Assessment of the Accuracy of Two Dental Screening Methods Used in a School Setting

Maha M.A. El Tantawi[a]/Wafaa E. AbdelAziz[b]

Purpose: To assess the accuracy of two screening methods used by dentists in the Health Insurance Organisation in Alexandria, Egypt aiming at identifying children who need referral for treatment.

Materials and Methods: The study included 45 dentists who examined 30 children using exclusively visual screening (VS) and visual screening with tongue blade (VSTB). A benchmark dentist examined the same group of children using mirror and probe (MP). VS and VSTB were compared to MP. Sensitivity (Sn), specificity (Sp), positive and negative predictive values (PPV and NPV, respectively) were calculated. The effect of dentist's gender, year of graduation and having postgraduate studies on the accuracy of the two methods was assessed.

Results: VS had greater accuracy than VSTB. Both methods had a Sn and Sp >82%. The PPV of both methods was >97%, whereas that of NPV was ≤ 44%. Males and recent graduates performed better than females and senior dentists when using VS and VSTB methods.

Conclusions: It is questionable whether screening using VS or VSTB can ensure effective referral of children for treatment. Further studies are needed to assess other aspects of screening, including whether referred children actually seek care and whether screening improves children's oral health.

Key words: accuracy, public health dentistry, school dental screening, visual examination

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Screening of schoolchildren is performed in different health-care systems around the world with different objectives, including assessment of disease burden, determination of treatment needs or referral to treatment.[21,24,28] Screening which is performed to refer children succeeds when it accurately identifies cases in need of treatment and then screened children and/or their families subsequently seek this treatment.

In Egypt, the Health Insurance Organisation (HIO) is responsible for maintaining the oral health of schoolchildren. Dentists working in the HIO screen 1st- and 4th-grade primary schoolchildren and students in the 1st preparatory and secondary grades. The number of dentists working in the HIO clinics in Alexandria, the 2nd largest governorate in Egypt in terms of population, was estimated recently to be 200. These dentists are required to provide services to almost one million students[8] with a dentist-to-population ratio of about 1:5000. Such services include screening children in schools and providing restorative and surgical treatment in clinics under constraints of the limited resources that are directed mostly to clinic-based therapeutic rather than field-based screening activities. Screening performed by the HIO dentists is either exclusively visual without the use of any instrument (visual screening: VS) or visual, aided by tongue blade (visual screening with tongue blade: VSTB). All children attending on the day of the examination are screened in a classroom or similar area in the school under natural daylight conditions with the

[a] *Professor of Dental Public Health, Department of Paediatric Dentistry and Dental Public Health, Faculty of Dentistry, Alexandria University, Alexandria, Egypt. Idea, study design and methods, performed statistical analysis, wrote manuscript, read and reviewed the final manuscript.*

[b] *Associate Professor of Dental Public Health, Department of Paediatric Dentistry and Dental Public Health, Faculty of Dentistry, Alexandria University, Alexandria, Egypt. Idea, conducted the gold standard examination, coordinated the dental exams, read and reviewed the final manuscript.*

Correspondence: *Dr. Maha El Tantawi, Department of Paediatric Dentistry and Dental Public Health, Faculty of Dentistry, Alexandria University, Champolion St., Azarita, Alexandria, Egypt. Tel: + 20-3486-9690/ext 221, Fax: +20-3486-8922.*
Email: maha_tantawy@hotmail.com

child seated on a chair or standing. No brushing or professional cleaning is done before the examination and no mirror, probe or drying is used. Children are referred to treatment if pathologic lesions are detected anywhere in the oral cavity with the greatest attention focused on caries. This simplified method was developed to suit the condition in which the screening is performed and the available resources. It also suits the purpose for which it is intended, since more comprehensive clinical examination follows afterwards in the HIO clinic to which the child is referred.

Several studies assessed simplified screening methods performed by oral health-care personnel under various examination conditions using different instruments and/or diagnostic aids. For example, to screen at the tooth level, a team consisting of a dental hygienist and a registered nurse used tongue blades and flashlights for intraoral illumination.[5] In another study, dental hygienists used mirrors and tongue depressors,[16] and in yet another study, dental hygienists used tongue blades and goose-neck lamps.[26] Using a different mix of personnel, Hecksher et al[14] included in their study a dental assistant and a school teacher using tongue blade and natural daylight. Haleem et al[12] assessed the accuracy of examination performed by dentists using wooden spatulas and toothpicks under natural light. Other studies followed the traditional medical definition of screening, where oral disease was identified at the person level.[2,7,23]

If the HIO method of screening does not identify the need for referral of the screened children with reasonable accuracy, it wastes the time of dentists who are already busy and burdened by other duties. In addition, it also deprives the children of their rightful access to health-care services to which they are entitled by law. Milsom et al[20] urged the scientific community to provide evidence assessing the usefulness of school dental screening based on data from countries where dental screening programmes exist.

The purpose of this study was to assess the accuracy of two simple screening methods used by the HIO dentists in Alexandria, Egypt (VS and VSTB) compared to a traditional mirror and probe clinical oral examination (MP). The hypothesis of the study is that the sensitivity and specificity of the two screening methods is ≥ 80%.

MATERIALS AND METHODS

The Dental Research Ethics Committee, Faculty of Dentistry, Alexandria University approved the study. Dentists and parents of children participating in the study consented to take part.

To determine sample size, the following assumptions were made: alpha error = 5%, study power = 80%, true difference between mean sensitivity (or specificity) and reference value (80%) = 0 with a 5% margin of equivalence for a sample drawn from a population of 200 dentists working in the HIO with a standard deviation of ± 15. Using PASS (NCSS and PASS, Number Cruncher Statistical Systems; Kaysville, UT, USA), a sample of 45 dentists was estimated to be needed to detect non-inferiority between sensitivity (or specificity) of VS or VSTB and the traditional MP.

Forty-five dentists working in the HIO in Alexandria were randomly selected to participate in the study. Each dentist examined the same group of 30 children who for different reasons attended the clinic of the Paediatric Dentistry and Dental Public Health Department at the Faculty of Dentistry, Alexandria University. The children were selected by the department intern who did not participate in the study and who was asked to recruit the children from among a day's visitors to the clinic and to include some caries-free children so that the disease spectrum would be represented. The actual caries status of each child was not known to the study team.

The dentists examined the children using VS and recorded the results independently of each other. In this examination, dentists used gloved hands to move the child's head for better visibility if there was a need. Nothing was inserted into the child's mouth. The child was seated on a dental chair or a bench and daylight was used for illumination. The outcome recorded was whether each child had/did not have caries depending on the presence or absence, respectively, of caries in any tooth in the oral cavity.

The same group of children was examined by a benchmark examiner using MP without prior cleaning of teeth or radiographs in order to determine if each child had any carious lesion present (yes/no at subject level). An air-water syringe, cotton and gauze were available during the benchmark examination to be used when needed to remove food debris. Children were examined on dental chairs with the aid of light from the dental unit. The benchmark examiner had previous experience applying the World Health Organization (WHO) criteria and

Table 1 Comparison between VS and VSTB as regards sensitivity (Sn), specificity (Sp), positive predictive value (PPV) and negative predictive value (NPV)

	Exclusively visual screening (VS) Mean (CI)	Visual screening with tongue blade (VSTB) Mean (CI)	Difference (VS - VSTB) Mean (CI)	p-value
Sensitivity (Sn)	83.28 (81.68, 84.87)	82.81 (80.77, 84.85)	0.46 (-0.79, 1.72)	0.32
Specificity (Sp)	92.44 (87.67, 97.22)	85.78 (79.44, 92.11)	6.67 (1.18, 12.15)	0.02*
Positive predictive value (PPV)	98.82 (98.12, 99.52)	97.96 (97.08, 98.83)	0.86 (0.13, 1.59)	0.02*
Negative predictive value (NPV)	44.13 (40.66, 47.60)	40.11 (35.68, 44.54)	4.03 (0.89, 7.16)	0.02*

CI: confidence interval. *Statistically significant at the 5% level.

methods for caries examination.[30] A child was considered to have caries if at least one carious lesion in any tooth was diagnosed.

The 45 dentists then examined the same group of children using VSTB to retract cheeks and tongue. No other aids to examination were used. Results of this examination were recorded on a form different from that used to record the child's caries status during VS. The order in which the children were examined was varied between the VS and the VSTB examination so that the dentists would not rely on memory to diagnose caries. The VSTB examination was also performed under natural daylight conditions. The benchmark examiner and each one of the dentists were blinded to the examination results of each other.

Caries was diagnosed if there was an unmistakable cavity, undermined enamel or detectably softened floor or wall detected in the MP examination.[30] The dentists applied the same criteria they use in schools for the VS and VSTB and recorded caries as any suspected break in tooth surface or whenever there was any doubtful lesion. This doubtful lesion was one where the break in the tooth surface indicating caries presence cannot be ascertained – an approach that differs from that of the WHO criteria, which classify such a lesion as sound. Dentists reported they always use these criteria when screening in schools to avoid liability if a parent complains that some disease was left untreated in a child.

At the end of the examinations, oral hygiene instructions were given to the children and parents were notified if there was a need to pursue treatment in the Department clinic or elsewhere as desired.

The MP examination was used as the gold standard and the accuracy of VS and VSTB were compared to it using sensitivity (Sn) and specificity (Sp). Positive predictive value (PPV) and negative predictive value (NPV) were used to assess the usefulness of the two methods. For all measures, 95% confidence intervals were calculated. The Wilcoxon signed ranks test was used to compare these values between VS and VSTB. The relationship was assessed between these values and dentist variables such as gender, year of graduation and having a postgraduate degree using the Mann-Whitney U-test, Kruskal-Wallis test and Mann-Whitney U-test, respectively. Alpha was set at the 5% level. Statistical analysis was done using SPSS version 17.0.

RESULTS

Forty-five dentists participated in the study. Of those, 9 (20%) were males, 9 (20%) graduated in the 70s, 30 (66.7%) graduated in the 80s and six (13.3%) graduated in the 90s. Fifteen (33.3%) dentists had postgraduate degrees: Diplomas and Masters in different specialties, including four degrees in Dental Public Health, four in Oral Medicine, three in Oral Surgery, three in Paediatric Dentistry and one in Operative Dentistry. Each dentist examined 30 children. The mean (SD) age of these children was 6.7 (0.4) and 60% of them were girls. The prevalence of caries in the children was 83.3%.

Table 1 shows the comparison of Sn, Sp, PPV and NPV between VS and VSTB. No significant difference was found in Sn between the two methods ($p = 0.32$). The Sp, PPV and NPV of VS were significantly higher than those of VSTB ($p = 0.02$ for all).

Tables 2 and 3 show the effect of dentist's gender, year of graduation and having postgraduate degrees on Sn, Sp, PPV and NPV of VS and VSTB. Gender had a significant effect on the Sp and PPV of VS and all parameters of VSTB with males performing better than females. Year of graduation

Table 2 Effect of dentist's gender, year of graduation and having postgraduate degrees on sensitivity (Sn), specificity (Sp), positive predictive value (PPV) and negative predictive value (NPV) of VS

		Sensitivity (Sn) Mean (CI)	Specificity (Sp) Mean (CI)	Positive predictive value (PPV) Mean (CI)	Negative predictive value (NPV) Mean (CI)
Gender	Male	85.66 (82.03, 89.30)	100 (100, 100)	100 (100, 100)	51.39 (44.41, 58.37)
	Female	82.68 (80.88, 84.48)	90.55 (84.71, 96.40)	98.52 (97.67, 99.38)	42.31 (38.42, 46.21)
	p	0.16	0.05*	0.05*	0.06
Year graduated	70s	83.18 (80.60, 85.76)	80.00 (56.94, 99.06)	97.14 (93.85, 99.44)	39.88 (28.98, 50.77)
	80s	82.13 (80.09, 84.18)	94.67 (91.55, 97.78)	99.09 (98.56, 99.62)	42.53 (38.92, 46.13)
	90s	89.13 (86.50, 91.77)	100 (100, 100)	100 (100, 100)	58.52 (53.96, 63.09)
	p	0.01*	0.24	0.24	0.002*
Has post-graduate degree(s)	No	81.85 (79.73, 83.89)	96.33 (93.53, 99.13)	99.39 (98.93, 99.85)	42.52 (38.75, 46.28)
	Yes	86.12 (84.55, 87.69)	84.67 (71.34, 97.99)	97.68 (95.77, 99.59)	47.35 (39.67, 55.04)
	p	0.01*	0.13	0.10	0.05*

CI: confidence interval. *Statistically significant at the 5% level.

had a significant effect on Sn and NPV of VS and all parameters of VSTB with more recent graduates performing better than older graduates. Having postgraduate degrees significantly improved the Sn and NPV of VS but had no significant effect on any of the parameters of VSTB. No differences were observed among dentists with various types of postgraduate degrees as regards any of the parameters of VS or VSTB (data not shown).

DISCUSSION

The present study assessed the accuracy and usefulness of VS and VSTB to screen schoolchildren and identify the need for referral for further examination and treatment in the HIO clinics.

One limitation of the study was that MP examination and the WHO criteria were used as a gold standard with the assumption that they represent the truth about caries status. Evidence indicates that this examination method and/or these criteria can miss some non-cavitated lesions in occlusal surfaces of permanent molars[10] and underestimate the need for restorative care by as much as 44% compared to examination accompanied by radiographs.[4] However, it is acknowledged that in school-based dental screenings, more sophisticated examination methods cannot be used.[1,10] MP examination with the WHO criteria was used as the gold standard in several studies assessing screening methods.[5,12,26] Another limitation of the study was that it was conducted in a setting where caries prevalence may be higher than in schools, since all children visiting the department clinic are seeking treatment, with a considerable portion doing so due to caries and its consequences. Other studies postulated that the setting where the accuracy of an examination method is assessed may influence the accuracy measures reported for this method and that the direction and extent of the setting effect cannot always be known beforehand to be corrected or adjusted for.[1,25] In the present study, it was not possible to conduct the screening in schools because of logistic difficulties related to accommodating the 45 dentists participating in the study in a single school, and therefore had to be conducted in a controlled setting such as the department clinic.

Caries is more frequently included in screening and surveillance activities than other oral diseases.[17,19] It is also reported to be a major criterion for referral of children screened in school settings,[27] although not all children identified with caries during screening are referred to treatment.[23] Screening for caries at the person level is used in other systems such as the Basic Screening Survey (BSS) developed by the ASTDD (Association for State and Territorial Dental Directors).[2] In that survey, and similar to the screening conducted by the HIO den-

Table 3 Effect of dentist's gender, year of graduation and having postgraduate degrees on sensitivity (Sn), specificity (Sp), positive predictive value (PPV) and negative predictive value (NPV) of VSTB

		Sensitivity (Sn) Mean (CI)	Specificity (Sp) Mean (CI)	Positive predictive value (PPV) Mean (CI)	Negative predictive value (NPV) Mean (CI)
Gender	Male	88.80 (85.55, 92.04)	100 (100, 100)	100 (100, 100)	59.00 (51.59, 66.40)
	Female	81.32 (79.11, 83.52)	82.22 (74.70, 89.70)	97.45 (96.41, 98.49)	35.38 (31.42, 39.35)
	p	0.001*	0.01*	0.01*	<0.0001*
Year graduated	70s	79.63 (76.81, 82.45)	63.33 (41.93, 84.73)	94.89 (91.79, 97.98)	29.27 (19.16, 39.39)
	80s	81.87 (79.43, 84.31)	89.67 (83.80, 95.53)	98.47 (97.69, 99.26)	39.24 (34.93, 43.54)
	90s	92.30 (90.02, 94.59)	100 (100, 100)	100 (100, 100)	60.72 (48.40, 73.03)
	p	<0.0001*	0.01*	0.01*	0.001*
Has post-graduate degree(s)	No	81.69 (78.79, 84.59)	88.00 (80.44, 95.56)	98.45 (97.49, 99.40)	38.50 (32.29, 44.71)
	Yes	85.05 (83.15, 86.95)	81.33 (68.74, 93.93)	96.99 (95.09, 98.89)	43.32 (37.96, 48.68)
	p	0.23	0.14	0.11	0.16

CI: confidence interval. *Statistically significant at the 5% level.

tistsin the present study, a person is classified as having/not having caries without differentiating between primary and permanent teeth (dmf/ DMF). The difference between the BSS and the HIO screening is in the use of the screening data; the BSS reports oral health data to the National Oral Health Surveillance System (NOHSS) (http://www.cdc.gov/nohss/), whereas the HIO screening refers children to treatment.

Methodological differences exist between the present study and other studies assessing the accuracy of simplified methods of oral examination and screening. These differences may limit direct comparison. Haleem et al[12] used wooden spatulas and toothpicks under natural light at the tooth level to detect caries. They reported higher Sn, Sp, PPV and NPV (97.08%, 99.70%, 97.84% and 99.59%, respectively) than the values in the present study for either VS or VSTB. Possible explanations for the higher values of accuracy parameters in Haleem et al's[12] study may be that their examiner was able to remove food debris from tooth surfaces using a toothpick and that there was only a single examiner who received training for examination and the application of the diagnostic criteria. Furthermore, results of Haleem et al's study and the present study may also differ because of the unit at which caries was diagnosed (subject level in the present study and tooth level in Haleem et al's study) and the fact that children free of caries (DMFT/ dft ≤ 1) were excluded from Haleem et al's study. In addition, there were differences in the purposes of the examination: in Haleem et al's study, the purpose was to increase awareness about dental treatment needs and in the current study, it was to refer for treatment.

In a study conducted by Beltran et al,[5] a hygienist and a dental nurse used tongue blades with a flashlight for intraoral illumination to visually assess different oral conditions. The accuracy of referring for any treatment need reported in that study was similar to that of the present study in terms of the values of Sn and Sp (83.28% and 92.44% for VS in the present study, 83.4% and 95.4% in Beltran et al) but with higher PPV for VS in the present study (98.82%) than in Beltran et al[5] (89%). However, the NPV in the present study was much lower than that reported by Beltran et al (44.13% and 92.9%, respectively).

In the present study, VS had significantly higher values than VSTB in most parameters. This may seem somewhat paradoxical, since it would be expected that the more instruments/aids used in screening or examination, the more accurate the results should be. However, this is not always true. In their systematic review of caries diagnostic methods, Bader et al[3] reported mean sensitivity values of 59%, 39% and 39% for detecting any occlusal lesion using visual, visual tactile and radiographic methods, respectively, and mean specifici-

ty values of 72%, 94% and 91%, respectively, for the same methods, indicating a decrease in sensitivity and an increase in specificity as more aids/instruments were used. An added sense of confidence attributed to the presence of the tongue blade may have affected the clinical judgment of the dentists or they may be more used to VS in the field so that they performed better with it than with VSTB. Based on this, VS may be recommended for use in screening in schools to a greater extent than VSTB. It also fits the description of screening and surveillance activities which are simpler than clinical examination performed in dental clinics and use less sophisticated instruments and diagnostic aids.[18]

Sensitivity reported in the present study was lower than specificity and both were ≥ 80% in most cases. Kingman[15] suggested that the sum of sensitivity and specificity of a marker/test/method should be at least 160 before it can be used in the community. Similarly, Wilson and Ashley[29] proposed that sensitivity and specificity of ≥ 80% would be acceptable. However, errors resulting from poor sensitivity and those related to low specificity have different consequences,[13] so that it is not useful to group both measures under the same standard of acceptable levels.

The calculated sensitivity and specificity of VS in the present study indicates that there would be lower chances of false positive rates compared to false negative rates (approximately 8% and 17%, respectively). This false positive rate means that 8 out of 100 disease-free children will be referred to the HIO clinic when there is actually no need. The false negative rate, on the other hand, indicates that 17 out of 100 children with caries are not identified during the screening on school premises and thus a chance is missed to provide them with the treatment they need. The low false positive rate adds little burden to the busy HIO dentists, since the time spent on 8% of the children who were referred although they were disease free can be used to stress the importance of oral hygiene and reinforce the health education message. The higher false negative rate is a greater problem. It may be argued that there is low risk to life associated with not providing treatment to these children since fatal oral diseases are less likely to occur in children. Furthermore, with the lower prevalence of caries today,[6] there is minimal chance that a missed lesion would develop quickly into something with serious consequences. However, the rationale of this screening is that the health-care system assumes the responsibility of drawing the attention of the patient and/or the patient's family to the presence of oral disease even if it is not fatal.[22] In addition, the next screening of schoolchildren by the HIO dentists would be scheduled three years later when the children are in the 4th grade of primary school. During this time, a missed lesion may proceed into the worst possible prognosis in children with unfavourable risk profiles.

The predictive values of the two screening methods lead to the same conclusions as do the Sn and Sp values. Out of each 100 children referred to the HIO clinic, only one would be sent away without treatment. Tact and good communication skills would be needed to explain to busy parents who take time off from work why their child will not be receiving any treatment. However, this single child out of 100 will not suffer any serious side effects or discomfort. Some parents may even consider a free dental checkup beneficial and would be relieved that there was nothing wrong and that no further visits are needed. Out of each ten children screened in schools and found not to be in need of referral, about six would be in actual need, thus depriving them of a chance to receive treatment. In a time when patients and their families are becoming increasingly aware of their rights, missing more than half the number of children in need of treatment would reflect badly on the dentists and expose them to complaints and threats of lawsuits. On the other hand, if dental awareness is limitied and the attitude towards dental disease leans towards accepting caries as part of life, it may be more realistic to expect no bad consequences from missing these children who need treatment. The bottom line, however, is that it is difficult to justify the time spent by the HIO dentists to screen and refer schoolchildren when the screening result indicating absence of caries is not correct in > 50% of the cases, so that these children do not receive the treatment they need.

Another problem may exist if screening is applied in schools where the need for referral is less prevalent, since it is reported that the positive predictive value may decrease, thus potentially creating a situation where both positive and negative predictive values are not optimal.[11] On the other hand, Petrie et al[22] commented that positive and negative predictive values of a test/method depend on its sensitivity and specificity in addition to the prevalence of the disease, and that as prevalence decreases, negative predictive values may increase. The direction and magnitude of change in

the predictive values need to be assessed under actual, real-life conditions of screening conducted in schools. However, a study conducted among first primary grade schoolchildren in Alexandria estimated the prevalence of caries (counted as lesions in any primary or permanent tooth) to be 78.1%,[9] which is not much lower than the prevalence of caries in the present study sample.

Male dentists and recent graduates performed consistently better, whereas mixed results were observed depending on whether the dentists had postgraduate degrees or not. The greatest effects of gender and year of graduation were observed on negative predictive values, although the higher values attained by male dentists and recent graduates still indicate missing at least four out of ten children who need referral. Thus, in spite of the better performance of a subset of the sample, assigning male dentists and/or recent graduates to screen schoolchildren will not improve accuracy to an acceptable level.

School dental screening has been and is widely advocated in many countries in different parts of the world.[20] The WHO endorsed dental screening of children in the school setting.[31] Milsom et al,[20] however, pointed out that evidence does not support the claim that screening improves health either for individual children or for the child population. They also recommended that country-specific research is required because of the weak evidence base for school dental screening.

CONCLUSION

The present study assessed the accuracy of screening that is usually practiced in a school setting which may help policy makers decide whether dental screening in schools should continue to be used and if it is a useful public health measure. The current screening methods used by the HIO dentists to refer children to treatment have an unacceptably low negative predictive value, which makes the success of the overall screening procedure unlikely. Training the HIO dentists to use standardised screening methods and criteria may in theory improve the accuracy of screening. However, the number of dentists and limited resources do not make this feasible. Thus, continuation of the screening as conducted in its present form is unjustifiable.

Accuracy of the screening is one factor that helps determine its success and usefulness. Other related factors include whether referred children and their families actually seek treatment and whether the provided treatment eventually improves oral health. Thus, further studies are needed to assess these other aspects of the screening process.

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