Introduction

Dyslipidemia, a major systemic disorder, is one of the most important risk factors for cardiovascular disease which is a major cause of morbidity and a leading contributor to mortality worldwide [1–4]. Due to its pronounced impact on many organs of the body, dyslipidemia has also been indirectly or directly linked to a wide range of eye diseases, including age-related macular degeneration, glaucoma, retinal vein occlusions and hypertensive retinopathy [5–22].

Most of these studies, however, were conducted on Western populations, in which the prevalence, risk factors, treatment strategies and therapy frequencies of dyslipidemia may be different from Asian populations. And most of these studies have often been hospital-based investigations with the potential risk of a referral bias. And most of the studies usually addressed the relationship between dyslipidemia and a single ocular parameter only (e.g., cataract), without taking account associations between dyslipidemia and other systemic disorders, such as level of education, body height and body mass index. Although this was a cross-sectional approach which by definition cannot give clues on the future development of diseases in association of baseline data such as the presence of dyslipidemia, the relatively large study population of more than 3000 participants, the population-based study sample recruitment, and the simultaneous inclusion of all major ocular diseases and some of the major systemic parameters may allow to arrive at results which may be more conclusive than those which have been available in previous investigations.

Results

The study included 2945 (90.6%) subjects (1671 women) for whom serum lipids measurements were available. The mean age was 60.4±10.0 years (median: 60 years; range: 45–89 years). Out of the 2945 individuals, 1545 (52.5%) subjects (840 women) came from the rural region, and 1400 (47.5%) subjects (831 women) came from the urban region. The subjects from the rural region compared with the subjects from the urban region were significantly younger (55.9±9.0 years versus 63.6±9.9 years; P<0.001), and had significantly lower monthly income (399±310 Yuan versus 2177±594 Yuan; P<0.001) and lower level of education (P<0.001). The participants of the survey 2006 compared with the non-participants were significantly younger (55.3±1.0 years versus 58.6±11.6 years; P<0.001), came more often from the rural region than from the urban region (1500/
1751 versus 473/714; \( P < 0.001 \)), and had a higher level of education \(( P = 0.001 \)).

There were no significant differences in gender (females/males 1830/1413 versus 668/521; \( P = 0.94 \)).

Mean levels of total cholesterol, HDL cholesterol, LDL cholesterol, and triglycerides were 4.92±1.01 mmol/L, 1.61±0.36 mmol/L, 2.88±0.85 mmol/L, and 1.76±1.29 mmol/L, respectively. A hypercholesterolemia (total cholesterol concentration ≥5.72 mmol/L (220 mg/dL)) was found in 19.0±0.7%, a hypertriglyceridemia (triglyceride concentration ≥1.70 mmol/L (150 mg/dL)) in 35.5±0.9%, and abnormally low high-density lipoprotein-cholesterol (HDL-C concentration ≤0.91 mmol/L (35 mg/dL)) in 1.7±0.2% of the study population. Dyslipidemia was found for 1332 subjects (prevalence: 45.1±9.9% (mean ± standard error; 95% CI: 43.3%, 46.9%)). A positive history for dyslipidemia was described by 842 (28.5%) subjects, so that the prevalence of dyslipidemia and the prevalence of retinal vein occlusions \(( P < 0.001 \)) and the prevalence of retinal artery narrowing \(( P < 0.001 \)) (Tables 1, 2). In this multivariate analysis, dyslipidemia was not significantly associated with the prevalence of glaucoma \(( \text{OR} = 0.81, 95\% \text{ CI}: 0.45–1.45, \text{P} = 0.43 \)) and age-related macular degeneration \(( \text{OR} = 0.58, 95\% \text{ CI}: 0.28–1.19, \text{P} = 0.01 \)).

With respect to non-ocular parameters, the presence of dyslipidemia was significantly associated with increasing age \(( P < 0.001 \)), female gender \(( P < 0.001 \)), urban region \(( P = 0.001 \)), body mass index \(( P < 0.001 \)), income \(( P = 0.01 \)), blood glucose concentration \(( P < 0.001 \)) and blood pressure \(( P < 0.02 \)), and smoking \(( P = 0.04 \)).

With respect to ophthalmic parameters, the prevalence of dyslipidemia was associated significantly (bivariate analysis) with increasing intraocular pressure \(( P < 0.001 \)) and smoking \(( P < 0.001 \)), larger area of beta zone of parapapillary atrophy \(( P = 0.01 \)), angio-narrowing \(( P = 0.02 \)) (Tables 1, 2). There were no significant associations between the prevalence of dyslipidemia and the prevalence of retinal vein occlusions \(( P = 0.21 \)), diabetic retinopathy \(( P = 0.12 \)), open-angle glaucoma \(( P = 0.99 \)), angle closure glaucoma \(( P = 0.60 \)), and age-related macular degeneration \(( P = 0.05 \) for early type; \( P = 0.30 \) for late type), refractive error \(( P = 0.91 \)), best corrected visual acuity \(( P = 0.07 \)), area of alpha zone of parapapillary atrophy \(( P = 0.39 \)), generalized retinal arteriolar narrowing \(( P = 0.64 \)), focal arteriolar narrowing \(( P = 0.69 \)), arterio-venous nicking \(( P = 0.23 \)), and the degree of nuclear cataract \(( P = 0.08 \)) and subcapsular cataract \(( P = 0.66 \)) (Tables 1, 2).

In a multivariate regression analysis adjusted for age, gender, area of habitation, body mass index, income, blood glucose concentration, diastolic blood pressure and smoking, dyslipidemia was significantly associated with higher intraocular pressure \(( \beta = 1.02 \); 95% CI: 1.01–1.02, \( P < 0.001 \)) and beta zone of parapapillary atrophy \(( \beta = 1.19 \); 95% CI: 1.02–1.39, \( P = 0.03 \)) (Tables 3, 4). In this multivariate analysis, dyslipidemia was not significantly associated with the prevalence of glaucoma \(( \text{OR} = 0.86, 95\% \text{ CI}: 0.57–1.31, \text{P} = 0.49 \)), and age-related macular degeneration \(( \text{OR} = 1.95, 95\% \text{ CI}: 0.70–5.64, \text{P} = 0.27 \)).

If the multivariate statistical analysis included dyslipidemia as dependent parameter and age, diastolic blood pressure and intraocular pressure as independent variables, dyslipidemia remained to be significantly associated with higher intraocular pressure \(( P < 0.001 \)) in addition to higher age \(( P < 0.001 \)) and higher diastolic blood pressure \(( P < 0.001 \)). If the whole study population was stratified into age groups of each 10 years each, the correlation between dyslipidemia and higher intraocular pressure (adjusted for diastolic blood pressure) remained to be statistically significant in the age group from 45–54 years \(( P = 0.02 \); \( \beta = 1.05 \); 95%CI: 1.01, 1.09 \)) and in the age group from 55–64 years \(( P = 0.01 \); \( \beta = 1.06 \); 95%CI: 1.01, 1.11 \)). In the remaining age groups, the association was not statistically significant, potentially due to the decreasing

| Table 1. Differences in Ocular Parameters in Subjects with and without Dyslipidemia in the Beijing Eye Study 2006 (Categorical variables). |
|-----------------|---------|-------------|---------|-------------|---------|---------|---------|
|                 | No Dyslipidemia | Dyslipidemia | Odds Ratio | 95% CI | \( P \) value |
|                 | n/N | %     | n/N | %     |         |         |
| Focal arteriolar narrowing | 136/1503 | 9.0% | 106/1230 | 8.6% | 0.95 | 0.73, 1.23 | 0.69 |
| Arterio-venous nicking | 128/1504 | 8.5% | 121/1230 | 9.8% | 1.17 | 0.90, 1.52 | 0.23 |
| Generalized narrowing | 295/1515 | 19.5% | 251/1214 | 20.2% | 1.05 | 0.87, 1.26 | 0.64 |
| Diabetic retinopathy | 57/1593 | 3.6% | 62/1310 | 4.7% | 1.34 | 0.93, 1.93 | 0.12 |
| Nuclear cataract | 113/1604 | 7.0% | 117/1327 | 8.8% | 1.28 | 0.98, 1.67 | 0.08 |
| Post. subcapsular cataract | 57/1503 | 3.8% | 52/1263 | 4.1% | 1.09 | 0.74, 1.59 | 0.66 |
| Cortical cataract | 102/1503 | 6.8% | 115/1263 | 9.1% | 1.38 | 1.04, 1.81 | 0.02 |
| Retinal vein occlusion | 21/1504 | 1.3% | 25/1327 | 1.9% | 1.45 | 0.81, 2.59 | 0.21 |
| Open-angle glaucoma | 39/1619 | 2.4% | 32/1332 | 2.4% | 0.99 | 0.62, 1.60 | 0.99 |
| Angle-closure glaucoma | 15/1619 | 0.9% | 10/1332 | 0.8% | 0.81 | 0.36, 1.80 | 0.60 |
| Age-related macular degen. | 97/1574 | 6.2% | 64/1291 | 5.0% | 0.79 | 0.57, 1.09 | 0.16 |
| Early stage | 95/1574 | 6.0% | 59/1291 | 4.6% | 0.75 | 0.53, 1.04 | 0.08 |
| Late stage | 2/1574 | 0.1% | 5/1291 | 0.4% | 3.07 | 0.60, 15.9 | 0.30 |

The denominators vary between various parameters, since these parameters could not be assessed in all subjects with a biochemical blood analysis.

95%CI: 95% confidence interval.

doi:10.1371/journal.pone.0026871.t001
significant in the younger subgroup (association between dyslipidemia and intraocular pressure was divided into two age groups with the cut-off at 60 years, the number of participants per group. If the whole study population was stratified into participants without or with diabetes mellitus, the relationship between dyslipidemia and intraocular pressure was significant in the non-diabetic group.

If the statistical analysis defined dyslipidemia as abnormal lipid concentrations (not including the history of abnormal lipid measurements), similar results were obtained as if the definition of dyslipidemia included the history of it. In univariate analysis, we found significant associations for the relationships between dyslipidemia (without taking into account history of dyslipidemia) with intraocular pressure ($P<0.001$; correlation coefficient: 0.10) and with beta zone of parapapillary atrophy ($P=0.001$; correlation coefficient: 0.06). For all other ocular diseases, the relationship was not statistically significant. In a multivariate regression analysis adjusted for age, gender, area of habitation, body mass index, income, blood glucose concentration, diastolic blood pressure and smoking, the prevalence of dislipidemia (not including the history of abnormal lipid measurements) was significantly associated with higher intraocular pressure ($\beta=1.06$; 95% CI: 1.03–1.09, $P<0.001$) and beta zone of parapapillary atrophy ($\beta=1.12$; 95% CI: 1.05–1.20, $P=0.002$).

**Discussion**

Our study was performed in search of associations between dyslipidemia and ocular parameters and diseases. It revealed a correlation of dyslipidemia with intraocular pressure and with beta zone of parapapillary atrophy.

The finding of a relationship between dyslipidemia and increased intraocular pressure has not been reported yet and therefore is in need of further confirmation. Interestingly, despite the association between dyslipidemia and intraocular pressure, dyslipidemia was not associated with the presence of glaucomatous optic neuropathy. In previous studies, similar findings were reported for the association between increased blood pressure and diseases such as diabetes mellitus and hypertension.

---

**Table 2. Differences in Ocular Parameters in Subjects with and without Dyslipidemia in the Beijing Eye Study 2006 (Continuous variables).**

|                         | No Dyslipidemia Mean ± SD | Dyslipidemia Mean ± SD | Mean Difference | 95% CI of the Difference | $P$-value |
|-------------------------|---------------------------|------------------------|----------------|--------------------------|-----------|
| Best corrected visual acuity | 1.08±0.32                 | 0.93±0.25              | 0.14           | −0.01, 0.30              | 0.07      |
| Refractive error (Diopeters) | −0.30±2.10                | −0.31±2.46             | 0.01           | −0.16, 0.18              | 0.91      |
| Intraocular pressure (mm Hg) | 15.36±2.90                | 15.93±3.00             | −0.57          | −0.78, −0.35             | <0.001    |
| Optic disc area (mm²) | 2.55±0.50                 | 2.63±0.51              | −0.08          | −0.12, −0.04             | <0.001    |
| Area of alpha zone area (mm²) | 0.49±0.51                 | 0.51±0.60              | −0.02          | −0.06, 0.02              | 0.39      |
| Area of beta zone area (mm²) | 0.29±0.95                 | 0.44±1.45              | −0.16          | −0.25, −0.07             | 0.001     |
| Neuroretinal rim area (mm²) | 1.68±0.32                 | 1.69±0.34              | −0.01          | −0.06, 0.04              | 0.69      |

---

**Table 3. Multivariate Regression Analysis of the Associations between the Presence of Dyslipidemia, Total Cholesterol, High-Density Lipoprotein Cholesterol, Low-Density Lipoprotein cholesterol, and Triglycerides with Major Ocular Diseases and Parameters in the Beijing Eye Study 2006.**

| Dyslipidemia | OR | 95%CI | $P$-V. | OR | 95%CI | $P$-V. | OR | 95%CI | $P$-Val. | OR | 95%CI | $P$-V. |
|--------------|----|-------|--------|----|-------|--------|----|-------|----------|----|-------|--------|
| Ret. vein occlusion | 1.07 | 0.29, 3.99 | 0.92 | 1.06 | 0.89, 1.27 | 0.51 | 1.14 | 0.84, 1.53 | 0.41 | 1.08 | 0.50, 2.33 | 0.85 | 1.23 | 0.93, 1.62 | 0.16 |
| Open angle glaucoma | 1.14 | 0.71, 1.84 | 0.99 | 0.99 | 0.81, 1.22 | 0.96 | 0.95 | 0.74, 1.22 | 0.70 | 0.84 | 0.40, 1.73 | 0.63 | 0.98 | 0.71, 1.35 | 0.91 |
| Diab retinopathy | 0.86 | 0.57, 1.31 | 0.49 | 0.92 | 0.77, 1.08 | 0.30 | 0.99 | 0.80, 1.24 | 0.99 | 1.96 | 0.92, 4.21 | 0.08 | 0.97 | 0.74, 1.29 | 0.86 |
| Nuclear Cat. | 0.58 | 0.28, 1.19 | 0.14 | 1.03 | 0.91, 1.16 | 0.62 | 0.97 | 0.82, 1.13 | 0.66 | 0.98 | 0.62, 1.53 | 0.93 | 0.99 | 0.81, 1.20 | 0.88 |
| Cortical Cat. | 1.03 | 0.48, 2.25 | 0.93 | 1.08 | 0.97, 1.20 | 0.19 | 0.94 | 0.81, 1.10 | 0.47 | 1.15 | 0.73, 1.79 | 0.55 | 0.93 | 0.77, 1.13 | 0.50 |
| Post. subcaps. Cat. | 0.80 | 0.28, 2.29 | 0.67 | 1.01 | 0.67, 1.18 | 0.87 | 0.96 | 0.78, 1.16 | 0.66 | 0.92 | 0.53, 1.59 | 0.77 | 0.91 | 0.71, 1.16 | 0.46 |
| Age-related mac. degener. | 1.59 | 0.70, 3.64 | 0.27 | 0.99 | 0.87, 1.13 | 0.93 | 0.96 | 0.81, 1.14 | 0.65 | 1.04 | 0.62, 1.73 | 0.90 | 0.87 | 0.71, 1.06 | 0.17 |
| Focal retinal ed. narrowing | 0.81 | 0.45, 1.45 | 0.48 | 0.91 | 0.80, 1.03 | 0.15 | 0.95 | 0.82, 1.10 | 0.51 | 1.17 | 0.81, 1.69 | 0.41 | 0.91 | 0.77, 1.09 | 0.41 |
| Retinal art-ven. nicking | 0.89 | 0.49, 1.64 | 0.71 | 1.01 | 0.91, 1.10 | 0.83 | 1.05 | 0.91, 1.20 | 0.51 | 0.99 | 0.68, 1.46 | 0.97 | 1.00 | 0.85, 1.17 | 0.97 |
| General. ret. art. narrowing | 1.02 | 0.65, 1.61 | 0.92 | 1.04 | 0.97, 1.11 | 0.25 | 0.98 | 0.89, 1.08 | 0.70 | 0.63 | 0.46, 0.86 | 0.004 | 1.04 | 0.93, 1.17 | 0.49 |

(Categorical variables; logistic regression analysis) (OR: Odds ratio; 95%CI: 95% Confidence interval; $P$-V.: $P$-Value).

doi:10.1371/journal.pone.0026871.t003
and intraocular pressure: although arterial hypertension was associated with increased intraocular pressure, it was not associated with glaucoma [23–26]. The finding of a relationship between dyslipidemia and parapapillary atrophy (beta zone) has neither been reported yet. This observation has to be considered to be relatively vague, until confirmed in future investigations. Interestingly, although beta zone of parapapillary atrophy was related to glaucomatous optic neuropathy [27,28], dyslipidemia was not associated with glaucoma.

Dyslipidemia was not significantly associated with the prevalence of diabetic retinopathy after controlling for systemic parameters of age, gender, body mass index, blood glucose concentration, diastolic blood pressure and smoking. The finding appears to disagree with results of previous population-based studies and of clinical investigations which showed a disappearance of retinal hard exudates in patients with diabetic retinopathy after lowering of systemic blood lipid concentrations [29,30]. One of the reasons for the discrepancy between the studies may be differences in lifestyle and food between adult Chinese participating in our study and adult Caucasians taking part in the previous population-based studies. Another reason may be that the number of subjects with hard exudates as part of diabetic retinopathy in our study was too small for statistical analysis. The missing of a clearly significant association between dyslipidemia and the overall presence of diabetic retinopathy in our study may suggest that factors such as blood glucose concentration, blood pressure, region of habitation and gender were more important than the additional factor of dyslipidemia for the development of diabetic fundus changes.

The result of our study that dyslipidemia was not associated with the presence of age-related macular degeneration agrees with data from the Complications of Age-Related Macular Degeneration Prevention Trial that showed that use of the cholesterol-lowering medications among patients with bilateral macular drusen was not associated with a higher or lower risk of progressing to advanced disease [31].

The observation that retinal vascular abnormalities (i.e. focal arteriolar narrowing, retinal arterio-venous nicking and generalized retinal arteriolar narrowing) were not significantly associated with the presence of dyslipidemia after controlling for the systemic factors of blood glucose concentration, diastolic blood pressure and smoking, confirmed a previous study by Leung and colleagues in which no consistent pattern of an association between serum total cholesterol or low-density lipoprotein cholesterol and any retinal microvascular signs was detected [32].

Potential limitations of our study should be mentioned. First, a major concern regarding any epidemiologic study is non-participation. The Beijing Eye Study 2006 had a reasonable response rate of about 73% (3251 of the 4439 subjects invited for the follow-up survey; or 61% of the group originally eligible in 2001). However, differences between participants and non-participants could have led to a selection artifact. Second, the number of subjects with some diseases, e.g., late age-related macular degeneration, was small so that the statistical power was not sufficient to exclude a weak association between the disease in question and dyslipidemia. However, we had adequate statistical power to determine associations of dyslipidemia to any age-related macular degeneration, glaucoma and age-related cataract. Third, a further limitation of the study design was that socioeconomic parameters, such as income, were assessed based on an interview, without re-checking in a more scientific manner. Fourth, the prevalence of dyslipidemia was 56%, a value higher than what might have been expected. Interestingly, however, the results of our study agreed with previous populations-based studies from China. To cite an example, if the results of our study were compared with the findings from the InterAsia Collaborative Group Study [33], the mean levels of total cholesterol, HDL cholesterol, LDL cholesterol, and triglycerides did not vary markedly between both studies. The prevalence of dyslipidemia and its associations found in our study also agreed with other studies from China such as the PRC-USA Collaborative Study in Cardiovascular and Cardiopulmonary Epidemiology and other investigations [34–36]. Fifth, our study was a cross-sectional investigation which primarily did not allow statements about longitudinal relationships. Sixth, it has to be considered, that a relatively high number of statistical comparisons were performed, so that a Bonferroni correction should be performed. It would reveal that the association between dyslipidemia and intraocular pressure continued to be significant, while the association between dyslipidemia and beta zone of parapapillary atrophy would no longer be statistically significant. Strengths of our study are that dyslipidemia was adjusted for major systemic parameters including socioeconomic factors so that it may have been unlikely that inter-relationships between dyslipidemia and non-ocular parameters

---

**Table 4. Multivariate Regression Analysis of the Associations between the Presence of Dyslipidemia, Total Cholesterol, High-Density Lipoprotein Cholesterol, Low-Density Lipoprotein cholesterol, and Triglycerides with Major Ocular Diseases and Parameters in the Beijing Eye Study 2006.**

|                                   | Beta Coef. | 95%CI | P-Val. | Beta Coef. | 95%CI | P-Val. | Beta Coef. | 95%CI | P-Val. | Beta Coef. | 95%CI | P-Val. | Beta Coef. | 95%CI | P-Val. |
|-----------------------------------|------------|-------|--------|------------|-------|--------|------------|-------|--------|------------|-------|--------|------------|-------|--------|
| Intraocular pressure (mm Hg)      | 1.02       | 1.01, 1.02 | <0.001 | 0.19      | 0.10, 0.27 | <0.001 | 0.26      | 0.15, 0.36 | <0.001 | 0.21      | 0.06, 0.52 | 0.16 | 0.27       | 0.14, 0.39 | <0.001 |
| Alpha zone of para-papillary atrophy (mm²) | 0.88     | 0.63, 1.23 | 0.47    | 0.01      | 0.01, 0.03 | 0.10  | 0.01 -0.01, 0.03 | 0.35 | -0.03 -0.06, 0.03 | 0.32 | 0.01 -0.01, 0.04 | 0.33 |
| Beta zone of para-papillary atrophy (mm²) | 1.19     | 1.02, 1.39 | 0.03    | 0.00      | -0.03, 0.03 | 0.84  | 0.03 -0.01, 0.07 | 0.10 | 0.05 -0.06, 0.16 | 0.40 | -0.03 -0.08, 0.02 | 0.31 |

(Continuous variables; linear regression analysis) (95%CI: 95% Confidence interval; P- Val. P-Value).

Each model was adjusted for factors significantly associated with each of the ocular parameters/diseases in bivariate analysis. 95%CI: 95% confidence interval of the odds ratio or of Beta coefficient.

doi:10.1371/journal.pone.0026871.t004
may have led to a confounding effect; that it was the first investigation on an association between dyslipidemia and major eye diseases in China; the relatively large study sample; and the application of internationally accepted definitions for ophthalmic diseases, such as the glaucoma definition by the International Society of Geographic and Epidemiological Ophthalmology ISGEO [37].

In conclusion, after adjusting for systemic and socioeconomic parameters, dyslipidemia in Chinese individuals was associated with increased intraocular pressure, diabetic retinopathy and parapapillary atrophy (beta zone). However, dyslipidemia was not associated significantly with the prevalence of glaucoma, retinal vein occlusions, and age-related macular degeneration, any type of age-related cataract, and the presence of retinal vascular abnormalities.

Methods

Ethics Statement

The Medical Ethics Committee of Beijing Tongren Hospital approved the study protocol and all participants gave informed consent according to the Declaration of Helsinki.

The Beijing Eye Study was a population-based study conducted in rural and urban regions of Greater Beijing. It has been described in detail recently [38–40]. At the time of the first survey in the year 2001, out of 5324 eligible subjects with an age of 40+ years, 4439 individuals participated (response rate: 83.4%). The current study population was examined in 2006, when participants of the survey of 2001 were invited for re-examination. Of the 4439 subjects who participated at baseline in 2001, 3251 subjects returned for the follow-up examination in 2006 (response rate: 73.2%).

All examinations were carried out in school houses or in common houses of the seven communities included. Trained research technicians asked the study participants questions from a standard questionnaire providing information on demographic variables such as age, gender, level of education, occupation, family income; on smoking and alcohol drinking habits; and on known diagnosis and current treatment of arterial hypertension and dyslipidemia. Body weight and height and the arterial blood pressure were measured. At the start of the examinations in the morning, fasting blood samples were taken and the fresh blood samples were biochemically analyzed within four maximum hours. In the fasting blood samples, the serum concentrations of total cholesterol, triglycerides, high-density lipoprotein-cholesterol (HDL-C) and low-density lipoprotein-cholesterol (LDL-C) were measured using the enzymatic method with a Hitachi 7600 auto-analyzer (Hitachi, Tokyo, Japan). Reagents of the same batch were used. Dyslipidemia was defined as any of hypercholesterolemia (total cholesterol concentration $\geq 5.72$ mmol/L (220 mg/dL)) or hypertriglyceridemia (triglyceride concentration $\geq 1.70$ mmol/L (150 mg/dL)) or low-high-density lipoprotein-cholesterol (HDL-C concentration $\leq 0.91$ mmol/L (35 mg/dL)), or as treatment of dyslipidemia [33]. Treatment of dyslipidemia was defined as the use of a pharmacological treatment to lower blood lipids during the previous 2 weeks.

A detailed ophthalmic examination was performed including refractometry, frequency doubling perimetry, slit lamp assisted optical coherence tomography of the anterior chamber morphology (Heidelberg Engineering, Heidelberg, Germany), ophthalmoscopy, and photography of the cornea, lens and fundus. Intraocular pressure was measured by a non-contact pneumotonometer (CT-60 computerized tonometer, Topcon Ltd., Tokyo, Japan). The anterior chamber depth was assessed using the method described by van Herick et al. [41]. Examining the lens photographs, nuclear cataract was graded in 6 grades based on the classification scheme of the Age-Related Eye Disease Study [42]. Nuclear cataract was defined as a grade of nuclear cataract of "4" or higher. The degree of cortical lens opacification and posterior subcapsular lens opacification was graded using photographs taken by retroillumination with the Neitz CI-R camera (Neitz Instruments Co., Tokyo, Japan). For the statistical analysis, cortical cataract and posterior subcapsular cataract were defined as any presence of cortical cataract or posterior subcapsular cataract, respectively. The occurrence of retinal vein occlusions was assessed using fundus photographs [43]. Retinopathy lesions were examined using criteria of the Early Treatment of Diabetic Retinopathy Study (ETDRS) [44,45].

Monoscopic photographs (on film) of the macula and optic disc were taken using a fundus camera (Type CR6-45NM, Canon Inc. U.S.A.). The optic disc photographs were digitized and the width of the neuroretinal rim and the diameters and area of the optic cup and optic disc were measured in the vertical meridian of the optic disc. Additionally, we measured the area of beta zone of parapapillary atrophy [46]. The vertical cup / disc diameter ratio (VCDR) was calculated. Glaucoma was defined according to the criteria of the International Society of Geographic and Epidemiological Ophthalmology ISGEO [37]. The differentiation between open-angle glaucoma (OAG) and angle-closure glaucoma (ACG) was performed according to Goldmann gonioscopy, which was carried out for all glaucoma subjects and glaucoma suspects, and according to the images of the anterior segment optical coherence tomography. For the evaluation of retinal vascular abnormalities, focal narrowing of arterioles, generalized narrowing of arterioles, and arteriovenous crossing abnormalities (arteriovenous nicking) were assessed using the protocol of the Atherosclerosis Risk in Communities (ARIC) study [47,48]. For the assessment of age-related macular degeneration, the Wisconsin Age-Related Maculopathy Grading system was applied [49].

Statistical analysis was performed using SPSS (SPSS for Windows, version 17.0, SPSS, Chicago, IL). Continuous data were presented as mean ± standard deviation. Student t tests were performed to compare mean values. In the first part of the analysis, the prevalence of dyslipidemia was the solely (categorical) exposure parameter (Tables 1, 2, 3, 4). In the second part of the analysis, the blood concentrations of total cholesterol, high-density lipoprotein cholesterol, low-density lipoprotein cholesterol and triglycerides served separately as continuous exposure parameters (Tables 1, 2, 3, 4). In the second part of the statistical analysis, multivariate models were calculated which included the systemic and demographic variables of age, gender, area of habitation, body mass index, income, blood glucose concentration, diastolic blood pressure and smoking. For continuous variables, beta coefficients (β) were reported; for categorical variables, odds ratios (OR) were presented, and 95% confidence intervals (CI) were described. All P-values were 2-sided and were considered statistically significant when the values were less than 0.05.
Author Contributions
Conceived and designed the experiments: SW LX JBJ YXW QSY HY. Performed the experiments: SW LX JBJ YXW QSY HY. Analyzed the data: SW JBJ. Contributed reagents/materials/analysis tools: LX JBJ. Wrote the paper: SW JBJ.

References
1. Murray CJ, Lopez AD (1997) Mortality by cause for eight regions of the world: Global Burden of Disease Study. Lancet 349: 1269-1276.
2. Reddy KS, Yusuf S (1998) Emerging epidemic of cardiovascular disease in developing countries. Circulation 97: 596-601.
3. Sanders J, Dav J, Darkins DB, Dyer AR, Greenland P, et al. (2000) Neaton JD. Relationship of baseline serum cholesterol levels in 3 large cohorts of younger men to long-term coronary, cardiovascular, and all-cause mortality and to longevity. JAMA 294: 311-318.
4. Blood pressure, cholesterol, and stroke in eastern Asia. Eastern Stroke and Coronary Heart Disease Collaborative Research. Lancet 1998;352(9143): 1801-1807.
5. Glader-Bernard A, Cosco G, Chabanel A, Zourdani A, Lelong F, et al. (1996) Dyslipidemia and eye diseases. Ophthalmology 103: 551–560.
6. Chowdhury TA, Hopkins D, Dodson PM, Yaffil GC (2002) The role of serum lipids in exudative diabetic maculopathy: is there a place for lipid lowering therapy? Eye (Lond) 16: 689-693.
7. Miyazaki M, Nakamura H, Kubo M, Kiyohara Y, Oshima Y, et al. (2003) Risk factors for age-related maculopathy in a Japanese population: the Hisayama study. Br J Ophthalmol 87: 469-472.
8. McGwin G, Jr, Owsey C, Gursoy CA, Grain RJ (2003) The association between statin use and age-related maculopathy. Br J Ophthalmol 87: 1121-1125.
9. Gupta A, Gupta V, Thapar S, Bhansali A (2004) Lipid-lowering drug atorvastatin as an adjunct in the management of diabetic macular edema. Am J Ophthalmol 137: 675-682.
10. Tomany SC, Wang JJ, Van Leeuwen R, Klein R, Mitchell P, et al. (2004) Risk factors for incident age-related macular degeneration: pooled findings from 3 continents. Ophthalmology 111: 1290-1297.
11. Wachter A, Sun J, Dach B, Krause P, Pauleikhoff D, et al. (2004) [Minuter age- and retina study (MARS). Association between risk factors for arteriosclerosis and age-related macular degeneration]. Ophthalmologe 101: 50–53.
12. McGwin G, Jr, Owsey C, Gursoy CA (2003) The use of cholesterol-lowering medications and age-related macular degeneration. Ophthalmology 112: 493–499.
13. Miyazaki M, Kiyohara Y, Yoshiida A, Inha M, Nose Y, et al. (2005) The 5-year incidence and risk factors for age-related maculopathy in a general Japanese population: the Hisayama study. Invest Ophthalmol Vis Sci 46: 1907-1910.
14. Smeeth L, Cook C, Chakravarthy U, Hubbard R, Fletcher AE (2005) A case control study of age related macular degeneration and use of statins. Br J Ophthalmol 89: 1171–1173.
15. Paukuniski A, Cimbalas A, Cerniauskiene LR, Luksiene DI, Margeviciene L, et al. (2005) Early age-related maculopathy and risk factors of cardiovascular disease in middle-aged Lithuanian urban population. Eur J Ophthalmol 15: 235-262.
16. McGwin G, Jr, Xie A, Owsey C (2006) 3-hydroxy-3-methylglutaryl coenzyme a reductase inhibitors and the presence of age-related macular degeneration in the Cardiovascular Health Study. Arch Ophthalmol 124: 33-37.
17. Douglas JJ, Cook C, Chakravarthy U, Hubbard R, Fletcher AE, et al. (2007) A case-control study of drug risk factors for age-related macular degeneration. Ophthalmology 114: 1164–1169.
18. Cheung N, Klein R, Wang J, Gotch ME, Islam AF, et al. (2008) Traditional and novel cardiovascular risk factors for retinal vein occlusion: the multiethnic study of atherosclerosis. Invest Ophthalmol Vis Sci 49: 4297-4302.
19. O’Mahony PR, Wong DT, Ray JG (2008) Retinal vein occlusion and traditional risk factors for atherosclerosis. Arch Ophthalmol 126: 692-699.
20. Jeganathan VS, Kawasaki R, Wang JJ, Aung T, Mitchell P, et al. (2008) Retinal vascular caliber and age-related macular degeneration: the Singapore Malay Eye Study. Am J Ophthalmol 146: 954-959.e1.
21. Yasuda M, Kiyohara Y, Hata Y, Arakawa S, Yonemoto K, et al. (2009) Nine-year incidence and risk factors for age-related maculopathy in a defined Japanese population the Hisayama study. Ophthalmology 116: 2135-2140.
22. Koenig N, Vinker S, Kaiserman I (2009) Statins do not decrease the risk for wet age-related macular degeneration. Curr Eye Res 34: 304–310.
23. Mitchell P, Lee AJ, Wang J, Rochtchina E (2005) Intraocular pressure over the clinical range of blood pressure: blue mountains eye study findings. Am J Ophthalmol 140: 131-132.
24. Klein BE, Klein R, Knobloch MD (2005) Intraocular pressure and systemic blood pressure: longitudinal perspective: the Beaver Dam Eye Study. Br J Ophthalmol 89: 284–287.
25. Xu L, Wang H, Wang Y, Jonas J (2007) Intraocular pressure correlated with arterial blood pressure. The Beijing Eye Study. Am J Ophthalmol 144: 461-462.