• Investigation •

Associations between near work, outdoor activity, parental myopia and myopia among school children in Aba, Nigeria

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Abstract

● **AIM:** To assess the influence of near work, time outdoor and parental myopia on the prevalence of myopia in school children in Aba, Nigeria.

● **METHODS:** Primary and secondary school children aged between 8 and 15y were randomly recruited from 12 schools in Aba. Information on family history, near work and outdoor activity was obtained using myopia risk factor questionnaire. Cycloplegic refraction was performed using autorefraction technique. Myopia was defined as spherical equivalent refraction (SER) ≤-0.50 D in the poorer eye. Data were analysed for 1197 (male: 538 and female: 659) children with full relevant data.

● **RESULTS:** Risk of developing myopia was positively associated with parental myopia [odds ratio (OR): 6.80; 95%CI, 2.76-16.74; *P*<0.01) for one myopic parent and (OR: 9.47; 95%CI, 3.88-23.13; *P*<0.01) for two myopic parents, longer daily reading hour (OR: 1.21; 95%CI, 1.03-1.42; *P*=0.02) and less time outdoors (OR: 0.8; 95%CI, 0.74-0.87; *P*<0.01).

● **CONCLUSION:** Parental history of myopia is the most important risk factor associated with myopia. In addition, children with both parents being myopic has increased odds of developing myopia than those with one myopic parent. It is recommended therefore, that children spend more time outdoors as this could reduce the prevalence and progression of myopia.

● **KEYWORDS:** myopia; near work; parental myopia; outdoor activity; school children

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INTRODUCTION

Myopia is increasingly becoming more common globally, especially in East Asia such as mainland China, Taiwan (China), and Singapore[1-2]. It is estimated that about 5 billion people worldwide will become myopic by the year 2050[3]. The prevalence of high myopia is also rising with associated comorbidities like glaucoma, cataract, retinal detachment and myopic retinal degeneration. With early onset and progressive nature of myopia during school years, children are at a greater risk of developing sight-threatening complications that could lead to permanent visual impairment, with a considerable impact on learning, achievement and quality of life[1-4].

The etiology of myopia remains unknown. Research toward the identification of myopia risk factors that could be modified to reduce the onset and progression of myopia in children are gaining more attention[5-6]. Studies show that children with myopic parents are more likely to have myopia than those with non-myopic parents[7-8]. Those who have two myopic parents are mostly at a higher risk than those who have only one[8-9]. The risk increases normally with each dioptre (D) of parental myopia[9]. Twin studies have also shown a high heritability index varying from 50% to 94%[10]. In addition, multiple myopic loci have been mapped in genetic linkage studies and over 70 different genes have been found in genome wide association study establishing myopia as a common complex disorder[11-12].

While these evidences suggest inheritance as a risk factor, the increase in prevalence of myopia experienced in countries with intensive and competitive education systems suggest that there is an impact of environmental factors on myopia development. The environmental risk factors include near vision work, lack of physical activity, light exposure, diet, a higher level of education, socioeconomic status and urbanization[8]. Among these variables, near work is most frequently associated with the development of school-age myopia[8-9,13]. Near vision work involves tasks of high accommodative demand, such as

reading, writing, computer work and close television viewing. The strongest correlation with near work is reading and writing[13-15]. Children with myopia spent more time studying and reading, and less time playing sports, than children without myopia. Technological inventions have complicated the near work question; many children presently use display terminals for computer-aided instruction, cellular and smart phones and video games, as well as increased television viewing[16].

Although, several studies have established the prevalence of refractive error (RE) in sub-Saharan Africa, only a few have completely evaluated the probable causes of RE[17-18]. The focus of these studies was mainly on age and gender, neglecting the important risk factors such as near work, parental myopia and outdoor activities. In view of the discrepancies in the reported prevalence of myopia across different geographic regions and cultural settings, understanding the influence of these factors on the prevalence and progression of myopia in any geographic area and/or ethnic origin should be crucial in unraveling the trends of myopia progression and thereby reducing the morbidity associated with it. Thus, this study aimed to investigate the influence of near work, time outdoor and parental myopia on the prevalence of myopia in school children in Aba, Nigeria.

SUBJECTS AND METHODS

Ethical Approval Approval for the study was granted from College of Medicine Health Research Ethics Committee, University of Nigeria as well as Biomedical Research and Ethics Committee, University of KwaZulu-Natal, South Africa. Permission to conduct the survey in schools in Aba was obtained from the Education Management Board, as well as, the heads of the various schools visited. Adequate information about the study including objectives, significance and procedures were provided to the parents and children by means of information leaflets written in English and local language. Thereafter, informed written consent and assent for the study including examination under full cycloplegia were obtained from the parents and children respectively. The study followed the tenets of the Declaration of Helsinki for research involving human subjects.

Study Participants The study was a school-based survey on prevalence and risk factors for myopia in children population of Aba. A report on the sampling methodology, prevalence of myopia along with its association with age and gender has previously been published[18]. In summary, school children between the ages of 8 and 15y were selected using a stratified multi-stage random cluster sampling from 12 schools out of 85 schools (n=113 2014) in the sample frame. The participating schools included a public primary and secondary school, and a private primary and secondary school each from the three cluster areas created for this study. The sample size was estimated for an assumed prevalence of 50% and desired error bound of 5% with 95% confidence interval (CI). The sample size was then adjusted for a design effect of 2.0 and an anticipated attrition rate of 10%. Overall, 1261 children between the age range 8-15y from grade level three to eleven was sampled. Children within the age group with any known anterior or posterior segment disease or with any known history of eye trauma affecting vision or with any known history of systemic disease that may affect vision were excluded from participation.

Study Procedure

Questionnaire Data were obtained using a myopia risk factor questionnaire and vision assessment procedures. The structured questionnaire included questions on near vision work and outdoor activity during and after school such as number of hours spent reading, writing, watching television, playing video games on computer use and number of hours spent indoors and outdoors. Questions on parents' level of education and occupation were also included. The questionnaire was administered independently prior to the vision assessment.

Vision Assessment Vision assessment procedures were conducted on site at each participating school. Validated optometric instruments were utilised, with an average of three readings obtained for each procedure. The examination procedures include visual acuity (VA) measurements, ocular motility evaluation, cycloplegic autorefraction and examination of the external eye, anterior segment, media and fundus. The field staff comprising of optometrist, ophthalmic nurse and research assistants were adequately trained before the main survey and research instruments were also pilot tested and any identified problems were addressed before the main survey. Monocular and binocular VA was measured at 4 m with a retro-illuminated logMAR chart (Precision Vision Villa Park, IL, USA) containing five optotypes per line. Ocular health status was evaluated using a direct ophthalmoscope and ocular motility was evaluated using the Broad-H-test. Ocular alignment was assessed using the corneal reflex (Hirschberg) test, the cover test using an occluder at distance and near.

Cycloplegia was achieved by giving two drops of cyclopentolate eye drop (1%) at 5-minute intervals. Cycloplegia was considered full when the pupil was fixed and ≥6 mm in diameter. If on evaluation after 20min, the pupillary light reflex was still present, a third drop was administered. Cycloplegic autorefraction was carried out with the Topcon RM-8000B (Topcon Corporation, Tokyo, Japan) auto-refractometer 60min after first instillation of the drops. An average of three readings was taken for each child and thereafter all participants underwent cycloplegic refraction[18-20].

Classification of Outcome Variables Spherical equivalent refraction (SER) was calculated as algebraic sum of the

spheres and half the cylinder. Myopia was defined as SER of -0.50 D or less in at least one eye and was sub-classified as low (0.50 D≤SER≤3.00 D); medium (3.00 D<SER≤6.00 D) and high (SER>6.00 D)[18]. The parents' education was classified into, no education/primary education, secondary/college level education, University level/professional qualification. Parents' profession was classified into low (farmers, traders, and artisan), medium (teachers and civil servants) and high income (politicians, lecturers, doctors, engineers, bankers and businessmen).

Statistical Analysis The statistical analysis was performed using commercially available Statistical Software Package for Social Science (SPSS for Windows, version 20.0, IBM-SPSS, Chicago, USA). Tables were used to present frequencies and distributions of variables. The association between the prevalence of myopia and other parameters was explored using the *Z*-test for two population proportions for categorical variables and Student's *t*-test for continuous variables. Multivariate logistic regression analysis was performed using presence and absence of myopia as the dependent variable, and the parameters which were significantly associated with the prevalence of myopia in univariate analysis as independent variables after adjusting for age and gender. Odds ratio (OR) and 95% CIs were presented. A *P* value <0.05 was used as the criterion for statistical significance.

RESULTS

Sample Characteristics Of the 1261 children randomly recruited from 12 schools, 51 did not participate in the study. The non-participants were those that did not return signed consent form and those that did not meet the eligibility criteria as well as those that were absent on the day of the survey. About 1210 children were examined, but data was analysed for only 1197 (94.9%) participants with complete relevant data[18]. There were 595 (49.7%) children between the ages of 8 and 11y, with a mean age of 9.5±1.2y and 602 (50.3%) children between the ages of 12 and 15y, with a mean age of 13.5±1.1y. The overall mean age of the participants was 11.5±2.3 (range 8-15)y. Six hundred and fifty-nine (55.0%) participants were female and 538 (45.0%) were male. Five hundred and forty-nine (45.9%) children were from primary schools and 648 (54.1%) were from secondary schools. There were 581 (48.5%) children in public schools and 616 (51.5%) in secondary schools. Approximately 2.7% myopia prevalence was observed in the study sample[18].

Risk Factors for Myopia

Near work, outdoor and indoor activities Table 1 illustrates the mean time spent by myopic and non-myopic children on near work, indoor sports and outdoor activities. A two-sided paired t-test was used to compare the mean hours spent by both myopic and non-myopic children on near work, sports and leisure activities on weekdays and weekends. Overall, myopic children spent more time reading (*P*=0.001), writing (*P*=0.001), using computer (*P*=0.001) and playing video games (*P*=0.037) on week days than non-myopic children. While on weekends watching television (*P*=0.040), playing video games (*P*=0.013) and using computers (*P*=0.001) were significantly associated with myopia. Children who had myopia spent less time on outdoor activities per week compared to non-myopic children (*P*=0.001). Watching television on weekdays (*P*=0.307) and playing indoor sports per week (*P*=0.403) did not differ between myopic and non-myopic children.

Table 1 Comparison of average time-based activities of children with or without myopia mean±SD

Activities	Myopic	Non-myopic	*P*
Daily reading hours	5.3±0.9	3.1±1.6	0.001[a]
Daily writing hours	4.0±0.8	2.7±1.8	0.001[a]
Daily computer hours/weekend	2.8±1.9	1.4±2.0	0.001[a]
Daily computer hours/week days	2.6±1.7	1.5±2.2	0.013[a]
Daily TV hours/weekend	3.3±1.6	2.7±2.2	0.040[a]
Daily TV hours/week days	3.2±1.6	2.9±2.0	0.307
Daily video games hours/weekend	2.6±2.0	1.6±2.1	0.013[a]
Daily video games hours/week days	2.3±2.1	1.5±1.9	0.037[a]
Week play outdoor sports/leisure hours	4.1±1.9	8.4±2.6	0.001[a]
Week play indoor sports hours	4.1±2.6	4.5±3.1	0.403

SD: Standard deviation. [a]*P* values indicate statistical significance.

Socioeconomic Factors Table 2 shows the data for socioeconomic factors among myopic and non-myopic participants. The family socioeconomic factor for participants was measured by asking questions on the parents' level of education and profession. The parents' level of education and profession were categorized into 3 different groups according to the definition criteria adopted for this study and compared between myopes and non-myopes using *Z*-test. The result shows that participants with paternal (*P*=0.002) and maternal (*P*=0.030) university education were at greater risk of developing myopia, whereas children with paternal secondary/college (*P*=0.018) education were at lower risk of developing myopia. Similarly, children who had paternal and maternal low-income jobs were at lower risk of developing myopia (*P*=0.016 and *P*=0.005 respectively).

Family History Figure 1 showed the proportion of myopic and non-myopic children with parental and no parental myopia. Our analysis shows that children with myopic parents are at greater risk of developing myopia (*Z*-test for proportions, *P*<0.001). Among the (2.7%) children with myopia, 12.5% with medium and high degree myopia had at least one myopic parent. The number of myopic children with parental myopia 23 (71.9%) and those with no parental myopia 9 (28.1%)

Table 2 Socioeconomic factors (indicators of family income) *n* (%)

Socioeconomic factors	Student		*Z*-test for proportions	
	Non-myopic (*n*=1165)	Myopic (*n*=32)	*Z*-score	*P*
Mother education				
Up to primary	129 (11.07)	1 (3.13)	-1.4256	0.1527
Secondary/college	633 (54.33)	14 (43.75)	-1.1853	0.2340
University/degree	403 (34.60)	17 (53.13)	2.1672	0.0300[a]
Father education				
Up to primary	107 (9.18)	1 (3.13)	-1.1857	0.23404
Secondary/college	647 (55.54)	11 (34.38)	2.3713	0.01778[a]
University/degree	411 (35.28)	20 (62.50)	3.1672	0.00152[a]
Mother profession				
Low income	423 (36.31)	5 (15.63)	-2.4084	0.01596[a]
Medium	653 (56.05)	22 (68.75)	1.4291	0.15272
High	89 (7.64)	5 (15.63)	1.6567	0.09692
Father profession				
Low income	383 (32.88)	3 (9.38)	-2.8085	0.00496[a]
Medium	688 (59.06)	24 (75.00)	1.8162	0.06876
High	94 (8.07)	5 (15.63)	1.529	0.12602

[a]*P* values indicate statistical significance.

differed significantly (*Z*-test for proportions, *P*<0.001). The risk for myopia tends to vary according to number of parents with myopia such that 41% had both parents as being myopic, 31% had only one parent as being myopic and 28% had no myopic parents (Figure 2).

Multivariate Model Table 3 show the multivariate logistic model with the presence and absence of myopia as the dependent factor while the variables that were significantly associated with myopia in univariate analysis were the independent factors. After adjusting for age, it was found that myopia remained significantly associated with longer reading hour, less time spent outdoors, parental myopia for one myopic parent and for two myopic parents.

DISCUSSION

In this school-based study on risk factors for myopia, the effect of parental history of myopia, near work, socioeconomic status and outdoor activities on prevalence of myopia was evaluated. Our findings show a strong relationship between prevalence of myopia and parental history of myopia. Daily reading hours and duration of outdoor activities were significantly associated with prevalence of myopia. However, parental level of education or profession was not significantly associated with myopia.

Among the near work variables evaluated in the present study, only reading for longer time was significantly associated with myopia in the multivariate logistic model. Due to high accommodative demand, prolong and intensive reading overtime could result in retinal defocus which leads to axial length elongation, thereby causing myopia[18]. Recent studies have also found similar associations between reading and myopia[8,21-22]. An increase of 1h reading per week was associated with a 5% increased risk of developing myopia

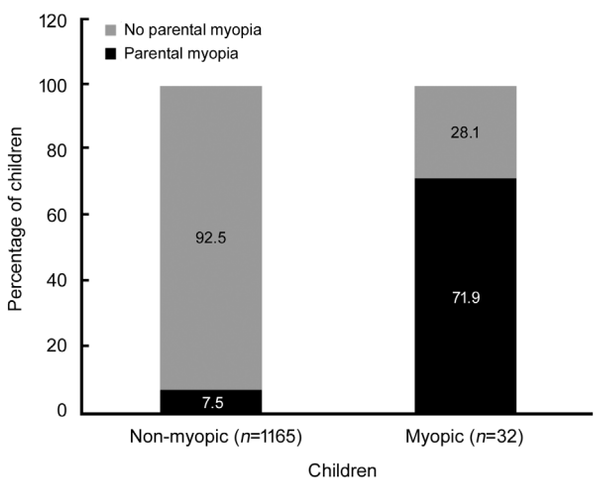

Figure 1 The proportion of myopic and non-myopic children with parental and no parental myopia.

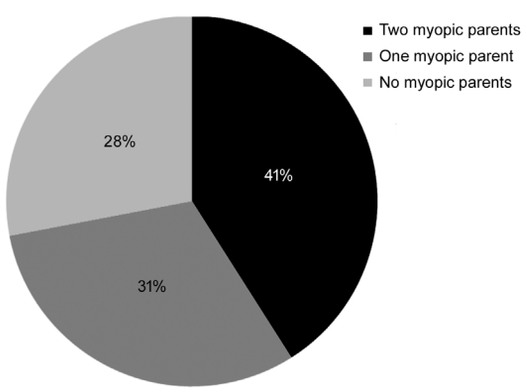

Figure 2 The proportion of parental myopia among myopic participants.

Table 3 Factors associated with myopia in multivariate analysis

Variables	OR (95%CI)	*P*
Parental myopia		
0 parent	Reference	
1 parent	6.80 (2.76-16.74)	
2 parents	9.47 (3.88-23.13)	<0.01[a]
Mothers education		
Up to primary school	Reference	
Secondary/college	1.54 (0.44-3.32)	
University/degree	0.10 (0.85-1.17)	0.94
Fathers education		
Up to primary school	Reference	
Secondary/college	1.21 (0.49-2.98)	
University/degree	0.88 (0.34-2.30)	0.79
Mothers profession		
Low income	Reference	
Medium income	2.14 (0.72-2.80)	
High income	3.28 (0.80-3.54)	0.09
Fathers profession		
Low income	Reference	
Medium income	0.62 (0.21-1.81)	
High income	0.45 (0.11-1.89)	0.28
Near work		
Daily reading hours	1.21 (1.03-1.42)	0.02[a]
Daily writing hours	0.89 (0.76-1.04)	0.14
Daily computer hours (weekend)	0.93 (0.82-1.06)	0.27
Daily computer hours (day)	1.00 (0.99-1.01)	0.98
Daily television hours (weekend)	0.98 (0.88-1.11)	0.75
Daily video games hours (weekend)	0.99 (0.98-1.01)	0.93
Daily video games hours (day)	0.99 (0.93-1.05)	0.87
Weekly outdoor sports/leisure activities	0.80 (0.74-0.87)	<0.01[a]

CI: Confidence interval; OR: Odds ratio. Model adjusted for other factors. [a]*P* values indicate statistical significance.

in Vietnamese's school children[22]. However, several other studies[6,23-25] have reported conflicting results which may be related to the various ways in which near work was quantified. A study by Ip *et al*[23] quantified near work using intensity and reading distance rather than duration of reading. The study found that children who read continuously for more than 30min were more likely to develop myopia compared to those who read for less than 30min continuously. Likewise, children who performed near-work at less than 30 cm were 2.5 times more likely to have myopia than those who worked at a longer distance. Saw *et al*[24] found a statistically significant association with myopia using the number of books read per week but using the number of hours spent reading per week was not statistically significant. There are also other studies that found no association between near work and myopia[6,25]. The impact of reading on the visual system can be influenced by several near work-related variables including reading distance, reading duration and reading posture as well as illumination and contrast level of the visual information[26-27]. In addition, most studies on myopia and near work are cross-sectional which utilized questionnaire in reporting near work variables. As such they may have been exposed to recall bias or reporting bias. It is unsurprising therefore that the findings on near work and myopia among these studies are inconsistent. An objective and standardized method of quantifying the near work variables and a longitudinal study may provide a better understanding of the relationship between near work and myopia as well as facilitate comparison among studies.

The association between increased time spent outdoors and decreased myopia found in the present study is consistent with the reports from cross-sectional and longitudinal studies on myopia and outdoor activities[28-29]. Preliminary data from China, once revealed that the inclusion of an extra 40min of time outdoors significantly reduced myopia progression in grade 1 children[30]. Several other epidemiological studies also showed that more time spent outdoors and participation in physical activity during childhood was associated with a decreased risk of myopia[13-14,28]. Furthermore, a shorter time spent outdoors, and longer time spent indoors studying was associated with greater axial length elongation[14,26,31]. Animal studies have also provided evidence in support of the role of light in myopia development. Chicken exposure to elevated light intensities eliminated the development of deprivation-myopia[32]. Constant sunlight or artificial light also resulted in shorter eyes and retardation in the process of emmetropization in Rhesus Monkey[33]. It is not clear how this protective effect was achieved but this may be explained by complex mechanisms. Suggested mechanisms include, the greater viewing distance outdoors leads to greater depth of focus, and hence a sharper image owing to pupil constriction, reduced peripheral hyperopic defocus, and less accommodative demand[26,28,32]. Altogether, this would create a more uniform dioptric space, this has been hypothesized to remove the stimulus for myopic growth[26,32]. Another possible protective mechanism is spectral composition, as the emmetropization process demonstrates sensitivity to chromatic aberrations[32]. Bright light has been reported to stimulate the release of retinal dopamine which is known to inhibit the growth of the eye[32-33].

The socioeconomic status (SES) of the present study included children from low, middle and high SES level schools. Although, socioeconomic status (indicator of family income) was not significantly associated with myopia, those with paternal and maternal university education were at higher risk of developing myopia compared to the other categories. This may be because the children read more so that they can also attain the same level of educational achievement as their parents. Similarly, low-income jobs of both parents were

negatively associated with myopia in the univariate analysis but did not continue in the multivariable model**.** This finding is consistent with the result of the study by Saw *et al*[34] on myopia and socioeconomic factors. The study by You *et al*[20] found a significant relationship between myopia and family income. The difference in the results of the present study with that of You *et al*[20] might have been owing to the method used in measuring socioeconomic status of participants by the two studies. While the study by You *et al*[20] measured socioeconomic status directly by asking questions on parents' annual income, the present study, measured socioeconomic status of the participants by using indicators of family income such as parents' level of education and profession. Furthermore, as the children are from a developed country they are more likely to have access to computer, video games and television. Thus, they may have spent a significantly greater number of hours in playing computers and video games compared to participants in our study who are from a less develop country.

There was a strong significant association between family history of myopia and development of myopia in the present study. The odds of developing myopia (9.4 for children with two myopic children and 6.8 for children with one myopic parent; Table 3) were three times higher than any other significant risk factor associated with myopia in the present study including near work. Different age-related cohort studies have also observed a significant association between family history of myopia and development of myopia[8,35]. For instance, Low *et al*[36] found that family history of myopia was the strongest factor responsible for preschool myopia, while near work was not significantly associated with myopia. Mutti *et al*[8] reported that heredity for one parents being myopic, for two parents being myopic and near work were significantly associated with myopia, with heredity the strongest factor; the authors did not find any evidence that supports the hypothesis that heredity is a strong factor because parents with myopia have children who do more near work. Parssinen *et al*[35] also observed that higher myopic prevalence in adulthood was strongly associated with parents' myopia but that neither near work nor outdoor activities was significantly associated with early myopia. In the present study on schoolchildren between 8 and 15y, it was observed that family history of myopia and near work was associated with myopia. However, parental myopia was the most important factor. Numerous genetic factors are involved in the development of myopia and the eventual development of myopia may be a result of early eye and neuronal development[12]. Therefore, the higher prevalence of myopia among those with myopic parents in the present study may suggest a strong influence of genetic factor in the development of myopia in the study sample. In future, studies may evaluate the relationship between the dioptre powers of parental myopia and myopia in children with parental history of myopia.

A limitation of the study was the cultural sensitivity associated with questions on annual income of a person in this area, the socioeconomic status of participants was determined by questions on parents' profession and education. The education and profession of a person may not truly reflect their earning power. While those working in the public sector may have almost unified salary structure, those in the private establishment are remunerated on the establishment policy and ability to remunerate. Nonetheless, the study included a well-design selection process involving a large sample representative of primary and secondary school children from different areas of the municipality. The selection process also included a strict adherence to the eligibility criteria and the response rate was approximately 95%. Data were collected using a validated questionnaire and reliable instruments in a detailed and systematic approach. Altogether, the study has a very high likelihood of having a reliable and valid data and findings can be generalized to the wider population.

Our study provides an understanding of the effects of environmental and genetic risk factors for the development and progression of myopia in school children in Aba. Information on the activities that could help to prevent myopia development and progression was communicated to parents and teachers. A balance between classwork and outdoor activities is important, since reading and outdoor activities can positively and negatively influence the development and progression of myopia, respectively. The implementation of ocular health education which may be integrated within the school eye health program should be a priority for education and health authorities.

In conclusion, the aim of the study was to determine the effect of parental myopia, near work, outdoor activities and socioeconomic factors on myopia prevalence in children in Aba. Parental myopia was the most important risk factor associated with myopia in the present study with children with both parents as being myopia at increased odds of developing myopia than those with one myopic parent. Other risk factors associated with increased prevalence of myopia include longer daily reading hour and less time spent outdoors. It is recommended therefore, that children spend more time outdoors as this could reduce the prevalence and progression of myopia.

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