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Original Article

Evaluation of some physical hazards which may affect health in primary schools

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Abstract

Aim: This study was performed with the objective to determine the levels of some physical hazards in primary schools.

Material and Methods: This study is a cross-sectional field survey. In this study which was conducted in 31 primary schools selected by appropriate sampling from the district of Keçiören of the province of Ankara, measurements related with temperature, light, electromagnetic field (EMF) and noise levels were done at hundreds of points. Approval was obtained from Gülhane Military Medical Faculty Ethics Committee (2007/97).

Results: Only 47.1% of the classes had a temperature value within the recommended limits (20-21°C). It was found that the illumination levels in 96.8% of the schools were above the standard values. However, the levels of illumination were found to be statistically significantly decreased towards the door and the back line ($p<0.05$). It was found that electromagnetic field levels were significantly higher in the schools who had a source of electromagnetic field nearby compared to the schools who did not have such a source nearby ($p<0.001$). It was found that the electromagnetic field levels in computer classes were statistically significantly higher compared to the other classes ($p<0.001$). Noise levels were found to be statistically significantly higher in classes which had 35 and more students ($p<0.05$). No statistically significant difference was found in schools near intensive vehicle traffic in terms of noise levels (62.8±5.0 (n=72), 62.0±6.4 (n=79), respectively, $p>0.05$).

Conclusions: It was found that primary schools in the region of Keçiören had aspects which had to be improved in terms of building age, building location, brightness, electromagnetic field and noise levels. School health programs directed to improve negative enviromental factors should be developed. (Türk Ped Arş 2014; 49: 217-23)

Key words: Illumination, electromagnetic field, noise, temperature, school health

Introduction

School health services are the total of practices performed in order to evaluate and improve the health status of students and teachers, to provide and maintain a healthy school life and to give health education to students and thus to the community (1). These services aim full well-being of students, teachers and school workers in terms of psychological, physical and social aspects (2). Practices related with evaluation, protection and development of the health status and environmental health and health education services in the school are included in the scope of school health services (1-4).

Practices of "school environmental health" which constitutes the basis of this study includes subject matters including school place and location, instruction properties, status and materials of the school building, infrastructure facilities, installment safety, quality of the air in the internal environment, water safety, restrooms, playing areas, heating and illumination levels, service hygiene and prevention of biological and geophysicochemical pollution in the school (5).

In the whole world, the population below the age of 15 years constitutes 28% of the total population (6). In Turkey, this rate is 26.2% and 63% of this (11 514 685) are in the period of elementary and preschool education (7).

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Children in the elementary school period which is a special part of life are more vulnerable against environmental conditions compared to adults, because they are in a physical and mental development process and the risk of permanent effects on children caused by environmental factors is considerably high because of rapid cell division, a larger body surface by weight, high metabolism rate, high oxygen consumption and lack of host defense mechanisms. (1, 8, 9).

Studies have shown that environmental factors including inappropriate temperature, illumination, EMF, noise, toxic indoor air pollutants etc. lead to school absanteeism and decreased academic success in addition to health effect (10-14).

Exposure to heat and cold has negative effects on performance depending on the exposure time (15). Studies have shown that decrease in self-confidence performance and in the capacity of thinking and concentration occurs as the temperature increases (16) and the optimum level of temperature for a comfortable learning environment is 20-21°C (10, 17).

Illumination which is another important factor in terms of school health is necessary in terms of reading-writing, long-term concentration, a comfortable studying environment and most importantly protection of eye health. According to international standards, the lower limit of illumination level is 200 lux for classes (18, 19).

Increasing evidence has recently suggested that some frequencies of non-ionizing radiation which is thought to be safe and have no side effects at common exposure levels may have a potential which may lead to biological damage (12). For example, in a population-based case-control study conducted in Japan, an article which reported that there was a relation between childhood leukemia and magnetic fields was published. It has been reported that high levels of exposure to EMF has a significant relation with childhood leukemia after measurement of magnetic field levels in bedrooms of children (20). Studies discuss the relation of use of wireless mobile phones and lymphoma, malign and benign brain tumors and blood pressure changes (21-23). In a case-control study, a relation was found between childhood leukemia and closeness to high-voltage electrical fields (24). In the light of available information, the International Agency for Research on Cancer (IARC) reports that exposure to EMF should be classified as potential carcinogen (25). The limit value for schools, children's play areas and kindergartens recommended by the International Comission on Non-Ionizing Radiation Protection (ICNIRP) is 2 miliGauss (mG) (26).

It has been reported that understanding and academic success is affected negatively in schools and classes where the level of noise is high and academic success is better in more silent schools (27, 28). The limit value for classes in schools, private education centers and kindergartens established by the national regulations is 35 decibel (dB) (29).

This study demonstrated the status of elementary schools in terms of some physical variables (EMF, noise, lightining, heat) in a sample representing the elementary schools in the county of Keçiören in the province of Ankara with measurements performed in the school and in the environement.

Material and methods

This study which is a cross-sectional field research was conducted between October 2007 and May 2009 in the public elementary schools (n=83) connected with the Ankara Keçiören National Education Directorship. The study was initiated by selecting a sample which would represent the population. The sample of the study was calculated using the formula "calculation of sample size when the population is known" and 31 elementary schools were included in the study.

Research plan

The study was planned to demonstrate the current status of elementary schools in terms of environmental health with all aspects (physical, chemical and microbiological); in the scope of the design, the compatibility of elementary schools to the Turkish standards in terms of environmental health, air and water samples, swab samples, physical variables including heat, lightining, noise and EMF level were examined and the results of the measurements were presented to the Scientific and Technological Research Counsel of Turkey (TUBİTAK) (Project number: 108S013). However, only the results related with physical hazards which were measured in the schools will be discussed in the scope of this article.

The measurements were started in the morning in the hours of work and completed at 15:00 at the latest after lunchtime. Since the study method was planned in a way to include many variables and the distance between the schools were considered, measurements were performed only in one school on one day.

Measurement method

If the school had only a single building, measurements were performed by taking one class from the right and left side of the corridor starting from the highest storey towards the lower storeys. The science laboratory, library, computer class and nursery class, if present were absolutely and specifically examined.

If the school had multiple buildings, all buildings were adressed starting from the building with the highest number of storeys and measurements were completed selecting only one class from each corridor from the highest storey towards the lowest storey.

Some physical environmental variables among indoor air risk factors were evaluated in the scope of the study as described below:

Measurements of heat level were performed with mercury thermometer (for 10 minutes) in the classes defined. 20-21°C was considered the normal limit value as determined by scientific studies (10, 17).

Measurements of illumination levels were performed using Illuminarion Measurement Device (Extech EA31®, USA) in the classes specified (9 measurements in the front, middle and rear rows) and corridors and stairs specified. National standards were taken as the basis (at least 200 lux for classes, at least 500 lux for libraries) for the level of illumination (18, 19).

Electromagnetic field level measurements were performed in the classes specified (a total of 5 measurements from four corners in the clockwise direction and from the the middle) using Gaussmetre Device (FW Bell 4090 Traxial Elf Magnetic Field Meter®, USA). The limit value was considered 2 mG as recommended by the International Comission on Non-Ionizing Radiation Protection (26).

Measurements of noise levels were performed in the classes specified, from the corridors and school yards (for 10 minutes) using a Noise Level Measurement Device (Delta OHM HD 9020®, Italy). The measurements were performed in the classes during lessons, in the corridors during pauses and in the schoolyard (when students were present and/or absent) for 10 minutes. Since the device did not have continuous measurement and recording properties, the measurements were performed by 10-minute monitoring of the mean value of the momentary noise level measurements for each minute. The limit value was considered 35 dB as determined by the national regulation (29).

The necessary administrative approval for the study was obtained from the Gülhane Military Medical Academy Deanship and Ankara Provincial Directorate of National Education and ethics committee approval was obtained from the Gülhane Military Medical Academy Medical Faculty ethics committee (2007/97).

Statistical analysis

Frequency distributions were evaluated as numbers and percentages and continuous variables (measurements) were evaluated as mean ± standard deviation. In assessment of the difference between the mean values of continuous variables, normality analysis was performed using the Kolmogorov-Simirnov test; t-test was used for the variables which showed a normal distribution and Mann-Whitney U test was used for the variables which did not show a normal distribution. The Kruskal Wallis test was used in comparison of more than two groups (Mann-Whitney U test was used in comparison of two groups). The analyses were done using Statistical Package for the Social Sciences (SPSS Inc., Chicago, IL, USA) Windows version 15.0 package program. A p value of <0.05 was considered significant in a 95% confidence interval.

Results

The mean temperature was found to be 21.4±1.7^{0}C in the classes of the elementary schools, 21.4±1.5^{0}C in the nursery classes, 19.9±2.4^{0}C in the laboratories and 19.9±1.6^{0}C in the libraries. The temperature values compatible with the recommended levels (20-21^{0}C) and the temperature values outside the recommended values (<20^{0}C, >21^{0}C) are presented in Table 1.

The mean level of illumination in all classes adressed in the study was 537.3±318.6 lux (median 466.1), while it was 395.7±227.2 (median 275.2) lux in the nursery classes and 425.8±285.0 (median 332.5) lux in the libraries (p<0.05).

According to the mean levels of illumination in the classes of elementary schools, it was found that only one school (3.2%) had a mean value below 200 lux which was specified in the standards. This value was 4 in the nursery classes (12.9%). It was found that 8 schools had no library and the illumination level of 500 lux specified in the standards was not achieved in 65% (15 schools) of the schools which had libraries.

According to the illumination measurements performed inside the classes in the elementary schools, it was found that the measurement performed in the row which was closest to the window was higher compared to the row which was close to the door. It was found that the measurements at the door were below 200 lux in 9 schools (29.0%). It was found the level of illumination statistically significantly reduced towards the door and rear row (p<0.05, Table 2).

It was found that none of the elementary schools was near high voltage transmission line, 9 schools (29.0%) were 300 m or nearer to an electrical transformer, 11 schools (35.3%) were 30 m or nearer to an electrical transformer and 7 schools (22.5%) were 200 m or nearer to a base station.

It was found that the mean EMF was higher in the schools which were found near EMF sources including base stations, electrical transformers and electricity distribution lines and the difference was found to be statistically significant (p<0.001) (Table 3, Figure 1).

While the mean EMF measurement of all classes (n=855) was found to be 1.5±1, it was found to be 1.3±1.3 in the nursery classes (n=155) and 3.5±1.4 in computer classes (n=140) (p<0.05).

Table 1. Temperature levels of elementary schools (°C)

	Classroom		Nursery class		Laboratory		Library	
Temperature level (°C)	Number	%	Number	%	Number	%	Number	%
19 and below	18	10.5	2	6.5	13	50.0	8	34.8
20-21	81	47.1	17	54.8	6	23.1	11	47.8
22 and above	73	42.4	12	38.7	7	26.9	4	17.4
Total	172	100.0	31	100.0	26	100.0	23	100.0

Table 2. Illumination (lux) levels of the elementary schools according to seating order inside the classroom (n=171)

Seating order	The group nearest to the window (mean±SD)	Middle row group (mean±SD)	The group nearest to the door (mean±SD)	General mean (mean±SD)
Front	1040.8±778.9	394.0±240.2	240.1±147.2	558.3±347.8*
Middle	1015.6±756.6	389.0±260.3	235.0±153.0	546.5±346.8
Rear	949.14±824.7	345.1±236.7	226.5±250.0	506.9±356.9*
General mean	1001.8±690.7*	376.0±227.1*	233.9±170.4*	

*p<0.05, Kruskal Wallis test; Mann-Whitney U test; SD: standard deviation

It was found that the mean EMF level measured in the computer classes was statistically significantly higher compared to the mean value measured in the other classes (p<0.001) (Table 4, Figure 2).

The measurements of electromagnetic field level in classes of 6 elementary schools (19.3%), in nursery classes in 7 schools (22.5%), in computer classes in 25 schools (80.6%), in the library and laboratory in four schools each were found to be higher than the value which would constitute a health risk (2 mG).

It was found that the EMF levels were statistically significantly higher in the classes of the schools which used LCD screens (0.35±0.21 mG) compared to the classes in the schools which did not use LCD screens (3.74±1.16 mG) (p<0.001, Mann-Whitney U test).

The mean level of noise in all schools was found to be 62 dB for the classes, 79.6 dB for pauses and 60.5 dB for the schoolyard. The lowest and highest noise levels were found to be 46-77 dB during lesson and 57-84 dB(A) during pause.

The mean levels of noise were higher in the classes which included 35 or more children [63.7±5.6 (n=86)] compared to the classes with a lower number of children [61.7±5.8 (n=65)] and the difference was statistically significant (p<0.05). No statistically significant difference was found in the schools which were near to intensive traffic (62.8±5.0 (n=72), 62.0±6.4 (n=79), respectively, p>0.05).

The rates of compatibility of physical environmental risk factors (heat, illumination, electromagnetic radiaton and noise) to the standards are presented in Table 5.

Table 3. Comparison of EMF levels between the schools with and without a EMF source nearby

School	Measurement number (n)	Mean±SD (mG)	p*
Source of EMF nearby (+)	43	2.11±1.79	<0.001
Source of EMF nearby (-)	112	1.12±0.91	

*Mann-Whitney U test; SD: standard deviation; EMF: electromagnetic field

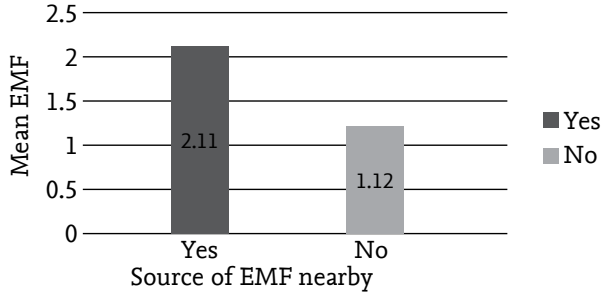

Figure 1. The mean EMF level is higher in schools with a source of EMF nearby compared to the schools without a source of EMF nearby
EMF: electromagnetic field

Table 4. Comparison of EMF levels of classrooms and computer classes

School	Measurement number (n)	Mean±SD (mG)	p*
Classroom	860	1.38±0.85	<0.001
Computer class	140	3.56±1.44	

*T-test; SD: standard deviation

Discussion

In a study which demonstrated the effect of heat on academic success, a learning test was performed at 20 and 27^{0}C in the language laboratory and it was reported that the verbal success was worse at 27^{0}C (30). In a class intervention study, children aged 9 years were tested at 20, 27 and 30^{0}C and the highest level of success was observed at 20°C (31). Studies have shown that the optimum temperature for learning is 21^{0}C (32). In our study, the optimum temperature level was achieved in only nearly half of the classes. Schools should be heated and/or cooled with appropriate methods to achieve the appropriate temperature levels. When choosing the appropriate method, the most appropriate fuel and heating efficiency should be considered. If heating is realized by central heating, the radiators should be covered in such a way that heat energy distribution is not prevented and accidents including falling and hitting are prevented. The temperature of the class should be kept between 20 and 22^{0}C in the winter and should not be reduced below 17^{0}C (5, 10). In this study, it was not interrogated how success and academic succes were affected by environmental factors. In addition, the fact that important variables including humidity and air flow rate related with the temperature of the environment were not measured may be considered a limitation of the study. Further studies should consider these variables.

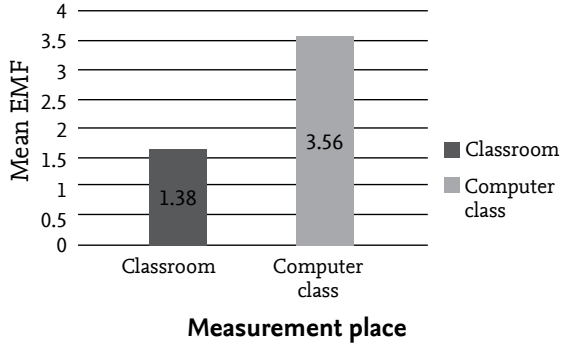

Figure 2. The mean electromagnetic radiation level measured in the computer classes in elementary schools was higher compared to the mean value of the classrooms

Adequate illumination is essential to provide visual acuity, the highest visual speed and efficient working. Visual acuity which means the ability to differentiate small details and small objects increases in proportion to the degree of illumination and reaches to a peak at about 1 000 lux. According to the international standards, the illumination level should be 200 lux in classes and above 500 lux in libraries (18, 19). In the study of Temel et al. (33), the mean value was found to be compatible with the standards in measurements performed in 25 classes, 8 laboratories and studios. However, the illumination level in the library was found to be below the standard level recommended. When the measurements in classes were examined individually, 60% of the mean values of the first row in the near-door group and 72% of the mean value of the rear row were below 200 lux. In our study, similar results were obtained in the measurements performed in classes. In addition, it was found that the standard illumination value could not be achieved in 65% of the libraries. This may be harmful in terms of establishing a comfortable reading environment in the library, providing long-term concentration, establishing a comfortable studying environment and most importantly protection of the reader's eye health. It was observed that the group sitting at the window were illuminated to a greater extent with the effect of natural lighting and the illumination values were considerably low in the group who sat far from the window. This may be solved with artifical illumination of the row group at the side of the door. When adequate illumination can not be provided, the children's eye health may be affected negatively and this may lead to a decrease in academic success.

One of the objectives of this study was defined as to provide the necessary precautions in terms of long-term effects of electromagnetic fields by demonstrating the EMF values in schools as an importan risk factor. High values of EMF was found especially in computer classes compared to the other classes and in the schools which were localized near EMF sources compared to the other schools. In a study conducted in Canada in which 43 009 measurements were performed in 79 schools, the rate of measurements above the limit value of 2 mG (0.2 μT) was found to be 7.8%. In analyses by rooms, the EMA values were found to be >2mG only in the rooms where electronic devices including computers, projectors and typewriters were found. The measurements performed

Table 5. Compatibility of physical environmental risk factors to standards

Environmental risk factor	Standard value	Classrooms		Nursery classes		Laboratory		Library	
		n	%	n	%	n	%	n	%
Temperature	20-21°C	81	47.1	17	54.8	6	23.1	11	47.8
Illumination	200-500 lux*	30	96.7	27	87.0	23	74.0	16	51.6
EMF	2 mG	136	79.1	7	77.4	26	83.8	27	87.0
Noise	35 dB	0	0.0	0	0.0	0	0.0	0	0.0

*200 lux for classrooms, 500 lux for libraries; EMF: electromagnetic field

in classes were found to be below 1 mG. According to the study, the results were not different from the results of home enviroment (34). In an echological descriptive study conducted in the elementary schools of two different cities in Spain (43 and 50 schools), approximately 2 500 considerably low frequency measurements were performed in different areas of the schools (canteen, classes, playground, school enterance etc.); values above 3 mG were found in 6% of the schools in the developed city which had larger schools, while values above 3 mG were not found in any school in the city with a smaller settlement ($p>0.05$) (35). The children who were born more than 600 m far from high-voltage electrical areas were compared with the ones who were born nearer to high-voltage electrical areas and it was found that the relative risk was increased 1.69-fold in the ones who were born 200 m far and 1.23-fold in the ones who were born 200-600 m far (24). In the study of Li et al. (36) conducted in 2004, 101 students attending 14 schools near a power line (≤100 m) and 123 students attenting 18 schools far from a power line (>100 m) were followed up for 24 hours; no statistically significant difference was found between the two measurement groups, but it was found that 17.8% students attending the school near the power line were exposed to a value above 4 mG during school hours and the same rate was 6.5% for the school which was far from the power line and the difference was statistically significant ($p=0.011$).

Since all environmental measurements were performed simultaneously, the background noise could not be checked by measurement. Since the measurement device drew the interest of students during pause measurements, students were mostly 1 m near the device. Measurements in schoolyards could not be performed, when air conditions showed a negative status including rain, snow etc.. According to the Regulation of Evaluation and Management of Environmental Noise, the level of noise allowed for classes in schools, internal part of preschool buildings, laboratories, private education institutions, institutions for disabled individuals etc. is determined to be 35 dB (29). Accordingly, the mean noise levels measured in the classes of all elementary schools were found to be higher than the limit specified in the regulation. The fact that no difference in terms of noise depending on the intensity of traffic was found may be related with the fact that the schools were at least 10-100 m far from intensive traffic, each school had a schoolyard with a schoolyard wall and the measurements were performed in indoor parts of the school buildings. In the study of Martins et al. (37) conducted in Sao Paulo, it was reported that the levels of noise measured in 10 schools ranged between 59.8 and 89 dB and the teachers had hearing problems related with noise. In a study conducted in 47 elementary schools in Hong Kong, the mean level of noise was found to be 60 dB (A) (38). In a study conducted in 142 schools in London, the mean level of noise was found to be 57 dB (A) and it was reported that the indoor noise levels changed by class activity (39). Although the levels of noise measured in classes were parallel to other studies, academic success or the hearing levels of students and teachers were not evaluated. This may be considered a limitation of our study.

Conlusively, it was found that the elementary schools in the region of Keçiören had aspects which should be improved in terms of age, location and settlement of school buildings, illumination and levels of EMF and noise. With "school health programs" which would be developed so as to include correction of negative environmental factors, an integrated service which would be efficient on the factors leading to morbidity will be provided and the continuance of this service will minimize the formation and/or effect of the factors leading to morbidity. Environmental and medical causes arising from physical conditions of schools will be prevented with regular measurements and supervision.

Ethics Committee Approval: Ethics committee approval was received for this study from the ethics committee of Gülhane Military Medical Academy Faculty of Medicine.

Informed Consent: Because the study included just some environmental analysis from school buildings, patient's consent was not required.

Peer-review: Externally peer-reviewed.

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