Evaluating Nutrient Intake of Children Using an Instant Digital Dietary Assessment Tool in Sidama, Ethiopia

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Abstract

Background: A digital dietary assessment tool called Calculator of Inadequate Micronutrient Intake for Ethiopia (CIMI-Ethiopia) was developed and validated. The present study aimed to determine acceptance and speed of CIMI-Ethiopia, and assess nutrient intake of children using CIMI in Sidama, Ethiopia.

Methods: A cross-sectional study was conducted on 80 mother-child pairs (MCP). The dietary intake data was collected by the CIMI-Ethiopia app on tablet. With CIMI-Ethiopia, the amounts of specific food groups consumed in the last 24 hours were asked. In order to determine acceptance and speed of CIMI-Ethiopia, the mothers were interviewed the amount of individual food items consumed on the same day through a classical 24-h dietary recall (24HR). Data about acceptance of CIMI-Ethiopia was obtained from the data collectors, and the mothers.

Results: CIMI-Ethiopia reduced the data collection time by 25% compared with the conventional 24HR, and automatically provided nutrient intake results directly after interview. The device was selected by two-third of the study participant mothers over a conventional 24HR dietary assessment method. CIMI-Ethiopia identified that over quarter of children had inadequate intakes of zinc and vitamin A, while 100% inadequate vitamin B12. Moreover, >50% of them suffered from low dietary energy, and 10% low protein intake.

Conclusions: The study demonstrated that CIMI-Ethiopia is well-accepted for dietary assessment. It also showed that CIMI-Ethiopia decreases time required for dietary data collection in field, and provides instant nutrient intake results. Also, it has been found that there is a possibility that all children in the study area could have an inadequate vitamin B12 intake.

Keywords: Acceptance; children; CIMI-Ethiopia; inadequate nutrient intake; rural Ethiopia; Sidama

Abbreviations: CIMI-Ethiopia - calculator of inadequate micronutrient intake for Ethiopia; MCP - mother-child pairs; WHO - World Health Organization; FAO - Food and Agriculture Organization, UNU - United Nations University

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Background

Young children appear in the category of population segment most vulnerable to micronutrient malnutrition [1]. For this, the reason is an increased nutritional requirement for their growth and development [2]. The deficiencies of iron, vitamin A, zinc and iodine are the four most widespread forms of micronutrient malnutrition worldwide [3]. However, iodine is not emphasized in this paper as CIMI-Ethiopia doesn't compute it from diet. Of the rest three, vitamin A deficiency alone contributes 5.3% to the global disability-adjusted life years (DALYs) in children under-5, while zinc and iron deficiencies 3.8% and 0.5%, respectively [4]. Moreover, Micronutrient Deficiencies (MND) increase the risk of dying, and contribute to impaired mental and physical development [1].

In Ethiopia, the deficiencies of iron, zinc, and vitamin A are amongst the well-known public health problems [5-7]. Limited studies sampled pregnant mothers from the current study zone identified that the deficiencies of vitamin A and zinc are public...
health problems [8, 9]. Another of such studies reported a very low intake of protein and energy [10]. Besides, a recently published study from a comparable agro-ecology reported correlation in the dietary intake of mothers and children [11]. Nevertheless, specific information on young children’s nutrient intake is too little. Furtherly, assessing the dietary intake of vitamin B12 attracted attention of the authors. The consequences of the deficiency of this vitamin are megaloblastic anemia and neurological symptoms [12].

Poor dietary intake is a primary contributor for MND [13]. Therefore, an early identification of child with inadequate dietary nutrient intake is absolutely essential for a timely intervention. To serve such purposes, CIMI-Ethiopia has been developed and validated in the country [14, 15]. Also, the validation of this program has been confirmed in other countries like Indonesia, Ghana and Tanzania [16-18]. Still, the acceptance and speed of the program needed further investigation.

CIMI-Ethiopia is an instant digital dietary assessment tool which is abbreviated for calculator of inadequate micronutrient intake for Ethiopia. It serves a dual purpose being used for dietary intake data collection from field, and instant identification of individuals with inadequate nutrient intake. The device computes energy, macro- and micronutrient intakes and percentage fulfillment based on the FAO/WHO recommended nutrient intake (RNI) [19-21]. Unlike a conventional 24-hr dietary recall (24HR) method, it asks the amounts consumed based on food groups and provides individual results directly after the interview. Conversely, the data from 24HR should be entered into a nutrition software for analysis at office seeking longer time to generate results of nutrient intake. Due to the variability in the daily dietary intake, such delayed results are less helpful to provide dietary counseling and other feasible interventions to the affected individuals.

Having the above problems in mind, the present study was designed to determine the acceptance and speed of CIMI-Ethiopia program, and assess nutrient intakes of children using CIMI in rural Ethiopia.

Materials and Methods

Study Area and Subjects

This study was conducted in Shebedino District of Sidama Zone from Southern Ethiopia. Shebedino is one of the nineteen districts and two city administrations of Sidama Zone [22]. The district has a total population of 264,383 [23]. Its capital town is Leku which is located at 299 km South from Adis Ababa Ethiopia. The district mainly produces maize, enset (Ensete ventricosum) and coffee.

This is a community-based cross-sectional study. The data collection was conducted in May 2018.

All mother-child pairs (MCP) were eligible for this study. In order to avoid the effect of poor appetite on dietary consumption pattern, the children who were reported sick during the survey were excluded from this study.

A convenient sample of 80 MCP was involved in the study. From the 13 well trained data collectors the acceptance data was assessed.

Data Collection

A structured and semi-structured questionnaire was prepared first in English, and then translated into Amharic. The purpose of this questionnaire was to collect data of socio demography, and acceptance from mothers. An online survey was prepared to collect acceptance data from the data collectors. The survey tools were pre-tested before actual data collection for the necessary adjustment.

Experienced data collectors were recruited. The data collectors were trained by the researchers. The data collection was conducted in four steps which are described in the next sections.

CIMI-app in the tablet was used for collection of dietary consumption data. The local units were used for estimation of the amounts of foods eaten and beverages consumed. The type and amount of food group consumed in 24 h preceding the survey were asked. For instance, “How many coffee cups of beans did your child consume from yesterday breakfast up to bed time?” The food pictures in CIMI-Ethiopia were used to facilitate the dietary recall. Data collectors probed for forgotten food items. CIMI-Ethiopia provided nutrient intake results immediately after the interview (1). A 24HR data was collected directly after interview with CIMI-Ethiopia. Unlike CIMI-Ethiopia, the 24HR study assessed individual food items consumed from breakfast to bed time. The purpose of 24HR data collection was to determine the acceptance and speed of CIMI-Ethiopia. The time spent for dietary intake data collection with the two methods was recorded in seconds (2). The acceptance data was collected from mothers (3). An online survey was conducted to collect acceptance data from data collectors (4).

Data Analysis

The dietary consumption data collected with CIMI-Ethiopia and the resultant nutrient intake data were transferred automatically to the server when WIFI was available. This data was downloaded from the server and imported into SPSS 20 (IBM Corporation, Armonk, NY, USA). The socio demographic and acceptance data from mothers was entered into SPSS. The acceptance data from data collectors was imported into SPSS. Finally, the data sets were pooled and checked for completeness. The data normality was checked using Kolmogorov-Smirnov test. Descriptive statistics was computed for analysis of acceptance data. The median was calculated with minimum and maximum intake for iron, zinc, vitamin A, B12, protein and energy. In addition, the mean was computed with Standard Deviation (SD). The percentage of children with inadequate nutrient intake was computed. The cutoff point for threshold of inadequate intake was having nutrient intake that is less than two-thirds of the FAO/WHO’s RNI [16, 19-21, 24, 25]. The p-value ≤0.05 was taken as a cut off point for statistical significance.
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Results
Socio-Demographic Study

From the mothers participated in this study, 35% and 63% were 18-24 and 25-34 years old respectively, while the rest were ≥35 years old. Nearly 79% of the mothers were lactating. More than half of the children were girls. Almost 67% of the data collectors had Bachelor Degree Table 1.

Table 1: Socio demographic characteristics of study participants, May 2018

<table>
<thead>
<tr>
<th>Variables</th>
<th>Categories</th>
<th>Number</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age of mothers (years) (N = 80)</td>
<td>18-24</td>
<td>28</td>
<td>35</td>
</tr>
<tr>
<td></td>
<td>25-34</td>
<td>50</td>
<td>63</td>
</tr>
<tr>
<td></td>
<td>≥35</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Physiological status (N = 80)</td>
<td>Lactating</td>
<td>63</td>
<td>79</td>
</tr>
<tr>
<td></td>
<td>Pregnant</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>Other</td>
<td>14</td>
<td>17</td>
</tr>
<tr>
<td>Age of children (months) (N = 80)</td>
<td>12-23 months</td>
<td>13</td>
<td>16</td>
</tr>
<tr>
<td></td>
<td>24-35 months</td>
<td>18</td>
<td>22</td>
</tr>
<tr>
<td></td>
<td>36-47 months</td>
<td>23</td>
<td>29</td>
</tr>
<tr>
<td></td>
<td>≥ 48 months</td>
<td>26</td>
<td>33</td>
</tr>
<tr>
<td>Sex (N = 80)</td>
<td>Boys</td>
<td>33</td>
<td>41</td>
</tr>
<tr>
<td></td>
<td>Girls</td>
<td>47</td>
<td>59</td>
</tr>
<tr>
<td>Educational level of data collectors (N = 9)</td>
<td>Diploma</td>
<td>1</td>
<td>11.1</td>
</tr>
<tr>
<td></td>
<td>Bachelor</td>
<td>6</td>
<td>66.7</td>
</tr>
<tr>
<td></td>
<td>Master</td>
<td>2</td>
<td>22.2</td>
</tr>
</tbody>
</table>

Acceptance and Speed of CIMI-Ethiopia

About 90% of the data collection staff responded that they select CIMI-Ethiopia over the 24HR method, and preferred it for their future research works. Likewise, majority of them confirmed a precise recording of the responses to both CIMI-Ethiopia-based and 24HR interview. All of the enumerators replied that CIMI is more convenient compared with 24HR. As well as, every enumerator was able to provide counseling on dietary approach for mothers based on immediate display of nutrient intake results by CIMI Table 2.

Two third, 66%, of the mothers participated in this study selected CIMI-Ethiopia as compared to conventional 24HR interview. Nearly half (49%) of the mothers replied that they preferred the recall for CIMI-based interview to the paper 24HR counterpart. In addition, almost 66% of the mothers responded that they easily answered for CIMI-based interview. All study participants confirmed that they were benefitted from the feedback given by the data collectors directly after the interview based on the directly displayed nutrient intake result in CIMI Table 3.

Additional analysis of the time spent for data collection showed that CIMI-Ethiopia is shorter than 24HR dietary assessment method by ~2 minutes, which is 25% of the time required, per interview (p<0.001) Table 4. In addition to this, much more time is saved by the fact that data input in a nutrition software after
Nutrient Intake of Children

The mean and median nutrient intakes and percent of study participants below threshold of inadequate intake are shown in Table 5. CIMI-Ethiopia determined that over quarter of the study participating children had inadequate intake of zinc and vitamin A. On top of this, vitamin B12 was inadequate in diet of all participants in this study, while over half had an inadequate energy, and ten percent low protein intake.

Table 5: Mean, median and percentage of children below threshold of inadequate nutrient intake (<2/3 RNI) assessed by CIMI-Ethiopia (N = 80)

<table>
<thead>
<tr>
<th>Nutrients</th>
<th>Mean (SD)</th>
<th>Median (Min., Max.)</th>
<th>N (%) &lt;2/3 RNI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Iron (mg)</td>
<td>16.6 (9.3)</td>
<td>14.8 (3.2, 62.3)</td>
<td>0 (0.0)</td>
</tr>
<tr>
<td>Zinc (mg)</td>
<td>4.4 (2.4)</td>
<td>3.7 (1.1, 14.1)</td>
<td>23 (28.0)</td>
</tr>
<tr>
<td>Vitamin A (µg)</td>
<td>674 (559)</td>
<td>649 (0.0, 3041)</td>
<td>24 (30.0)</td>
</tr>
<tr>
<td>Vitamin B12 (µg)</td>
<td>0.0 (0.1)</td>
<td>0.0 (0.0, 0.4)</td>
<td>80 (100)</td>
</tr>
<tr>
<td>Protein (g)</td>
<td>21.9 (11.2)</td>
<td>19.6 (6.2, 68.7)</td>
<td>8 (10.0)</td>
</tr>
<tr>
<td>Energy (kcal)</td>
<td>841 (351)</td>
<td>813 (310, 2575)</td>
<td>42 (52.5)</td>
</tr>
</tbody>
</table>

CIMI-E: calculator of inadequate micronutrient intake for Ethiopia; Min: Minimum; Max: Maximum; N: number; RNI: recommended nutritional intake; Breast milk was not considered in computing nutrient intakes.

Discussion

Acceptance and Speed of CIMI-Ethiopia

Compared with the classical paper-based 24HR method, CIMI-Ethiopia saved nearly 25% of the time required i.e. nearly two minutes per respondent in the field survey Table 4. In addition, the immediate results from the device helped the respondents to obtain nutrition counselling at their home from the data collectors. These scenarios showed that CIMI-Ethiopia is a contemporary device which provides nutrient intake results quickly for timely intervention. CIMI-Ethiopia avoids labor costs incurred with other techniques of dietary assessment, such as two times data entry (firstly, paper-based data collection in field, and secondly, data entry into a nutrition software at office), and carrying questionnaire and food samples from house to house during data collection.

Majority of the data collectors confirmed that CIMI is more convenient Table 2 in a rural setting with a shortage of infrastructure. Maybe this is due to the fact that internet connection is not necessary for data collection with CIMI-Ethiopia, and tablets can be charged by solar panel in rural area without electricity supply. The same way, more than half of the study participant mothers preferred CIMI-Ethiopia to a conventional paper-based 24HR Table 3. These results imply that CIMI is acceptable for dietary nutrient intake assessment in rural areas to identify individuals with inadequate nutrient intake.

It would be worthwhile to note that CIMI immediately transfers survey data to the server for backup when WIFI is available. It also registers timestamp of interview and GPS information of the surveyed households. This enables the researchers to trace back the data and households later for longitudinal and intervention studies. Moreover, the local units and food pictures displayed during interview with CIMI-Ethiopia could enhance memory, and reduce biases in portion size estimation.

Nutrient Intake of Children

A prior study conducted 24HR in Hula District of Sidama Zone in Southern Ethiopia reported the mean iron intake of 16.9 mg which is in agreement with the finding from CIMI-Ethiopia [26]. Nonetheless, the present median is higher when compared with previous weighed record (WR) reports from a comparable agro-ecology and Damot Gale District of Southern Ethiopia, a multiple pass 24HR from Southern Region, and pastoralist community from Ethiopia [27-30]. Even so, the current median is comparable with report from multiple pass 24HR study from North Wollo of North Ethiopia which considered intake from breast milk [31]. The observed variation could be due to several reasons: difference in data collection period, data collection method, children’s age, agricultural production, and dietary pattern in the above studies. Moreover, the current study did not find any children who had intake of iron below 2/3 RNI. This could be due to a high availability and consumption of vegetables such as Ethiopian kale (Brassica carinata) during the data collection season. Another possible explanation could be a low and convenience sample. Yet, the authors recommend further study on hemoglobin and biomarkers of iron status of the children. This is because, an earlier study recruited non-pregnant women concluded that iron deficiency is not the major cause of anemia in Sidama [32].

The median zinc intake determined by CIMI-Ethiopia is higher from the prior report for 6-35 months old children in Southern Ethiopia, but lower than the report for 12-23 month old children in Damot Gale District [28, 29]. In contrary, it is higher compared with the report for 12-23 months old children in a comparable agro-ecology [27]. On the other hand, nearly 30% were below threshold of an inadequate intake Table 5. This could be attributable to little or no consumption of meat. The present finding is consistent with the report from North Wollo (3.3 mg), if the amount from breast milk was not considered [31].

Even though the median vitamin A was found to be higher than earlier reports from Ethiopia, CIMI-Ethiopia identified that over a quarter of the study participating children were with an inadequate intake [28-31] Table 5. The high median intake could be explained by an increased availability, and consumption of vegetables at the time of survey which was a wet season.

Information on the dietary intake of B12 is limited in Ethiopia. Herrador and colleagues found a 1.3% prevalence of B12 deficiency in school age children from North-western Ethiopia [6]. This percent is considerably lower than that of the reports...
on Kenyan school age children (40%), and Nepalese 6-23 months old children (30.2%) [33-34]. Such kind of high variations in the prevalence of vitamin B12 deficiency could be associated with the differences in dietary habits, stomach problems and biomarker used for measuring the deficiency. The above studies determined B12 deficiency regarding serum B12 level. Yet, several studies showed that this parameter has limited diagnostic value as a stand-alone marker. A severe functional deficiency of this micronutrient has been documented in the presence of normal and even high levels of serum vitamin B12 [35]. Therefore, we recommend studies that will use established markers like serum trans-holocobalamin and/or methylmalonic acid in urine to determine functional B12 status related to such low B12 intakes identified in the present study. The observed gap in vitamin B12 intake could be associated with the lack of animal source foods in diets as they are the usual sources of this vitamin [36].

A median protein intake of 19.6 g was reported for 12-23 months old children from pastoralist communities in Ethiopia [30]. The median from CIMI-Ethiopia is in agreement with the above result. Conversely, it is higher than others from the country [27, 29, 31]. The observed discrepancies might be due to pulse intake, and low sample size in addition to the reasons stated in paragraph one here.

The study from North Wollo found a higher mean energy intake compared with our result. In contrary, CIMI-Ethiopia calculated higher median as reported from the same agro-ecological zone, Southern Region, and pastoralist communities from Ethiopia [27, 29, 30, 31]. Despite of that, CIMI-Ethiopia identified that over half the children consumed a diet not reaching 2/3 of the recommended energy intake. Addition of more butter and oils in foods, and increasing consumption of pulses and nuts can improve the energy intake.

**Limitations**

Though this study has several strengths using CIMI-Ethiopia after external and internal validation studies, the recall-based dietary data collection imply possible memory lapse, and recall bias. One critical limitation for assessing nutrient intake in infants and toddlers is the missing consideration of nutrient intake from breast milk by CIMI-Ethiopia. This feature was not implemented, because the amount of milk cannot be quantified properly. In addition, the content of several micronutrients in breast milk is dependent on the nutritional status of the mother. Due to this high variability, nutrient data of breast milk has not been included in CIMI. Furthermore, lack of internet access has reduced response rate of the data collectors. Only 9 of 13 data collectors have answered the online-feedback questionnaire.

**Conclusions**

This study demonstrated that CIMI-Ethiopia is acceptable for dietary assessment. It also showed that the device reduces time required for dietary data collection in field, and provides instant nutrient intake results. These findings are interesting for health workers, non-government and government organizations concerned with dietary assessment. CIMI-Ethiopia identified that vitamin B12 is inadequate in diets of all study participant children. Furthermore, more than quarter of them suffer from inadequate intake of vitamin A and zinc, while over half from low energy, and ten percent from low protein intake. Nutrition education and increasing animal source food consumption could help in improving intake of vitamin B12, and other lacking nutrients in Sidama, Ethiopia.

**Declarations**

**Competing Interests**

The authors declare that they have no competing interest related with this study.

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**Author Contributions**

Design of the study: TB, BBD, CL, SR, AM, Ug and HKB.

Data collection: TB, BBD and SR.

Data entry: TB and BBD.

Data analysis, interpretation and draft of the manuscript: TB.

Critical review of the manuscript: TB, CL, SR, AM and HKB. All co-authors read and approved the manuscript.

**Ethical Approval and Consent to Participate**

Ethical clearance was received from Institutional Review Board of Hawassa University, Ethiopia; and Ethik-Kommission, Landesäztekammer Baden-Württemberg, Germany (F-2016-127). Permission was obtained from health administration of the study district. Written informed consent was taken from mothers before data collection. Data was kept confidential using pseudonymous codes.

**Availability of Data and Material**

Data supporting the conclusions are available from the corresponding author up on a reasonable request.

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