STUDY OF SCHOOL NOISE IN THE CAPITAL CITY OF TEHRAN-IRAN

*[1]R. Golmohammadi, [2]F. Ghorbani, [3]H. Mahjub, [4]Z. Daneshmehr

[1]Department of Occupational Health, School of Public Health and Research Center for Health Sciences, Hamadan University of Medical Sciences, Hamadan, Iran.
[2]Department of Occupational Health, School of Public Health, Hamadan University of Medical Sciences, Hamadan, Iran
[3]Department of Biostatistics, School of Public Health, Hamadan University of Medical Sciences, Hamadan, Iran
[4]Department of Research and Standards, Ministry of Education, Iran

Received 11 October 2009; revised 21 June 2010;accepted 20 August 2010

ABSTRACT
Noise pollution has a detrimental effect upon the learning and attainments of school children. Poor acoustical condition and high noise levels can cause many problems for the instructors and students. The acoustical indices and conditions of classrooms are important factors in the learning achievement of students. The purpose of this study was to find the relations of noise levels in indoor/outdoor and acoustical conditions of classrooms. Noise measurements and acoustical indices of 244 classrooms in 90 random samples consisting of primary, secondary and high schools in Tehran were considered. It was found that the average equivalent noise levels inside classrooms and corridors, yards and street sides in teaching condition were 72 dB(A), 65.8 dB(A), 64.1 dB(A) and 64.5 dB(A), respectively. Deference between mean indoor LAeq and background noise level in teaching conditions (above 32 dB) indicates that outdoor district noise sources could not significant affect indoor noise levels (P = 0.521). Comparison of means between equivalent noise level in classrooms of boy schools with girl schools showed a significant difference (P=0.0001). For the case of classrooms in primary, secondary and high school this Comparison had a significant deference (P=0.0001). Site selection, improving acoustic quality, controlling opening in doors and windows and educating noise reduction for studied schools were proposed.

Key words: Noise; Noise pollution; Classroom; Schools; Acoustical condition; Tehran

INTRODUCTION
A main effect of noise pollution in the classrooms is the reduction of speech intelligibility, and the hearing and understanding of speech by children of different ages in various noise and acoustic conditions. It is generally accepted that noise has a detrimental effect upon the learning and attainments of primary school children. Moreover, they may lead to voice problems for the instructor, who is forced to raise his/her voice when lecturing, to compensate for poor acoustical conditions (Hodgeson, 2002; Shield and Dockrell, 2003).

*Corresponding author: E-mail: golmohamadi@Umsha.ac.ir
Tel: +988 11 8255963, Fax: +98 811 8255301

Koszarny showed that the noise level in study classrooms were in the range of an equivalent sound level of 60-95 dB(A) and the most frequent noise level was 80dB(A). Sound pressure level in corridors in break time in elementary schools was 85dB(A) and for high schools was 77dB(A). Also studies have show this index for classrooms with over 30 students was 3 dB(A) higher than classrooms with 25 students or less (Koszarny, 1990 and 1992).
Noweir in a study of noise pollution in Jeddah schools found that the mean average L_{eq} levels (60-89.2 dB(A)) highly exceeded the recommended levels (Noweir and Ikhwan, 1994). Zannin and

Zwirtes in a study of public school classrooms found that the equivalent noise levels during class was 73.7-74.0 dB(A) (Zannin and Zwirtes, 2009). Daily measurements of equivalent sound levels in Clark study in the classes (L_{eq} during school day) ranged from 59 to 87 dB(A) (Clark, 2006).

Limits of classroom noise levels in different countries are given in Table 1 (Zannin and Loro, 2007). Minimum transmission losses for separation wall in school recommended by Iranian Ministry of Housing and Urban Development are shown in Table 2 (MHUD, 2000). World Health Organization (WHO) in the guideline for community noise has specified an appropriate background noise level for classrooms as 35dB (L_{Aeq}) during teaching sessions (WHO, 1999).

Mackenzie in a study of primary school classrooms found that the average L_{Aeq} was 56.3 dB(A) when pupils were quiet. He found that the ambient noise level in an occupied primary school classroom was closely related to the pupil activity and external noise had an effect on the internal noise level only when pupils were engaged in quite activities (Shield and Dockrell, 2004).

Hodgson in a study of university classrooms found that the presence of students has a significant effect on the acoustical conditions and verbal communication. This effect must be taken into account in classroom design, and when setting classroom acoustical criteria (Hodgson, 1999).

The reaction of students and teachers has indicated that the main source of acoustic discomfort is the noise generated by the neighboring classrooms (Carmen and Paulo, 2004). Astolfi and Pellerey in a study about assessment of acoustical quality in secondary school classrooms, have reported that no significant difference was observed noise levels between males and females, while the average value for the text reading. They also found that the noise came mainly from inside the school buildings (Astofi and Pellerey, 2008).

Traffic noise level (Leq) near the road sides in the city of Tehran are reported as 74.7 ± 3.7 dB(A) and 74.32 ± 2.5 dB(A), (Mohsseni, 1998; Mansouri, 2006) respectively.

The purpose of this study was to evaluate the noise pollution and find the relations between noise levels in indoor/outdoor and acoustical conditions of classrooms in Tehran schools.

MATERIALS AND METHODS

The present study was conducted in the metropolitan city of Tehran. 244 classrooms in 90 random sample schools consisting of primary, secondary and high schools were selected. Sample size was estimated based on the results of sound pressure level of classrooms in related studies of other researches (Koszarny, 1990 and 1992) with a sample error equal to 5% and confidence interval of 95%.

Samples were based on proportional randomly selection school numbers based on sex, type (grade) and traffic load (low traffic load< 2500V/h and high traffic load ≥ 2500V/h) around the schools. In each sample school, measuring requirement parameters consisting of dimensions and acoustic characteristics of classrooms were considered and equivalent sound pressure level (LAeq10min) in indoor and outdoor of the classrooms were measured.

In each school, a classroom was randomly for each flat selected and then sound pressure level in teaching condition (direct teaching) and break time in the center of classroom was measured. Noise level was measured by calibrated sound level meters (QUEST 2700 and TES 1358) based on ISO 1996-1 and ANSI/ASA S1.13 (ANSI/ASA, 1999; ISO, 2003) in hearing height of student in classrooms and corridors. The research data were transferred into SPSS data sheet for statistical analysis. To compare means of variables, T-test analysis, and for regression analysis, the analysis of variance (ANOVA) test were used. Reverberation time and transmission loss of classrooms were estimated based on the recommended equations and techniques (Harris, 1991; Bell and Bell, 1994).

RESULTS

The means and standard deviations of the measured parameters for each location are shown in Table 3. It was found that the average equivalent noise level inside classrooms (in teaching condition) was 71.98 dB(A). It can be observed that the mean of outdoor noise levels in yard side was similar to the street sides. Normal distribution of equivalent noise levels in classrooms in teaching condition are shown in Fig. 1.

The average background noise level (LAeq) in classrooms (when pupils were silent) was 39.41 dB(A). The standard deviation of mean

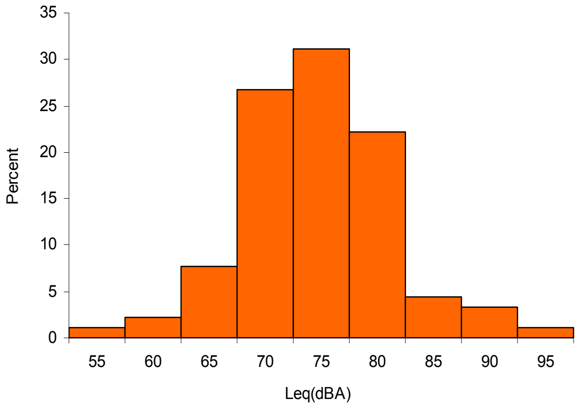

Fig.1: Distribution of equivalent noise levels in classrooms in teaching condition

background noise and the equivalent sound pressure level in classrooms in teaching condition was about 6 dB(A).

Results also showed that the mean crest factor of sound pressure level in teaching condition in classrooms and corridors were 4.95 and 6.26 dB(A), respectively. Also the crest factor in the break condition in corridors and yards was found to be 6.58 and 7.26 dB(A), respectively. Mean L_{Aeq} in classrooms by sex of pupils, traffic load and type of schools are shown in Table 4. The mean of pupil population, dimension and acoustic conditions of classrooms are shown in Table 5. Regression analyses between some important variables are shown in Table 6.

Table 1: Limits of classroom noise levels in different countries

Country	Noise index	Limit dB(A)
Brazil	L_{Aeq} [a]	40
Japan	L_{Aeq}	40
UK	$L_{Aeq,30\,min}$	35
USA	L_{Aeq} [b]	35
	L_{Aeq} [c]	40
Iran[d]	L_{AS}	40
	$L_{Aeq,30\,min}$	35

[a]- Do not indicate value for duration measurement.
[b]- One hour average steady background noise level.
[c]- Increased by 5 dB when the noisiest hour is dominated by transportation noise with maximum volume of 566 m^2.
[d]- Recommended by Ministry of Housing and Urban Development, Iran, 2000.

Table 2: Minimum transmission loss for separation wall in school*

Locations	Transmission Loss (dB)
Between classrooms and outside	40
Between laboratory/practice room and outside	35
Between classrooms	50
Between classrooms and corridors	35
Between laboratory and corridors	30
Between laboratory and corridors	33
Between practice room and corridors	35

* Recommended by Ministry of Housing and Urban Development, Iran, 2000.

Table 3: Parameters of LAeq * in the studied classrooms

Locations	Number	Min	Max	Mean	S.D.
Classrooms, in teaching condition	244	53.22	91.58	71.98	6.55
Background, in teaching condition	34	24.44	50.06	39.41	6.27
Corridors, in teaching condition	243	53.78	82.53	65.77	4.61
Yards, in teaching condition	90	50.61	87.68	64.13	7.56
Street sides (outdoor) , in teaching condition	35	47.19	79.06	64.52	7.82
Corridors, in break condition	243	60.49	95.54	79.79	6.06
Yards, in break condition	90	58.88	96.81	78.66	6.16
Street sides, in break condition	11	62.09	82.55	69.91	6.16

* All the level measurements are based on dB(A) for slow mode condition.

DISCUSSION

The purpose of this study was to evaluate the noise pollution and to find the relations between noise levels in indoor/outdoor and acoustical condition of classrooms in Tehran schools.

Measurements of equivalent sound pressure levels in outdoor of classrooms were compared with Iran Department of Environment (IDE) regulations (IDE, 2009), which sets the limit at 65 dB(A).

Table 4: Mean (L_{Aeq})* in classrooms by sex of pupils, traffic load and type of schools

Items		Mean	S.D.
Sex of pupils	Male	75.70	6.45
	Female	68.73	4.66
Traffic load	Low	71.12	7.24
	High	72.77	5.79
Elementary		72.28	6.65
Intermediate		70.65	5.70
High school		73.01	7.20

* Measurement in teaching conditions

Hence, 52% of street side levels and 48% of yard side levels were above the recommendation level. Although, the mean equivalent sound pressure level (Table 3) were exceeded the limitation levels and they had about 10 dB(A) less than the Mohsseni and Mansouri's results for Tehran noise levels near the roads (Mohsseni, 1998; Mansouri, 2006). These results could refer that the distance of studied schools from main roads were sufficient.

Table 5: Population, dimension and acoustic conditions of classrooms

Items	Number	Min	Max	Mean	S.D.
Students number	244	18	43	30.61	5.10
Area (m^2)	244	9	56	33.51	10.73
Space (m^3)	244	27	192	102.00	34.93
Absorption index (unoccupied) (sabin.m^2)	244	1.84	20.35	4.56	2.09
Absorption index (occupied) (sabin.m^2)	244	14.37	41.23	25.86	4.30
Reverberation time (occupied) (s)	244	0.26	1.30	0.63	0.20
Transmission loss of windows side (dB)	243	21.00	40.00	26.50	2.37
Transmission loss of corridors side (dB)	243	17.00	35.00	29.72	2.27

Table 6: Correlation coefficients between L_{eq} dB(A) and some important variables

Items	Number	Pearson correlation	P-value
Number of students in classrooms	244	-0.048	0.655
Number of students in schools	89	0.090	0.401
Classroom area (m^2)	244	0.124	0.243
Classroom volume (m^3)	244	0.127	0.232
Windows area (m^2)	244	0.212*	0.045
Doors area (m^2)	244	0.244*	0.021
Absorption coefficient of internal surfaces	244	-0.173	0.103
Absorption index (sabin.m^2)	244	-0.066	0.534
Reverberation time(occupied) (s)	244	0.172	0.104
Transmission loss of corridors side (dB)	243	-0.009	0.930
Transmission loss of windows side (dB)	243	-0.231*	0.029
L_{eq} in yard in teaching condition, dB(A)	243	0.286**	0.006
L_{eq} in corridors in teaching condition, dB(A)	243	0.336**	0.001
L_{eq} in street side in teaching condition, dB(A)	35	0.112	0.521

* Correlation is significant at the 0.05 level (2-tailed).
** Correlation is significant at the 0.01 level (2-tailed).

It was found that the average equivalent noise levels inside classrooms (in teaching condition) was 71.98 dB(A), that had a normal distribution shape (Fig. 1) and predicated the enough sample size. Although, the measured mean of LAeq in classrooms in this study were similar to the results of other studies (Koszarny, 1992; Nowier, 1994; WHO, 1999; Clark, 2006; Zannin, 2007 and 2009); but, 61.1% of internal noise level exceeded the recommended levels (WHO, 1997;

MHUD, 2000). The average background noise level (L_{Aeq}) in classrooms (when pupils were quiet) was 39.41 dB(A) which was lower than the Mackenzie study results (Shield and Dockrell, 2004), but 70.6% of background noise level in classrooms exceeded the recommended levels (WHO, 1997 and 1999; MHUD, 2000).

Regression between background noise level in classrooms with outdoor noise levels for street side (R = 0.575) and yard side (R = 0.761) locations had a significant coefficient (P=0.0001). Results also showed that 99% of street side walls and 100% of separator walls between classrooms and corridors did not have enough efficiency for isolation against outside noise levels (WHO, 1999; MHUD, 2000). Regression between classrooms noise levels with windows area and doors area had a significant coefficient ((P=0.045) and (P=0.021), respectively). These results led us to the fact that the transmission loss of separator walls was not adequate for noise control.

Regression between noise levels in classrooms in teaching condition with outdoor noise levels for yard side (R = 0.286) and corridors (R = 0.336) locations had a significant coefficient ((P=0.006) and (P=0.001), respectively). This result was the same as the Astolfi and Pellerey results (Astolfi and Pellery, 2008). Difference between mean indoor LAeq and background noise level in teaching conditions (above 32dB) revealed that outdoor district noise sources could not significantly affect indoor noise levels. Therefore, it can be said that the internal sources were the main sources for noise pollution in schools.

Comparision of the means between equivalent noise level (L_{Aeq}) in classrooms of boy schools (75.70 dB(A)) with girl schools (68.73 dB(A)) showed a significant deference (P=0.0001). This result is different from the Astolfi and Pellerey results (Astofi and Pellery, 2008). Also deference between primary (72.28 dB(A)), secondary (70.65 dB(A)) and high schools (73.01 dB(A)) noise levels, was significant (P=0.0001). Regression between equivalent noise levels in classrooms in teaching condition with number of students in classrooms (R=-0.048) and schools (R = 0.090) had not significant coefficient ((P=0.655) and (P=0.401), respectively). Means between street side noise levels and background noise levels in classrooms with traffic load area (near the schools) showed significant deference ((P = 0.0001) and (P = 0.002), respectively).

Noise produced by students in break time (mean = 78.66 dB(A)) was the major source for raising the noise levels in corridors and yards. Therefore, it is believed that, the schools were the noise pollutant source for neighborhoods.

As it is shown in Tables 5 and 6, acoustic characteristics of classrooms had a poor condition for acoustic absorption index for internal noise and poor transmission loss in window side and corridor side for reduction of noise against outdoor noise. Therefore, it is believed that the acoustic condition of classrooms were inadequate to avoid increasing of noise pollution.

Finally, it is to denote that, the internal sources were the main cause of noise pollution in studied schools. Improving acoustic reform, controlling opening in doors and windows and educating students about noise reduction and acoustic based designing for future construction were proposed.

ACKNOWLEDGEMENTS

The authors would like to thank the Department of Research and Standards, Ministry of Education of I.R. Iran, for financing this project, and the schools, children and teachers who took part in this research.

REFERENCES

American National Standard (ANSI/ASA), (1999). American National Standard Methods for the Measurement of Sound Pressure Levels. ANSI/ASA S1.13- 1995 (R1999), USA.

Astolfi, A., and Pellerey, F., (2008). Subjective and objective assessment of acoustical and overall environmental quality in secondary school classrooms. J. Acoust. Soc. Am. **123**(1): 163-173.

Bell, L., and Bell, D., (1994). Industrial noise control, Marcel Dekker, New York, 135-183.

Carmen, P.L., and Paulo ,T.Z., (2004). Classroom acoustics in public schools: A case study, J. Acoust. Soc. Am., **115**(5): 2371-2375.

Clark, C., Martin, R., Kempen, E.V., (2006). Exposure-effect relations between aircraft and road traffic noise exposure at school and reading comprehension, Am. J. of Epidemiology, **163**(1): 27-37.

Harris, C.M., (1991). Handbook of acoustical measurements and noise control, USA, McGraw-Hill, 9.1- 9.18.

Hodgson, M., (1999). Experimental investigation of the acoustical characteristics of university classrooms. J. Acoust. Soc. Am. **106**(4): 1810-1819.

Hodgson, M., (2002). Rating, ranking, and understanding acoustical quality in university classrooms. J. Acoust. Soc. Am., **112**(2): 568-575.

Iran Department of Environments (IDE), (2009). Regulations for outdoor noise levels, IDE Press, Tehran .

International Standard Organization (ISO), (2003). Acoustics - Description, measurement and assessment of environmental noise - Part **1**: Basic quantities and assessment procedures, ISO, ISO 1996-1, Geneva.

Koszarny, Z. ,and Gorinsky, P., (1990). Exposure of school children and teacher to noise at school, Annals of National Institute of Hygiene, **41**(5-6): 297-310.

Koszarny, Z., (1992). Evaluation of school noise by teacher and assessment of its effect on health and general feeling, **43**(2): 201-210.

Mansouri, N., Pourmahabadian, M., Ghasemkhani, M., (2006). Road traffic noise in downtown area of Tehran, Iran. J. Environ. Health Sci& Eng., **3**(4): 267-272

Mohsseni, P.H., (1998). Correction for the road traffic noise model in Tehran, MSc thesis, Islamic Azad University (IAU)- Research branch.

Ministry of Housing and Urban Development (MHUD), (2000). Regulations for noise levels and sound isolation, MHUD Press, Bulletin **19,** Iran.

Noweir, M.H., and Ikhwan, M.A., (1994). Study of noise pollution in Jeddah schools, Journal of Egypt Public Health Association, **69**(3-4): 149-62.

Shield, B., and Dockrell, J.E., (2003). The effects of noise on children at school: A review. Building Acoustics, **10**: 97-116.

Shield, B.,and Dockrell, J.E., (2004). External and internal noise surveys of London primary schools. J. Acoust. Soc. Am. **115**(2): 730-738.

World Health Organization information (WHO), (1997). Primary school physical environment and health, World Health Organization information series on school health: Document **2,** WHO.

World Health Organization information (WHO), (1999). Guidelines for Community Noise, World Health Organization, http:// www.who.int/peh/.

Zannin, P.H., and Loro ,C.P., (2007). Measurement of the ambient noise level, reverberation time and transmission loss for classrooms in a public school, Noise control engineering J., **55**(3): 327-333.

Zannin, P.H., and Zwirtes, D.P., (2009). Evaluation of the acoustic performance of classrooms in public schools. Applied Acoustics **70**: 626-635.