Reports

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Factors Underlying Different Myopia Prevalence between Middle- and Low-income Provinces in China

Currently available data on myopia and spectacle wear are drawn largely from China's richer and middle-income areas, and little is known about refractive error and spectacle wear in the lowest income provinces. Studies from China and elsewhere suggest that large differences in myopia prevalence may exist between areas of different socioeconomic status within countries, but reasons for these differences are not well understood. The current report details the prevalence and predictors of myopia measured using the identical protocols and equipment in 2 adjoining provinces of western China, middle-income Shaanxi and low-income Gansu. Study methods including institutional review board approvals and consent have been described elsewhere.[1]

The study was carried out in Yulin prefecture, Shaanxi, and Tianshui prefecture, Gansu Province, which are nearby areas. Shaanxi's gross domestic product per capita is $US6108 and was ranked 14th among China's 31 administrative regions in 2012, while Gansu is the second-poorest province in the country (per capita gross domestic product of $US3100).[2] Yulin is a relatively wealthy region in a middle-income province and Tianshui constitutes a poor region of one of China's lowest-income provinces.

A complete list of primary schools was obtained, and 1 school from each township in the 2 prefectures was selected at random (Yulin, Shaanxi n = 132; Tianshui, Gansu n = 120). Within each school, 1 class was randomly chosen in each of the 4th and 5th grades.

The following data were collected in September 2012: children's age, sex, boarding at school, parental schooling and migration for work, family wealth, classroom blackboard use, and visual acuity. Children with uncorrected visual acuity of ≤6/12 in either eye underwent cycloplegic refraction. A study-specific mathematics test was administered as an index of academic achievement. In May and June 2013, we collected data on parental spectacle wear, children's time spent outdoors and in near/middle distance work using validated instruments.[3]

Clinically significant myopia was defined as uncorrected visual acuity of ≤6/12 in either eye and a spherical equivalent of ≤−0.5 diopter in both eyes. Characteristics were compared between children in the 2 prefectures, accounting for sampling weight and school clustering. Relative risk (RR) estimation using general linear modeling with Poisson regression and robust error variance was used to determine the association between potential risk factors and myopia for the 2 provinces separately and for the total study population. Subjects with missing myopia data (n = 306 [1.5%]) were excluded.

Among 9489 children in Shaanxi (mean age, 10.4±1.03 years; 53.1% boys), the prevalence of clinically significant myopia (22.9%; 95% CI, 21.2%−24.7%) was nearly twice that of 10 137 children (mean age, 10.7±1.24 years; 49.1% boys) in Gansu (12.7%; 95% CI, 11.3%−14.1%; RR for Shaanxi vs Gansu 1.81 [95% CI, 1.58−2.07; $P < 0.001$]).

Parents out-migrating for work were less common in the Shaanxi cohort (8.10%) than in the Gansu cohort (16.8%; $P < 0.001$), and families were less likely to be in the lowest wealth tertile for the total sample in Shaanxi (17.2% vs 38.7%; $P < 0.001$). One-half of our Shaanxi cohort (49%) versus 3.6% in Gansu lived in low population density areas ($P < 0.001$). Mathematics scores were higher in Shaanxi ($P = 0.03$), and the blackboard was used less in Shaanxi than in Gansu (26.7% of classes spending the majority of classtime directed at the blackboard in Shaanxi vs 45.5% in Gansu; $P < 0.001$; Table 1, available at www.aaojournal.org). Differences in outdoor activity and near and middle distance work were minimal between Shaanxi and Gansu, and between children with and without myopia (Table 2, available at www.aaojournal.org).

Older age (RR, 1.07; 95% CI, 1.02−1.13), parental glasses wear (RR, 1.57; 95% CI, 1.39−1.77), and higher math score (RR, 1.20 [95% CI, 1.13−1.28] per increase of 1 standard deviation in score) were associated with increased risk for myopia in both provinces separately and in the total study population (above RRs are for the total study population). Male sex (RR, 0.81; 95% CI, 0.73−0.91) was associated with lower risk and near work (RR, 1.02 [95% CI, 1.00−1.03] per hour/week increase), with greater risk in the total study population and in Shaanxi alone, but not in Gansu alone. Blackboard use and family wealth were not associated with myopia risk in the multivariate model and no clear linear pattern was found for population density across quartiles (Table 3). Residence in Shaanxi was associated with a 69% increased risk of myopia (RR, 1.69; 95% CI, 1.39; 2.06) after adjusting for other risk factors. The likelihood ratio test ($P < 0.001$) and pseudo R^2 (<20%) both suggest that the current model fits the data well, and that the conclusion is valid that real, as-yet-unexplained differences exist between myopia prevalence in Shaanxi and Gansu.

Even after adjusting for differences in factors associated with myopia, such as near work,[4] school achievement,[4] and outdoor activity,[3] we could not explain much of the large variation in prevalence of clinically significant myopia between middle-income Shaanxi and low-income Gansu. The current study is among the first to compare known myopia risk factors between nearby areas with large differences in myopia rates. It is possible that the low near work demand in the current cohort (8 hours in both Gansu and Shaanxi vs 23−30 hours in Singapore and Australia[3]) might explain the lack of large effects of near work and outdoor activity.

Greater blackboard use was protective against myopia in univariate analyses (data not shown), perhaps owing to lower near work demands: weekly near work was lower with highest (6.7 hours) versus lowest (7.6 hours; $P < 0.05$) blackboard use. Greater blackboard use was also associated with less wealth here (data not shown), because schools in low-income areas could not afford textbooks, which may confound the association with myopia. More research is needed on myopia risk and classroom use of near and distance teaching tools.

Our definition of myopia included visual acuity, which limits comparisons with other studies, although not internal comparison between Shaanxi and Gansu. Primary school attendance rates are >95% in the area[5]; thus, this school-based sample is likely representative of the population. It is unlikely that genetic factors

Table 3. Multiple Regression Model of Risk Factors for Myopia in Shaanxi and Gansu*

Characteristics	Shaanxi			Gansu			All		
	RR	*95% CI*	*P*	*RR*	*95% CI*	*P*	*RR*	*95% CI*	*P*
Age	**1.09**	**1.02, 1.17**	**0.02**	1.07	0.99, 1.16	0.10	**1.07**	**1.02, 1.13**	**0.008**
Male sex	**0.73**	**0.64, 0.82**	**<0.001**	0.99	0.81, 1.20	0.90	**0.81**	**0.73, 0.91**	**<0.001**
One or both parents with high school or greater education	0.91	0.76, 1.09	0.30	**1.28**	**1.01, 1.63**	**0.04**	1.04	0.90, 1.21	0.57
Both parents out-migrated for work	0.99	0.75, 1.30	0.92	0.97	0.75, 1.26	0.82	0.97	0.80, 1.17	0.75
Family wealth									
Lowest tertile		Reference			Reference			Reference	
Middle tertile	1.01	0.82, 1.23	0.95	1.07	0.85, 1.33	0.56	1.03	0.89, 1.20	0.69
Highest tertile	1.13	0.94, 1.36	0.18	0.94	0.72, 1.23	0.65	1.08	0.92, 1.25	0.35
Parents wearing glasses	**1.61**	**1.39, 1.86**	**<0.001**	**1.51**	**1.22, 1.87**	**<0.001**	**1.57**	**1.39, 1.77**	**<0.001**
Population density (persons/km^2)									
≤83		Reference			Reference			Reference	
83–166	**0.76**	**0.65, 0.88**	**0.001**	1.06	0.64, 1.74	0.83	**0.76**	**0.66, 0.88**	**<0.001**
166–319	0.80	0.63, 1.01	0.06	1.13	0.72, 1.75	0.59	**0.80**	**0.66, 0.98**	**0.03**
>319	0.53	0.27, 1.02	0.06	1.31	0.85, 2.03	0.21	0.94	0.74, 1.19	0.59
Total time spent in near-work (h/wk)	**1.02**	**1.00, 1.04**	**0.02**	1.01	0.98, 1.04	0.57	**1.02**	**1.00, 1.03**	**0.04**
Baseline math scores	**1.19**	**1.10, 1.28**	**<0.001**	**1.22**	**1.09, 1.37**	**0.001**	**1.20**	**1.13, 1.28**	**<0.001**
Proportion of class-time using blackboard									
More than half		Reference			Reference			Reference	
Half	0.95	0.79, 1.14	0.58	**1.39**	**1.12, 1.71**	**0.002**	1.13	0.98, 1.29	0.09
Less than half	1.01	0.86, 1.19	0.88	1.36	0.97, 1.89	0.07	1.14	0.98, 1.33	0.08
Shaanxi vs Gansu residency		—			—		**1.69**	**1.39, 2.06**	**<0.001**

Values in boldface are significant at the $P < 0.05$ level.
*Relative risk (RR) and 95% CI for multiple regression including all potential risk factors (1st column) taking into account sampling weight and clustering within schools.

explain refractive differences between these populations, which unlike some parts of western China, are both >90% Han. Nutrition-related differences in body height have also not been associated with refractive errors in previous studies in China.

Although unexamined or unknown economic factors might have better explained differences in myopia between these regions, it remains unclear how economic differences affect myopia, if not through known behavioral risk factors. Understanding reasons for low myopia prevalence in low-income areas might eventually lead to myopia prevention strategies.

Zhongqiang Zhou, MD, PhD[1]
Xiaochen Ma, PhD[2]
Hongmei Yi, PhD[3]
Xiaopeng Pang, PhD[4]
Yaojiang Shi, PhD[5]
Qianyun Chen, MS[1]
Mirjam E. Meltzer, PhD[1]
Carlos Price-Sanchez[1]
Mingguang He, MD, PhD[1]
Scott Rozelle, PhD[6]
Ian Morgan, PhD[1]
Nathan Congdon, MD, MPH[1,7]

[1]*State Key Laboratory of Ophthalmology and Division of Preventive Ophthalmology, Zhongshan Ophthalmic Center, Sun Yat-sen University, Guangzhou, China;* [2]*Department of Agriculture and Resource Economics, University of California Davis, Davis, California;* [3]*Center for Chinese Agricultural Policy, Institute of Geographical Sciences and Natural Resources Research, Chinese Academy of Sciences, Beijing, China;* [4]*School of Agricultural Economics and Rural Development, Renmin University of China, Beijing, China;* [5]*School of Economic Management, Xibei University, Xi'an, China;* [6]*Freeman Spogli Institute of International Studies, Stanford University, Stanford, California;* [7]*ORBIS International, New York, New York*

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Correspondence:
Nathan Congdon, MD, MPH, State Key Laboratory and Translational Research for Equitable Eyecare, Zhongshan Ophthalmic Center, Sun Yat-sen University, Guangzhou 510060, China. E-mail: ncongdon1@gmail.com.

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