Environmental risk factors for refractive error among Egyptian schoolchildren

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عوامل الاختطار البيئية المسبِّبة لأخطاء الانكسار لدى التلاميذ المصريِّين

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الخلاصة: تم في هذه الدراسة تقييم عوامل الاختطار البيئية التي يمكن تـَوَقِّيها، والمسبِّبة لعيوب الانكسار، وذلك لدى 1292 من تلاميذ المدارس في مصر، ممَّن تتراوح أعمارهم بين 7 و15 عاماً، والذين تم اختيارهم من 12 مدرسة بطريقة العيِّنات العشوائية المتعدِّدة المراحل. وقد تم استكمال استبيان يتناول المعلومات الشخصية والطبية والاجتماعية والبيئية لدى المصابين بعيوب الانكسار. وبيَّن التحليل الإحصائي أن التلوث البيئي، والعمر، والجنس، ووجود سوابق عائلية من عيوب الانكسار، والحالة الاجتماعية الاقتصادية، والمشكلات العينية، والمستوى المدرسي، وعدد ساعات القراءة في اليوم، كل أولئك يترابط ترابطاً يُعتدُّ به إحصائياً مع انتشار عيوب الانكسار. كما دلَّ تحليل التحوُّف اللوجستي، المصحَّح بحسب الجنس، على أن المستوى المدرسي، وعدد ساعات القراءة في اليوم، والحالة الاجتماعية الاقتصادية، والسوابق المرضية في العائلة، كل ذلك يترابط مع انتشار عيوب الانكسار.

ABSTRACT This study evaluated the preventable environmental risk factors of refractive error (RE) among 1292 Egyptian schoolchildren aged 7–15 years, chosen from 12 schools using multistage random sampling. A questionnaire was completed, covering personal, medical, social and environmental data. Statistical analysis revealed that living in an area with many sources of environmental pollution, age, sex, family history of RE, socioeconomic status, ocular problems, school level and amount of near-work (hours/day) were significantly associated with RE. Logistic regression, after adjustment for sex, found that school level, near-work, socioeconomic status and family history were associated with RE.

Les facteurs de risque environnementaux de développement de troubles de la réfraction oculaire chez les écoliers égyptiens

RÉSUMÉ Les facteurs de risque environnementaux de développement de troubles de la réfraction oculaire (TRO) susceptibles d'être évités ont été évalués chez 1292 écoliers égyptiens âgés de 7 à 15 ans, sélectionnés selon la méthode de l'échantillonnage aléatoire à plusieurs degrés au sein de 12 établissements scolaires. Il a été demandé à cet échantillon de servir un questionnaire couvrant les données personnelles, médicales, sociales et environnementales. L'analyse statistique a révélé l'existence d'une association significative entre la prévalence des TRO et la pollution environnementale, l'âge, le sexe, les antécédents familiaux de TRO, le statut socioéconomique, les troubles oculaires, le degré d'instruction et la quantité de travail rapproché (nombre d'heures/jour). Après ajustement en fonction du sexe, la régression logistique a mis en évidence l'association entre la prévalence des TRO et les facteurs suivants : degré d'instruction, travail rapproché, statut socioéconomique et antécédents familiaux.

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Introduction

Refractive error (RE) is the cause of a significant proportion of visual impairment and blindness. Most prominently, myopia and other refractive errors appear to be increasing worldwide [*1*], and have been grouped among the leading causes of blindness and vision impairment in the world [*2,3*]. RE is believed to result from a combination of genetic and environmental factors [*4,5*].

Control of RE and low vision are one of the priorities of the global initiative for controlling blindness. A survey conducted among 5839 Egyptian schoolchildren aged 7–15 years found that the prevalence of RE (visual acuity $\leq$ 6/12) was 22.1% [*6*]. The objective of the present study was to evaluate preventable environmental risk factors for RE among these schoolchildren in Egypt, under the World Health Organization (WHO) programme "Vision 2020" [*7*]. The mission of Vision 2020 is to eliminate the main causes of avoidable blindness by the year 2020 by bringing together governments and non-governmental agencies.

Methods

The present study was a cross-sectional descriptive study, conducted during the school year 2003–04 in 12 urban government schools: 4 primary schools, 4 male preparatory schools and 4 female preparatory schools. The schools were chosen using multistage random sampling technique from 4 different educational divisions in Cairo governorate. The sites were selected to have different environmental characteristics, population activities and pollution sources:

- El-Waiely: mixed area (residential, industrial and heavy traffic) in north-eastern Cairo governorate.
- Mataria: industrial and residential area in north of Cairo governorate.
- Roxy: residential area with heavy traffic density in north of Cairo governorate.
- Nozha: new residential area with low traffic density in east of Cairo governorate.

All students in the schools were included in the study (5839 students). A total of 1292 students were diagnosed with RE by parallel visual screening [*6*]. The students ranged in age from 7 to 15 years and came from different socioeconomic status families.

All the students were given a structured questionnaire that covered personal, medical, social and environmental data. Personal data included age, sex, school level (primary/secondary) and residential area. Environmental data sought were about the residential area and the sources of pollution based on the previously published methods [*8*]. We asked children about the source of residential pollution near their houses: bread ovens, refuse burning, heavy traffic, workshops for manufacturing ceramic tiles or carpenters. Moreover, we asked the child about the cooking fuel used and if their mothers frequently used pesticides.

The medical questionnaire included ocular manifestations of eyestrain and previous ophthalmic problems. We asked children if they had suffered from redness of the eyes, head pains (headache) or difficulty reading the blackboard at school. The questionnaire about ocular manifestations of eyestrain and previous ophthalmic problems was reviewed with the school file of the children, to see if there had been any referral to an ophthalmologist, and what was the medical cause.

The questionnaire also asked about family history of consanguinity and family history of RE. Children were asked if their parents were from the same family or from

different families and if there was anyone else in the family wearing glasses.

Socioeconomic status was divided into 3 levels according to the education and occupation of the parents: high level (highly educated and occupation reasonable for their educational level), middle level (high or secondary educated and occupation below their education level) and low level (illiterate and occupation not permanent).

The questionnaire also asked how much near-work the child currently practised in hours per day, such as reading, writing and watching television.

One social worker from each school was trained by the authors to complete the structured questionnaire according to the available data, either from the students or from their parents. To ensure the accuracy of the data, the questionnaires were filled by the social workers with each child, and the authors revised them in a pilot check.

Statistical analysis

Data were collected from the selected schools with the same protocol and forms. The data were analysed using *SPSS*, version 7.5. Pearson chi-squared test was used for univariate analysis. The variables found to be significantly associated with RE were entered into logistic regression with crude odds ratio (OR) and adjusted for sex differences calculated to establish the statistically significant factors. Differences were considered significant at $P < 0.05$.

Results

The prevalence of RE was significantly higher among the students from a heavy traffic residential area (Roxy) compared with the other residential areas ($P < 0.0001$) (Figure 1).

The prevalence of RE was significantly higher among the students aged ≥ 12 years (20.7%) compared to those with age < 12 years (15.5%) ($P < 0.0001$) (Figure 2). The prevalence of RE was significantly correlated with the student's age ($r = 0.9$, $P < 0.0001$).

The prevalence of RE was significantly higher among the female students (21.4%) compared with males (13.6%) ($P < 0.05$) and among students of high and low socioeconomic status compared with those of middle status ($P < 0.001$ and $P < 0.005$ respectively) (Figure 3).

The prevalence of RE was significantly higher among students with positive family history of RE (80%) compared with no family history ($P < 0.0001$). Figure 4 shows that 80.9% of the positive family history was parents with RE (38.9% fathers, 32.0% mothers and 10.0% both parents). History

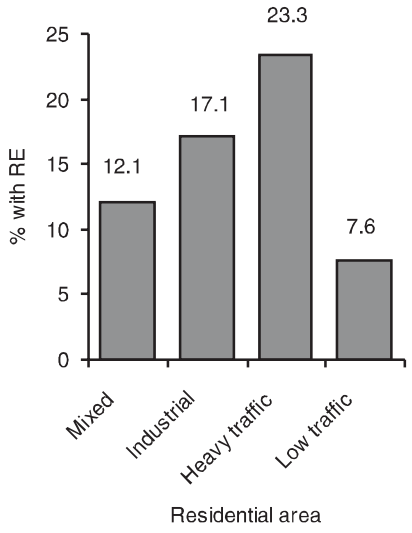

Figure 1 **Prevalence of refractive error (RE) of schoolchildren (*n* = 1292) by type of residential area**

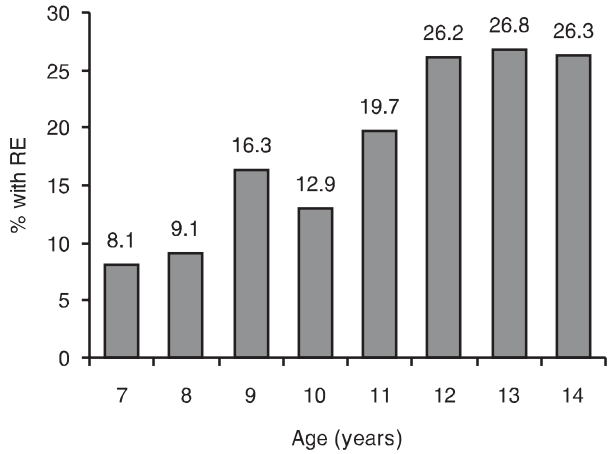

Figure 2 **Prevalence of refractive error (RE) of schoolchildren (*n* = 1292) by age**

of consanguinity had no significant effect on the prevalence of RE ($P > 0.05$).

Past history of ocular problems was found in 24% of the students with RE, in the form of symptoms of eyestrain (redness of the eyes, headache, difficulty reading the blackboard or recorded comments in the medical file of the child about referral to ophthalmologist, and the cause of referral). The prevalence of RE was significantly higher among preparatory school students (20.6%) compared with primary students (11.3%) ($P < 0.0001$). Figure 5 shows that the prevalence of RE and low vision was significantly higher among students exposed to near-work for ≥ 5 hours/day (23.4%) compared with those exposed for < 5 hours/day (17.1%) ($P < 0.0001$). There was a significant positive correlation between the prevalence of RE and the hours of near-work ($r = 0.8$, $P < 0.0001$).

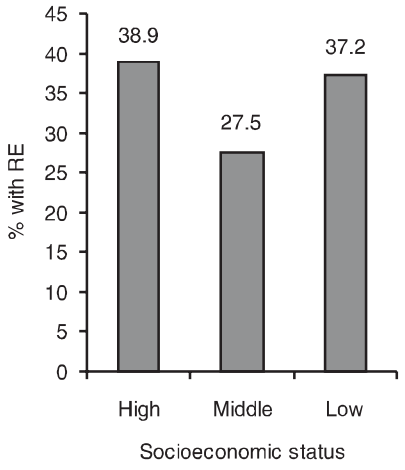

Figure 3 **Prevalence of refractive error (RE) of schoolchildren (*n* = 1292) by socioeconomic status**

Logistic regression showed that according to the level of significance, socioeconomic status, school level, sex, near-work and family history of RE were the independent significant variables associated with the prevalence of RE (Table 1). Age and living in an area with many sources of environmental pollution were not significantly associated with RE. After adjustment of significantly associated environmental

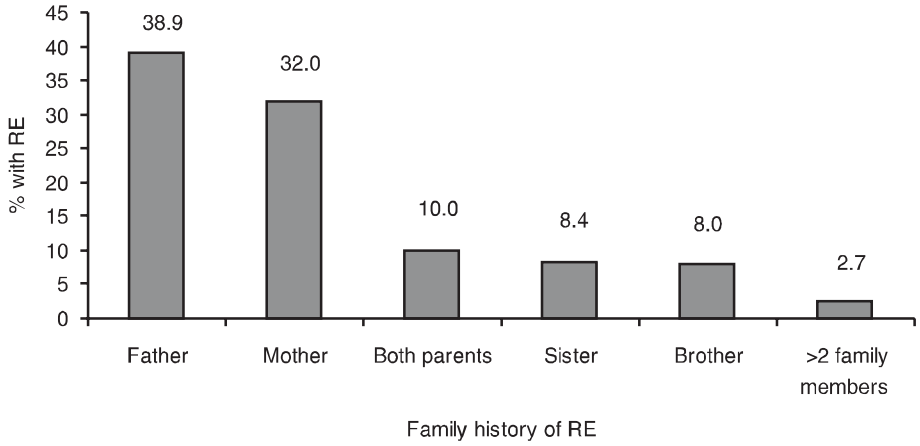

Figure 4 **Prevalence of refractive error (RE) among schoolchildren (*n* = 1292) by family history of RE**

risk factors to sex differences, logistic regression found that school level became the most important risk factor, followed by hours of near-work per day, socioeconomic status and positive family history of RE.

Discussion

There is strong evidence for rapid, environmentally induced change in the prevalence of RE associated with increased education

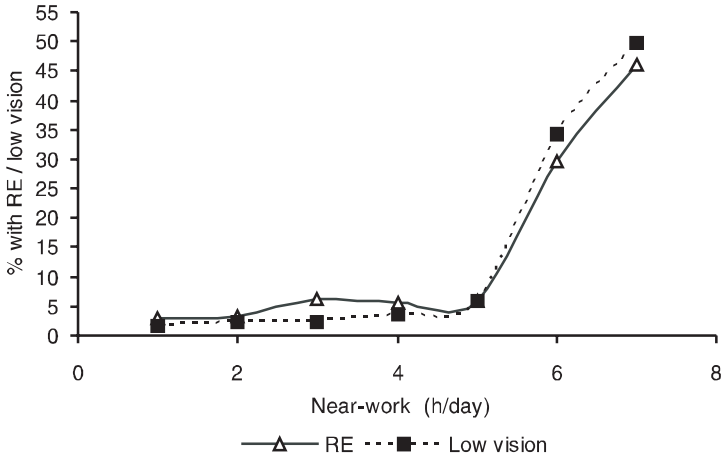

Figure 5 **Prevalence of refractive error (RE) and low vision among schoolchildren (*n* = 1292) by hours of near-work per day**

Table 1 **Logistic regression analysis of the risk factors associated with the presence of refractive error (RE)**

Variable	Crude OR*	95% CI	Adjusted OR[a]	95% CI
Sex				
Female versus male	1.60	1.42–1.80	–	–
Socioeconomic status				
High versus middle	2.17	1.73–2.72	0.44	0.37–0.52
Low versus middle	1.39	1.11–1.73	0.62	0.52–0.74
School level				
Preparatory versus primary	1.82	1.58–2.09	2.41	1.93–2.99
Near-work (hrs/day)				
< 5 versus ≥ 5	0.68	0.57–0.81	0.74	0.60–0.93
Family history of RE				
No versus yes	0.02	0.01–0.02	0.02	0.02–0.03

[a]*Adjusted for sex.*
OR = odd ratio; CI = confidence interval.

and urbanization [*9*]. The effect of geographical distribution was considered a risk factor for RE both for young and old age groups [*10*]. The screened students in this study were from different residential areas with different environmental conditions. El-Waiely residential sector in Cairo is a heavily populated commercial sector, with many small factories and workshops concentrated in this area, beside 3 secondary lead smelters, which emit large quantities of pollutants into the atmosphere, including lead [*11*]. The second selected residential area was Mataria, an industrial residential area with middle traffic density. Most of the industries in this location had low irritating emissions. The concentrations of irritant gases such as SO_2 in Roxy Square (the third selected site) were found to exceed the permissible WHO limits for high traffic density areas [*12*]. Nozha, the fourth selected area, is a new residential area with low traffic density and without industrial activities.

The prevalence of RE was significantly higher among students living in a heavy traffic residential area (Roxy area) compared to those from mixed, industrial, and low traffic areas. However, logistic regression showed that living in an area with many sources of environmental pollution was not significantly associated with the prevalence of RE.

Changes in prevalence of RE with age are noteworthy. In Taiwan, 2 studies of schoolchildren aged 6 to 18 years showed a prevalence of RE more than 80% by age 18 years [*1*]. The present study showed that the prevalence of RE was significantly higher among students aged 12–15 years compared with those below 12 years. Moreover, the prevalence of RE was significantly correlated with the age of the screened students. But the association of age and the prevalence of RE might be explained by other environmental confounders, such as higher school level and greater hours of near-work per day. Logistic regression found that there was no significant association between prevalence of RE and age.

In the present study, the prevalence of RE was significantly higher among female students compared to males, and logistic regression revealed significant association of sex with RE. This finding is similar to other studies [*13–15*], and contrary to the Baltimore Eye Survey that found no sex difference [*16*]. Wong et al. attributed the significant elevation of the prevalence of RE among females to the fact that women's eyes have a shorter axial length and shallower anterior chamber depth than those of men, and hence a higher probability of being hyperopic [*12*].

Few population-based studies have investigated the role of socioeconomic factors in the development of visual impairment [*17,18*]. In the present study, a U-shaped relation was found between the socioeconomic status of the students and the prevalence of RE, suggesting that those with higher and lower socioeconomic status were more likely to have RE than those of middle status. The reasons for this are not clear, although it could be related to increases in the hours of near-work per day. Students of high socioeconomic status may spend a longer time watching television and playing computer games, while those from low socioeconomic status spend longer studying their lessons in badly illuminated, crowded rooms. The idea that the way in which we use our eyes early in life can affect ocular growth and RE is gaining scientific credence. It has been hypothesized that prolonged reading or the retinal blur of prolonged near-work leads to the development of myopia [*3*]. Logistic regression of the present data revealed that socioeconomic status was found to be the most important environmental factor that might affect an individual's risk of developing RE. However, after adjustment for sex differences, school level (primary or preparatory) and hours of near-work were more important than socioeconomic status.

There is no doubt that RE is inherited, since the relation between RE in parents and siblings showed stronger correlations than would be expected by chance [*19*], and myopic parents are much more likely than non-myopic parents to have myopic children [*20*]. The study of Zadnik et al.—a thorough longitudinal prospective study into RE in parents and children—showed that children with myopic parents, although not yet myopic themselves, tended to have longer eyes than children with non-myopic parents, resulting in a predisposition to becoming myopic later in life [*21*]. A small proportion of myopia is clearly familial, with defined chromosomal localizations, and in some cases causal genetic mutations [*9*].

In Egypt, a screening programme in Tanta city found a positive family history of RE in 63.1% of RE cases [*22*]. The present study revealed that family history of RE was recorded in 80% of the students with RE. However, the significant effect of the other environmental factors must not be neglected as only 26.3% of the students with RE were of consanguineus parents. Wu and Edwards also showed that having myopic parents increased the odds ratio for having a myopic child, showing a genetic influence [*5*]. But they also found that the odds ratio of having myopia increased in offspring of non-myopic parents, suggesting an environmental influence. Logistic regression in the present study showed that family history of RE increased the odds of having students with RE even after adjustment for sex.

Myopia may be associated with other conditions including congenital ptosis, vitreal, retinal haemorrhages, and inflammatory keratitis [*3*]. The present study however revealed that few cases of RE had a

past history of ocular problems, in the form of symptoms of eyestrain.

There is no doubt that extended near-work appears to be the major risk factor for RE. Cross-sectional studies have also found a positive association between myopia and near-work activity such as reading and writing [*23*]. Since 1988, Mahmoud et al. also found that the incidence of RE was 55% in workers using computers in their work for long periods [*24*]. Mutti et al. concluded that heredity was the most important factor associated with juvenile myopia, but there was no evidence that children inherit a myopigenic environment or a susceptibility to the effects of near-work from their parents [*20*]. The risk factor analysis in Saw et al.'s study revealed strong associations with education and factors related to education such as tuition lessons in primary school [*25*]. They also found that educational level and educational stream were positively related to myopia. Prolonged near-work was thought to lead to progressive myopia through the direct physical effect of prolonged near-work, but according to current theory prolonged near-work leads to myopia via the blurred retinal image that occurs during near focus [*3*]. This retinal blur initiates a biochemical process in the retina to stimulate biochemical and structural changes in the sclera and choroid that lead to axial elongation [*26*].

Thus, the long school days of reading and writing, hours of home study and watching television could explain the patterns of RE among the students in the present study. The prevalence of RE was significantly higher among preparatory school students than among primary students. This could be attributed to the higher degrees of educational attainment and cumulative amount of near-work. A significant correlation of prevalence of RE and hours of near-work per day was confirmed in the present study. Previous studies showed that the correlation between level of academic achievement and the prevalence and progress of RE is strong [*14,23,27*]. Further myopiogenic stimuli such as prolonged reading or occupations that require extensive near-work may lead to mild myopia later in life [*3*].

In the present study according to logistic regression analysis, high and low socioeconomic status, school level, sex, hours of near-work per day and family history of RE were the environmental factors most closely associated with the prevalence of RE. Anatomically, female's eyes tend to have RE more often than those of males [*14,15*]. So, after adjustment for the sex difference to overcome anatomical variation and to detect the preventable risk factors, the main environmental risk factors associated with the prevalence of RE became school level, near-work, socioeconomic status and family history of RE.

The main recommendation of this study is to control for environmental risk factors through early detection of cases of RE, especially among students with a family history and high levels of academic achievement. Proper management is needed for students with RE, including correction of visual acuity and controlling hours of near-work per day to minimize the progress of the condition.

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VISION 2020: The Right to Sight?

"VISION 2020: The Right to Sight" is a global initiative to eliminate avoidable blindness. The programme is a partnership between the World Health Organization and the International Agency for Prevention of Blindness, a large umbrella organization for eye-care professional groups and nongovernmental organizations involved in eye-care. The aim of VISION 2020 is to eliminate avoidable blindness by the year 2020. Attainment of this aim implies the development of a sustainable comprehensive health-care system to ensure the best possible vision for all people and thereby improve quality of life.

A CD, "Developing an action plan to prevent blindness at national, provincial and district level: version 2" has been produced. The content can be browsed on the Internet in English, French and Spanish, or downloaded in Arabic, English, French and Spanish. Links to the downloads can be found at: http://www.who.int/blindness/publications/en/. A free copy of the CD can be requested from whopbd@who.int.