.82)	
Related to spouse				
No	123 (90.4)	75 (88.2)	1.0	
Yes	13 (9.6)	10 (11.8)	2.13 (0.56–8.15)	
Smoker				
No	134 (98.5)	84 (98.8)	1.0	
Yes	2 (9.6)	1 (1.2)	0.60 (0.04–9.73)	
Previous hearing test				
No	132 (97.1)	82 (96.5)	1.0	
Yes	4 (2.9)	3 (3.5)	1.83 (0.19–18.07)	

OR odds ratio, CI confidence interval

^aAdjusted for all covariates based on biological plausibility^bHosmer-Lemeshow test: $p=0.935$; Nagelkerke Pseudo- $R^2=0.174$; c statistic=0.705^c $p=0.017$ ^d $p=0.037$

exposure to excessive noise may be difficult to determine from person to person, it is perhaps more appropriate to intervene much earlier than 10 years from a policy perspective. Additionally, working as late as over 12 hours was less likely to be associated with NIHL compared to those who usually worked between 8 and

TABLE 5 Self-reported symptoms of hearing loss among pepper grinders

Symptom	Normal hearing (<i>n</i> = 51)	Hearing loss (<i>n</i> = 85)	Sensitivity	Specificity	Positive predictive value
Difficulty with listening to TV or Radio	0 (0.0)	6 (7.1)	7.0	100.0	100.0
Difficulty conversing on phone	0 (0.0)	6 (7.1)	7.0	100.0	100.0
Difficulty in engaging in conversation	0 (0.0)	5 (5.9)	5.9	100.0	8.8
Difficulty in hearing shortly after leaving shop	1 (2.0)	8 (9.4)	9.4	98.0	88.9
Ringing in the ear	19 (37.3)	32 (37.6)	37.6	62.7	56.1
Any one of five symptoms	19 (37.3)	38 (44.7)	44.7	62.7	66.7

12 hours daily. This may suggest that the avoidance of continuous exposure within the usually busy daytime by staggering the activities over a longer period may have a protective effect on NIHL. The worse results observed in the right ears are likely due to the fact that most of the grinders are right-handed and thus tend to listen with right ear to the sound of the grinder as they manually crush the pepper in the receptacle or loading bowl of the grinder. The chronological age was not an independent predictor of NIHL consistent with a similar report from Nigeria.¹⁸

Self-reported questionnaire may be a cost-effective means in resource-poor countries for identifying persons with NIHL as has been demonstrated in some studies.^{21,22} For example, one study found that simply asking “Do you feel you have a hearing loss?” appeared sufficiently sensitive and specific to identify persons with hearing loss.²¹ Another study reported that the question “Do you consider the noise level where you are working now high” had a sensitivity of 93.4% in identifying persons exposed to a noise level greater than 85 dBA and a sensitivity of greater than 86% but specificity of not more than 24%.²² However, the evidence from this study showed that giving a positive response to one of five questions was associated with the best combination of sensitivity and specificity but was unsatisfactory as a screening tool. Further investigation to determine a more discriminatory set of questions is warranted.²³

A number of limitations of this observational study are worth-noting. It was uncertain the extent to which the participants and findings in this study were representative of pepper grinders in other markets throughout the country or in other developing countries. The scope of occupational hazards studied was limited to NIHL, whereas this occupation is also commonly associated with respiratory and other health problems. Nonetheless, this study offers valuable insights on the silent burden of occupational risks in the growing but unregulated informal sectors in resource-poor countries at the verge of imminent urban transition which warrant urgent attention.

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