Evaluation of an algorithm for integrated management of childhood illness in an area of Kenya with high malaria transmission

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In 1993, the World Health Organization completed the development of a draft algorithm for the integrated management of childhood illness (IMCI), which deals with acute respiratory infections, diarrhoea, malaria, measles, ear infections, malnutrition, and immunization status. The present study compares the performance of a minimally trained health worker to make a correct diagnosis using the draft IMCI algorithm with that of a fully trained paediatrician who had laboratory and radiological support.

During the 14-month study period, 1795 children aged between 2 months and 5 years were enrolled from the outpatient paediatric clinic of Siaya District Hospital in western Kenya; 48% were female and the median age was 13 months. Fever, cough and diarrhoea were the most common chief complaints presented by 907 (51%), 395 (22%), and 199 (11%) of the children, respectively; 86% of the chief complaints were directly addressed by the IMCI algorithm. A total of 1210 children (67%) had Plasmodium falciparum *infection and 1432 (80%) met the WHO definition for anaemia (haemoglobin <11 g/dl). The sensitivities and specificities for classification of illness by the health worker using the IMCI algorithm compared to diagnosis by the physician were: pneumonia (97% sensitivity, 49% specificity); dehydration in children with diarrhoea (51%, 98%); malaria (100%, 0%); ear problem (98%, 2%); nutritional status (96%, 66%); and need for referral (42%, 94%). Detection of fever by laying a hand on the forehead was both sensitive and specific (91%, 77%). There was substantial clinical overlap between pneumonia and malaria (*n *= 895), and between malaria and malnutrition (*n *= 811).*

Based on the initial analysis of these data, some changes were made in the IMCI algorithm. This study provides important technical validation of the IMCI algorithm, but the performance of health workers should be monitored during the early part of their IMCI training.

Introduction

Diarrhoeal disease, acute respiratory infection (ARI), malaria and measles cause more than half of the estimated 12.7 million annual deaths in children under 5 years of age (*1*). In 1993 the World Health Organization (WHO) completed the development of a draft algorithm for the integrated management of childhood illness (IMCI), which deals with acute respiratory infections (ARI), diarrhoea, malaria, measles, ear infections, malnutrition, and immunization status. The algorithm is based on the experience of programmes of diarrhoeal diseases and ARI management, which has been shown to decrease the disease-specific and overall mortality among young children (*2–5*), and also takes into account the concerns that disease-specific algorithms might not result in optimal management of sick children. Recent studies have suggested that a disease-specific orientation may not be ideal where disease syndromes overlap in clinical presentation, where diagnostic resources are limited, and where many children present with multiple acute and chronic illnesses (*6–8*). In addition, developing single (or vertical) programmes for a number of disease processes (e.g. malaria, malnutrition, human immunodeficiency virus (HIV) reduces the efficiency of already over-extended health facilities and personnel in management, training, and resource utilization.

The present study was designed to compare the

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performance of a minimally trained health worker to make a correct diagnosis using the newly developed IMCI algorithm with that of a fully trained paediatrician who had laboratory and radiological support.

Patients and methods

The study was conducted at Siaya District Hospital (SDH), a 200-bed Ministry of Health facility in Nyanza Province in western Kenya. This hospital is the primary referral centre for approximately 600000 persons who live in the district; about 50 ill children are seen daily in the outpatient paediatric clinic.

Before the study began, an experienced physician from WHO gave on-site training in the use of the IMCI algorithm to the participating health workers and the physician. All the health workers were high school graduates whose formal training in health care ranged from none (or minimal) to completion of a 2-year clinical officer training programme provided by the Kenyan government. All the children in the study were evaluated by health workers who had completed this training on the IMCI algorithm. The physician was a Kenyan medical graduate with specialty training in paediatrics at Kenyatta National Hospital in Nairobi, Kenya. Being a native of the area where the study was conducted, she was familiar with local languages and customs.

A systematic sample of sick children (e.g., every 5th or 10th), aged between 2 months and 5 years, was selected from among those waiting to be seen in the outpatient paediatric clinic. Consent for participation was obtained from the child's carer who was usually the mother. The health worker first laid a hand on the child's forehead to test for the presence of high fever; the result was recorded prior to the measurement of axillary temperature using a digital thermometer (≥37.5 °C was considered febrile). The child's illness was classified using the IMCI algorithm, the data being collected on a form similar in format to the IMCI recording form.

The child was then evaluated by the physician without knowledge of the health worker's assessment using the IMCI algorithm. The physician carried out a complete standardized history and physical examination that included all the symptoms and signs on the IMCI algorithm as well as additional information. The physician was instructed to assess signs and symptoms included on the IMCI algorithm as she had been taught to do by the trainer. For signs and symptoms not included on the chart she was instructed to use her judgement based on her medical training and experience.

After the physician had completed the history and physical examination form, all the children underwent laboratory evaluation. *Haemoglobin* was measured from a capillary finger-prick blood sample (HemoCue, Mission Viejo, CA, USA). Severe anaemia was defined as a haemoglobin level <5 g/dl; children with moderate anaemia had haemoglobin levels in the range 5.0–7.9 g/dl. Anaemia was diagnosed when the haemoglobin level was <11.0 g/dl, which is the WHO definition for children aged 6 months to 6 years (*9*).

Thick and thin blood smears were stained with 3% Giemsa for 30 minutes. The number of *malaria parasites* were determined per 300 white blood cells and parasite density was calculated using the white blood cell count, or assuming 8000 white blood cells/mm^3 if no white blood cell count was available. Parasitaemia was considered to be clinically significant if there were more than 5000 parasites/mm^3.

Serology for *human immunodeficiency virus-1* (HIV-1) was carried out using an enzyme-linked immunosorbent assay (ELISA) (Wellcozyme, Wellcome Laboratories, Research Triangle Park, NC, USA); all positive results were confirmed by Western blot (Dupont de Nemours, Geneva, Switzerland).

Blood cultures were obtained if the child's oral temperature was ≥37.5 °C, if a chest X-ray showed pneumonia, or if a lumbar puncture was indicated.

Chest radiographs were obtained if a child was classified as having severe pneumonia or pneumonia by the health worker using the IMCI algorithm during the first year of the study. After the first year of the study, chest radiographs were ordered by the physician when required. Chest radiographs were read by the physician at the time of study enrolment and by a paediatric radiologist at Emory University (Atlanta, GA, USA), who had no knowledge of the clinical history or the physician's interpretation of the radiograph.

After the laboratory results (haemoglobin and blood smear for malarial parasites) and chest radiograph had been interpreted by the physician, she was asked to classify the child using both the IMCI algorithm and her clinical judgement supported by the laboratory and X-ray results. She also decided on a treatment and management plan that could include follow-up in the clinic or referral for hospitalization. All decisions about management of children were made by the physician, regardless of the health workers' classification using the IMCI algorithm. All the children who were admitted to the hospital were followed up to determine the outcome of hospitalization.

Sensitivities and specificities for components of the IMCI algorithm (signs and symptoms as well as disease classifications) were calculated using the physician (plus laboratory and radiological support) as a "gold standard". Since most of the IMCI algorithm classifications have three levels of severity (for ear pain, the classification of ear infection is subdivided into acute and chronic ear infection), and the first two levels indicate severe disease and disease requiring specific treatment at home, these two levels were combined for comparison with those children who were judged to have no disease or to require only supportive care at home. With cough, for example, the sensitivities and specificities of severe pneumonia or very severe disease and pneumonia were compared to no pneumonia. Children with a severe classification were recommended to be referred for hospitalization; the sensitivity and specificity for such referral were calculated for the overall IMCI algorithm, compared to the physician's recommendation for referral, rather than for specific diseases. Data were entered in dBASE3 and analysed using Epi Info version 6.0 (Centers for Disease Control and Prevention, Atlanta, GA, USA) and SAS (SAS Institute Inc., Cary, NC, USA).

Results

During the 14-month study period (June 1993 to September 1994), 1795 children (48% female) were enrolled, with a mean age of 17.7 months and median age of 13 months.

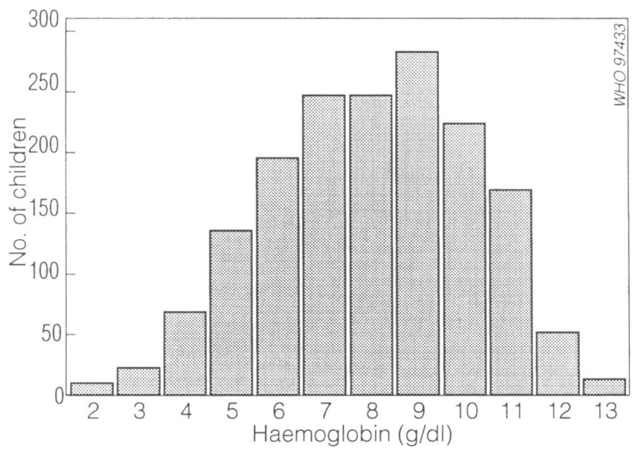
Fever, cough and diarrhoea were the most common chief complaints and accounted for 907 (51%), 395 (22%), and 199 (11%) children, respectively. Swelling of an extremity or of the face (n = 40) and ear pain (n = 12) were the chief complaints of an additional 52 children. If swelling of an extremity or of the face was considered to be a manifestation of malnutrition, the IMCI algorithm addressed the chief complaints of 1553 children (86%). An additional 58 children (3%) presented with skin-related complaints including skin wound, ulcer or sore (n = 29), skin rash (n = 27), and pruritus (n = 2).

Of the enrolled children, 785 (44%) had an axillary temperature of ≥37.5 °C; among these the median temperature was 38.5 °C. A total of 1210 children (67%) had evidence of *Plasmodium falciparum* infection on blood smear (mean parasitaemia per mm^3 = 18600, SD = 27100, median = 7400); 857 children (48%) had more than 2500 parasites/mm^3 and 721 (40%) had more than 5000 parasites/mm^3. The distribution of haemoglobin values is shown in Fig. 1 (mean haemoglobin = 8.5 g/dl, SD = 2.2, median = 8.5 g/dl).

Testing for HIV-1 virus infection was carried out on sera from 1315 children; 127 (9.6%) were positive for antibody by ELISA and 105 of these were confirmed by Western blot (3 were negative, 8 were indeterminant, and 11 were not tested). A total of 66 (63%) of the children with Western blot confirmation were under 1 year of age (range, 2–10 months).

The three danger signs used by the IMCI algorithm to identify children requiring immediate referral were relatively uncommon; a recent history of convulsion was reported for 46 (2.6%) children, 10

Fig. 1. **Distribution of haemoglobin levels (g/dl) among 1666 study children.**



children were abnormally sleepy or difficult to wake up, and only 3 children were unable to drink.

The four key symptoms questions (see below), asked of all children during IMCI algorithm evaluation revealed that recent fever and cough were the most common and were reported in 1675 (93%) and 1405 (78%) children, respectively. Diarrhoea and an ear problem were reported in 679 (38%) and 177 (10%) children, respectively. Table 1 summarizes the sensitivities and specificities of classifications using the IMCI algorithm, compared with the physician's diagnoses using laboratory and radiological support.

- *Is the child coughing?*

Children with cough were classified by the IMCI algorithm as having severe pneumonia or very severe disease if they had danger signs, chest indrawing, or stridor. Children with fast breathing (≥50 breaths per minute for a child aged 2–12 months; ≥40 per minute for a child aged 12 months to five years) and no chest indrawing were classified as having pneumonia.

Since danger signs and stridor, which was not identified by the health workers and was reported only once by the physician, were rare, most children were classified by the IMCI algorithm based on the presence or absence of chest indrawing and fast breathing. The sensitivity of the health worker, compared to the physician, in detecting chest indrawing was 57%; specificity was 97%, and there were 41 false positives. The sensitivity and specificity for detection of fast breathing were 86% and 64%, respectively; there were 197 false positives.

Table 1: **Integrated management of childhood illness (IMCI) algorithm classifications of children by health workers, compared with diagnoses by the physician using laboratory and radiological support, with sensitivities, specificities and false positives of the health workers' classifications**

IMCI algorithm classifications	Health workers[a]	Physician[b]	Sensitivity, specificity[c]	False positives[c]
Cough (*n* = 1405):				
Severe pneumonia[d]	132 (9)[e]	3 (0)[e]		
Pneumonia	833 (59)	543 (39)	97%, 49%	434
No pneumonia	440 (31)	858 (61)		
Diarrhoea (*n* = 679):				
Severe dehydration[d]	6 (1)	1 (0)		
Some dehydration	35 (5)	50 (7)	51%, 98%	15
No dehydration	638 (94)	628 (92)		
Fever (*n* = 1674):				
Fever requiring referral[d]	56 (3)	280 (16)		
Malaria	1617 (96)	938 (56)	100%, 0%	456
Malaria unlikely	1 (0)	456 (27)		
Ear problem (*n* = 177):				
Mastoiditis[d]	1 (0)	0		
Acute ear infection	161 (91)	42 (24)		
Chronic ear infection	11 (6)	9 (5)	98%, 2%	123
No ear infection	4 (2)	126 (71)		
Nutritional status (*n* = 1792):				
Severe malnutrition[d]	111 (6)	71 (4)		
Malnutrition	766 (43)	354 (20)	96%, 66%	471
No malnutrition	915 (51)	1269 (71)		
Referral (*n* = 1794)				
Yes	243 (14)	399 (22)		
No	1551 (86)	1395 (78)	42%, 94%	77

[a] Classifications by the health workers using only the IMCI algorithm.
[b] Classifications by the physician after measurement of temperature, haemoglobin determination, blood smear for malarial parasites, and chest X-ray.
[c] Top two (top three for ear problem) classifications were combined for comparison to "no" or "unlikely" classifications for the calculation of sensitivities, specificities and identification of false positives, except for hospital referral.
[d] The IMCI algorithm recommends that children with this classification (in **bold** type) should be referred for hospitalization.
[e] Figures in parentheses are percentages.

Of the 678 children classified by the IMCI algorithm as having pneumonia or severe pneumonia during the first year of the study (from 14 June 1993 to 13 June 1994), 597 (88%) had chest X-rays. The physician interpreted 356 (59%) of these as consistent with pneumonia, while the paediatric radiologist read only 68 (11%) as having pneumonia (sensitivity = 92% and specificity = 34%).

The physician reported abnormal auscultatory findings in 165 (24%) of the 678 children classified as having pneumonia or severe pneumonia; 152 (92%) of these children had chest X-rays and 37 (24%) were found to be consistent with pneumonia by the paediatric radiologist. The most commonly reported findings were rales (or crepitations) in 109 (66%) children; rhonchi were identified in 60 (34%), decreased air entry in 42 (26%), and bronchial breathing in 12 (7%).

If children with severe pneumonia or pneumonia were confined to those who showed pneumonia in their chest X-ray (as interpreted by the paediatric radiologist) or had one or more abnormal auscultatory signs (found by the physician), the sensitivity and specificity of the IMCI algorithm for identification of severe pneumonia or pneumonia versus no pneumonia was 90% and 41%, respectively.

• *Does the child have diarrhoea?*

The signs and symptoms evaluated on all children with diarrhoea included the following: general condition (abnormally sleepy or difficult to wake up, restless and irritable, or well and alert); eyes (very sunken and dry, sunken, normal); tears (absent, present); mouth (very dry, dry, moist); thirst (assessed by offering fluid: drinks poorly or not able to drink, drinks eagerly — thirsty, drinks normally — not thirsty); and skin pinch of abdomen or thigh (goes back very slowly — longer than 2 seconds, slowly, quickly). Table 2 shows the numbers of children reporting diarrhoea who were found by the health worker and physician to have abnormalities associated with dehydration based on the draft IMCI algorithm (see Fig. B, in introductory article in this Supplement (*20*)); the sensitivities and specificities for detection of these signs and symptoms by the health worker when compared to the physician are also shown.

Table 2: **Evaluation of dehydration in children with diarrhoea by health workers and the physician, with sensitivities and specificities**

Parameters for assessment of dehydration	No. of children with diarrhoea (*n* = 679) consistent with dehydration: Health workers	Physician	Sensitivity, specificity
General condition	12 (2)[a]	27 (4)[a]	28%, 99%
Eyes	58 (8)	63 (9)	60%, 97%
Tears	18 (3)	24 (4)	21%, 98%
Mouth	28 (4)	67 (10)	27%, 98%
Thirst	42 (6)	29 (4)	64%, 96%
Skin pinch	28 (4)	27 (4)	63%, 96%

[a] Figures in parentheses are percentages.

Of the 640 children who reported diarrhoea (to both health worker and physician), 520 (81%) had three or more loose stools during the preceding 24 hours (range 0–20, mean 4.9, median 5) and 212 (33%) had three or more vomiting episodes during the previous 24 hours.

Of the 679 children who reported diarrhoea, 5 (1%) were classified as having severe persistent diarrhoea and 20 (3%) as having persistent diarrhoea by the health worker using the IMCI algorithm. The physician classified 2 children as having severe persistent diarrhoea and 19 as having persistent diarrhoea. The sensitivity and specificity of the health workers' classifications of severe persistent and persistent diarrhoea versus no persistent diarrhoea, compared to the physician's diagnoses, was 48% and 98%, respectively. The health worker identified 55 (8%) children and the physician 33 (5%) children with a history of blood in stools. The sensitivity and specificity of the health workers' classifications of dysentery versus no dysentery, compared to the physician's diagnoses, was 85% and 96%, respectively.

• *Has the child had fever?*

Children with a history of fever were classified by the IMCI algorithm as having fever that required referral, malaria, or malaria unlikely. If a child had a danger sign (as detailed earlier) or a stiff neck, they were classified as fever requiring referral. If there was fever by measurement or touch by the health worker, the child was considered to have malaria; if there was no fever, the child was classified as malaria unlikely. If children had a rash and at least one of the following: cough, runny nose or red eyes, they were additionally classified as having measles requiring referral, complicated measles, or uncomplicated measles, based on the presence or absence of a sore mouth and mouth ulcers, pus draining from the eye, and clouding of the cornea.

Among children presenting with a history of fever, the detection of high fever by touch compared to measured axillary temperature ($\geq$37.5 °C was considered febrile) was 89% sensitive and 92% specific by the health worker, and 91% sensitive and 77% specific by the physician.

Questions were asked about the duration of the fever, if the fever was intermittent, whether there were chills, sweats or shaking (asked as one question by the health worker and separately by the physician), and if there had been vomiting repeatedly. The median duration of fever was 3 days (range, 1–120 days). Having fever for less than 3 days (odds ratio (OR) = 1.02; 95% CI = 0.81–1.29) or less then 4 days (OR = 1.13; 95% CI 0.92–1.39) was not significantly associated with malaria (defined as >5000 parasites/mm^3). Fever was reported to be intermittent in over 90% of children, and was not associated with malaria parasitaemia. Similarly, when the health worker asked if the children had experienced chills, sweats or shaking, over 97% were affirmative, but there was no association with malaria. However, when asked as separate questions by the physician, chills (OR = 1.4; 95% CI = 1.1–1.7; P = 0.002) and shaking (OR = 1.4; 95% CI = 1–1.9; P = 0.046) were weakly associated with malaria by univariate analysis. Sweats (OR = 0.92; 95% CI = 0.72–1.2) were not associated with malaria. Repeated vomiting was rare; it was reported in only 3 children evaluated by the health worker and in 20 children by the physician.

According to the physician's examination, splenomegaly (OR = 2.5; 95% CI = 2.0–3.2) and hepatomegaly (OR = 2.1; 95% CI = 1.6–2.7) were both associated with malaria. The presence of palmar pallor on examination by the physician was also associated with malaria (OR = 2.8, 95% CI = 2.5–3.5).

Only 9 children were classified as having measles by the health worker using the IMCI algorithm (2 with complicated measles and 7 with measles). The physician identified 12 children she thought had measles. (3 with complicated measles and 9 with straightforward measles). The sensitivity and specificity of the health worker using the IMCI algorithm, compared to the physician, for identification of measles was 33% and 100%, respectively.

- *Does the child have an ear problem?*

Children with a reported ear problem were classified by the IMCI algorithm as having mastoiditis, acute ear infection, chronic ear infection, or no ear infection. If there was a tender swelling behind the ear the child was classified as having mastoiditis. If there was ear pain or if pus was seen draining and discharge was reported for less than two weeks, the child was considered to have an acute ear infection. If pus was seen draining from the ear and discharge was reported for 2 weeks or more, the child was classified as having a chronic ear infection. Children were considered to have no ear infection if they had no ear pain and no pus was seen draining from the ear.

The low specificity for classification of ear problems using the IMCI algorithm was due to comparison of the reported ear pain or acute discharge with the physician's diagnosis using an otoscope to visualize the tympanic membrane. Of the 161 children classified by the health worker using the IMCI algorithm as having an acute ear infection, 135 (84%) had both tympanic membranes adequately visualized by the physician, but only 17 (13%) of these were considered to have had otitis media by the physician.

The sensitivity and specificity of the health worker's detection of pus draining from the ear was 97% and 95%, respectively, compared to the physician. Among the 31 children identified as having pus draining from the ear by the physician, 74% had at least one perforated tympanic membrane; 16% of the children had bilateral perforations. The median duration of ear discharge reported to the physician was 4 days (range, 1–240 days).

Checking for malnutrition

All children underwent evaluation for malnutrition using the IMCI algorithm. They were classified as having severe malnutrition, malnutrition, or no signs of malnutrition based on criteria that included severe visible wasting, oedema of both feet, conjunctival pallor (severe pallor, pallor, or normal), foamy patches on the white of the eye, and weight-for-age. Children were considered to have severe malnutrition if they had visible severe wasting, severe pallor, foamy patches on the white of the eye, or oedema of both feet. If they had a low weight-for-age, foamy patches on the white of the eye, or pallor they were

Table 3: **Evaluation of nutritional status by health workers and the physician, with sensitivities and specificities**

Parameters for assessment of malnutrition	No. of children with signs of malnutrition: Health workers	Physician	Sensitivity, specificity
Visible severe wasting	27 (2)[a]	49 (3)[a]	49%, 100%
Oedema of hands and feet	20 (1)	29 (2)	59%, 100%
Conjunctival pallor			
Severe pallor	38 (2)	59 (3)	
Pallor	530 (30)	893 (50)	52%, 91%
Normal	1227 (68)	843 (47)	
Foam patches on white of eye	0	14 (1)	0, 100%
Weight-for-age:			
Very low	65 (4)	—	—
Low	479 (27)		
Normal	1241 (69)		

[a] Figures in parentheses are percentages.

considered to have malnutrition. Children were considered to have no signs of malnutrition if they did not have a low weight-for-age and had no other signs of malnutrition.

Table 3 shows the number of children found by health workers and the physician using the parameters for assessment of malnutrition; the sensitivities and specificities for detection of these signs by the health worker when compared to the physician are also shown.

The performance of the clinical signs of anaemia compared to measured haemoglobin is presented elsewhere in this Supplement (*10*).

Referral for hospital admission

A total of 233 children who were referred for hospital admission by the physician were not classified as needing hospital admission by health workers using the IMCI algorithm. Table 4 shows selected characteristics associated with these children (n = 233), compared with children not referred for hospitalization by the physician or health workers using the IMCI algorithm (n = 1319).

Overlaps

Pneumonia and malaria. Of the 1795 children enrolled, 1330 (74%) had a history of cough and fever; 895 (50%) were classified as having malaria and pneumonia by the health worker using the IMCI algorithm.

Malaria and malnutrition. Of the 1617 children who had a history of fever and were classified as having malaria, 811 (50%) were also classified as having severe malnutrition or malnutrition by the health worker; 524 (64%) of these children had conjunctival pallor.

Blood and cerebrospinal fluid cultures

Blood cultures were obtained from 577 children; 566 (98%) had a history of fever, 399 (69%) had an axillary temperature of ⩾37.5°C and 224 were thought to have pneumonia according to the chest X-ray (as interpreted by the physician, but only 37 were confirmed by the radiologist). *Salmonella* spp. were the most frequently isolated pathogenic organisms; 29 children (5% of those tested) had *Salmonella* spp. isolated from the blood (*Salmonella* non-*typhi*, 26; other *Salmonella* species, 2; *Salmonella typhi*, 1). Other organisms identified included *Staphylococcus aureus* from 18 children, *Streptococcus pneumoniae* from 4 children, *Escherichia coli* from 2 children, and other Gram-negative rods (lactose and oxidase negative) from 2 children.

Of 11 children who underwent lumbar punctures, cultures of cerebrospinal fluid (CSF) were positive in only one child who had *Salmonella* non-*typhi* isolated.

While 19 (63%) of the 30 children with *Salmonella* spp. isolated from the blood or CSF were referred for hospital admission by the physician after initial evaluation, only 5 (17%) of these children

Table 4: **Selected characteristics associated with children referred for hospitalization by the physician but not by the health workers using the IMCI algorithm, compared to children not referred for hospitalization by the physician or health workers**

Characteristic	No. referred for hospitalization by the physician but not by the health workers (n = 233)	No. not referred for hospitalization by the physician or by health workers (n = 1319)	Odds ratio/ 95% confidence interval
Physician's diagnosis of malaria and anaemia	72 (31)[a]	420 (32)[a]	1.0/0.7–1.3
Three or more disease classifications by health workers using the IMCI algorithm	120 (52)	370 (28)	2.7/2–3.6
Fever (⩾37.5°C axillary)	174 (75)	500 (38)	4.8/3.5–6.7
Fast breathing	202 (87)	662 (50)	6.5/4.3–9.8
Anaemia (haemoglobin <8.0 g/dl)	143 (61)	405 (31)	3.6/2.7–4.8
Malaria parasitaemia (>5000/mm^3)	130 (56)	479 (36)	2.2/1.6–3

[a] Figures in parentheses are percentages.

were referred for hospitalization by the health worker using the IMCI algorithm. Similar trends were seen among the 18 children with *S. aureus* bacteraemia and the 4 children with *S. pneumoniae* bacteraemia. Among the children with *S. aureus* infections the physician referred 6 (33%) for hospitalization, compared to 3 (17%) by the health worker using the IMCI algorithm. Of the 4 children with *S. pneumomiae*, all were referred for hospitalization by the physician compared to two by the health worker using the IMCI algorithm.

Discussion

The present study on the classification of childhood illness by minimally trained health workers using the IMCI algorithm, compared to a fully trained paediatrician with some laboratory and radiological support, reveals a range of sensitivities (51–100%) and specificities (0–98%), depending on the type of disease (Table 1). In general, the IMCI algorithm was designed to provide adequate sensitivity for detection of disease, even at the expense of specificity. With the exception of classification of diarrhoea (sensitivity, 51%) and referral for hospital admission (42%), we found the IMCI algorithm to be sensitive. The classification of fever and ear problem had low specificities (0% and 2%, resp.) because the physician was able to exclude malaria on the basis of a blood smear and ear infections through otoscopy. Specificities for classification of cough (49%), diarrhoea (98%), and nutritional status (66%) were higher.

The IMCI algorithm directly addressed 86% of all primary chief complaints among children who presented at the first-level health facility we used for our study. It may be possible to gain some additional coverage of chief complaints by adding a section to the IMCI algorithm concerning the classification and management of skin problems, but this would have resulted in only a minimal gain (about 3%) in our study population. There are reports suggesting that this proportion may be higher in other developing countries (*11–13*).

Anaemia and malaria were the predominant health problems in our study population (*14*): 80% of all enrolled children met the WHO definition for anaemia (haemoglobin <11 g/dl) (*9*) and two-thirds had *P. falciparum* infection. This provided an opportunity to evaluate the sensitivity and specificity of physical examination at various sites for judging the presence and severity of pallor for identification of anaemia (*10*). The health worker evaluated the eyelid (conjunctiva) for absence of pallor, pallor, or severe pallor. The physician evaluated all sites. Sensitivities and specificities of the health workers' and physician's assessment of the conjunctiva were similar.

Detection of fever by placing the hand on the forehead was sensitive and specific. Several other questions were asked about the character of fever to determine whether they could be used to improve the specificity of the fever algorithm for diagnosis of malaria. In addition, the physician included some signs from physical examination that have been proposed to improve the non-laboratory-based diagnosis of malaria (e.g., splenomegaly). Fevers with chills and shaking (tremor), and splenomegaly, hepatomegaly and palmar pallor by physical examination were only weakly associated with malaria parasitaemia.

This study also allowed us to look at the sensitivity and specificity of key items in physical examination for the assessment and classification of illness. Although the overall sensitivity for detection of pneumonia was high (97%), health worker sensitivity was relatively low for detection of chest indrawing (57%) and for fast breathing (64%); admittedly, while both these signs may be present intermittently, they are critical in deciding, using the IMCI algorithm, whether children with cough have pneumonia. The explanation for the low sensitivity of the diarrhoea section (51%) of the IMCI algorithm is at least in part explained by the low sensitivities (21–28%) of some of the key items in the physical examination including general condition, presence or absence of tears, and mouth dryness.

One of the goals of IMCI is to address appropriately children whose illnesses overlap. As expected, there was substantial overlap between the cough and fever sections of the IMCI algorithm (*6*, *15*). Almost half of all children enrolled were classified as having pneumonia and malaria by the health worker using the IMCI algorithm. When using the treatment section of the IMCI algorithm, these children were given sulfamethoxazole + trimethoprim (co-trimoxazole), taking advantage of its unique antibacterial and antimalarial properties (*16*, *17*). Unfortunately, this approach has disadvantages too. For example, the possibility of more rapid development of resistance, either among bacteria or malarial parasites, when applied to large populations (*18*, *19*); and concerns about compliance with the 5-day course of co-trimoxazole therapy and uncertainty about the efficacy of a shorter course.

There was also substantial overlap in classification of illness between fever and malnutrition. The explanation for this lies in the associations between malaria and anaemia, and malnutrition and anaemia. Similar in magnitude to the overlap between pneumonia and malaria was malaria and malnutrition, which almost half of all children were classified as having; most of these children were classified as having malnutrition on the basis of pallor (i.e., evidence for anaemia). In the treatment section of the IMCI algorithm these children receive an antimalarial and treatment for anaemia including use of iron supplements. One approach to this problem in areas of high malaria incidence may be to integrate more fully the assumption that most anaemia will be primarily due to malaria. This could be done by including pallor as a classification criteria in the fever assessment for diagnosis of malaria.

Initially we were concerned that the IMCI algorithm would lead to too many children being referred for hospitalization and that the danger signs (i.e., findings requiring urgent referral) would be relatively common and might have low specificity for serious illness. What we found was the opposite. First, danger signs were uncommon; only 59 (15%) of the 399 children were referred for admission by the physician. Second, the overall sensitivity for referral by the health worker using the IMCI algorithm, compared to the physician, was only 42%. We attempted to look for possible explanations for this by comparing the 233 children who were referred by the physician, but not the health worker using the IMCI algorithm, to those children who were not referred by either. The strongest univariate association we found was with fast breathing, which suggests that our physician may have felt uncomfortable with sending these children home, as would have been recommended by the IMCI algorithm for most of them. However, we also found an association between having three or more disease classifications and the referral of such children. In making her decision about referral, our physician may have been considering clinical parameters that are not covered by the IMCI algorithm, such as multiple disease processes, evidence of HIV infection (affecting almost 10% of our study children), or poor social situation.

Our study provides important technical validation of the IMCI algorithm, but the data should not be construed as proof that its implementation will improve child survival. Although some parts of the IMCI algorithm have already been shown to decrease both overall and disease-specific child mortality when used alone (e.g., those dealing with diarrhoea and cough), it will be important to study its impact on child survival when these interventions are delivered in an integrated fashion in first-level health facilities. Optimal care for ill children is likely to require integration of these efforts with home and community-level health care and promotion, and with care delivered at referral-level facilities.

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Résumé

Evaluation d'un algorithme pour la prise en charge intégrée des maladies de l'enfant, dans un secteur du Kenya à transmission palustre élevée

En 1993 l'OMS a achevé la mise au point d'un projet d'algorithme pour la prise en charge intégrée des maladies de l'enfant (IMCI) qui porte sur les infections respiratoires aiguës, la diarrhée, le paludisme, la rougeole, les infections de l'oreille, la malnutrition, et la situation vaccinale. La présente étude compare la qualité des diagnostics portés, d'une part par un agent de santé ayant reçu une formation minimale, au moyen du projet d'algorithme IMCI, et d'autre part par un pédiatre ayant une formation complète et bénéficiant du soutien du laboratoire et de la radiologie.

Pendant les 14 mois de l'étude, 1795 enfants de 2 mois à 5 ans vus en consultation externe de pédiatrie de l'hôpital du district de Siaya dans l'ouest du Kenya ont été recrutés; 48% d'entre eux étaient des filles et l'âge médian était de 13 mois. La fièvre, la toux et la diarrhée étaient les symptômes majeurs les plus fréquents, observés chez 907 (51%), 395 (22%), et 199 (11%) enfants respectivement; 86% des symptômes majeurs étaient abordés directement par l'algorithme IMCI. Un total de 1210 enfants (67%) étaient parasités par *Plasmodium falciparum*, et 1432 (80%) remplissaient les critères OMS de définition de l'anémie (hémoglobine <11 g/dl). Les chiffres de la sensibilité et de la spécificités de la classification de la maladie par l'agent de santé utilisant l'algorithme IMCI, comparés au diagnostic porté par le médecin, étaient respectivement de 97% et 49% pour les pneumopathies, 51% et 98% pour la déshydratation chez l'enfant diarrhéique, 100% et 0% pour le paludisme, 98% et 2% pour les affections de l'oreille, 96% et 66% pour l'état nutritionnel, 42% et 94% pour la nécessité d'un transfert. La détection de la fièvre en posant sa main sur le front est à la fois sensible et spécifique (91% et 77%). On observe un recouvrement important entre les pneumopathies et le paludisme (n = 895), et entre le paludisme et la malnutrition (n = 811).

Donnant suite à l'analyse préliminaire de ces données, quelques changements ont été apportés à l'algorithme IMCI. Cette étude fournit une

validation technique importante de l'algorithme; toutefois, la qualité des prestations des agents de santé doit être surveillée au début de leur formation à la prise en charge intégrée des maladies de l'enfant.

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