Clinical Effectiveness of School Screening for Adolescent Idiopathic Scoliosis: A Large Population-Based Retrospective Cohort Study

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ABSTRACT

Study Design. Retrospective cohort study

Objective. To evaluate the clinical effectiveness of school scoliosis screening using a large and long-term-followed cohort of students in Hong Kong.

Summary of Background Data. School screening for adolescent idiopathic scoliosis (AIS) has been criticized as resulting in over-referrals for radiography and having low predictive values. Indeed, all but one previous retrospective cohort studies had no follow-up assessments of students until their skeletal maturity, leaving any late-developed curves undetected. The one study that completed this follow-up was well conducted but had low precisions due to its small sample size.

Methods. A total of 157,444 students were eligible for a biennial scoliosis screening, and their screening results and medical records up to 19 years of age were available. Screening tests included a forward bending test (FBT), angle of trunk rotation (ATR), and moiré topography for those who showed signs of AIS. Students with an ATR ≥ 15°, ≥2 moiré lines, or significant clinical signs were referred for radiography and had their Cobb angle measured.

Results. Of the 115,190 screened students in the cohort, 3,228 (2.8%, 95% CI = 2.7% to 2.9%) were referred for radiography. At the final follow-up, the positive predictive values were 43.6% (41.8% to 45.3%) for a Cobb angle ≥20° and 9.4%

(8.4% to 10.5%) for needing treatment, while the sensitivities were 88.1% (86.4% to 89.6%) and 80.0% (75.6% to 83.9%), respectively.

Conclusions. This is the largest study that has demonstrated that school scoliosis screening in Hong Kong is predictive and sensitive with a low referral rate. Screening should thus be continued in order to facilitate early administration of conservative treatments.

Key words: adolescent idiopathic scoliosis, school screening program, clinical effectiveness

INTRODUCTION

Scoliosis is a lateral deviation of the spine.[1] Although the disorder has been recognized for decades, the etiology is unknown for over 80% of patients and is therefore labeled as idiopathic. Apart from the cosmetic concerns, patients with severe spinal deformity may also suffer from a higher risk of mortality or morbidity.[2] Aggressive spinal fusion is currently the only treatment option for severe curves, but if they are detected early, curve progression may be prevented with bracing. Hence, because the majority of spinal curves are detectable during adolescence, school screening for early detection of adolescent idiopathic scoliosis (AIS) was initiated. The first program was started in Delaware in the late 1950s,[3] and other programs were subsequently started elsewhere, either by legislation or voluntarily.[4-12]

The use of school scoliosis screening remains controversial. Some programs were discontinued, perhaps due to the unfavorable recommendations by some professional bodies.[13] In particular, the United States Preventive Services Task Force (USPSTF) stated in 1996 that there was insufficient evidence to either recommend or refute routine screening for AIS. In 2004, the USPSTF advised against screening on the grounds of reasonable evidence of unnecessary brace prescriptions and referrals for specialty care.[14, 15] This policy change was criticized as being based not on new evidence but on a change of rating methodology on the available evidence.[16] In contrast, the American Academy of Orthopaedic Surgeons, the Scoliosis Research Society, the Pediatric Orthopaedic Society of North America, and the American Academy of Pediatrics have continually supported scoliosis screening for detecting reversible spinal curves before they progress.[16]

The controversy over school scoliosis screening was due mainly to over-referral of students who do not require follow-up or treatment for radiography,[3] leading to a positive predictive value (PPV) as low as 0.5% for identifying curves ≥20°.[6] Indeed, there was a large variation across studies, with a reported PPV of 64%.[17] The variation is likely due to the diversity in study design, referral criteria, screening tests used, frequency of screening, and duration of follow-up.[18] In particular, all studies except one did not have all screened students followed until skeletal maturity. Insufficient follow-up may lower the PPV, since referred students may at first show insignificant curves but later progress. Moreover, whether or not scoliosis develops during adolescence is not known in all screened students. Hence, the sensitivity and specificity of the tests (which are measures of screening accuracy robust to the disorder prevalence) cannot be obtained.[19] The exception was a retrospective cohort study conducted in Rochester, US.[11] It followed 2,242 screened students until they were 19 years old or they left school. In the 68 students referred for radiography, the PPV and sensitivity for identifying curves ≥20° were 17.4% (95% CI = 10.3% to

26.7%) and 64.0% (42.5% to 82.0%), respectively. These amounted to errors of 9.3% and 21.5%, which are large because of the small sample size. Therefore, we needed a large retrospective cohort study with a sufficient sample size to ensure proper and reliable evaluation of school scoliosis screening.

In Hong Kong, school screening for AIS was introduced in 1995 by the Department of Orthopaedics and Traumatology of the University of Hong Kong in collaboration with the Duchess of Kent Children's Hospital and the Department of Health (DH). By 2006, 886,906 students had been screened. We thus aimed to determine the clinical effectiveness of school screening for AIS.

METHODS

Study Design

This was a retrospective cohort study. Students in grade 5 (mostly 10 years old) in the academic years of 1995/96 or 1996/97 were included. For each eligible student, screening history and all medical records related to scoliosis were traced until they reached 19 years of age. The study was approved by the IRBs of the investigating universities and the relevant health authorities.

School Scoliosis Screening Program

The screening program for AIS in Hong Kong was administered by the

Department of Health using a standardized protocol designed by the Department of Orthopaedics and Traumatology of the University of Hong Kong. Participation in the screening was voluntary, and students in grade 5 or aged 10 years or above were eligible for screening until they either reached grade 13 or were 19 years old. The flowchart for the screening protocol is shown in Figure 1.

AIS screening was first performed at the Student Health Service Centres (SHSC) using the FBT and measurement of the angle of trunk rotation (ATR) using a scoliometer.[20, 21] Students in grades 5, 7 and 9 (mostly 10, 12 and 14 years old, respectively) were screened by trained doctors or trained registered nurses. Students with an ATR between 0° and 2° had the tests repeated biennially, and those with an ATR of 3° or 4° repeated them annually. When students had an ATR between 5° and 14° or obvious signs of trunk or shoulder asymmetry, or there was special concern from medical staff or parents, they were further evaluated in a Special Assessment Centre (SAC). Students with an ATR ≥15° were referred directly to one of the two specialist hospitals that manage spinal deformities, in which they would have X-ray examinations of the whole spine.

In the SAC, the students were assessed by a specially trained doctor using ATR and moiré topography. Moiré topography is a biostereometric technique that projects contour lines, or moiré fringes, on a subject's back.[22] A moiré photograph is then taken, from which the number of fringes that deviate from symmetry between the left and right sides are counted; this reflects the severity of the back deformity. This method was reported to be more sensitive than conventional clinical screening.[23] In the current protocol, students who had <1 moiré line were referred back to the SHSC for yearly screening but were referred to the SAC again if their ATR deteriorated by 1° or more within one year. Students with 1 to <2 moiré line differences underwent a repeat assessment every 6 to 12 months. For students who had ≥2 moiré line differences or showed significant clinical signs, including uneven shoulder height, pelvic tilt, rib or loin hump, or a scapular prominence and/or truncal shift, a standing posteroanterior X-ray of the whole spine was taken, from which the Cobb angle was measured. Students with a Cobb angle under 20° had an ATR and moiré assessments repeated every 6 to 12 months and had X-rays repeatedly taken when they showed a deterioration of 1 or more moiré lines. Students who had a Cobb angle ≥20° were referred to a specialist hospital for follow-up and treatment.

In summary, students who resulted an ATR ≥15°, ≥2 moiré lines, or showed significant clinical signs of scoliosis would be referred for radiography, and those who were found a Cobb angle ≥20° would be followed-up in a specialist hospital until skeletal maturity.

Treatment and follow-up of AIS

Students referred to a specialist hospital received a standing posteroanterior X-ray and were assessed by orthopedists. All patients were followed up every 3 to 6 months and were observed or treated according to the severity of the spinal curvature, the rapidity of progression and their skeletal maturity. Immature patients with curve progression of at least 5° or with a Cobb angle between 30° and 45° were required to wear a brace for prevention of progression. Patients with a Cobb angle over 45° were offered surgical correction.

Data Collection

For each student in our cohort, the demographic information, school grade, date and results of tests performed at each visit and the Cobb angle measurements were obtained from SHSC and SAC. For those who visited the two specialist hospitals, the date, Cobb angle and body height were measured at each follow-up visit, and the type of treatment (brace or operation) was recorded. Students who did not take part in the screening program but were diagnosed with AIS and referred from other sources were also identified from records at the two specialist hospitals. They were included in the cohort if they were born in 1985 or 1986, since they should have been in grade 5 in 1995/96 or 1996/97.

Statistical Analysis

Based on the students referred for radiography, the prevalence and measures of clinical effectiveness were estimated for different conditions, including different spinal curvatures and treatment. These measures included the PPV, the negative predictive value (NPV), and the sensitivity and specificity. For detecting a condition, the PPV was the proportion of students with the condition in those referred by screening and NPV was the proportion of students without the condition in those not referred. The sensitivity was the proportion of students who had the condition correctly detected by screening, and specificity was the proportion of students without the condition not referred by screening. There were students referred for radiography who did not show up for the assessment. They were considered to be non-scoliotic, which is conservative for the estimation of the PPV and sensitivity.

Per protocol, students were referred for radiography when they had an ATR $\geq 15°$, $\geq$2 moiré lines or significant clinical signs. Unlike the ATR and moiré topography, clinical signs cannot be objectively measured, but were subjectively judged by the screeners. Moreover, some students who had borderline screening results had visited a specialist hospital by themselves and might have eventually met the referral criteria had they stayed in the screening program. To assess the impact of the use of clinical signs for referral and the borderline cases on the clinical effectiveness, we performed a sensitivity analysis on four groups of students. Group A comprised students who were referred for radiography with an ATR $\geq 15°$ or $\geq$2 moiré lines (objective referral criteria) only. Group B1 consisted of students who had 1 to <2 moiré lines and were referred because they had significant clinical signs of scoliosis. Group B2 consisted of those who had 1 to <2 moiré lines but had visited a specialist hospital without referral and did not have clinical signs. Students in these two groups might eventually have met the objective referral criteria had they continued being screened with the ATR and moiré topography. Thus, we optimistically considered these students as having met the objective referral criteria. Finally, we defined Group C as the students who were referred due to the presence of clinical signs. Again, they might have met the objective referral criteria had they continued being screened. Hence, we also accepted them as if they had been referred by the objective referral criteria.

All estimates were accompanied by exact 95% confidence intervals based on a binomial distribution, and a 5% level of significance was used in all significance tests. The data management and analysis were performed by the Statistical Analysis System (SAS) version 9.1.[24]

Role of the funding source

The funding agencies financially supported a research postgraduate student who performed the study design, data collection and analysis, interpretation of results, and writing of the article, but they were not involved in the study. The corresponding

author had full access to all the data in the study and had final responsibility for the decision to submit for publication.

RESULTS

According to the Hong Kong Education Bureau, there were 81,173 and 76,271 students enrolled at grade 5 (mostly 10 years old) in the academic years of 1995/96 and 1996/97, respectively. Consequently, 157,444 students eligible for screening were included in our cohort.

The numbers of students who participated in the screening program, who were referred for radiography, and in whom AIS was detected are summarized in Figure 2. Prior to the commencement of screening, 51 students had already detected scoliosis and were not considered to have been identified by screening. Among the 42,203 (26.8%) non-participants, 71 (0.17%) had AIS detected by the age of 19, 4 cases of which were severe enough to require surgery despite an unknown Cobb angle. For the 115,190 (73.2%) participants, 12 were diagnosed non-idiopathic scoliosis (4 congenital, 1 neuromuscular, 4 Marfan syndrome, and 3 neurofibromatosis). A total of 3,228 (2.8%, 95% CI = 2.7% to 2.9%) students were referred for radiography by 19 years of age, 2,425 objectively and 803 due to clinical signs, and 271 students had self-initiated radiography performed, probably as a result of parental concerns. A detailed disposition of screened students by their ATR results obtained in the SHSC by the age of 19 can be found in Table 1.

The prevalence rates of AIS for different curvatures and treatment in Hong Kong are shown in Table 2. AIS was more common in girls than in boys ($p<0.001$ by Fisher's exact test), and the girls-to-boys ratio increased with the severity. The prevalence of treatment was 0.33% (95% CI = 0.30% to 0.36%), and girls were 8.4 times more likely to have treatment than boys ($p<0.001$ by Fisher's exact test).

Table 3 compares the treatment outcomes for the objective and protocol referral criteria. The additional use of clinical signs for referral identified an additional 107 students who eventually required treatment. A good agreement (unweighted kappa = 0.79, 95% CI = 0.75 to 0.82) was found between the treatment outcomes of the students referred with and without the use of clinical signs. Nevertheless, use of the protocol criteria identified 0.09% (95% CI = 0.08% to 0.11%, $p<0.001$ by McNemar's test) more students requiring treatment than use of the objective criteria alone.

The clinical effectiveness of the Hong Kong school screening program for AIS is summarized in Table 4. In the cohort, 252 students who had 1 to <2 moiré lines were also X-rayed in an SAC due to the presence of clinical signs (Group B1), and another 16 students who had 1 to <2 moiré lines were X-rayed in a specialist hospital without meeting the protocol referral criteria (Group B2). These students might have attained ≥2 moiré lines had they continued the screening. Taking them as if they met the objective criteria, the accuracy measures substantially improved. Further improvement was observed when referral by clinical signs was also considered (Groups A+C).

DISCUSSION

This was the largest retrospective cohort study in the area of scoliosis screening, and added to the only study in the literature that adequately followed screened students in a school scoliosis screening program in Rochester.[11] Contrary to the Rochester study, the Hong Kong screening program appears to be sensitive and predictive for screening AIS patients with only a low referral rate.

Using an ATR ≥ 15° or ≥2 moiré lines as the referral criteria for radiography, the PPVs for curves with a Cobb angle ≥20° and treatment were 36.5% and 8.1%, respectively, at a referral rate of 2.1%. In other screening programs that used moiré topography, the PPVs for curves ≥20° and treatment may range from 3.0% to 10.8% and 0.4% to 4.8%, respectively, with referral rates in the range of 3.0% to 8.4%.[5, 9, 12] A screening program using moiré topography and low-dose roentgenography referred only 0.3% of all screened students and resulted in a PPV of 64.0% for curves ≥20°.[17] Another program using the same screening tools evaluated in a much larger sample size had a referral rate of 1.0% and a PPV of 24.2%.[8]

In the Rochester study, which used only FBT/ATR for screening but followed students till skeletal maturity, the PPVs for curves ≥20°and treatment were 17.4% and 5.4%, respectively, with 4.1% rate of referral.[11] The school scoliosis screening program in Hong Kong was thus more clinically effective than other comparable programs.

By following all screened students, the sensitivity of scoliosis screening in Hong Kong was estimated as 55.5% for curves ≥20°, and 51.7% for treatment. These values fall in the confidence intervals of those reported in the Rochester study, the only evaluation that reported sensitivity. However, the Rochester study size was small, which resulted in 21% and 18% error in the sensitivities for curves ≥20° and treatment, respectively. In contrast, our estimates had at most 2.5% error.

In the screening protocol of the Hong Kong program, apart from the objective criteria, a student would also be referred for radiography when there are significant signs of scoliosis, including uneven shoulder height, pelvic tilt, rib or loin hump, or scapular prominence and truncal shift. Referral by clinical signs was also used in many other screening programs, especially in those that used FBT only.[7, 25, 26] These programs were much less effective than the Hong Kong screening program, which had PPVs of 43.6% for curves ≥20° and 9.4% for treatment, with corresponding sensitivities of at least 80%. These were attained with only a slightly increased referral rate of 2.8%. This shows a clear clinical effectiveness of the Hong Kong scoliosis screening program whether or not it is compared with other existing programs.

The reasons for the high clinical effectiveness of school scoliosis screening in Hong Kong are manifold. First, moiré topography was utilized for screening as opposed to the use of FBT/ATR alone in many other programs. Indeed, moiré topography has been demonstrated to be more accurate than FBT/ATR alone.[27] Second, since treatment would be considered for curves exceeding 25°,[1] our program, aiming to detect curvature ≥20°, is less likely to unnecessarily refer students who require no treatment than most other programs targeting a common cut-off of 10°. Third, we had follow-up information for all screened students, which resulted in a higher PPV, as students may at first have insignificant curves that later progress. Fourth, students in this program were screened by trained doctors and registered nurses, who were more skilled and experienced than the non-professionals who carried out the screening in some previous studies.[4] Finally, this screening program is highly centralized and coordinated by the DH, and the two specialist hospitals are within the only two medical school teaching hospitals in Hong Kong. This triad is the most appropriate combination to provide public health and medical services for scoliosis patients.

Participation in the Hong Kong screening program was satisfactory, with 73.2% of eligible students screened at least once. This screening program was voluntary, but participation was comparable to or better than that in other regions such as Singapore, Minnesota and the Netherlands, where participation rates were 51%, 75% and 80% (estimated), respectively.[10, 28, 29]

The estimated prevalence of AIS with curves ≥10° by the age of 19 years in Hong Kong students is 2.5%. Although this is within the range reported in the literature,[3] the true prevalence is probably higher, since the Hong Kong program aimed to detect curves ≥20° and the number of undiscovered curves between 10° and 20° was unknown. On the other hand, the estimated prevalence of curves ≥20° was 1.4%, which is higher than that reported elsewhere.[3] However, most other studies estimated point prevalence, i.e. prevalence at the time of screening, but students who developed AIS later were not accounted for. In contrast, we estimated a period prevalence by the age of 19 years, and all screened students who were ever diagnosed with AIS with a Cobb ≥20° during adolescence were included.

We have not examined if our scoliosis screening program attained the ultimate goal of minimizing the operation rate.[30] However, a reduction in the operation rate depends not only on the effectiveness of screening but also on the efficacy of conservative bracing treatments.[31] Its efficacy was supported by a well-known prospective cohort study performed by the Scoliosis Research Society.[32] A more recent review also concluded its long term effect even after treatment.[33] However, proper randomized controlled trials (RCTs) are still lacking. Two multi-center RCTs were recently initiated and their results will be important.[28, 34]

School scoliosis screening provides information essential to the understanding of the epidemiology and the etiology of AIS, which can be a life-long disorder if managed improperly or too late.[35] Moreover, it sets up a platform to facilitate research on improving conservative treatments. The scoliosis screening program in Hong Kong, which screened both boys and girls for the whole adolescent period, and referred them for radiography when an ATR ≥ 15°, ≥ 2 moiré lines were resulted or significant clinical signs were observed, was clearly predictive and sensitive for detecting curves requiring follow-up or treatment. It is better than what has been reported in the literature in terms of both clinical effectiveness and the way these programs were evaluated. The current evidence supports the continuation of school scoliosis screening. The screening protocol being used in Hong Kong could be regarded as a model for further evaluation or refinement in other places.

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Figure 1. Protocol of the school screening programme for AIS in Hong Kong

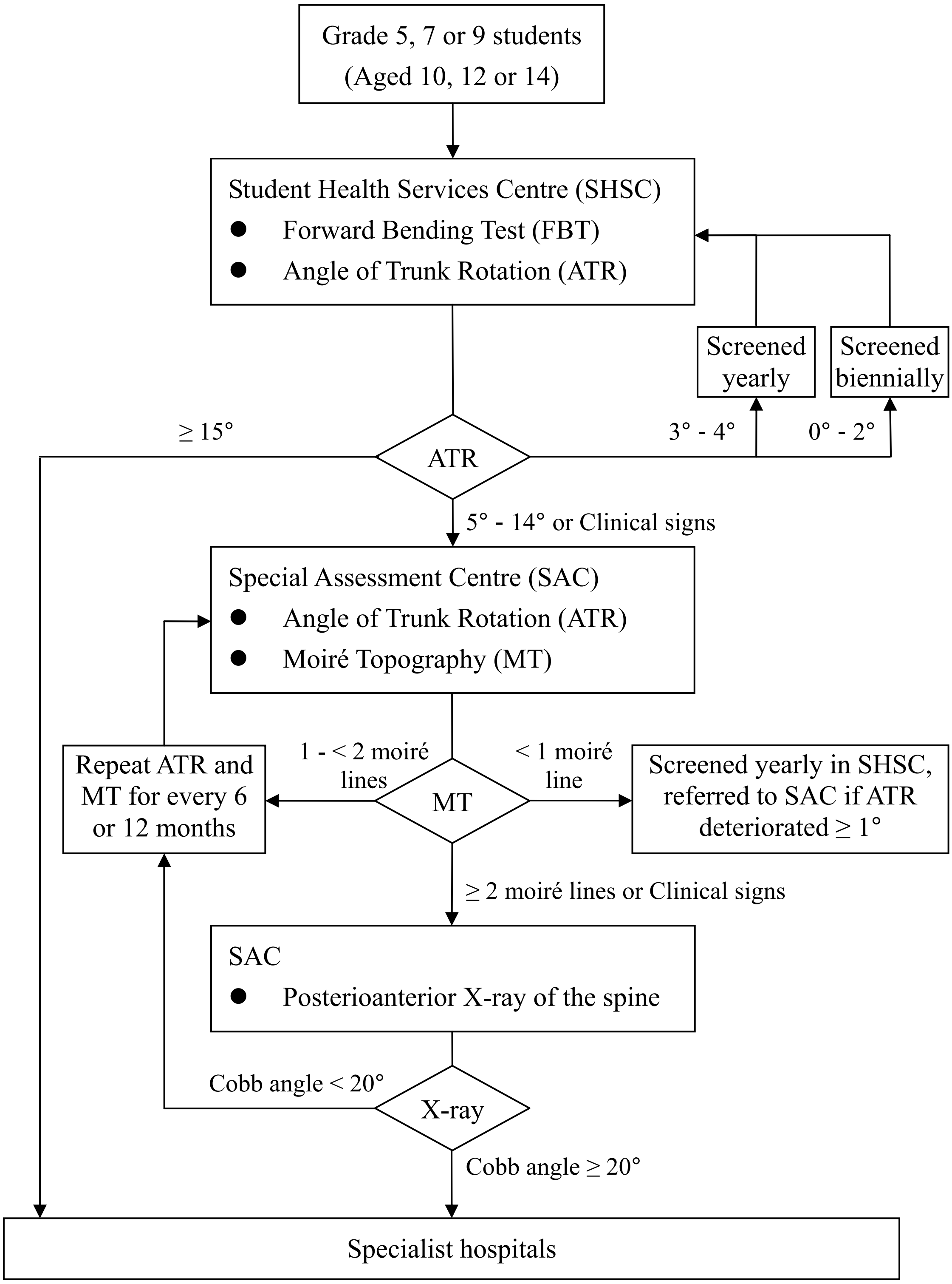
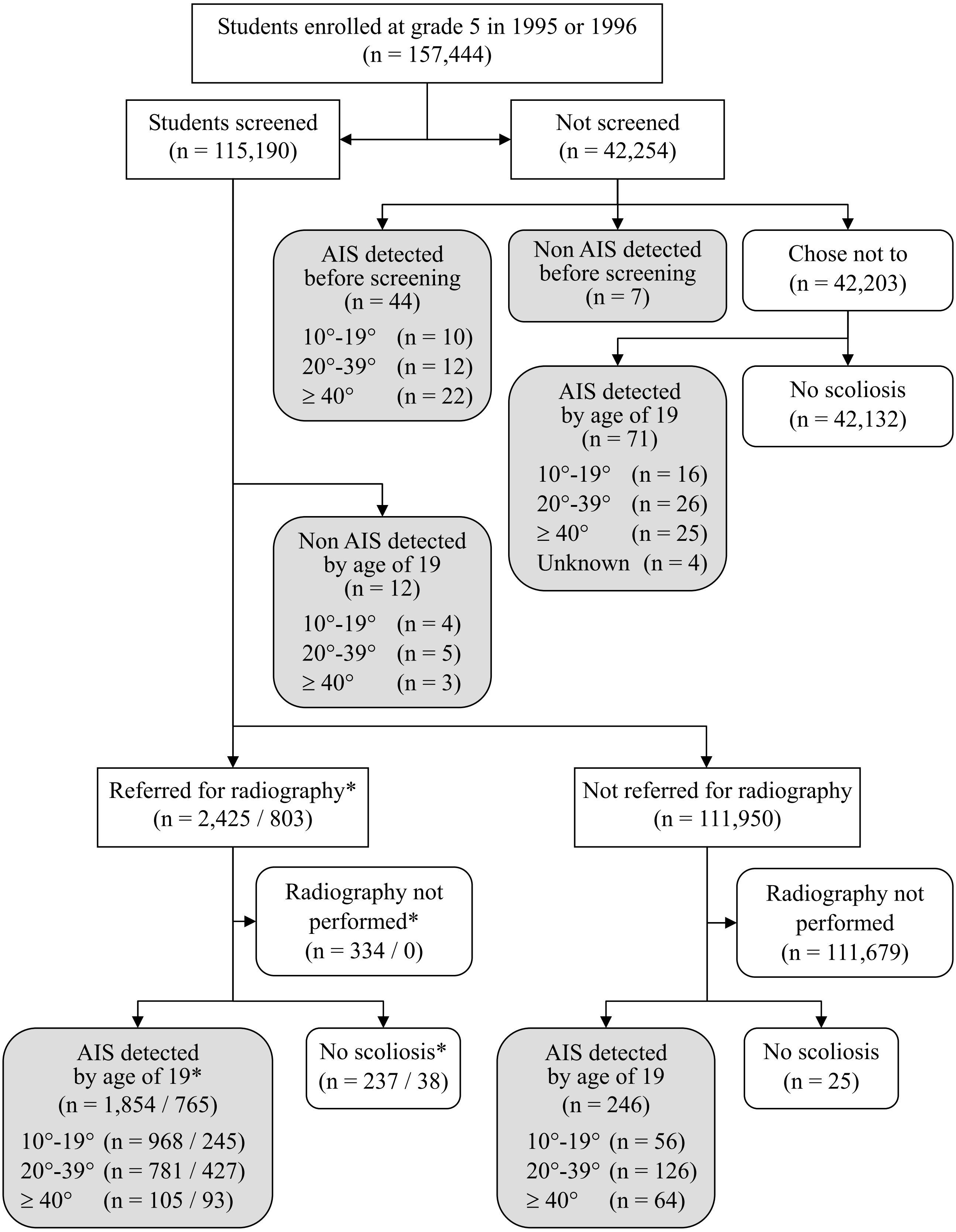


Figure 3. School screening for adolescent idiopathic scoliosis (AIS)



* Numbers of students referred due to (i) ATR ≥ 15° or ≥ 2 moiré lines / (ii) clinical signs.

Table 1. Disposition of students by angle of trunk rotation (ATR) results at Student Health Centres (SHSC) by age of 19 years

	Screening result in SHSC		
	Only had ATR < 5° (n = 105393)	Only had ATR 5° - 14° (n = 9614)	Ever had ATR ≥ 15° (n = 171)
Subsequent screening	N (%)	N (%)	N (%)
Visited a Special Assessment Centre (SAC)			
Moiré topography not performed	73 (0.1)	538 (5.6)	1 (0.6)
Moiré topography performed, but result unknown	2 (0.0)	41 (0.4)	0 (0.0)
Less than 1 moiré line	22 (0.0)	521 (5.4)	3 (1.8)
1 to less than 2 moiré lines	57 (0.1)	3078 (32.0)	6 (3.5)
2 or more moiré lines	28 (0.0)	2226 (23.2)	10 (5.8)
Less than 2 moiré lines and X-rayed	6 (0.0)	797 (8.3)	8 (4.7)
Visited a specialist hospital			
Directly from SHSC	125 (0.1)	102 (1.1)	41 (24.0)
Through at SAC	15 (0.0)	1215 (12.6)	65 (38.0)
Did not visited SAC nor specialist hospital	105080 (99.7)	2311 (24.0)	47 (27.5)

Table 2. Prevalence of AIS by age of 19 in Hong Kong

	Total (Exact 95% CI)	Boys (Exact 95% CI)	Girls (Exact 95% CI)	Girls : Boys Ratio
Curves ≥ 10°	2.49% (2.40%, 2.58%)	1.34% (1.25%, 1.44%)	3.59% (3.45%, 3.75%)	2.7
Curves ≥ 20°	1.39% (1.32%, 1.45%)	0.50% (0.44%, 0.56%)	2.24% (2.12%, 2.36%)	4.5
Curves ≥ 40°	0.23% (0.20%, 0.26%)	0.05% (0.03%, 0.07%)	0.40% (0.35%, 0.45%)	8.1
Treatment	0.33% (0.30%, 0.36%)	0.07% (0.05%, 0.09%)	0.58% (0.52%, 0.64%)	8.4
Brace only	0.28% (0.25%, 0.31%)	0.06% (0.04%, 0.08%)	0.48% (0.43%, 0.54%)	8.0
Surgery only	0.02% (0.01%, 0.03%)	0.01% (0.00%, 0.02%)	0.03% (0.02%, 0.05%)	5.8
Brace and Surgery	0.04% (0.03%, 0.05%)	0.00% (0.00%, 0.01%)	0.07% (0.05%, 0.09%)	18.8

Table 3. Treatment outcomes of students by both objective and protocol referral criteria

	Total (n = 115178) N (%)	Boys (n = 56566) N (%)	Girls (n = 58612) N (%)	Girls : Boys Ratio
Referral criteria for radiography: ATR ≥ 15° or ≥ 2 moiré lines				
Referred	2425 (2.11)	771 (1.36)	1654 (2.82)	2.1
Brace only	175 (7.22)	14 (1.82)	161 (9.73)	11.1
Surgery only	5 (0.21)	2 (0.26)	3 (0.18)	1.4
Brace and Surgery	16 (0.66)	0 (0.0)	16 (0.97)	N.A.
Not referred	112753 (97.89)	55795 (98.64)	56958 (97.18)	1.0
Brace only	142 (0.13)	20 (0.04)	122 (0.21)	5.9
Surgery only	16 (0.01)	1 (0.002)	15 (0.03)	14.5
Brace and Surgery	25 (0.02)	2 (0.004)	23 (0.04)	11.1
Referral criteria for radiography: ATR ≥ 15°, ≥ 2 moiré lines or presence of clinical signs				
Referred	3228 (2.80)	976 (1.73)	2252 (3.84)	2.2
Brace only	264 (8.04)	27 (2.62)	237 (10.52)	8.5
Surgery only	10 (0.3)	2 (0.19)	8 (0.36)	3.9
Brace and Surgery	29 (0.88)	0 (0.0)	29 (1.29)	N.A.
Not referred	111950 (97.20)	55590 (98.27)	56360 (96.16)	1.0
Brace only	53 (0.05)	7 (0.01)	46 (0.08)	6.3
Surgery only	11 (0.01)	1 (0.002)	10 (0.02)	9.7
Brace and Surgery	12 (0.01)	2 (0.004)	10 (0.02)	4.8

Table 4. Clinical effectiveness of school screening for adolescent idiopathic scoliosis in Hong Kong

	Students taken as those referred for radiography by screening			
	Those who had ATR≥15° or ≥2 moiré lines (A)	(A) + Those who had 1 to <2 moiré lines and referred by clinical signs (B1)	(A) + (B1) + Those non-referrals who had 1 to <2 moiré lines but X-rayed in a specialist hospital (B2)	(A) + Those referred by clinical signs (C)
Sensitivity				
Curves ≥ 10°	64.7% (62.9%, 66.5%)	72.8% (71.1%, 74.4%)	73.2% (71.6%, 74.8%)	91.4% (90.3%, 92.4%)
Curves ≥ 20°	55.5% (53.0%, 58.0%)	63.0% (60.6%, 65.3%)	63.5% (61.1%, 65.8%)	88.1% (86.4%, 89.6%)
Curves ≥ 40°	40.1% (34.1%, 46.3%)	45.8% (39.7%, 52.0%)	46.2% (40.0%, 52.4%)	75.6% (69.9%, 80.7%)
Treatment	51.7% (46.6%, 56.9%)	58.8% (53.7%, 63.8%)	59.4% (54.2%, 64.4%)	79.9% (75.6%, 83.9%)
Positive Predictive Value				
Curves ≥ 10°	76.5% (74.7%, 78.1%)	77.9% (76.3%, 79.5%)	77.9% (76.3%, 79.5%)	81.1% (79.7%, 82.5%)
Curves ≥ 20°	36.5% (34.6%, 38.5%)	37.5% (35.7%, 39.4%)	37.6% (35.8%, 39.5%)	43.6% (41.8%, 45.3%)
Curves ≥ 40°	4.3% (3.6%, 5.2%)	4.5% (3.7%, 5.3%)	4.5% (3.7%, 5.4%)	6.1% (5.3%, 7.0%)
Treatment	8.1% (7.0%, 9.2%)	8.3% (7.3%, 9.4%)	8.4% (7.3%, 9.5%)	9.4% (8.4%, 10.5%)

The specificity and negative predictive values were larger than 95% for curves ≥ 10°, ≥ 20°, ≥ 40° and for treatment in all scenarios, and thus were not presented here.