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Validity and Reliability of the 'Ten Questions' Questionnaire for Detecting Moderate to Severe Neurological Impairment in Children Aged 6–9 Years in Rural Kenya

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Key Words
Validity · Reliability · Neurological impairment

Abstract
Background: The 'Ten Questions' Questionnaire (TQQ) is used to detect severe neurological impairment in children living in resource-poor countries. Its usefulness has been established in Asia and the Caribbean, but there are a few published studies from Africa. We evaluated the TQQ as part of a larger study of neurological impairment in a rural community, on the coast of Kenya. ***Methods:*** The study was conducted in two phases from June 2001 to May 2002; in phase one, a community household screening of 10,218 children aged 6–9 years using the TQQ was performed. Phase two involved a comprehensive clinical and psychological assessment of all children testing positive on the TQQ (n = 810) and an equivalent number of those testing negative (n = 766). Data were interpreted using the impairment-specific approach. ***Results:*** Overall, the sensitivity rates for screening the different impairments were: cognitive (70.0%), motor (71.4%), epilepsy (100%), hearing (87.4%) and visual (77.8%). All the specificity rates were greater than 96%. However, the positive predictive values were low, and ranged from 11 to 33%. ***Conclusions:*** These results are similar to those from other continents and provide evidence that the TQQ can be used to compare the epidemiology of moderate/severe impairment in different parts of the world. Furthermore, the TQQ can be used to screen for moderately/severely impaired children in resource-poor countries; however, the low positive predictive values mean that other assessments are required for confirmation.

Background

There are few studies on the prevalence of neurological impairment (NI) in children in resource-poor countries, yet most of the neurological disorders are thought to occur in these areas [1]. In this region, identification of children with NI is difficult, since the major sources of referral used in western countries, i.e. schools and medical services, do not provide enough information to detect impairment [2]. Other techniques such as national census interviews or key informant techniques often underestimate the number of children with NI [3].

A 'Ten Questions' Questionnaire (TQQ) was developed to rapidly screen children aged 2–9 years for several types of impairment. Studies have been reported from Jamaica, Pakistan, Saudi Arabia and Bangladesh [4–9], but the use of the TQQ in other continents has not been

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Table 1. Definitions of moderate and severe impairment

Impairment	Moderate	Severe
Cognitive	some delay in attaining growth milestones, difficulty in speech as well as moderate cognitive deficit	fine motor deficits, delay in speech and in attaining growth milestones, as well as significant cognitive deficit
Motor	difficulty in holding implements, dressing and sitting upright, able to move around with help	inability to walk and absence of functional use of hands
Epilepsy	more than one nonfebrile seizure per month	more than one nonfebrile seizure per week
Hearing	a 41- to 70-dB loss in the best ear and difficulty in hearing even with a hearing aid	more than 70 dB loss in the best ear, no useful hearing
Vision	vision loss of 6/18 m	visual acuity worse than 6/60, only light perception

Source: WHO, 1980; Procedure Manual, 1987.

widely assessed. As part of a study to identify children with NI in a rural Kenyan community, we assessed the validity and reliability of the TQQ as a tool for identifying children with moderate to severe NI (table 1).

Methods

Study Setting

This study was conducted in a demarcated study area in the Kilifi District on the coast of Kenya. The area is subdivided into 87 enumeration zones, with sketch maps of each zone drawn in 1992 and updated in 2000, showing major landmarks, footpaths and homesteads, with their relative positions and survey numbers (fig. 1). The sketch maps were used to relocate each household both during the census in October 2000 and the NI survey between June 2001 and March 2002.

Population

A study population of 10,218 children aged 6–9 years was drawn from a population of about 100,000 people. This rural population consists mainly of the Mijikenda ethnic group, in which the Giriama subgroup predominates. This age group was chosen because it is more difficult to identify impairments in children younger than 6 years (particularly hearing and visual impairment), and due to the lack of culturally appropriate cognitive assessment tools for children below 6 years of age. Furthermore, since one of the aims of this study was to identify acquired NI, the most likely causes (bacterial meningitis and cerebral malaria) will only have occurred by the age of 6 years. Children in this age group were identified through the census conducted in October 2000. Only children who had been residing in the area for at least 6 months preceding the survey were included.

TQQ Screening Instrument

The TQQ consists of 10 questions (Appendix 1): 1 each addressing the child's vision, hearing, movement and seizures, 6 on cognition competence, and 1 extra question regarding other serious health problems. The questionnaire was translated into Kigiriama and back to English to ensure the intended meaning remained the same, before being used. A screening test was considered positive if there was a positive response to any one of the 10 questions.

Pilot Survey

A pilot survey was performed on 102 children who had earlier undergone both neurological and cognitive impairment as part of another study investigating the impact of malaria and seizures on epilepsy [Carter et al., in prep.]. Twenty-nine (28%) of these children had impairments.

Initially, 45% of the children tested positive on the TQQ, with global sensitivity and specificity values for any impairment of 47 and 55%, respectively. We explored the reasons for the highly positive result by checking the Kigiriama translation and the inter-interviewer administration of the questionnaire. In 4 focus group surveys, with 28 mothers from the community, questions 1, 3 and 4 were found to have been misunderstood. In question 1, the difficulty occurred in the concept of delay in developmental milestones. In this community, mothers tend to compare their child's development with those of other siblings; for instance, walking at the age of 11 months might not be a significant delay; however, a mother whose other children walked by the age of 8 months may consider this a delayed milestone. In question 3, a direct translation of the question to the local dialect resulted in two interpretations pertaining to hearing and inattention (an inattentive child). The Kigiriama translation was therefore revised to reflect the aspect of hearing alone. Likewise, question 4 had two interpretations: the child's understanding of simple instructions and a behavioral aspect (obeying of instructions).

After the revision, the questionnaire was again piloted on guardians of 439 children aged 6–9 years, before being administered to the target population. Eleven percent of the children tested positive, with questions 1 and 3 accounting for most of the positive responses.

Study Design

To test the validity of the TQQ, a two-stage design was followed. Stage one involved the screening of the entire population of children aged 6–9 years residing in the study area, using the TQQ tool. In stage two, all the children testing positive on the TQQ underwent comprehensive clinical and psychological assessments. Based upon

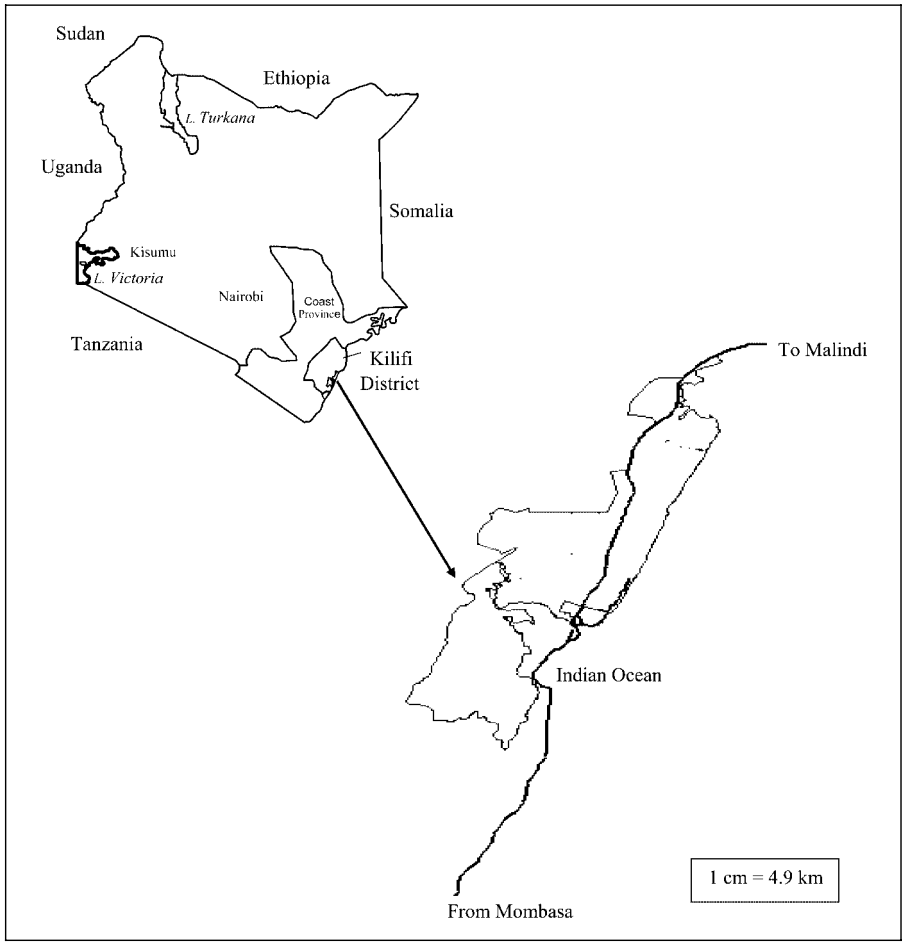

Fig. 1. Country and area of the study.

the pilot data and estimates from other studies [4–8], we chose to select every twelfth child who tested negative on the questionnaire to undergo similar assessments. The assessments focused on detecting impairments of vision, hearing, motor, and cognition, and the diagnosis of epilepsy. Assessments were performed within 1 week of the screening. None of the clinicians and assessors involved in the study knew the result of the TQQ screen at the time of the examination.

Household Screening

Five trained field interviewers fluent in Kigiriama performed the household screening after undergoing a week's training in field methods and questionnaire administration. The fieldworkers administered the TQQ to the guardians of between 80 and 100 children on each day. All those with at least 1 positive response and an equal number of children testing negative were referred to the research center for detailed assessment.

Psychological and Neurological Assessment

A team of 3 clinicians and 5 psychosocial assessors performed assessments. The assessments included a vision test, with the Sonksen-Silver Acuity system for measuring acuity distance [10]. Hearing was measured with a Kamplex screening audiometer to establish the hearing thresholds of the children. The thresholds were measured at 500, 1,000, 2,000 and 4,000 Hz [11]. Finally, motor impairments (clinical examination) were assessed. The diagnosis of epilepsy was based upon history elicited by clinicians, and an electroencephalogram used to classify the type of epilepsy. The electroencephalogram was performed on children who had a history of epilepsy (more than 1 seizure), with at least 1 seizure within the last 12 months, or had partial seizures. Local adaptations of assessments of cognition, speech and language were used. The cognitive assessment involved a 7-item battery, which included 'Panga Mutu' (testing intellectual and developmental maturity of a child through observing how a child deploys a set of basic skills to represent his/her knowledge of the human form) [12], a local adaptation of the matching familiar figures (assessing information processing speed and impulsivity) [13], digit span (auditory short-term memory) [14], a construction task using wooden sticks (simultaneous processing, visuomotor coordination, visuospatial perception and reasoning) [15], category fluency (executive function) [14], information questions [15] and picture vocabulary test (receptive vocabulary, verbal comprehension, achievement and association of pictures and words) [15]. The speech and language assessment battery included measures of comprehension, expression and the child's phonological system [16]. The neurological assessment involved eliciting birth, developmental and medical history, clinical and physical examination and observation of function and anthropometric measurement (height, weight, head and mid-upper arm circumferences).

Table 2. Screening results for children testing positive on the TQQ and the test-retest reliability kappa coefficients

	n	% positive	Kappa coefficients
Total	10,218	–	–
Positive on any question	955	9.3	–
1 Dev. milestones	417	4.1	0.2 (0.1–0.3)
2 Vision	40	0.4	1.0
3 Hearing	307	3.0	0.3 (0.2–0.4)
4 Cognitive	52	0.5	1.0
5 Motor	50	0.5	1.0
6 Seizure	125	1.2	1.0
7 Cognitive	17	0.2	1.0
8 Cognitive, speech	53	0.5	1.0
9 Cognitive, speech	103	1.0	1.0
10 Cognitive	197	1.9	0.7 (0.6–0.8)

Figures in parentheses indicate 95% CIs.

TQQ Reliability

Three months after the survey, the TQQ was readministered to the guardians of 270 children by a second interviewer to test for inter-rater agreement of the questions.

Data Storage and Analysis

All phase 1 and 2 data were double-entered and verified with the Fox-pro version 4 software. Impairment-specific interpretations [8] were adopted, in which a child with a given impairment had to be positive for at least 1 screening question specific to that impairment in order to be considered a true-positive. For example, a child with a cognitive impairment has to test positive for at least 1 question on cognitive competence for him/her to be considered to have a cognitive impairment.

Sensitivity, specificity, positive and negative predictive values were calculated to measure the validity of the TQQ [17]. Cohen's kappa scores were used to measure the test-retest reliability [17].

Results

A total of 10,218 children were screened, of whom 955 (9.3%) were positive (table 2). Delayed milestones and hearing problems were the most common types of problems reported, while learning and visual problems were the least reported (table 2). There was no difference between the sexes in those screened.

In total, 1,576 underwent assessment, and 810 (51.4%) of them were those who tested positive on the TQQ. Half of these children were (51.4%) boys. Overall the sensitivity of the TQQ to detect the different impairments (moderate/severe and severe only) was greater than or equal to 70% for all domains, with lowest for cognitive impairment (70.0%) and highest for epilepsy (100%; table 3). In this study, specificities were high (>71%) for all the impairments; however, positive predictive values (PPV) were low. There was a difference in sensitivity rates between boys and girls in the cognition (63.4 vs. 48.1%) and motor (66.7 vs. 80.0%) domains.

In total, 322 (20%) of the children assessed had some form of impairment. Twenty percent of them were those who tested negative on the TQQ. From this group (false-negatives) 45% were aged 7 years and 66.2% were females. The associated impairments for the false-negatives were cognition in 70.9% of the children, epilepsy in 24.6% and hearing and vision in 4.5%.

Reliability of the TQQ

The test-retest reliability of the TQQ was excellent for questions on vision, motor, seizures, speech and 4 of the questions on cognition (table 2). It was fair on the general questions about developmental milestones and hearing.

Psychological and Clinical Assessments

The interrater agreement of the clinical examinations was good (kappa 0.40–0.75), with that of epilepsy being excellent (kappa = 0.78). For the cognitive and language tests, the statistical measurements of interrater reliability were at an acceptable level of congruence between assessors, with the mean difference in scores being less than 10% of the mean score [18].

Discussion

This study demonstrates that the TQQ is reliable and useful for detecting moderate/severe impairment in children aged 6–9 years in rural Africa. The high sensitivity ensures that most cases of NI are identified, while the very high specificity means that resources can be targeted towards assessing these children. The low PPV suggests that a large number of the children who screen positive on the TQQ are false-positives for moderate or severe impairment. Many of these children may have mild impairments. This suggests that the TQQ alone is insufficient for use in case finding in epidemiological studies of severe impairment, but still remains useful as a screening tool in selecting cases for further assessment.

Unlike in the other studies where only 6–10% of children who screened negative were evaluated, findings from our study are stronger in that an equivalent number of those that screened negative were evaluated [4–8]. These studies had comparable sensitivities for cognition and

Table 3. Estimated sensitivity, specificity, positive and negative predictive values of the TQQ screen for moderate to severe impairment in 10,218 children screened and 1,576 assessed

Impairment	Sensitivity		Specificity		Positive predictive value		Negative predictive value	
	moderate/severe	severe	moderate/severe	severe	moderate/severe	severe	moderate/severe	severe
Cognitive	70.0 (63.2–76.0)	79.1 (72.2–84.9)	71.4 (69.1–73.6)	71.2 (69.0–73.4)	23.9 (20.7–27.6)	22.8 (19.6–26.4)	94.8 (93.5–96.0)	96.9 (95.8–97.8)
Motor	71.4 (47.7–87.8)	100 (56.1–100)	98.3 (97.5–98.8)	98.0 (97.2–98.6)	32.6 (20.0–48.1)	18.4 (8.3–34.9)	99.7 (99.2–99.9)	100 (99.9–100)
Epilepsy	100 (73.2–100)	100 (67.9–100)	92.9 (91.5–94.1)	92.8 (91.4–94.0)	11.2 (6.5–18.4)	8.8 (4.7–15.6)	100 (99.7–100)	100 (99.7–100)
Hearing	87.4 (78.1–93.2)	92.9 (75.0–98.8)	85.5 (83.6–87.1)	84.3 (82.6–86.0)	24.8 (20.1–30.0)	8.5 (5.7–12.3)	99.2 (98.5–99.6)	99.9 (99.5–100)
Vision	77.8 (40.2–96.1)	80.0 (29.9–98.9)	98.0 (97.4–98.7)	98.0 (97.2–98.5)	17.5 (7.9–33.4)	9.8 (3.2–24.1)	99.9 (99.5–100)	99.9 (99.6–100)

Figures in parentheses indicate 95% CIs.

Table 4. A comparison of sensitivities and specificities for moderate/severe impairment for Kilifi (Kenya), Bangladesh and Pakistan

		Rural Kilifi (Kenya)	Rural Bangladesh [6]	Urban Karachi (Pakistan) [8]
Screened subjects		10,218	7,635	6,365
Age of children, years		6–9	2–9	2–9
Cognitive	sensitivity	70.0	65.0	76.0
	specificity	71.4	91.3	91.0
Motor	sensitivity	71.4	100	75.0
	specificity	98.3	91.4	96.0
Epilepsy	sensitivity	100	100	93.0
	specificity	92.9	91.0	96.0
Hearing	sensitivity	87.4	100	54.0
	specificity	85.5	91.2	99.0
Visual	sensitivity	77.8	100	34.0
	specificity	98.0	91.1	99.0

epilepsy. The sensitivity of the TQQ in Kilifi was not as high as that reported from a rural Bangladeshi population, for motor, hearing and vision, but higher than that from a urban Pakistani population for hearing and vision (table 4). All these studies used impairment-specific interpretation of the data. The differences in the sensitivity and specificity could have been caused by different cultural perceptions of impairment, differences in the development of the questionnaire or population groups (rural vs. urban). It is clear that the TQQ does require considerable development, piloting and reliability tests before being utilized.

Vision, hearing and cognitive impairments are often underreported by parents [19]. In our study, the TQQ was able to detect moderate/severe impairments in vision and hearing. The low sensitivity for detection of cognitive impairment may have arisen from the poor reliability of question number 1 on the child's development. Furthermore, the assessments of cognitive impairment were not comprehensive, but were developed to test the main domains of cognition within an hour. A more detailed assessment of cognition may indicate that the TQQ has a higher sensitivity for cognitive impairment.

Reliability data for the TQQ were shown to be consistent over time for all the questions except for the questions on milestones (question number 1) and hearing (question number 3) where the reliability was fair [17]. The lower level of reliability on the hearing question may have been due to misunderstandings about the nature of persisting hearing impairment, within this culture, partic-

ularly parents' perception of a child's inattention compared with actual deafness. Furthermore, fluctuating hearing levels due to ear infections or upper respiratory tract infections may have contributed to this result. However, the results suggest that the TQQ is a reliable tool, a finding that was also demonstrated by the Pakistani study, which established reliability coefficients in the range of 0.6–0.8 [20].

We have found that the TQQ is a useful screen for moderate/severe NI in epidemiological studies of children because of its ability to identify more than 70% of the seriously impaired children. However, the low PPV means that it should not be used alone to detect such impairments.

Appendix 1

The 'Ten Questions' Questionnaire

(1) Compared with other children, did the child have any serious delay in sitting, standing or walking?

(2) Compared with other children, does the child have difficulty in seeing, either in the daytime or at night?

(3) Does the child appear to have difficulty in hearing?

(4) When you tell the child to do something, does he/she seem to understand what you are saying?

(5) Does the child have difficulty in walking or moving his/her arms or does he/she have weakness and/or stiffness in the arms or legs?

(6) Does the child sometimes have fits, become rigid, or lose consciousness?

(7) Does the child learn to do things like other children of his/her age?

(8) Does the child speak at all (can he/she make himself/herself understood in words; can he/she say some recognizable words)?

(9) Is the child's speech in any way different from normal (not clear enough to be understood by people other than his/her immediate family)?

(10) Compared with other children of his/her age, does the child appear in any way mentally backward, dull or slow?

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