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Research Article

Effectiveness of *mHealth* in improving active case finding in a community-based management of acute malnutrition program in Binga, Zimbabwe

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Abstract: Community-Based Management of Acute Malnutrition (CMAM) is a proven high impact and cost-effective approach in large-scale detection and treatment of undernutrition. However, the success of CMAM programmes is usually undermined by lack of adherence to admission and treatment protocols by health workers as a result of poor reporting and follow up. Therefore, this study aimed to determine the effectiveness of mobile health (*mHealth*) in improving the screening and admission outcomes of the CMAM programme. A retrospective hospital-based cross-sectional study was done in 14 health facilities in Binga district, Zimbabwe where both pre- and post-intervention periods were studied. A paper checklist was used to collect the differences in errors between the paper based and mobile application. Project summary reports were used for collecting information on total screening and admission statistics between the comparison groups. Sensitivity and specificity rates were calculated using SPSS version 21. Error rates were 6.5% and 0.2% for the paper-based data management and *mHealth* application respectively. *mHealth* approach had a higher (1.0, 0.77) sensitivity in identifying cases with severe acute malnutrition (SAM) and moderate acute malnutrition (MAM) compared to the paper-based approach (0.81, 1.0). However, the specificity of the two methods were comparable. CMAM *mHealth* was effective in improving diagnostic accuracy and treatment outcomes in managing acute malnutrition. Hence, *mHealth* has the potential to improve the speed of response to surges in caseloads in this and related low-income settings.

Keywords: *mHealth, SAM, MAM, CMAM, screening, admissions*.

INTRODUCTION

Malnutrition remains a significant global health challenge and the single biggest contributor of child mortality and global burden of diseases, globally, 50 million children under 5 were wasted, of which 16 million were severely wasted in 2014 (UN, 2015). While the prevalence of stunting and wasting in children under five has been decreasing globally over the past two decades, in 2016 Zimbabwe indicated a worsening nutrition situation, the Global Acute Malnutrition rate of children aged 6-59 months was at 5.7% the highest recorded in 15 years. Severe Acute Malnutrition rate was at 2.1%, slightly above the 2% threshold for emergency response(ZimVac, 2016) .

The Lancet series of 2013 on maternal and child undernutrition documented evidence justifying the urgent prioritisation of global and countrywide nutrition interventions (Black *et al*., 2008). In Zimbabwe, the Community-based Management of Acute Malnutrition (CMAM) program was adopted by the Ministry of Health and Child Care (MOHCC) with support from United Nations Children ‘s Fund (UNICEF) and several Non-governmental organisations. CMAM has been proven to be a high-impact and cost-effective approach in the treatment of SAM and MAM in developing countries, in which the majority of cases are treated as outpatients at community level (Tine Frank *et al.*, 2017). It enables community health workers and volunteers to promptly identify and initiate treatment for children with acute malnutrition through standard case management, using ready to use supplementary feeds (RUSF), ready-to-use therapeutic foods (RUTF) and routine medications which caregivers can give their children at home (Chanani *et al*., 2016).

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The success of CMAM programmes is undermined by several factors which include lack of adherence to treatment protocols by health workers; inaccurate record keeping due to lack sufficient training and supervision. Nutrition monitoring systems are constrained by time consuming paper-based data collection tools which are prone to errors followed by manual data entry (Barnett & Gallegos, 2013). Data management presents another significant challenge as data transfer takes time to reach a level at which it can be analysed and lack of human resources to accomplish analysis often leads to further delays (Keane *et al*., 2018). In an effort to improve the effectiveness of the CMAM programme through monitoring of nutrition outcomes in real time, Save the Children (SC) in partnership with the Ministry of Health and Child Care (MOHCC) in 2017, initiated the development of mobile diagnosis application for managing SAM and MAM. The rationale was to improve the quality of CMAM programme delivery and to assess the children's nutritional status more accurately.

Since the inception of the CMAM *mHealth* pilot initiative, there had not been any formal assessment to determine the effectiveness of the *mHealth* application in Zimbabwe. Lack of evaluation of the program limits the potential for equitable advances(Curioso & Mechael, 2010). Therefore, this study was designed to determine the effectiveness of *mHealth* on improving management of acute malnutrition, in terms of diagnostic accuracy and treatment outcomes in the pilot district Binga, Zimbabwe.

METHODS

Study Setting

The study was conducted in Binga district, which is located in Matabeleland North Province in Zimbabwe. Binga (study area) is one of the administration districts which lies on the south eastern shore of Lake Kariba, located 391 km from Harare. The district catchment population was estimated to be 139,092 (Zimstat, 2012). The district consists of 25 wards divided into two parliamentary constituencies, Binga north and Binga south. The study area consists of 14 rural health facilities providing CMAM services.

Study Design

A retrospective health facility-based cross-sectional study was conducted on records from October 2017 to June 2018 in which both pre- and post-intervention periods of measurement of both groups were the same. Both groups were comparable for key characteristics.

Study Population

This study included all health facilities (14) with health workers (25) trained on the community management of acute malnutrition (CMAM) and the *mHealth* application, built on a Commcare platform in Binga district. Records of all the children screened for acute malnutrition, those admitted for SAM and MAM in these health facilities from October 2017 to June 2018 and fulfilled inclusion criteria were included in this study.

Inclusion and Exclusion Criteria

For the pre-intervention group, data from facilities in Binga district with health workers who were trained on CMAM but still using the paper-based registers were included in the study. All raw screening data of children 6-36 months from paper-based registers in the last 3 months of implementation from October 2017 to December 2017 were included. For the intervention group, data from health facilities in Binga district with trained health workers who received a tablet with the CMAM application and having used the application for at least two months were included in the study. All data of children 6-36 months screened using *mHealth* in the last 3 months of application use from April 2018 to June 2018 were included in the study. Health workers in Binga not trained on CMAM were excluded in this study. Incomplete data records of children aged 6-36 months were excluded from this study.

Sample Size

Sample size calculation was done using statistical software Epi info version 7.2.2.16. All 14 rural health clinics in Binga district were studied. A sample size of 14 health centres was found to be sufficient.

Data Collection Procedures

The raw data was collected through CMAM record reviews of children (6-36 months of age) screened for acute malnutrition, by using a prepared checklist. The checklist was used to check for errors in acute malnutrition grade allocation and weight for height calculations. The checklist included screening admission data, treatment protocols and outcomes in a format that was cross matched with available paper records. CMAM project summary reports were used to collect data on cure rates, death rate, defaulter rate and non-response rate for both pre-intervention and post intervention periods.

Data Processing and Analysis

The screening data collected by the health workers along with the malnutrition grades were entered into the Statistical Package for the Social Sciences (SPSS) version 21 for analysis. Data cleaning and analysis were all done using SPSS. For testing the normality of the data, Q-Q plots were used. For testing differences in errors, sensitivity and specificity rates, the Pearson chi-square test was used. Level of statistical significance was declared at p value < 0.05 levels. Sensitivity was estimated as the proportion of children who were either SAM or MAM, who were correctly identified as either SAM or MAM, using either the paper-based tables or the *mHealth* application. Specificity was estimated as the proportion of children who were normal and correctly identified as normal using either the paper-based tables or the *mHealth* application.

Ethics Approval and Consent to Participate

Ethical clearance was granted by the Medical research council of Zimbabwe (MRCZ/B/1637). In addition, approvals for data collection in Binga was granted by the Ministry of Health and Child Care (MOHCC) at national, provincial and district levels. The clinics also rechecked for ethical compatibility and permitted the data access. The confidentiality of study participants was secured. In addition, all data were kept confidential. All participants gave written informed consent to participate.

RESULTS

Treatment outcomes were better in mHealth compared to paper based. Cure rates improved from 83% (paper report) to 89% (*mHealth*). CMAM screening classification, sensitivity and specificity pre and post intervention.

Table 1 presents sensitivity and specificity estimations for 14 rural health facilities using both paper based and *mHealth* screening methods. The sensitivity rate for diagnosis of SAM increased from 0.81 to 1. Similarly, positive and significant increases in sensitivity for MAM (0.77 to 0.998) diagnosis and specificity rates (0.98 to 0.998) are observed.

Table 1. Comparison of Sensitivity and Specificity Rates for CMAM Screenings pre-and post-intervention

Variable	CMAM Screening Classification Correct n (%)	Incorrect n (%)	Total n (%)	P value
Paper based				
SAM	103 (81.1)	40 (24.7)	143 (11.3)	
MAM	140 (77.2)	24 (18.9)	164 (13.0)	<0.001*
Normal	953 (98.1)	18 (1.9)	971 (75.7)	
SAM Sensitivity			0.81	
MAM Sensitivity			0.77	
Specificity			0.98	
***mHealth* based**				
SAM	237 (100)	0 (0)	237 (12.5)	
MAM	136 (99.8)	3 (0.2)	139 (7.4)	
Normal	1514 (99.8)	3 (0.2)	1517 (80.1)	<0.001*
SAM Sensitivity			1.0	
MAM Sensitivity			0.998	
Specificity			0.998	

Notes: [1]P value based on Pearson's Chi-square Test, *Association was significant at P<0.05. SAM classification (Weight for Height (W/H) <-3 SD, MAM Classification (Weight for Height (W/H) <-2 & ≥-3 SD, Normal (Weight for Height (W/H) ≥-2)(MOHCC, 2011).

Screening statistics and grading errors pre and post intervention

Paper-based screening had 6.5% grading errors were 82 out of 1260 screenings of children younger than 3 years of age were wrongly graded. After switching to the *mHealth* application, this error rate fell significantly to 0.2% or 3 out of 1890 screenings of children younger than 3 years. Table 2 shows human error rate in calculating malnutrition grades.

Table 2: Screenings statistics of children 6-36 months for the pre-and post-intervention study

	Total Screenings	Grade Errors	% Error
Paper field tables	1260	82	6.5
m-Health application	1890	3	0.2

DISCUSSION

The study aimed to determine the effectiveness of mobile health (*mHealth*) in improving the screening and admission outcomes of the CMAM programme. The *mHealth* intervention was found to be more specific in identifying SAM and MAM cases for the CMAM program. The strategy of introducing CMAM *mHealth* to aid health workers in Binga district, in standard case management of acute malnutrition significantly reduced the error rate by a margin of 6.3% in assessing acute malnutrition at district level. These results are consistent with the results obtained by Chanani *et al.*, (2016) which showed a significant reduction of malnutrition grade errors by approximately 5%. There were no missing or unreadable data because the application identified gaps and errors and prompted the health workers to correct and complete them while they were assessing the child.

The CMAM *mHealth* application incorporated typical electronic data entry validation techniques that prevented entry of measurement outliers and informed health workers with error messages when they entered out-of-range measurements. The ability of the *mHealth* application to prevent entry of measurement outliers most likely reduced both errors in taking weight and height/ length measurements and recording weight and height/ length.

Data using the *mHealth* application were found to be 99.8 per cent accurate with a small number of errors. The error rate in the CMAM *mHealth* application could have been due to application functionality during the initial stages of implementation. This small error rate was consistent with results obtain by Frank *et al.*, (2016) in Kenya, which showed 0.7 per cent error rate due to software functionality. The implications for large improvements in diagnostic accuracy are important for reaching out to large numbers of vulnerable children. Upon introduction of the application more cases were screened (1890) in a period of 3 months compared to statistics for the pre-intervention group (1260) within the same period. Therefore, *mHealth* has the potential to improve the speed of response to surges in caseloads.

The results of the study indicate effectiveness of the CMAM *mHealth* intervention in reducing variability in error rates across health workers in Binga district which warrants the scaling up of the intervention to national level. From the study it was observed that health workers who had difficulties in accurately identifying children with acute malnutrition from using the World Health Organization (WHO) simplified field table began performing at the same level as those health workers who were considered the best once *mHealth* was introduced. The correct identification of children with SAM and MAM improves the quality of the CMAM program treatment outcomes.

A reanalysis of all WHZ-scores from the raw weight and height data in the paper registers found that more children were inaccurately admitted into the CMAM program as indicated by lower sensitivity values. The introduction of *mHealth* significantly increased MAM and SAM sensitivity and specificity ($p < 0.05$). *mHealth* increased sensitivity and specificity values because, the application automatically calculates the WHZ-score based on the entered height and weight of the child, therefore reducing errors in the classification of WFH and eliminating incorrect admissions. These results obtained from the study are consistent with those from Chanani *et al.*, (2016) who investigated the effectiveness of "*mHealth* on improving screening accuracy of acute malnutrition in a community-based management of acute malnutrition program in Mumbai informal settlements". The significant increase in sensitivity for SAM and MAM detection is important for the program's capacity to immediately refer and treat the most vulnerable children in the community.

Limitations of the Study

Switching to *mHealth* effectively removed errors in using paper-based field tables and selecting the grade of child on the WHO WFH field tables, as part of the anthropometric process. However, the study neither measured nor studied the impact of any strategies to reduce errors encountered when measuring and taking down anthropometric measurements. Furthermore, there is still a gap on the cost effectiveness of *mHealth* interventions. Therefore, further research is needed for effective implementation of CMAM programs.

CONCLUSIONS

The CMAM *mHealth* application was effective in improving CMAM screening and admission diagnostic outcomes. CMAM programs using a technological innovation such as the *mHealth* can be adopted with greater confidence that more children are screened and correctly admitted. CMAM *mHealth* has the potential to improve the speed of response to surges in caseloads, identify and resolve operational bottlenecks and improve coverage, quality of care and effectiveness in treatment in this and related low-income settings.

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Conflict of Interest

All Authors declare no conflict of interest.

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