I. Introduction

Ophthalmic diseases have a significant negative impact on human life. Blindness, the most severe outcome, impedes economic participation and the ability to live independently. Consequently, the prevention and management of ophthalmic conditions are essential for health and well-being.

To prevent eye diseases, regular eye examinations and management at the population level are essential. However, in low-income countries, conducting ophthalmic examinations on a large scale is challenging due to limited human and material resources [1]. In such countries, the

Prevalence of Selected Ophthalmic Diseases Using a Smartphone-Based Fundus Imaging System in Quang Tri and Thai Nguyen, Vietnam

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Objectives: This study investigated the prevalence of ophthalmic diseases in Quang Tri and Thai Nguyen, Vietnam, utilizing a smartphone-based fundus imaging (SBFI) system. Methods: This cross-sectional study included nearly 10,000 patients who visited community health centers between July and August 2019. All participants underwent visual acuity testing and fundus imaging. We collected demographic data and medical histories, and fundus images were captured using the EYE-LIKE system. Data were compiled on an online platform, allowing clinicians from other regions to make diagnoses. Results: The study revealed significant variations in visual acuity and the prevalence of ophthalmic diseases between the two regions. In Quang Tri, nearly 50% of the population had media haze, while in Thai Nguyen, about one-third of the population was affected. The prevalence of glaucomatous optic nerve and age-related macular degeneration was approximately 1% higher in Quang Tri than in Thai Nguyen. These findings provide valuable insights into the eye health status of these regions, indicating that eye health in Quang Tri was poorer than in Thai Nguyen. Conclusions: The prevalence rates of ophthalmic conditions in this study were within the expected ranges compared to those in other Asian countries, though they were somewhat low. The SBFI method, being simpler and more efficient than the Rapid Assessment of Avoidable Blindness, offers a promising approach for measuring and estimating the prevalence of ophthalmic diseases.

Keywords: Cross-Sectional Studies, Visual Acuity, Cataract, Glaucoma, Macular Degeneration, Diabetic Retinopathy
Rapid Assessment of Avoidable Blindness (RAAB) serves as the primary national-level survey, primarily focusing on the prevalence of avoidable blindness [2]. Essentially, RAAB targets the incidence and prevalence of visual impairment or blindness. As a result, using RAAB data alone makes it difficult to accurately determine the incidence or prevalence of specific ophthalmic conditions.

Remote diagnosis using fundus images could serve as a viable option for RAAB or as an alternative to RAAB for measuring or estimating the prevalence of ophthalmic diseases. It can also complement RAAB by providing broader coverage of eye health issues. Recently, various medical devices have been developed that allow the capture of fundus images through smartphone cameras, enhanced by artificial intelligence (AI) technologies, to diagnose ophthalmic diseases [3,4]. This method facilitates accurate diagnoses, assuming that clinicians capture high-quality fundus images, even in the absence of specialized ophthalmic knowledge. Several studies have confirmed that the accuracy of remote diagnosis technologies is comparable to that of traditional methods [5].

In 2019, the Project Bom team from Yonsei University’s Severance Hospital conducted eye screenings in Vietnam using the EYELIKE device, a system developed in Korea (Figures 1, 2).

II. Case Description
1. Participant Selection
This cross-sectional study was conducted from July to August 2019, covering 26 sub-districts in Quang Tri and eight sub-districts in Thai Nguyen. It targeted individuals over the age of 50, as aging is a significant risk factor for eye diseases. The majority of the examinations took place at community health centers, which are more accessible than secondary and tertiary hospitals, thereby facilitating data collection.

To maximize coverage of the population, participants were not selected randomly. Instead, a majority of individuals within the target age group who visited community health centers were examined. The examination rates, relative to the total population aged 50 and older, varied across different survey locations, ranging from 10% to 74%.

2. Methodology
Demographic data, including gender, age, and medical history related to hypertension and diabetes, were collected. Visual acuity was assessed using the Monoyer vision chart. A presenting visual acuity ranging from 10/10 to 3/10 was considered normal, while 2/10 to 1/10 was categorized as visual impairment, and 0/10 was indicative of blindness. Fundus images were captured using the EYELIKE device (Figure 1) developed by LabSD, Inc. (Seoul, South Korea).

Figure 1. EYELIKE digital ophthalmoscope.

Figure 2. Remote diagnosis system used in Vietnam. CAM: Camera (EYELIKE), IDC: Internet Data Center.
EYELIKE is a digital ophthalmoscope that can be used with a smartphone to see and take pictures of patients’ retinas. Its name means “I like, eye like.” This ophthalmoscope has been used in developing countries such as Vietnam, Bangladesh, and India from 2019 to 2023 to improve the population’s eye health via official developmental aid programs. Galaxy S7 and S8 smartphones were employed to photograph patients’ retinas, utilizing the rear camera of these devices. In both the Galaxy S7 and S8 devices, the rear camera features 12 million pixels, with a photo resolution consistently set at 4032 × 3024 (4:3).

After pupillary dilation with 1% tropicamide eye drops, trained doctors performed fundoscopy examinations. The fundus images were then transmitted to clinicians responsible for diagnosis in remote areas via online database platforms (Figure 3). The diagnosis of ophthalmic conditions based on the fundus images occurred in two stages: seven Vietnamese optometrists played a crucial role in the first-stage diagnoses, while two ophthalmologists (one Korean retina specialist and one Vietnamese ophthalmologist) led the second stage. In the first stage, two optometrists trained in fundus image interpretation independently diagnosed the same image; if their diagnoses agreed, the diagnosis was confirmed without proceeding to the second stage. If the diagnoses differed, the ophthalmologists at the second stage provided the confirmed diagnosis based on the fundus images. This collaborative approach ensured accurate diagnoses.

Diagnosed ophthalmic conditions included media haze, age-related macular degeneration (AMD), diabetic retinopathy (DR), epiretinal membranes, glaucomatous optic nerve, and retinal vein occlusion. If the image appeared cloudy, it was classified as media haze. Among the symptoms of media haze, cataract is the most common diagnosis; however, diagnosing cataracts using only images is challenging. In cases of AMD, we did not differentiate between the types of AMD (dry and wet) due to the minimal number of wet AMD cases. Therefore, in this paper, the diagnosis of AMD includes both types. For glaucoma, we used the diagnosis “glaucomatous optic nerve”; our diagnosis was based solely on fundus images without an intraocular pressure test, thus identifying the condition as glaucomatous optic nerve rather than glaucoma.

Data analysis was performed using STATA software version 17.0 (StataCorp LLC, College Station, TX, USA). The prevalence of visual impairment and eye diseases was calculated by region (province), sex, and different age groups. The visual acuity level and distribution of eye diseases for each region were analyzed with a significance level set at \( p < 0.05 \).

III. Results

1. Demographic Data and Medical History

The initial study included 14,219 eyes, but duplicates (\( n = 39 \)) and data from individuals either over 100 or under 50 years of age were excluded. The final analysis involved 13,615 eyes from 7,023 individuals, including 431 individuals diagnosed with eye conditions in one eye only. Participants were residents of both Quang Tri and Thai Nguyen, with variations in age distribution between the two regions.

In Quang Tri, the majority of participants were in their 70s (44.29%), followed by those in their 80s, while Thai Nguyen had the highest proportion of individuals in their 70s (44.29%), followed by those in their 80s, while Thai Nguyen had the highest proportion of individuals in their...
60s (38.95%), with a similar representation of those in their 70s. Of the participants, 5,105 were from Quang Tri, and the remaining 1,918 were from Thai Nguyen. In Quang Tri, 35.96% were male and 64.04% were female; in Thai Nguyen, 29.67% were male, and 70.33% were female. Among Quang Tri subjects, 7.03% had a history of diabetes, and 35.58% had a history of hypertension. In contrast, among Thai Nguyen subjects, 12.77% had a history of diabetes, and 38.22% had a history of hypertension. The study subjects’ demographic data and medical history by region are presented in Table 1.

2. Eye Health
Since not all individuals underwent examinations for both eyes, the analysis treated each eye as a separate case when discussing ophthalmic diseases (number of cases: 13,615 eyes).

1) Visual acuity
Visual acuity measurements based on the Monoyer chart indicated that most participants in both regions scored 3 or higher (indicating normal vision) in both eyes (Table 2). In Quang Tri, approximately 60% of the study subjects demonstrated good visual acuity (normal) in both eyes. However, in Thai Nguyen, only about 50% exhibited good visual acuity (normal) in both eyes. Although the subjects in Thai Nguyen were not older on average than those in Quang Tri, these findings suggest regional variations in average visual acuity.

2) Ophthalmic diseases
Fundoscopy examinations revealed that nearly two-fifths of the subjects had normal findings (41.54%), with media haze being the most prevalent eye disease (42.01%), followed by glaucomatous optic nerve (10.17%), and AMD (2.21%). The prevalence of major eye diseases varied by region. In Quang Tri, media haze was prevalent in nearly 50% of the population, while in Thai Nguyen, the prevalence of cataracts was approximately one-third. Glaucomatous optic nerve and AMD also showed higher prevalence in Quang Tri than in Thai Nguyen, with a difference of approximately 1%. Overall, the eye health status appeared to be worse in Quang Tri.

Table 1. Demographic data and medical history of subjects by region (%)

<table>
<thead>
<tr>
<th>Sociodemocratic status</th>
<th>Quang Tri (n = 5,105)</th>
<th>Thai Nguyen (n = 1,918)</th>
<th>Total (n = 7,023)</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age group ≥50 (yr)</td>
<td></td>
<td></td>
<td></td>
<td>0.000</td>
</tr>
<tr>
<td>50–60</td>
<td>16.16</td>
<td>38.95</td>
<td>22.38</td>
<td></td>
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<tr>
<td>60–70</td>
<td>44.29</td>
<td>37.80</td>
<td>42.52</td>
<td></td>
</tr>
<tr>
<td>70–80</td>
<td>26.84</td>
<td>17.00</td>
<td>24.15</td>
<td></td>
</tr>
<tr>
<td>80–90</td>
<td>11.32</td>
<td>5.53</td>
<td>9.74</td>
<td></td>
</tr>
<tr>
<td>90–100</td>
<td>1.39</td>
<td>0.73</td>
<td>1.21</td>
<td></td>
</tr>
<tr>
<td>Sex</td>
<td></td>
<td></td>
<td></td>
<td>0.000</td>
</tr>
<tr>
<td>Male</td>
<td>35.96</td>
<td>29.67</td>
<td>34.24</td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>64.04</td>
<td>70.33</td>
<td>65.76</td>
<td></td>
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<tr>
<td>Medical history</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Diabetes</td>
<td>7.03</td>
<td>12.77</td>
<td>8.60</td>
<td>0.000</td>
</tr>
<tr>
<td>Hypertension</td>
<td>35.38</td>
<td>38.22</td>
<td>36.15</td>
<td>0.027</td>
</tr>
</tbody>
</table>

Table 2. Visual acuity by region

<table>
<thead>
<tr>
<th></th>
<th>Quang Tri (n = 5,105)</th>
<th>Thai Nguyen (n = 1,918)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Right eye</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Blind or visual</td>
<td>Normal</td>
</tr>
<tr>
<td></td>
<td>impairment</td>
<td></td>
</tr>
<tr>
<td>Left eye</td>
<td>1,295</td>
<td>414</td>
</tr>
<tr>
<td></td>
<td>460</td>
<td>2,936</td>
</tr>
<tr>
<td></td>
<td>1,755</td>
<td>3,350</td>
</tr>
</tbody>
</table>

Values are presented number of cases.
than in Thai Nguyen. The prevalence of major diseases is presented in Figure 4.

IV. Discussion

Due to the lack of national-level data on eye health in Vietnam, it is challenging to compare the study results with national averages. Instead, we can refer to the prevalence rates in other Asian countries for context. For example, in Korea, the prevalence of cataracts in individuals over 40 was 38.9% for men and 42.3% for women [6]. In China, the prevalence rates for those over 50 were 37.2% for women and 26.0% for men [7]. These statistics suggest that the prevalence of media haze in Vietnam may be comparable to that of cataracts in other Asian countries.

The observed prevalence of DR was notably low. Given that the prevalence of diabetic complications can vary by race, this low incidence of DR may be influenced by racial factors [8]. Alternatively, it could be due to issues with participant selection. DR, as a complication of diabetes, typically indicates that the condition has progressed to an advanced stage. Therefore, individuals who are aware of their diabetes status often receive treatment or management at specialized medical institutions rather than at community health centers, where most of the data for this study were collected. To accurately assess the prevalence of ophthalmic diseases in future studies, the disease severity of participants should be taken into account.

Our methodology using the EYELIKE system presents significant advantages over RAAB. RAAB evaluates the prevalence and causes of vision impairment and blindness in individuals aged 50 and older, and it provides key indicators for eye care services [9]. Typically, the prevalence of eye diseases is calculated and estimated based on RAAB data [9]. However, RAAB may not adequately estimate the prevalence of ophthalmic conditions as it primarily addresses vision loss that has already occurred and identifies the underlying causes of blindness. Consequently, it is likely that studies that capture fundus photographs of the general adult population, rather than focusing exclusively on individuals who are blind, would yield more accurate insights into ophthalmic conditions.

Our methodology might offer superior accuracy and resource efficiency in measuring the prevalence of ophthalmic conditions. Unlike RAAB surveys, which necessitate the presence of an ophthalmologist on the investigative team and do not provide a means to verify the accuracy of diagnoses, our approach does not require an ophthalmologist on the screening team; instead, it utilizes a camera to capture images transmitted over the Internet for remote diagnosis. Also, cross-checking on diagnosis using fundus images is possible.

Furthermore, this approach has yielded real-world benefits. In countries such as Vietnam and other developing nations, access to ophthalmic care is often limited, primarily because healthcare providers are concentrated in major urban areas. In this study, a remote diagnosis system was used to evaluate the prevalence of ophthalmic conditions. This system helps in quickly identifying patients who require medical intervention and facilitates their appropriate referral.

LabSD Inc. is developing an AI system to diagnose eye diseases using data collected on its platform. AI-based automatic diagnosis systems can provide efficient examinations while requiring minimal resources. This cost-effective and high-efficiency screening approach can promote preventive measures in eye health, rather than diagnosing eye issues only after there has been a deterioration in visual acuity or other eye abnormalities.
Conflict of Interest

Holden Yoon Seung Kim and Jaewon Kim are LabSD staff members, and Sangchul Yoon is a leading member of Project Bom; however, this article is written only based on documents with an objective basis and academic evidence.

Acknowledgments

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