School-based screening for scoliosis: is it cost-effective?

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ABSTRACT

Introduction: School-based scoliosis screening was implemented in Singapore in 1981. The rationale for the programme was so that conservative treatment (bracing) can be initiated early to prevent progression of curves, avoid the complications of severe scoliosis and reduce the need for surgery. The evidence for, or against, scoliosis screening and regular follow-up remains controversial. To date, there has been no formal cost analysis of Singapore's screening programme. The aim of this paper was to examine if there are economic justifications to continue with school-based scoliosis screening.

Methods: This cost-effectiveness analysis was done by comparing Singapore's existing school-based scoliosis screening and follow-up programme with the alternative of not having a programme. As the aim of the existing programme was to detect curves early, allowing bracing to be initiated and reducing the need for surgery, this analysis assumed that without the programme, students who otherwise would have received bracing and not needed surgery, would have required surgery instead. This retrospective analysis was based on School Health Service data obtained from screening 45,485 students in 1999 and 44,051 of this same cohort in 2001. Nett programme costs and health effects were computed, and a decision rule applied.

Results: The nett cost of the current mass screening programme was negative, while the nett health effects, albeit mostly intangible, positive; which made the programme an economically valuable one.

Conclusion: Singapore's school-based scoliosis screening programme, which is implemented as part of a larger school screening and immunisation programme, is cost-effective. Cost-effectiveness may be further improved by targeting screening at high-risk groups, such as prepubertal females. More research is needed to quantify the positive health effects of scoliosis screening.

Keywords: costs analysis, healthcare costs, mass screening, scoliosis, School Health Services, targeted health screening

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INTRODUCTION

Scoliosis screening has been included in the Singapore School Health Service (SHS) school-based screening programme since 1981. The programme is based on the rationale that early detection of scoliosis will allow for remedial action without involving surgery. Conservative treatment, i.e. bracing, when applied in the early stages upon onset, can produce better clinical outcome by preventing the progression of curve deformation. Doing so will not only circumvent the complications of severe scoliosis, such as cosmetic deformities, back pain and restrictive pulmonary disease, it will also eliminate the need for reparative surgery. In addition, children with more significant scoliosis, who often present no other symptoms, may be detected at a time when surgical treatment is more effective.[1]

A review of the literature, however, shows that there is no strong evidence for, or against, screening and regular follow-up for scoliosis, with organised nationwide school screening mandatory in some places and opportunistic screening being carried out in others.[2-4] The US Preventive Services Task Force (USPSTF) Report on screening for adolescent scoliosis was unable to reach a conclusion on the effectiveness of school screening due to the lack of randomised controlled trials or observational studies of the outcome.

Due to the dearth of prospective studies evaluating the outcome of organised scoliosis screening programmes, the effectiveness of scoliosis screening has been inferred from studies that compared outcomes before and after screening programmes had been implemented. For example, a Swedish study, conducted ten years after the initiation of an organised information campaign promoting screening, showed a significant increase in the number of referrals to the local scoliosis clinic, and in the use of braces. There was also a decrease in the mean curve size, number of curves progressing to

40° and the number of cases requiring surgery. Other studies have reported similar trends following the initiation of school-based screening programmes.[5] A review by the USPSTF found one randomised controlled trial, three cohort studies and one case series of meta-analysis which compared different treatments for idiopathic scoliosis during adolescence. Unfortunately, the quality of these studies is mixed, there was inadequate correction for confounding cases, and none of these studies primarily involved screening-detected scoliosis.[6]

A prospective, controlled study by the Scoliosis Research Society, which evaluated the effectiveness of bracing in preventing progression of 6° or more in girls with a mean age of 12 years and seven months, showed treatment by bracing to have a 74% (95% CI 52–84) success rate until the girls were 16 years of age.[7] In Singapore, thoracolumbosacral bracing and surgery are accepted treatment methods, with bracing generally used for smaller curves of between 20° and 35° and in children within a year of puberty. Surgery is usually considered only when bracing fails and there is documented progression to a Cobb angle between 40° and 50° or if the patient presents with a large curve of between 40° and 50°. Lateral electrical surface stimulation (LESS) is used in some centres overseas as a conservative form of treatment and as an alternative to bracing. A meta-analysis of the efficacy of non-surgical treatment methods showed that bracing was significantly more successful than LESS in treating idiopathic scoliosis.[8]

Locally, there has been no study on the effectiveness of the scoliosis screening programme in reducing curve size or in decreasing surgery rates. Neither is there data on how effectively scoliosis would be detected by parents, physicians or others in the absence of a screening programme. In the absence of a screening programme, it is likely to be difficult, if not impossible, to detect early scoliosis under the loose-fitting clothing that is de rigueur for adolescents nowadays. In the early stages of scoliosis, when the signs of scoliosis (e.g. uneven shoulders/hips, humps) are subtle, screening using a scoliometer would be the only means to identify affected individuals without subjecting them to x-rays. In the current screening programme, visual inspection, the Adam's forward bending test (FBT) and the scoliometer are used. Using these three screening modes together increases reliability while remaining simple and acceptable.[9,10] When left untreated, the potential sequelae of scoliosis include cosmetic deformities, back pain and restrictive pulmonary disease. There is no local data on these potential sequelae. Internationally, there is limited data on poor cosmesis and related psychosocial issues, such as poor self-image, lower marriage rates and limited job opportunities during adulthood. Most of the studies that reported these psychosocial effects were uncontrolled and many of the patients had spinal conditions other than scoliosis.[5]

Most of the international research done pertaining to the cost of scoliosis screening has dealt with the actual cost per child screened and/or per child treated for scoliosis.[11] A cost-effectiveness analysis published in 1990 compared three different screening methods – no specific screening, conventional clinical screening (i.e. using the FBT and clinical inspection) and the combined clinical Moiré screening alternative; this last option was found to be cost-effective.[12] The SHS used to employ Moiré contourgraphy as a second level screening tool in the late 1980s and early 1990s. This was subsequently replaced by the more sophisticated computerised skeletal analysis or rasterstereography that is used today.

While there have been two previous local prevalence studies, there has been no formal economic evaluation of the school-based scoliosis screening programme. This paper is based on the premise that despite the lack of prospective trials, studies of the outcome before and after the implementation of screening programmes have shown positive trends,[5] and that bracing has been shown to be effective in delaying curve progression.[7] The Singapore programme has been in place for more than 20 years and has its fair share of proponents and opponents. While the jury remains out on the topic of organised scoliosis screening, the aim of this paper is to examine if, based on the existing evidence and structure of the programme, there are economic justifications to continue with the current school-based scoliosis screening and follow-up programme.

METHODS

This retrospective cost-effectiveness analysis was carried out by computing nett programme costs and nett health effects, and then applying a decision rule based on these nett costs and health effects.[13] This analysis was based on data obtained from screening 45,485 primary six students (11- to 12-year-olds) in 1999 and from screening 44,051 of this cohort of students again in 2001. The study population comprised primary six students who were screened in school in 1999, referred to the Student Health Centre (SHC), SHS for further assessment and examined again in school in 2001. The main data source was obtained from the SHS computerised database of both the field and clinic records. The data were presented in Microsoft Excel tables. However, as not all variables were coded, and much of the information was in text form, individual records were also checked. Both the mainframe system as well as the manual records were vetted, to ensure that data was as clean as possible and exclusions were kept to a minimum.

The current scoliosis screening programme is a component of SHS' annual health screening of all primary and secondary school students in Singapore. Students in the different educational levels are screened for different conditions. Besides screening for health conditions, immunisation is also carried out during these annual visits to the schools. Doctors screen primary six students for scoliosis as part of the school-based medical examination, while nurses screen the secondary two students. Students are screened using the FBT and scoliometer measurements.

Students needing further assessment are referred to the SHC, where they undergo a physical examination and, where necessary, a second level of screening using computerised skeletal analysis. Spinal radiographs are performed for selected patients. Students with more severe curves or curves with the potential of progressing are referred to the Spinal Specialist Clinic at the SHC, where they are assessed by a spine specialist. If treatment is indicated, the students will either receive spinal bracing or they will be referred to a tertiary institution for surgery.

For the purpose of this analysis, costs were computed from a societal perspective, i.e. as far as possible, all costs were taken into account, regardless of who pays. As scoliosis is part of a larger screening programme which involves medical, nursing and clerical personnel, and utilises a proprietary computer system (the School-based Health Programme System or SHPS), all aspects of the screening costs (manpower, transport of equipment to the schools and computer maintenance costs) were prorated based on the amount of time taken to screen for scoliosis.

For the direct costs of follow-up, costs of surgery and subsequent follow-up were computed based on the cost that would be incurred by a full-paying patient – i.e. the non-subsidised cost. In computing the indirect costs, the time cost for a parent accompanying his child for treatment and follow-up was based on an average daily wage of Singapore dollars (SGD) 50. Transport cost was taken as SGD 10 per visit. After computing the cost of the existing programme, the cost of the "alternative model" was calculated. This cost was calculated based on the assumption that, if there were no school screening, all the students who had their curves braced as a result of detection through the screening programme would instead require spinal surgery, and all the students who had surgery even with the screening programme, would still require surgery. The nett cost was then calculated by computing the difference in cost between the existing programme and the alternative of not having a programme.

RESULTS

45,485 primary six students (11- to 12-year-olds) were screened in 1999. 44,051 of this cohort of students were screened again in 2001 when they were in secondary two. 1,310 students of the primary six students (2.9% of the cohort) were screened as positive in 1999 and referred to the SHC for follow-up. Of these 1,310 students, 1,277 were screened again in school in 2001. Of the remaining 33 students, eight had left school after primary six, 11 had been referred to the SHC for a condition other than scoliosis and 14 did not have any further field screening or clinic records following their screening in primary six and therefore, their outcomes could not be measured.

The 1,277 students were analysed for ATR progression, follow-up at the SHC, or at other institutions and interventions, if any. 24 students had bracing done with good outcomes during the follow-up period from 1999 to 2001. Based on ATR progression of the group that did not attend their follow-up appointments at the SHC but who were seen again in school in 2001, it was computed that 12 more would have received bracing during the two years, had they attended follow-up as scheduled. 14 students had undergone surgery, with or without prior bracing. Again, based on similar ATR progression patterns, it was computed that an additional seven students would have needed surgery, but had not attended their follow-up appointments at the SHC. The costing was, therefore, based on the premise that, even with the screening programme, about 21 students from the 1999 primary six cohort would have needed surgery, and 36 students in the cohort would have had their curves braced with good results (and would not have required surgery).

As this analysis was based on the three-year period from 1999 to 2001, students detected with positive FBTs in secondary two but who had normal FBTs in primary six were not included in the costing. The gross programme cost is shown in Table I. The direct cost of screening was considerably lower in 2001. This is largely due to lower manpower costs for the secondary two screening. Scoliosis screening in the secondary school was done by nurses, while primary six screening (in 1999) was conducted by medical officers as part of a more comprehensive medical examination. In addition, there are no direct screening costs in 2000, as scoliosis screening was carried out only at the primary six and secondary two levels. The total cost to screen, follow-up and treat the 1999 cohort of primary six students over the three-year period from 1999 to 2001 was SGD 1,063,010.82.

The computation of the "savings" or the cost of not having a screening programme is shown in Table II. As the aim of the screening programme is to

Table I. Gross cost (in Singapore dollars) of school-based screening and follow-up programme.

Costs		1999	2000	2001
Direct ($)	Screening*	55,792.21		17,877.24
	Follow-up†	305,215.01	357,595.30	74,705.56
Indirect ($)	Follow-up‡	98,700.00	88,900.00	47,985.00
	Treatment§	5,250.00	8,544.90	2.445.60
Annual total ($)		464,957.22	455,040.20	143,013.40

* Direct cost of screening: sum of costs of manpower, transport and computer system maintenance (all prorated based on time spent on screening for scoliosis).

† Direct cost of follow-up: sum of costs of manpower (doctors, technicians, radiographers, specialist clinic staff), computer system maintenance, fees payable by patient, bracing (for 36 students), surgery (for 21 students) and follow-up.

‡ Indirect cost of follow-up: sum of time cost for parent accompanying child to clinic and transport cost. X-ray exposure (assumed to be minimal) was not given a dollar value.

§ Indirect cost of treatment: sum of time cost for parent accompanying child for bracing, transport and post-surgical follow-up. Adverse effects from bracing and other intangibles (anxiety, psychosocial effects) were not given a dollar value.

Table II. Cost without school-based scoliosis screening programme.

Cost	No screening programme*
Direct costs of surgery and follow-up† ($)	1,322,724.90
Indirect costs‡ ($)	35,379.90
Total ($)	1,358,104.80

* Assumption: without the screening programme, 57 students will undergo surgery for scoliosis.

† X-ray exposure (assumed to be minimal) was not given a dollar value.

‡ Indirect costs: sum of time cost for parent accompanying child for surgery and subsequent hospital stay, transport, post-surgical follow-up costs. X-ray exposure and other intangibles (anxiety, psychosocial effects) were not given a dollar value.

detect curves early and to institute bracing, therefore avoiding surgery, it was assumed that without the screening programme, all students who had their curves braced (36 in total) would have had surgery. In addition, all the 21 students who had surgery even with the screening programme would still require surgery. The total of SGD 1,358,104.80 is the sum of the direct costs of surgery and follow-up, and the indirect costs, comprising time costs for the parents accompanying the child for the surgical admission and follow-up visits. The nett cost, which is the difference between the cost of the programme and the 'savings' in the absence of the programme, is therefore minus SGD 295,093.98.

While analysing the savings in the absence of a structured scoliosis screening and follow-up programme, an assumption was made; besides the 21 students who had to undergo surgery despite the screening, all 36 of the others who were braced would need surgery. A sensitivity analysis was then performed by varying these numbers who would need surgery (Table III). Even if only about 65% of the 36 patients required surgery, the nett cost remains negative. Ideally, the desired outcome is a reduction in surgical rates and a decrease in the number of large curves seen in the target population. However, due to the paucity of local studies for comparison, the postulated health effects calculated from this study are based on the literature and anecdotal evidence from patients and their parents who attend the SHC.

A positive health effect of the screening programme would be the alleviation of anxiety in knowing (or believing) that surgery has been avoided by the more moderate option of controlling the progression of the spinal curvature by bracing. While it is acknowledged that being screened and evaluated for a possible spinal curve may be accompanied by some degree of anxiety and may have an effect on future health insurance and work eligibility, these are largely postulated adverse effects and have not been proven in controlled studies.[5] It is also unlikely that these levels of anxiety would match those accompanying a surgical intervention.

Preventing curve progression via bracing would also have the positive health effect of improving cosmesis and decreasing the risk of cardiopulmonary complications, which are associated with severe scoliosis. The main negative health effect(s) would be those associated with the inconvenience of bracing – for example, physical effects such as skin irritation and the psychosocial effects of having to wear a brace. On final analysis, although most of the health effects

Table III. Sensitivity analysis: varying the number of students who undergo spinal surgery.

No. of students	48*	45†	39‡	21§
Direct costs‖ ($)	1,113,873.60	1,044,256.50	905,022.30	487,319.70
Indirect costs¶ ($)	2,973.60	27,931.50	24,207.30	13,034.70
Total ($)	1,143,667.20	1,072,188.00	929,229.60	500,354.40
Net cost ($)	(74,656.43)	(3,177.23)	139,781.17	568,656.37

* These 48 students comprise the 21 who underwent surgery even with the screening programme and 27 (i.e. 75% of a total of 36) who otherwise would have been braced, and not have undergone surgery, with the screening programme.

† These 45 students comprise the 21 who underwent surgery even with the screening programme and 24 (i.e. 67% of a total of 36) who otherwise would have been braced, and not have undergone surgery, with the screening programme.

‡ These 39 students comprise the 21 who underwent surgery even with the screening programme and 18 (i.e. 50% of a total of 36) who otherwise would have been braced, and not have undergone surgery, with the screening programme.

§ These 21 students comprise the 21 who underwent surgery even with the screening programme and none of the 36 who would have been braced with the screening programme.

‖ Direct costs: costs of surgery and follow-up.

¶ Indirect costs – sum of time cost for parent accompanying child for surgery and subsequent hospital stay, transport and post-surgical follow-up costs. X-ray exposure and other intangibles (anxiety, psychosocial effects) were not given a dollar value.

of screening are intangible and difficult to assign a tangible monetary benefit, it would seem that the nett health effects of having a screening programme is positive. Based on a positive nett health effect and negative nett cost, the existing scoliosis screening programme can be considered "economically valuable".

DISCUSSION

Organised scoliosis screening is a rather peculiar entity in that it has as many supporters as it has detractors. The available evidence suggests that early detection by screening leads to early institution of conservative treatment (bracing) and a reduction in surgical rates. The evidence also suggests that without screening, there will be an increase in large curves and surgical rates.[5,7] However, there have been no controlled studies that explored the relationship between the degree of curve size reduction, and/or surgical rates, and screening. With the information gathered, coupled with some evidence of the natural history of scoliosis locally,[14] certain assumptions were made when comparing the screening programme with the alternative of not having a screening programme. For example, the sensitivity analysis was performed based on a "worst case" and "best case" scenario – with the "worst case" being that all those who received bracing as a result of the screening programme would instead need surgery if there were no screening programme; the "best case" being that none who received bracing would require surgery in the absence of a screening programme.

The situation in Singapore is rather unique in that there is a large, well-organised school-based health screening programme where all primary and secondary schools are visited by health teams annually. Based on the computation of nett cost, the current school-based scoliosis screening and follow-up programme is cost-effective. This is largely due to the relatively low screening cost as scoliosis screening is just one item of a much larger school-based screening and immunisation programme. This translates to many of the high costs such as manpower and transport costs being prorated; a "stand-alone" programme would obviously cost significantly more. The fact that scoliosis currently has limited effective treatment options (i.e. bracing and surgery), also contributes to the cost-effectiveness of the programme as the alternative of "no screening" (which assumes that more students would require expensive surgery), is much more costly.

It is well-documented that the incidence of scoliosis progression increases with an increase in curve magnitude. Lonstein showed a direct correlation between the magnitude of the original curve and the incidence of progression.[15] Local data suggests that the highest probability of progression occurred in girls, who among other factors, had a Cobb angle of more than 20°.[14] 36 students from the study cohort had their curves braced with good outcomes (i.e. not needing surgery). As these 36 students would have had a Cobb angle of more than 20°, it is likely that without the screening programme, the majority of these 36 students would have required surgery, without which their curves would have progressed to become severe curves with poor cosmesis and possible cardiopulmonary complications. As the sensitivity analysis showed, even if only about 65% of the 36 required surgery, the nett cost is still negative.

Given the current climate of "doing more with less", some strategies to further improve the cost-effectiveness of the existing programme could be designed to reduce the nett cost and/or increase the nett health effect. Some strategies that may be considered to decrease the nett cost would be to limit screening to high-risk groups, such as screening females only or screening prepubertal females. Another alternative would be to reduce manpower costs by employing nurses instead of doctors to screen the primary six students. However, given the structure of the current screening programme, this may not be logistically possible. An increase in the nett health effect may be obtained by reducing the negative health effects of bracing, for example, through improvements in bracing methods and design to reduce discomfort and improve compliance.

A lack of randomised controlled trials and/or observational studies of the outcomes in an organised screening programme makes it challenging to correlate screening per se with outcome in terms of curve sizes and quality of life. A shortcoming of this analysis is the inability to quantify the positive health effects in terms of curve sizes. Ideally, the effectiveness of the screening programme would be best shown by a decrease in the number, or proportion, of large curves in the participating population, as well as a reduction in surgical rates. The analysis would also have been strengthened by a longer follow-up period beyond the three years currently analysed. It would be useful to measure the health effects in quality-adjusted life-years (QALYs); QALYs and disability-adjusted life-years (DALYs) for scoliosis, and musculoskeletal conditions in general, are not well-developed. Nevertheless, organised school-based scoliosis screening in Singapore is equitable, with close to 100% of the 11–12-year-old cohort in Singapore being screened annually. This analysis has shown this screening to be cost-effective.

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