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Airport noise and its impact on exposed urban population in Kuwait

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ABSTRACT

The urban areas of the Gulf nations of the Cooperation Council (GCC) have grown rapidly over the last 3 decades. In the absence of a national strategic plan however, the urban infrastructural growth has resulted in a number of adverse impacts on the urban environment and has deteriorated the quality of urban life. This paper presents the results of the first study of aircraft noise and its impacts on the exposed population in the State of Kuwait. Noise from a sample of 1,007 landing aircrafts was measured during a ten-months period in four urban districts located under the "approach path" of landing aircrafts. The perceived impact of aircraft noise on the health and welfare of the exposed population of the four districts were also obtained and evaluated. Various indicators of noise (the L_{min}, L_{90}, L_{50}, L_{eq}, L_{10}, L_{max}, and the L_{eqpd}) are presented. The results of a person-interview survey of a random sample of 1,000 residents of the four districts are also discussed. A significant percentage of the sample population were annoyed with aircraft noise, and suffer from its interference with their daily conversation, watching TV, eating, relaxing, working, and sleeping activities. More than a quarter of the exposed individuals felt tiredness and nervousness and often experienced headaches from aircraft noise. A number of recommendations for the improvement of aircraft noise pollution in Kuwait end the paper.

Keywords: Aircraft noise; exposed pollution; perceived impacts; Kuwait.

INTRODUCTION

The objectives of this research study were to provide answers to the following questions:

1 - What is the level of aircraft noise at the districts located under the "approach path" of landing aircrafts in Kuwait?

2 - What are the perceived impacts of aircraft noise on their welfare and health of exposed individuals?

3 - Are these individuals perceptions of noise impacts valid and justified?

Airports are known to be major sources of noise pollution, and the issue of the effect of airport noise on human health and the environment has for sometime been a major concern for the public and policy makers worldwide (Fay 1991, Holzman 1997, Stenzel 1996). The rapid growth in demand for air travel is expected to intensify in the near future and the problem of noise pollution will further frustrate the mitigation of environmental problems. Air traffic is expected to double in the U.S. for example by the year 2017, and internationally by 2010 (Holzman 1997).

The Kuwait metropolitan area has experienced a tremendous growth in population and socio-economic activities, as well as a demand for air travel, especially since the Iraqi invasion of 1990. Figure 1 charts the rapidly growing trends in passenger and aircraft movements between 1992 and 2004 in Kuwait (Kuwait Civil Aviation Statistics 2005). Figure 2 shows current average hourly variation of arrivals and departures at Kuwait International Airport. Figure 2 also shows the large number of departures and arrivals during the evening and night time, a cause of concern with regards to airport noise for residents in affected areas.

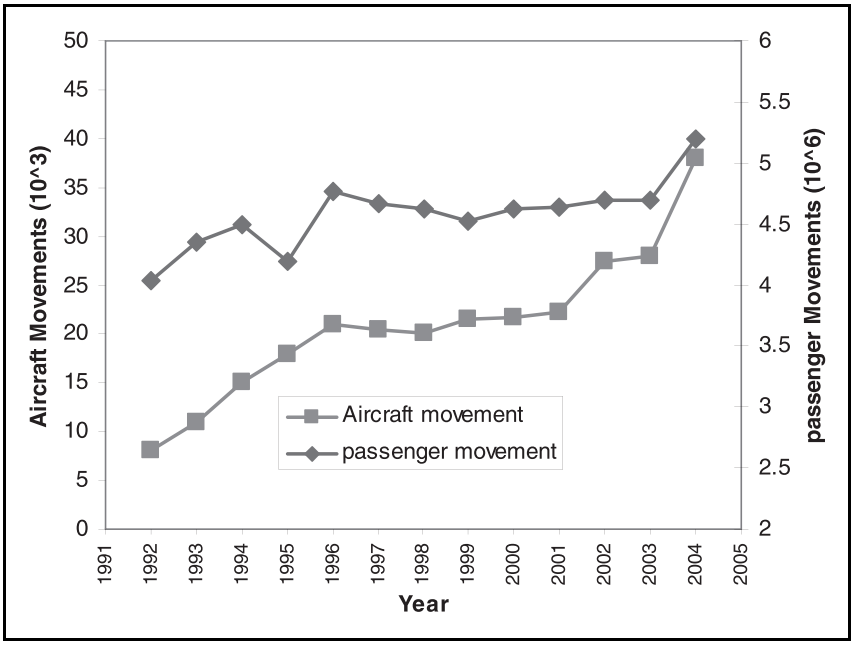

Figure 1. Passenger and aircraft movements in Kuwait: 1992-2004

cognitive performance (Abel 1990); occupational performance (Bragdon 1972); psychological functioning (Standeld 1992); increased irritability and problems with interpersonal relationship (Jansen 1976); and on pro-social behavior (Sherrod and Downs 1974). Airport noise has been found to harm children as well. Children exposed to noise from aircraft have experienced significant increases in blood pressure and the stress hormones (Cohen Et al. 1961).

In a recent study of the economic cost of noise pollution, Barreiro (2005) evaluated the economic value of a noise reduction program in Spain. The study found that urban residents generally valued noise negatively and were willing to pay for noise reduction. In addition, the majority of the surveyed households were willing to pay more for larger decreases in the level of disturbance from noise.

Aircraft noise has been a disturbing problem for those who reside in the vicinity of airports worldwide. In London, for example, the Civil Aviation Authority (CAA) estimates the noise exposure around the London Airports (Heathrow, Gatwick, and Stansted) every year. The magnitude and extent of aircraft noise around these airports are depicted on maps by contours of constant aircraft noise index (L_{eq}) values (Monkman Et al. 2005). A comparison of the 2003 and 2004 data, for example, have indicated that the total noise-effected area (57 dBA 16-hour L_{eq}), within the 2004 terrain decreased by 7.5% and the effected population within this contour by 9.1%. These improvements were realized by modal split of runway direction and a quieter aircraft fleet.

Kuwait has two distinct pouplation segments: Kuwaiti and Non-Kuwaiti (foreign temporary workers). Kuwaiti citizens often live in separate areas with better facilities than their expatriate counterparts. Since the expatriate workers are generally from poorer countries, and a majority of these workers consists of an unskilled, relatively poorer population exposed to noise and other environmental problems in their home countries, they often do not complain of high noise levels.

Land-use planning in Kuwait has not often been given its due importance in the planning process. Although there were Master Plan studies, the recommendations were often ignored due to political interference. To cater for the ever increasing foreign labor in Kuwait, residential areas exclusive to these temporary workers and their families were developed near the airport. Since this segment of population has limited choice of where they would live, these residential areas have become over populated.

Four large and populated urban districts are located under the "approach path" of landing aircrafts: Farwaniya, Omariya, Khaitan, and Shuwaikh, listed in the same order as their proximity to the airport (Figure 3). Residential and commercial land uses in Farwaniya are between 3 to 5 Km, in Khaitan 8.5 Km, Omariya 12.5 (Km), and in Shuwaikh 14.5 Km away from the airport's runway thresholds. The population of the four districts (by nationality and their

approximate distances to runway thresholds) is shown in Table 1 (Annual Statistics 2004). More than 116,000 individuals live and work in the exposed districts, more than half of which are non-Kuwaitis. Of the total State's population of 2.65 million, only less than 1 million are Kuwaitis. The remaining includes individuals from some 16 nationalities who reside and work in Kuwait. The mean distance between the districts and the airport is 10.1 kilometers (6 miles). Kuwait Airport has two parallel runways, as shown in Figure 2.

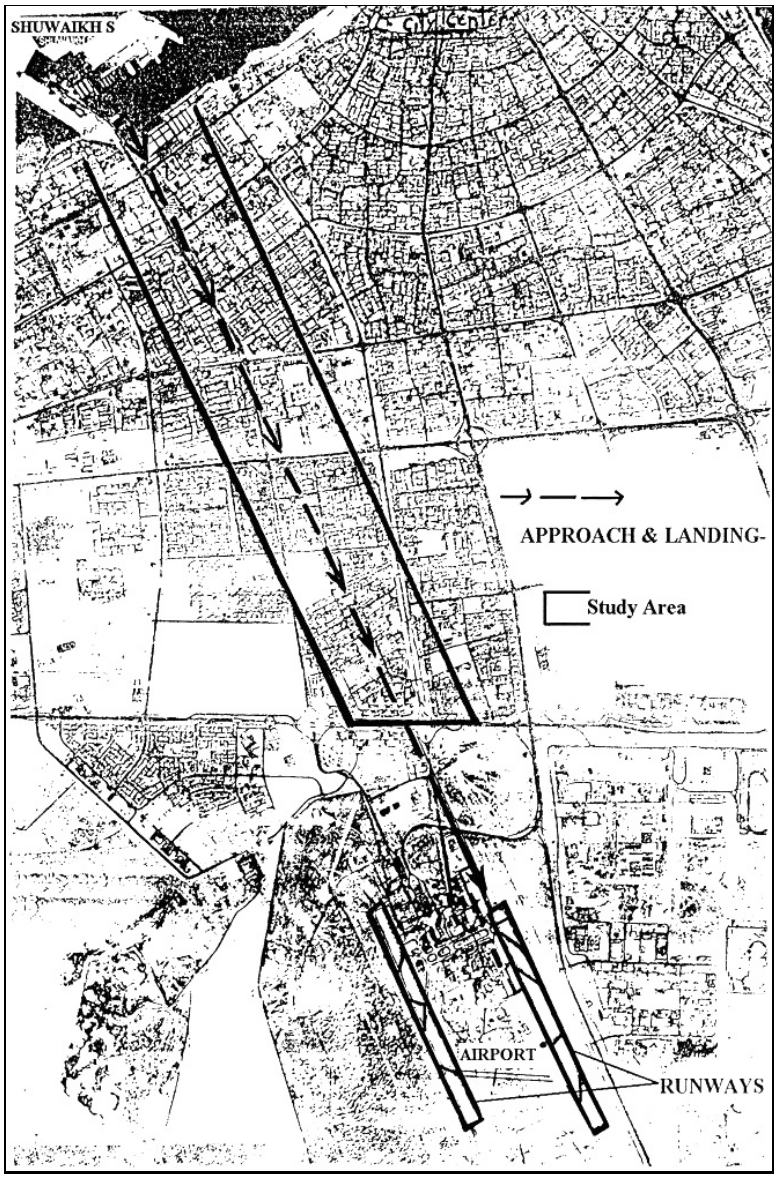

Figure 3. Study districts under the approach path

Table 1. Exposed population to aircraft noise and their distances from runway thresholds

District name[1]	Population		Median distance from runway thresholds (km)
	Kuwaiti	Other	
Shuwaikh	1,365	1,925	14.5
Omariya	7,380	10,620	12.5
Khaithan	7,616	10,960	8.5
Farwaniya	31,232	44,945	< 5.0

[1]Districts located under the approach path of landing aircrafts

In spite of the very rapidly growing trends in the national income, the socio-economic activities, the number of aircraft movements, as well as the close proximity of a significant percentage of urban population to the airport, no study of the magnitude of aircraft noise and/or of its adverse impact on the welfare and health of exposed individuals has been performed in Kuwait. This research study was undertaken to narrow this important data gap.

DATA AND METHODS

The noise of 1007 approaching/landing aircrafts (departing aircrafts take-off over vacant desert land) were measured during 18-hour periods of the sampling days at proximity to work places and residential areas of the four study districts over a period of 8 months from July 2004 through February 2005. Measurements were made during morning, afternoon, and evening hours of airport operation. Bruel and Kjear Integrating Sound Level meters, Type 2238 (complying with BS 5969 and BS 6698), were utilized to measure aircraft noise. A polarized 1/2" condenser Microphone Type 4188 was also used with the sound level meter, and a sound-level calibrator Type 4231 was employed to calibrate the instrument at 94 and 114 dB, as per specifications (Bruel and Kjear 1998). In the selection of the aircraft noise measurement locations, every attempt was made to minimize the effect of background noise. The mean measured background noise level during the 8-month measurement period was 65.3 dBA, with a standard deviation of 3.6 dBA.

The exposed populations perception's of aircraft noise and its impacts were sought via a survey design which included, the design of a structured questionnaire and its pre-testing (to ensure clarity and response accuracy),

determination of the sample size and sampling method, and finally the implementation of the survey. The questionnaire addressed a) the socio-educational traits of the exposed population, b) the number of years living/working at the study districts, and c) the perceived welfare and health impacts of aircraft noise. One thousand (1000) systematic-randomly selected individuals at their residences and work places in the study districts were person-interviewed and requested to fill-in the questionnaire. Every attempt was made to include residential blocks occupied by Kuwaiti/Non-Kuwaiti nationalities, so that the sample population would be a representative of the affected population as a whole. A total of 801 completed questionnaires (80%), were processed for the database. It should be noted that a systematic-random sample of 801 individuals would result in a sampling error of $\pm$ 3%, at the 95% confidence level (Walpole Et al. 2002). The Statistical Analysis Software (SAS), was employed to process and analyze the data.

RESULTS

Mean Statistics

The mean, the standard deviation, the minimum and the maximum values for selected study variables are presented in Table 2. On the average, a sample individual had lived in the study districts for more than 8 years (std. dev. = 8.2) and/or had worked in the district for 7 years (std. dev. 6.2). There has been an increase in expat population in Kuwait post liberation period of Kuwait. Many of the expats living in Kuwait are newer compared to Kuwaiti population. Hence the standard deviation values are larger. The mean age of the sample respondents was nearly 35 years. The equivalent noise level, L_{eq}, (the average noise level over the measurement time period) for the entire measurement period was 76.2 dBA with a standard deviation of 4.3 dBA. The L_{epd} was nearly 76 dBA. The highest 10 percentile noise level, L_{10}, was 80.6 dBA. Maximum noise levels were more than 95 dBA. It is important to note however that the permitted outdoor noise pollution level is 70 dBA, for residential and 75 dBA for commercial landuse (US DHUD). On the average, the noise of each landing aircraft was measured for more than 43 seconds, the time period that the aircraft flew over the monitoring location.

Table 2. Descriptive statistics for selected study variables

Variable Name	Statistics			
	Mean	**Std. Dev.**	**Min.**	**Max.**
HLLH	8.4	8.2	1.0	50.0
HLW	7.0	6.2	1.0	33.0
Age	34.8	10.8	18.0	60.0
L_{eq}	76.2	4.3	67.7	86.9
L_{min}	53.6	2.3	40.7	65.4
L_{max}	84.9	4.9	52.6	95.9
L_{90}	59.0	2.3	48.0	66.0
L_{10}	80.6	4.5	70.5	91.5
L_{50}	71.2	4.1	58.0	81.5
L_{epd}	75.9	4.4	50.2	86.6
Etime (sec)	43.4	9.2	19.0	79.0

HLLH : How Long Lived Here (years)
HLW : How Long Worked Here
A_{ge} : Age (year)
L_{eq} : Equivalent noise level dBA
L_{min} : Minimum noise level dBA
L_{max} : Maximum noise level dBA
L_{90} : The lowest 10 percentile noise level dBA
L_{10} : The highest 10 percentile noise level dBA
L_{50} : The 50 percentile noise level dBA
L_{epd} : Perceived noise level dBA
Etime : Aircraft Noise Exposure Time (Flying Over) (sec)

Frequency Distributions

The distribution of the sample population's nationality, gender, marital status, and education traits is presented in Table 3. Nearly of the sample individuals were Kuwaitis; slightly more than half were males; and 2/3 was married. While 3.5 percent did not have any formal education, more than 8 percent held post-graduate degrees. Nearly 40 percent had graduated from college.

Analysis of the data also indicated that approximately 90 percent of the surveyed individuals had lived in the study districts for 15 years or less, and the remaining 10 percent, for more than 15 years. The distribution of years working

also showed that the bulk of the sample population (94%), had worked in the study area for 15 years or less, and 6 percent for more than 15 years. Less than 5 percent of the exposed individuals were younger than 22 years in age. A similar percentage were 60 years or older. More than 54 percent of the respondents ranged in age between 30 to 39 years.

Table 3. Nationality, gender, marital status and education traits of the exposed sample population

Variable name	Freq.	Percent	Cum. percent
Nationality:			
Kuwaiti	395	49.8	49.8
Non-Kuwaiti	399	50.2	100.0
Gender:			
Male	400	50.2	50.2
Female	397	49.8	100.0
Marital Status:			
No	274	34.7	34.7
Yes	516	65.3	100.0
Education:			
No Education	28	3.5	3.5
Elementary School	58	7.3	10.8
High School	139	17.6	28.4
Institute	186	23.5	51.9
University	315	39.8	91.7
Post-Graduate	66	8.3	100.0

The responses of the sample population to the question: Is aircraft noise a problem in your area? indicated that nearly a third stated "Yes" and 41.6 percent stated "to some extent". For the remaining 26.1 percent, noise was not perceived as a problem (Table 4). The perceptions of noise as an urban environmental problem were related to the level of education of the exposed individuals. As presented in Table 5, the percentage of respondents who perceived noise as a problem varied from a low of 22.4 percent, for those with no education, to a high of 47.7 percent, for those with post-graduate degrees. The test of chi-square also confirmed the existence of such pattern ($\chi^2 = 21.9$, df $= 10$, $p < 0.01$, significance level $= 95\%$).

The respondent's nationality also showed association with his/her perception of noise as an urban environmental problem (Table 5). The percentage of those who perceived noise as a problem however was significantly higher for Kuwaitis (37.8%) compared to that of non-Kuwaitis (27.3%), and these differences in perceptions by nationality were not chance-related, as indicated by the chi-square test result ($\chi^2 = 10.1$, df = 2, $p < 0.006$). It should be noted that the majority of the Non-Kuwaiti population in Kuwait includes low-income workers from Egypt, Pakistan, India, Sri Lanka, Bangladesh and Philippines. These individuals are usually exposed to high noise levels in their home nations since urban areas are much more heavily populated and much noisier (Koushki Et al. 2002, Mehra 1986) than those measured in the study urban districts.

Table 4. Exposed sample populations perceptions of aircraft noise

Variable name	Freq.	Percent
Is aircraft noise a problem in your area?		
No	208	26.1
To some extent	332	41.6
Yes	258	32.3
Does aircraft noise annoy you?		
No	111	13.9
Sometime	479	60.0
Yes, always	208	26.1
When is the aircraft noise more annoying?		
Morning	222	28.9
Afternoon	247	32.2
Evening	299	38.9
Has the aircraft noise affected your property value?		
No	134	17.0
I dont know	138	17.6
To some extent	274	34.8
Definitely	241	30.6

Table 5. Sample exposed populations perceptions of aircraft noise as an urban problem by education and nationality

Variable name	Perceptions of noise as a problem (%)		
	No	To some extent	Yes
Educational:			
None	44.8	32.8	22.4
Elementary	27.3	44.6	28.1
High school	24.9	44.3	30.8
Institute	23.9	43.3	32.8
College	25.0	32.1	42.9
Post Graduate	21.5	30.8	47.7
	($\chi^2 = 21.9$, df = 10, $p < 0.01$)		
Nationality:			
Kuwaiti	23.2	39.0	37.8
Non-Kuwaiti	28.8	43.9	27.3
	($\chi^2 = 21.9$, df = 10, $p < 0.01$)		

Only less than 14 percent of the sample population were not annoyed by aircraft noise, as oppose to more than 26 percent who were always annoyed with this urban environmental problem (Table 4). Sixty percent of the respondents were "sometimes" annoyed with aircraft noise, and the noise from aircrafts was more annoying in the evenings. Nearly 40 percent of the exposed individuals were annoyed with aircraft noise during this time period (Table 4). The second largest percentage (32.2%) included those who were annoyed with aircraft noise during the afternoon hours and the rest expressed annoyance with aircraft noise in the mornings.

The sample population's annoyance with aircraft noise was also related to their education level, their nationality, and their gender. Table 6 charts these patterns of association. The data in Table 6 indicate that the percentage of those who were annoyed with aircraft noise increased significantly as their level of education increased: 15.8 percent, for those with no education versus 53.0 percent, for those with a post-graduate degree. This pattern was confirmed by the test of chi-square ($\chi^2 = 41.5$, df = 10, $p < 0.0001$). A similar association also existed for the nationality variable: more Kuwaitis were annoyed with aircraft noise compared to Non-Kuwaitis ($\chi^2 = 12.3$, df = 2, $p < 0.002$). For gender, a significantly higher percentage of the sample males (31.3%) were annoyed with aircraft noise compared to their female (21.0%) counterparts ($\chi^2 = 19.5$, df = 2, $p < 0.0001$).

Table 6. Sample exposed populations annoyance with aircraft noise by education, nationality, and gender

Variable name	Annoyance with aircraft noise (%)		
	No	**To some extent**	**Yes**
Educational level:			
None	24.6	59.7	15.8
Elementary	15.8	60.4	23.7
High school	11.4	69.2	19.5
Institute	12.7	60.8	26.4
College	14.3	50.0	35.7
Post Graduate	12.1	34.9	53.0
	($\chi^2 = 41.5$, df = 10, $p < 0.0001$)		
Nationality:			
Kuwaiti	9.9	60.5	29.6
Non-Kuwaiti	17.6	59.7	22.7
	($\chi^2 = 12.3$, df = 2, $p < 0.002$)		
Gender:			
Male	16.2	52.5	31.3
Female	11.1	67.9	21.0
	($\chi^2 = 19.5$, df = 2, $p < 0.0001$)		

More than 65 percent of the sample respondents (the "definitely" and "to some extent" groups) stated that aircraft noise has negatively affected their property values in the district. 17 percent believed it had not. The remaining 17.6 percent included those who "did not know" the existence of such a likely impact (Table 4).

The equivalent noise level, L_{eq}, and the highest 10 percentile noise level, are commonly utilized to indicate the noisiness of a given environment. The frequency distribution of the measured level of these two indicators are presented in Table 7. The L_{eq} varied between 70 and 85 dBA - always above the outdoor limit for residential areas. In more than a third of the measurement times (35.1%), the equivalent noise level from aircrafts was above 80 dBA, and the highest 10 percentile noise level was in excess of 85 dBA during nearly the same time period. This is considered a harmful level (Table 7).

Table 7. Frequency distribution of aircraft noise indicators

Noise indicator	Frequency	Percent
Equivalent Noise Level, L_{eq} dBA:		
70 - 75	265	33.1
76 - 80	255	31.8
81 - 85	281	35.1
The 10-Percentile Noise Level, L_{10} dBA:		
75 - 80	261	33.0
81 - 85	258	32.0
> 85	282	35.0

The cumulative frequency distribution of the measured aircraft noise at the four study districts is presented in Figure 4. A number of points concerning these distributions deserve attention. First, in 55 and 38 percent of the measurement periods, the level of aircraft noise exceeded the 70 dBA outdoor limit at Farwaniya/Khaitan, and Omariya/Shuwaikh districts, respectively. Second, during 10 percent of the measurement periods, the level of aircraft noise was in excess of 83 and 86 dBA at Khaitan and Farwaniya, respectively. Third, the districts under the "approach path", and closer to the airport (Farwaniya and Khaitan), were significantly noisier than those located farther away from the airport (Shuwaikh and Omariya), as was expected.

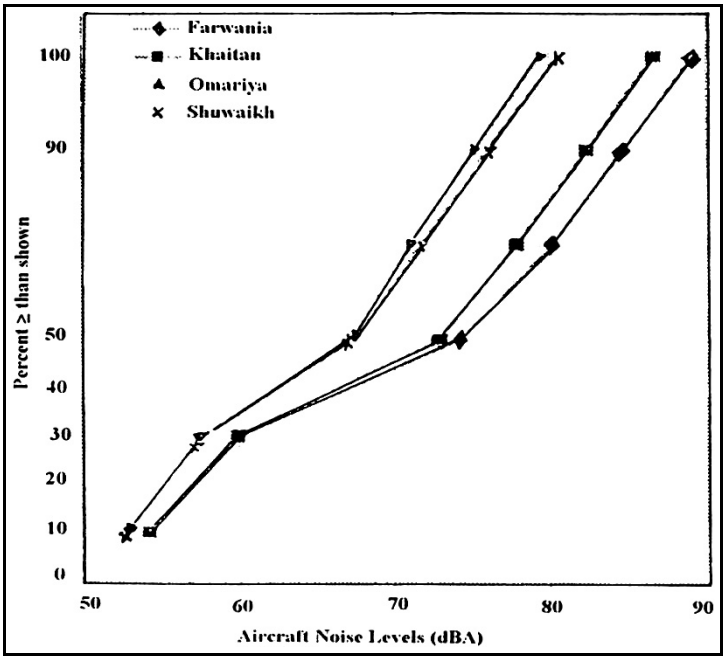

Figure 4. Cumulative aircraft noise pollution levels at study districts

Perceived Impacts on Welfare and Health

Question 2 the study asked, "What are the perceived impacts of aircraft noise on their welfare and health of exposed individuals?", the study also aimed to understand socio-educational traits affected their perceptions of aircraft noise impacts. Responses to these questions are presented in Table 8.

Table 8. Perceived adverse impacts of aircraft noise on welfare activities

Variable name	Freq.	Percent
Telephone conversation:		
I don't know	59	7.5
No	156	20.0
To some extent	343	43.9
Yes	224	28.6
Eating:		
I don't know	76	9.8
No	402	51.9
To some extent	179	23.1
Yes	118	15.2
Relaxing:		
I don't know	49	6.3
No	120	15.4
To some extent	347	44.4
Yes	265	33.9
Working productivity:		
I don't know	59	7.6
No	143	18.3
To some extent	328	42.0
Yes	251	32.1
Sleeping:		
I don't know	66	8.3
No	150	19.0
To some extent	226	28.5
Yes	350	44.2
Watching TV:		
I don't know	87	11.1
No	245	31.3
To some extent	268	34.3
Yes	182	23.3
Talking with someone:		
I don't know	57	7.3
No	166	21.1
To some extent	344	43.9
Yes	217	27.7

Overall, less than 10 percent of the surveyed individuals stated they "did not know" about the impact of aircraft noise on their routine welfare activities. The combined "I dont know" and "no" response categories ranged from a low of 21.7 percent, for the impact on relaxing activity, to a high of 61.7 for eating. On the other hand, the percent of respondents who stated "yes" to the adverse welfare impacts of noise was the highest for the "sleeping" activity (44.2%), followed by impact on relaxation (33.9%), work productivity (32.1%), and telephone conversation (28.6%). In general, it is thus fair to conclude that the majority of the surveyed population were unaware of the negative impacts of aircraft noise on their routine welfare activities (Table 8).

The analysis of the data also indicated that only the education level of the exposed sample population demonstrated a positive relationship with their perceptions of the negative impact of aircraft noise on work productivity. As presented in Figure 5, a sharp increase in perceived impacts is observed with an increase in the level of formal education, especially for those with college and post-graduates degrees. For example, while only 3 percent of the sample individuals with no education pointed to the existence of noise impact on work productivity, 34 percent of those with a post-graduate degree indicated the same (11 times as many). The existence of a trend between education and perceptions was also confirmed by the test of chi-square ($\chi^2 = 67.0$, df $= 15$, $p < 0.0001$).

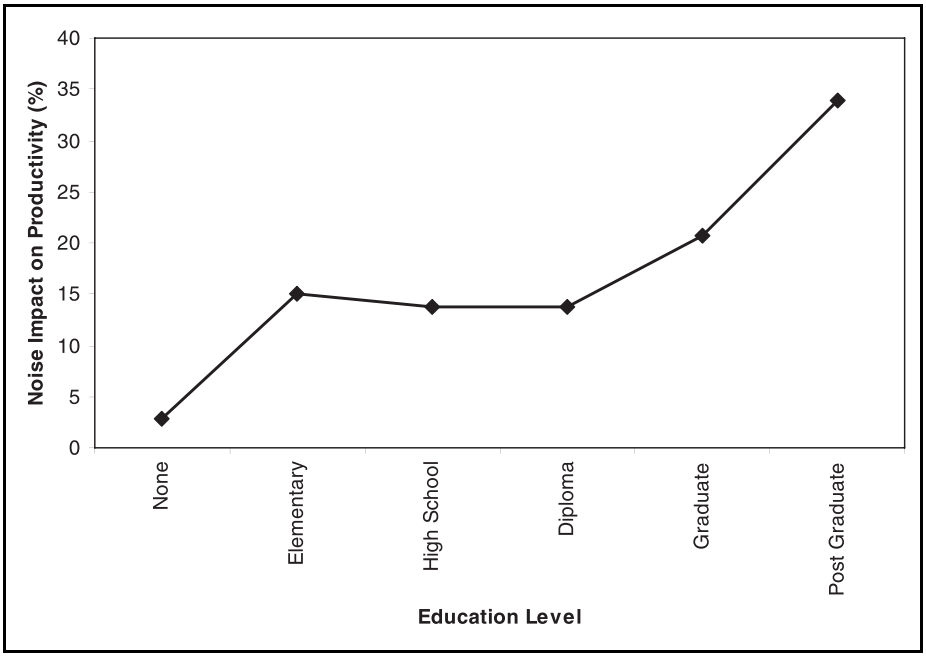

Figure 5. Perceived noise impact on work-productivity by educational level

The perceived impact of aircraft noise on health are presented in Table 9. A clear majority of the exposed population felt tired sometimes (46.1%), or often (13.9%) because of the daily exposure to aircraft noise. On the other hand, a significant percentage of the sample individuals did not think that noise could act as a stressor and could result in tiredness. Less than 10 percent were simply unaware of this likely impact.

Table 9. Perceived health impacts of aircraft noise (tiredness, nervousness, headaches) and productivity

Variable name	Freq.	Percent	Cum. percent
Tiredness:			
I don't know	66	8.4	8.4
No	249	31.6	40.0
To some extent	364	46.1	86.1
Yes, often	110	13.9	100.0
Nervousness:			
I don't know	52	6.6	6.6
No	104	13.2	19.8
To some extent	410	52.1	71.9
Yes, often	221	28.1	100.0
Headaches:			
I don't know	90	11.5	11.5
No	283	36.1	47.6
To some extent	294	37.6	85.2
Yes, often	116	14.8	100.0

As also indicated in Table 9, more than 80 percent of the respondents stated that the noise from aircrafts was "often" the cause of their feeling nervous (28.1%), or "sometimes" (52.1%). The remaining 19.8 percent included those who responded "no," and those who were not aware of the existence of such impact. More than ½ of the surveyed population experienced headaches from aircraft noise, often (14.8%), or sometimes (37.6%). Again, more than 11 percent simply did not know of the existence of such impact (Table 9).

The factors of education and nationality once again demonstrated associations with the perceptions of health impacts of aircraft noise. As presented in Table 10, an increase in the level of education was accompanied by a significant increase in the percentage of those who felt nervous because of aircraft noise impact. For example, while only 17.8 percent of the sample population with no education stated "yes" to the existence of noise impact on

nervousness, 44.6 percent of those with post-graduate education perceived such a relationship. This trend was also supported by the result of chi-square test (χ^2 = 67.5, df = 15, p < 0.0001). A similar relationship was found to exist between the nationality of the respondents and their perceptions of aircraft noise impact on nervousness (Table 10). The importance of the role of public education and awareness programs to promote the publics understanding of the adverse welfare and health impacts of noise is emphasized by these findings.

Table 10. Sample populations perceptions of nervousness impact of noise, by education and nationality

Variable name	Perceptions of noise impact on nervousness (%)			
	I don't know	No	To some extent	Yes
Education:				
None	16.1	17.9	48.2	17.8
Elementary	5.8	18.0	50.4	25.8
High school	9.2	9.3	60.3	21.2
Institute	25.9	14.8	33.4	25.9
College	3.2	13.6	51.8	31.4
Post Graduate	1.5	7.7	46.2	44.6
	(χ^2 = 57.5, df = 15, p < 0.0001)			
Nationality:				
Kuwait	2.8	13.6	53.3	30.3
Non-Kuwaiti	10.4	13.0	50.6	26.0
	(χ^2 = 18.7, df = 3, p < 0.0003)			

The analysis of the data also showed that a positive relationship (although not very strong) existed between the sample respondents' education level and nationality with their perceptions of aircraft noise impact on headaches. The existence of such a trend was again supported by the test of chi-square (χ^2 = 35.0, df = 15, p < 0.0003, for the education level, and χ^2 = 8.6, df = 3, p < 0.03, for the nationality).

VALIDATION OF PERCEPTIONS

Question 3 of the study asked, "Are these individuals' perceptions of noise impacts valid and justified?". The following two hypotheses were tested to provide answers to these questions.

Hypothesis 1: H_0: The distance between the airport and exposed individual's place of residence/work is important in determining levels of annoyance from noise.

H_1: Otherwise.

Hypothesis 2: H_0: The level of aircraft noise is important in determining exposed individual's perceptions of adverse noise impacts.

H_1: Otherwise.

The data were used to examine and test these hypotheses.

The distance from the airport, the measured noise level (L_{eq}), and the perceptions of aircraft noise impact are presented in Table 11. Although the four study districts are all located under the "approach path" of the landing aircrafts, Farwaniya is the closest district to the runway thresholds in the airport. This is followed by Khaitan, Omariya, and Shuwaikh.

Table 11. Sample populations perceptions of noise impacts and measured noise levels by district/distance from the airport

Variable name	Sample populations perception's of noise impacts (%)			
	Farwaniya	Khaithan	Omariya	Shuwaikh
Distance from runway threshold (Km):	< 5.0	8.5	12.5	14.5
Equivalent noise level dBA:	80.2	78.4	73.5	71.8
Is aircraft noise a problem?	76.9	75.1	67.9	65.2
Does aircraft noise annoy you?	89.6	89.6	80.1	82.0
Is your sleep affected by aircraft noise?	69.8	62.7	53.4	57.6
Does aircraft noise affect your work productivity?	75.1	64.0	57.2	62.1
Does aircraft noise affect your nervousness?	79.2	75.8	61.6	67.3

As the data in Table 11 shows, perceptions of aircraft noise as an urban problem, and its adverse impact on annoyance, sleep, work productivity, and nervousness, became more pronounced as the individual's distance to the airport decreased. Those who lived closer to the airport perceived the impact stronger than those who lived farther away. The H1 hypothesis was therefore rejected.

The data in Table 11 also indicate that the mean level of aircraft noise was significantly higher at districts closer to the airport (as is expected): more than 80 dBA in Farwaniya, the closest district to the airport, and 71.8 dBA in Shuwaikh the farthest approach district. These perceived higher impacts of aircraft noise were therefore associated with higher levels of measured noise at their places of residence or work. The H_1 for hypothesis number two was also rejected: individual's perceptions of aircraft noise impacts were thus both valid and justified.

A category analysis was also performed to further examine and test the significance of noise-perceptions relationships. Figure 6 shows the relationship between the sample individual's perceptions of noise as a problem and the measured mean noise level at the district where they resided or worked. It is clear that those who complained about the problem of aircraft noise were those who lived or worked in noisier areas (L_{eq} = 80.2 dBA), as compared to those who lived/worked at less noisy areas. This trend is also supported by the test of chi-square (χ^2 = 14.5, df = 6, p = 0.01).

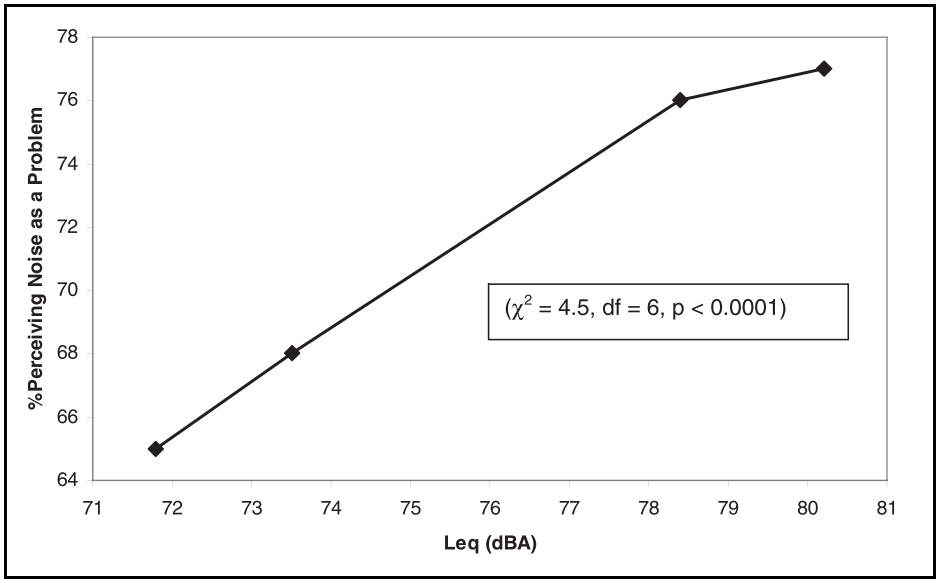

Figure 6. Relationship between L_{eq} and percent perceiving aircraft noise

Also examined was the relationship between the perceived annoyance and the measured mean noise level at participants residences and/or work places. As shown in Figure 7, the percentage of individuals who lived/worked in the noisiest area (Farwaniya, L_{eq} = 80.2 dBA), and who expressed annoyance with aircraft noise was more than 2.3 times the percentage of those who lived/worked

in the least noisy area (Omariya, L_{eq} = 71.1 dBA). Both of these findings further support the rejection of hypothesis two, thus an evidence for the validation and justification of people's perceptions of aircraft noise and its impacts. This general finding is very much in line with other studies concerning aircraft/airport noise.

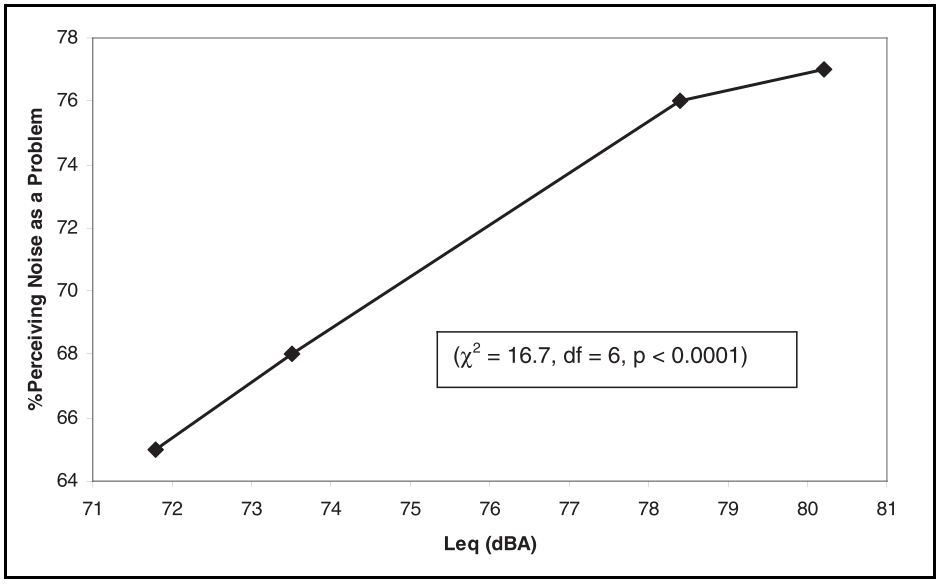

Figure 7. Relationship between L_{eq} and percent annoyed aircraft noise

Relative Impact Contribution to Annoyance

The exposed population's annoyance with aircraft noise was due to noise interference with their daily welfare activities. Herein, an attempt was made to examine and estimate the relative influence of these factors on the annoyance level of the sample exposed population. Similar to an approach employed by Flachsbart Et al. (1987), and Koushki Et al. (1992), the standard deviation of annoyance level due to each welfare impact factor was expressed as a percentage of the average annoyance level and was defined as the percent relative factor standard deviation for a given welfare impact K, % $RFSD_K$:

$$\%\mathrm{RFSD_K} = \frac{\mathrm{SD_K}\bar{y}}{\bar{y}}$$

where: SD_K = standard deviation of annoyance level for welfare impact factor K, and $\bar{y}$ = the average annoyance level. A summary of the estimates of the contribution to annoyance by each welfare impact factor is presented in

Table 12. The percent RFSD of a given welfare factor associated with annoyance level, if all other factor were held constant, is presented in Column 2. It indicates that if, for example, the noise impact on telephone conversation was the only source of variation, the annoyance level is estimated to vary 19.2 percent of the average annoyance level for various reported percentages of impact on telephone conversation. The contribution of the unknown sources to variation to annoyance level (work, family, etc. sources of annoyance) is higher than that of any single welfare impact factor to the overall % RFSD.

Table 12. Relative welfare impact contribution to annoyance level

Welfare impact factor	% RFSD, if factor the only source of variation	% RFSD, if factor was removed	Reduction in total variation
Telephone conversation	19.2	79.2	8.1
Eating	6.7	85.7	1.6
Relaxing	23.8	73.1	14.2
Working productivity	21.4	74.6	12.7
Sleeping	26.1	68.9	18.4
Watching TV	12.6	81.4	5.9
Talking with someone	18.7	80.2	7.1
Unknown sources of contribution to annoyance level	36.9	58.8	28.5

The data in Column 3 of Table 12 show the effect of each factor on the total variation in annoyance level in the presence of all the other welfare factors. The values in Column 3 are estimated from a comparison of the % RFSD when all impact factors are present against the % RFSD when a given factor is removed. If, for example, the telephone conversation impact was held constant, the amount of total variation would be reduced to 79.2 percent of the average annoyance level. This represents a reduction of 8.1 percent from the total estimated variation of 87.3 percent, as presented in Column 4 of Table 12. The adverse impact of aircraft noise on sleeping, relaxing, and at work were the main known contributors to the total variation in the annoyance level of exposed individuals.

CONCLUSIONS

The findings of the first study of aircraft noise and its impact on exposed individuals in Kuwait are presented in this paper. The overall conclusion of the study was that aircraft noise at the vicinity of the airport in Kuwait is well above the permitted outdoor level during a major portion of day/night, and a significant percentage of the exposed population is adversely affected by its impact.

The exposed population includes more than 116,000 people who live and/or work in areas directly located under the "approach path" of the landing aircrafts -some less than 3 kilometers away from the runway thresholds. These individuals are normally exposed to daily aircraft noise doses, which exceed 76 dBA for more than 70 percent of the times that aircrafts approach and land at the airport. The highest 10 percentile noise level during these times was in excess of 80 dBA. This is a disturbing noise level. It should be noted that according to the Federal Aviation Administration (FAA) of the United States, the average day/night levels should not exceed 65 dBA (moderate noise exposure).

A significant percentage of the surveyed population was annoyed with aircraft noise and believed that it adversely affected their daily routine activities. Aircraft noise affected their phone conversations, relaxation, watching TV, talking to someone, sleeping, and productivity at work. Annoyance was mostly caused by noise interference with sleeping, relaxing, and working of the exposed individuals. A significant percentage also perceived that aircraft noise negatively affected their health. Effects include tiredness, feeling nervous, and having headaches. The sample Kuwaiti nationals, the sample males, and those with higher education levels, perceived these negative impacts more pronouncedly.

People's perceptions of adverse welfare and health impacts of aircraft noise were both justified and valid. Those who lived and/or worked closer to the airport perceived these impacts more strongly. Also, those who perceived the welfare and the health impacts of aircraft noise more strongly, were exposed to significantly higher levels of aircraft noise.

RECOMMENDATIONS

Considering the rapid rate of growth in the population, the socio-economic activities, and the associated increase in air travel in Kuwait, the problem of aircraft noise pollution will intensify in the near future, and a larger percentage of urban population will be adversely affected. Government policies and decisions are thus urgently needed to address the problem of aircraft noise, both, in the short -and long-runs. In the short-run, the "approach path" for the landing aircrafts, and the direction of take-offs should be changed (wind

permitting) to avoid flights over the residential areas to the east of the airport. Fortunately, vacant desert land limits the airport to the west. In addition, the following measures should also be examined for airport noise reduction in Kuwait.

1 - The airport and airlines should be charged the full cost of airline travel. The landing fees should be increased to cover lost property value, insulation programs, health effects, and annoyance. Fuel taxes should be increased to account for environmental and public health damage.

2 - A nighttime curfew should be adopted. Around the world, airports already have curfews. Airport pricing/charges may be utilized as means of dealing with noise externalities. This is already a common practice in many European airports (e.g. Amsterdam, Brussels, London-Heathrow).

3 - Soundproofing programs should be implemented in all homes, schools, hospitals and commercial businesses experiencing a day/night noise level of 65 dBA or more (This for the Kuwait airport covers the entire study area).

4 - Air carriers should be required to gradually replace the older and noisier aircrafts with newer and quieter ones. This would be a policy which would improve the problem of aircraft noise in the medium-run.

5 - For the long-run, reduction of aircraft noise in Kuwait will require the construction of a new airport at an appropriate location away from the urban population. Fortunately, the availability of unlimited land to the north, west, and southwest of the existing airport provides optimum locations for the construction of a new airport in Kuwait.

6 - The local control of airport should be increased, and people who are adversely affected by airport noise (residents of Farwania, Omariya, Khaitan, and Shuwaikh), should be able to exercise more control with regard to expansion, number and time of takeoffs, landings, and ground operations.

7 - Finally, a regular noise monitoring program should be in place in the affected areas, as is the practice at several airports worldwide (see John Wayne Airport, Noise Abatement Guidelines 2008). Noise limits should be implemented and violators penalized. An exclusive noise complaint office should also be established at Kuwait International Airport.

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ضجيج المطار وتأثيره على السكان المجاورين في الكويت

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خلاصة

المناطق الحضرية بدول مجلس التعاون الخليجي تطورت سريعا في العقود الثلاثة الماضية وفي غياب التخطيط الاستراتيجي فإن التطور العمراني كان له آثار سلبية على البيئة الحضرية وجودة الحياة. هذا البحث يوضح نتائج أول دراسة عن ضجيج الطائرات وتأثيره على السكان في دولة الكويت. تم قياس ضجيج 1007 طائرة في مدة عشرة شهور في أربع مناطق حضرية قريبة من ممرات هبوط الطائرات وملاحظة وتقييم تأثيره على الصحة والبيئة. الدراسة أحصت عدة مؤشرات للضجيج مثل (Lmin, L90, L50, Leq, L10, Lmax, and the Leqpd) بالاضافة إلى مقابلة عينة عشوائية من ألف شخص في مناطق الدراسة الأربع. وجد أن نسبة ملحوظة من العينة أظهرت الضيق من ضجيج الطائرات والمعاناة من تداخلها في المحادثات بين الأفراد ومشاهدة التلفاز والأكل وأوقات الراحة والعمل والنوم. أكثر من ربع العينة شعرت بالتعب والعصبية والصداع من ضجيج الطائرات. والدراسة أيضا بها بعض التوصيات الهامة لمواجهة هذا التلوث السمعي في الكويت.