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Aircraft Noise Levels, Annoyance and General Health of Residents of Communities contiguous to a Major Airport in Lagos State

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Abstract

The purpose of this study was to investigate the relationship between the aircraft noise exposure, annoyance reactions and health status of the residents living within the vicinity of the Murtala Muhammed International Airport (MMA) in Lagos state, Nigeria. Aircraft noise monitoring was conducted in five locations within the vicinity (0-5Km) of MMA, and a sixth distant location (14km away). Levels of aircraft noise for all five locations within the vicinity of the airport exceeded the EPA Victoria threshold of 75 dB LAmax for the residential area (outdoor). A survey on annoyance induced by aircraft noise exposure and general health status was conducted on 450 local residents in the study locations using the International Commission on Biological Effect of Noise question and a single question that has been applied in Dutch national health care surveys since 1983 on self-reported general health status respectively. Percentage of residents within the vicinity of MMA that were highly annoyed (%HA) exceeded 15% guideline limit stipulated by Federal Interagency Committee on Urban Noise while 14.5% reported poor health status. There was a significant association between the annoyance reactions and aircraft noise levels in the study locations while the association between self-reported health status and aircraft noise levels was not significant. Taken together, the residents within the vicinity of the airport are exposed to aircraft noise levels above permissible limit which may be associated with high annoyance reaction but may not be associated with poor health rating. Evidence-based aircraft noise related policies by government are advocated.

Keywords: *aircraft noise, resident, health, annoyance, communities.*

Introduction

Noise pollution, a by-product of urbanization and industrialization, is now recognized as a major problem for the quality of life in urban areas (Essandoh and Armah, 2011). The rapid growth in the number of domestic airports, scale and number of flights in recent years may lead to an increasingly stronger influence of aircraft noise on the environment and human health especially in densely populated areas (Guoqing *et al*, 2012). Hence, people living near the airports are concerned about health effects of aircraft-related pollution and safety. These concerns are substantiated by findings that aircraft noise may have adverse effects such as annoyance, sleep disturbance, cardiovascular diseases and interference with children's learning abilities in schools exposed to aircraft noise (Stanfeld and Crombie, 2011; Ana *et al*., 2009; Mestre, 2008; Franssen *et al*. 2004; Stansfeld and Matheson, 2003).

Since the 1960s, comprehensive social surveys have been conducted among the residents around airports in many developed countries to evaluate the effects of aircraft noise on human beings. Annoyance has been viewed as the single most significant effect associated with aviation noise in these studies (Guski, 2017; Seabi, 2013; Guoqing *et al*., 2012; Franssen *et al*., 2004; Mestre, 2008; Stansfeld and Matheson, 2003; Finegold *et al*., 1994, Newman and Beattie, 1985). Exposure-response relationship synthesized from these studies has been useful in predicting the effect of general transport noise on people in Environmental Impact Analysis (EIA). Relatively, very few studies have been conducted on aircraft noise and its effects in Africa (Seabi

2013; Akpan *et al*., 2012; Pillary 2011; Hume *et al*., 2008; Goldschagg 2007) and non-auditory health effects such as annoyance and sleep disturbance has been established.

There is also a high population growth rate in some cities of developing countries such as Lagos in Nigeria (Lagos has an annual population growth rate of 6.4% compared with the national population growth rate of 2.8% (Debate to Action, 2007)). The increasing population density has led to encroachment of communities living closer to the airports to hitherto demarcated landspace serving as buffer zones. Secondly, the aviation industry experiencing rapid growth in Nigeria leading to expansion and increase in the number of runways for an increasing number of flights per day. Consequently, communities contiguous to airports are increasingly exposed to noise levels above permissible limit of 55dB LAeq or 85dB LAmax for residential areas (Bajdek, 2006; EPA Victoria, 2008; Berglund et al., 1999). There is therefore the need to carry out aviation noise assessment and monitoring to determine exposure levels in such communities and compare with permissible limits considering the possible noise related health effects.

Unlike two previous studies conducted in Nigeria (Akpan *et al*., 2012), the internationally standardized general-purpose noise reaction questions for community noise surveys developed by International Commission on Biological Effects of Noise (ICBEN) was used to measure annoyance. The previous studies were on Margaret Ekpo International Airport, Calabar and Port-Harcourt International Airport. However, this study, intends to investigate communities contiguous to Nigeria's busiest airport, Murtala Mohammed International Airport, Lagos in order to generate a more comprehensive database on the prevalence of annoyance experienced by communities within the vicinity of the airport using standardized instruments that will be comparable internationally and hence, a reliable tool for strong advocacy and policy formulation for noise control.

Therefore, the study:

1. Assessed the aircraft noise levels within the communities contiguous to the Murtala Mohammed Airport (MMA) and developed a noise risk map for the area.
2. Assessed the level of annoyance due to aircraft noise exposure experienced by communities within the vicinity of the MMA and compare with the guideline limit.
3. Assessed the self-reported general health status of individuals living in communities within the vicinity of the MMA and
4. Determined the relationship between the annoyance and self-reported health status with the aircraft noise level exposure in the communities within the vicinity of the MMA respectively.

Method

Study Area

Ikeja, the state capital and administrative nerve center of Lagos State Government, is located 80 Km north of Lagos. The division incorporates a concentration of each medium and large-scale industries at intervals the Mushin-Isolo-Oshodi and bigger Ikeja Industrial advanced, whereas conjointly having an oversized agricultural space in its rural Alimosho, Kosofe and Agege districts. It equally has a fledging Central Business District (Alausa/Agidingbi) and Nigeria's biggest and busiest International Airport (Murtala Mohammed Airport). The Ikeja division is a socio-cultural representative of the typical Nigerian society with various ethnic groups being well represented. It also occupies a strategic and central location in the state and therefore serves a transit point within the Lagos metropolis, other state and outside world. It houses the Murtala Muhammed International Airport and its local wing, thus making it the gateway to Nigeria (see Fig 1).

Study design and Study population

The study was a cross-sectional study. The study population was residents of Ikeja, Oshodi-Isolo, Alimosho and Agege communities. Alimosho has the highest population of 1,277,714 followed by Oshodi-Isolo which has a population of about 621,509 people; Agege has 461, 743 people while Ikeja has 313,196 people (NPC, 2007). Males and females within the age group of 15 to 65 years and capable of providing authentic information for the study whose houses are located along the flight paths of the aircraft were the participants in the study.

Aircraft noise monitoring

The aircraft noise levels produced during each flight incidence (arrival or departure) was recorded using a well caliberated high-quality AEMC mobile sound level meter (SLM) with shockproof holster (CA 832) in line with International Civil Aviation Organization (ICAO) Standard and Recommended Practices, Annex 16, 1993. Measurements were done using maximum sound levels (Lmax) in decibels (dB(A)). When the measurements were made, the microphone of the SLM was placed in such a way that it is not in the acoustic shadow of any obstacle in appreciable field of reflected waves. This was ensured by choosing measuring points of not less than 3.5 meters from reflective surfaces, such as walls and buildings, other than the ground (EPA Victoria, 2008). SLM was raised in the direction of the flying aircraft at an arm's length, some distance away from the body of holder, about 1.5 meters high from the ground to correspond to the ear position of an average person. The monitoring points were more than 50 m away from a possible noisy setting/area like a large/major market, a busy main road and an industrial site, with ambient/ background noise within the range 60-65dB(A).

The aircraft noise level was measured over a period of 8 weeks at six monitoring points within the vicinity of the airport and distances spatially distributed. Periods of noise measurement for noise studies are usually divided into day-time (0700h – 2200h) and night-time (2200h – 0700h). However in this study, three sets of noise level readings per day were obtained at each study location, in the day-time: morning (0900h-1200h) and evening (1600h-2200h) and night-time (2200h-0100h) respectively and three days in a week (Monday, Wednesday and Sunday). An average of twelve (12) noise readings were obtained at each measuring point per day for a period of about twelve (12) hours of a day, and was written down in a notebook provided for this purpose. In all, about one thousand seven hundred and twenty-eight (1728) noise readings were obtained from the 6 measuring points used in this study. The meter was set at A-weighting frequency network and at "fast" response range. The fast response corresponds to the time constant of 0.125s and this approximates the time constant of the human hearing system.

The frequency of the flight in the study location was obtained as secondary data from the Federal Airport Authority of Nigeria (FAAN). This was to analyze the daily and weekly pattern of aircraft noise exposure level in the communities and also to identify peak periods for noise levels produced by the arriving or departing aircraft. Aircraft noise within the airport facility was monitored for one week to determine the noise level within the facility during the same events.

Measurements obtained were compared with the WHO and EPA Victoria guideline limits for the aircraft noise level in residential areas. Excessive residential noise exposure was defined as >55dB LAeq or 75dB LAmax according to the WHO and EPA Victoria standards respectively. The noise index or metrics used for aircraft noise monitoring was Lmax. This is an alternative to integrated noise metrics such as LAeq (EPA Victoria, 2008).

Risk Map Development

A hand-held, battery powered Global Position System (GPS) was used to obtain the geographic coordinates of the monitoring points. These were input into a Geographical Information Systems (GIS) software. GIS is a software application that can be used in describing the spatial relationships in the development of noise risk map. According to Adejobi (2012), the geographic concept of distance decay effect can be applied in explaining the spread of noise from a source. It explains the effect of distance on spatial interactions; therefore as one moves away from the source, the noise generation decreases with distance because of natural attenuation. Therefore, areas closer to the source of noise generation (take-off, landing and overflight of aircraft), experience higher levels of noise from it than areas farther from the noise source. GIS extension tools, in this case, Inverse Distance Weighted (IDW) shows the variation and susceptible boundaries to decibel levels in the area of study. Coordinates of sampled points and aircraft noise levels (LAmax) were imputed into the GIS and IDW was used to create boundaries of aircraft noise levels and safety areas in order to develop a risk map for aircraft noise levels in the study locations.

The mean noise level of the locations was classified into three main zones namely: low risk (<75 dB(A)), Medium risk area (75-85 dB(A)) and high risk (>85 dB(A)) using the EPA Victoria guideline limit for land use compatibility for residential buildings with respect to aircraft noise exposure (EPA Victoria, 2008). This was used to indicate the different risk zones in the study communities contiguous to Murtala Muhammed International Airport and its local wing. In the risk map, different colors were used to represent areas with different levels of risk and safety.

Social Survey

Residents who lived within 5 km away from the airport (Ikeja, Oshodi-Isolo, Alimosho and Agege communities) and 14km away (Festac) were assessed for effective comparison. A calculated sample size was used. A total of 450 questionnaires were evenly distributed among respondents in the six monitoring points/sampling locations whose GPS coordinates were obtained. Respondents were purposively and randomly selected in each location provided they met the eligibility criteria. Males and females within the age group of 15 to 60 years and capable of providing authentic information for the study whose houses are located along the fly paths of the aircrafts were selected as participants in the survey. To generate comparable data on the level of annoyance due to aircraft noise, the standardized general-purpose noise reaction questions for community noise surveys developed by International Commission on Biological Effects of Noise (ICBEN) was used (Fields *et al*., 2001). The ICBEN scale was applied and the respondents were asked questions like “thinking about the last 12 months or so, when you are here at home, how much does noise from noise source bother, disturb, or annoy you, by selecting one of 11 categories from 0 (not annoyed at all) to 10 (extremely annoyed)”. A single question that has been applied in Dutch national health care surveys since 1983 for self-rated general health status was also used in the survey to obtain information on the general health status of residents (Franssen *et al*, 2004).

Statistical Analysis and Data management

Percentage of respondents “Highly annoyed” (%HA) was set as the assessment basis of noise annoyance (Guoqing *et al*., 2012; Fields *et al*, 2001). Annoyance responses were elicited by means of an 11-point numerical scale of ICBEN. Responses in the top three out of 11 categories (10. 9 and 8) were categorized as “highly annoyed” (Guouing *et al*., 2012; Fields *et al*, 2001). For analysis of the general health status, the five-point scale single question: (1) very good (2) good (3) moderate (4) sometimes good sometimes bad (5) bad was dichotomized into “good” (categories (1) and (2)) and “poor” (the last 3 categories) (Franssen *et al*, 2004). Overall and stratified prevalence of annoyance and self-reported health per location were calculated. The association between the health indicators (annoyance and self-reported health) and aircraft noise exposure was assessed using χ^2 after the aircraft noise levels were categorized into high (>85 dB LAmax), medium (75-85dB LAmax) and low (<75 dB LAmax) (EPA Victoria, 2008). P-values below 0.05 were considered statistically significant. All analyses were performed using SPSS version 16.

Results

Aircraft Noise Levels

Table 1 shows mean aircraft noise levels of the study locations. The mean aircraft noise levels across the seven study locations were significantly different (p=0.000). There was a strong negative correlation (r =-0.946) between aircraft noise levels and distance to the MMA (p=0.002). The overall mean aircraft noise levels at different periods of the day, morning (0900-1200), evening (1600-1900) and night (2200-0100) were 87.4 dB LAmax, 88.3 dB LAmax and 86.4dBA LAmax respectively and the difference were not statistically significant (p>0.05). As shown in Fig 2, the mean aircraft noise levels at all the study locations except Festac exceeded the WHO and EPA Victoria guideline limit of 75 dB LAmax for residential buildings (outdoor) throughout the period of monitoring (p= 0.000).

Aircraft Noise Risk Map of Study Locations

Fig 3 shows the aircraft noise risk map for the study locations indicating the various risk zones due to aircraft noise exposure in communities within the vicinity of the airport. Table 2 shows the EPA Victoria guideline for siting of residential buildings near the airport and the risk categories used to develop the risk map based on aircraft noise levels (LAmax). Risk was categorized into low (below 75 dBA), medium (75-85 dBA) and high (greater than 85 dBA). Santos and Beesam are at high risk of experiencing noise-related health effects due to aircraft noise such as annoyance, sleep disturbance, speech interference, learning interference and reduction in cognitive performance. Mafoluku, Agege and Ajao are at moderate risk of experiencing the same while Festac the control area is at minimal or zero risk.

Socio-demographic characteristics of the study population

Table 3 shows the characteristics of the study population generally and specifically for each of the six study locations. Sex and age were similarly distributed among the six selected locations (p>0.05). Respondents were evenly distributed between the two sexes with a male and female ratio of 9:8. Over 80% of respondents are aged 15-34 years. The mean age was 27.3 ±9.5 years with the minimum and maximum ages of 15 and 64 years respectively. Most of the socio-demographic characteristics of the six selected locations were similar as shown in Table 3.

Annoyance

Table 4 shows the percentage highly annoyed (%HA) at different LAmax (aircraft noise levels) at the six study locations (p<0.05). Generally, %HA in the study locations increased with decreasing distance to the MMA and increasing aircraft noise levels. Considering its location to the MMA and its mean aircraft noise level (85.2dB(A)), Mafoluku respondents had an unusually high %HA (50%HA). Santos had the next highest %HA (45.9%) being closest to the airport (100m) and exposed to the highest mean aircraft noise level (97.9dB), followed by Beesam (42.4%, 91.2dB(A)), Agege (42.0%, 85.5dB(A)), Ajao (27.3%, 82.0dB(A)) and the least was Festac (0%, 62.1dB(A)). Fig.4 shows that %HA for all the study locations except Festac exceeded the recommended 15% guideline limit of highly annoyed persons to transportation noise as the criterion for determining incompatibility for residential land usage (according to Federal Interagency Committee on Urban Noise(1980) and Federal Interagency Committee on Noise (1992) of USA).

The relationship between aircraft noise level and annoyance was investigated. The aircraft noise levels in the study locations were categorized into high (>85dB(A)), medium (75-85dB(A)) and low level (<75dB(A)) and had a significant association with annoyance (p=0.000)(Table 4).

General Health Status

Table 6 shows that there was no significant difference in the general health status of residents in the study locations (p=0.136). Poor self-rated health was highest in Santos estate (23.9%) and least in Festac (11.1%). The average poor self-rated health status among all respondents was 14.5%. Statistical analysis also revealed that there was no significant association of general health status in the study locations with aircraft noise levels they were exposed to (p= 0.065) as shown in Table 7

Discussion

The aircraft noise levels in the study communities within the vicinity of the MMA (0 to 5 km radius) ranged from 73.5 to 106.2 dB LAmax. A similar study in Margret Ekpo International Airport, Calabar, Nigeria recorded values of 95 – 118 dB (A) in nearby communities (Akpan *et al*., 2012). The mean aircraft noise level of these study locations (85.5 - 97.9dB) exceeded the EPA Victoria-recommended threshold of 75dB Lmax except for Festac (62.1dB) a non-exposed group. It must be noted here that there is no locally established guideline limit for aircraft noise level in Nigeria as at the time of this study. Hence, EPA Victoria recommendation which is for Commonwealth countries was adopted for this study.

According to the EPA Victoria guideline for building acceptability based on maximum noise levels, Santos estate and Beesam estate, are clearly in "unacceptable" zones of aircraft noise exposure (>85dB). Ajao estate is within the zone of "conditional" acceptance (75-85dB) but none of those conditions are met in this area such as incorporating noise control features in the construction of residential buildings. Mafoluku and Agege are in the borderline between the two zones of aircraft noise exposure mentioned above. Only Festac residents were found to be living within the "acceptable" zone of aircraft noise exposure. The aircraft noise risk map developed from the above result shows that Santos and Beesam are under high-risk areas of health effects due to aircraft noise such as annoyance, sleep disturbance, speech interference, learning interference and reduction in cognitive performance. Mafoluku, Agege and Ajao are under moderate risk while Festac is under low risk based on aircraft noise exposure.

This risk map may be used as a reference document in siting buildings within these areas or in carrying out advocacy for noise control related programmes in the future.

This study confirmed that a significant association exists between aircraft noise levels and annoyance. Secondly, %HA had a linear relationship to aircraft noise levels when aircraft noise in the locations was categorized or used as a continuous variable. The dose-effect relationship has also been established for annoyance and transportation noise in many other studies where annoyance increases with increasing noise level exposure (Akpan *et al*.,2012; Gouquing *et al*., 2012; Finegold *et al*.,1994). Many researchers also see evidence that aircraft noise is rated as more annoying than other forms of transportation noise such as railroad or highway noise (Mesre, 2008; Finegold *et al*., 1994). The loudness, sudden and intermittent nature of aircraft noise, frequency, duration of exposure and number of events are factors that determine annoyance. Annoyance reactions due to noise involves broad psychological feelings which include irritation, discomfort, distress, and frustration, when noise interrupts one's psychological state or ongoing activities, and interferes with an individual's quality of life. Aircraft noise could therefore indirectly result in poor health, whereby noise annoyance from chronic noise exposure may cause prolonged activation of physiological responses such as increased blood pressure, heart rate and endocrine outputs (Clark and Stansfeld, 2007). A similar study conducted near Schiphol and Heathrow airports demonstrated adverse effects of aircraft noise on blood pressure (van Kempen *et al*., 2006).

All the study locations except Festac exceeded the recommended 15% guideline limit of highly annoyed persons to transportation noise as the criterion for determining incompatibility for residential land usage according to Federal Interagency Committee on Urban Noise(1980) and Federal Interagency Committee on Noise (1992). The WHO guideline limit for community noise in the outdoor residential environment for serious annoyance is 55 dB LAeq (16 hrs). In an airport study in China, 72.9 dB LAmax was the annoyance threshold established (Gouquing *et al*., 2012). Equivalent LAmax value is not given in the WHO guideline limit which is the noise metric used for this study. However, the 15% HA guideline limit by FICON shows that these residential communities near the MMA are currently situated in areas non-compatible for residential buildings due to excessive aircraft noise exposure. Annoyance may lead to other critical behavioral changes such as reduction in helping behavior and increase in aggressive behavior.

The result shows that the average poor self-rated health status among all respondents was 14.5%. This is surprisingly lower than a similar study in Netherland using the same single question that has been applied in Dutch national health care surveys since 1983 where poor self-reported health was 20% (Franssen *et al*., 2003). This may be due to relatively low access to quality health care by Nigerians to accurately know their health status and/or poor health-seeking behavior of residents.

There was no significant difference in the general health status among respondents of the study locations. Statistical analysis also revealed that there was no significant association between general health statuses in the study locations with aircraft noise levels. This result is consistent with the findings from one of the largest epidemiological studies (RANCH study), which established no effect of aircraft or road traffic noise on health (Haines *et al*., 2001). In another study perceived to be the first largest study to date to examine the effects of aircraft noise exposure on children's health and annoyance reactions within the African continent, similar findings were established (Seabi, 2013). It thus seems that exposure to aircraft noise does not have an adverse effect on self-reported health outcomes. However, these findings contradict those found in the Munich Airport Study, which demonstrated a significant decrease of total quality of life up to 18 months after the relocation of the airport (Bullinger *et al*., 1999). It is therefore recommended that future studies should either use the same instrument that measured the total quality of life in the Munich Study or objective measures of health to determine if aircraft noise exposure impacts negatively on health.

Conclusion

Having established that communities within the vicinity of Murtala Muhammed Airport are currently exposed to aircraft noise level above permissible limit (75dB LAmax) and a significant relationship between the aircraft noise and annoyance reactions among residents of these surroundings, effort should be geared towards reducing the amount of exposure of these community residents to the noise and also reducing the noise levels to recommended standard in order to improve the quality of life of the residents.

Nigeria is one country, among many developing countries, where a community survey on aircraft noise and health effects has not been used to establish any current environmental policies and strategies for aircraft noise control in the airport vicinity. Hence, the various stakeholders including the relevant government ministries, department and agencies such as Federal Ministry of Environment, Federal Ministry of Transport, Federal Airport Authority of Nigeria (FAAN), Nigerian Civil Aviation Authority (NCAA) and Nigerian Airspace Management Agency (NAMA), Land use agencies and residential communities need to collaborate with environmental health consultants in order to set local guideline limit for aircraft noise in communities within the vicinity of MMA which will be backed up by legislation.

Strategies to achieve aircraft noise abatement/mitigation in residential communities may include community awareness programs, attitudinal surveys, sound insulation programs, aircraft noise monitoring, noise and flight track system, preferred runways and flight path usage, aircraft certification, land-use compatibility, curfew, ground running and setting up complaints unit should be implemented by the appropriate agencies.

Figures and tables

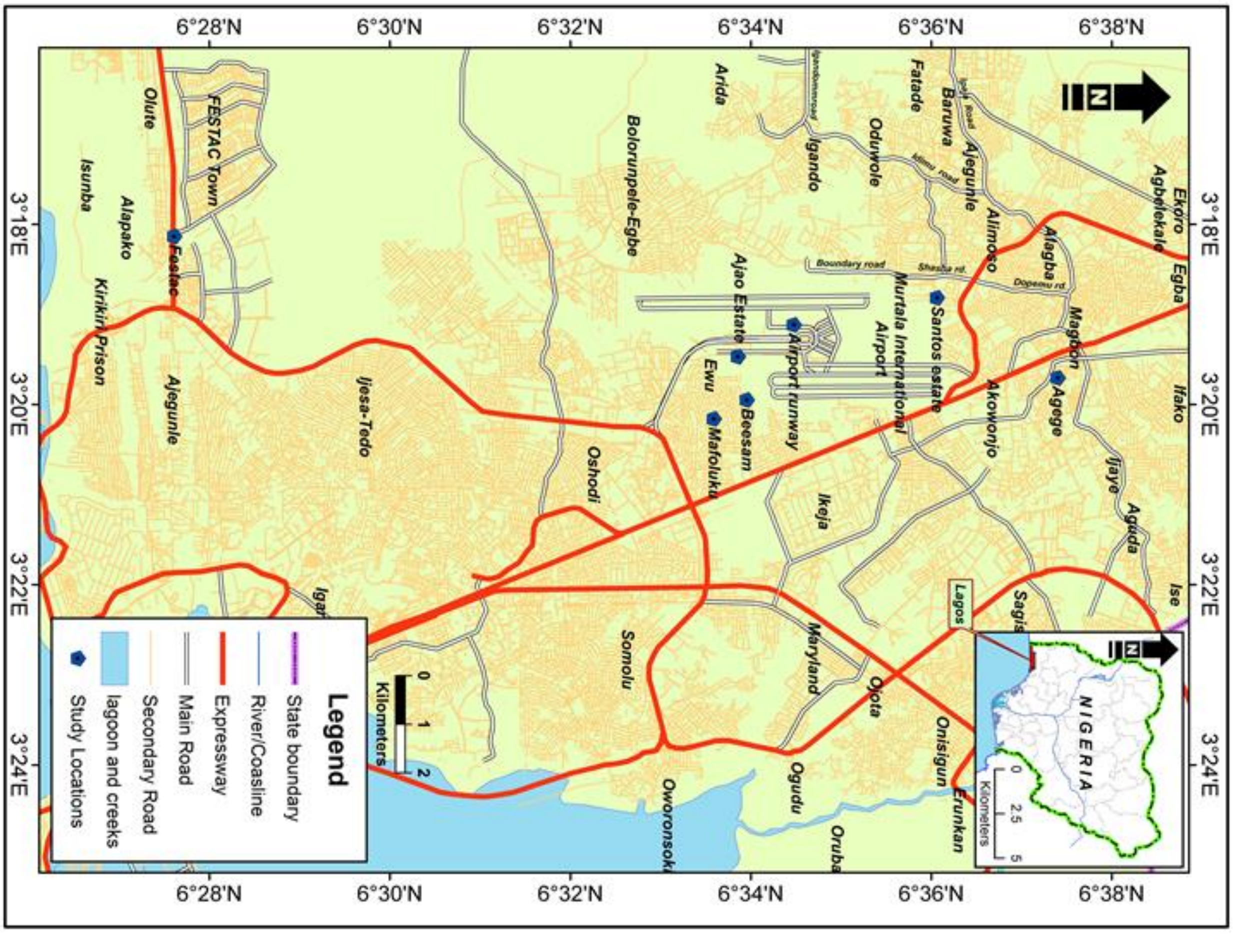

Figure 1. Murtala Mohammed International Airport and the selected study locations/communities contiguous to the airport

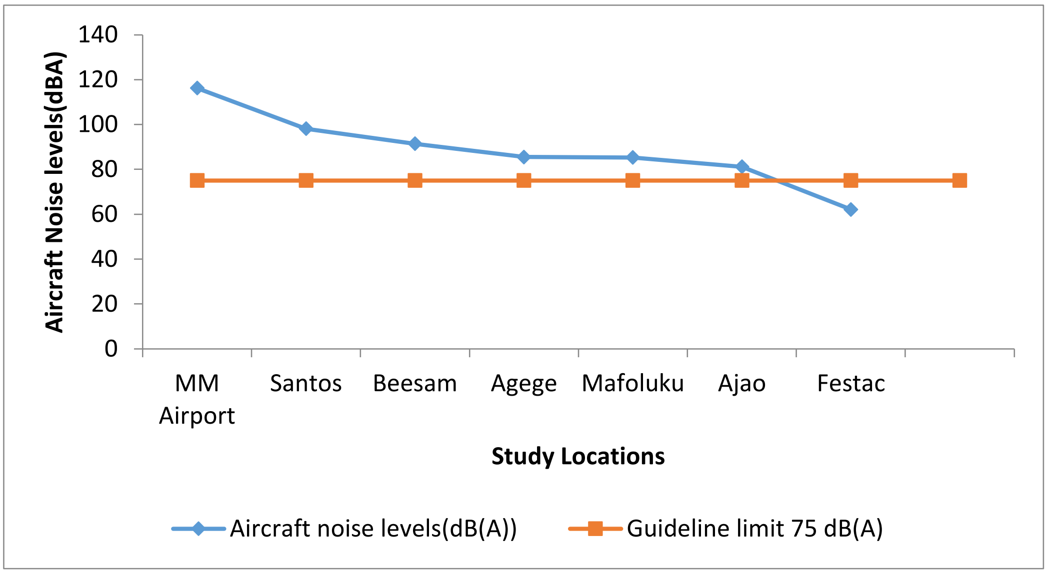

Figure.2. Aircraft noise levels at study locations compared with EPA Victoria guideline limit of 75 dB LAmax for residential buildings (outdoor) for 8 weeks of monitoring

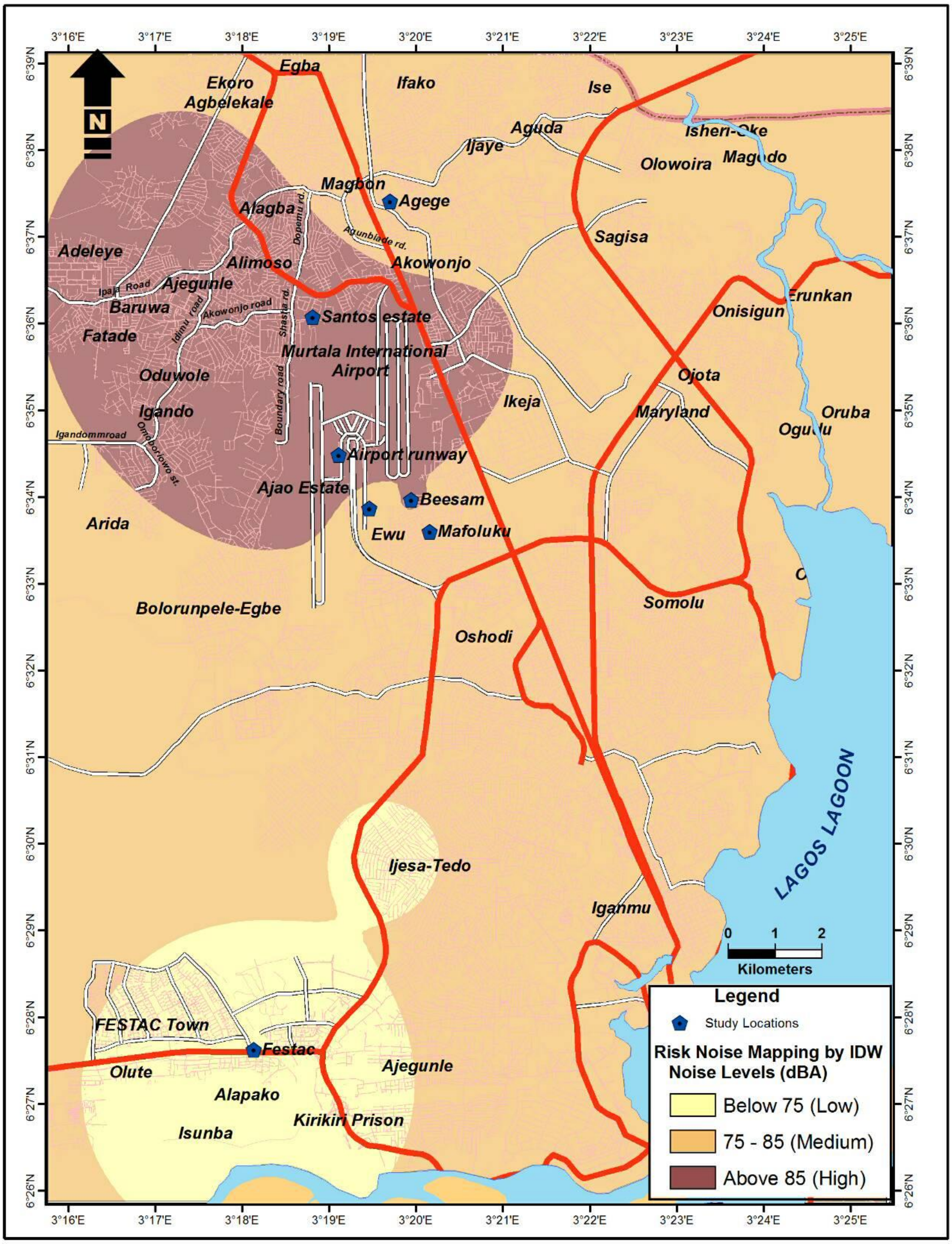

Figure 3. Aircraft noise risk map showing the risk levels of the study locations

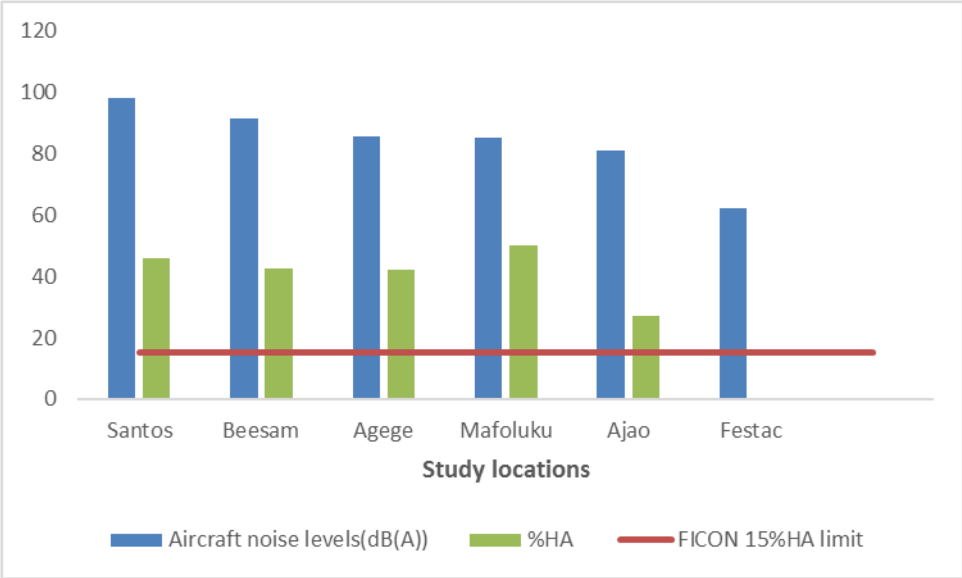

Figure 4. Aircraft noise levels at study locations and corresponding %HA compared with FICON guideline limit of 15%HA for residential areas

Table 1. Aircraft Noise Levels in the Study Locations

Location	**Geographic coordinates, elevation level(m)**	**Distance to Airport wall(m)/Flight path axis**	**Mean Aircraft Noise Levels (dBA)**	**Aircraft Noise levels Range (dBA)**
Airport runway	N06° 34.483´ E003°19.116´ 41m	0	116.2	97.8 – 122.8
Santos estate	N06° 36.070´ E003°18.816´ 54m	100/approach	97.9	83.4 – 106.2
Beesam	N06° 33.962´ E003°19.951´ 40m	350/take-off	91.2	84.9 – 103.4
Mafoluku	N06° 33.597´ E003°20.160´ 38m	1100/take-off	85.2	73.5 – 95.7
Ajao estate	N06° 33.863´ E003°19.470´ 41m	2500/take-off	82.0	76.7 – 94.1
Agege	N06° 37.408´ E003°19.706´ 73m	2600/approach	85.5	83.0 – 92.5
Festac	N06° 27.617´ E003°18.136´ 62m	14000/off-route	62.1	58.5 – 66.1

Table 2. Aircraft noise categorized according to EPA recommendation for land use compatibility

Lmax (dB(A))/Zone	**Compatibility**	**Location**	**Risk**
>85 (A)	Unacceptable	Santos estate and Beesam	High
75-85 (B)	Conditionally acceptable	Mafoluku, Agege and Ajao estate	Medium
<75 (C)	Acceptable	Festac	Low

Table 3. Socio-demographic characteristics of study population per location in percentage

Location	Santos estate	Beesam	Mafoluku	Ajao estate	Agege	Festac	Total	P-value
Sex (n=450) Male Female	 64.0 36.0	 52.6 47.4	 56.6 43.4	 41.9 58.1	 62.2 37.8	 43.7 56.3	 53.3 46.7	 >0.05
Age 15-34 35-54 55-74	 70.7 26.7 2.7	 90.8 9.2 0	 80.3 18.4 1.3	 77.0 20.3 2.7	 76.1 21.1 2.8	 86.7 13.3 0	 80.3 18.1 1.6	 >0.05
Religion Christianity Islam Traditional Others	 62.7 24.0 5.3 8.0	 59.2 31.6 0 9.2	 80.3 11.8 5.3 2.6	 86.5 9.5 2.7 1.4	 68.9 29.7 0 1.4	 89.3 10.7 0 0	 74.4 19.6 2.2 3.8	 <0.05
Ethnic group Yoruba Igbo Hausa Others	 41.3 34.7 10.7 13.3	 31.6 46.1 19.7 2.6	 31.6 55.3 6.6 0	 29.7 52.7 8.1 9.5	 81.1 5.4 6.8 6.8	 24.0 52.0 9.3 14.7	 39.8 41.1 10.2 8.8	 <0.05
Education No formal Formal	 13.3 86.7	 42.1 57.9	 5.3 94.7	 9.5 90.5	 4.1 95.9	 6.7 93.3	 13.6 86.4	 <0.05
Employment status (n=285) Employed Unemployed	 67.2 32.8	 64.9 35.1	 77.6 22.4	 73.0 27.0	 91.7 8.3	 79.5 20.5	 74.7 25.3	 >0.05
Occupation (n=217) Low skilled High skilled	 60.0 40.0	 73.9 26.1	 **50.0** **50.0**	 **31.4** **68.6**	 46.9 53.1	 18.2 81.8	 44.7 55.3	 <0.05
Length of residency < 1 year > 1 year Building type Bungalow Storey bldg Others	 14.7 73.3 38.7 54.7 6.7	 27.6 72.4 38.2 56.6 5.3	 14.5 85.5 57.9 39.5 2.6	 22.3 77.7 27.0 71.6 1.4	 14.9 79.7 24.3 70.3 5.4	 10.7 84.0 29.3 64.0 6.7	 14.9 78.7 36.0 59.3 4.7	 >0.05 <0.05
Floor of storey bldg (n=215) Ground floor Upper floors	 54.2 45.8	 15.4 84.6	 26.7 73.3	 16.1 83.9	 9.1 90.9	 6.5 93.5	 18.6 81.4	 <0.05

Table 4. % HA due to aircraft noise at the different study locations

Location	%HA (%) numeric scale	Mean Aircraft Noise Level (dB LAmax)	P-value
Santos estate	45.9	97.9	0.000
Beesam	42.4	91.2	
Mafoluku	50.0	85.2	
Agege	42.0	85.5	
Ajao estate	27.3	82.0	
Festac	**0**	62.1	

Table 5. Association between levels of aircraft noise exposure and %HA (n=394)

Aircraft Noise Level Lmax (dB(A))	%Highly Annoyed	%Not Highly Annoyed	P value
High exposure (>85)	43.7% (55)	56.3% (71)	0.000
Medium exposure (75-85)	39.9% (79)	60.1% (119)	
Low exposure (<75)	0% (0)	100% (70)	
Total	34.0% (134)	66.0% (260)	

Table 6. Self-rated health status among respondents categorized by location in Percentages (n = 433)

Health effect*	Santos estate	Beesam	Location Mafoluku	Ajao estate	Agege	Festac	Total	P-value
Good	76.1	83.8	89.3	90.4	83.8	88.9	85.5	0.136
Poor	23.9	16.2	10.7	9.6	16.2	11.1	14.5	

* Nonresponse excluded

Table 7. Association between levels of aircraft noise exposure categorized and Self-rated General health status

Aircraft Noise Level Lmax (dB(A))	Good	Poor	P value
b	72.0% (115)	28.0% (29)	0.065
Medium exposure (75-85)	79.6% (191)	20.4% (26)	
Low exposure (<75)	42.7% (64)	57.3% (8)	
Total	70.9% (370)	29.1% (63)	

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