A preliminary study of the effects of aircraft noise on families who reside in close proximity to an airport

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Abstract

Background: The use of air transportation has grown in the last century, escalating the noise exposure of families residing in close proximity to airports. The audiological effects need to be assessed to determine the impact of this increase on children and young adults living near to airports in South Africa.

Method: Hearing patterns for these individuals were compared to those residing 30 km away from the airport. Sixty people, between the ages of 12-30 years, were assessed. Participants completed a questionnaire and were subjected to a diagnostic audiological test battery and tested using diagnostic distortion product otoacoustic emissions (DPOAEs).

Results: Participants residing in close proximity to the airport presented with a notch configuration in the high frequencies, as opposed to those who lived further away. DPOAEs indicated a change in hearing in the high frequencies between the test populations. The positive relationship between the pure tone results and the DPOAEs strengthens the claim that aircraft noise has an effect on the hearing patterns of individuals living near to airports. Participants also experienced annoyance resulting from such noise.

Conclusion: The results highlight the need for investigation into the hearing of individuals who reside in close proximity to airports. Comprehensive studies will be informative and beneficial to the field of audiology in South Africa. The highlighted health and safety issues require in-depth study to formulate a stronger argument for monitoring the hearing of families who are exposed to aircraft noise.

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Introduction

The presence of noise is typical in everyday living, however excessive noise exposure can have drastic effects on one's sense of hearing.[1] Sources of excessive noise exposure that may impact on hearing include industrial machinery, music, gunfire and transportation.[2] Transportation has been revolutionised in recent years,[3] while aviation has expanded and changed since the first policies were developed on the effects of aircraft noise in 1985.[1] The use of air transportation has increased since the early 1960s and is currently a necessity for an urban lifestyle. However, this creates greater intrusion on the communities living nearby to airports.[4]

The increase in aircraft traffic has raised public concern regarding aircraft-noise pollution in areas located around airports.[5] The effect of this noise on the auditory systems of families living close to airports should be ascertained.[5,6,7,8] Such families may be at risk of hearing loss due to the high levels of aircraft noise. Individuals who are exposed to excessive noise may exhibit noise-induced hearing patterns. With continual noise exposure, they may develop noise-induced hearing loss (NIHL).[9] Damage of the peripheral cochlear mechanism occurring in individuals near aircraft noise was confirmed by Chen et al while researching two random groups in Taiwan who were located at different distances from the airport.[5] The researchers concluded that 68.7% of the people residing near the airport presented with hearing loss, with the figure being only 6.5% for those residing further away. Chen and Chen investigated the influence of high-frequency aircraft noise on the function of the auditory system in school-age children and confirmed damage to the peripheral cochlear mechanism in the group living close to the airport.[7] The researchers also found that

the hearing of students attending school near the airport was significantly poorer than those attending a school further away.

The geographical distribution of residents shows that their proximity to the airfield strongly suggests that the cause of the hearing loss is due to exposure to aircraft noise.[8] Exposure to high sound levels (> 80 dB) of any kind could result in a short-term decrease in an individual's hearing level, a temporary threshold shift (TTS).[10] The hearing level of somebody who experiences TTS recovers to its original level after a short duration. When TTS does not recover completely, it is regarded as a permanent threshold shift (PTS).[10] The intensity of the noise, in conjunction with the length of exposure, will determine the effects on the auditory system.[11] This condition occurs in the presence of continual noise exposure and may result in hearing pattern changes. PTS, which may result in NIHL, was confirmed by Miyakita et al (2001), who defined NIHL in individuals exposed to aircraft noise. Notably, not all of those who were exposed to continuous noise presented with a NIHL. A person's susceptibility to NIHL may vary according to factors such as age, the tonotopic region of the cochlea, or gender. The use of physiological measures, in addition to a basic test battery, is a common feature noted among international studies. Distortion product otoacoustic emissions (DPOAEs) offer the ability to effectively evaluate frequency-specific regions of the cochlea, and they are a useful tool in the identification of NIHL.[12]

As demonstrated by international studies, apart from the physiological effects of noise on well-being, it is imperative to note that the concomitant psychological effects of noise, particularly annoyance, is equally damaging to health. Annoyance is an important criterion in assessing the health-impairing effects of noise.[13] Areas most affected are communication, speech, sleep and relaxation. School-goers attending a school situated in close proximity to an airport were found to be significantly annoyed by the aircraft noise.[14] Children are at a higher risk of experiencing the adverse effects of noise exposure due to the distraction caused by the excessive noise exposure.[15] High levels of aircraft noise may impact on everyday activities such as homework, schoolwork and playing.

Families living near airports in South Africa have voiced concern over exposure to the aircraft noise, with regard to the consequences for their auditory systems, as well as the psychological effects of annoyance on their well-being.[16] Exposure to noise can have wide-reaching negative effects on mental health and performance.[17] In addition, in this study, there were ongoing concerns and investigations into the health-impairing effects of environmental pollution in the area close to this South African airport. These concerns highlight the effects on public health and the well-being of individuals in the area.

In light of the abovementioned motivations, this study was conducted to investigate the hearing patterns of individuals between the ages of 12-30 years who reside in close proximity to an airport (population A) compared to those living further away (population B).

There is a dearth of information regarding the hearing effects of aircraft noise in South Africa. Research in this area will assist audiologists in early identification of noise-induced hearing loss among people staying in close proximity to airports and will exemplify the need for aviation policies to be finalised. In addition, research of this nature further supports advocacy for primary prevention of hearing loss, and awareness and conservation of hearing health care.

Methodology

Ethical clearance was obtained from the University of KwaZulu-Natal Ethics Committee.

Main aim

To determine the effects of aircraft noise on families residing in close proximity to an airport.

Objectives

- To determine the hearing patterns of individuals living near to the airport.
- To determine the hearing patterns of matched individuals residing approximately 30 km away from the airport.
- To compare the hearing results obtained from both populations.
- To determine if, as a result of aircraft noise, annoyance occurs.

Preliminary site survey

A preliminary investigation into the various types and number of aircrafts frequenting the airport, and the resultant noise levels emanating from their landing and take-off, was conducted. The results from the investigation were utilised to support the motivation for the current study.

Various types of light and heavy aircraft use the airport on a daily basis. Some of these aeroplanes include the Boeing 737-800, Boeing 727, Boeing 747, Boeing 737-200, McDonald Douglas MD82, Jetstream 41, Cessina and Cherokee. The noise levels emanating from them vary according to their

size. The engine noise discharged from light and heavy aircrafts differs, but may reach 140 dB. At the airport, the number of aeroplanes landing and taking off differed with regard to day and night flights. On average, the numbers of aeroplanes landing and taking off within a 24-hour period were 60 and 65 aeroplanes, respectively. Therefore, it is noted that an aeroplane either lands or departs at the airport every 20 minutes.

The Dawe Instruments Limited Sound Level Meter BS 3489 was utilised to obtain the various noise levels of the aircraft. These readings were attained at ground level within a 2-km radius from the airport. The measurements were taken in a quiet environment in the residential area. It was established that each aircraft emits noise ranging from 85-115 dB upon landing, and 87-100 dB when taking off. The noise generated at the maximum level lasted 20 seconds and decreased as the aircraft moved further away. It was audible for one minute during the take-off and for 30 seconds during the landing. The environmental noise levels at site B were recorded to be between the ranges of 30-50 dB.

Participants

Thirty individuals were assessed from population A and 30 from population B. Those from population A were selected from a residential community living 2 km away from the airport, while the distance for those from the latter population, also living in a residential community, was 30 km away.

Both populations comprised men and women between the ages of 12-30 years. Participants from both populations were similar in chronological age, ethnicity and gender. The age distribution was as follows:

Population A

- Ages 12-15 years: 15 individuals
- Ages 16-20 years: 10 individuals
- Ages 21-30 years: 5 individuals

Population B

- Ages 12-15 years: 16 individuals
- Ages 16-20 years: 10 individuals

Purposive sampling was used to select participants. Posters were distributed in the residential areas inviting people to participate in the study. The test areas in this study were similar in terms of socio-economic status, housing structure, ethnicity, age and physical environment. Participants who responded to the poster advertisement were required to satisfy the following criteria:

- To be in the age range of 12-30 years.
- To have no previous exposure to excessive noise, e.g. industrial noise, gunshot noise and power tools.
- To have no previous history of endogenous or exogenous auditory disorders.
- To reside in the test area for a minimum of three years.

Research design

The research was a quantitative, comparative study employing a quasi-experimental design. The quantitative facet was used to analyse the data obtained during the diagnostic hearing assessment.

Instrumentation/measurement tools

Figure 1 indicates the two phases of the study. Phase A involved step 1, completion of a case history questionnaire, and step 2, an otoscopic examination and immittance audiometry tests. Phase B consisted of diagnostic audiometric procedures and DPOAEs to investigate the hearing status of all participants who passed phase A of the study.

Diagnostic audiometric assessments and DPOAEs were conducted utilising calibrated diagnostic equipment in a soundproof booth. Participants who had outer and/or middle ear pathologies did not complete phase B of the study. They were referred accordingly.

Pilot study

A pilot study was conducted to determine the efficacy of the test protocol employed in the research study. The study was carried out on a person from each test area. These

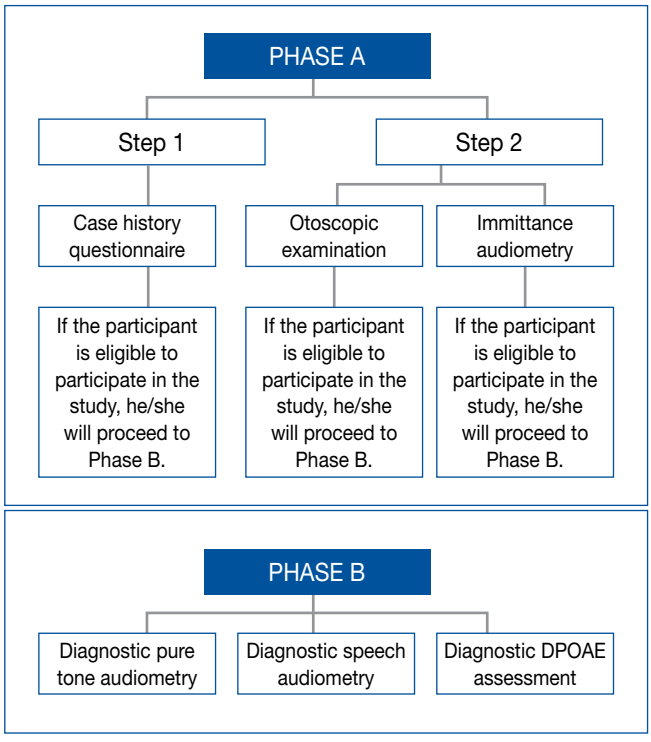

Figure 1: A description of the two-phase methodology employed

participants did not form part of the research study. No changes to the test procedures were necessary, as they were effective in obtaining the type of data required for this study.

Data analysis

To ensure greater validity of results obtained via inferential statistics, data were analysed utilising 60 ears in each test population, rather than 30 individuals. This study permitted researchers to analyse ears, as opposed to individuals from each population, as an objective of the study was to assess cochlear function. In addition, it was noted that there was no significant difference between the right and left ears of participants in each population. The t-test was used to determine if there was a significant difference between the pure tone results and DPOAE results obtained from the two populations.

Results and discussion

Results were obtained to fulfill the requirements of the first, second and third objectives:

- To determine the hearing patterns of individuals residing in close proximity to the airport.
- To determine the hearing patterns of matched individuals living approximately 30 km away from the airport.
- To compare the hearing results obtained from both populations.

Pure tone results

Pure tone thresholds were obtained for all participants in the frequency range of 125-8 000 Hz. All 120 ears presented with results of 10 dB hearing level or above on the audiogram for the following frequencies: 250 Hz, 500 Hz, 1 000 Hz, 2 000 Hz, 3 000 Hz, 4 000 Hz and 8 000 Hz. Visual examination of results at 6 000 Hz for both populations indicated a distinct difference between the populations. Population A presented with a notch configuration at 6 000 Hz, while population B did not illustrate this feature.

The t-test was utilised to assess and confirm visual observations of variations in the hearing patterns that existed in high frequency between test populations A and B. Pure tone thresholds at the 6 000 Hz high frequency were analysed in both test populations. A score of 4.4 was obtained from the pure tone analysis.

The results indicated an increase in the mean magnitude of notch for ears from test population A, as opposed to ears from test population B. The raw and mean scores for both test populations were applied to the t-test to determine the magnitude of difference between the test populations and their significance. A statistically significant difference was obtained between the two test populations. This finding indicates that a larger number of participants who reside in close proximity to the airport present with a notch configuration at 6 000 Hz, as opposed to those who live further away. This pilot study, conducted on a limited number of participants, indicates the need for further investigation into the cochlea functioning of both populations. Therefore, the inclusion of DPOAEs in this research permitted the researcher to validate and support the pure tone analysis findings.

Distortion product otoacoustic emission measures

DPOAEs were attained for all participants in the study in the frequency range of 2 000-8 000 Hz. The results from this high-frequency range were employed, as the pure tone results did not indicate a significant difference at other assessed frequencies. The distortion product/noise floor (DP/NF) differences in the high frequencies were examined in terms of mean values so as to determine a raw score. Participants from population A attained a mean DP/NF difference raw score closer to, or below, 6 dB, as opposed to those from population B. The results from both test populations were thereafter applied to the t-test to determine the magnitude of difference between the test populations, and their significance. In the current study, a statistically significant score of 3.96 was obtained when comparing test population A and B according to the level of significance employed in the t-test. This finding indicated that people in population A attained poorer DPOAEs compared to those in population B. These results illustrate that participants in the former group demonstrated early signs of the negative effects of aircraft noise on the cochlea.

The results obtained via pure tone audiometry are supported by results obtained from the DPOAE results for the same participants. This pilot study provides substantial evidence of the early signs of damage to the cochlea hair cells at 6 000 Hz for individuals who reside in close proximity to the airport. However, due to the limited sample size, it is recognised that a study on a larger scale is required. Thereafter, conclusive results from a larger sample size will assist with public advocacy with regard to noise pollution.

Annoyance

These results were obtained to fulfill the requirements of the fourth objective, which was to determine if annoyance occurs as a result of aircraft noise.

In addition to the audiological findings, this study found that participants experienced annoyance due to the aircraft noise. They stated that the most irritation occurred during the following times: while sleeping, studying, when on the telephone, while watching television, and when having a conversation. Figure 2 graphically represents the number of people who were annoyed according to specific categories.

People aged 12-15 years were all irritated during conversation, while on the telephone, watching television and studying. Those aged 16-30 years were all disturbed during sleep, in comparison to six people aged 12-15 years who were annoyed during sleep.

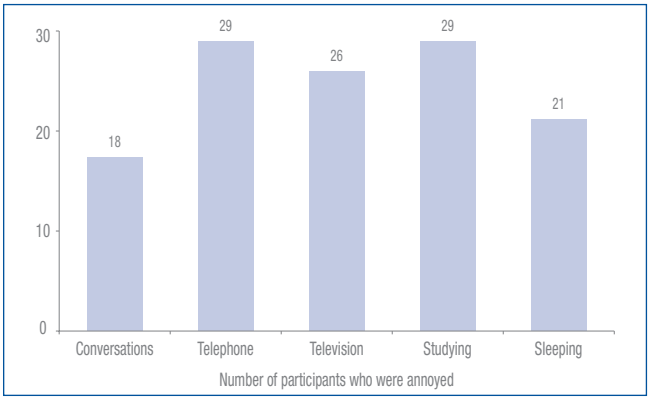

Figure 2: Annoyance rating of all participants residing in close proximity to the airport

Conclusion

On the basis of these findings, it is suggested that the hearing patterns of individuals living near the airport indicate the early effects of aircraft noise exposure. The positive relationship between the pure tone results and the DPOAEs strengthens the argument that aircraft noise affects the hearing patterns of people who reside close to the airport. In addition to the audiological effects of aircraft noise on individuals living in close proximity to the airport, annoyance is a major factor for these residents. They stated that sleeping, studying, telephonic conversations, and talking in general are affected by the aircraft noise.

The effects of noise pollution on people living near the airport should be ascertained. The hearing health of school-aged children is important in the context of listening and learning in the classroom environment. A study on a larger scale could provide a motivation for hearing conservation programmes within these communities.

Therefore, it is vital that further research is conducted to assess a larger number of individuals who reside in close proximity to South African airports. Further studies on a larger scale are required, as the information gained will be informative and beneficial to the field of audiology in South Africa. The promotion of good hearing and the prevention of hearing loss are necessary for families in situations where excessive noise is not a choice.

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