Using Lot Quality Assurance Sampling to Assess Measurements for Growth Monitoring in a Developing Country's Primary Health Care System

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Background. Local supervisors used lot quality assurance sampling (LQAS) during routine household visits to assess the technical quality of Costa Rican community-based health workers (CHW): measuring and recording weights of children, interpreting their growth trend, and providing nutrition education to mothers.

Method. Supervisors sampled 10 households in each of 12 Health Areas (4–8 hours per area). No more than two performance errors were allowed for each CHW. This LQAS decision rule resulted in judgements with a sensitivity and specificity of about 95%.

Results. Three categories of results are reported: (1) CHW adequately weighed children, calculated ages, identified children requiring nutritional services, and used the growth chart. (2) They needed to improve referral, education, and documentation skills. (3) The lack of system support to regularly provide growth cards, supplementary feeding to identified malnourished children, and other essential materials may have discouraged some CHW resulting in them not applying their skills.

Conclusions. Supervisors regularly using LQAS should, by the sixth round of supervision, identify at least 90% of inadequately performing CHW. This paper demonstrates the strength of LQAS, namely, to be used easily by low level local health workers to identify poorly functioning components of growth monitoring and promotion.

Keywords: growth monitoring, primary health care, quality assurance, LQAS, nutrition, child survival, international health, community health, Latin America

Although growth monitoring and promotion (GMP) have been very effective in small projects, GMP has been less useful when applied generally. Some public health professionals suggest improvements to GMP can be made by more scientific scrutiny, greater community involvement, and more attention to underlying economic and epidemiological issues related to malnutrition. Other practitioners question how frequent these debates, it is fundamentally important to maintain high quality growth monitoring since inaccurate measurement and recording can exacerbate health problems for the child and result in irrelevant social policies. This paper addresses this issue by showing how Costa Rica applied an industrial quality assurance technique (Lot Quality Assurance Sampling: LQAS) to identify rapidly weaknesses in its own GMP system.

Growth monitoring and promotion is defined as: assessing the child’s growth curve, and taking corrective...
actions should it deviate from the standard. Ideally, the mother should take such corrective actions. However, no matter who takes the remedial action, correct diagnosis requires accurate measurement of growth at each point that forms the curve. Because LQAS is rapid and easy to use, it is one which local supervisors can use regularly to manage community-based health workers (CHW) performing GMP.\textsuperscript{4} Previous applications of LQAS assessed other primary health care (PHC) services: vaccination,\textsuperscript{5} oral rehydration therapy,\textsuperscript{*} health education,\textsuperscript{**} record keeping,\textsuperscript{5} and reproductive health.\textsuperscript{1} One study using LQAS for CHW supervision demonstrated that when used at three 6-month intervals, of 36 problematic activities originally detected in the vaccination system, 30 improved by a factor of at least 80\%, and three improved by 25\%.\textsuperscript{6} These experiences showed that LQAS can be used by minimally trained CHW in different cultures for assessing complex as well as simple tasks in the health system.

The following sections describe an application of LQAS to assess the quality of CHW GMP, and present findings relevant to health system management and training.

\section*{METHODS}

\textbf{LQAS Principles}

LQAS uses the binomial formula to calculate small samples and to formulate decision criteria for classifying CHW by their performance using a three-part triage system: adequate, inadequate, and very inadequate service delivery. In earlier assessments of PHC coverage the criteria used to assign a CHW to a triage system stratum were: (1) judge coverage as adequate if 80\% or more of the target population receives the service, (2) judge it as inadequate if between 50\% and 80\% are covered, and (3) judge it as very inadequate if 50\% or less of the target population is covered.\textsuperscript{3}

LQAS calculates a probability estimating whether a CHW reached a predetermined performance standard (e.g. 80\% or more of his target population received the PHC); it does so by analysing the number of children in a small sample who have not received a particular service. For example, in a sample of 19 children if six or fewer have not received the service, the CHW is classified as providing \textit{adequate} coverage. If more than six have not received the service the CHW's performance is judged as \textit{very inadequate}. The exact coverage of a given CHW is less important than deciding whether coverage was adequate. In most instances of day to day health system management, a supervisor needs to detect extremes of performance to make rational decisions about resources allocation.

Because LQAS uses binomials, it can precisely identify quality at either end of the continuum: adequate or very inadequate. It is less sensitive to CHW within the middle category. However, this limitation is not severe since the closer the quality is to either end of the triage system, the greater the likelihood that CHW will be classified as \textit{adequate} or \textit{very inadequate}. The two extreme categories of CHW are the most important to identify correctly so that: (1) resources can be directed to improve low quality services that otherwise could heighten health risks in communities; and (2) resources are not needlessly spent on adequately performing CHW.

To use LQAS three initial decisions must be made:

1. Define \textit{performance standards} for the service delivery unit under assessment using a three-part triage system.
2. Decide \textit{the permissible classification error of the LQAS screening}, for example, a sensitivity of 92\% and a specificity of 93\%.
3. Develop a \textit{decision rule that stipulates the maximum number of individuals who have not received the intervention allowed in the LQA sample}. Any number greater than this threshold results in judging a CHW's performance as \textit{very inadequate}. In the above example, if six or fewer children do not receive a service, the CHW is judged as having performed \textit{adequately}. If seven or more do not receive it, the CHW is judged as \textit{very inadequate}.

The LQA sample size depends on all three decisions. Performance standards, the classification error, and the number of permissible performance errors are all interrelated. A complete discussion of LQAS theory and a comprehensive set of Tables for sample sizes ranging from five to 50, can be found elsewhere.\textsuperscript{5,7,8}

\textbf{Sample Size and Sampling Methods}

Sample sizes were selected using LQAS principles to make two assessments: (1) the quality of GMP technique of individual CHW, and (2) the proportion of CHW...
with adequate GMP skills working throughout the national programme.

Sampling within a Health Area. A CHW is responsible for growth monitoring of all children under six in approximately 500 households that form a Health Area (HA).

Because this application of LQAS assesses the quality of GMP technique, the Ministry of Health (MOH) used higher performance standards than those presented in earlier examples about coverage of a population with a service. Almost all of the time a CHW should deliver services using proper technique. The MOH defined the following triage system: adequate CHW skills if \( \geq 95\% \) of the time the CHW used the correct technique, \( 95\% > \text{inadequate} > 50\% \), very inadequate \( \leq 50\% \). The desired sensitivity and specificity was 95%. The resulting decision rule was: observe a CHW monitoring the growth of 10 children, if performance errors are observed in a component of GMP in more than two children then classify the CHW as having inadequate growth monitoring technique. This simple decision rule has a corresponding sensitivity of 94.5% and a specificity of 99%.

This decision rule misclassifies about 1% of CHW with performance quality of 95%, and about 5% of CHW with skill quality of 50% (Table 1). Performance between 95% and 50% is more likely to be classified as adequate as it approaches 95%, and classified as very inadequate as it approaches 50%. Thus, LQAS identifies the best and worst services with small error, but services in the middle range of quality have higher classification errors.

Sampling procedures within Health Areas. A trained supervisor using a checklist observed a CHW measuring the growth of the 10 children in each child's home. Each supervisor randomly selected the first of 15 households in a CHW's HA (five extras in case some mothers or children were not at home); the remaining 14 were homes located near to the first household. The CHW then visited the corresponding households with a supervisor and monitored the growth of one child in the household. The first household was chosen randomly to eliminate CHW preferences for easily accessible and compliant mothers. The remaining 14 was a convenient sample due to the assumption that CHW performance is independent of the location of the child's home. Any resulting Hawthorne effect was assumed to benefit the assessment since if CHW over performed for the evaluators and still committed errors they surely would continue to do so when not being observed.

Selecting Health Areas throughout the country. The second focus of the evaluation was to decide whether a sufficient proportion of CHW adequately carried out GMP throughout the country. Therefore, a sample size of CHW and a decision rule had to be developed. Selecting the sample of CHW required the same decisions to be made as when selecting the number of households to observe. One constraint was that all six Costa Rican regions had to be represented in the sample. A 95% : 50% triage system was chosen since the MOH decided that at least 95% of CHW should perform adequately for any given task. The MOH decided upon a national sample of 12 CHW with a 12 : 2 decision rule; these choices resulted in a sensitivity and specificity of 98%. The sample was stratified by region and population density (rural/urban). The MOH team randomly selected one rural and one urban CHW in each of the six health regions.

Summary of sample design. A two-stage LQA sample was used. The first stage selected 12 CHW to assess overall national performance. The second stage selected households in an HA to assess a CHW monitoring the growth of 10 children.

Evaluation Instruments
The evaluation team developed and pretested two instruments. The first one assessed the availability of essential supplies (an accurate scale and a supply of growth charts) at the HA, and registration of malnourished children. The supervisor provided growth charts when necessary.

The second one was an observation checklist used in the household. It distinguished separate tasks that
comprise GMP and aggregated them in five subsystems that must function correctly to learn the nutritional status of a child based on weight-for-age. They are: weight calculation, age calculation, use of the growth chart, education of the mother, and documentation of GMP data.

As the study assessed CHW GMP skills at the household level, it did not consider issues such as motivation or time constraints that may affect a CHW's performance. However, earlier studies in Costa Rica have considered this issue.9

**Data Collection**

Nurses and rural health supervisors (all of whom we refer to as supervisors) conducted data collection, accompanied by an observer from the MOH evaluation team. Due to previous experience with a similar supervision instrument the supervisors used the instrument easily with little instruction.5

Each supervisor observed each CHW with 10 children. During 5 weeks supervisors observed 12 CHW deliver services in 120 households distributed across the nation, spending 4–8 hours with each CHW. The time variation was mostly due to the different travelling conditions within each HA.

**RESULTS**

**Quality of Essential Supplies and Registration**

The CHW require essential supplies to carry out regular growth monitoring. These include a functioning suspension scale and an adequate supply of growth charts. Half the areas visited did not have a working scale or a supply of growth charts. However, most CHW had at least one growth chart to use as a guide to classify children.

To follow-up and refer malnourished children, HA personnel should register identified children. At a national level the system for registering malnourished children was inadequate; eight of 12 CHW did not maintain the system.

**Weighing the Child**

The MOH identified eight tasks (Table 2) included in the process of weighing a child. Each can affect the accuracy of the weight measurement. At a national level, CHW performed only three components adequately: (1) remove shoes and heavy clothing, (2) read the scale from directly in front of the scale’s face, and (3) accurately read the scale. Although the other components were not carried out adequately, results confirm they did not affect the accuracy of the weight reading. Besides observing the weighing process, we also compared the supervisor’s weight reading (used as the standard) with the CHW’s weight reading. As all measurements were within 0.1 kg, national performance was judged adequate. When the CHW did not calibrate the scale, the supervisor did so before measurements were taken.

There are several possible explanations why inadequate weighing procedures did not result in inaccurate weights. Performance standards may be too strict; greater tolerance may be allowed without affecting the weight measurement. Alternatively, the supervisors may have had similar readings to CHW because they were making similar mistakes. However, as supervisors were skilled in growth monitoring and because one of the evaluation team always observed them, it seems unlikely that this occurred.

**Age Calculation**

Supervisors judged each CHW’s ability to calculate accurately children’s ages using date of birth. They compared a CHW’s age calculation with his/her own calculations to verify accuracy. Ages were judged as accurate if the CHW age calculation was within one month of the supervisor calculation. All components of this subsystem were adequate in all 12 HA.

**Use of the Growth Chart**

Supervisors expected CHW to use a sex-specific National Center for Health Statistics weight-for-age growth chart. As supervisors judged all 12 CHW as adequate, national performance was also judged as adequate.

The CHW must also correctly plot current weight and age (one of 12 CHW plotted inadequately) and then connect the point to previous measures to chart the

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**Table 2 The GMP activities CHW should perform while weighing the child**

<table>
<thead>
<tr>
<th>Tasks</th>
<th>Inadequate CHW (n = 12)</th>
<th>National performance is adequate (Yes/No)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Position scale in a safe, well-lit place</td>
<td>5</td>
<td>No</td>
</tr>
<tr>
<td>2. Set scale to zero</td>
<td>5</td>
<td>No</td>
</tr>
<tr>
<td>3. Remove shoes and heavy clothing</td>
<td>0</td>
<td>Yes</td>
</tr>
<tr>
<td>4. Wait until child is still to read weight</td>
<td>3</td>
<td>No</td>
</tr>
<tr>
<td>5. Read scale from directly in front of</td>
<td>2</td>
<td>Yes</td>
</tr>
<tr>
<td>scale face</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6. Read weight out loud</td>
<td>4</td>
<td>No</td>
</tr>
<tr>
<td>7. Record weight immediately</td>
<td>7</td>
<td>No</td>
</tr>
<tr>
<td>8. Weigh child twice</td>
<td>7</td>
<td>No</td>
</tr>
<tr>
<td>9. Accurately read scale</td>
<td>0</td>
<td>Yes</td>
</tr>
</tbody>
</table>
child’s progress (five CHW were inadequate). National performance was adequate for the former activity and inadequate for the latter. In many HA the growth chart had no previous growth points to connect.

All CHW used the available data to classify children correctly. This task was measured by comparing the supervisor’s classification with the CHW’s classification. This result, however, has to consider that some judgements had no previously recorded growth points to use as a reference.

Education of the Mother

The nutrition education that accompanies growth monitoring is an important and difficult task to assess. The CHW are expected to inform all mothers of the nutritional status of their children and to use the growth chart as a visual aid during the explanation. National CHW performance for each of these components was not adequate (three of 12 CHW and eight of 12 CHW were inadequate, respectively). Ideally, the family as a unit should receive education being sure to include older family members and family decision makers.

Beyond informing the mother of the child’s nutritional status, CHW should refer malnourished or overweight children to the health centre and supplementary feeding programmes where appropriate; they should also educate mothers about: breastfeeding, feeding of preschoolers, prevention of diarrhoea, and hygiene. LQAS results show that all CHW need improvement. Of 38 malnourished (n = 30) or overweight (n = 8) children, CHW referred children to the health centre, or verified that the child was followed-up in only 10 cases. Of the 30 malnourished children, CHW referred and gave information about supplementary feeding to nine of them.

Although some CHW may have been unaware of their duty to refer children, other considerations may explain referral problems. The CHW may have already detected growth faltering on previous visits and discussed this condition with mothers during those visits. A milk shortage during the time of the study affected the supplementary feeding programme, and CHW may have been hesitant to discuss milk supplements which were not available. The CHW expressed their dissatisfaction with the government nutrition services. Supervisors agreed that none of these issues excused lack of referral by CHW.

Discussions of diarrhoea prevention, oral rehydration therapy and breastfeeding were not satisfactorily performed. However, supervisors had instructed CHW to perform only GMP and nutritional assessments for the study. Therefore it is possible that during a regular household visit these issues would be discussed. Nevertheless, it is clear from these results that CHW do not see diarrhoea prevention or breastfeeding as an integral part of GMP.

The CHW are also expected to discuss the nutritional needs of preschoolers. They were mentioned 60% of the time.

Education concerning personal hygiene and food preparation hygiene was inadequate. However, supervisors explained this deficiency as possibly due to CHW being reluctant to criticize hygiene in the presence of a member of the evaluation team.

Besides failure to inform and refer, many CHW did not provide appropriate nutrition education when they encountered a malnourished or overweight child. In cases where CHW conveyed health education, supervisors did note deficiencies in education skills. The CHW did not routinely check to see that the mother had retained nutrition information, and did not reinforce the educational messages by repetition or example.

Documentation

Table 3 Documentation of growth monitoring information

<table>
<thead>
<tr>
<th>Tasks</th>
<th>Inadequate CHW (n = 12)</th>
<th>National performance is adequate (Yes/No)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Name of child</td>
<td>3</td>
<td>Yes</td>
</tr>
<tr>
<td>2. Birth date</td>
<td>9</td>
<td>No</td>
</tr>
<tr>
<td>3. Health record number</td>
<td>3</td>
<td>No</td>
</tr>
<tr>
<td>4. Today’s weight</td>
<td>3</td>
<td>No</td>
</tr>
<tr>
<td>5. Today’s age</td>
<td>3</td>
<td>No</td>
</tr>
</tbody>
</table>

Documentation of growth monitoring requires, at a minimum: name of the child, birth date, health record number, weight and age measurements recorded on the growth chart. Although CHW did record the name of the child, national performance was inadequate for other documentation tasks (Table 3). Since age and weights were accurately measured, the biggest problem in this subsystem is that CHW failed to record the information.

Subsequent investigation revealed that this problem relates to deficiencies in material supply. For the study, when CHW did not have growth charts; supervisors gave them one for each child being monitored as they had brought their own supply. Because CHW did not usually have a supply of growth charts, they did not fill them out regularly. Therefore, they were unaccustomed to do so.
DISCUSSION

This rapid LQAS assessment led to major findings. Firstly, CHW can identify children who need nutritional services, but they need to improve their referral, education, and documentation skills. Secondly, the supply system and the documentation system that support growth monitoring do not function well. However, these two problems may be interrelated since the weak support system may have been responsible for CHW not applying their skills.

Our second finding (inadequate supplies and documentation of required GMP data) leads us to suspect that growth monitoring is not being carried out regularly; these problems are possibly due to a lack of scales and growth charts. Also, the health system is not following-up children identified with nutritional deficiencies; this problem may be because facilities that detect nutritional problems do not maintain a register and refer children systematically. This latter problem may explain why CHW were not referring malnourished children. In several discussions with CHW, they indicated that because institutions responsible for follow-up are not performing their function, they were discouraged from carrying out GMP. We should note, however, that in assessments of other services in Costa Rica for which CHW were exclusively responsible, they tended to perform well.5,6

A third conclusion was derived from a consensus between the supervisors and the evaluation team. The CHW face considerable time constraints that affect their ability to carry out regular growth monitoring. During our own data collection we found that the team needed 4–8 hours to observe growth monitoring in 10 households. Yet, the health system expects CHW to carry out an average of 10 complete household visits each day. During these visits, besides growth monitoring, they should provide PHC as needed including: vaccinations, ante- and post-natal care, ORT training, monitoring blood pressure and more. The resulting time constraints may impede regular GMP.

These LQAS findings were detected with one supervisor visit. As presented in Table 1 the specificity was quite high for adequately performing CHW. The sensitivity was high for CHW whose technique was very inadequate, although it was less sensitive for the middle category of CHW. However, as Figure 1 displays, with each subsequent supervision visit misclassification error of substandard CHW continues to decrease; this is because the cumulative probability of identifying an inadequate performer increases with each round of supervision. By the sixth visit nearly all CHW with performance quality of £80% could be identified. Therefore, regular supervision should eventually lead to identification of all CHW whose performance is not adequate. Earlier studies show that either nurses or experienced CHW are equally conservative supervisors.7,8

These results demonstrate that regular detection of GMP problems by community-based personnel is viable with LQAS methods. Its strength is the ability to identify a poorly functioning end product. However, amelioration of problems may require corrective action either at the level of the CHW or at each higher level of the national programme.

ACKNOWLEDGEMENTS
The work upon which this paper is based was performed in part under a subagreement with the Center for Human Services under its Cooperative Agreement No. DPE-5920-00-A-5056-00 with the US Agency for International Development. The original data collection and data analysis occurred while Dr Valadez was a faculty member of the Office for Health, Harvard Institute for International Development, Harvard University; final analyses were performed after Dr Valadez joined the faculty of the Department of International Health, The Johns Hopkins School of Hygiene and Public Health. Special recognition is given to Dr Carlos Valerin (Director General of Health), without whose support this research would not have been possible. We also gratefully acknowledge the helpful suggestions of Professor Andrew Tomkins of the Institute of Child Health who reviewed a draft manuscript.

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(Revised version received September 1995)