Electronic Integrated Management of Childhood Illness (eIMCI): Evaluation of an electronic decision-making tool for management of sick children under five years in primary health care facilities in KwaZulu-Natal, South Africa

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EXECUTIVE SUMMARY

Background

In response to the large numbers of children under five years dying from preventable and treatable childhood illnesses, WHO and UNICEF developed a strategy to address child mortality by improving care of children in primary health care (PHC) and in the community. This strategy is known as the Integrated Management of Childhood Illness (IMCI) and was launched in 1996. Since then IMCI has been adopted in over 100 countries, with each country adapting the generic IMCI guidelines to address prevalent childhood illnesses in that country. IMCI aims to improve case management of sick children in health facilities using a series of algorithms to provide simple, evidence-based, management guidelines at PHC level, and has been shown to improve child mortality in several countries. IMCI was adopted as standard of care for sick children in South Africa in 1998.

However, most IMCI evaluation studies conducted over the years have shown challenges with IMCI implementation, with poor adherence to the algorithm leading to missed opportunities to provide essential care. Further, there have also been major challenges to scale-up and sustainability. IMCI training is costly and requires skilled facilitators, so that quality of IMCI training has been difficult to sustain at scale. Ongoing supervision and support of IMCI practitioners is crucial to the success of the programme but requires supervisors with high level clinical skills and has been challenging in many settings. As a result, there have been widespread concerns about whether IMCI remains the best approach for case management of sick children. In particular, in South Africa the ministerial committee on morbidity and mortality in children (CoMMiC) has expressed concern about poor and inconsistent implementation of IMCI in PHC facilities despite considerable investment over more than two decades.

In response to these concerns, and following the success of mobile health technologies in other settings, an electronic decision-making tool based on IMCI was developed in KwaZulu-Natal, South Africa. This tool, known as eIMCI, mirrors the existing paper-based IMCI (pIMCI) guidelines using a computer-based application to assist IMCI trained health workers to implement IMCI correctly and comprehensively. eIMCI follows the same IMCI assessment process as pIMCI, so that eIMCI practitioners enter their clinical findings into the eIMCI application on the computer as they proceed through the consultation with a sick child. On completion of the assessment, eIMCI generates a list of the child's classifications, key counselling messages and treatments required, including drugs and dosages. All components of eIMCI are mandatory, so that eIMCI practitioners are required to enter all relevant information and clinical findings before they can move to the next step. The eIMCI application was developed for use on desktop computers that are currently available in PHC clinics and was piloted in Umgungundlovu district in KZN.

E-IMCI evaluation

We present the findings of a mixed methods study to evaluate the feasibility, acceptability and effectiveness of eIMCI implementation in one district in KZN. We conducted a cluster randomized controlled trial (cluster RCT) to determine whether implementation of eIMCI improved the management of sick children compared to the use of pIMCI. We also conducted a series of in-depth interviews (IDIs) and focus group discussions (FGDs) among eIMCI practitioners to qualitatively explore enablers and barriers to eIMCI implementation. A cost-effectiveness evaluation was conducted in real time to determine the incremental cost of eIMCI compared to pIMCI.

Study Methods

▶ *Quantitative methods*

A two-arm cluster RCT was conducted to determine whether implementation of eIMCI improved the management of sick children compared to the use of pIMCI (current standard of care).

Sample selection: The study population comprised PHC clinics, IMCI trained nurses and mothers of children attending participating clinics. At the start of the study 30 clinics in the district were randomly allocated to intervention (eIMCI) or control (pIMCI) groups (15 clinics per group). One IMCI trained nurse in each clinic was

randomly selected to participate in the study from among a sampling frame of all IMCI trained nurses in the clinic who regularly consulted with sick children.

eIMCI intervention: After clinics had been allocated to the intervention or control groups, the intervention clinics were visited and set up for eIMCI implementation. New computers were provided for those clinics where suitable computers were unavailable, as well as missing components like mouses, keyboards and cables as required. Printers were provided for all intervention clinics. The eIMCI application was loaded onto the computer and selected eIMCI participants were provided with log-in details.

IT support was provided throughout the study period to ensure that computers and printers were functional at all times. A telephone hotline was set up at the start of eIMCI implementation, so that participants could easily contact the IT support technician during working hours. Ink and paper were provided for the printers when required

Participating IMCI trained nurses in both the intervention and control groups received training and mentoring at the start of the study. IMCI training for both groups mirrored each other with participants being provided with the same IMCI updates, practice cases and exercises. However, eIMCI participants received an additional day of computer training to provide them with the specific skills required to use the eIMCI application. After training, all participants received a minimum of two mentoring visits from an IMCI mentor to support transfer of new skills to the workplace

Data collection: Quantitative data was collected by two teams of trained data collectors, each team comprising an expert IMCI practitioner and a fieldworker. Data was collected in each clinic for one week using android tablets. All mothers attending with a sick child aged 2months to five years were approached to participate. All mothers provided written informed consent.

Data collection comprised the following tools and activities:

- *A structured exit interview* to describe activities that occurred during the consultation as reported by the mother.
- *A gold standard IMCI assessment*- each child was reassessed by the IMCI expert and correct findings recorded to provide a gold standard against which the IMCI participant's performance was judged.
- *A record review tool* where all findings recorded by the IMCI participant on the child's records were recorded. All notes from the day's consultation were then scanned to provide a record of the IMCI participant's findings. Medication provided to the mother was also recorded.

The performance of IMCI participants in assessing, classifying and managing sick children was determined by comparison of the with a gold standard IMCI assessment.

▶ *Qualitative methods*

A series of in-depth interviews (IDIs) and focus group discussions (FGDs) among eIMCI practitioners was used to qualitatively explore enablers and barriers to eIMCI implementation. Qualitative data was collected by two experienced qualitative researchers using a series of semi-structured IDI guides and FGD guides.

eIMCI practitioners were purposively selected to participant in a series of IDIs based on their reported computer self-efficacy as assessed by a telephone survey. We selected the three highest scoring participants, the three lowest scoring participants and three participants with moderate scores. IDIs were conducted at four time points as follows: before eIMCI training (pre-training), after eIMCI training (post-training), after mentoring (2-3 months after training), and after 5-7 months of using eIMCI (final).

The FGDs were conducted after completion of the quantitative survey and were used as platform to challenge eIMCI practitioners to explore the barriers and challenges that prevented them from implementing eIMCI as planned.

▶ *Cost-effectiveness evaluation*

A prospective micro-costing was conducted to estimate the total and incremental cost of eIMCI. Costing was done for three scenarios of the intervention, the cost of implementing the trial, the cost of continuing the intervention at the same scale on ongoing basis, and the cost of the intervention at scale. The scenarios differ in their treatment of capital costs and the assumptions made regarding the level of mentoring and IT support. In each scenario, the cost of pIMCI and eIMCI were calculated.

Ethics

Ethical approval was obtained from the Biomedical Research Ethics Committee (BFC 157/19) at the University of KwaZulu-Natal and the KwaZulu-Natal Department of Health (KZ_201907_001). All participants provided written informed consent to participate.

Results

Implementation of eIMCI was tracked in intervention clinics during the implementation period using a function of the eIMCI application. This is shown in Table 1 as a proportion of the total under-5 headcount seen using eIMCI in each clinic each month. There was poor implementation of eIMCI over the project period. The proportion of all consultations using eIMCI each month ranged between 0- 66.5% in individual clinics with several clinics showing minimal implementation of eIMCI.

Table 1: Proportion of under-5 children seen using eIMCI in each clinic per month

The proportion of all child consultations undertaken by eIMCI									
Year	**2020**			**2021**					
Month	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**
Clinic 211	7,5%	16,6%	36,7%	0,0%	30,2%	63,8%	66,5%	58,6%	19,2%
Clinic 201	3,2%	18,6%	22,5%	14,7%	11,7%	10,4%	9,8%	2,9%	14,4%
Clinic 213	13,3%	17,2%	12,8%	4,5%	4,1%	21,5%	1,4%	5,6%	0,8%
Clinic 202	29,7%	23,7%	35,7%	23,6%	21,0%	30,1%	15,2%	23,4%	16,6%
Clinic 207	1,7%	3,2%	2,5%	0,0%	0,9%	0,3%	0,5%	2,0%	4,1%
Clinic 208	12,5%	44,6%	48,3%	56,7%	61,7%	57,0%	58,3%	61,2%	36,1%
Clinic 205	0,0%	24,4%	14,0%	4,5%	0,0%	9,7%	16,1%	7,4%	7,7%
Clinic 212	11,7%	14,2%	11,3%	9,3%	6,1%	4,4%	5,7%	3,0%	0,0%
Clinic 209	1,1%	10,0%	14,1%	5,4%	23,6%	24,2%	34,0%	32,8%	0,0%
Clinic 215	2,4%	4,8%	0,0%	8,1%	24,3%	26,1%	29,6%	10,4%	1,0%
Clinic 203	11,8%	20,3%	5,5%	4,1%	0,2%	30,2%	4,8%	1,0%	1,0%
Clinic 206	5,4%	6,3%	19,8%	18,1%	6,7%	26,4%	51,9%	42,3%	40,6%
Clinic 210	3,2%	6,7%	3,8%	1,7%	0,0%	1,1%	0,3%	0,0%	0,0%
Clinic 204	0,1%	1,3%	1,1%	3,1%	3,4%	7,3%	0,2%	0,0%	0,0%
Clinic 214	0,0%	2,4%	1,3%	23,4%	11,0%	25,2%	23,1%	5,8%	1,6%

Quantitative evaluation

At the end of IMCI training, before the start of the study, IMCI knowledge was assessed in both intervention and control groups and there was no significant difference in IMCI knowledge between participants in the intervention (55.32%; IQR 36.1-76.6) and control (57.45%; IQR 46.8-70.2) groups (0.91).

▶ *Survey results*

A total of 291 children were enrolled in the study, comprising 152 in the intervention (eIMCI) group and 139 in the pIMCI (control) group. All mothers of children enrolled in intervention clinics reported that the nurse used the computer during the consultation, and all eIMCI practitioners printed their findings using the eIMCI printouts. IMCI recording forms were consistently used in 14/15 control clinics.

Ages of participating children was similar in both groups (p=0.506). The duration of the consultations in minutes (median; IQR; min-max) was longer for children assessed by eIMCI practitioners (28; 20-35; 4-74) compared to pIMCI (25; 17-32; 6-74).

▶ *Performance of eIMCI practitioners and pIMCI practitioners in classifying sick children*

Table 2 shows a comparison of classifications made by IMCI practitioners in the pIMCI and eIMCI groups and the expert IMCI practitioner. In all cases the expert classifications were considered the gold standard and IMCI practitioners were evaluated based on whether their findings agreed with the correct findings. The proportion of children correctly classified for main symptoms was consistently better in the pIMCI group compared to the eIMCI group. However, the proportion of correct classifications for screening symptoms (nutrition, anaemia, TB and HIV) was higher in the eIMCI group reflecting that these actions are mandatory in eIMCI.

Table 2: Performance of eIMCI and pIMCI practitioners in classifying sick children

	eIMCI		pIMCI		P value	p value adjusted
MAIN SYMPTOM	N	Correctly classified	N	Correctly classified		
Cough or difficult breathing	76	57 (75.0)	73	65 (89.0)	0.03	0.6
Dehydration	25	17 (68.0)	12	11 (91.7)	0.22	0.16
Fever	44	16 (36.4)	43	29 (67.4)	0.005	0.01
Ear infection	5	3 (60.0)	10	7 (70)	0.9	0.6
All main symptoms correct	109	59 (54.1)	105	61 (58.1)	0.559	0.6768
SCREENING CLASSIFICATIONs						
Malnutrition	152	115 (75.7)	139	87 (62.6)	0,02	0.07
Anaemia	152	149 (98.0)	139	83 (59.7)	<0.001	<0.001
HIV	152	106 (69.7)	139	50 (36.0)	<0.001	<0.001
TB	152	124 (81.6)	139	100 (71.9)	0,051	0.017

Looking at the proportion of screening classifications that were omitted by participants in the intervention and control groups, eIMCI practitioners failed to make any screening classification in 27/608 (2.2%) of cases, whereas pIMCI practitioners failed to classify in 115/556 (20.7%) of cases. Thus, poor performance of pIMCI was at least in part due to pIMCI practitioners omitting to make classifications for screening conditions.

Table 3 shows the proportion of positive screens that were identified by practitioners in each group. Although the numbers are small, this suggests that eIMCI practitioners were more successful in identifying moderate and severe malnutrition than pIMCI practitioners, reflecting that the Z-scores are calculated by eIMCI. However, for the other screening conditions (anaemia, HIV and TB), the higher proportion of correct classifications shown in table 2 does not result in more at-risk children being identified.

Table 3: Proportion of positive screening conditions correctly identified.

	eIMCI		pIMCI	
	Number screened positive	Number identified by eIMCI practitioner	Number screened positive	Number identified by pIMCI practitioner
Anaemia	1	0	1	0
Severe acute malnutrition with or without medical complications	2	2	2	1
Moderate acute malnutrition	7	6	6	0
Not growing well	16	4	13	4
HIV infection	1	1	1	1
Symptomatic of HIV infection	3	1	3	0
High risk of TB	2	0	1	0
Risk of TB	27	5	16	2
HIV exposed	4	1	0	0

▶ *Performance of eIMCI practitioners and pIMCI practitioners in providing medications to sick children*

Medications provided to participating children were compared to the medications identified by expert practitioners to determine the proportion of children in the intervention and control groups who received all required medications. Table 4 shows that for curative medications pIMCI practitioners were more likely to provide all medications required.

Table 4: Proportion of children receiving correct prescriptions

	ELECTRONIC IMCI	PAPER IMCI	ALL	P value	Adjusted
	N=152 n (%)	N= 139 N (%)	N= 291		
All curative meds given today (cough, diarrhoea, fever, ear infection)	124 (81.6)	126 (90.6)	250 (85.9)	0.026	0.0695
HIV treatment correct	5/30 (16.7)	4/33 (12.1)	9/63 (14.3)	0.73	0.66
TB treatment correct	0	0	0	n/a	n/a
Vit A up to date	128 (84.2)	130 (93.5)	258 (88.7)	0.01	0.03
Deworming up to date	124 (81.6)	127 (91.4)	251 (86.2)	0.015	0.15
Immunisation up to date	145 (95.4)	134 (96.4)	279 (95.9)	0,77	0.65

In addition, many children were given medications that were not indicated, most commonly these were antibiotics, multivitamin syrup, and co-trimoxazole prophylaxis for HIV exposure. One in four children received unnecessary medication and that this was more common in the eIMCI group.

Table 5: Over-prescription of medication by eIMCI and pIMCI practitioners

	ELECTRONIC IMCI	PAPER IMCI	ALL	P value	Adjusted P value
	N=152 n (%)	N= 139 N (%)	N= 291 N (%)		
Any over-prescription	48 (31.6%)	20 (14.4%)	68 (23.4%)	0,001	0,004
Unnecessary antibiotic given	16 (10.5%)	7 (5.0%)	23 (7.9%)	0,08	0,12
Multivitamins	27 (17.8%)	8 (5.8%)	35 (12.0%)	0,002	0,003
Other over-prescription	5 (3.3%)	2 (1.4%)	7 (2.4%)	0,5	0,30

Costing analysis

Costing analysis is presented according to the 3 scenarios mentioned and shows that incremental costs of eIMCI were considerable for the implementation of the intervention as it stands.

Table 6: Cost per clinic and per consultation, 3 scenarios (2021 South African Rand)

	S1 - As implemented		S2 - As implemented, ongoing		S3 – At scale	
	pIMCI	eIMCI	pIMCI	eIMCI	pIMCI	eIMCI
Monthly costs per clinic						
Training	404	630	86	134	86	123
Hardware and set up	0	1542	0	438	0	438
Mentoring	3748	3061	3748	3061	3373	2761
IT support	0	1932	0	1746	0	953
Clinic level variable cost	9718	10854	9718	10854	19435	21708
Overhead	968	968	968	968	968	968
Total cost per month per clinic	14838	18986	14520	17200	23862	26951
Number of consults per month per clinic	50	50	50	50	100	100
Cost per consult	297	380	290	344	239	270
Incremental cost of eIMCI	-	83	-	54	-	31

Qualitative results

Nine eIMCI practitioners completed the series of IDIs and were interviewed at four time points from training to 6 months post implementation. Three FGDs were conducted with 11 eIMCI practitioners in the intervention group following completion of quantitative data collection.

Overall, eIMCI practitioners were impressed by eIMCI stating that it made their work more efficient. They mentioned that eIMCI was user friendly and effective in the management of sick children, and were impressed that the programme did everything for them including prescribing medication, referring children to hospital for treatment, giving information on health education for mothers, providing return dates to the clinic for mothers, and alerting them when urgent referral is required.

However, when challenged about poor eIMCI implementation, eIMCI practitioners identified a variety of challenges they experienced when implementing eIMCI in their clinics. All these challenges frequently led them to return to paper IMCI, particularly when the clinic was busy. Many eIMCI practitioners stated that they did not use eIMCI because it was too time consuming and they were concerned that the queue was getting longer. Lack of computer skills made consulting with eIMCI more time consuming.

Challenges to eIMCI implementation

We present the findings as challenges related to the functioning of the eIMCI application, technical IT challenges and lack of health system support for eIMCI.

Functioning of eIMCI: Participants reported that eIMCI was not always aligned to the chart booklet and sometimes eIMCI omitted medications. In particular, eIMCI printouts were considered to be incomplete or incorrect, and at times did not reflect what was shown on the computer. This was perceived by eIMCI practitioners as eIMCI missing things out and several nurses expressed that they did not always agree with the eIMCI treatments. Overall, these concerns undermined eIMCI practitioners trust in eIMCI.

Participants noted that they were unable to bypass questions during the eIMCI assessment and this sometimes caused a problem if the information was unavailable, particularly if the child was brought by a carer who was not the mother. In these situations, participants admitted that they sometimes guessed the information to allow them to continue with the assessment.

Another concern that participants mentioned was that they were unsure how to integrate the computer into the consultation. While some participants described how they were able to talk to the mother and complete the eIMCI questions as they went through the assessment, most participants asked the questions and did the examination first and only then logged onto the computer. This was time consuming and not user friendly and was likely to lead eIMCI practitioners to make mistakes or guess information.

Technical challenges: Most participants mentioned that they had technical issues while using eIMCI. The most common problems were with logging into the system, capturing a child that is already in the system, saving patient cases and not being able to print. Substantial IT support was required to solve these issues and this was made more difficult by participants' poor computer skills which made telephonic support challenging. As a result, there were times when eIMCI was not functional because of unresolved technical issues.

Health system failed to support eIMCI: Many participants mentioned overcrowding, staff shortages, and eIMCI not aligning with other programmes in the clinics as key challenges within the health system that had an impact on the implementation of eIMCI. Due to staff shortages, participants often had to consult with other patients, not just children, so they had to log on again to the computer each time they saw a child. Participants were also frequently deployed to rooms in the clinic where there was no computer. Using eIMCI resulted in more admin work for participants to comply with the requirements of other priority programmes. The result was that using eIMCI was time-consuming and some nurses preferred to go back to using paper where they felt more confident.

Recommendations

This evaluation of eIMCI has highlighted the challenges to the use of electronic decision-making tools to support clinicians. Although the results are discouraging for now, they also show a way forward to address the challenges for future implementation of eIMCI or for similar electronic decision-making tools. We suggest that careful formative work to anticipate the challenges would guide future implementation of such programmes.

In particular, we have the following recommendations for implementation of eIMCI or other electronic decision-making tools to support successful implementation:

- Improve the baseline computer skills of participants.
- Common IT challenges should be directly addressed during training, including how to manage a login that had timed out, what to do to restart the computer after an electricity outage etc.
- Review the user-friendliness of eIMCI in a real world setting to resolve barriers to integrating the computer into the consultation.
- A structured process is required to ensure that newly trained eIMCI practitioners have the space and time required to gain confidence in eIMCI implementation.
- The format of eIMCI printouts and other recording requirement should be revised to be more comprehensive and compatible with requirements of other clinic programmes.

Conclusion

Using the current approach and format eIMCI implementation did not improve care for sick children and added significantly to the cost. However, the findings of the study clearly demonstrate several key reasons why the approach did not work, and many of these could be feasibly addressed. In particular, as computers are more widely used in clinical settings in the future, it can be anticipated that IT support will be more widely available. We conclude that there remains potential for implementation of electronic supports to clinical decision-making, particularly in low resource settings, with consideration for the challenges highlighted in this evaluation.