Cost Effectiveness Analysis of a Visual Screening Program for Primary School Children in Thailand

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Objective: *To analyze the cost-effectiveness of a visual screening program for primary school children in southern Thailand.*
Material and Method: *The visual acuity of 1,900 primary school children from 11 schools in southern Thailand was assessed using the Snellen chart, Hirschberg test, an eye examination by penlight, and observation of the red reflex by direct ophthalmoscope, between April 2006 and March 2007. Children with visual acuity of < 20/40 or an abnormal observation in either eye were referred for further eye examination and refraction measurement, at which time they were categorized, according to the severity of the eye condition(s). A cost analysis was then performed for various severity-of-condition groupings.*
Results: *One hundred sixty eight children (8.8%) were found with referable problems, of which 122 parents signed a consent form for further testing. The mean age was 8.7 years (range 6-12 years). One hundred seven of the 122 subjects (87.7%) were considered to have a refractive error with or without one or more other eye conditions. The mean direct cost for visual screening by the assistant researcher, not including project management and traveling expenses, was 14.9 Baht per student (~0.5 USD, 0.3 Euro). For nationwide implementation, the per head expenditure for children with treatable problems would be 1,018.4 Baht if children with mild, moderate and severe abnormal eye conditions were targeted, and increased to 2,270.1 Baht if only children with moderate and severe conditions were targeted.*
Conclusion: *The results of the present study indicate that this visual screening program is efficient and useful for preliminary school children in Thailand.*

Keywords: *Cost analysis, Students, Vision screening*

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The visual system is very important for the process of learning. Development of the eye and brain occur early, beginning by 6 weeks gestational age and proceeding through the postnatal period. The normal development of visual function is dependent on normal anatomy and proper stimulation. Amblyopia is the term used to describe loss of vision due to interruption of normal development during the early months or years of life, and it covers such things as strabismus, congenital cataract, and refractive error. Poor vision has been correlated with poor academic performance, as reported by parents[1]. Such problems are harder to notice in younger children with a mild visual problem or a deficiency in only one eye and psychosocial disturbances can also be related to visual symptoms[2].

Refractive errors, especially high refractive error and anisometropia, affect visual development and correlate with asthenopic symptoms[3], but many young children with such a condition are asymptomatic. Visual screening can be useful for detecting asymptomatic visual problems, however compliance with spectacle wearing may be very low for many reasons, such as forgetting to wear glasses,

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concern about appearance, or not feeling glasses are needed[4]. Worldwide visual screening in schoolchildren has found a variety of prevalence of problems, with the main problems detected refractive errors, strabismus, and amblyopia. Basic screening may be carried out effectively by parents, teachers, school health staff, nurses, or orthoptists[5-8]. Until now, a widespread visual testing program has not been attempted in Thailand because of a shortage of ophthalmologists in the country. However, the authors will attempt to demonstrate that a program of school-based preliminary testing followed by eye clinic visits for students found with problems that could be helped is financially feasible.

A screening program for amblyopia followed by appropriate treatment is effective in reducing this condition[9]. Most normal populations show only a small number of severe eye problems without abnormal symptoms in school children[10], and although screening can help, financial resources for health care are limited but with many demands. Therefore, a consideration of the cost-effectiveness of any program is necessary. The purpose of the present study was to analyze the cost effectiveness of a visual screening program for primary school children in Thailand. The results may be useful in planning a health screening program to improve public health services.

Material and Method

The present study was built on an earlier study on "Visual acuity and visual behaviors among primary school children in Nakhon Hatyai municipality, Songkla province[11]". For this first study, an assistant researcher was trained to assess visual acuity using a Snellen chart, the Hirschberg test, an eye examination by penlight, and observation of the red reflex by direct ophthalmoscopic examination. One thousand nine hundred children were randomly selected from 11 preliminary schools in southern Thailand.

The visual screenings were performed by the assistant researcher between April 2006 and March 2007. Children with visual acuity of $\leq$ 20/40 or with an abnormal observation in either eye were requested to obtain informed consent from their parents for further examination at the project- affiliated hospital. The parents of children with only mild, normally self-correcting abnormalities were informed of the condition and left to make their own arrangements for additional eye investigations if they desired. The parents of forty-six students did not wish their children to have the complete eye examination, leaving 122 students of the initial 1,900 examined referred for a more complete evaluation, which included a visual acuity test, an orthoptic examination, and noncycloplegic and cycloplegic refractions, performed by an orthoptist. Anterior and fundal examinations were performed by an ophthalmologist (the scheme of investigations is shown in Fig. 1). The first study simply assessed the extent of the problem, and now the current study attempts to assess the costs and effectiveness of a nationwide program based on the data from that first study. The research followed the tenets of the Declaration of Helsinki and approved by the ethic committee, Faculty of Medicine, Prince of Songkla University.

Cost assessment

The direct costs of the initial screening program were estimated based on the original budget of the study discussed above. Cost analysis was considered and calculated in Thai baht. On average, the mean currency exchange rates in the year of study of 2007 were 33 Baht and 45 Baht to 1 U.S. dollar (USD)

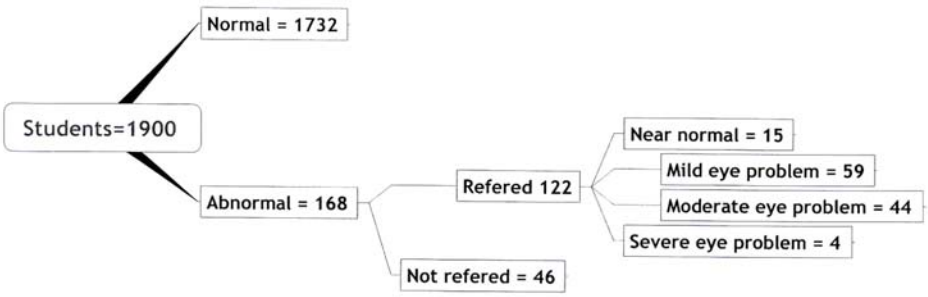

Fig. 1 Visual screening in school-age children study pathway

Table 1. Cost analysis in 3 cost categories

Item	Cost type 1 (Baht)	Cost type 2 (Baht)	Cost type 3 (Baht)
Assistant researcher salary	22,300	22,300	-
Researcher salary	32,810	-	-
Training costs for assistant researcher	500	500	-
Travel costs for research management	3,656	3,656	-
Travel costs to transfer children to hospital	1,099	1,099	-
Eye examination (research) costs	12,400	-	-
Eye examination cost (service prices in Songklanagarind Hospital)	-	61,000	61,000
Cost to train teachers in 11 schools	-	-	6,000
Teacher salary, 3,815 bath x 11 schools	-	-	41,965
Total	72,765	88,555	108,965

and 1 Euro, respectively. The direct costs were divided into 3 types, as shown in Table 1.

The Type 1 Cost referred to the actual cost of the original study, based on the actual research expenditures; in this first study, the actual hospital examination fee was provided free of charge for the research, so its cost is herein estimated.

The Type 2 Cost referred to the actual costs of the original study, based on the actual fee that the hospital charged for regular walk-in patients at the time.

The Type 3 Cost referred to the estimated costs of the original study, but to make it more realistic it also allows for the cost of a teacher at the school, who would take some training and then use free time to give a visual assessment to the students in her or his school; the monthly salary of the young teacher who would be called on to do these assessments is 7,630 Baht per month, and it is estimated that approximately two weeks of the teacher's spare time would be required for the testing.

Sensitivity analysis

To analyze the cost of the type 3 option, in which all cases of abnormal visual screening in the students would be referred to our institution (Songklanagarind Hospital in Hat Yai), the following assumptions were made:

Model 1 Worst-case analysis assumed that all 46 students whose parents refused the complete eye examination had moderate to severe eye problems. These students numbered 15, 59, 86, and 8 in groups 1, 2, 3 and 4 respectively.

Model 2 Best-case analysis assumed the 46 students whose parents refused the complete eye examination were near normal. These were 61, 59, 44, and 4 students in groups 1, 2, 3 and 4 respectively.

Model 3 Proportional-case analysis assumed the 46 students whose parents refused the complete eye examination were divided to 4 groups in the same ratio as referred cases, giving 21, 81, 61, and 5 students in groups 1, 2, 3 and 4 respectively.

Outcome analysis

The subgroup analysis portion of the cost analysis refers to the dividing of students into 4 subgroups, based on severity of eye condition:

Group 1 near normal: Children with normal or near normal vision, defined as nothing more than a mild refractive error (hyperopia, myopia, astigmatism) $\leq$ 0.5 D (diopter).

Group 2 mild eye problem: Children with a more serious refractive error (hyperopia, myopia, astigmatism) > 0.5 D-2.0 D, or improper glasses or heterophoria.

Group 3 moderate eye problem: Children with a fairly serious refractive error (hyperopia, myopia, astigmatism) > 2.0 D, heterotropia, or a congenital optic nerve anomaly.

Group 4 severe eye problem: Children with a severe eye problem with visual morbidity. If such conditions are not managed early, they can lead to permanent disability such as cataract or suspected glaucoma.

Results

One thousand nine hundred primary school children from 11 schools were given the eye examination in the first study as described above in their schools by the assistant researcher. There were 168 children

(8.84%) with visual acuity ≤ 20/40 in either eye. One hundred and twenty-two parents gave informed consent for a further eye examination in the hospital. The mean age was 8.7 years, with a range of 6-12 years (Table 2), and 54.84% were boys. Of the 122 subjects who had the follow-up eye examination, 107 (87.70%) were found to have a refractive error. The other eye problems were exophoria (12.29%), intermittent exotropia (1.64%), exotropia (1.64%), suspected glaucoma (2.46%), and cataract (0.82%). The number of students in subgroups 1, 2, 3 and 4 (near normal vision, mild, moderate and severe eye problems) were 15, 59, 44 and 4, respectively (Fig. 1).

The direct costs were analyzed based on the 3 types, as shown in Table 3. The mean cost for visual screening by the assistant researcher, excluding management and travel costs, was 14.9 Baht (~0.5 USD, 0.3 Euro) per screened student.

Sensitivity analysis (Table 4)

Worst-case model: There were 15,59,86, and 8 students in groups 1, 2, 3 and 4, respectively. So the per head expenditure would be 1,403.9 Baht (45.3 USD, 28.1 Euro) to cover groups 3 and 4.

Best-case model: There were 61,59,44, and 4 students in groups 1, 2, 3 and 4 respectively, so the per head expenditure would be 2,749.3 Baht (88.7 USD, 54.9 Euro) for covering groups 3 and 4.

Proportional-case model: There were 21, 81, 61, and 5 students in groups 1, 2, 3 and 4 respectively,

Table 2. Distribution of visual screening subjects

Group	No. of children	Mean age (range) years	Sex	
			% Female	% Male
Total children	1,900	9.8 (6-13)	48.50	51.50
Children referred to hospital for further tests	122	8.7 (6-12)	45.16	54.84
Near normal	15	9.2 (6-11)	53.33	46.67
Mild eye problem	59	8.4 (6-12)	40.68	59.32
Moderate eye problem	44	9.0 (6-12)	50.00	50.00
Severe eye problem	4	8.0 (6-10)	50.00	50.00

Table 3. Distribution of cost per head among 3 types, with different inclusion cutoffs

Group	No. of children	Cost of type 1 (Baht)	Cost of type 2 (Baht)	Cost of type 3 (Baht)
All cases	122	596.4	725.9	893.2
Mild, moderate and severe eye problem	107	680.0	827.6	1,018.4
Moderate to severe eye problem	48	1,515.9	1,844.9	2,270.1
Severe eye problem	4	18,191.3	22,138.8	27,241.3

Table 4. Sensitivity analysis of cost per head (nationwide) of 3 analysis models

Group	No. of childrenin in model worst/best/ proportional case	Cost for worst case	Cost for best case	Cost for proportional case
All cases	168/168/168	785.5	785.5	785.5
Mild, moderate and severe eye problem	153/107/147	862.5	1,233.3	897.7
Moderate to severe eye problem	94/48/66	1,403.9	2,749.3	1,999.5
Severe eye problem	8/4/5	16,495.6	32,991.3	26,393.0

so the per head expenditure would be 1,999.5 Baht (64.5 USD, 39.9 Euro) for covering groups 3 and 4.

Discussion

The prevalences of refractive error (myopia, hyperopia, and astigmatism) and amblyopia from eye screening in school children worldwide have been found to be 4.5 to 66% and 0.14 to 7.3%, respectively[5-6,12-15]. The wide variance may be from different methodologies, techniques, and criteria for measuring or diagnosing refractive error. Myopia has been associated with a higher-grade level, female gender, urban centers, higher parental education, and Chinese ethnicity[16-18]. For the present, a refractive error $\geq$ 0.5 diopter (subgroups 2 and 3) was found in 84.4% of the children who were sent to the hospital for further testing.

Visual screening programs have been found to be beneficial in all age groups[9,11,19-21], with differing benefit-to-cost ratios, depending on various factors such as the age group, method of measurement, and geographical and socio-economic settings. Joish VN, et al[19] found that the marginal cost per child for visual acuity screening was 2 USD, with a benefit-to-cost ratio for the 7-8 years age group vision screening of 153 USD. In Thailand, the cost of living is quite low compared to most Western countries so the cost of a visual screening program is appropriately contained. In the earlier Hat Yai study upon which the current study was based, the mean cost for visual screening by the assistant researcher, excluding management and travel costs, was 14.9 Baht per child (~0.5 USD, 0.3 Euros). This per head expenditure is reasonable and suitable for government health service implementation.

For nationwide implementation, then, the initial basic visual screening would be approximately 15 Baht, but children with abnormal vision must then undergo a further examination. The different options can be considered based on the present study implementation costs for four different options. Strategy 1: if students with any level of eye problem (mild, moderate or severe) underwent further testing, the per head expenditure, based on this Hat Yai study, would be 1,018.4 Baht (30.9 USD, 22.6 Euro) per child given eye clinic assessment. Strategy 2 would cover only moderate to severe eye problems, at a per head expenditure of 2,270.1 Baht (68.8 USD, 50.5 Euro). For sensitivity analysis, cost in this group was 1,403.9 Baht (45.3 USD, 28.1 Euro) to 2,749.3 Baht (88.7 USD, 54.9 Euro) per case. Strategy 3 would deal only with students with a severe eye problem, at a per head expenditure of 27,241.3 baht (825.5 USD, 605.4 Euro), as shown in Table 3.

A similar study in German kindergartens showed a cost-effectiveness ratio of 924 Euros per detected case[22], so the per head expenditure in Thailand, based on the study, is about 2/3s that of Germany.

Besides financial considerations, the setting of health service priorities depends on the magnitude of the problem considered, the prevalence of risk factors, the health services infrastructure, relevant knowledge, and political concern and wills.

The costs of long-term compliance and adaptation were not included in the study, but are needed before a larger screening and intervention program is considered on a nationwide basis.

In conclusion, it seems from the study that the per head expenditure for a visual screening program for Thai primary school children would be cost-effective, and a larger analysis of the whole country situation should be undertaken.

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การวิเคราะห์ประสิทธิภาพเมื่อเปรียบเทียบกับค่าใช้จ่ายของโครงการตรวจคัดกรองสายตาสำหรับเด็กนักเรียนระดับประถมศึกษาในประเทศไทย

สุภาภรณ์ เต็งไตรสรณ์, ภาสุรี แสงศุภวานิช, วรรณี จันทร์สว่าง

วัตถุประสงค์: *วิเคราะห์ประสิทธิภาพเมื่อเปรียบเทียบกับค่าใช้จ่ายของโครงการตรวจคัดกรองสายตาสำหรับเด็กนักเรียนระดับประถมศึกษาในภาคใต้ของประเทศไทย*

วัสดุและวิธีการ: *เด็กนักเรียนระดับประถมศึกษาจำนวน 1,900 คน จาก 11 โรงเรียนในภาคใต้ของไทยได้รับการประเมินการเห็นชัดด้วยแผ่นตัวอักษรของ Snellen การทดสอบของ Hirschberg การตรวจตาด้วยไฟฉายและการสังเกตกิริยาสนองฉับพลันเป็นสีแดงด้วยการกล้องส่องตรวจลูกตาโดยตรง ในระหว่าง เดือนเมษายน พ.ศ. 2549 ถึง เดือนมีนาคม พ.ศ. 2550 เด็กนักเรียนที่มีระดับสายตา 20/40 หรือน้อยกว่าหรือพบความผิดปกติอย่างหนึ่งอย่างใดของตาข้างหนึ่งข้างใดได้รับการส่งต่อเพื่อตรวจตา และตรวจการหักเหของตา เพื่อแยกประเภทตามความรุนแรงของภาวะความผิดปกติและวิเคราะห์ความคุ้มค่าในแต่ละกลุ่ม*

ผลการศึกษา: *เด็กจำนวน 168 คน (ร้อยละ 8.84) มีปัญหาที่ควรได้รับการส่งต่อมีพ่อแม่จำนวน 122 คน ลงนามในใบยินยอมสำหรับการตรวจเพิ่มเติม เด็กมีอายุเฉลี่ย 8.7 ปี (พิสัยระหว่าง 6-12 ปี) เด็ก 107 คน จาก 122 คน (ร้อยละ 87.70) มีการหักเหของตาข้างหนึ่งข้างใดหรือทั้งสองข้างผิดปกติ ค่าใช้จ่ายโดยตรงเฉลี่ยของการตรวจคัดกรองสายตาด้วยนักวิจัยผู้ช่วย โดยไม่รวมค่าเดินทางและค่าบริหารโครงการเท่ากับ 14.9 บาทต่อคน (~0.5 USD, 0.3 Euro) สำหรับการดำเนินการอย่างกว้างขวางทั่วประเทศ ถ้ากำหนดเป้าหมายเป็นเด็กมีภาวะตาผิดปกติระดับเล็กน้อยปานกลาง และรุนแรง ค่าใช้จ่ายต่อหัวเท่ากับ 1,018.4 บาท ถ้ากำหนดเป้าหมายเป็นเด็กมีภาวะตาผิดปกติระดับปานกลาง และรุนแรง ค่าใช้จ่ายต่อหัวเพิ่มเป็นเท่ากับ 2,270.1 บาท*

สรุป: *ผลการศึกษานี้ชี้บ่งว่าโครงการตรวจตัดกรองสายตามีประสิทธิภาพและได้ประโยชน์สำหรับ เด็กนักเรียนระดับประถมศึกษาในประเทศไทย*