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Housing Conditions and Health Implications on Residents of Makurdi Town, Benue State, Nigeria

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Abstract

Human health status is determined by several factors one of which is housing conditions. Features of housing may determine the physical, social and mental well-being of residents. More than 100 million people globally are without homes while over a billion live in homes that are not only inadequate but are also harmful to health. This study determined the health implications of housing conditions on residents of Makurdi Town, Benue State, Nigeria. A descriptive cross sectional study design was adopted for the study. Multi-stage sampling technique was used to select 400 respondents. Primary data were obtained using semi-structured, self-administered questionnaire. Chi-square analysis was used to express relationships between housing conditions and reported health problems. The findings of this study indicated that most (65.5%) of the respondents did not renovate their houses. Pour flush toilets were the prevalent faecal disposal facility (58.6%) of the respondents. Major source of water for household use was hand dug wells (51.2%). Most (59.3%) of the respondents practised open dumping of refuse. Malaria fever (66.5%) was the prevailing health challenge among the residents. Statistically significant associations existed between variables such as common vectors, occupancy per room, sources of water, place where food is cooked and sources of heat for cooking and reported common health problems at P= 0.000, 0.013, 0.003, 0.022, and 0.002 respectively at significant level of $P \leq 0.05$. This study concludes that housing conditions have health implications on the residents. Routine public enlightenment on the health implications of housing conditions on health is thus encouraged.

Les Conditions de Logement et des Implications sur la Santé des Résidents de la Ville de Makurdi, etat de Benue le, Nigéria

Résumé

L'état de santé humaine est déterminé par plusieurs facteurs, y compris les conditions de logement. Les caractéristiques du logement peuvent déterminer le bien-être physique, social et mental des résidents. Plus de 100 millions de personnes dans le monde sont sans logement tandis que plus d'un milliard vivent dans des logements non seulement inadéquats, mais également nocifs pour la santé. Cette étude a déterminé les implications sur la santé des conditions de logement des résidents de la ville de Makurdi, dans l'État de Benue, au Nigéria. Une conception d'étude transversale descriptive a été adoptée pour l'étude. Une technique d'échantillonnage à plusieurs degrés a été utilisée pour sélectionner 400 répondants. Les données primaires ont été obtenues à l'aide d'un questionnaire semi-structuré et auto-administré. L'analyse du chi carré a été utilisée pour exprimer les relations entre les conditions de logement et les problèmes de santé signalés. Les résultats de cette étude indiquent que la plupart (65,5 %) des répondants ne renouvellent pas leur maison. Les toilettes à chasse d'eau étaient l'installation d'élimination des matières fécales la plus répandue (58,6 %) des répondants. La principale source d'eau à usage domestique était les puits creusés à la main (51,2%). La plupart (59,3 %) des répondants pratiquaient la décharge à ciel ouvert. La fièvre palustre (66,5%) était le problème de santé prédominant parmi les résidents. Des associations statistiquement significatives existaient entre des variables telles que les vecteurs communs, l'occupation par pièce, les sources d'eau. Le lieu où les aliments sont cuits et sources de chaleur pour la cuisson ont signalé des problèmes de santé courants à P=0,000, 0,013, 0,003, 0,022 et 0,002 respectivement à un niveau significatif de $P \leq 0,05$. Cette étude conclut que les conditions de logement ont des implications sur la santé des résidents. L'information courante du public sur les implications sanitaires des conditions de logement sur la santé est ainsi encouragée.

Introduction

Housing is one of the basic necessities that has immense effects on the health, welfare and productivity of individuals. Others are clothing and food. Housing is not considered purely as shelter but embraces social, educational and economic needs which satisfies the needs and aspirations of the residents as well as contribute to their well-being (Ademiluyi, 2010). Housing also provides optimum quiet environment, indoor and outdoor space, privacy, sanitary, safety and aesthetic satisfaction" (Okechukwu, 2009).

The association between housing conditions and health has long been recognized and is now generally accepted (Coker, Awokola, Olomokoye, & Booth, 2007). Housing conditions play a vital role in the inhabitant's health status as many of the features of housing may determine physical, social and mental well-being of occupants (Sharpe *et al.,* 2018). Although the exact relationship between poor housing and health is complex and difficult to quantify, research based on the various sources of housing and health data indicates that poor housing is associated with increased risk of cardiovascular diseases, respiratory diseases; depression and anxiety, rheumatoid arthritis, nausea and diarrhoea, infections, allergic symptoms, hypothermia, physical injury from accidents and food poisoning (UK House of Parliament, 2011).

The Public Health Laws of Nigeria of 1959 (still in force) stipulates unsafe conditions for human dwellings. Specifically, section 6 (a-m) states clearly, situations which if present in a house makes it unhealthy for human habitation and needs corrective actions to remove the conditions (Nick, 2003). Specific requirements of such regulations require that, dwellings for humans should not be damp, ill-ventilated, littered with refuse, lack important sanitary amenities. Houses should have accessible roads, drainage channels, facilities for prompt and sanitary solid waste disposal, regular and safe water supply, alongside other requirements (Amao, 2012).

Rural-urban migration of people is rapidly increasing (Amao, 2012). This rural- urban drift has caused housing scarcity. In Sub-Saharan Africa, 71.8% of urban dwellers live in slums, the highest proportion in the world and the proportion of urban dwellers in Nigerians living in slums is about 75% (Olotuah & Bobadoye, 2009). Slums are communities characterized by insecure residential status, poor structural quality of housing, overcrowding, and inadequate access to safe water, sanitation and other infrastructure.

Overall, more than two billion people are in desperate need of better housing (Igwe, Okeke, Onwurah, Nwafor and Umeh, 2017). By improving housing issues, public health practitioners address an important social determinant of health (Krieger & Donna, 2002). Studies on other aspects of housing have been conducted in Makurdi Town but none looked at the health implications of conditions of housing on the residents.

Therefore, this study determined housing conditions and health implications on residents in Makurdi Town of Benue State, Nigeria.

Materials and Methods

Study Area

The study was carried out in Makurdi Town, the capital of Benue State and also the Local Government Council Headquarters. It is located in the north central geo-political region of Nigeria (6°45'-8°15'E, 7°30'-9°45'N). The population of the town is 297,398 with an area of 41,035 km^2. Makurdi has eleven (11) political council wards.

Study design

Cross-sectional descriptive study design was employed to identify conditions of housing units and their health implications in Makurdi Town. This study design is preferred because it examines the relationship between variables as they exist in a specific population at a given point in time.

Sample size and recruitment of respondents

A total of 400 households/housing units were selected using a multi-stage sampling technique. The procedure is as shown below:

Stage 1: Selection of ward: Out of the 11 wards in Makurdi Town, five (5) wards were selected using simple random sampling technique by ballot method.

Stage 2: Selection of streets: In each of the five (5) selected wards, the names of streets in these wards were written out using the Makurdi Street Guide. Eight (8) streets per ward were selected using simple random sampling technique by ballot method, giving a total of (5×8) =40 streets. Stage 3: Selection of households. In each of the forty (40) selected streets, ten (10) households were selected using systematic sampling technique where a general sampling interval of three was used. The second household on each street was used as the starting point for selecting the households until ten (10) households were selected to obtain a total of (40×10) = 400 households. Stage 4: selection of respondents: In each of the four hundred selected households, one respondent aged 18 and above was randomly selected for the study. The dependent variable was commonly reported health problems while the independent variables were common vectors, number of people per room, sources of water, cooking places, sources of heat supply for cooking, roofing materials, number of windows per room and level of awareness on the influence of housing conditions on health.

Data collection and analysis

The instrument for data collection was a semi-structured self-administered questionnaire. The questionnaire comprised 35 items divided into six sections. Section A consisted of socio-demographic data, Section B: type of housing, Section C: consisted of data about the attribute of the location of housing units, Section D: indoor housing condition, section E: vectors and disease conditions in housing units and section F: knowledge of housing conditions and health among residents. Data were analysed using SPSS version 21 and results were presented as frequencies and percentages using tables. Association between variables was analysed using chi-square test.

Ethical considerations

Ethical approval was obtained from the Benue State Research Ethics Committee, Ministry of Health, Makurdi. Traditional rulers, elders and youth leaders in the five (5) randomly selected council wards were contacted and briefed of the purpose, objectives and significance of the study after which verbal permission was sought and obtained from them before occupants of houses were met. Occupants were informed of the objectives, significance of the research and guarantee of utmost confidentiality of information before voluntary participation, were sought and obtained from them.

Results

More than half (65.5%) of the respondents were males, aged 18-28 years (26.9%) with more than half (56.8%) married. Majority (84.1%) of the respondents were Christians. Most of the respondents (48.3%) attained tertiary education. The highest level of participation by occupation was found among 23.53% of the respondents who were civil servants. Participants who earned #1000 - #10000 per month (23.08%) participated most, as shown in Table 1.

In Table 2, results on structural attributes of housing revealed that concrete walls were found in 39.1% of the houses. Majority (88.7%) of the roofs were in zinc with more than half (59.6%) of

Table 1: Socio-demographic characteristics of respondents (N=391)

Socio-demographic characteristics	Frequency	Percentage (%)
Sex		
Male	256	65.5
Female	135	35.5
Total	391	100
Age (years)		
18-28	105	26.9
29-38	78	19.9
39-48	78	19.9
49-58	79	20.2
=59	51	13.0
Total	**391**	**100**
Marital status		
Single	115	29.4
Married	222	56.8
Widow/widower	45	11.5
Divorced/separated	4	1.00
Co-habitation	5	1.30
Total	**391**	**100**
Religion		
Christianity	329	84.1
Islam	49	12.5
Traditional	13	3.30
Total	**391**	**100**
Level of Education		
No formal education	37	9.50
Primary education	25	6.40
Secondary education	140	35.8
Tertiary education	189	48.3
Total	**391**	**100**

the houses having glass windows. Results on the number of windows per room showed that 87.7% of the houses had two windows per room. Non renovation of houses was found among 65.5% of the respondents.

Table 2: Structural attributes of housing in Makurdi Town (N=391)

Variables	Frequency	Percentage (%)
Wall material		
Concrete	153	39.1
Mud cement plastered	30	7.70
Mud wall	21	5.30
Burnt bricks plastered	141	36.1
Burnt bricks un-plastered	46	11.8
Total	**391**	**100**
Roof		
Asbestos roofing sheets	19	4.90
Zinc	347	88.7
Thatch	21	5.40
Roofing tiles	4	1.00
Total	**391**	**100**
Window		
Glass	233	59.6
Zinc	22	5.60
Wood	136	34.8
Total	**391**	**100**
Type of house		
Singleroom (self -contain)	53	13.6
Singleroom (not self-contain)	92	23.5
Two bedroom flat	119	30.4
Three bedroom flat	101	25.8
Duplex	11	2.80
Round hut	15	3.80
Total	**391**	**100**
Number of windows per room		
One	30	7.70
Two	343	87.7
Three	10	2.60
Four	4	1.00
None	1	0.30
Others	3	0.70
Total	**391**	**100**
Age of building		
1-10yrs	60	15.3
11-20yrs	99	25.3
21-30yrs	63	16.1
31-40yrs	42	10.7
41-50yrs	6	1.50

Results showed that 43.0% of the respondents cooked their food in kitchens outside the house. Kerosene stove (32.5%) was the major appliance for cooking. Pour flush toilets (58.6%) were the dominant types. Majority (91.3%) of the bathrooms were "stand and pour" types. Hand dug wells (51.2%) were the predominant source of water supply. Electricity was found in 89.5% of the houses which also supplement electric supply, with generators. There was no drainage system in (69.6%) of the housing units. Most (59.3%) of the occupants practised open dumping of refuse as presented in Table 3a.

Table 3a: Basic housing requirements in Makurdi Town (N= 391)

Variable	Frequency	Percentage (%)
Place where food is cooked		
Separate kitchen within the house	164	41.9
Kitchen outside the house	168	43.0
Bedroom	3	0.70
Corridor	28	7.20
Open space	28	7.20
Total	**391**	**100**
Sources of heat supply for cooking		
Kerosene stove	127	32.5
Gas cooker	107	27.4
Fire wood	103	26.3
Charcoal	52	13.3
Electric cooker	2	0.50
Total	**391**	**100**
Types of latrine		
Pour flush	229	58.6
Pit latrine	25	6.40
Water closet	130	33.2
None	7	1.80
Total	**391**	**100**
Types of Bathroom		
Bath tub	2	0.50
Shower	27	6.90
"Stand and pour"	357	91.3
None	5	1.30
Total	**391**	**100**
Main source of water supply		
Pipe borne water supply	2	0.50
Borehole water	88	22.5
Stream	6	1.50
Hand dug well	200	51.2
Water vendors	95	24.3
Total	**391**	**100**
Main sources of light		
Generator	8	2.10
Kerosene lamp	11	2.80
Candle and electricity	9	2.30
Electricity and generator	350	89.5
Other sources	13	3.30
Total	**391**	**100**
Availability of gutters		
Available	119	30.4
Not available	272	69.8
Total	**391**	**100**

Noise emanating from generators was reported by 51.2% of the respondents. Results on the occupancy of the rooms in houses showed that most rooms were occupied by two persons, 39.1%. Results also revealed that 60% of the respondents were aware that some conditions of their houses can affect their health. Radio set (36%) was the dominant source of awareness as shown in Table3b.

In Table 4, results revealed that, mosquitoes (60.6%) were reported as the predominant vectors with 66.5% reporting malaria prevalence. Skin rashes were reported among 56.2% of the respondents. Majority 80% of the respondents indicated having one-three three sick persons in their houses in the previous six months as at the time of the research.

Table 3b: Basic housing requirements in Makurdi Town (N= 391)

Variables	Frequency	Percentage (%)
Common source of noise		
Generator	200	51.2
Traffic	106	27.1
Sound system	43	11.0
Mosque/Church	36	9.30
Others	6	1.50
Total	**391**	**100**
Number of people per room		
One	39	10.0
Two	153	39.1
Three	135	34.5
Four	55	14.1
Others	6	1.50
No response	3	0.80
Total	**391**	**100**
Awareness on the effects of housing conditions on health		
Aware	235	60.0
Not aware	156	40.0
Total	**391**	100
Source of Awareness		
Environmental Health Officer	82	21.0
Television	97	25.0
Radio	141	36.0
Public Lecture	21	5.00
Others	50	13.0
Total	**391**	**100**

Table 4: Vectors and diseases' conditions in Makurdi Town (N=391)

Variable	Frequency	Percentage (%)
Common vector in dwellings		
Cockroaches	82	21.0
Rats	50	12.8
Mosquitoes	237	60.6
House flies	22	5.60
Total	**391**	**100**
Diseases mostly reported		
Malaria	260	66.5
Cough	70	17.9
Hypertension	15	3.80
Typhoid fever	46	11.8
Total	**391**	**100**
Skin conditions mostly reported		
Skin rashes	220	56.2
Eczema	13	3.20
Ring worm	42	10.6
None	116	30.0
Total	**391**	**100**
Number of people sick in the last six month		
1-3	313	80.0
4-6	41	10.5
=7	1	0.30
None	36	9.20
Total	**391**	**100**

As shown in Table 5, Chi-square analysis revealed that common vectors, number of persons per room, sources of water and sources of heat supply for cooking were found to have statistically significant relationship with commonly reported health problems ($p < 0.05$). With this result, the null hypothesis is therefore rejected. In effect, there is statistically significant relationship between housing conditions and commonly reported health problems in Makurdi Town.

Table 5: Chi-square test results for some housing conditions and reported health problems in Makurdi Town

	Calculated X^2	df	Tabulated X^2	P value
Common vectors and commonly reported health problems	47.475	18	28.87	0.000
Number of people per room and Commonly reported health problems	31.016	16	26.29	0.013
Sources of water and commonly reported health problems	29.257	16	26.29	0.022
Places where food is cooked and commonly reported health problems	41.270	20	31.41	0.003
Sources of heat supply for cooking and commonly reported health problems	36.920	16	26.29	0.002
Roofing materials and commonly reported health problems	4.676	18	28.87	0.792
Number of windows per room and commonly reported health problems	22.557[a]	30	43.77	0.311
Awareness and commonly reported health problems	8.676[a]	6	12.59	0.070

Discussion

Majority of the houses were roofed with zinc (corrugated iron sheets), had glass windows and majority were built with concrete. Such houses protect the inhabitants from exposure to rain, dust, dangerous animals, wind and human attacks. This is similar to the findings of the study conducted on knowledge of quality housing in North-Central Nigeria where 91.3% of the houses were observed to be built with concrete and 88.8 % roofed with corrugated iron sheets (Tagurum *et al.,* 2015) . These types of building materials are recommended for buildings in Nigeria (Nigeria, 2006).

Majority (87.7%) of the houses had two windows per room. This is different from a study in North Central Nigeria that found that most rooms had one window per room (Tagurum *et al.*, 2015). This could be from the high level of awareness of the respondents who are mostly the owners of the houses, as regards the link between conditions of housing and health. The replacement of air inside a building is one of the primary factors determining health and well-being (Atolagbe, 2014).

Frequency of house renovation in Makurdi Town was poor. Majority (65.5%) of the respondents indicated that their houses were not renovated. Lack of adequate maintenance culture was reported as a major problem affecting most buildings in Nigeria (Ibiwumi, 2015). This has adverse effects on health as lack of building maintenance has been implicated in building collapse, causing injuries and human death as well as 'Sick Building Syndrome' with occupants usually coming down with such symptoms as neuropsychiatric disturbances, skin disorders, asthma, headaches, nausea, cold, sore throat, fatigue, unpleasant odour and taste sensations. (Ibiwumi, 2015; Windapo & Rotimi, 2012).

Some of the respondents indicated cooking their food on the corridor and even within their bedrooms. This increases health risks among the residents. Exposure to smoke in a housing facility can increase the health risks of eye irritation and respiratory disorders on the residents (Olukolajo, Adewusi, & Ogungbenro, 2013). In this study, 32.5% of the respondents indicated that they used kerosene stoves as their source of heat for cooking. This agreed with the study of Olukolajo *et al.* (2013) who reported that 58.58% of the respondents used kerosene stoves for cooking. Exposure to smoke among the residents was also observed as some of the residents cooked inside their bedrooms and along the corridors.

With regard to type of toilet, most (58.6%) of the respondents indicated that they were using 'pour flush' toilets. Olukolajo *et al.* (2013), in his study reported that the common types of toilet facilities reportedly used by respondents were pit latrines. This dissimilarity could be because of the difference in architectural design in the study areas. Some respondents however reported not having toilets and resorted to open defecation. This practice is risky to health as open faeces can cause massive faecal contamination of the environment thereby causing repeated exposure of the residents to faecal bacteria and faecal pathogens (Mara, 2017).

The major (51.2%) source of water supply in this area was indicated by the respondents to be hand dug wells. This agreed with the findings from a study in Moniya community in Ibadan which showed that 63.74% of the inhabitants obtained water from hang-dug wells (Owoeye & Ogundiran, 2015). This is unsafe as water from hand dug wells are easily contaminated, especially in flood prone areas like Makurdi, and could result in outbreaks of water-borne diseases. A protected water supply with the aid of pipes into a housing facility is the best means of providing adequate quantities of safe water (Musoke *et al.*, 2018).

Investigation on drainage conditions in the study area revealed that 69.8% of the houses did not have gutters in the immediate housing environment. Lack of gutters is a major contributor to flooding (Ocheri & Okele, 2012). Flooding leads to contamination of the environment and breeding of mosquitoes which lead to disease epidemics and collapse of buildings resulting in injuries and death of inhabitants (Ocheri & Okele, 2012).

Results on the methods of refuse disposal in Makurdi town revealed that most of the inhabitants (59.3%) of housing units practised open dumping. This disagreed with the report by Tagurun *et al.,* (2014) who reported that half of the houses employed burning as their main refuse disposal method. This practice of refuse disposal defaces the environment, encourages the breeding of rats, house flies and cockroaches which are vectors of diseases that affect man and also produce foul odour (Park, 2013).

Slightly above half (51.2%) of the respondents indicated that generators were the main sources of noise. This high use of generators in the study area could be as a result of shortage in supply of public electricity in the area as reported by Akin and Adejumobi (2017) in Ogbomoso, Nigeria. Noise pollution produces direct and cumulative negative effects that weaken health and degrade residential, social, working, and learning atmosphere with corresponding economic and well-being losses (Oyedepo, 2012).

Findings on occupancy ratio per room revealed that two people to a room accounted for 39.1% which is similar to the report by Tangurum *et al.,* (2014), where most (47.5%) of the respondents indicated that two people occupied a room in their housing units. This shows that occupancy ratio per room in this area is commendable based on the Nigerian government prescribed occupancy ratio of 2.0 persons per room. This implies that the physical and mental health risks associated with overcrowding will be minimal in this area (Park, 2013).

Responses indicated 47.8% of damp homes from various sources mostly from failed damp proof course. Dampness in houses causes the growth of mould and resultant health effects such as asthma, bronchitis, migraine and depression (Bonnefoy, 2007).

Findings on common vectors in houses in the study area revealed that mosquitoes were the most prevalent (60.6%). Malaria fever (66.5%) cases were the most prevalent health issues also. This is similar to studies carried out in Calabar Municipality by Ita (2010). Ogundahunsi and Adejuwon, (2014) and Olukolajo *et al.* (2013), who also reported malaria fever as the most reported disease in housing units. Malaria fever cases are high where there are mosquitoes and there is weak or no control and preventive measures put in place.

Results on skin conditions mostly reported in houses in the study area revealed skin rashes as the most reported skin condition. The high prevalence of skin rashes could be as a result of the high environmental (external and internal) temperature of the study area. In addition, space and building placement were observed to be violated in most parts of the study area as leapfrog pattern of building placement was seen. This can hinder free flow of air.

Results on the number of people that were sick in homes in the earlier six months as at the time of this research, in Makurdi town showed that 80% of the houses had one - three sick persons. Results also showed that 60% of the respondents were aware of the relationship between housing conditions and health. This agreed with the study by Tagurum *et al.,* (2015), which reported that 66.3% of the respondents were aware that conditions of housing affect the health of the residents. This showed that awareness on the relationship between housing conditions and health was high in the study area. This can also be the reason for the few number of sick persons in the housing units. This awareness could be as a result of the high level of education of the respondents with most (48.3%) of them having attained tertiary education. This study further reported that (36%) of the respondents got awareness through the radio. A study carried out in Indonesia revealed that higher educational status was found to be associated with better knowledge of housing (Sudarmadi *et al.,* 2001). Common vectors, number of persons per room, sources of water and sources of heat supply for cooking were also found to have statistically significant relationship with commonly reported health problems ($p < 0.05$). These findings thus suggest that housing conditions have implications on health of residents in Makurdi Town.

Conclusion

This study concludes that housing conditions in Makurdi Town has health implications on the residents. Among the notable findings are statistically significant relationships between common vectors, number of persons per room, sources of water, sources of heat supply for cooking and reported health problems. Some of the basic requirements of housing meant for human habitation were lacking or inadequate in quality and quantity. Some of the houses were damp, ill-ventilated, littered with refuse, or lacked important sanitary facilities. In addition, some of the houses lacked secured drainage channels, as well as facilities for prompt and sanitary solid waste disposal, including regular and wholesome water supplies, among other requirements. Good health can only be attained through good housing facilities. Therefore, routine enlightenment campaign on the health implications of housing conditions on residents is highly recommended.

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Profiles of Indoor Airborne Microbes in Federal University of Technology, Owerri, Imo State, Eastern Nigeria

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Abstract
The indoor air quality of some selected sites at the Federal University of Technology, Owerri were analysed using the Buck Air Sampler. A total of five hundred and four microbiological air samples were analysed from the forty-two sites in the morning and afternoon during the dry and wet seasons. Microbiological analysis of total heterotrophic bacterial counts and total heterotrophic fungal counts were analyzed. Results from the study revealed that there were higher bacterial counts (202.3 CFU/μ^3) and fungal counts (23.3 CFU/μ^3) in dry season than in wet season. The microorganisms isolated were *Bacillus* sp, *Micrococcus* sp, *Staphylococcus* sp, *Klebsiella* sp, *Streptococcus* sp, *Fusarim* sp, *Penicillium* sp, *Aspergillus* sp and *Mucor* sp. The highest bacterial count was recorded in the afternoon during both seasons indicative of the influx of students and others at this time. *Staphylococcus aureus* was the most frequently assessed bacterium (100%) whereas *Penicillium* sp (71.4%) was the predominant fungus isolated. The presence of pathogenic airborne microorganisms observed in the indoor air was of great concern as these pathogens play significant roles in causing ill-health in humans.

Les Profils des Microbes Aériens D'intérieur à L'université Fédérale de Technologie, Owerri Dans L'état D'imo, a L'est du Nigéria

Résumé
La qualité de l'air intérieur de certains sites sélectionnés à l'Université fédérale de technologie d'Owerri a été analysée à l'aide de l'échantillonneur Buck Air. Au total, cinq cent quatre échantillons microbiologiques d'air ont été analysés sur les quarante-deux sites le matin et l'après-midi pendant les saisons sèches et humides. L'analyse microbiologique des dénombrements bactériens hétérotrophes totaux et des dénombrements fongiques hétérotrophes totaux ont été analysés. Les résultats de l'étude ont révélé qu'il y avait des comptages bactériens (202,3 CFU/µ3) et fongiques (23,3 CFU/µ3) plus élevés en saison sèche qu'en saison humide. Les microorganismes isolés étaient Bacillus sp, Micrococcus sp, Staphylococcus sp, Klebsiellasp, Streptococcus sp, Fusarimsp, Penicilliumsp, Aspergillus sp et Mucorsp. Le nombre de bactéries le plus élevé a été enregistré dans l'après-midi au cours des deux saisons, ce qui indique l'afflux d'étudiants et d'autres personnes à cette époque. Staphylococcus aureus était la

bactérie la plus fréquemment évaluée (100 %) tandis que Penicilliumsp (71,4 %) était le champignon prédominant isolé. La présence de micro-organismes pathogènes en suspension dans l'air observé dans l'air intérieur était très préoccupante, car ces agents pathogènes jouent un rôle important dans la mauvaise santé des humains.

Introduction

Bio-aerosols are defined as airborne particles of biological origin. Bio-aerosols include airborne bacteria, viruses, fungi and other biological fragments such as airborne DNA fragments (Ambrose *et al.,* 2015). In modern urban setting, people spend more than 90% of their time in enclosed spaces such as houses, office buildings and schools.

Therefore, indoor contamination has caught the attention of scientists and the general public in many countries (Elena *et al.,* 2015). Indoor deposition of bio-aerosol is one of the most important factors that determines the adverse side effects of particle exposure on human health (Elena et al., 2015). An individual on an average inhales 14m^3 air per day (Shahinur *et al.,* 201). Thus, presence of high concentration of microorganisms in the inhaled air can adversely affect health and activities of the people. Pathogenic living cells present in the air and /or the chemical substances secreted by the airborne microbes can cause severe human infections and diseases (Shahinur *et al.,* 2016). The aim of this study is to determine the profile of indoor air microbes and the influence of seasonality on the microbial profile within Federal University of Technology, Owerri Campus.

Description of the Study Area

This study was conducted at the Federal University of Technology Owerri, Imo State from January to August. The Federal University of Technology, Owerri (FUTO) Campus is located in Ihiagwa. The great Otamiri River passes through the town. FUTO is located on Latitude (DMS) 5^{0}24$^/$Longitude (DMS) 7^0 1$^/$ OE Nigeria Altitude (Metres).

Materials and Methods

Media used are Nutrient Agar, Sabouraud Dextrose Agar, Mannitol Salt Agar, MacConkey and Muller - Hinton agar.

Collection of Samples

A total of five hundred and four (504) microbiological indoor air samples were analysed from the forty-two (42) sites during the dry and wet seasons (January and August). Air samples were collected from seven (7) different indoor sites namely Canteen/ Eateries, Conference halls, Lecture halls, Lecturers' offices, Students' toilets, Hostels and Laboratories. A microbial air sampler, Bucks air Bio-culture pump (Model B30120 Buck INC) was used for sample collection. The Buck Bio-culture pump was adjusted to aspirates 240 flow rate litre of air per 2 minutes at 4.8 pressure mm/H_{20} onto the solid culture media. Each day, the air samples were collected twice, in the morning (10-11am) and in the afternoon (1-2 pm). Upon collection, the media plates were transported to the laboratory for microbiological analysis using recommended standard microbiological methods according to Cheesbrough (2006). The volumetric sampling machine was coupled with prepared solid agar media plates and the knob was adjusted to the required volume and time. The volume of air to be aspirated is based on this adjustment. Upon collection, the media plate was aseptically covered immediately to avoid inflow of additional air.

The plates were sealed in sampling bags for onwards forwarding to the laboratory for analysis. The bacteria media plates were incubated at 37^{o}C for 24hrs. The fungal plates were kept at room temperature for five (5) days (Cheesbrough, 2006).

Enumeration of Microbial Counts

Colonies which developed on the different culture media plates after incubation were counted and recorded as Colony Forming Unit/ Cubic Metre (CFU/m^3) of the sample analyzed using the conversion table formula on the sampling machine manufacturers guide (Buck, 2003).

$$Pr = N\,[1/N + 1/N-1 + 1/N-2 + \ldots 1/N-r]$$

Where N = 400 (Number of holes in perforated lid of the sampler)
r = Number of CFU counted on petri-dish
Pr = Statistically corrected total count of bacteria in tested air volume.

Bacterial Identification

The bacterial growth which developed on the culture media plates were cultured sub- on freshly prepared nutrient Agar plates. Characterization and identification of pure isolates were performed using standard microbiological techniques. All biochemical test reagents were obtained from Oxoid, UK. Bergey's Manual of Determinative Bacteriology was used for characterization and identification of bacterial isolates.

Fungal Identification

The fungal growths which developed on the fungal plates where subcultured on freshly prepared Sabouraud Dextrose Agar (SDA) plates. A three-day old fungal isolates on SDA plates subcultured from SDA slants were used for microscopic examination of the fungal isolates using wet preparations of the isolates in Lacto-phenol cotton blue stain. Fungal Atlas was referred to for the identification and characterization of organisms observed.

Anti-microbial Susceptibility Testing

Anti-microbial susceptibility tests were performed using the modified Kirby-Bauer Disc Diffusion Technique (Bauer *et al.*,1966). Bacterial suspension turbidity was adjusted to 0.5McFarland Standard. Antimicrobial agents used are: Vancomycin (30 µg) , Methicillin (5µg) Oxacillin (5µg), Tetracycline (30µg), Cefotaxime (µg), Ceftazidime(30 µg), Erythromycin (15 µg), Streptomycin (10 µg), Ciprofloxacine (5µg) and Gentamicin (30µg). Antimicrobial agents were selected based on clinical significance, local treatment protocol and literature data search. The results were integrated using Clinical and Laboratory Standards Institute Guidelines.

Results and Discussion

The profile of indoor airborne microbes in Federal University of Technology Owerri, Imo State, Nigeria revealed the presence of bacterial and fungal isolates. The microorganisms isolated from the sites analysed were *Bacillus subtilis, Micrococcus* spp.,*Klebsiella* spp.,*Streptococcus* spp., *Staphylococcus aureus, Staphylococcus epidermidis, Salmonella* spp., *Trichophyton* spp., *Fusarium* spp., *Penicillium* spp., *Aspergillus and Mucor* spp. Most people spent 90% of their entire time indoor. The daily indoor activities of people in education environment including influx of students, sweeping, waste generation practices from some of the sites contributed to the buildup and spread of airborne microbes in the sample sites at the university. High burden of indoor air microbes was also reported in different countries in the world (Hayleeyesus and Manaye, 2014; Ekhaise and Ogboghodo, 2011 and Shahinur *et al.,* 2016). The most common microbes in the indoor environment are the saprophytic bacteria of the normal flora of human body which are emitted into the indoor air through droplets from the airways by sneezing, coughing and talking. The upmost layer of the human body is renewed continuously and skin scales containing bacteria are shed into the environment. Others are the heterotrophs from human activities as well as moist environment, thus the *Bacillus spp.* and the fungi.

Table 1: The mean of total heterotrophic microbial counts of the sampling sites during the dry and wet seasons

Sampling sites	Dry season THBC (CFU/m^3) M. A	Dry season THFC (CFU/m^3) M. A	Wetseason THBC (CFU/m^3) M. A	Wetseason THFC (CFU/m^3) M. A
Canteens	115.7143.9	14.317	57. 79.3	7.3. 8.3
Conference room	102.3114.3	23.321.3	86. 77	8.3. 7.3
Lecture Halls	143147.7	19.317	71.6. 73	10. 9.7
Offices	110202.3	1523.3	55. 101.3	8. 11.6
Toilets	147.676	10.317.7	73.7. 38	5.8. 9
Hostel rooms	132.345.3	17.719	66.3. 35	8.7. 9
Laboratory	87.596.2	8.36	36.7. 28	9.3. 7.3

Key: M= morning, A= Afternoon. THBC= Total Heterotrophic Bacteria Count.
THFC=Total Heterotrophic Fungal Count.

The mean of the total heterotrophic microbial count of the sites analysed showed that mean bacterial count ranges from 202.3 cfu/m^3-45.3cfu/m^3 in dry season which is higher than that of the wet season which ranges from 101.3-3.5cfu/m^3. The fungal counts of the wet season were far less than that of the dry season. This could be due to the fact that fungi are known to disperse more during the dry season. The microbial loads of the lecture hall, and hostels were higher than that of offices and laboratory. This is attributed to the influx of activities in these places. The growth was observed to be higher in the afternoon than in the morning. The clear evidence of seasonal changes in the microbial load could be attributed to environmental conditions such as high temperature, windy atmosphere and low humidity that favour the growth and proliferation of microorganisms. This is in agreement with the study by (O'Connel, 2000) whose report shows that dry season favours the proliferation of microorganisms.

Table 2 shows the percentage of occurences of the isolates, *Staphylococcus* was predominant (100%) followed by *Klebsiella* sp (85%). Other isolates include *Bacillus* sp (71.4%), *Penicililum* sp. (71.4%), *Micrococcus* sp (57.1%) and *Streptococcus* sp. (57.1%). *Aspergillus* sp., S*taphylococcus epidermidis* also had (57.1%) respectively. *Mucor* sp., *Fusarium* sp., *Trichophyton* sp. and *Salmonella* sp. had (42.9%) respectively. Bonetta *et al.* (2010), found *Staphylococcus* and *Micrococcus* as the most prevalent bacterial genera in indoor environment.

The sampling sites that had the highest microbial occurrence were the hostels (75%), Canteen and Lecture halls (66.7%) respectively. The office and toilet had (58.3%) while the unoccupied conference halls had the least (33.3%). This result showed that different room or indoor environment exhibited different microbial load depending on the activity that is going on there.

In student hostels, poor ventilation exists due to overcrowding caused by large number of inhabitants in the rooms and frequent movement of too many occupants in and out of the room for various activities that created more opportunities for microorganisms to be introduced. This study recorded high microbial counts in student hostels. The canteens, lecture halls and student hostels had high microbial counts due to influx of human activities in those places. Laboratories and lecture halls are used for lectures and the use of ceiling fans in these sites for ventilation also contributed to the presence of air microbes. Sources of ventilation such as ceiling fans and air conditioners serve as sources of dispersal of airborne bacteria and fungi. O'Connel and Humphrey (2000) also brought attention to air conditioning systems as potential microbial dispersions in canteens and other units where people converge.

The bacterial isolates that occurred most frequently in the sampling sites were *Staphylococcus aureus*, *Bacillus* sp., *Klebsiella* sp., and *Micrococcus* sp. *Penicillium* sp. and *Aspergillus* (Table 2).

From this result, organisms of great public health importance occurred frequently. For instance, *Bacillus* spp. and *Klebsiella* spp. are known to possess spores and capsules. This is of great concern as these organisms tend to affect the total health of the occupants if they come in contact with them. Students formed the greater population of the environment under study. As such there is great need to monitor the air inflow to avoid any disease outbreak.

The percentage occurrence of each microbial isolates in all the sampling sites as shown in Table 2 revealed that *Staphylococcus aureus* and *Klebsiella species* had the highest occurrence (100%) followed

Table 2: Percentage occurrence of microbial isolates from sampling sites during dry season

SAMPLING SITES	LABORATORY	CONFERENCE HALL	TOILET	OFFICE	LECTURE HALL	HOSTEL	CANTEEN	% OCCURRENCE
STAPHYLOCOCCUS AUREUS	+	+	+	+	+	+	+	
***BACILLUS* SP**	+	−	+	−	+	+	+	**100**
***SALMONELLA* SP**	−	−	+	−	+	−	+	**71.4**
MICROCOCCUS	+	−	−	−	+	+	+	**42.9**
***KLEBSIELLA* SP**	+	+	+	−	+	+	+	**57.1**
***STREPTOCOCCUS* SP**	+	−	−	+	+	+	−	**85.7**
STAPHEPIDERMIS	+	−	+	+	−	+	−	**57.1**
***TRICHOPHYTON* SP**	+	−	−	+	−	+	−	**57.1**
***FUSARIUM* SP**	−	+	−	+	+	−	−	**42.9**
***PENICILLUM* SP**	+	−	+	+	−	+	+	**42.9**
***ASPERGILLUS* SP**	−	−	+	−	+	+	+	**71.4**
***MUCOR* SP**	−	−	−	+	−	−	+	**57.1**
% OCCURENCE	**66.7**	**33.3**	**58.3**	**58.3**	**66.7**	**75**	**66.7**	**42.9**

Table 3: Percentage occurrence of microbial isolates from the sampling sites during the wet season

SAMPLING SITES	LABORATORY	HOSTEL	TOILET	OFFICE	LECTURE HALL	WALK WAY	CANTEEN	% OCCURRENCE
	+	+	+	+	+	+	+	
STAPHYLOCOCCUS AUREUS								
	−	−	+	−	+	+	+	100
								57.1
BACILLUS SP	+	−	+	+	+	−	−	
								57.1
	−	+	−	−	+	+	−	
SALMONEL LA SP								42.9
	+	+	+	+	+	+	+	
								100
	−	+	+	−	+	−	+	
MICROCOC CUS								
	+	−	−	+	−	−	+	57.1
	−	−	+	−	−	+	−	42.9
KLEBSIELL A SP								
	−	−	+	−	+	−	+	28.6
STREPTOCO CCUS SP	+	+	−	−	+	+	+	
								42.9
	+	+	−	−	+	−	+	
STAPH EPIDERMIS								71.4
	−	+	−	+	−	−	+	42.9
TRICHOPHY	**50**	**58.3**	**58.3**	**41.7**	**75**	**50**	**75**	

by *Penicillium* species (71.4%), *Salmonella Bacillus, Streptococcus* and *Asperigillus* species had the same occurrence (57.1%), *Micrococcus, Staphylococcus epidermis, Fusarium and Mucor* species had the same occurrence (42.9%) while *Tricophyton* species had the least occurrence (28.65%). The overall percentage occurrence of all the microbial isolates in each sampling site showed that canteen and lecture hall had the highest occurrence (78%), followed by toilet and conference hall (58.3%) each, hostel and laboratory recorded the same percentage occurrence (50%) each while office had the least occurrence (41.7%).

The antibiotics resistance pattern of the bacterial isolates is shown in Table 4. The bacterial isolates were tested for different antibiotics.

All gram positive isolates (*Bacillus, Micrococcus, Streptococcus, Staphylococcus aureus* and *Staphylococcus epidermis*) were susceptible to vancomycin, tetracycline, gentamacin and ciprofloxacin. The gram negative isolates (*Klebsiella* sp, and *Salmonella* sp) were resistant to vancomycin and sensitive to tetracyclin, erythromycin, streptomycin, ciprofloxacin and gentamycin. All isolates were resistant to ceftazidime and oxacillin.

Among the isolates investigated, 100% exhibited resistance to Ceftazidime and Oxacillin, while 100% of the isolates were sensitive to Ciprofloxacin, Gentamycin and Erythromycin. This result is in agreement with previous studies where Erythromycin and Gentamacin were found highly effective against *Staphylococcus aureus, Bacillus* sp and *Micrococcus* sp. (Shahinur *et al.,* 2016 and Agbagwa and Jirigwa 2015).

Table 4: Antibiotics susceptibility of bacterial isolates

ANTIBIOTICS	*Bacillus* **Sp**	*Micrococcus* **sp**	*Klebsiella* **sp**	*Streptococcus* **sp**	*Staphylococcus* **aureus**	*Salmonella* sp	*Staphylococcus* epidermidis
VANCOMYCIN (30µG)	**S**	**S**	**R**	**S**	**S**	**R**	**S**
METHICILLIN (5µG)	**R**	**S**	**S**	**S**	**R**	**S**	**R**
TETRACYCLIN (30µG)	**S**	**S**	**S**	**S**	**S**	**S**	**S**
CEFOTAXIME (30µG)	**S**	**R**	**S**	**S**	**S**	**R**	**R**
CEFTAZIDIME (30µG)	**R**	**R**	**R**	**R**	**R**	**R**	**R**
ERYTHROMYCIN (15 µG)	**S**	**S**	**S**	**S**	**S**	**S**	**S**
STREPTOMYCIN (10 µG)	**S**	**S**	**S**	**S**	**R**	**S**	**S**
CIPROFLOXACIN (5µG)	**S**	**S**	**S**	**S**	**S**	**S**	**S**
GENTAMYCIN (10µG)	**S**	**S**	**S**	**S**	**S**	**S**	**S**
OXACILLIN (5µG)	**R**	**R**	**R**	**R**	**R**	**R**	**R**

NOTE: S = SENSITIVE R = RESISTANT

Conclusion

In this study, the levels of bacteria and fungi <300 CFU/μ^3 were higher than the intermediate categories of air quality. The microbial loads were higher in the afternoon than in the morning. It was observed that students and visitors were mostly around in the afternoon than in the morning, hence the higher counts recorded. Therefore, it is highly recommended that appropriate methods for maintaining regular cleaning and disinfections of classrooms, offices, laboratories, canteens e.t.c., in universities be instituted so as to decrease indoor airborne microbes and health-related issues associated with bio aerosols and the resistance of the isolates to 3rd and 4th generation cephalosporins, which poses great concern. Further studies on the DNA profile of the isolates are recommended to estimate their genetic make-up and possible reasons for the gross resistibility.

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