Original Research Article

Evaluation of the utility of IMNCI algorithm in predicting illness, hospitalization, and management of children aged 2 months to 5 years in a tertiary referral centre

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Abstract

Background: India has around 240 million under-five children and contributes close to 25% of under-five mortality. About 70% of such deaths are due to diarrhea, pneumonia, measles, malaria or malnutrition and often a combination of these conditions. These are also the diseases that are seen to afflict three out of every four sick children seeking care at a health facility.
Aim of the study: To evaluate the utility of the WHO / UNICEF guidelines for "Integrated Management of Neonatal and Childhood Illness" among children aged two months to five years attending an Urban center.
Materials and methods: This Prospective observational study was did in the outpatient department and emergency room, The Institute of child Health and Hospital for Children, Egmore, Chennai. Children attending the outpatient department and emergency room aged between 2 months and 5 years for the first time for a fresh complaint due to any illness were included in the study. Each study subject was assessed and classified according to IMNCI guidelines and the treatment options were identified and recorded in a proforma. Each child was evaluated using IMNCI algorithms for high

malaria risk areas and low malaria risk areas. The IMNCI algorithm was split into four modules dealing with specific complaints (cough/breathing difficulty, diarrhea, fever, ear problems) and the classification and treatment options arrived at for each child on applying the specific split algorithms guided by the presenting complaints were also noted.

Results: 517 complaints were reported by the parents/other caregivers accompanying the children enrolled in the study; an average of 1.72 complaints per child. depicts the frequency of these symptoms. Over 43% (227) of such complaints comprised of respiratory problems such as cough or difficulty in breathing. One-fourth of all presenting complaints (125) were fever and another 10% (56) consisted of loose or bloody/mucoid stools. Other complaints frequently reported were convulsions (15, 2.9%), vomiting everything (14, 2.7%), lethargy/unconsciousness (11, 2.1%), not being able to drink/breastfeed (11, 2.1%) and ear problems (9, 1.7%).

Conclusion: Multiple diagnoses are the rule than an exception in under five sick children. Hence vertical, disease-specific algorithms are inappropriate in the evaluation and management of a sick child. Integrated approaches must be preferred. The IMNCI algorithm can address most complaints that sick children present with. When implemented by health workers with appropriate training, the referral criteria of IMNCI are fairly good predictors of serious illness which requires medical attention.

Key words

IMNCI algorithm, Respiratory problem, Gastrointestinal problems, Ear pain, Neurological manifestation.

Introduction

Sick children seldom have a single illness and even when they present with a single complaint, multiple problems can become evident to a discerning health worker. Hence, a scheme of assessment that is based on the sole presenting complaint is often inappropriate and may lead to failure to diagnose potentially life-threatening problems, which could have been controlled easily, had they been diagnosed when the child had sought care initially [1]. Further, many of the childhood illnesses can present with overlapping complaints. Therefore child health programmes should address the sick child as a whole and not as single diseases. However, peripheral health workers in rural areas who constitute the first point of contact of sick children with the public health care system in India have been accustomed to delivering services under the ambit of vertical health programmes, each of which was focused on one or few diseases, until the recent past [2]. One of the foremost challenges in the implementation of an integrated approach in the management of sick children thus lies in the primary health care sector. This workforce needs appropriate training to impart adequate knowledge and skills in the clinical evaluation, appropriate treatment, recognition and referral of children with serious illness and follow-up care in the community [3]. Further, simplified protocols for assessment and management of sick children using an integrated approach and job-aids for use in the field are necessary. WHO and UNICEF had developed an approach called “Integrated Management of Childhood Illness” (IMCI) with the experience gained from various disease-specific control programmes in the early nineties. IMCI adopts a holistic and integrated approach to child health and development [4]. IMCI has three main areas of focus: improving health worker skills, improving health systems and improving family and community practices. For successful implementation of IMCI strategy, all the three independent components should be addressed appropriately IMCI has developed locally adaptable guidelines and algorithms to assist health workers in implementation [5]. These guidelines and algorithms have been refined through research and field tests in various parts of the world by W.H.O. and UNICEF. IMCI guidelines rely on case detection based on simple, easily elicited clinical symptoms and signs that can be picked up by health workers after appropriate training, without the need for laboratory tests [6]. Case management under IMCI is through action-oriented classification, rather than exact diagnoses. This approach permits treatment of several important diseases and facilitates the treatment of children who present with multiple clinical problems. The core intervention of IMCI approach is integrated case management of five major killer diseases of under five years age namely acute respiratory infection (ARI), diarrhea, measles, malaria and malnutrition and of commonly associated conditions [7].

Materials and methods

This Prospective observational study was did in the outpatient department and emergency room, The Institute of child Health and Hospital for Children, Egmore, Chennai. Children attending the outpatient department and emergency room aged between 2 months and 5 years for the first time for a fresh complaint due to any illness were included in the study. Each study subject was assessed and classified according to IMNCI guidelines and the treatment options were identified and recorded in a proforma. Each child was evaluated using IMNCI algorithms for high malaria risk areas and low malaria risk areas. The IMNCI algorithm was split into four modules dealing with specific complaints (cough/ breathing difficulty, diarrhea, fever, ear problems) and the classification and treatment options arrived at for each child on applying the specific split algorithms guided by the presenting complaints were also noted.

Inclusion criteria: Children attending the outpatient department and emergency room aged between 2 months and 5 years for the first time for a fresh complaint due to any illness.

Exclusion criteria: Children, who already received treatment for the present illness, Children with injuries and other external causes of morbidity such as poisoning.

All relevant investigations as dictated by the provisional diagnosis and treatment options being considered were performed. These included complete blood count, peripheral smear, urine routine examination, stool microscopy examination, x-ray chest, ultrasonogram, computerized tomographic scan, biochemical investigation, lumbar puncture, cultures etc. were performed. The opinion of specialists was sought whenever needed. The final diagnoses and therapeutic procedures were noted from the patient records on the same day while leaving the hospital for children advised home-based care. For children advised admission or observation, the diagnoses and treatment decisions were captured from the case- sheets at the time of their discharge from the hospital. These final diagnoses and treatment decisions were considered as the gold standard. The treatment options according to the gold standard were grouped into three categories namely hospitalization, observation for a period not more than 24 hours and sent home after initial evaluation. Hospitalized children were followed up until discharge or death. Children who were sent home immediately after evaluation and after some time of observation were asked to come for routine follow-up after 2-5 days to determine the outcome. For each child, information on diagnosis and treatment was thus available from at least four evaluation streams; gold standard, IMNCI high malaria risk algorithm IMNCI low malaria risk algorithm and one (or more) split IMNCI algorithms. All diagnoses and treatment categories were tabulated manually and the diagnostic and therapeutic agreements were compared. The total disagreement was considered when none of the diagnoses made using the IMNCI algorithms matched with the gold standard diagnoses. When some but not all of the IMNCI diagnoses matched with the gold standard diagnoses, it was considered as Partial agreement.

Statistical analysis: Measures of validity such as Sensitivity, Specificity, Positive Predictive Value (PPV), Negative Predictive Value (NPV) and Odds Ratio with 95% Confidence Interval (OR

95% CI) were computed for the IMNCI algorithm. The proportion of diagnostic/therapeutic agreements and disagreements were calculated for each IMNCI algorithm and split algorithm. For assessing statistical significance, tests such as Chi-Square test, Chi-Square test for linear trend, Paired and Unpaired Student-t-test and Kappa statistic were employed.

Results

Three hundred children aged between 2 months and 5 years, attending the Pediatrics OPD or emergency room at the Institute of Child Health, between January 2010 and September 2011 were enrolled in the study. About 56.3% (169) were recruited from the outpatient department and the rest from emergency room visits.

Table – 1: Age and sex distribution of study population (n = 300).

Age Group	**Male**		**Female**		**Total**	
	No.	**%**	**No.**	**%**	**No.**	**%**
2 months – 12 months	21	7.00	25	8.33	46	15.33
13-24 months	46	15.33	43	14.33	89	29.67
25-36 months	41	13.67	32	10.67	73	24.33
37-48 months	31	10.33	27	9.00	58	19.33
49-60 months	16	5.33	18	6.00	34	11.33
Total	**155**	**51.67**	**145**	**48.33**	**300**	**100**

Male vs Female: χ^2 = 1.62, p = 0.805

Table – 2: Mean frequency of morbidities in different methods of evaluations (n = 300).

Parameter	**Gold Standard**	**IMNCI**		**Vertical (Split IMNCI) algorithm**
		High Malaria Risk	**Low Malaria Risk#**	
Total Number of illnesses	711	795	686	332
Mean number of illnesses	2.37	2.65	2.29	1.11
Standard deviation	1.17	1.29	1.31	0.57

Excluding the classification of “Fever – Malaria Unlikely” vP < 0.005 ** P = 0.732, *** P<0.001) (using paired t test)
Gold Standard VS * High malaria risk, ** Low Malaria risk, *** Vertical (split IMNCI)

Table – 3: Treatment modalities of the children in study as per gold standard (n = 300).

Treatment modality	**No. of Children**	**% of Total**
Hospitalization	143	47.67%
Observation	57	19.00%
Home Treatment	100	33.33%
Total	**300**	**100%**

Table – 4: Comparison of referral criteria of IMNCI algorithm with mean frequency of morbidities of study population (n = 300).

Status of referral criteria (IMNCI algorithm)	**Number of Children**	**Mean Number of morbidities**	**Standard Deviation**
Yes	166	2.55	1.28
No	134	2.30	1.32

p = 0.245 (unpaired t-test).

Table – 5: Role of the referral criteria in predicting the treatment modality (n = 300).

Criteria	Children needed hospitalization		Children kept under observation for not more than 24 hours		Children sent home immediately after initial evaluation		Total	
	No.	**%**	**No.**	**%**	**No.**	**%**	**No.**	**%**
Children without any referral criteria	17	12.68	23	17.16	94	70.15	134	100
Children with anyone of the referral criteria including General Danger signs	126	75.90	34	20.48	6	3.61	166	100
Children with General Danger signs	87	76.99	20	17.70	6	5.31	113	100

*$\chi2$ = 161.07, $p < 0.001$ (Vs children without any referral criteria) ** $\chi2$ = 123.87, $p < 0.001$ (Vs children without any referral criteria).

Table – 6: Analysis of diagnostic and therapeutic agreements between 'gold standard' and IMNCI and vertical (split IMNCI) algorithms (n = 300).

Parameter	IMNCI Algorithm		Vertical (Split IMNCI) Algorithm
	High Malaria Risk No. (%)	**Low Malaria Risk No. (%)**	
Total Agreement	239(79.67)	258(86.0)	169(56.33)
Partial Agreement	38(12.67)	24(8.0)	34(11.33)
Total Disagreement	23(7.67)	18(6.0)	97(32.33)
Over-diagnosis	117(39.00)	45(15.0)	17(5.67)
Under-diagnosed	62(20.67)	66(22.0)	218(72.67)

Table - 1 presents the age and gender distribution of the study sample. 155 (51.7%) of children who participated in our study were males and 145 (48.3%) females. Children aged 2 months to 12 months constituted 15% of the study participants. About 30% of participants were aged 13 to 24 months, while another 24% belonged to the 25 to 36 months age group. Children aged four to five years comprised only 11% of the study sample. No significant differences in the age distribution between genders were appreciated in the sample.

Algorithms.711 illnesses were diagnosed as per the 'gold standard', viz, standard procedures of care followed in the hospital (Mean: 2.37, SD: 1.17). When the IMNCI algorithms were used on these children, the high malaria risk algorithm yielded 795 diagnoses and the low malaria risk algorithm yielded 686 diagnoses. However, only 332 diagnoses were made using the vertical (split IMNCI) algorithm. The difference in the mean number of illnesses diagnosed using the high malaria risk algorithm (Mean: 2.65, SD: 1.29) and the gold standard was statistically significant using paired t-test ($p<0.005$), as was the difference between vertical algorithms (Mean: 1.11, SD: 0.57) ($p<0.001$) and gold standard. The difference between low malaria risk algorithm (Mean: 2.29. SD: 1.31) was, however, not statistically significant ($p=0.548$). The number of children who received more than one diagnosis as per gold standard evaluation was 209 (69.7%). 246 (82%) children received multiple diagnoses using the IMNCI high malaria risk algorithm whereas 193 received multiple diagnoses (64.3%) using the IMNCI low malaria risk algorithm (**Table – 2**).

Of the 300 children, 143 (47.7%) were admitted in the hospital according to the standard treatment and care practices followed in the hospital. 57 (19.0%) were kept under observation in the hospital for a period less than 24 hours while 100 (33.3%) were treated on an outpatient basis, and sent back home immediately with appropriate treatment and counseling (**Table – 3**).

On application of the IMNCI algorithms, 166 (55.3%) children met one or more criteria for referral to a hospital. Such children had a greater number of illnesses diagnosed by the gold standard (mean number of morbidities – 2.55 and standard deviation – 1.28), than children without referral criteria (mean number of morbidities – 2.30 and standard deviation – 1.32), however, the difference was not statistically significant using paired t-test (p = 0.245) as per **Table – 4**.

Over three-fourths (n=126) of children with one or more referral criteria (including the general danger signs) from the IMNCI algorithms were eventually admitted in the hospital by the treating pediatricians. 34 children (20.5%) were kept under observation in the hospital for not more than 24 hours, while 6 of them (3.6%) were advised home-based care after the initial evaluation. When children who presented with general danger signs alone were considered, the changes observed were minimal; the proportion advised admission, observation and home-based care were 76.9%, 17.7%, and 5.3% respectively. In line with these findings, it was noted that about 70% of children who did not meet any of the IMNCI referral criteria were sent home after the initial evaluation. 17% of such children were placed under observation for a period not exceeding 24 hours, while 12% required admission in the hospital (**Table – 5**).

Upon assessing the therapeutic and diagnostic agreement of the IMNCI algorithms with the gold standard, it was seen that total agreement was highest for the IMNCI low malaria risk algorithm and lowest for the vertical (split IMNCI) algorithmic approach. Total agreement was considered when the child's classification as per the IMNCI referral criteria matched with the modality of treatment offered (hospitalization/ observation/ home treatment) or when all diagnoses made using the IMNCI algorithms matched with the corresponding gold standard diagnoses. Total agreement with gold standard was seen in 258 children (86%) when the low malaria risk algorithm was used and 239 children (79.7%) when the high malaria risk algorithm was used. Total agreement was seen only in 169 children (56.3%) when the vertical (split) algorithms were used (**Table – 6**).

Discussion

All previous studies have indicated that a small proportion of complaints were not addressed by the algorithm. Early in the development of the IMNCI algorithm, Weber et al. had reported from Gambia that vomiting and poor feeding, two symptoms commonly encountered in pediatric practice, were not included in the IMNCI algorithm [8]. This led to a revision of the IMNCI algorithm when poor feeding and vomiting everything were added in to the algorithm as general danger signs. Other common complaints such as skin problems and pain abdomen have been reported in other studies as being not addressed by IMNCI algorithm [9]. Prominent among those complaints which were not covered by the IMNCI algorithm in the present study were worms in stools and perianal itching, skin problems and abdominal problems. The inclusion of more complaints in the IMNCI algorithm is likely to make it unwieldy for use in the field setting and may lead to oversight of more common problems by the health worker that can endanger the life of the child if left untreated. Considering this, it is desirable that the algorithm is kept simple and efforts made for training the field workers to elicit other symptoms/signs from the parents/guardians/children under the "Assess other problems" section in the IMNCI algorithm [10]. The priority in low resource settings is early recognition of serious illness so that such children can be referred for hospital care. Thus the referral criteria form the backbone of the IMNCI approach. Before advocating for wider adoption and use, the validity of the referral criteria in predicting serious illness has to be verified locally. High sensitivity and positive predictive value are imperative for any screening tool to avoid individuals with the disease getting left out [11]. At the same time, the test or tool should have specificity in an acceptable range so that false positives and hence wasteful expenditures are minimized. About 55% of children met one or more of the IMNCI referral criteria in the present study. The sensitivity of the algorithm in recognizing severely ill children who need in-hospital care through the referral criteria is the most important measure of the utility of the IMNCI approach [12]. This ranged from 41% to 84% in studies from Africa and 81% to 86% in studies from India and Bangladesh. Specificity of the tool ranged from 64% to 74% in the latter, and from 79% to 98% in the former. Positive predictive values ranged from 55% to 71% [13]. A recently published study from Ludhiana, India by Kalter HD, et al. reported excellent sensitivity and specificity at 99.3% and 97.3% respectively. The sensitivity, specificity, and positive predictive value for predicting hospitalization in the present study were 88.1%, 74.5% and 75.9% respectively. The IMNCI algorithms also had dissonance with the gold standard diagnoses in the cough or difficult breathing category, where many children with bronchial asthma, bronchiolitis, empyema or tuberculosis were classified as having pneumonia, severe pneumonia or URI. This makes the former set of conditions to be under-diagnosed, and pneumonia/respiratory infection to be over-diagnosed [14]. However even with incorrect diagnoses, all cases of bronchiolitis, severe asthma and empyema had met the IMNCI criteria for referral and hence would have been referred to a doctor. But it is not so with cases of bronchial asthma who were misclassified as pneumonia or URI and thus would have received inappropriate treatment. IMNCI algorithm also resulted in slight over-diagnosis of anemia and classification of a few children with grade II malnutrition as being severely malnourished (very low weight for age). The former is due to reliance on palmar pallor to classify anemia [15]. The use of weight for age rather than weight for height curves to classify malnutrition may result in such discrepancies as noted in this study; however weight for age curves are much simpler to use in the field, where measurement of height or length of the child may become problematic [16]. Adoption of IMNCI strategy also provides for the detection of children who have not been immunized adequately for their age. This is a common aspect that may be overlooked by over-burdened health staff attending to sick children in the community and the algorithm provides a reminder in this regard so that missed opportunities for immunization may be avoided. In the current study around 17% children were found to be not appropriately immunized for age and were provided vaccines as deemed necessary [17]. Immunization counseling was offered to all parents and guardians. Further improvements in IMNCI algorithm are needed in the cough/difficult breathing category to avoid under-diagnosis of bronchial asthma (being misclassified as URI or pneumonia) and in the fever category to avoid over or under-diagnosis of malaria and other febrile illnesses through incorporation of simple diagnostics such as rapid antigen tests, QBC etc., if necessary [18]. The study area is a malaria non-endemic zone, the low malaria risk algorithm seems most suited for evaluation of a child with a fever, however, it may underdiagnose malaria. But in high malaria zones, it is considered safe to over-diagnose a child with malaria and offer treatment. Similar findings have been reported from New Delhi. The IMNCI algorithm is a tool meant to be used in the community and low resource health care facilities, by primary health care workers. Studies such as the present one which is done in tertiary care centers hence are of limited utility in assessing the performance of the algorithms in the field [19]. The case-mix seen in tertiary centers is entirely different from what is seen in a rural health center and hence patterns of diagnostic/therapeutic agreement estimated in these studies may not be replicated in field studies. Further, such hospital-based studies are often conducted by pediatricians or physicians with vastly different skill sets compared to a peripheral health worker [20]. Hence, as noted before, the measures of validity reported in the Indian studies are not reflective of what may be obtained in primary care settings and estimates reported in the African studies seem more plausible [21]. Many studies from African countries have also assessed the performance of the health worker and based on their observations, some modifications have been done in the IMNCI algorithm to improve its utility [22]. A study from the United Republic of Tanzania, assessed the performance of three types of health workers (medical assistants, rural medical aides, and MCH aides) after adequate training and found that all three groups overall were able to assess, classify, and treat most sick children and most of them were able to provide adequate counseling [23]. Studies done in Kenya and Uganda had compared the drug costs incurred with standard treatment by physicians against projected costs upon using the IMNCI algorithm and found that adoption of the IMNCI approach is associated with a cost advantage [24]. It must be noted that despite a decade since its adoption, few serious attempts at evaluation of the IMNCI strategy have been taken up in India [25].

Conclusion

The IMNCI algorithm can address most complaints that sick children present with. When implemented by health workers with appropriate training, the referral criteria of IMNCI are fairly good predictors of serious illness which requires medical attention. Diagnostic concordance of the low malaria risk IMNCI algorithm with the gold standard is good. IMNCI also ensures prompt assessment of nutritional and immunization status, which may be often missed by health workers during the evaluation of a sick child. Thus it provides opportunities to foster better growth and development of the child through preventive care. Further refinement of the algorithm (for ex: to eliminate difficulties in diagnosing bronchial asthma and malaria) can be considered, after a careful appraisal of the performance of the tool in actual field settings where it is intended to be used.

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