Analytic Module to Improve Nutrition Screening for Children Under-five Years at Maternal and Child Health (MCH) Facilities

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Abstract: In this paper, the design of the nutrition screening system is described. The system will facilitate nutrition screening and assessment. Nutrition screening and assessment are very essential processes for effective malnutrition management. The design combines nutrition screening and assessment because it is of advantage to have a nutrition screening process combined with nutrition assessment process as it enables identification of not only malnutrition or potential malnutrition risk but also evaluation of nutritional status. When used this system will quicken and perfect nutrition screening process, improve the productivity of nurses, and enhance utilization of anthropometric and other clinical data.

Key words: Malnutrition, Analytic Module for nutrition Screening for Children, Nutrition screening system, Nutrition screening process

1 Introduction

Malnutrition is defined as the condition that hinders good health, which is mainly caused by inadequate or unbalanced food intake or poor absorption of nutrients (FAO, 2008). It can be in form of under-nutrition, where by the overall nutrient intake is low, or over-nutrition where by the overall nutrient’s intake has exceeded not limits (Angeles-Agdeppa, Lana and Barba, 2003). Malnutrition has been mentioned as one of the major health challenges in developing countries (UNICEF, 2009). In sub-Saharan African countries, malnutrition is associated with about 45% of deaths of children under five years (Black et al., 2013) (Bhutta et al., 2013). In Tanzania, 42% of children under five years are affected and 600,000 are estimated to have died before five years due to malnutrition (World Vision, 2015) (MOHSW, 2008). Malnutrition is also the leading cause of diseases as it lowers body immunity; this makes children to die with diseases they could survive if they were nourished (Kavishe, 2010) (Matthias, 2003) (Foster, Parr and Wright, 2005). Furthermore, malnutrition retards children’s physical and cognitive development, which results to poor work performance in adulthood (Ramani and Souza, 2014). Malnutrition is a major problem in public health; its effects and consequences are a burden to the individual, society and nation as a whole (Bain, et al., 2013).

Despite the effect malnutrition has to a child, it is often unrecognized and goes untreated (Cao et al., 2014). Effective nutrition screening will not only identify malnourished children for treatment but also reduce the burden of malnutrition on health facilities, society and the nation. Nutrition screening the process of identifying individuals who are malnourished or at risk of becoming malnourished, and nutrition assessment the process of establishing nutritional status and energy requirement, are both highly recommended (Santarpia, Contaldo and Pasanisi, 2011). The two processes therefore are essential processes towards combating malnutrition. Numerous nutrition screening tools have been developed for use in different contexts to facilitate the nutrition screening process. Many of these tools are facility and community specific and offer limited flexibility in terms of optimizing the parameters. The tools are mostly manual and therefore do little to improve productivity of care facilities which are normally burdened by huge number of patients. There is no golden nutrition screening tool that is accepted worldwide for malnutrition and malnutrition risk identification as well as detecting individuals who need nutritional intervention (van Bokhorst-de van der Schueren et al., 2014). Lack of golden nutrition screening tool is one among the barriers towards combating malnutrition. This study therefore, proposes and designs a nutritional screening system that will facilitate nutrition screening process at health facilities. The system intends to quicken and perfect nutrition screening process at
maternal and child health facility centres, improve productivity of nurses, and enhance utilization of anthropometric and other clinical data.

2 Related works

It is argued that Nutrition Screening Tools (NST) that facilitates nutrition screening or nutrition assessment processes should be quick and simple to use while maintaining their validity and reliability. Moeeni and Day (2012), identified different categories of NST: there are simple tools such as Mid Upper Arm Circumference (MUAC), standard deviation that measure the distance between the child’s value and the expected value of the reference (z-score) and sophisticated tools such as Nutrition Risk Score (NRS), Simple Paediatric Nutritional Risk Score (SPNRS), Subjective global Nutritional Assessment for children (SGNA), Screening Tool for Assessment of Malnutrition in Paediatric (STAMP), Screening Tool for Risk on Nutrition and Growth (STRONGkids) and Paediatric Yorkhill for Malnutrition Score (PYMS) (Moeeni and Day, 2012).

Despite the variety of nutrition screening tools, Z-score is a widely recognized system for expressing anthropometric values in several standard deviations. In screening children nutrition, the most common anthropometric nutrition indicators such as weight for height, weight for age and weight for height are interpreted using a z-score (Matthews, Billiet and Borrell, 1983). Although z-score is mostly recognized descriptor of malnutrition, studies show that it has some limitations. The z-score cannot be appropriately used on individual bases; it is sex dependent as it has different values for each sex (De Onis and Blössner, 1997). Furthermore, the z-score’s complex computations make it less usable at most community maternal and child health facilities.

MUAC, the circumference of the left upper arm; it is useful in screening of nutritional status. MUAC has been in use for a long time and it has been recommended as the best for nutrition screening for children under-five years and for adult during famine (Rahma, 2001) (Manary and Sandige, 2008). Its simplicity in use makes it a preferable indicator over other nutritional indicators although it lacks solid cut-off points in reference to age and ethnicity. Also errors that arise in MUAC measurements, and lack of reproducibility in measurement makes some health centres and agencies to be sceptical on using it (Ouannes et al., 2012) (Saeed et al., 2015) (Collins, Duffield and Myatt, 2000).

STRONGkids is a nutrition screening tool used for children. A study done by Huysentruyt et al (2013) reviewing the validity of STRONGkids in nutrition screening showed that it is an appropriate tool for nutrition screening in hospitalized children. However, another study compared three nutrition screening tools, namely STRONGkids, STAMP and PYMS in evaluation of nutrition status; the study results showed that among the three, PYMS is the most reliable tool (Humphrey et al., 2014). STAMP is quick and easy tool to use; it is developed for children aged two years and above. A study done by McCarthy et al, comparing STAMP with dietetic specialist assessment showed the sensitivity, specificity and positive values shown by STAMP are in line with general expectations results of a screening tool (Wong et al., 2012). SGNA successfully screens children nutrition and categorizes screened children into well nourished, moderately malnourished and severely malnourished categories. Due to its ability of identifying children with malnutrition and categorize according to malnutrition extent, Secker & Jeejeebhoy (2007) recommend SGNA as the valid tool for assessing nutritional status in children.

Numerous Screening tools have been developed and used for nutrition screening in children. But none of them is adequately capable of screening nutrition. Some scholars argue that development of new NST is redundant and it might not lead to new insights (van Bokhorst-de van der Schueren et al., 2014). However, it is important to consider that nutrition screening tools are designed and developed for diverse purposes, for use by people with different backgrounds, and for application in one or more specific settings and for one or more specific disease groups (Joosten and Hulst, 2014). Also, for better nutrition screening results, the nutrition screening tool should be developed specifically for intended group (Phillips et el., 2010). Nevertheless, these nutrition screening tools for children mentioned above were developed specifically for developed countries. Given the differences in nutritional status between developed and developing countries, applicability and validity of these tools in developing countries context like Tanzania may vary substantially and make the tools inappropriate (Van Bokhorst-de van der Schueren et al., 2014). Therefore, we highly recommend the ideal nutrition screening tool for the developing countries specifically Tanzanian that can be quick and reliable in identifying the nutritional status for children.
3 System design

3.1 System definition

Nutrition Screening System is a module-based system that will facilitate nutrition screening process at health facilities, and provide real-time results and reports on nutrition status, nutrition progress and malnutrition trend. The development of the nutrition screening system aims to support malnutrition management by facilitating quick and reliable nutrition screening.

3.2 Requirements Specification

The nutrition screening system will be used for nutrition screening of children under five years. Therefore, the system should be able to register and maintain child’s records, use the child’s anthropometric measurements to establish nutrition status, provide real-time nutrition status and nutrition reports. The system requirements are described in Table 1 below.

Table 1: Specific System Requirements, source: (author)

<table>
<thead>
<tr>
<th>Requirement</th>
<th>Purpose</th>
<th>Rationale</th>
</tr>
</thead>
<tbody>
<tr>
<td>Child Registration</td>
<td>Required for child registration</td>
<td>Registration allows entrance of the child’s particulars into the system.</td>
</tr>
<tr>
<td>Nutrition Screening</td>
<td>Required for nutrition screening</td>
<td>Nutrition screening allows identification of the malnourished child, establishment of the extent the child is undernourished and the progress the child has made after starting the care plan.</td>
</tr>
<tr>
<td>Reporting</td>
<td>Required for report creation</td>
<td>Report creation allows dissemination of nutrition related data and information and malnutrition trend.</td>
</tr>
<tr>
<td>Nutrition Progress Establishment</td>
<td>Required for monitoring nutritional progress</td>
<td>Nutrition Progress establishment allows monitoring of children nutritional progress to children who are under malnutrition treatment (care plan)</td>
</tr>
<tr>
<td>Malnutrition Extent Establishment</td>
<td>Required for malnutrition magnitude establishment</td>
<td>Malnutrition extent establishment allows identification of malnutrition magnitude to a child</td>
</tr>
</tbody>
</table>

3.3 Nutrition Screening Process flow

Figure 1 shows the nutrition screening process workflow for the proposed nutrition screening system. To accomplish the nutrition screening task, several sub-processes are included as shown in the nutrition screening process workflow.
4 Individual components of the nutritional screening process and their contribution to the overall nutritional screening process

Each of the individual components is significantly correlated with the overall nutritional screening process. For nutrition screening, the most important components are measurements, calculation of nutritional indicator score, progress establishment and extent establishment.

4.1 Process Inputs

Objective data; The objective data will be obtained from anthropometric measurements, which are weight in kilogram (kg), height in centimetre (cm) and MUAC in millimetres (mm).

Subjective data; the subjective data will be obtained from clinical and dietary records; symptomatic data will also be captured from the child’s physical appearance. This data will include clinical, dietary and symptoms information as shown in Table 2 below.
Table 2: Subjective data, source: (author)

<table>
<thead>
<tr>
<th>Category</th>
<th>Subjective data</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clinical</td>
<td>Chronic illness</td>
</tr>
<tr>
<td>Dietary</td>
<td>Problem in food intake</td>
</tr>
<tr>
<td>Symptoms</td>
<td>Oedema (water retention)</td>
</tr>
</tbody>
</table>

4.2 Calculations of Nutritional Indicators
The main objective of the nutrition screening system is to establish nutrition status. MUAC tape and z-score formula will be used to find the nutritional indicator value, for this case child’s arm circumference and z-score value.

Z-SCORE
The following z-score formula will be used:

\[ i = \frac{\text{Child's measurement} - \text{Reference median}}{\text{Reference Standard Deviation}} \]

Key:
- \( i \) is z-score value obtained
- Child Measurement – weight or height of a child at age \( X \)
- Reference Median – Mean or 50th percentile of the reference population at age \( X \)
- Standard Deviation – Standard deviation of the reference population at age \( X \)
- \( X \) – Child’s age

Table 3: Cut-off points, source: (CDC and WFP, 2005)

<table>
<thead>
<tr>
<th>Indicator</th>
<th>Severe Malnutrition</th>
<th>Moderate Malnutrition</th>
<th>Adequate Malnutrition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mid Upper Arm Circumference (MUAC)</td>
<td>MUAC &gt; 110 mm and &lt;115mm</td>
<td>MUAC &gt; 115 and &lt; 125 mm</td>
<td></td>
</tr>
<tr>
<td>Z-Score</td>
<td>Z-score &lt; - 3</td>
<td>-3 &lt; Z-score &lt; - 2</td>
<td>-2 &lt; Z-score &lt; + 2</td>
</tr>
</tbody>
</table>

4.3 Nutritional Progress Establishment
To monitor child’s condition and to identify whether the child is recovering from malnutrition or not, the system will establish a nutrition progress. Nutrition indicators used in nutrition screening will establish progress whereby running average method will be used. The decision on whether the child is progressing well or deteriorating will depend on the slope of the last two points of the graph. The positive slope of the graph will denote progress, the negative slope of the graph will denote deterioration, and the zero slope will denote that the child is stagnant (see Figure 2 below).
Figure 2: Nutrition progress graph, source: (author)
4.4 Rule based malnutrition extent establishment

To establish magnitude of malnutrition in a child, we use a rule-based approach. The decision rules are based on the previous and current anthropometric measurements, clinical data, dietary data, observed symptoms like oedema, and also inputs from local practitioners. In total, the system uses sixty-four (64) rules. Below are examples of such rules.

Rule I: If (\(AM_P = 0, CD_P = 1, EP = 1 \&\& AM_C = 0, CD_C = 1, EC = 1\)) then the child will be considered as severely malnourished.

Rule II: If (\(AM_P = 0, CD_P = 1, EP = 1 \&\& AM_C = 1, CD_C = 0, EC = 0\)) then the child will be considered as moderately malnourished

Rule III: If (\(AM_P = 1, CD_P = 0, EP = 0 \&\& AM_C = 0, CD_C = 1, EC = 1\)) then the child will be considered as severely malnourished

Rule IV: If (\(AM_P = 1, CD_P = 0, EP = 0 \&\& AM_C = 1, CD_C = 0, EC = 0\)) then the child will be considered as moderately malnourished

Rule V: If (\(AM_P = 1, CD_P = 0, EP = 0 \&\& AM_C = 1, CD_C = 1, EC = 0\)) then the child will be considered as severely malnourished

Key:
- AM = Anthropometric Measurement
- CD = Clinical and Dietary Data
- E = Oedema
- P = Previous
- C = Current
- 0 = Low and No
- 1 = Medium and Yes

5 Evaluation

We wanted to evaluate the system using real anthropometric measurements. However, getting such data from hospitals became a challenge. Instead we used synthetic data to evaluate the system.

5.1 Objectives of the evaluation

- To test the accuracy and precision of the system in establishing the progress of a malnourished child.
- To test the accuracy and precision of the system in establishing the extent of malnutrition.

5.2 Data

In collaboration with health facilities, we drafted twelve (12) records (one-year period) of anthropometric measurements for eight (8) children. The experts at the facility manually helped to interpret the data by doing the following:

- Stating whether a child’s trend constitutes a progress (positive or a negative or a stagnant progress case).
- Stating whether a child is moderately or severely malnourished.

Table 4 below shows sample records of one child for evaluation. A single record contains a record number, the current anthropometric score (i), chronic disease or difficult in food intake status, and confounding factor (oedema). Against each record, the experts provided the two interpretations stated above.
Table 4: Expert Record Interpretation of One Child in a Year, source: (author)

<table>
<thead>
<tr>
<th>Record No.</th>
<th>Score (i)</th>
<th>Confounding factor (oedema)</th>
<th>Chronic disease / difficulties in food intake</th>
<th>Extent</th>
<th>Progress</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Low</td>
<td>Yes</td>
<td>Yes</td>
<td>Severe</td>
<td>Deteriorate</td>
</tr>
<tr>
<td>2</td>
<td>Low</td>
<td>Yes</td>
<td>No</td>
<td>Severe</td>
<td>Stagnant</td>
</tr>
<tr>
<td>3</td>
<td>Low</td>
<td>Yes</td>
<td>Yes</td>
<td>Severe</td>
<td>Stagnant</td>
</tr>
<tr>
<td>4</td>
<td>Medium</td>
<td>Yes</td>
<td>No</td>
<td>Severe</td>
<td>Stagnant</td>
</tr>
<tr>
<td>5</td>
<td>Low</td>
<td>Yes</td>
<td>No</td>
<td>Severe</td>
<td>Progress</td>
</tr>
<tr>
<td>6</td>
<td>Low</td>
<td>No</td>
<td>No</td>
<td>Severe</td>
<td>Progress</td>
</tr>
<tr>
<td>7</td>
<td>Low</td>
<td>No</td>
<td>No</td>
<td>Severe</td>
<td>Progress</td>
</tr>
<tr>
<td>8</td>
<td>Medium</td>
<td>No</td>
<td>No</td>
<td>Moderate</td>
<td>Progress</td>
</tr>
<tr>
<td>9</td>
<td>Medium</td>
<td>No</td>
<td>No</td>
<td>Moderate</td>
<td>Progress</td>
</tr>
<tr>
<td>10</td>
<td>Medium</td>
<td>No</td>
<td>No</td>
<td>Moderate</td>
<td>Progress</td>
</tr>
<tr>
<td>11</td>
<td>Medium</td>
<td>No</td>
<td>No</td>
<td>Moderate</td>
<td>Progress</td>
</tr>
<tr>
<td>12</td>
<td>Medium</td>
<td>No</td>
<td>No</td>
<td>Moderate</td>
<td>Progress</td>
</tr>
</tbody>
</table>

Of the eight children five (5) had moderate malnutrition and three (3) had severe. The number of children progressing positively was six (6), while those progressing negatively were two (2).

5.3 Method and results

The proposed system was used to interpret the data records. That is, when each child’s record data were fed into the system, the system suggested the extent of malnutrition and whether there was a progress. We then compared the results against the recommendation by the expert by establishing accuracy and precision using the below formulas.

**Accuracy** = \( \frac{TP + TN}{TP + FP + TN + FN} \)

**Precision** = \( \frac{TP}{TP + FP} \)

For extent:

- \( TP \) = Number of moderate cases by the system which are also moderate by the expert.
- \( TN \) = Number of severe cases by the system which are also severe by the expert.
- \( FP \) = Number of moderate cases by the system but are severe by the expert.
- \( FN \) = Number of severe cases by the system but are moderate by the expert.

For progress:

- \( TP \) = Number of positive progress cases by the system which are also positive progress cases by the expert.
- \( TN \) = Number of negative progress cases by the system which are also negative progress cases by the expert.
- \( FP \) = Number of positive progress cases by the system but are negative progress by the expert.
- \( FN \) = Number of negative progress cases by the system but are positive progress by the expert.

The results were as shown in Table 5 below.

Table 5: Accuracy and Precision Results, source: (author)

<table>
<thead>
<tr>
<th>Indicator</th>
<th>Accuracy %</th>
<th>Precision %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Progress</td>
<td>100</td>
<td>92.3</td>
</tr>
<tr>
<td>Extent</td>
<td>100</td>
<td>100</td>
</tr>
</tbody>
</table>
6 Conclusion
This paper describes the design of the nutrition screening system, which will facilitate nutrition screening and assessment. Nutrition screening and assessment are very essential processes for effective malnutrition management. These processes should be simple, easy and rapid to be carried by a health worker. The design combines nutrition screening and assessment because it is of advantageous to have a nutrition screening process combined with nutrition assessment process as it enables identification of not only malnutrition or potential malnutrition risk but also evaluation of nutritional status.

The design incorporates both objective and subjective data; this will enable the system to yield reliable screening results and be applicable in both settings. Most nutrition screening tools assess the risk of malnutrition to a child by using subjective data such as recent weight loss, food intake, disease severity and other measurements of predicting malnutrition risk. These tools left out objective data (anthropometric measurements such as height, weight or MUAC). For this matter, these tools are more appropriate to be used for hospitalized children whose malnutrition condition is due to disease they are suffering from or due to hospital stay and less appropriate to the rest.

7 References


Humphrey, A., Dinakar, C., City, K., Padron, G. T. and Hernandez-trujillo, V. 2014. The PACCI is a valid measure of multiple associated clinical immunotherapy trial had slgE levels performed by the Immulite System (Siemens AG, Munich, Germany) within 4 weeks of initial SPT testing. pp. 5–8. doi: 10.1542/peds.2014.


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