Prevalence of reduced visual acuity among school-aged children and adolescents in 6 districts of Changsha city: a population-based survey

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Abstract

Background: To calculate and evaluate the prevalence of reduced visual acuity(VA) in primary and secondary school students in 6 districts of Changsha, Hunan, China.

Methods: A population-based retrospective study was conducted in 239 schools in 6 districts of Changsha. After routine eye examination to rule out diseases that can affect refraction, 250,980 eligible students from elementary, middle and high schools were enrolled in the survey. Then the uncorrected distant and near visual acuity of each eye were measured. Categories of key schools, districts, grades, eye exercises and sports time were also documented and analyzed.

Results: The overall prevalence of reduced VA was 51.8% (95% confidence interval [CI]: 51.6%-52.0%) in 6 districts of Changsha. Results of individual districts were as follows: Furong district 59.9%(95% CI: 57.9%-61.8%), Tianxin district 62.3%(95% CI: 60.5%-64.0%), Wangcheng district 47.8%(95% CI: 46.8%-48.8%), Kaifu district 58.5%(95% CI: 58.0%-58.9%), Yuhua district 47.0%(95% CI: 46.7%-47.4%) and Yuelu district 52.6%(95% CI: 52.3%-52.9%). The proportion of normal VA is seen to decrease from primary grade 3. The proportion of mildly reduced VA is higher in primary grade 1 and 2. The proportion of moderately reduced VA remains similar during 12 grades. The proportion of severely reduced VA increases with grades. Multivariate analysis shows that the prevalence of reduced VA is lower in the province level key schools (odds ratio [OR]=1.23, 95% CI 1.13-1.33) than in the municipal level key schools (OR=1.47, 95% CI 1.44-1.50).

Conclusion: According to the existing data analysis results, the prevalence of reduced VA among primary and secondary school students in Changsha is very high. Some effective measures need to be taken to prevent it.

Background

According to existing surveys, reduced visual acuity (VA) has become the focus of public health in China. The main cause of reduced VA is uncorrected refractive errors (URE)[1] that are mainly manifested as visual impairment(VI). According to the World Health Organization (WHO) survey, URE is the main cause of severe VI, which comprised 216.6 million of the global population in 2015[2]. Myopia, the commonest URE among students, can lead to a decline in learning ability and may compromise the individual's academic performance, social communication, psychological development and quality of life[1, 3, 4]. Prevalence of myopia in the world is 28.3%[5]. It is reported that myopia affects 80−90% of teenagers in East Asia[6]. Meta-analysis showed that 69% of people from the age of 1 to 18 are myopic[7]. A survey carried out by researchers in southern China shows the prevalence of myopia in 13-year-olds and 17-year-olds as 36.8% and 53.9% respectively[8].

Given the current critical state of visual health in China, we can suggest measures to prevent, control and treat reduced VA of the students in this period of their critical visual development based on the results of

data analysis.

Methods

Study population

This project is a population-based, retrospective study of students of 239 schools in all 6 districts of Changsha from 2017 to 2018. It covers 4 schools in Furong district, 4 in Tianxin district, 10 in Wangcheng district, and 65, 69 and 87 in Kaifu, Yuelu and Yuhua district respectively. Objects of investigation were in range from primary school grade 1 to high school grade 3, 12 grades in total.

Ethical committee approval was sought from the Central South University and Changsha Aier Eye Hospital Review Board. The study was conducted adhering to the declaration of Helsinki involving human participants and the approved guidelines. Due to large work of written consent from such sample size, verbal consents has been approved by Central South University and Changsha Aier Eye Hospital Review Board, also students and their parents. After introducing examination procedures to students, parents, guardians and school committees, the vision data with informed consents will be uploaded to cloud platform. Finally, the survey will be carried out accompanied by the school staff after their approval.

Eye examination

Students were first examined by experienced ophthalmologists from Changsha Aier Eye Hospital using portable slit lamp (YZ3; 66vision Ltd., Suzhou, China) to rule out any disorder of anterior segment that may affect refraction, such as glaucoma, lens opacity or other diseases[9]. Students with pathological ocular conditions were excluded. Eligible participants then underwent measurement of uncorrected distance visual acuity (UCDVA) at 5 m (Standard Logarithmic Visual Acuity E chart) and uncorrected near visual acuity (UCNVA) at 40 cm. UCDVA was reported in decimal form, UCNVA written from J1 to J7 represents the worsening of VA[10-12]. UCDVA and UCNVA of all eyes were uploaded to the cloud platform and processed for data analysis. Participants without anterior segment abnormalities but with extremely poor VA were sent to hospital for further ophthalmic examination.

Operational definition of reduced VA

VA < 1.0 was defined as reduced VA, which was further divided into 3 groups according to the severity: mild: 0.6 < VA < 1.0, moderate: 0.4 ≤ VA ≤ 0.6, and severe: VA < 0.4.

Questionnaire

Questionnaires were filled in by school faculties with simple items: 1. Is your school a key school? If so, is it provincial level or municipal level? 2. Are eye exercises carried out in your school? If so, how frequent are they? 3. Do you have any physical education classes in your school? If so, how often are they?

Statistical analysis

Statistical Package for the Social Sciences (SPSS) 22.0 statistical software was used for data analysis. The prevalence of reduced VA was defined as the proportion of students presenting with UCDVA < 1.0 in worse eye. Not only did we analyze the overall prevalence of the sample, we also evaluated the prevalence of reduced VA by districts and grades respectively. After Homogeneity of Variance test, types of key schools were estimated in odds ratio (OR) and 95% confidence interval (CI) was determined based on one-way ANOVA test.

Results

250,980 students were finally included to this investigation. Table 1 (Table 1. Distribution of participants) shows the distribution of participants by districts and grades. In this table, blank marks ("/") represent missing data in Furong, Tianxin and Wangcheng districts due to tough schedule and thus unavailability of students who were preparing for entrance exams for further education, especially in secondary grade 3 and high school grade 3. For this reason, 7,195 (2.87%) subjects from secondary grade 3 and high grade 3 participated in this screening program.

After analyzing the data, we found out that the overall prevalence of reduced VA was 51.8% (95% CI 51.6%-52.0%) in 6 districts of Changsha city. Figure 1 (Fig. 1. The prevalence of reduced visual acuity in 6 districts) shows the prevalence p in each district: Furong 59.9%(95% CI: 57.9%-61.8%), Tianxin 62.3%(95% CI: 60.5%-64.0%), Wangcheng 47.8%(95% CI: 46.8%-48.8%), Kaifu 58.5%(95% CI: 58.0%-58.9%), Yuhua 47.0%(95% CI: 46.7%-47.4%) and Yuelu 52.6%(95% CI: 52.3%-52.9%). We also estimate the prevalence in groups by grades as Fig. 2 (Fig. 2. The prevalence of reduced visual acuity in 12 grades) shows. Primary Grade 1: 59.5%(95% CI: 59.0%-60.0%), Primary Grade 2: 49.4%(95% CI: 48.9%-49.9%), Primary Grade 3: 34.8%(95% CI: 34.3%-35.3%), Primary Grade 4: 38.7%(95% CI: 38.1%-39.2%), Primary Grade 5: 44.8%(95% CI: 44.2%-45.3%), Primary Grade 6: 52.4%(95% CI: 51.7%-52.9%), Secondary Grade 1: 60.9%(95% CI: 60.3%-61.5%), Secondary Grade 2: 64.6%(95% CI: 64.0%-65.3%), Secondary Grade 3: 72.4%(95% CI: 71.3%-73.5%), High Grade 1: 71.2%(95% CI: 70.3%-72.2%), High Grade 2: 72.4%(95% CI: 71.3%-73.6%), High Grade 3: 80.9%(95% CI: 78.4%-83.3%).

Figure 3 (Fig. 3. The distribution of reduced visual acuity in 6 districts by intensity) and Fig. 4 (Fig. 4. The distribution of reduced visual acuity in 12 grades by intensity) presents the proportion of reduced VA by intensity in 6 districts and 12 grades respectively. From the Fig. 3 we can see the proportion of four intensity groups remain in a narrow fluctuation in 6 districts. Figure 4 shows that the proportion of intensity changes with grades. The detailed data is shown in the format of the percentage of normal VA/mildly reduced VA/moderately reduced VA/severely reduced VA: Primary Grade 1: 40.48%/46.40%/11.35%/1.77%, Primary Grade 2: 50.59%/35.67%/10.86%/2.88%, Primary Grade 3: 65.19%/14.75%/14.33%/5.73%, Primary Grade 4: 61.33%/12.29%/16.78%/9.60%, Primary Grade 5: 55.24%/11.06%/19.66%/14.04%, Primary Grade 6: 47.61%/10.48%/22.21%/19.70%, Secondary Grade 1: 39.09%/10.64%/23.95%/26.32%, Secondary Grade 2: 35.35%/10.53%/24.01%/30.11%, Secondary Grade 3: 27.63%/9.06%/22.72%/40.59%, High Grade 1: 28.75%/9.62%/23.67%/37.96%, High Grade 2: 27.57%/8.81%/21.64%/41.98%, High Grade 3:19.14%/5.02%/ 20.98%/54.86%. Figure 5 (Fig. 5. The

tendency of prevalence of reduced visual acuity by intensity in 12 grades) demonstrates the tendency with a curve. The proportion of normal VA can be seen to decrease from primary grade 3 onwards. The proportion of mildly reduced VA is higher in primary grade 1 and 2. The proportion of moderately reduced VA remains similar during 12 grades. The proportion of severely reduced VA increases with grades.

Aiming to identify possible risk factors, homogeneity of variance test and one-way ANOVA test were run. We found out that the prevalence of reduced VA correlates with categories of key schools as follows: province level key school (OR = 1.23, 95% CI 1.13−1.33), municipal level key school (OR = 1.47, 95% CI 1.44−1.50). As all 239 schools maintained the same eye exercise and physical exercise period, it is difficult to determine whether there is any correlation between reduced VA and these two factors.

Additionally, 3,496(1.39%) students manifested severe unilateral visual impairment with the other eye's VA being normal: Furong 61, Tianxin122, Wangcheng 94, Kaifu 505, Yuhua 1,053 and Yuelu 1,658.

Based on data analysis, we can suggest measures to prevent, control and treat reduced VA of the students.

Discussion

Located in the middle region of China, Changsha is the capital city of Hunan province with a population of 7.9 million (www.changsha.gov.cn). In order to estimate and evaluate the prevalence of reduced VA in primary and secondary school students of Changsha, Changsha Eye Health of Children and Adolescents Screening Program was initiated by Changsha Aier Eye Hospital with the agreement of local health government. In this program, 250,980 students from 239 schools in 6 districts of Changsha have been screened.

According to the statistical results, it is obvious that the prevalence of reduced VA, 51.8%, is rather high in Changsha. In a previous study that investigated the prevalence of reduced VA in ethnic Han students, similar results were seen, reporting a prevalence of reduced VA of 66.6%, the major cause suspected being myopia[13]. In our study also, most participants with reduced VA have a normal UCNVA yet an abnormal UCDVA, therefore myopia can be suspected as the main refractive error. Rise in the prevalence of myopia with age was confirmed by a study carried out in Qingdao city, which is in accordance with our findings since a statistically significant difference in prevalence was observed among grades ($P < 0.05$)[14]. Another epidemiological study in 6 provinces of China reveals that the prevalence of myopia was 35.8% in age group 6−8 years, 58.9% in age group 10−12 years, 73.4% in age group 13−15 years and 81.2% in age group 16−18 years[15]. These age groups match with grades. For instance, students are about 6−12 years old in primary school, about 13−15 in secondary and 16−18 in high school. Our results are close to this study also. Considering the counterbalance of participants distribution, a multi-resource nonparametric test was run. Statistical significance was observed among districts ($P < 0.05$) which may distribute to the difference of sample size.

We analyzed suspected risk factors like categories of key schools, eye exercises and sports time. We found that the prevalence of reduced VA was higher in the key schools than in the non-key schools (In China, a key school associates with added educational resources and intense studying environment). The same finding was confirmed by an earlier study carried out in Beijing city[20]. The duration of eye exercises and physical exercise was the same in all 239 schools, in accordance with protocols implemented by Changsha Education Bureau. Therefore, it is difficult to determine whether there is any correlation between reduced VA and these two factors.

We additionally found out that there were 3,496 students having severe unilateral visual impairment with the other eye's VA being normal. This may indicate an organic non-refractive cause such as retinal detachment. Further examination and investigations are required in such cases to guide appropriate treatment.

The high prevalence of reduced VA warns us about the deteriorating ocular health of children and adolescents and urges us to take appropriate measures. In the current scenario of insufficient eye care services, there are worldwide efforts to establish telemedicine and even artificial intelligence for eye care[21, 22]. UK National Health Service (NHS), for instance, has established the Hospital Eye Service (HES) with virtual technology, namely the glaucoma monitoring service[23]. These technological achievements represent the direction of mainstream development of current medical technology. Under such circumstance, we conceive to set up a cloud platform to collect the visual data and analyze the prevalence of reduced VA in screening program, to optimize human resource management and promote work efficiency, this can in line with these international developments.

The cloud platform includes a data logging system and a primary system. The students, guardians and school faculties are all allowed to log in with specified permission. We upload visual data after ocular examination and gather data for an overview. The data can be archived and downloaded whenever it is needed. Individual visual data file can be downloaded to clinic terminal when patients come to visit and be updated after the examination. Changes are then analyzed and development trend predicted. Thus, we can offer appropriate refractive prescriptions and suggestions. If clients establish individual visual data file from childhood to adulthood, we are able to monitor their visual development over a long period of time. Even when these individuals age and come across age-related ocular diseases like age-related cataract, the additional information is valuable in offering refractive cataract surgery options[24]. This cloud platform also can be regarded as supplement for epidemiology data bank. Our privacy policy includes building firewall to raise data security. Besides data archive and push messages, we expect to explore more functions to run a better and more efficient cloud platform.

This study is the initial stage of our whole program. The observation indices were UCDVA and UCNVA only at this stage. More observation indices like corneal curvature, axial length, subjective refraction, autorefraction and others will be included in future. Another limitation of this study is the sample size. In our investigation, a statistically significant difference was found in the prevalence of reduced VA among districts, which may attribute to the difference in sample size. Further studies in minor sample size

districts are expected to be conducted. More schools ought to be examined and appropriate schedules set to meet the available time of students in high school grade 3.

Conclusion

Our study reveals a high prevalence of reduced VA in school-aged children and adolescents in Changsha, which correlates with grades and key school categories, this may applied to further eye healthcare work, to instruct effective reduced VA prevention and control. We going to deploy a cloud platform to archive vision data and provide data download and review to monitor visual development. Furthermore, with the assistance of the cloud platform, our work efficiency can be promoted dramatically.

Abbreviations

VA: visual acuity; OR: odds ratio; CI: confidence interval; URE: uncorrected refractive error; VI: visual impairment; WHO: World Health Organization; NHS: National Health Service; HES: Hospital Eye Service; UCDVA: uncorrected distance visual acuity; UCNVA: uncorrected near visual acuity; SPSS: Statistical Package for the Social Sciences

Declarations

Ethics approval and consent to participate:

Ethical committee approval was sought from the Central South University and Changsha Aier Eye Hospital Review Board. The study was conducted adhering to the declaration of Helsinki involving human participants and the approved guidelines. Due to large work of written consent from such sample size, verbal consents has been approved by Central South University and Changsha Aier Eye Hospital Review Board. After introducing examination procedures to students, parents, guardians and school committees, the vision data with informed consents will be uploaded to cloud platform. Finally, the survey will be carried out accompanied by the school staff after their approval.

Consent for publication:

Not applicable

Availability of data and material:

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

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Tables

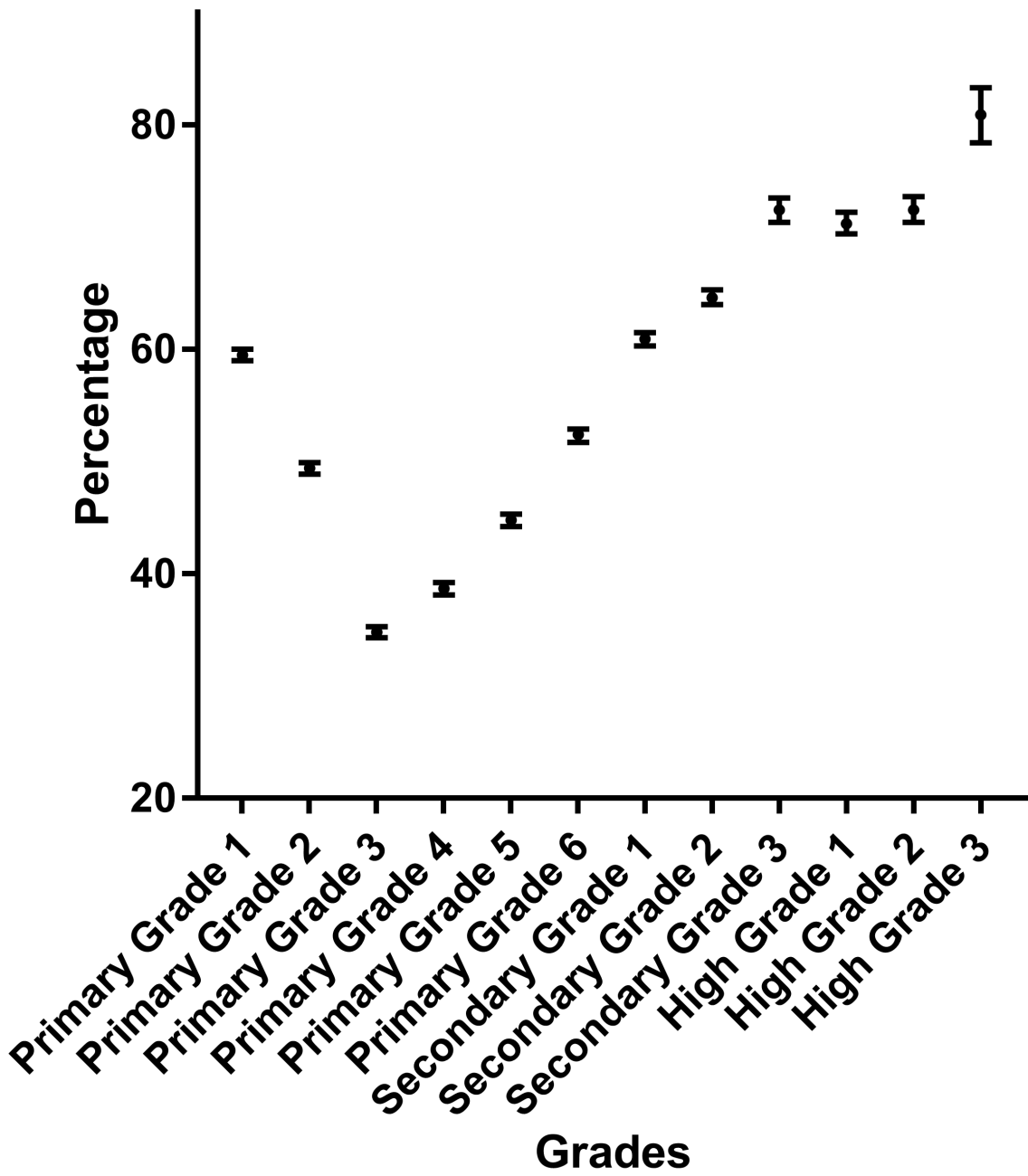Please see the supplementary files section to access the table.

Figures
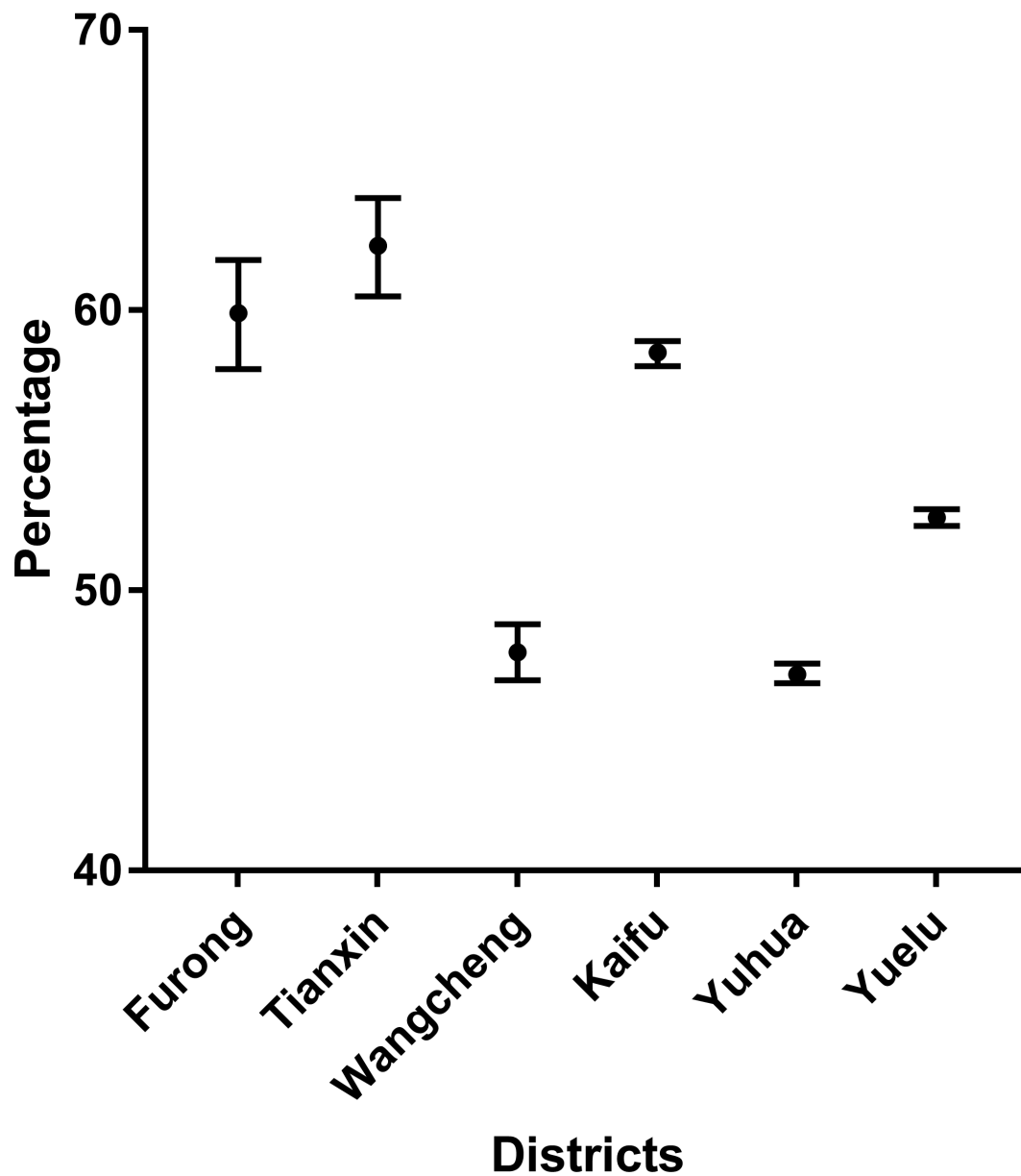
Figure 1. The prevalence of reduced visual acuity in 6 districts
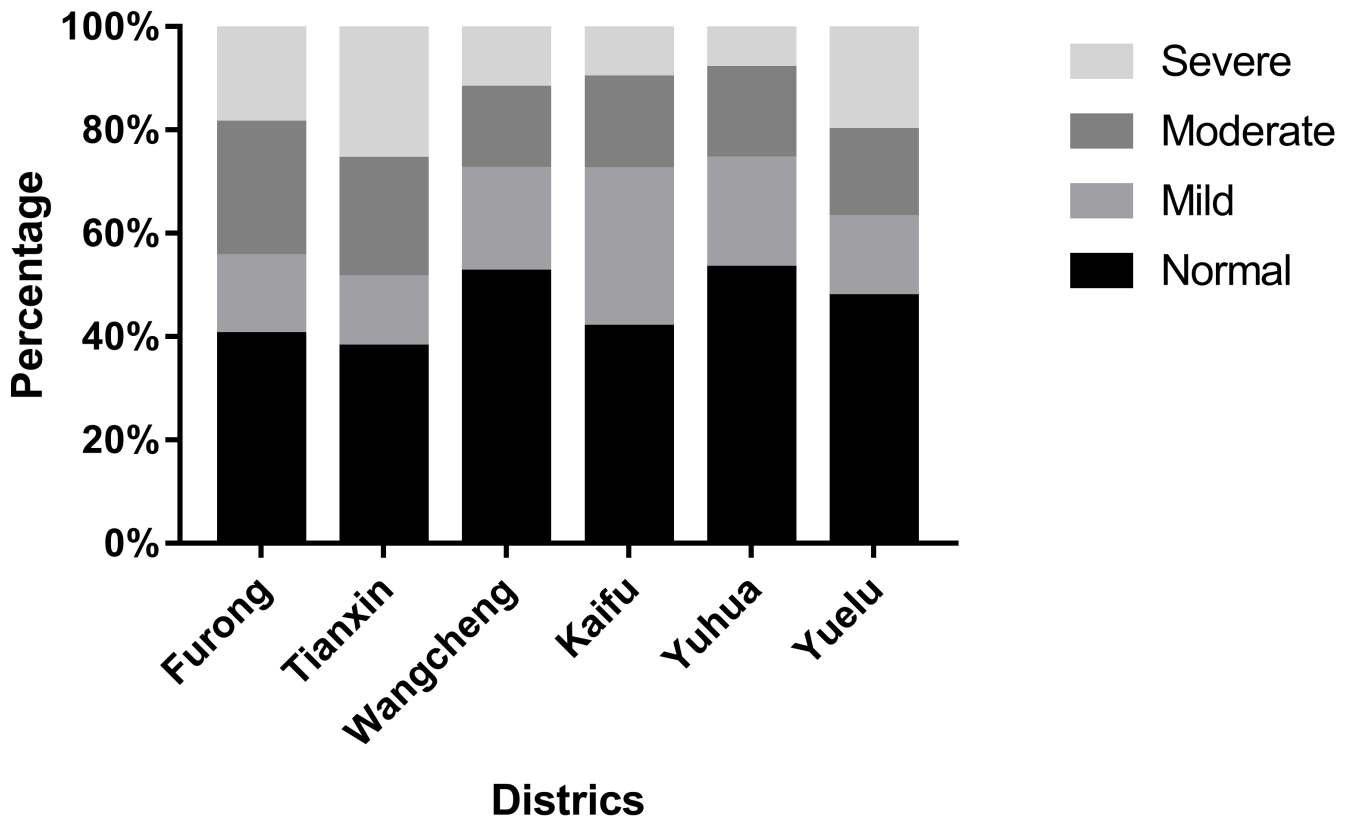
Figure 1

The prevalence of reduced visual acuity in 6 districts

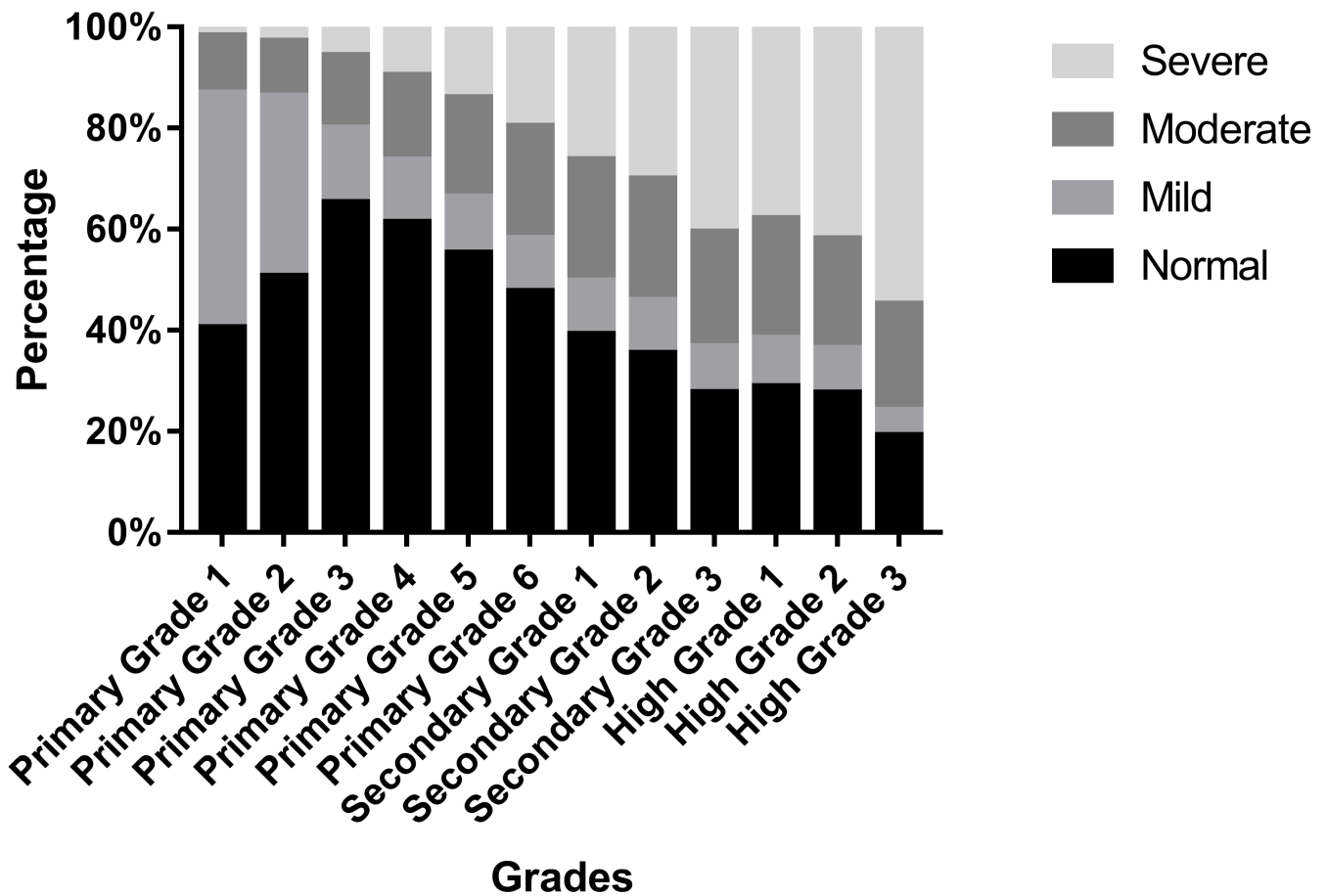**Figure 2.** The prevalence of reduced visual acuity in 12 grades

Figure 2

The prevalence of reduced visual acuity in 12 grades

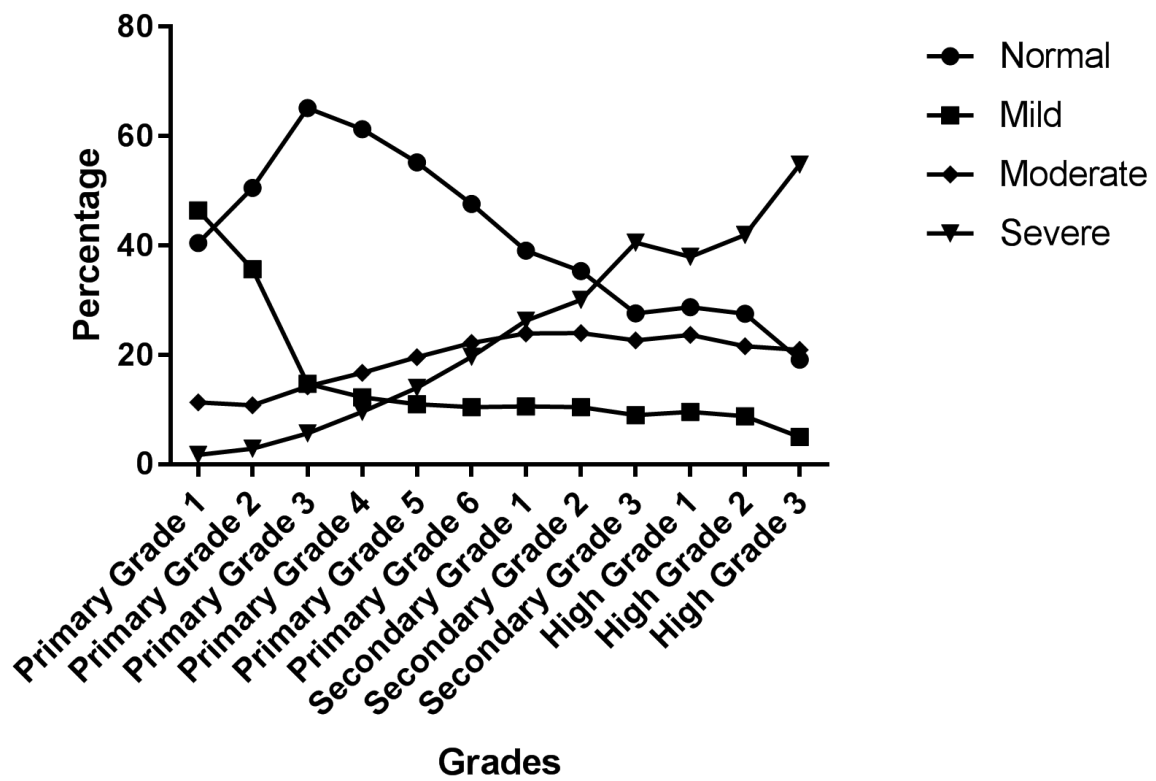**Figure 3.** The distribution of reduced visual acuity in 6 ditricts by intensity

Figure 3

The distribution of reduced visual acuity in 6 districts by intensity

Figure 4. The distribution of reduced visual acuity in 12 grades by intensity

Figure 4

The distribution of reduced visual acuity in 12 grades by intensity

Figure 5. The tendency of prevalence of reduced visual acuity by intensity in 12 grades

Figure 5

The tendency of prevalence of reduced visual acuity by intensity in 12 grades

Supplementary Files

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- Table1.pdf