Managing data for a multicountry longitudinal study: Experience from the WHO Multicentre Growth Reference Study

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Abstract

The World Health Organization (WHO) Multicentre Growth Reference (MGRS) data management protocol was designed to create and manage a large data bank of information collected from multiple sites over a period of several years. Data collection and processing instruments were prepared centrally and used in a standardized fashion across sites. The data management system contained internal validation features for timely detection of data errors, and its standard operating procedures stipulated a method of master file updating and correction that maintained a clear trail for data auditing purposes. Each site was responsible for collecting, entering, verifying, and validating data, and for creating site-level master files. Data from the sites were sent to the MGRS Coordinating Centre every month for master file consolidation and more extensive quality control checking. All errors identified at the Coordinating Centre were communicated to the site for correction at source. The protocol imposed transparency on the sites' data management activities but also ensured access to technical help with operation and maintenance of the system. Through the rigorous implementation of what has been a highly demanding protocol, the MGRS has accumulated a large body of very high-quality data.

Key words: Data collection, data processing, database management system, longitudinal study

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Members of the WHO Multicentre Growth Reference Study Group and Acknowledgments are listed at the end of the first paper in this supplement (pp. S13–S14).

Introduction

The World Health Organization (WHO) Multicentre Growth Reference Study (MGRS) data management system was set up and operated according to a protocol designed to ensure a high quality of banked data, stored securely against unauthorized manipulation and accidental loss. The data were collected over a period of more than six years (July 1997 to November 2003) and in six different sites with variable levels of data management experience. In this context, using a standardized protocol in all study sites simplified the compilation and maintenance of the central master files at the MGRS Coordinating Centre as well as facilitating Coordinating Centre-to-site and intersite technical support whenever required. The system also imposed transparency to the extent that the Coordinating Centre could replicate and extend key elements of the quality control procedures that sites were expected to carry out as part of the data collection and management protocols. The confidentiality of the study participants was ensured by limiting identification information in the study data files to numbers without names or other information that might identify them beyond the purposes of the study.

The purpose of the present article is to share experience gained in managing the large body of data collected in the MGRS. We describe the data management model, the standard operating procedures (SOPs) used for handling forms and data, the computerized system with its inbuilt quality assurance features, the respective responsibilities of the sites and the Coordinating Centre, data quality checking and cleaning during the data collection phase, and the closure of data management activities in the sites.

General organization of the data management system

The longitudinal and cross-sectional components of the MGRS are described elsewhere in this supplement

[1], where detailed information on the specific data collected from the sample is also provided. In the data management environment, the longitudinal and cross-sectional study components were treated as separate projects with respect to assembling and processing batches of data and creating master files.

Briefly, the longitudinal study data set consists of eight master files, the first of these being the file that describes all screened subjects, regardless of whether or not they were enrolled in the study. Other questionnaires recorded information on the initiation of breastfeeding in the hospital and its continuation at home; baseline demographic and parental characteristics; child feeding, morbidity, and anthropometry during follow-up; and motor development. All enrolled subjects had an end-of-participation form completed indicating when they ended participation and for what reason. The eighth longitudinal study master file contains data from the 12-month study involving refusals and early dropouts who agreed to respond to an interview on the child's first birthday. The cross-sectional data set comprises two essential files: a screening master file with records of all screened subjects, and a survey master file with records of all subjects who responded to the cross-sectional study interview and had their anthropometric measurements taken. One supplemental form was used in Brazil and the United States, where the mixed-longitudinal design was used [1–3]. In these two sites, some cross-sectional study participants received one or two follow-up visits at which an abbreviated version of the survey questionnaire was used to collect data on anthropometry and intercurrent morbidity. A summary of the types of forms and number of records accumulated by each site up to end of May 2003 is presented in table 1 for the longitudinal study and table 2 for the cross-sectional study.

Preparatory work and system setup

A decentralized data management model was chosen for the study: each site collected, entered, verified, and validated data, and then locally created, updated, and cleaned study master files. Copies of the data files were transferred every month to the Coordinating Centre, where the consolidated study master files were created and updated with incoming data from the sites. Figure 1 illustrates the data flow and summarizes the tasks undertaken by the sites and the Coordinating Centre.

In order for this organizational system to work, the sites followed a common data management protocol, which included the use of centrally prepared data collection forms (questionnaires) and the same data processing system (software and dictionaries). The

TABLE 1. Longitudinal study forms received by May 2003

Form	Brazil (n = 4,801)	Ghana (n = 2,057)[a]	India (n = 692)[a]	Norway (n = 836)	Oman (n = 4,957)	USA (n = 398)	All countries (n = 13,741)
Screening	4,801	538	433	836	4,957	398	11,963
Breastfeeding (hospital)	—	343	353	322	446	237	1,701
Breastfeeding (home)	—	1,241	1,254	1,188	1,221	834	5,738
Baseline	368	351	331	308	328	212	1,898
Follow-up	5,864	6,090	5,435	5,605	5,488	3,843	32,325
12-month visit	101	12	60	41	72	28	314
Motor development	—	2,651	2,623	2,209	2,436	1,726	11,645
End of participation	388	364	234	322	450	232	1,990
All forms	11,522	11,590	10,723	10,831	15,398	7,510	67,574

a. Ghana and India prescreened subjects owing to local circumstances [4, 5] before the MGRS screening interview was administered, hence the difference between the number of subjects and the number of screening forms in these 2 sites.

TABLE 2. Cross-sectional study forms received by May 2003

Form	Brazil (n = 2,292)	Ghana (n = 4,622)	India (n = 3,886)	Norway (n = 5,185)	Oman (n = 4,509)	USA (n = 919)	All countries (n = 21,413)
Screening	2,292	4,622	3,886	5,185	4,509	919	21,413
Cross-sectional survey	487	1,323	1,490	1,387	1,432	562	6,681
Follow-up survey I	450	—	—	—	—	422	872
Follow-up survey II	419	—	—	—	—	364	783
All forms	3,648	5,945	5,376	6,572	5,941	2,267	29,749

electronic dictionaries in the data management system exactly matched the questionnaires and interviewer guides. For example, the interviewer guide specified when contingency questions were to be skipped, and the data entry dictionary had a corresponding rule to skip the variable during data entry in order to reduce unnecessary key punching. To facilitate data entry further, electronic forms were formatted so that the data entry screens matched the pages of each respective data collection form. In sites where questionnaires required translation from English (Brazil, Norway, and Oman), they were translated into the local language and independently back-translated into English to ensure that the content of the questions remained unchanged. The interviewer guides were also translated in these sites.

Before the start of data collection, the data manager of each site participated in a week-long training workshop at the Coordinating Centre in Geneva. The workshop included a presentation of the WHO Good Clinical Practice and data management principles [6], and the DMS/2 data processing software for data entry, verification, validation, and file update. Exercises and dummy runs were organized to ensure that participants clearly understood the SOPs in data management and why it was important to implement them. Some time was devoted to discussing and defining the responsibilities of the sites and the Coordinating Centre with respect to data monitoring, transferring study data, and obtaining help whenever required. Before data collection began, each data manager was given a timetable with exact dates for monthly data submission to the Coordinating Centre for the duration of the data collection phase.

The complete system installation package was distributed to each data manager. This included the full set of dictionaries for all study questionnaires and the DMS/2 software with documentation for its operation. The dictionary for each form defines its data variables and types, labels, plausible value ranges, and data entry skip-and-fill rules, as well as intervariable cross-checks. The data managers were involved in interviewer training before data collection began in the site to stress the importance of completing the questionnaire forms legibly and according to the instructions in the interviewer guides.

Standard operating procedures at site level

The data management procedures are simple and follow a natural sequence. The data manager had to ensure that each step was successfully completed before moving to the next. Because of the repetitiveness of these operations during data collection, it is easy to miss a problem, therefore the need for rigorous application of the procedures was emphasized during training.

Each form received from interviewers was manually checked for legibility, completeness, and consistency, and any additional coding was done at this stage. All

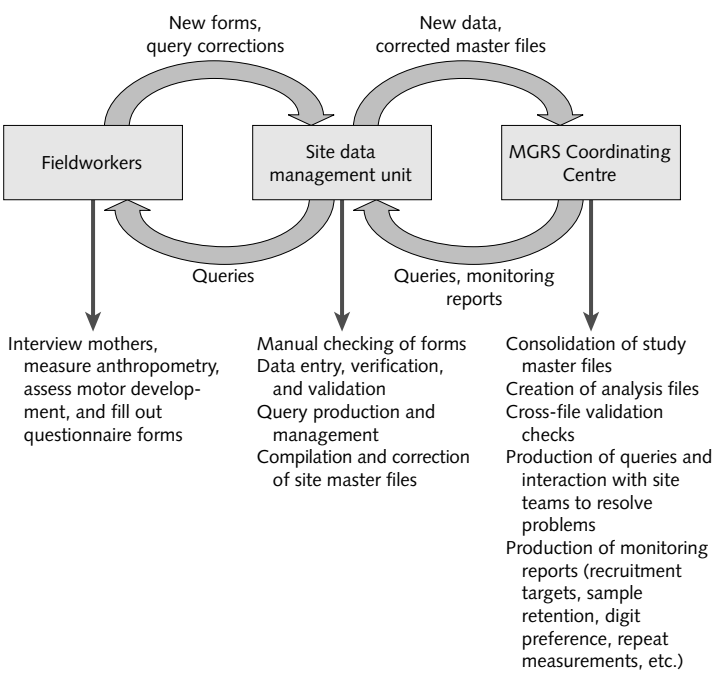

FIG. 1. Data management standard operating procedures and data flow at sites and at the Coordinating Centre

forms received were recorded in the subject form register, a manual or electronic spreadsheet that indicated completed visits and when they had been done for each subject. The subject form register facilitated timely detection and correction of duplicated forms and errors in subject identification, and helped to keep track of missed visits and losses to follow-up. The data managers periodically printed out a computer form register, a replica of the subject form register showing which forms had been accumulated in the master files for each subject. This was a useful double-checking tool for identifying any forms that might have been misplaced between reception at the study center and the data entry unit.

The forms received over one or two days were assembled into a batch that was assigned an identification number. An entry for the batch was added to the batch log register. A cover form was attached to each batch to indicate its source and contents (number and types of form and subject identification numbers). This form provided spaces for recording the dates when the batch was received, entered, verified, validated, and updated to master files. All forms in a batch remained under the same cover until they had been processed through to master file updating. With the batch cover form in order, the batch was sent for data entry. The SOPs specified that data be entered twice, preferably by different data entry operators. For the first entry, the operator activated the relevant electronic dictionaries by indicating which forms were included in the batch. The operators were trained and required to key in data exactly as they appeared on the form. The second entry was done on the same or following day. For this run, the system was set to verification mode, that is, the original entries were hidden and the operator keyed the same data over them. Whenever there was a discrepancy between the original and the verification entry, the system stopped and the operator was required to verify the correct information from the form and enter it.

The next step was to validate the data. This was done on the basis of the range and consistency rules built into the data entry dictionary. The validation procedure created a query file, from which query sheets were printed. Each query was first checked against the data form, and if it was not a data entry error, i.e., the flagged data were as recorded on the data form, it was sent to the interviewer for investigation. It was necessary in some instances to revisit the respondents to obtain correct information. When data were confirmed to be correct despite the queries, the interviewer indicated this and no correction was made. When corrections were necessary, they were recorded on the data form and the query sheet. The query sheets with corrections were handed back to the data management unit, where the data manager created a correction batch to update the master file.

All master file updates and corrections were carried out using transaction batch files and correction files, respectively. The procedure for updating master files included a compulsory step in which backup copies of the old master files and the transaction files were saved. The output report was checked after each update to assess whether the procedure had been successfully completed, and if there were any problems, such as duplicate records in the new master file, or if some records in the batch had been rejected in the updating process. The latter occurred if a record with duplicate identification had already been saved in the master file. To correct data errors and delete duplicate or faulty records, correction statements were processed against the master file with the same backup requirements and output listings, as described for adding new records to the master file. Interactive correction of the master files was not permitted, which, together with the careful documentation of queries and corrections, helped to maintain a clear data audit trail. Moreover, in the event of a computer crash, the master files could be recreated by rerunning the transactions and updates in their right order.

The batches were dismantled once the data forms had been processed through to master file updating. At this point, the processing history from the batch cover form was copied into the batch log register, the batch cover form was filed away, and the data forms were stored in the individual subject folders kept in the archiving unit for each study participant.

Standard operating procedures at the Coordinating Centre

The Coordinating Centre had the same software and the same electronic questionnaire dictionaries as the sites, making it possible to replicate some of the site procedures. For the first six months of data management, sites sent their monthly returns in the form of transaction files. The Coordinating Centre replicated the validation and update of these files to evaluate each site's compliance with the SOPs. After the initial period of six months, only master files were transferred to the Coordinating Centre. A log was kept of all data received, and master file update listings were used to double-check that the Coordinating Centre had exact copies of the master files kept in each respective site.

The different master files were combined at the Coordinating Centre to create an analysis file (separate for longitudinal and cross-sectional studies) in which each subject had a single record with aggregate data from separate questionnaires. Data from repeating forms (e.g., the 20 follow-up forms) were reorganized to create only one record per subject instead of having a record for each follow-up visit. The data were thus arranged in suitable format and structure for analyses using standard statistical software programs. This

process also permitted further validation checks for consistency among data originating from different master files, e.g., measurements changing abnormally relative to the chronology of follow-up visits, or visit dates that were inconsistent with the sequence of visits. Derived variables were created from existing variables; for example, in the longitudinal study a feeding compliance indicator was derived from data on breastfeeding and complementary food intake recorded at different follow-up visits.

Descriptive statistics and data plots were also routinely studied to identify data problems. Queries about inconsistent and dubious data were fed back to the site to investigate and implement any required corrections. As with locally generated queries, the interviewers returned to the forms and sometimes to the respondents to verify queried data. Documentation of these queries and the responses to them were kept on file at both the site and the Coordinating Centre. When queries could not be adequately resolved through e-mail correspondence, they were reviewed on site during monitoring visits that were undertaken annually by a member of the Coordinating Centre team.

In addition to quality control checking and interacting with sites to resolve data problems, the Coordinating Centre also produced reports that were used to monitor sample recruitment and retention, and, in the longitudinal study, compliance with MGRS feeding recommendations and smoking restrictions. Detailed monitoring reports were produced periodically to inform the Executive Committee and the Steering Committee of the progress of the study.

During the data collection phase, summary statistics were produced to evaluate each interviewer's digit preference in anthropometric measurements. Significant digit preferences were studied to determine if they might lead to overall biased measurements and were communicated to the site for discussion with the relevant interviewers. The frequency of measurements that had been repeated because the maximum allowable differences between observer pairs had been exceeded was also monitored to assess adherence to the Measurement and Standardization Protocols of the MGRS [7].

Closure of data management activities

After data collection was completed in a given site, a period of about six months was dedicated to in-depth data quality checking and master file cleaning. The Coordinating Centre produced detailed validation reports, descriptive statistics, and plots from the site's master files. For the longitudinal study, each anthropometric measurement was plotted for each individual child from birth to the end of his or her participation. These plots were examined individually for any questionable patterns. Query lists from these analyses were sent to the site for investigation and correction or confirmation as required. As with the data collection process, the site data manager prepared correction batches to update the master files. The updated master files were then sent to the Coordinating Centre, and this iterative quality assurance process continued until the site and the Coordinating Centre were satisfied that all identifiable problems had been detected and corrected.

At this point, a team from the Coordinating Centre carried out a data management closure visit with the following objectives: to clean up any outstanding data problems and document those that could not be resolved; to certify the site's adherence to the data management SOPs; and to produce the final site data set, list closure analyses, and archive all study materials.

Any pending data errors were corrected during the visit, and those that could not be resolved were documented, such as observations flagged as out of the probable range but confirmed to be correct. Clerical procedures for handling data collection forms as well as computer procedures for handling the data in the electronic files were reviewed and documented. Finally, a set of descriptive analyses was run on the final data set, and the results were reviewed with the site team. An inventory of all study materials was made, and the location of their storage and their retention period were discussed with the site team and documented. The final site master files were archived, and copies of the same were sent to the Coordinating Centre for inclusion in the MGRS master data set.

Closure of data management activities meant that master files were henceforward frozen and therefore not to be changed by either the site or the Coordinating Centre. Any problems identified thereafter could only be dealt with and documented at the analysis stage. The final master file copies and other study documentation were kept in read-only format at the Coordinating Centre with CD-ROM backups of the same.

Discussion

Among the criteria applied in selecting sites for the MGRS were the existence of local expertise and the capacity to implement the study. The need to have personnel with adequate skills and computing facilities for data management was integral to this criterion. In addition, the data manager from each site received specific training in implementing the MGRS data management protocol and using the centrally prepared computing system. Each site had at least two computers dedicated exclusively to data management. The staff involved had variable data management experience, but since all sites used a standard package, those that experienced problems received technical support from the Coordinating Centre or the data managers from other sites whenever

required. For example, the first data manager in Ghana left before the study began, and her replacement was trained on-site by the Norwegian data manager.

The setup and operation of the system were designed to ensure the accumulation of high-quality data and to secure them against unauthorized manipulation and accidental loss. We chose to decentralize data handling rather than use a centralized model in which all data would have been sent to the Coordinating Centre for entry, verification, validation, and creation of the primary master files [8]. The chosen organizational model had the advantage of fostering capacity building in the sites and provided a framework for intersite technical support. The decentralized system also kept the questionnaire forms close to the data sources, which minimized the risk that data would be damaged or lost and made the process of verifying queried data efficient, especially when it was necessary to revisit the respondents. Few problems were experienced over the years in transferring data through the Internet, and these were minor, easily resolved ones, such as corrupted files. The sites kept their reporting schedules throughout data collection, which facilitated the Coordinating Centre's task of ensuring that the central master files were up-to-date with the site master files. It also helped the timely detection of problems that could only be revealed when data from separate master files were combined in the analysis file, so sites could be alerted to investigate them within weeks of the initial data entry.

Data management in the longitudinal study in Brazil proceeded differently from the process described in this article, because the site began data collection well ahead of the others (in July 1997) and served to pilot test the MGRS protocol and questionnaires [1, 2]. This head start also explains why Brazil did not have forms for breastfeeding and motor development data (table 1), as decisions to collect and record these data were taken after this site had initiated data collection [1]. The first data management workshop was conducted in Geneva in November 1998, by which time Brazil was in the second year of the longitudinal follow-up. The data from that site had therefore to be converted from Epi Info [9] to the DMS/2 system for incorporation into the MGRS master files. The conversion process was achieved with the Coordinating Centre's assistance over the Internet and a site visit to Brazil by the Norwegian data manager. Once the data files were converted to DMS/2, they were subjected to the same in-depth validation and quality checking that was standard for the other MGRS sites. The cross-sectional study data were collected using the centrally prepared questionnaires and computer processed using the standard package.

The inbuilt range and consistency checks of the computerized system, as well as the ongoing data monitoring routines at the Coordinating Centre, were highly effective in detecting data errors, and since data cleaning kept pace with data collection and entry, most problems were detected and corrected soon after the data had been computerized at the site or received at the Coordinating Centre. The emphasis on keeping a clear audit trail in all data handling also helped in identifying sources of problems and taking appropriate measures to strengthen the quality assurance system.

The multiple tiers of data checking steps may have been too labor-intensive for some sites, but where routine might lead to errors being overlooked, the possibility of their detection was provided by the next checking level. Individual anthropometry plots were checked at the end of data collection in each site, and hence a few data errors were detected long after the data were collected. These very few obviously erroneous measurements that could not be corrected were excluded from the analysis file. Overall, however, the site and Coordinating Centre data management teams implemented the data management protocol with a high degree of rigor, and the MGRS data set is of very high quality.

References

1. de Onis M, Garza C, Victora CG, Onyango AW, Frongillo EA, Martines J, for the WHO Multicentre Growth Reference Study Group. The WHO Multicentre Growth Reference Study: planning, study design, and methodology. Food Nutr Bull 2004;25(1)(suppl 1):S15–26.
2. Araújo CL, Albernaz E, Tomasi E, Victora CG, for the WHO Multicentre Growth Reference Study Group. Implementation of the WHO Multicentre Growth Reference Study in Brazil. Food Nutr Bull 2004;25(1)(suppl 1):S53–9.
3. Dewey KG, Cohen RJ, Nommsen-Rivers LA, Heinig MJ, for the WHO Multicentre Growth Reference Study Group. Implementation of the WHO Multicentre Growth Reference Study in the United States. Food Nutr Bull 2004;25(1)(suppl 1):S84–9.
4. Lartey A, Owusu WB, Sagoe-Moses I, Gomez V, Sagoe-Moses C, for the WHO Multicentre Growth Reference Study Group. Implementation of the WHO Multicentre Growth Reference Study in Ghana. Food Nutr Bull 2004;25(1)(suppl 1):S60–5.
5. Bhandari N, Taneja S, Rongsen T, Chetia J, Sharma P, Bahl R, Kashyap DK, Bhan MK, for the WHO Multicentre Growth Reference Study Group. Implementation of the WHO Multicentre Growth Reference Study in India. Food Nutr Bull 2004;25(1)(suppl 1):S66–71.
6. World Health Organization. Guidelines for good clinical practice (GCP) for trials on pharmaceutical products. Geneva: World Health Organization, 1995.
7. de Onis M, Onyango AW, Van den Broeck J, Chumlea WC, Martorell R, for the WHO Multicentre Growth Ref-

erence Study Group. Measurement and standardization protocols for anthropometry used in the construction of a new international growth reference. Food Nutr Bull 2004;25(1)(suppl 1):S27–36.
8. Pinol A, Bergel E, Chaisiri K, Diaz E, Gandeh M. Managing data for a randomised controlled clinical trial: experience from the WHO Antenatal Care Trial. Paediatr Perinat Epidemiol 1998;12(suppl 2):142–55.
9. Dean AG, Dean JA, Coulombier D, Brendel KA, Smith DC, Burton AH, Dicker RC, Sullivan K, Fagan RF, Arner TG. Epi Info, version 6.04a, a word processing, database, and statistics program for public health on IBM-compatible microcomputers. Atlanta, Ga, USA: Centers for Disease Control and Prevention, July 1996.

Implementation of the WHO Multicentre Growth Reference Study in Brazil

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Abstract

The World Health Organization (WHO) Multicentre Growth Reference Study (MGRS) South American site was Pelotas, Brazil. The sample for the longitudinal component was drawn from three hospitals that account for approximately 90% of the city's deliveries. The cross-sectional sample was drawn from a community survey based on households that participated in the longitudinal sample. One of the criteria for site selection was the availability of a large, community based sample of children whose growth was unconstrained by socioeconomic conditions. Local work done in 1993 demonstrated that children of families with incomes at least six times the minimum wage had a stunting rate of 2.5%. Special public relations and implementation activities were designed to promote the acceptance of the study by the community and its successful completion. Among the major challenges of the site were serving as the MGRS pilot site, low baseline breastfeeding initiation and maintenance rates, and reluctance among pediatricians to acknowledge the relevance of current infant feeding recommendations to higher socioeconomic groups.

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Mention of the names of firms and commercial products does not imply endorsement by the United Nations University.

Key words: Anthropometry, Brazil, breastfeeding, child health, child nutrition, growth, growth monitoring, growth references, infant feeding practices

Introduction

The World Health Organization (WHO) Multicentre Growth Reference Study (MGRS) South American site was Pelotas, Brazil. Pelotas is in the state of Rio Grande do Sul in the southernmost region of Brazil. The city has approximately 330,000 inhabitants. It has a highly experienced Epidemiology Research Center, with internationally recognized expertise in longitudinal studies of maternal and child health nutrition [1, 2].

Among the site selection requirements for the MGRS was that social and environmental conditions experienced by the study sample permit unconstrained growth in early childhood [3, 4]. Data from all children born in Pelotas in 1993 [2] were analyzed to identify a socioeconomic cutoff above which children in Pelotas have a prevalence of stunting of 2.3% based on the current international reference [5]. These analyses demonstrated that children in this community from families whose monthly incomes are at least six times the minimum monthly wage (approximately US$600) have a stunting rate of 2.5% [6]. This cutoff was used to define socioeconomic eligibility for the sample from this site.

Breastfeeding rates were known to be low from previous research conducted by the research team. However, their experience also demonstrated that baseline breastfeeding initiation and continuation rates could be improved substantially with adequate breastfeeding promotion.

This site piloted the MGRS protocol, and its experiences were of particular value in the implementation of the study in other sites.

Planning phase

Study timeline and preparatory activities

The MGRS protocol is summarized elsewhere in this supplement [3]. The study timeline of the site is summarized in figure 1.

The required sample size necessitated the successful recruitment of approximately 6 infants per week to achieve a longitudinal sample size of 300 within 12 consecutive months. The 1993 study [6] referred to above was used to estimate the prevalence of other MGRS exclusion criteria within the group of mothers whose income met or exceeded the socioeconomic criterion used to define eligibility (table 1).

The sample for the longitudinal component of the study was recruited from the Santa Casa de Misericórdia, Beneficência Portuguesa, and São Francisco de Paula hospitals. The three hospitals were visited by the study coordinator to explain the objectives of the study and procedures and request authorization for data collection in each facility. A meeting was held for all pediatricians practicing in the city to explain the goals of the study and request their collaboration, especially concerning the promotion of breastfeeding. Letters also were sent to each participating child's pediatrician asking for their support and offering lactation counseling services to their practices.

TABLE 1. Prevalence estimates of exclusion criteria based on the cohort of children born in Pelotas, Brazil in 1993

Exclusion criterion	Prevalence (%)
Gestational age less than 37 weeks	7.3
Maternal smoking	23.8
Admission to intensive care unit	2.2
Admission to nursery ward	3.2
Twin birth	2.3
Nonintention to breastfeed for at least 12 months	25.9
Any of the above	50.2

Institutional ethical approvals were obtained from the Ethical Committee of the Federal University of Pelotas.

Study teams

Six teams were set up to implement the longitudinal and cross-sectional components of the study: the screening, lactation counseling, follow-up, cross-sectional, coordination, and data management teams. The composition and coordination of the teams are summarized in figure 2. Participation in any team was not exclusive, so, for example, the same interviewers

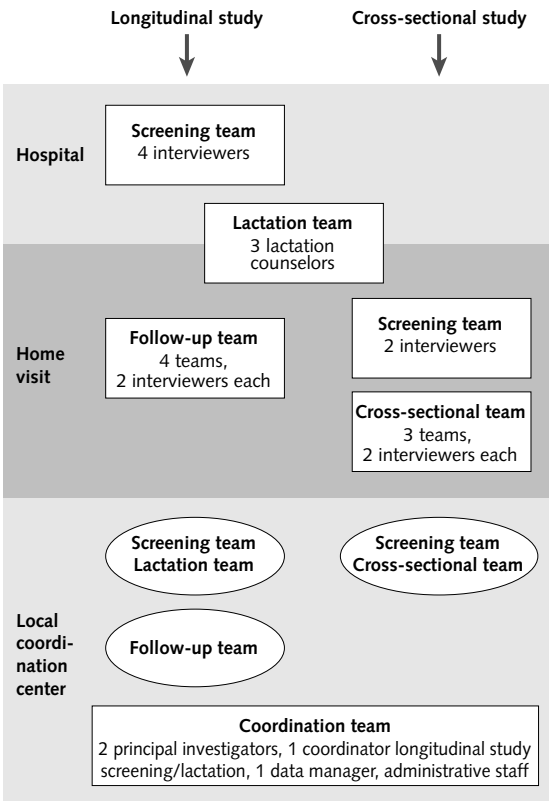

FIG. 2. Composition and coordination of study team

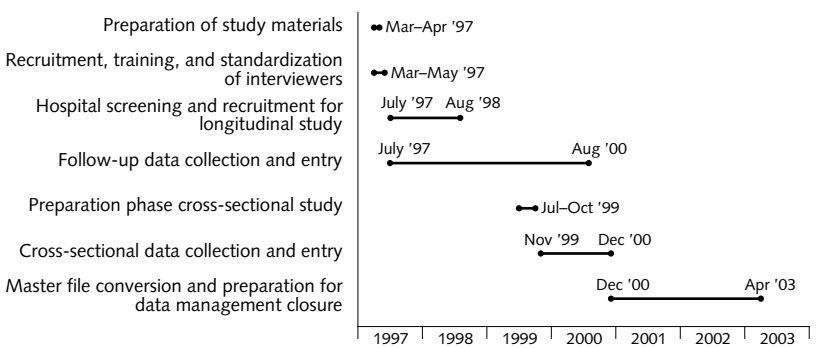

FIG. 1. Study timeline

participated in the longitudinal and cross-sectional components of the study. All follow-up and cross-sectional team interviewers worked full-time on the project. With one exception, all had college degrees, six of them in nutrition.

The screening team, composed of four interviewers and one supervisor responsible for quality control in the hospitals and for reviewing the questionnaires for completeness and accuracy, was in charge of screening all mothers in the hospitals to determine eligibility. The lactation counseling team included a senior lactation consultant and three registered nurses, one of whom made the first visit while the mother was in the hospital. The follow-up team included four groups of two interviewers each and one fieldwork supervisor. The cross-sectional team included two screeners and three pairs of interviewers. At the coordination level there were two local principal investigators (one of whom coordinated the follow-up and cross-sectional studies), one coordinator for the screening and lactation teams, and two administrative staff members. The data management team was composed of one data manager and two data entry clerks.

Training and initial standardization

Fourteen female candidates were screened. After detailed explanations of the project and anthropometric training had been provided to each of them, 11 were recruited. Each of the 11 team members participated in the initial anthropometric standardization session conducted by one of the two WHO-designated lead anthropometrists. Based on the results of this standardization session, the eight interviewers who performed best were selected.

Members of the lactation support team completed the 40-hour WHO lactation support training course [7]. This course was provided by two International Board Certified Lactation Consultants.

Adaptation of study materials and procedures

Brazil was the first country to begin data collection; the original forms and operational manuals for the longitudinal study were developed in Portuguese for pretesting at this site. They were later translated and adapted by the other MGRS sites, as described in the methodological paper in this supplement [3]. The instruments for the cross-sectional component were written originally in English, and therefore the standard translation procedure was used in adapting them [3].

The reluctance of some mothers to undress their infants completely for weighing in winter was anticipated. Therefore, samples of children's clothes were weighed and a list of clothing weights was prepared. This list was used to correct weights of partially or completely dressed children. A similar list was compiled for parents' clothing. A list of the main brands of infant formulas used by this community was also prepared for coding nonhuman milk intakes. A list of vitamin and mineral supplements was developed to help mothers identify the brand names of products they used and/or provided to their infants.

Public relations activities

The success of the study required the close collaboration of the city's hospitals, doctors, and families. This required that attention be paid to public relations activities. These activities included visits to the three hospitals involved by the study coordinators, with lectures on the rationale for the study and the need to promote and support breastfeeding; donation of medical textbooks to the hospitals; breastfeeding lectures, to which all pediatricians in the city were invited; an initial study newsletter that included reprints of WHO Feeding Recommendations [8]; distribution of breastfeeding promotion leaflets to all mothers giving birth in the study hospitals (whether or not they fulfilled the eligibility criteria); regular newsletters to all pediatricians and other doctors of participating families that included breastfeeding information and feedback from the study; study advertisements in local newspapers; and regular publication of articles on the study and/or breastfeeding in local newspapers.

Maintaining excellent rapport between interviewers and families was viewed as essential to the success of the study. The role of the interviewer's attitude and perceived friendliness and helpfulness was stressed. Small gifts, such as infant participation diplomas on which infant weights were recorded and a photo album delivered at the infant's first birthday, were also designed to demonstrate to families how much their help was appreciated. Additionally, on their second birthday, children who participated in the longitudinal study received a T-shirt with the WHO logo and the statement "I participated in the International Multicentre Growth Reference Study."

Implementation of the longitudinal study

Sampling strategy

All women who resided in Pelotas and delivered at one of the three hospitals listed above, who gave birth to a full-term singleton, and whose baby was not admitted to a nursery or child intensive care unit for more than 24 hours were interviewed from July 1997 to August 1998. For convenience, only deliveries taking place between 6 pm Sunday and 6 pm Friday were screened. Analyses of the 1993 cohort data set showed no differ-

ences between babies born on weekdays and weekends (e.g., in rates of vaginal deliveries).

Screening and enrollment of children

All enrolled infants met the eligibility criteria outlined in the MGRS protocol [3]. Other selection criteria specific to this site are shown in table 2. The exclusion criterion "mother planning to stop exclusive breastfeeding before four months" in the MGRS protocol was not applied, because local data showed that the intended duration of exclusive breastfeeding—as reported soon after delivery—is unrelated to actual duration. Estimates of gestational age were based on ultrasound measurements; the interviewers carried gestational age calculators to assist with this estimate. The study supervisor subsequently checked all calculations [9]. If no ultrasound examination was available, the date of the last menstrual period was used to estimate gestational age. If neither the last menstrual period nor an ultrasound examination was available, and the child fulfilled all other eligibility criteria, the screening coordinator (a pediatrician) was contacted immediately. The pediatrician estimated the infant's gestational age by the Dubowitz method [10].

At the end of the interview, mothers with eligible infants were invited to participate in the study. Consent obtained in the hospital was regarded as preliminary. Written consent was obtained during the first home visit.

Follow-up logistics

Pelotas was subdivided into four areas. Each was assigned to a pair of interviewers on the follow-up team. The four pairs of interviewers conducted follow-up visits and obtained all measurements for the longitudinal component of the study. Each team was organized so that one of the interviewers was fixed and the other was rotated every two months. This rotation among teams was designed to minimize systematic errors caused by reinforcement of faulty techniques and also allowed the comparison of measurements among distinct interviewer pairs. The consistency of one interviewer visiting any given subject helped ensure good rapport with mothers and children.

TABLE 2. Longitudinal study selection criteria specific to the Brazilian site

Criterion	Operationalization
Perinatal morbidity	Absence of significant perinatal morbidity (newborns with postnatal stay in intensive care > 24 hours excluded)
Intention to breastfeed	Mothers who expressed intention to breastfeed, regardless of duration
Socioeconomic criteria	Family income at least US$600 per month

During the first home visit, at 14 days, the interviewers explained the schedule and methods of the study to the mothers and the importance of their participation. The study forms completed in the follow-up visits have been described elsewhere in this supplement [3]. The interviewers returned the completed questionnaires to the local coordination center twice a week.

Decisions by one or both parents to leave the study were reported immediately to the study coordinator, who immediately contacted the mother to review the reasons for this decision. The coordinator outlined the requirements of the study to ensure that the decision was a well-informed one.

To assess the possibility of selection bias, it was important to have information on mothers and infants who refused to participate or who dropped out of the study [3]. Attempts were made to locate by telephone the families of all children who were designated as eligible during the hospital screening, but who, for various reasons, were not participating at age 12 months. A home visit was scheduled for all who consented to participate in the 12-month study [3].

Lactation support team and complementary feeding

In addition to the initial hospital lactation counseling visit, the lactation support team made home visits at 5, 15, 30, and 45 days and at 2, 3, 4, 6, 8, 10, and 12 months after delivery. Extra visits were conducted whenever there were problems requiring further attention, such as cracked nipples. Telephone calls were made at 5, 7, 9, and 11 months after delivery to assess how breastfeeding was proceeding. Additional visits were scheduled on the basis of these inquiries.

The first hospital visit included advice on the advantages of breastfeeding; nursing was observed, and correction of the baby's position was advised if necessary; instructions on how to express milk manually were given, and a breastfeeding promotion leaflet was distributed. The home visits included the same content. When the infant was six months of age, the mother received advice on the need to introduce complementary feeding, and on recommended foods [8] (table 3).

One lactation counselor was assigned to each mother throughout the study. On average, each lactation counselor was responsible for visiting two newly enrolled mothers per week. The lactation support team coordinator visited each enrolled mother at least once during the study. She also accompanied lactation counselors in their visits whenever there were particularly difficult lactation problems.

A telephone hotline was maintained 24 hours a day, seven days a week, to assist mothers who experienced

TABLE 3. Complementary feeding guidelines at the Brazilian site

Age (mo)	Recommendations
0–5	Breastfeed Do not give teas, water, or other types of milk or food
6–11	Breastfeed Introduce complementary foods, with emphasis on Meat Eggs Fruits and vegetables (mainly yellow) Mashed beans Avoid diluted foods with high water content Use cup and spoon, not baby bottles Start with 1 complementary feed per day and increase to 3 feeds per day
12–23	Breastfeed Give complementary foods at least 5 times a day Family foods should be the main type of food

particularly severe problems. The hotline number was provided to all mothers and to their pediatricians.

Implementation of the cross-sectional study

Sampling strategy

The cross-sectional study was designed as a "panel study" in which children aged 18 to 71 months were enrolled and visited up to three times, at three-month intervals. This was aimed at increasing the number of available measurements. Children who reached the age of 72 months during the implementation of the cross-sectional study were visited only once or twice.

The sampling strategy of the cross-sectional component was designed to obtain a sample of children aged two to five years who were similar to children enrolled in the longitudinal component. To accomplish this aim, the addresses of children taking part in the longitudinal study were plotted on a city map. The homes of index children were used as points of departure for identifying participants in the cross-sectional component. The interviewers were instructed to move in a clockwise direction relative to the index child's household. The interviewers visited all houses or apartments on blocks shared by the index households until three children within the required age group were located. If three eligible children were not located in the first block, the interviewers moved to another previously defined block in the same neighborhood. The neighbors were asked to provide information concerning any child under age 10 living in homes with whom contact could not be made. The age of 10 was selected to provide a margin of safety in order not to miss potentially eligible children. If two different neighbors provided consistent information that no children under 10 lived in the targeted home, the home was excluded. In doubtful cases, the interviewers revisited the home in question. When children aged 18 to 71 months were identified, a screening questionnaire was administered to a responsible caregiver. If the child fulfilled all eligibility criteria, the mother or guardian was invited to participate in the study. Appointments for consenting children were made to obtain anthropometric measurements. Children who were enrolled or had participated in the longitudinal component of the study were ineligible for the cross-sectional component.

Standardization, quality control, and data management activities

Standardization sessions

Anthropometry standardization procedures followed the MGRS protocol [11]. Initial practice sessions were conducted at two municipal day-care centers. Subsequent anthropometric standardization sessions were conducted with 17 children under three years of age at one of the two day-care centers in which initial training was conducted. Each of the study anthropometrists measured the same child twice, as did the local lead anthropometrist. The local lead anthropometrist's measurements were regarded as "reference values." Nineteen standardization sessions were carried out, one every two months, in addition to the initial standardization session held by one of the two WHO-designated MGRS lead anthropometrists. Intra- and interobserver technical errors of measurement (TEM) were calculated for each fieldworker from data collected in these standardization sessions.

The motor development component of the MGRS was not performed at this site, so no standardization sessions related to this component were scheduled.

Quality control activities

The interviewers returned the completed questionnaires to the site's coordinating center within four days of all interviews. The questionnaires were reviewed and open questions were coded by the relevant team's supervisor. Problems encountered at this stage were discussed at the next team meeting to permit the group to review all discrepancies, allow agreement to be reached on how each discrepancy should be resolved, and identify how best to prevent the recurrence of similar problems. After appropriate follow-up was

completed, any required corrections were made, and the questionnaires were forwarded to the data manager for double data entry. Team meetings were scheduled at two-week intervals throughout the study.

Quality control questionnaires that repeated questions about morbidity, vitamin or mineral supplement intake, maternal work, and child feeding were administered to 20% of mothers visited each week. To determine which mothers would be reinterviewed, a list with the numbers of the questionnaires completed during the week was prepared, and 20% were selected randomly. The quality control interview was carried out by telephone by the quality control staff, one to two days after the actual interview.

Calibration of equipment was conducted as outlined in the MGRS measurement and standardization protocols [11].

Data management

Data management in Pelotas differed from that at other MGRS sites. This was partly because Pelotas served as the MGRS pilot site. Data collection was started before data entry routines used in the other sites had been fully developed at the WHO Coordinating Centre in Geneva.

All databases in the longitudinal study were originally created using Epi Info software [12]. All data were entered twice; comparison of the two files allowed the correction of data entry errors. Data cleaning procedures were conducted separately for each file. In order to adapt these databases to the MGRS master file structure, all variables were renamed and reformatted using SPSS 8.0 for Windows software. After this process, all data files were satisfactorily incorporated into the master files at the WHO Coordinating Centre [13].

Conclusions

The MGRS is a complex study that required careful planning and implementation. The research team in Brazil gained much experience both from the methodological aspects of this study and from interaction with the other participating centers. The site's major challenges were related to breastfeeding. The lactation support team experienced the greatest turnover, and securing the adherence of local pediatricians to the feeding recommendations of the study was often difficult. The high turnover of the lactation support team was probably a result of team members' clinical responsibilities related to their ancillary nursing duties. These affected their availability to make home visits to, and receive telephone calls from, participants who experienced breastfeeding problems.

Another important challenge was that some of the city's pediatricians were not supportive of current feeding recommendations. Mothers were often encouraged to administer teas, water, and/or juice to their infants starting at one week of age. The pediatricians often recommended formula feeding at the earliest sign of any breastfeeding difficulty. Pediatricians also commonly had little, if any, knowledge about lactation support. Letters, reprints and other educational material sent to selected physicians were inconsistently effective in changing practices. It was not uncommon for mothers to contact a lactation consultant immediately after appointments with their pediatricians to check if advice they had just received was consistent with the recommended practices of the study. Despite these constraints, lactation support was highly successful: whereas prior to the study about 18% of mothers who fulfilled the inclusion criteria breastfed for one year, this proportion almost doubled in the MGRS.

References

1. Barros FC, Victora CG, Vaughan JP. The Pelotas (Brazil) Birth Cohort Study 1982–1987: strategies for following up 6000 children in a developing country. Paediatr Perinat Epidemiol 1990;4:267–82.
2. Barros FC, Victora CG, Vaughan JP, Tomasi E, Horta BL, Cesar JA, Menezes MB, Halpern R, Post CL, del Mar Garcia M. The epidemiologic transition in maternal and child health in a Brazilian city, 1982–1993: a comparison of two population-based cohorts. Paediatr Perinat Epidemiol 2001;15:4–11.
3. de Onis M, Garza C, Victora CG, Onyango AW, Frongillo EA, Martines J, for the WHO Multicentre Growth Reference Study Group. The WHO Multicentre Growth Reference Study: planning, study design, and methodology. Food Nutr Bull 2004;25(1)(suppl 1):S15–26.
4. Garza C, de Onis M. A new international growth reference for young children. Am J Clin Nutr 1999;70(suppl 1, part 2):169S–72S.
5. National Center for Health Statistics. Growth curves for children birth-18 years, United States. Vital and Health Statistics, Series 11, No. 165. Department of Health, Education, and Welfare Publication No. PHS 78–1650. Washington, DC: Government Printing Office, 1977.
6. Post CL, Victora CG, Barros FC, Horta BL, Guimarães PRV. Desnutrição e obesidade infantis em duas coortes de base populacional no sul do Brasil: tendências e diferenciais. Cadernos de Saúde Pública 1996;12(suppl 1): 49–75.
7. World Health Organization/United Nations Children's Fund. Breastfeeding counselling: a training course. Documents WHO/CDR/93.3-6 and UNICEF/NUT/93.1-4. Geneva: World Health Organization, 1993.
8. Giugliani E, Victora CG. Normas alimentares para crianças brasileiras menores de dois anos (bases científicas). Brasília, Brazil: Organização Panamericana de Saúde/Organização Mundial de Saúde, 1997.

9. Organización Panamericana de la Salud/Organización Mundial de la Salud. GESTOGRAMA—Boletín del Centro Latino Americano de Perinatogía y Desarrollo Humano. Montevideo, Uruguay: CLAP, 1997.
10. Dubowitz LMS, Dubowitz V, Goldberg C. Clinical assessment of gestational age in the newborn infant. J Pediatr 1970;77:1–10.
11. de Onis M, Onyango AW, Van den Broeck J, Chumlea WC, Martorell R, for the WHO Multicentre Growth Reference Study Group. Measurement and standardization protocols for anthropometry used in the construction of a new international growth reference. Food Nutr Bull 2004;25(1)(suppl 1):S27–36.
12. Dean AG, Dean JA, Coulombier D, Brendel KA, Smith DC, Burton AH, Dicker RC, Sullivan K, Fagan RF, Arner TG. Epi Info, Version 6.04a, A Word-processing, Database, and Statistics Program for Public Health on IBM-Compatible Microcomputers. Atlanta, Ga, USA: Centers for Disease Control and Prevention, July 1996.
13. Onyango AW, Pinol AJ, de Onis M, for the WHO Multicentre Growth Reference Study Group. Managing data for a multicountry longitudinal study: experience from the WHO Multicentre Growth Reference Study. Food Nutr Bull 2004;25(1)(suppl 1):S46–52.

Implementation of the WHO Multicentre Growth Reference Study in Ghana

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Abstract

The World Health Organization (WHO) Multicentre Growth Reference Study (MGRS) African site was Accra, Ghana. Its sample was drawn from 10 affluent residential areas where earlier research had demonstrated the presence of a child subpopulation with unconstrained growth. This subpopulation could be identified on the basis of the father's education and household income. The subjects for the longitudinal study were enrolled from 25 hospitals and delivery facilities that accounted for 80% of the study area's births. The cross-sectional sample was recruited at 117 day-care centers used by more than 80% of the targeted subpopulation. Public relations efforts were mounted to promote the study in the community. The large number of facilities involved in the longitudinal and cross-sectional components, the relatively large geographic area covered by the study, and the difficulties of working in a densely populated urban area presented special challenges. Conversely, the high rates of breastfeeding and general support for this practice greatly facilitated the implementation of the MGRS protocol.

Key words: Anthropometry, breastfeeding, child health, child nutrition, Ghana, growth, growth monitoring, growth references, infant feeding practices

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Members of the WHO Multicentre Growth Reference Study Group and Acknowledgments are listed at the end of the first paper in this supplement (pp. S13–S14).

Introduction

The World Health Organization (WHO) Multicentre Growth Reference Study (MGRS) African site was Accra, Ghana. Ghana is in the West Africa subregion, has a population of 18.3 million [1], and lies 420 km north of the equator. It has two main seasons: the wet season, which peaks from April to June, and the dry season between November and March.

Inclusion of the Ghanaian site was dependent on identifying a subpopulation of children with no socioeconomic constraints on growth. Government property valuations were used to identify 10 communities in the most affluent areas of Accra: the Airport Residential area, Atomic, Adenta, Cantoments, Dansoman, Dzorwulu, East Legon/Legon, Manette/Sakumono/Lashibi, Roman Ridge, and Tema. They were surveyed to assess the feasibility of conducting the MGRS [2]. Households with children aged between 12 and 23 months were identified; information on household demographic and socioeconomic characteristics was collected; and anthropometric measurements of the children, their mothers and grandmothers were obtained. This information was used to identify socioeconomic factors associated with unconstrained growth in early childhood. Information was also collected on hospitals and other delivery facilities used by women in the selected residential areas.

The survey identified the socioeconomic characteristics associated with unconstrained growth of children from affluent families to be high level of education (tertiary) of the father and household income [2]. Having met the criteria required of participating sites [3], Accra was selected as the African MGRS site. Twenty-five hospitals and other delivery facilities were identified that accounted for 80% of births in the targeted subpopulation. The subjects were recruited from those sites. The objective of this paper is to provide an overview of the implementation of the MGRS at the Ghanaian site.

Planning phase

Study timeline and preparatory activities

The MGRS protocol is described in detail elsewhere in this supplement [3]. The timeline for its implementation in Accra is summarized in figure 1. The preparatory phase lasted from June to October 1999; data collection for the longitudinal component of the study was initiated in December 1999 and completed in December 2002. The cross-sectional component lasted from November 2001 to May 2003.

The principal investigators and/or one of the other members of the research team visited each of the 25 hospitals and other delivery sites to discuss the aims and procedures of the study. Letters were also sent to each hospital formally seeking permission to recruit infants. All gave written consent, except for one facility whose director gave oral consent. Each facility identified one or two maternity ward nurses to serve as contacts between the project and the delivery ward. These senior maternity ward nurses in charge of deliveries enabled the project to identify all deliveries within the required 24 hours after birth.

Institutional approvals were obtained from the University of Ghana Medical School Ethical Review Committee.

Study teams

The site had four study teams: coordination, screening, lactation support, and follow-up. The positions for all field research assistants were advertised in the University of Ghana. Qualified applicants were interviewed and recruited based on their motivation, communication skills, dedication to work, and ability to work in a team.

The coordination team consisted of the two principal investigators, lactation supervisors, a quality control manager, a data manager, a project secretary, and a project adviser. The coordination team was responsible for the overall administration of the study.

The screening team was made up of six members, all with undergraduate university degrees in nutrition or nursing. This team was hospital based and was responsible for the identification and screening of newborns for eligibility and for obtaining initial anthropometric measurements of enrolled subjects. The screening team worked five days a week (Monday to Friday).

The lactation team was made up of 10 senior or principal nursing officers working with the Ghana Health Service. Each had successfully completed the WHO lactation management and breastfeeding counseling course [4] before the MGRS was implemented in Ghana. Each also used the knowledge and skills gained through that training in their usual employment. The lactation counselors assisted newly delivered mothers to initiate breastfeeding successfully in the hospital, encouraged mothers to comply with the feeding recommendations of the study, and helped them solve any breastfeeding problems that they experienced. They administered the breastfeeding questionnaires and obtained infant weights at the first home visit. The lactation counselors worked part-time; however, the mothers could call their assigned lactation counselors or the lactation team supervisor 24 hours a day, seven days a week.

The follow-up team was made up of six individuals, all with undergraduate degrees in nutrition. The team was responsible for home visits. They administered baseline and follow-up questionnaires and took anthropometric measurements of children and parents. The team normally worked from Monday to Saturday. Some home visits were scheduled on Sundays to ensure the father's availability. The same follow-up interviewers participated in the longitudinal and cross-sectional components of the study. Figure 2 shows the coordination of study teams.

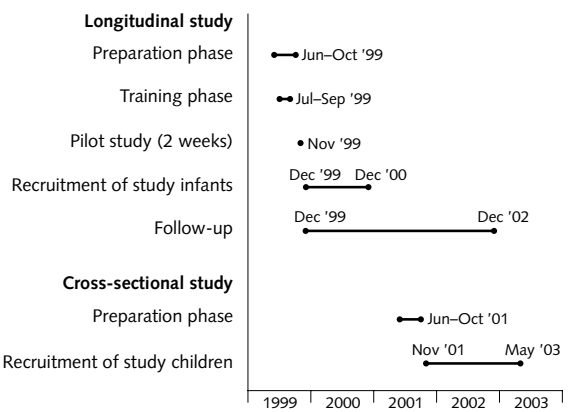

FIG. 1. Study timeline

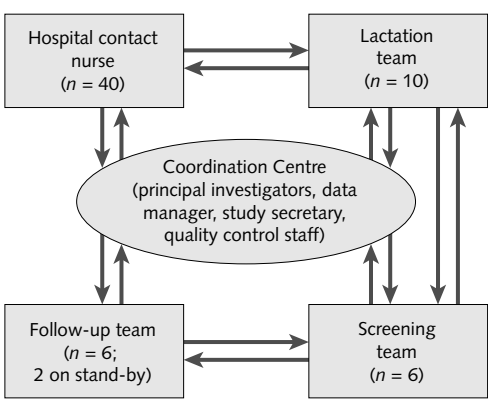

FIG. 2. Study team coordination chart

Training and initial standardization

A one-day workshop was held for all nurses serving as project contacts to review the project's goals and procedures and their respective roles in its successful implementation. The field research assistants' training included a review of the background and objectives of the MGRS, the administration of questionnaires, and the standardized use of study forms and interviewer guides. Particular attention was given to the estimation of gestational age, which was calculated on the basis of ultrasound or estimated from the last menstrual period. The interviewers were trained in the use of "gestograms" [5] using the last menstrual period as the base for the calculation. Follow-up interviewers also conducted role playing sessions at participating maternal and child health clinics to hone interviewing skills. A counseling expert provided training in interviewing techniques and reviewed culturally acceptable behaviors to be observed during home visits.

Anthropometric training and standardization followed the MGRS procedures [6]. Practice sessions on the proper handling of newborns were conducted at one of the participating hospitals, and the screening team received practical training in obtaining measurements on newborns. The follow-up team practiced anthropometric measurement techniques on children attending growth monitoring and immunization clinics. Before the start of data collection, the anthropometry teams participated in a formal standardization session involving one of the two WHO-designated lead anthropometrists, as described elsewhere in this supplement [6]. Team members whose measurements were characterized by low accuracy and/or precision were given corrective training. After this initial standardization with the WHO-designated lead anthropometrist, six screening and six follow-up interviewers were selected for the initial teams. Two adequately trained interviewers were selected as backups. The anthropometry standardization sessions were repeated every two months, separately for the screening and follow-up teams, with the participation once a year of the WHO-designated lead anthropometrist.

Selected interviewers were also trained by staff from the MGRS Coordinating Centre in Geneva to assess the achievement of the six motor developmental milestones, following the MGRS protocol [7].

The training of the lactation support team members for the study focused on providing support to mothers in fulfilling the MGRS feeding requirements [3], administering the breastfeeding questionnaires, and measuring mothers' and babies' weights at the week 1 visit.

Three weeks before data collection was initiated, a two-week pilot study was conducted to test the logistics of the site. The 25 hospitals and other delivery facilities from which subjects would be recruited were grouped into three clusters of nine, nine, and seven. One pair of screeners was assigned to each cluster. The pilot study demonstrated that Accra's heavy traffic would be a major challenge. On the basis of these experiences, the screening teams were required to start their day no later than 7 am, and the clustering of hospitals and other delivery facilities was reorganized to avoid heavy traffic areas.

Adaptation of study materials and procedures

The generic Manual of Operations was adapted to the circumstances of the site with the assistance of the WHO Coordinating Centre, as described elsewhere in this supplement [3]. The eligibility criteria specific to the Ghana site are shown in table 1. This site did not use nonintention to breastfeed as an exclusion criterion, since breastfeeding is nearly universal in Ghana. At our site it was not necessary to translate the study questionnaires into local languages. The mothers enrolled in the study all spoke English fluently, as would be expected in this socioeconomic group. Therefore, all interviews were conducted in English.

Public relations activities

Several public relations activities were undertaken to enhance community acceptance and help ensure the successful implementation of the study. The project was launched officially by the Deputy Minister of Health, the Vice-Chancellor of the University of Ghana, and representatives of WHO and UNICEF in Ghana. Health-related organizations, physicians, and nurses from all participating hospitals and the media were present. The Deputy Minister of Health awarded a baby diploma to the first mother recruited to the study. The local principal investigators also appeared on popular television and radio programs to present the MGRS project to the public.

Breastfeeding information and other leaflets describing fathers' roles in supporting their breastfeeding wives were provided to subjects and their families. Each infant was presented with a baby participation diploma and a bib with the project's logo. At one year of age, all study infants were given personalized birthday cards and an educational toy. At two years, each child

TABLE 1. Eligibility criteria for enrollment of children at the Ghanaian site

Absence of significant perinatal morbidity (newborns with postnatal stay in intensive care > 24 hours excluded)
Socioeconomic criteria:
Father has polytechnic education and income > 1 million cedis
Father has university education and income > 200,000 cedis

1 US$ = 2,300 cedis (exchange rate July 1998).

received a book.

For the cross-sectional study, day-care center heads or directors were invited to attend a one-day workshop. Its purpose was to explain the goals and objectives of the MGRS cross-sectional component and the roles they and their centers could play. The keynote speaker at the workshop was the Deputy Minister of Education. He encouraged all the centers to support the project.

Implementation of the longitudinal study

Sampling strategy

The average number of monthly deliveries in the 25 participating hospitals and other delivery sites was about 1,276. A successful recruitment rate from that pool of less than 10% was anticipated, based on the expected prevalence of exclusion criteria and refusals among women delivering at the various sites. A recruitment rate of 6 or 7 children per week was necessary to meet the project's target of recruiting 300 eligible infants in one year. Thus, all infants born in the 25 study hospitals and other delivery facilities whose parents resided in the study areas were screened.

Screening and enrollment of children

Hospital contact nurses assisted in identifying potentially eligible mothers. Using a simple one-page prescreening form, the contact nurse asked prospective subjects if they lived in any of the study areas and inquired about the husband's years of formal education. If both criteria were met, the mothers and their infants were considered potentially eligible. In cases where the mothers were uncertain about their husband's educational level, residence in one of the designated areas was sufficient to establish potential eligibility. Contact nurses were asked to report potentially eligible mothers to the site's coordination office. Unfortunately, not all contact nurses were equally cooperative. To compensate for this, the screening teams visited all 25 hospitals and other delivery facilities at intervals of less than 24 hours. The hospital with the highest number of daily births was visited twice daily, in the morning and late afternoon.

Subjects for whom no preliminary exclusion criterion was identified were interviewed by the screening team, and newborn anthropometric measurements were obtained. Eligible mothers who were willing to participate in the study gave oral consent at the hospital.

Follow-up logistics

Each enrolled subject was assigned a pair of follow-up interviewers. Each subject was visited consistently by one member of each pair; the other member of the pair was rotated among other follow-up teams every two months, after each bimonthly (every two months) anthropometric standardization session [3].

At the first follow-up home visit, the study was reviewed with mothers and their husbands, if present, and written consent to participate was obtained at this time. This visit also provided a second opportunity to confirm the mother's and infant's eligibility. Mothers who were enrolled at the hospital visit but were found not to have complied with study feeding recommendations or not to have conformed with other inclusion requirements were classified as "hidden ineligibles." Those who remained eligible but rescinded their decision to participate were classified as "hidden refusals." Hidden ineligibles and hidden refusals were excluded from the study and replaced in the sample following the MGRS protocol [3]. Eligible mothers who dropped out of the study after the first follow-up visit were requested to consent to one measurement when the child reached 12 months.

The motor development study and the 12-month follow-up visit of refusals and dropouts were conducted in accordance with the MGRS protocol [3, 7].

Lactation support and complementary feeding

The enrolled mothers usually received the first lactation support visit in the hospital. In cases where this was not possible, they were visited no more than three days after discharge. After this initial visit, the lactation support team made home visits at one and two weeks and at three and six months, as specified in the MGRS protocol. However, extra visits were scheduled at one and two months for primiparous mothers and for mothers who had breastfeeding problems at weeks one and two. Between three and six months, no extra visits were scheduled except when requested by the mother.

The mothers were advised to introduce complementary foods to the infant by six months of age. The complementary feeding guidelines, shown in table 2, were developed by the Nutrition Unit of the Ghana Health Service [8]. These guidelines were developed to facilitate the activities of field extension workers involved in nutrition education.

Implementation of the cross-sectional study

Sampling strategy

A summary of the protocol of the cross-sectional component is given elsewhere in this supplement [3]. The cross-sectional component sought to recruit and measure children between the ages of 18 and 71

TABLE 2. Complementary feeding guidelines at the Ghanaian site

Before 6 months, give only breastmilk. Do not give any water, fruits/fruit juice or porridge
Introduce new foods gradually by 6 months of age:
The first complementary food may be cereal porridge given by spoon one or two times a day
As the child grows, increase the amount and frequency of feeding
Continue to breastfeed on demand
Feed a variety of foods:
Cereal porridge
Enrich cereal porridge, soups, and stews with at least one of the following: milk, mashed beans, fish powder, mashed poultry or meat, groundnut paste, vegetable oil
Fruits and vegetables
Feed iron-rich foods such as fish, fish powder, meat, and poultry
Give fruit or fruit juice with meals or snacks to help absorb iron in other foods
Feed vitamin A–rich foods such as palm oil, mangoes, pawpaw, carrots, green leafy vegetables, and eggs
The child's food must be well cooked, mashed, and softened
Do not add pepper or other spices to the child's food
Wash hands with clean water and soap before touching food or feeding the child
The child should have his or her own bowl so that there is no competition with older children for food
Children who refuse food should be persuaded to eat; do not force the child to eat. Do not fuss over a child who refuses to eat. Make mealtimes happy times

months who were similar to those enrolled in the longitudinal component. Various recruitment strategies to accomplish this aim were considered. In Accra, the most suitable strategy was recruitment from day-care centers, because most mothers enrolled in the study worked outside the home, and it was common practice among the targeted socioeconomic group to send their preschool children to crèches and nurseries.

The parents in the longitudinal study were interviewed in order to determine which day-care centers the target population chose for their children and at what age the children began to attend them. A total of 130 day-care centers were identified. Eighty of these either were used or were intended to be used by 80% of the mothers in the longitudinal study. The 80 day-care centers served about 6,000 children between the ages of 18 and 71 months who resided in the study areas. The following rates were applied to estimate the number to be screened: low socioeconomic status, 30%; twin births, 3%; gestational age < 37 weeks or ≥ 42 weeks, 5%; significant morbidity, 5%; breastfed < 3 months, 1%; enrolled in the longitudinal study, 10%; refusals, 2%; and residence out of study area, 1%. On this basis, it was estimated that 53% of the sample was potentially eligible. Following the MGRS protocol [3], children who participated in the longitudinal study were excluded, as were their siblings. An additional criterion at this site was that eligible children must have resided in one or more of the study areas for at least the previous six months.

Screening, enrollment, and survey logistics

Letters seeking permission to recruit subjects were sent to the 80 day-care centers. An additional 37 centers located within the study areas were added subsequently, because the first 80 provided an insufficient number of children. Consent was received from all but 1 of the 117 centers. Letters also were sent through schools to parents with children within the age group of interest (18–71 months) seeking permission for their children to participate in the study. Parents who consented provided home addresses and contact telephone numbers. Two field assistants were responsible for sending parental consent forms to, and retrieving them from, day-care centers. Follow-up interviewers made appointments with the parents for home visits, during which a screening questionnaire was completed with the parent. If no exclusion criterion was present, the subject was considered eligible; a survey questionnaire was administered, and anthropometric measurements were taken.

Standardization, quality control, and data management activities

Several measures were put in place to ensure data quality. These have been described elsewhere in this supplement [3]. Standardized procedures to ensure accurate and precise anthropometric measurements were followed, as described in the MGRS protocol [6]. Generally, 10 newborns were recruited for the screening team's bimonthly (every two months) standardization session. The follow-up team conducted their standardization sessions with infants aged 4 to 12 months recruited at growth monitoring clinics. For the height standardization sessions, older children were recruited from nursery school. One of the two WHO-designated lead anthropometrists participated once annually in a standardization session to assess the accuracy and precision of each interviewer's measurements [6].

Bimonthly motor development standardization exercises were also held for all the interviewers assigned this function. Staff from the WHO Coordinating Centre visited the site every year to assess the team's performance and provide training as needed [7].

Team supervisors checked forms routinely for consistency and completeness of recorded responses. The forms approved by the team supervisors were forwarded to the staff in charge of quality control for a final check before data entry, verification, and valida-

tion [9]. Errors or inconsistencies detected at any of the manual or computerized quality control checks were referred to the appropriate interviewer for investigation and resolution.

Regular weekly meetings were held with the principal investigators and the team supervisors. Problems encountered by the respective teams were discussed, and decisions were made. Problems that could not be resolved locally were referred to the MGRS Coordinating Centre. The team member responsible for quality control also telephoned or visited 10% of randomly selected participants. This procedure was used to verify that visits were made as scheduled, assess rapport between interviewers and mothers, and verify the accuracy of collected data.

Conclusions

There were numerous challenges to realization of the MGRS in Ghana. A highly committed staff was essential to the establishment of an efficient system that enabled three pairs of screening interviewers to cover all 25 hospitals and other delivery facilities daily. The logistic and training problems presented by these sites and the 117 day-care centers were formidable but solvable because of the human resources available to the project.

The underdeveloped system of physical addresses in Accra made it difficult and time-consuming to locate study participants' homes. Despite this, the project staff persisted until each home was located. Locating fathers for measurements was also a challenge. With the help of some head teachers at day-care centers, a few fathers were measured at those facilities. Teams also made home visits on Sundays if this was the only time that fathers were available. The first lactation home visit at one week often coincided with the child's naming ceremony. This often required rescheduling visits. Some study mothers were concerned about exclusive breastfeeding up to six months when they had to resume work at four months. Such mothers were taught to express breastmilk for storage until needed, and others obtained permission to bring the infant to work.

Our site's success in implementing the MGRS protocol with the level of rigor that was required is attributable to the collaboration and support of many individuals and institutions. Among these were the University of Ghana, the Ministries of Health and Education, and the local offices and headquarters of WHO and UNICEF. Equally important was the collaboration of the participating hospitals and day-care centers, the study team's enthusiasm and commitment, and the participating mothers' perseverance. Without these contributions, the study could not have overcome the major challenges it faced. Patience, negotiation, and persuasion were required to secure the collaboration of all responsible personnel at the 25 hospitals and 117 day-care centers.

References

1. Ghana Statistical Service (GSS) and Macro International (MI). Ghana demographic and health survey 1998. Calverton, Md, USA: GSS and MI, 1999.
2. Owusu WB, Lartey A, de Onis M, Onyango AW, Frongillo EJ. Factors associated with unconstrained growth among affluent Ghanaian children. Acta Paediatr, in press.
3. de Onis M, Garza C, Victora CG, Onyango AW, Frongillo EA, Martines J, for the WHO Multicentre Growth Reference Study Group. The WHO Multicentre Growth Reference Study: planning, study design, and methodology. Food Nutr Bull 2004;25(1)(suppl 1):S15–26.
4. World Health Organization/United Nations Children's Fund. Breastfeeding counselling: a training course. Documents WHO/CDR/93.3-6 and UNICEF/NUT/93.1-4. Geneva: World Health Organization, 1993.
5. Organización Panamericana de la Salud/Organización Mundial de la Salud. GESTOGRAMA. Boletín del Centro Latino Americano de Perinatogía y Desarrollo Humano. Montevideo, Uruguay: CLAP, 1997.
6. de Onis M, Onyango AW, Van den Broeck J, Chumlea WC, Martorell R, for the WHO Multicentre Growth Reference Study Group. Measurement and standardization protocols for anthropometry used in the construction of a new international growth reference. Food Nutr Bull 2004;25(1)(suppl 1):S27–36.
7. Wijnhoven TMA, de Onis M, Onyango AW, Wang T, Bjoerneboe GEA, Bhandari N, Lartey A, Al Rashidi B, for the WHO Multicentre Growth Reference Study Group. Assessment of gross motor development in the WHO Multicentre Growth Reference Study. Food Nutr Bull 2004;25(1)(suppl 1):S37–45.
8. Nutrition Unit, Ministry of Health. Nutrition Facts for Ghanaian Families. Accra: Government of Ghana, 1995.
9. Onyango AW, Pinol AJ, de Onis M, for the WHO Multicentre Growth Reference Study Group. Managing data for a multicountry longitudinal study: experience from the WHO Multicentre Growth Reference Study. Food Nutr Bull 2004;25(1)(suppl 1):S46–52.

Implementation of the WHO Multicentre Growth Reference Study in India

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Abstract

The World Health Organization (WHO) Multicentre Growth Reference Study (MGRS) Asian site was New Delhi, India. Its sample was drawn from 58 affluent neighborhoods in South Delhi. This community was selected to facilitate the recruitment of children who had at least one parent with 17 or more years of education, a key factor associated with unconstrained child growth in this setting. A door-to-door survey was conducted to identify pregnant women whose newborns were subsequently screened for eligibility for the longitudinal study, and children aged 18 to 71 months for the cross-sectional component of the study. A total of 111,084 households were visited over an 18-month period. Newborns were screened at birth at 73 sites. The large number of birthing facilities used by this community, the geographically extensive study area, and difficulties in securing support of pediatricians and obstetricians for the feeding recommendations of the study were among the unique challenges faced by the implementation of the MGRS protocol at this site.

Key words: Anthropometry, breastfeeding, child health, child nutrition, growth, growth monitoring, growth references, India, infant feeding practices

Introduction

The World Health Organization (WHO) Multicentre Growth Reference Study (MGRS) Asian site was New Delhi, India. Its sample was drawn from a subpopulation of selected neighborhoods in South Delhi in which relatively large groups of affluent, educated individuals reside. Data from a previous survey showed that children in this community having at least one parent with at least 17 years of education experience unconstrained growth [1]. To select the required community-based subpopulation, all 133 residential neighborhoods in South Delhi were identified. After neighborhoods with institutional residential areas, hostels, or low-income group housing had been excluded, 95 neighborhoods remained. Of these, the 58 with the highest land valuations were included [2, 3]. The survey referenced also showed that 80% of births in this population occurred in 46 hospitals or nursing homes throughout South Delhi [1]. This characteristic presented unique challenges for the site, as described below in greater detail.

Planning phase

Study timeline and preparatory activities

The initiation and duration of key study phases are summarized in figure 1. Preparatory activities were initiated on January 1, 2000. The first child was enrolled on April 9, 2000, and the last on October 31, 2001. The study was completed at the end of 2003.

Among the principal preparatory activities designed to facilitate study initiation and community acceptance were the recruitment of dedicated personnel for the various study activities and public relations efforts. To conduct the survey, written permission was obtained from local associations to survey the 58 neighborhoods described above. In some neighborhoods, presentations were made to groups of residents to facilitate required approvals and the collaboration of the community.

Institutional ethical approvals were obtained from the Ethics Committee of the All India Institute of Medical Sciences.

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Members of the WHO Multicentre Growth Reference Study Group and Acknowledgments are listed at the end of the first paper in this supplement (pp. S13–S14).

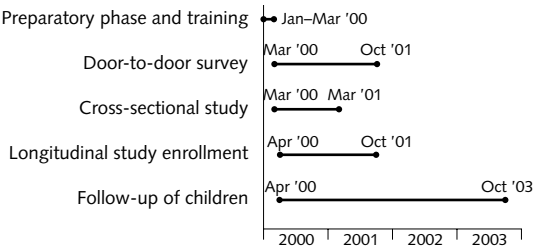

FIG. 1. Study timeline

Study teams

The survey team, coordinated by a physician, was composed of five workers who conducted the door-to-door survey described below, and three pairs of workers who completed the cross-sectional questionnaire and took anthropometric measurements of the recruited subjects. An eight-member team, working in pairs and supervised by another physician, conducted the longitudinal follow-up. The lactation counseling team was made up of five members supervised by the overall study coordinator. A six-member data management team was also recruited and supervised by the site's data manager. The overall study coordinator conducted quality control activities and provided overall supervision of the study.

All team coordinators were physicians with training in pediatrics; the overall coordinator was an obstetrician/gynecologist. The fieldworkers were postgraduates in nutrition or social sciences. Trained lactation counselors were not available in New Delhi at the time of initiation of the study. Postgraduates in nutrition with effective interpersonal skills were therefore recruited and, together with the coordinators and physicians of the study, completed a 40-hour WHO/UNICEF breastfeeding counseling training course [4].

Training and initial standardization

The members of the teams underwent training for various periods up to three months. The training sessions focused on applying questionnaires, the correct filling in of forms, and minimizing inter- and intraobserver variability of anthropometric and motor development measurements or observations through rigorous standardization exercises, as appropriate. Staff from the WHO Coordinating Centre and an international lead anthropometrist conducted the initial standardization session. The local team repeated standardization sessions every two months, and fieldworkers whose performance deviated from the MGRS protocol were retrained by the local lead anthropometrist. The international lead anthropometrist participated in the bimonthly sessions once a year and provided retraining as required [5].

The follow-up team members conducting the motor development assessments were trained by staff from the WHO Coordinating Centre following the motor development study protocol [6]. The site's data manager was especially trained by WHO staff to use the centrally prepared MGRS data management system described elsewhere in this supplement [7].

Public relations

Strong community and health professional education and communication efforts were major features of the study. These were conducted in early and subsequent phases, as needed. Public awareness of the study was enhanced by posters displayed in public places, such as shops, clubs, and meeting halls in the 58 neighborhoods from which the study sample was drawn. Other informational material was distributed to local neighborhood associations, and presentations of the goals and methods of the study were made to community officials and other leaders.

A meeting was organized for pediatricians, obstetricians, and administrators of the area's major hospitals. The goals and methods of the study were presented, with the principal aims of gaining acceptance of the infant feeding recommendations of the study and building a communication network for sustaining cooperation and adherence to recommended feeding guidelines throughout and after the conclusion of the study. The network also provided a means of keeping the community and its health professionals informed of the progress of the study.

The study investigators and/or physicians visited all 73 hospitals where pregnant women recruited through the survey (described below) intended to deliver. The number of hospitals and delivery facilities was substantially larger than expected from the survey done in this community [1]. Material that was specially designed to provide information about the goals and methods of the study was distributed to administrators, pediatricians, and obstetricians and reviewed with them by study personnel.

The media were also utilized in the preparatory and subsequent phases of the study. The study received coverage in a leading daily newspaper and on a popular television news program when the first child was enrolled.

Implementation of the longitudinal study

Overall strategy

A door-to-door survey was conducted in the 58 selected neighborhoods to identify pregnant women whose newborns were likely to be eligible for the longitudinal study. Children aged 18 to 71 months also were

identified by this survey for inclusion in the MGRS cross-sectional component.

All selected neighborhoods were listed alphabetically and given identification numbers (1 to 58). A computer-based random-number generator was used to determine the sequence in which neighborhoods would be surveyed. Serial numbers were assigned to the generated sequence, and the neighborhoods were surveyed in that order. All 58 neighborhoods were surveyed twice to identify 1,000 pregnant women, which was projected to be the necessary number for recruitment of the required sample size. Figure 2 summarizes the calculation of this estimate.

Exclusion criteria specific to the Indian site are shown in table 1. A total of at least 17 years of education for the mother or father was used as a criterion to select a subpopulation of infants with no constraints on physical growth, as validated in a prestudy survey conducted in the same subpopulation [1]. The morbidity criteria were selected through a consensus process among senior pediatricians of conditions most likely to affect physical growth and development significantly. The remaining exclusion criteria for individuals are described in the methodology paper included in this supplement [8].

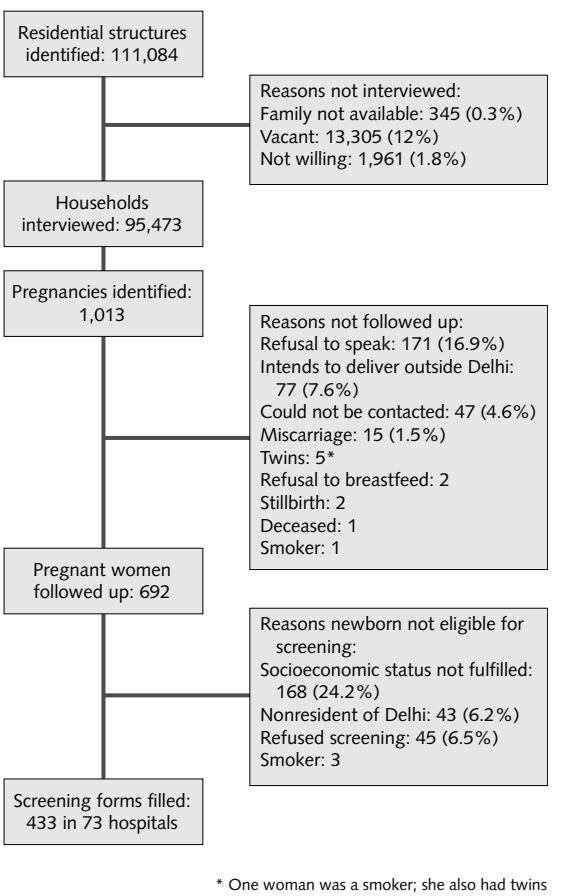

FIG. 2. Flow chart for identification of pregnancies

TABLE 1. Exclusion criteria specific to the Indian site

Perinatal morbidity such as severe birth asphyxia, congenital heart disease, congenital malformations, chromosomal anomalies, hormonal abnormalities, congenitally acquired infections (cytomegalovirus, toxoplasmosis, syphilis), nursery stay for more than 24 hours for morbidity
Not intending to breastfeed at all
Both parents have had less than 17 years of education

Informed consent was obtained from all pregnant women who were identified in the surveys and who agreed to participate in the study. Consenting women intending to deliver in New Delhi and fulfilling the socioeconomic eligibility criteria were revisited as appropriate at 10, 24, and 36 weeks of gestation. A study physician made the first visit, and subsequent visits were made by one of the study lactation counselors. Daily contact was maintained with all pregnant women after 36 weeks of gestation through telephone calls and/or home visits.

The intended place of delivery was ascertained at the first visit. The study coordinator contacted the hospital authorities and the subject's designated obstetrician and pediatrician. They were informed of the study and given documents relevant to its goals and methods, and permission was requested for a visit to their patients soon after delivery. The families were requested to inform the study coordinator or lactation counselor of the delivery as soon as possible. Mobile telephone numbers of study personnel were attached to the expectant mother's antenatal card to help families meet this request.

A lactation counselor visited the hospital soon after each delivery. A study physician and two members of the follow-up team visited after the initial visit of the lactation counselor. These teams were on 12-hour shifts to ensure contact with the mother as soon after delivery as possible. The follow-up team physician screened the child for eligibility and obtained oral informed consent from a parent for the infant's participation.

Follow-up logistics

The first visit of the follow-up team was scheduled for two weeks after delivery. The child was given a gift and rescreened for eligibility at this visit. This was necessary to identify "hidden refusals" or "hidden ineligibles," e.g., infants whose fathers did not support the mother's initial decision to participate or infants whose mothers used formula soon after delivery. Written informed consent was obtained at this visit, and a baby's participation diploma was given to the mothers. Anthropometric measurements were recorded on the diploma at each visit. Hidden refusals and ineligibles

were excluded. All refusals, subjects ineligible owing to breastfeeding intentions, and dropouts from the study were contacted at the child's first birthday for the 12-month study [8].

Home visits for obtaining anthropometric measurements and ascertaining feeding practices, intake of vitamin and mineral supplements, and morbidity were made according to the MGRS protocol [8]. Visits by the follow-up and lactation teams were conducted separately. If the mother inadvertently made concurrent appointments for both teams, the follow-up team waited outside the room until the lactation counselor completed her interview (fig. 3).

When the infants were four months of age, motor development assessments were initiated and repeated monthly in the first year and every two months in the second year until the child could walk independently [6].

Lactation support and complementary feeding

Several visits by the lactation counselors were made to boost the low rates of exclusive breastfeeding characteristic of this setting [1]. These included alternate-day visits during the first week after birth and weekly visits for the first four months. Visits were made every two weeks from four to six months, and monthly visits were made until the child's first birthday. The lactation counselors often interacted with grandmothers, because in this setting they often determine child feeding practices.

A week before the child reached the age of six months, the lactation counselor visited to provide guidance on complementary feeding. Each mother was given complementary feeding guidelines prepared by the investigators, a booklet containing nutritious and appetizing recipes, a plate and spoon, and a food calendar divided by months that permitted the caregivers to record foods consumed by the child. The complementary feeding guidelines developed by the investigators were finalized following feedback that was obtained from nutritionists and pediatricians of the major participating hospitals (table 2).

Implementation of the cross-sectional study

Children aged 18 to 71 months were selected for the cross-sectional study from the door-to-door survey conducted primarily to identify participants for the longitudinal study. Two members of the cross-sectional team visited children recruited to this study component. If a household had a pregnant woman and one or more eligible children aged 18 to 71 months, only the

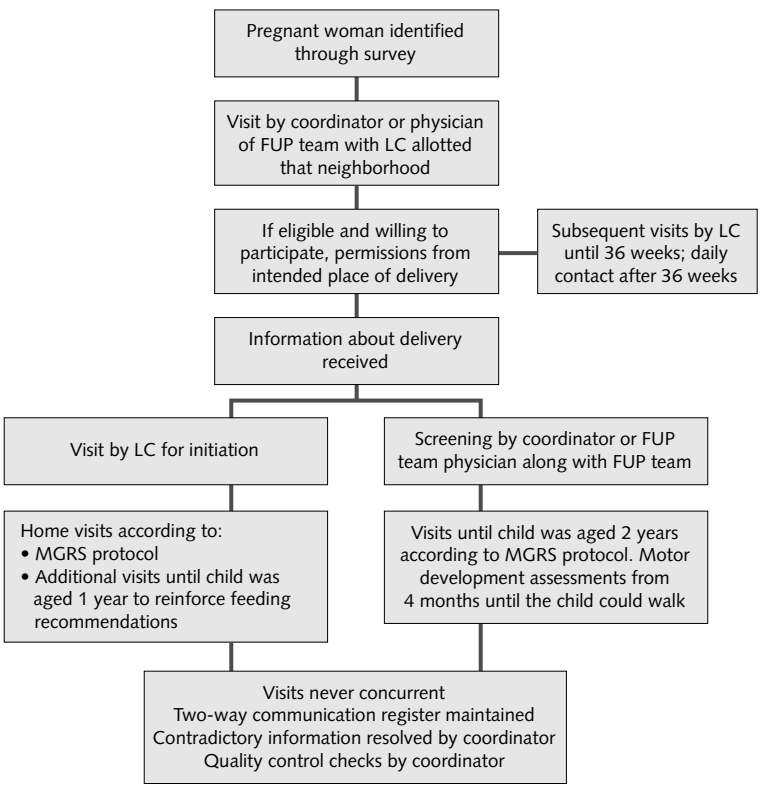

FIG. 3. Coordination between screening, follow-up (FUP) team, and lactation counselor (LC)

TABLE 2. Complementary feeding guidelines at the Indian site

Feeding practice	6–8 mo	9–11 mo	12–24 mo
Breastfeeding	Continue	Continue	Continue
Complementary foods			
Start	At 6 mo		
Quantity	280 kcal	450 kcal	750 kcal
Frequency (meals and snacks)	2–3	3–4	4–5
Consistency	Mashed, very soft	Soft	Finger foods, family diet
Food diversity	Give vitamin A–rich fruits and vegetables, meat, poultry, and fish. Use fortified foods such as iodized salt and iron-fortified flour		
Active feeding	Feed infants yourself, assist older children. Offer favorite foods if appetite is low. Talk to the child while feeding. Feed slowly and patiently. Minimize distractions. Feed from a separate bowl or plate		
Feeding during illness	Feed frequently and patiently. Give favorite foods. After recovery feed more often		
Hygiene and food handling	Wash your hands and the child's hands before feeding. Serve foods immediately after preparation. Use clean utensils to prepare and serve food. Do not use feeding bottles		
Other advice	Ensure immunization schedules are complete. Use oral rehydration therapy during diarrhea. Follow your pediatrician's recommendations for multivitamins and iron–folic acid supplements. Provide children with opportunities for exploration and autonomy		

pregnancy was followed up; if multiple eligible children 18 to 71 months were present in a household, only the youngest child in the family was included in the cross-sectional study component. The 1,490 children for the cross-sectional study were recruited successfully after surveying the first 51 neighborhoods.

Standardization, quality control, and data management activities

Standardization sessions

Anthropometric and motor development standardization sessions were conducted regularly for the relevant teams, as specified in the MGRS protocol [5, 6]. The anthropometry sessions were conducted every two months in one of the study clinics at an urban field site. Standardization sessions involving newborns were conducted at the All India Institute of Medical Sciences. The children assessed during the motor development standardization sessions were taken from among the participants in the longitudinal study.

Quality control activities

Quality control checks were performed on 10% of the follow-up and lactation visits. These were fixed for the Wednesday and Saturday of each week. On these days, the coordinator listed all follow-up and lactation visits that had been made since the last quality control check and randomly selected 10% of them for follow-up. Telephone calls were made to those selected. Information pertaining to morbidity, supplement intake, child feeding practices, maternal work, and the follow-up team's anthropometry technique and, if appropriate, lactation counseling was obtained from mothers. Feedback was obtained on the frequency and content of counselors' visits. Feedback also was obtained on any problems they faced as participants in the study. Information obtained in these quality checks was compared with information obtained by the teams. The study coordinator reviewed any inconsistencies with the relevant team.

Daily meetings were held by each of the study teams with their coordinators. Weekly review meetings were held with the project coinvestigators and each of the study teams. However, most queries and problems were resolved on a daily basis.

Data management

Data management activities followed procedures established by the centrally developed data management system [7]. The forms filled out by the different study teams were checked manually by the respective coordinators and forwarded to the data manager within 24 hours of collection. Double data entry and validation were completed within the subsequent 48 hours. The data were transmitted to the MGRS Coordinating Centre in Geneva on a monthly basis.

Conclusions

The implementation of the MGRS at the Indian site was a challenging task that required careful planning and

implementation. The large number of hospitals and other delivery sites used by this community precluded identifying potentially eligible infants soon after birth, as was done in all other MGRS sites. The requirement of the protocol that anthropometric measurements be obtained soon after birth made that approach impossible. Thus the door-to-door survey described above was necessary. This was particularly challenging. It meant obtaining permission to survey in each of the 58 neighborhoods and visiting 111,084 households over an 18-month period. The study area covered 116 km^2. This required overcoming serious practical constraints presented by gated communities and the work and social demands on the largely professional class of participants.

Another important challenge concerned securing the support of pediatricians and obstetricians and their endorsement of the feeding recommendations central to the MGRS protocol. Few physicians in this setting are convinced that withholding prelacteal feeds and exclusive breastfeeding for six months are relevant for families of high socioeconomic status. This barrier could not have been overcome without the public relations efforts initiated at the onset of the study and the strong international presence evident in all MGRS sites.

There were and are few well-trained lactation counselors in New Delhi. Thus the services of those trained for this study were in great demand. Although this was helpful in supporting recommended feeding practices, lactation counselors were often called upon to support both study participants and those not participating. Throughout the study, a lactation counselor was on call 24-hours a day, and a study vehicle remained with her so that visits could be made until late evening, if required. As a result of the MGRS implementation, lactation training workshops for nurses were organized at some of the major hospitals and the All India Institute of Medical Sciences on several occasions. In the end, it is gratifying that a great team effort helped overcome these multiple challenges and ensured data of high quality.

References

1. Bhandari N, Bahl R, Taneja S, de Onis M, Bhan MK. Growth performance of affluent Indian children is similar to that in developed countries. Bull WHO 2002;80: 189–95.
2. Delhi Development Authority. Order No. F.R. 116/7/82 L& B/3026-34 dated 31.1.1992.
3. Ministry of Urban Development (Lands Division), Government of India. Letter No. J-220 11/1/91-LD.
4. World Health Organization/United Nations Children's Fund. Breastfeeding counselling: a training course. Documents WHO/CDR/93.3-6 and UNICEF/NUT/93.1-4. Geneva: World Health Organization, 1993.
5. de Onis M, Onyango AW, Van den Broeck J, Chumlea WC, Martorell R, for the WHO Multicentre Growth Reference Study Group. Measurement and standardization protocols for anthropometry used in the construction of a new international growth reference. Food Nutr Bull 2004;25(1)(suppl 1):S27–36.
6. Wijnhoven TMA, de Onis M, Onyango AW, Wang T, Bjoerneboe GEA, Bhandari N, Lartey A, Al Rashidi B, for the WHO Multicentre Growth Reference Study Group. Assessment of gross motor development in the WHO Multicentre Growth Reference Study. Food Nutr Bull 2004;25(1)(suppl 1):S37–45.
7. Onyango AW, Pinol AJ, de Onis M, for the WHO Multicentre Growth Reference Study Group. Managing data for a multicountry longitudinal study: experience from the WHO Multicentre Growth Reference Study. Food Nutr Bull 2004;25(1)(suppl 1):S46–52.
8. de Onis M, Garza C, Victora CG, Onyango AW, Frongillo EA, Martines J, for the WHO Multicentre Growth Reference Study Group. The WHO Multicentre Growth Reference Study: planning, study design, and methodology. Food Nutr Bull 2004;25(1)(suppl 1):S15–26.

Implementation of the WHO Multicentre Growth Reference Study in Norway

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Abstract

The World Health Organization (WHO) Multicentre Growth Reference Study (MRGS) European site was Oslo, Norway. Oslo has a high breastfeeding rate. Ninety-nine percent of mothers initiate breastfeeding soon after delivery, and 80% continue for at least six months. There is no evidence that socioeconomic conditions constrain growth. As in other sites, the study had two components, longitudinal and cross-sectional. Recruitment for the longitudinal component was conducted in three hospitals that account for most births in Oslo. Approximately 850 subjects were screened in one year by using a systematic allocation scheme to recruit a sample of about 300. Recruitment for the cross-sectional component was based on a systematic interval sampling scheme prepared by the National Registry. More than 4,000 subjects were screened to achieve the required sample size. One of the major challenges of the study was to achieve an acceptable participation rate; great efforts were made to motivate pregnant women via the health care system and the media.

Key words: Anthropometry, breastfeeding, child health, child nutrition, growth, growth monitoring, growth references, infant feeding practices, Norway

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Members of the WHO Multicentre Growth Reference Study Group and Acknowledgments are listed at the end of the first paper in this supplement (pp. S13–S14).

Introduction

The World Health Organization (WHO) Multicentre Growth Reference Study (MGRS) European site was Oslo, Norway. The population of Oslo is about 500,000, and there are approximately 7,700 births annually [1]. The city has a high breastfeeding rate. Ninety-nine percent of women initiate breastfeeding soon after delivery, and 80% continue breastfeeding for at least six months [2]. Oslo's infant mortality rate was 3.2 per 1,000 live births in 1998 [3], and there is no evidence that socioeconomic status constrains growth in early childhood [4]. The city has an excellent breastfeeding support system and a population characterized by low geographic mobility, and it is at sea level.

As in all other sites, this study had two components, longitudinal and cross-sectional. The longitudinal component followed children from birth through 24 months. The cross-sectional component studied children aged 18 to 71 months. The sample for the longitudinal component was drawn from three hospitals that account for more than 95% of the city's births: Ullevaal, Rikshospitalet, and Aker. All three are designated as Baby-Friendly Hospitals by WHO/ UNICEF [5]. Less than 1% of women deliver their infants at home [6].

Planning phase

Study timeline and preparatory activities

Planning for the study began in September 1998, when a coordination center was established at the National Breastfeeding Centre in Rikshospitalet University Hospital. The timeline for the major phases of the study is summarized in figure 1.

The study was presented to the directors of the three participating hospitals, their physicians-in-chief and head midwives, and other maternity ward staff. Health personnel working in antenatal care or child health clinics were informed through meetings and written material of the goals and procedures of the

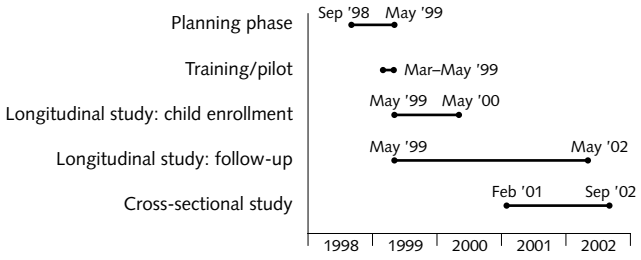

FIG. 1. Study timeline

study and their respective roles in supporting the successful implementation and completion of the study. Almost 100% of parents take their children to Oslo's public child health clinics during the children's first years of life. Cooperation agreements were therefore developed with child health clinics, and the research team sent letters outlining study procedures to the respective clinics as children from their catchment areas were enrolled.

Announcements in journals for health personnel and in the city's newspapers were used to recruit staff for the various positions in the study. Since the response was high, personnel with the best qualifications were recruited.

Institutional approvals were obtained from Rikshospitalet, Ullevaal, and Aker hospitals, the Regional Ethics Committee for Medical Research, the Data Inspectorate, and the Norwegian Board of Health.

Study teams

The study team consisted of two principal investigators who were physicians, one project coordinator, one supervisor, five lactation counselors who had been trained as midwives or public health nurses, eight follow-up interviewers who were nurses' aides (specially trained to work with children), a data manager and two data clerks, one quality control staff member, and a study secretary.

Training and initial standardization

The training phase lasted two months. Extensive practical anthropometric training with children of relevant ages followed a review of the underlying physiology of physical measurements and growth. The measurement techniques of the screening and follow-up teams were standardized against the measurements of one of the two WHO lead anthropometrists [7]. All candidates met the standardization criteria.

The follow-up team was trained in interview techniques and dietary assessment methods. The lactation team went through an extended training program on lactation counseling. All members of the lactation team became International Board Certified Lactation Consultants during the study period.

Adaptation of study materials and procedures

The study materials were translated and adapted to local conditions. The questionnaires reflected exact translations of the master English version, with a few site-specific variables (e.g., indicators of socioeconomic status and site-specific complementary foods) added as required in the master Manual of Operations [8].

Child rearing practices and encouragement by training could influence the acquisition of motor development milestones [9]. As a general practice, Norwegian parents are advised by the child health clinics not to push the baby to sit in an upright position, but to wait for the child to do this spontaneously. Hands-and-knees crawling is considered an important milestone that children should not skip. If it does not occur within a certain period, parents are advised to actively stimulate its development [10]. These practices were not contradicted by the study team when implementing the motor development study protocol [11].

Public relations activities

Achieving a high rate of participation was considered a challenge, because this community generally does not accept efforts of this type easily. Thus the assistance of the National Nutrition Council in the development and implementation of a public relations plan was particularly valuable.

Health personnel working in antenatal care were requested to display posters specially made for the study and to distribute informational leaflets to pregnant women to prepare them for a possible screening interview. All child health clinics were also sent posters introducing the study to the public.

A launching ceremony was organized with the Director-General of WHO, Dr. Gro Harlem Brundtland, as the main speaker. The event was given extensive media coverage. A proactive press strategy resulted in the publication of several articles in the main newspapers during the data collection period.

The children participating in the longitudinal study received small gifts at enrollment and on their first two birthdays, and those who completed the study were entered in a drawing in which the five winners would each receive US$280. Every year a picnic for all participants was arranged in Oslo's main park to express the gratitude of the MGRS team and provide motivation for continued participation. Newsletters relating the progress of the study were also distributed to participants. The main factors motivating the parents to participate were probably the study team's professionalism and the global importance of the study. Both of these aspects were incorporated into all public relations activities.

Implementation of the longitudinal study

Sampling strategy

The screened population was selected to represent all children born in Oslo from May 1999 to May 2000. The recruitment rate at each hospital was related to the percentage of births each hospital was expected to contribute to the city's annual deliveries. An even seasonal distribution was achieved in all hospitals by frequent, regular visits to each by the study team.

Although most selection criteria were common to all sites [8], exclusion on the basis of morbidity was site-specific (table 1). In Norway the pediatric practice is not to measure the length of breech-delivered infants, because of concerns related to the risk of hip dislocation. Therefore, breech-delivered newborns were excluded at screening. Since there is no evidence for constrained growth among economically less privileged groups in Norway, socioeconomic status was not a criterion for eligibility. Regarding intention to breastfeed, no questions were asked regarding the intended duration of breastfeeding, because the rates of initiation are high, the duration is generally six months or longer, and the duration is often related to factors other than a mother's motivation to breastfeed.

TABLE 1. Exclusion criteria for morbidity at the Norwegian site

Criteria for assessing newborns
Serious birth asphyxia (hypoxic ischemic encephalopathy [HIE] level 2 or 3)
Seizures
Lack of muscle tone indicating possible neurological diseases
Hydrocephalus or cerebral hemorrhage
Serious infections, sepsis, meningitis, or encephalitis
Impaired respiratory function (definition: is in need of mechanical ventilation or increased oxygen requirements for more than 72 hours)
Congenital cardiovascular conditions (not atrial septal defect [ASD] or persistent ductus arteriosus [PDA])
Congenital abnormalities
Symptoms indicating chromosome abnormalities, Down syndrome, Turner syndrome, and others
Signs of having suffered from intrauterine infection
Criteria for assessing children between 18 and 71 months
Malignant disease, past or present
Chronic anemia
Chronic cardiac disease that influences daily activities
Chronic lung disease that influences daily activities
Chronic gastrointestinal, liver, or renal disease
Endocrine disorders
Chronic neurological disease that influences daily activity
Chronic mental disease that influences daily activity
Chronic systemic disease
Malformations that clearly influence daily activities and/or interfere with anthropometric measurements
Other chronic diseases that clearly influence normal daily activities

Screening was carried out only on weekdays. This was not expected to result in a biased sample. Data from the 1997 Medical Birth Registry of Norway showed that 14.6% of children born at Oslo hospitals were delivered by cesarean section; 5.4% were planned cesarean sections, performed on weekdays [6]. Screening on weekdays alone thus implied a slight overrepresentation (by 2.2 percentage points) of elective cesarean section deliveries in the sampling frame. However, any bias introduced by this scheme had little if any relevance to expected child growth, so extending screening to include weekends was not considered further.

Screening and enrollment of children

The longitudinal component required that 300 infants be enrolled [8]. Thus, based on the number of days available for screening in one year, six children were to be enrolled weekly. The available data related to the different exclusion criteria and the anticipated enrollment rate indicated that 43% of those screened would be enrolled successfully. Therefore, to enroll six children per week, 14 screening interviews were needed per week. The sampling fraction recruited from each hospital was determined by dividing the estimated number of children born during a five-day week (see above) by the 14 screening interviews needed. The first child screened was the first born after 8 am on the index recruitment day. Thereafter, sampling was performed by systematic allocation (every fourth birth). If a designated screening interview could not be carried out because of a language barrier or serious illness, the next mother on the chronological list was interviewed as a replacement. A total of about 850 mothers were screened during a 12-month period. Written informed consent was obtained from all mothers participating in the study.

Follow-up logistics

Follow-up was carried out as outlined in the MGRS protocol [8]. The first home visit was scheduled at two weeks postpartum, during which baseline data were collected and eligibility and consent were reassessed. Mothers who indicated that they smoked or were already giving formula to their infants on a regular basis were considered "hidden ineligibles" and excluded from further participation, in accordance with the MGRS protocol. Mothers who initially agreed to participate but were no longer interested by day 14 were considered "hidden refusals." Hidden ineligibles and refusals, as well as children who dropped out of the study before the age of 12 months, were contacted a few weeks before the child's first birthday for participation in the 12-month study [8]. The procedure was to call

at least five times at different times of the day over a two-week period. If no contact was achieved by then, the family was defined as "not traceable."

The motor development assessments [11] were initiated in April 2000, about 10 months after screening was initiated, which meant that the initial milestones could not be assessed for some infants.

Lactation support and complementary feeding

A combined screening and lactation team was established. Soon after enrollment, the lactation counselors helped newly delivered mothers in the maternity ward with the initiation of breastfeeding. The same consultant followed the mother–infant pair until the child's first birthday to provide frequent and individual lactation support. The mothers were contacted by telephone and lactation was assessed the day following discharge from the hospital, usually two to four days postpartum. Close follow-up of breastfeeding problems was offered from their onset. In addition to four scheduled home visits at weeks 1 and 2 and months 3 and 6, lactation counselors kept in contact with mothers by telephone at least once per month. Mothers having breastfeeding problems received extra support until the problems were resolved. A hotline for emergency support was available seven days a week from 8 am to 8 pm.

The mothers were advised to introduce complementary foods to their infants by six months. The infant nutrition guidelines developed by the Norwegian National Nutrition Council [12] were followed (table 2). The council's feeding guidelines are based on Norway's dietary patterns, which include cereals and potatoes as important staples. Cod liver oil is recommended from the age of four weeks as a vitamin D and essential polyunsaturated fatty acid supplement. In addition to the prevention of vitamin D deficiency, sufficient iron intake is a concern. Iron-fortified porridge is recommended most commonly to ensure that the infant's iron needs are met. Water rather than sweetened beverages is recommended, since consumption of the latter tends to replace more nutrient-dense diets.

TABLE 2. Complementary feeding guidelines at the Norwegian site

From the age of four weeks, 10 µg of vitamin D is recommended, preferably through cod liver oil
If the baby needs a supplement to breastmilk, iron-fortified infant formula is recommended for the first 12 months
Complementary foods should be gradually introduced from the age of four to six months, while the baby is still breastfed, giving small amounts of only one type of food for some days so that possible reactions can be detected. This recommendation was revised in 2002, and exclusive breastfeeding for the first six months of life is now recommended
Introduction of complementary foods may start with pureed potatoes, vegetables, fruits, and/or porridge
After the introductory phase, pureed fish and meat, together with the staple potato and vegetables (dinner) should be introduced
Do not add salt to baby food
Iron-fortified baby cereals are a good source of iron. Two meals per day will ensure an adequate intake. If the child receives other good sources of iron such as dinner with meat, one may also use home-prepared porridges based on oatmeal, for example
If the child has a history of food allergy, eggs, fish, and peas should not be introduced until the child is one year old
Offer the child water instead of squash
From the age of one year, children should receive the family food without too much salt

Implementation of the cross-sectional study

Sampling strategy

The number of children aged 18 to 71 months living in Oslo during the implementation of the cross-sectional component of the study was estimated to be 28,000 [1]. From this population, 1,260 children were to be selected for the cross-sectional study. The sampling was done in cooperation with Statistics Norway [13]. All persons living on a permanent basis in Norway are registered in the National Registry. Information on each registrant includes an identity number and the name and address of the mother and father. The registry is updated every third week. By combining files from the National Registry and the Medical Birth Registry, it was possible to select only children both born and living in Oslo, to eliminate twins, and to select only one child per family. Based on population characteristics and experience from the longitudinal study, a participation rate of 31% was anticipated. According to the experience of Statistics Norway, it was necessary to increase the sample size by about 20% to allow for factors such as families not responding to telephone solicitations. A total of 5,185 children were sampled for the screening interview.

The sample to be screened was selected by a systematic interval sampling scheme. All children in the targeted age groups were sorted according to age and their home's postal code. A random entry point of sampling was selected, and then sampling was carried out at a fixed interval. This method results in a randomly selected, representative sample of designated age cohorts and provides a representative geographic distribution.

The sampling was divided into four periods to enable better focus on specified age groups. This method provided the most up-to-date lists possible and included fewer families who had left Oslo.

Screening, enrollment, and survey logistics

A letter explaining the goals and procedures of the study was sent to mothers of potentially eligible children one to two weeks before a projected screening interview. These letters were followed by telephone calls. Mothers were called at least five times at different times of the day over a two-week period. If no contact was achieved after the fifth attempt, the family was defined as "not traceable." Appointments for the cross-sectional survey interview and measurements were made with subjects who were eligible and willing to participate. Most visits occurred in the evenings in the subjects' homes to accommodate parents working outside the home.

Standardization, quality control, and data management activities

All quality control procedures outlined in the MGRS protocol were implemented [8]. Every questionnaire was checked, and irregularities were resolved in consultation with the appropriate interviewer. Ten percent of mothers (randomly selected) were called by telephone to review previous responses to interview questions, validate that visits were done, and assess the content of the visits.

Data management procedures were implemented by using the MGRS data management system, and the data management procedures of the study, described elsewhere in this supplement [14], were adhered to. The interviewers were given an overview of the data management system and brief hands-on experience with data entry. This provided a more complete understanding of the data management procedures and emphasized the importance of completing questionnaires accurately.

Conclusions

The MGRS was a demanding study, and several major challenges had to be overcome to bring it to a successful completion in Norway. Chief among these in the longitudinal component of the study was the need to maintain a high level of momentum for continued participation in 21 follow-up visits over a two-year period. Because both parents of most young families work outside the home, maintaining commitment over a two-year period was a major achievement for the families and the study team. The behavioral and technical skills of the follow-up team were crucial to achieving high rates of continued participation, and more than 85% of the enrolled sample completed the 21 visits. The main reason for dropping out was the family's leaving Oslo.

The bimonthly (every two months) anthropometric standardization sessions were also a very demanding aspect of the longitudinal component of the study. Nonetheless, their necessity was also evident [7]. The difficulties presented by these sessions are clear from the fact that a 40% overrecruitment rate was necessary to ensure that a sufficient number of parents and children participated in any single session. Most children appeared to find the sessions stressful.

Despite these and other challenges, parents and staff sustained their participation because of the important role that growth standards play in developing and developed countries. Most participants viewed their participation as meeting a larger public service responsibility to Norway's and the world's children.

References

1. Municipality of Oslo. Statistical yearbook of Oslo 1999, 99th ed. Oslo: Municipality of Oslo, 1999.
2. Lande B, Andersen LF, Baerug A, Trygg KU, Lund-Larsen K, Veierod MB, Bjorneboe GE. Infant feeding practices and associated factors in the first six months of life: the Norwegian infant nutrition survey. Acta Paediatr 2003;92:152–61.
3. Statistics Norway. Statistical yearbook 1998. Oslo: Statistics Norway, 1999.
4. Nafstad P, Jaakkola JJK, Hagen JA, Pedersen BS, Qvigstad E, Botten G, Kongerud J. Weight gain during the first year of life in relation to maternal smoking and breast feeding in Norway. J Epidemiol Community Health 1997;51:261–5.
5. World Health Organization/United Nations Children's Fund. Baby-Friendly Hospital Initiative. Part II: Hospital level implementation. Geneva: World Health Organization, 1992.
6. Medical Birth Registry of Norway. Annual report 1997. Bergen: University of Bergen, 1998.
7. de Onis M, Onyango AW, Van den Broeck J, Chumlea WC, Martorell R, for the WHO Multicentre Growth Reference Study Group. Measurement and standardization protocols for anthropometry used in the construction of a new international growth reference. Food Nutr Bull 2004;25(1)(suppl 1):S27–36.
8. de Onis M, Garza C, Victora CG, Onyango AW, Frongillo EA, Martines J, for the WHO Multicentre Growth Reference Study Group. The WHO Multicentre Growth Reference Study: planning, study design, and methodology. Food Nutr Bull 2004;25(1)(suppl 1):S15–26.
9. Super CM. Environmental effects on motor development: the case of 'African infant precocity.' Dev Med Child Neurol 1976;18:561–7.
10. Misvaer N, Oftedal G. Manual for child health clinics [in Norwegian]. Oslo: Kommuneforlaget, 2002.

11. Wijnhoven TMA, de Onis M, Onyango AW, Wang T, Bjoerneboe GEA, Bhandari N, Lartey A, Al Rashidi B, for the WHO Multicentre Growth Reference Study Group. Assessment of gross motor development in the WHO Multicentre Growth Reference Study. Food Nutr Bull 2004;25(1)(suppl 1):S37–45.
12. National Nutrition Council. Infant feeding recommendations [in Norwegian]. Oslo: National Nutrition Council, 1993.
13. Hougen HC, Wangen G-E. WHO Multicentre Growth Reference Study—sampling for the cross-sectional study [in Norwegian]. Oslo: Statistics Norway, 2002
14. Onyango AW, Pinol AJ, de Onis M, for the WHO Multicentre Growth Reference Study Group. Managing data for a multicountry longitudinal study: experience from the WHO Multicentre Growth Reference Study. Food Nutr Bull 2004;25(1)(suppl 1):S46–52.

Implementation of the WHO Multicentre Growth Reference Study in Oman

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Abstract

The World Health Organization (WHO) Multicentre Growth Study (MGRS) Middle East site was Muscat, Oman. A survey in Muscat found that children in households with monthly incomes of at least 800 Omani Rials and at least four years of maternal education experienced unconstrained growth. The longitudinal study sample was recruited from two hospitals that account for over 90% of the city's births; the cross-sectional sample was drawn from the national Child Health Register. Residents of all districts in Muscat within the catchment area of the two hospitals were included except Quriyat, a remote district of the governorate. Among the particular challenges of the site were relatively high refusal rates, difficulty in securing adherence to the protocol's feeding recommendations, locating children selected for the cross-sectional component of the study, and securing the cooperation of the children's fathers. These and other challenges were overcome through specific team building and public relations activities that permitted the successful implementation of the MGRS protocol.

Key words: Anthropometry, breastfeeding, child health, child nutrition, growth, growth monitoring, growth references, infant feeding practices, Oman

Introduction

The Middle East site of the World Health Organization (WHO) Multicentre Growth Reference Study (MGRS) was the capital city of the Sultanate of Oman, Muscat. Oman is located at the southeastern corner of the Arabian Peninsula. The city overlooks the Arabian Sea and the Persian Gulf. Its population resides at altitudes close to sea level. Of the country's 2.5 million inhabitants, more than a quarter reside in the capital area. About half of the resident population in Muscat (55%) is Omani [1], the remainder being expatriates. Muscat's population is relatively affluent and has ready access to highly developed preventive and curative health services.

Ninety-six percent of births in Muscat take place in two hospitals: Royal (4,969 births in 2001) and Khoula (3,548 births in 2001) hospitals [1]. These births include high-risk pregnancies that are referred from outside the capital area. Both hospitals serve a clearly defined catchment area that includes most of the women resident in Muscat. All communities within the catchment area were included in the study except Quriyat, a remote district of the Governorate.

A survey was conducted to identify socioeconomic, demographic, and behavioral characteristics of the subpopulation within Muscat whose children's linear growth is unconstrained by social and other environmental conditions [2]. The mothers of 336 children aged 28 to 43 months were selected from the national Child Health Register and interviewed. The children's weights and heights, the maternal height, child feeding practices, and the families' socioeconomic status were assessed. The participants' potential willingness to participate in the MGRS was also ascertained. The survey had a refusal rate of 0.1% [2]. The survey results demonstrated that more than 20% of those interviewed were able to follow MGRS feeding recommendations. The survey also identified specific socioeconomic status indicator cutoffs of families whose children experience unconstrained growth in early childhood. These were a monthly household income of at least 800 Omani Rials (US$2,083) and at least four years of maternal education. Mobility was low, but some families (39%) usually traveled out of Muscat on vacation for short periods during the summer months.

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Members of the WHO Multicentre Growth Reference Study Group and Acknowledgments are listed at the end of the first paper in this supplement (pp. S13–S14).

Planning phase

Study timeline and preparatory activities

The initiation and duration of the key phases of the study are summarized in figure 1. Approval to recruit from the two participating hospitals was obtained from the Directors General of the Royal Hospital and Muscat Region (for Khoula Hospital). Members of the research team met with the chief nurses and the heads of the maternal and pediatric units of each hospital to explain the aims and procedures of the study and their respective roles in its successful implementation, especially in facilitating subject recruitment and the breastfeeding of newborns.

Study teams

The study group was composed of three field teams—the screening, follow-up, and lactation support teams—with their respective supervisors and quality control staff. The data management team based at the local coordination center was supervised by the site data manager and his assistant. The coordination team was made up of the site's principal investigator, a research associate, the supervisors and quality control staff of the three field teams, the data manager and assistant, a pediatric consultant, and a breastfeeding adviser. The field teams were formed for functions defined by the longitudinal study, but two of them implemented the cross-sectional study: the lactation team to screen and the follow-up team to interview recruited subjects and take anthropometric measurements. When the cross-sectional component began, lactation counseling activities were nearly completed, and the volume of longitudinal follow-up visits was low enough to accommodate the additional visits. The supervisors and quality control staff members fulfilled their functions in positions determined by local needs at different stages of the implementation of the study. The pediatric consultant defined the neonatal morbidity exclusion criteria and held meetings with the pediatricians of the two hospitals to secure their support for the implementation of the study. The Muscat Region Director General provided key logistic and personnel support for the implementation of the study.

Six nutritionists were recruited to the screening team. This group worked in pairs and rotated between the hospitals. An International Board Certified Lactation Consultant trained nine nurses from the maternal and pediatric wards of the two hospitals, four of whom were recruited as lactation counselors for the study. Each counselor was assigned to specific residential areas. Eleven nurses and dietitians were recruited to form five working pairs of the follow-up team. One member of each pair was assigned permanently to a specific residential area, and the other six were rotated every two months. Three part-time data entry clerks worked on the data management team, and three part-time study secretaries were responsible for day-to-day administration and coordination functions (fig. 2).

Training and initial standardization of study teams

The longitudinal screening and follow-up teams were trained to make anthropometric measurements by a member of the MGRS Coordinating Centre and standardized against the WHO lead anthropometrist before the start of data collection. All interviewer teams were trained to administer oral interviews and complete questionnaire forms with the aid of the interviewer guides. Six members of the follow-up team were trained to perform motor development assessments. In addition to the overall administration of the project, the secretaries were trained to coordinate the day-to-day activities of the various teams and to maintain study registers and participation flux charts.

Adaptation of study materials and procedures

The MGRS Manual of Operations was adapted to the Omani context, and all questionnaires were translated

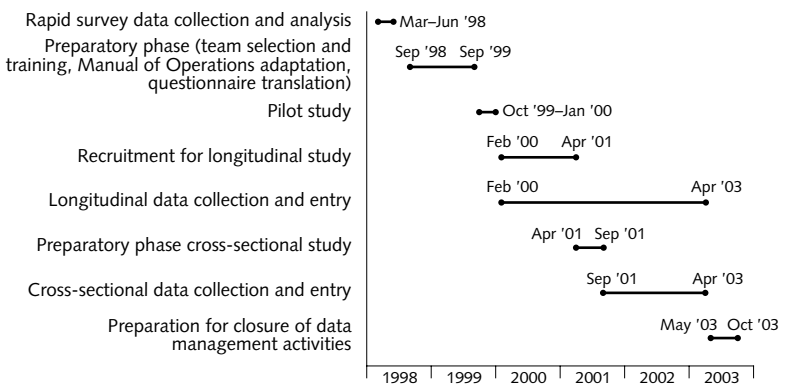

FIG. 1. Study timeline

into Arabic and back-translated into English at WHO headquarters in Geneva [3]. The interviewer guides were also translated into Arabic. Gender segregation is the norm in Oman. Thus, the availability of men during home visits was often low, and the fieldworkers, all of them female, were often not permitted to take their measurements. Therefore, two men were trained to measure adult weight and height, and the fathers had the option of coming to the local coordination center or were visited at work or at the health center nearest their home for these measurements to be taken.

Public relations activities

Media coverage, mostly by newspapers and radio, was secured when the study was launched and in the initial phases of the cross-sectional component. Despite these efforts, the study experienced a high refusal rate. To address this problem, the public relations officer in one of the hospitals assisted the longitudinal screening team by meeting with fathers during afternoon visiting hours and encouraging them to participate. Occasionally a male member of the coordination team would also talk with a reluctant father about the importance of taking part in the study.

A booklet explaining the importance of breastfeeding and offering practical advice on how to do it successfully, an informational leaflet describing the aims and procedures of the study, and letters requesting fathers' and employers' collaboration were distributed. A study newsletter in Arabic was also distributed to all families recruited in the longitudinal component. Another newsletter in English was published for hospital and health clinic staff and other key supporters.

Two receptions were held for the longitudinal study participants at which gifts were given to all the children and their mothers. This was done to maintain the group's morale and thank the participants for their commitment to the study. Discount cards to shops and eateries were also provided, and the coordination team helped arrange doctor's appointments for enrolled children when required. MGRS seals also were placed on the children's health cards. This accorded them priority status at health centers. The mothers also were given tokens of appreciation at the end of the two-year follow-up.

Implementation of the longitudinal study

Sampling strategy

The recruitment target was set at 6 to 8 babies per week in order to enroll 312 children over 12 consecutive months. High ineligibility and refusal rates in the pilot phases of the study demonstrated the need to screen

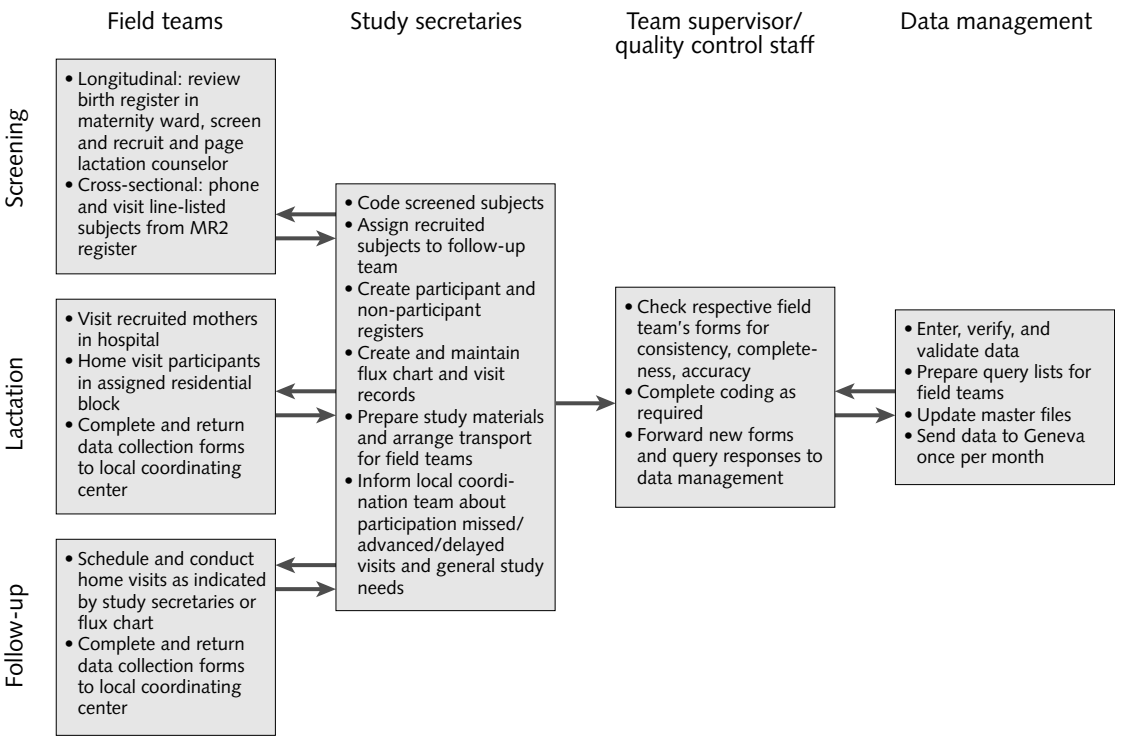

FIG. 2. Team coordination flow chart

all births in order to meet the sample size target. A weekly enrollment ratio of 4:3 from the Royal and Khoula hospitals was decided on to reflect the number of births in each hospital.

Screening and enrollment

Screening was done twice daily in each hospital, at 8 am and 8 pm Saturday through Wednesday. All children born in the previous 12 hours were screened. Screening stopped at each hospital when that hospital's weekly quota was met, but the quota was sometimes exceeded to compensate for recruitment shortfalls in previous weeks. All babies admitted to the Special Care Baby Unit for more than 24 hours were excluded, unless the unit's attending physician indicated that the infant's diagnosis would not affect growth adversely. The perinatal morbidity exclusion criteria are summarized in table 1. Only oral consent was obtained at screening in most cases because of the disinclination in most families to give written consent.

Follow-up logistics

The enrolled subjects were listed in the study register at the local coordination center and assigned for follow-up to the team responsible for their residential area. Each mother was followed throughout the study by one nonrotating member of the follow-up team to provide stability. Motor development assessment was done from the age of five months by members of the follow-up team on the same schedule as the follow-up visits.

Lactation support and complementary feeding

The lactation counselors visited the enrolled mothers within 24 hours of delivery to ensure successful initiation of breastfeeding and reconfirm the mothers' willingness to participate. They maintained a 24-hour hotline, seven days a week, to respond to acute breastfeeding problems and answer the mothers' questions and concerns. The lactation team supervisor assisted with difficult lactation problems and periodically made home visits to support the mothers, foster compliance with breastfeeding guidelines, and enhance the mothers' confidence in the study team. The MGRS in Oman adopted the complementary feeding guidelines developed by the Ministry of Health. A booklet containing these guidelines was distributed at the five-month visit (table 2).

A list of eligible families who refused to participate, were unwilling to follow the MGRS breastfeeding requirements, or dropped out of the study while the child was an infant was generated for follow-up at the child's first birthday. A random sample of 72 was selected and visited by the follow-up team to obtain anthropometric measurements, as outlined in the MGRS protocol [3].

TABLE 1. Local exclusion criteria for the Omani site

Term	Definition
Perinatal morbidity	Admitted to Special Care Baby Unit for more than 24 hours, or information on the infant diagnosis sheet completed by attending physician identified a disease affecting growth
Intention to breastfeed	Mother unwilling to try to breastfeed for at least four months
Socioeconomic status	Household income less than 800 Omani Rials (0.384 OR = US$1) or maternal education less than four years

Implementation of the cross-sectional study

Sampling strategy

The sample for the cross-sectional study was drawn from Child Health (MR2) registers in the 12 health centers that serve the population in Muscat. Investigations done in preparation for this study component established that 93% of the children born in the Royal and Khoula hospitals were included in the MR2 register at any 1 of the 12 health centers. The preparatory investigations also tested the ability of the MR2 registers to provide a random sample of children aged 18 to 71 months similar to that recruited for the longitudinal component of the study. Only 72% of a sample drawn from the 1995 and 1998 MR2 registers could be traced, and nearly 75% of the families had more than one child in the age range required (both nuclear and joint families). Additional resources were required to increase the contact rate so as to screen at least 80% of the target population, and the latter finding revealed the need to expand the sampling frame, since only one child per household would be eligible for the study.

After multiple births and births to expatriates had been excluded, a master list of 24,000 children aged 18 to 71 months was drawn from the 12 MR2 registers. The eligibility and consent rates observed in the preparatory phase of the study indicated that 8,000 children should be screened to recruit the required number (1,400), and therefore a random sample of 8,000 from the master list was selected for contact.

Screening, enrollment, and survey logistics

The mothers were contacted initially by telephone to ascertain the presence of a potentially eligible child.

The child had to be within the targeted age range, to have been breastfed for at least three months, to meet the residency requirements, and to have an Arabic-speaking mother. Consenting eligible families were visited in their homes to complete the full screening interview. When the telephone number was out of service or the call went unanswered, the family was sought at the physical address indicated in the MR2 register. The four members of the screening team each covered the same residential areas assigned to them for lactation counseling in the longitudinal component. Several efforts were set up to maximize the contact rate for screening. One team member was employed full-time to obtain additional contact information on subjects who could not be contacted by telephone or at the listed home address. Computerized registers maintained in the 12 health centers and in the city's principal obstetrics/gynecology clinic, where all women in their third pregnancy trimester are attended to, were reviewed. Health educators from each of the health centers, voluntary support groups, and the areas' wali or sheikhs also assisted in locating those who could not be contacted. These collaborative efforts were key to achieving an 80% contact rate. Two staff members were added a few months into the data collection period to assist with recruitment. At the local coordination center, the recruited subjects were assigned to the follow-up team working in their residential blocks for the home visit. The follow-up team visited each household once to administer the cross-sectional survey interview and take anthropometric measurements.

Standardization, quality control, and data management activities

Throughout the data collection phase, the anthropometry and motor development teams participated in bimonthly (every two months) standardization sessions and received remedial training if their performance deviated from MGRS norms. The anthropometry standardization sessions of the screening team were conducted in the Royal Hospital maternity ward, and the follow-up team standardization sessions for both anthropometry and motor development were held in the Bowshar polyclinic. The children who participated in the standardization sessions of the follow-up team were recruited from well-baby clinics and from participants in the longitudinal component of the study. Standardization procedures are described elsewhere in this supplement [4, 5].

Quality control activities were also carried out as described in the MGRS protocol and Manual of Operations [3]. Telephone calls were made following all cross-sectional component screening visits, and the team supervisor made random repeat home visits to validate information that had been obtained by the fieldwork-

TABLE 2. Ministry of Health Complementary Feeding Guidelines, Oman site

Continue frequent, on-demand breastfeeding, including night feeding for infants up to the 24th month
Introduce complementary foods between the beginning of the 5th month and the end of the 6th month
Increase food quantity as the child gets older:
Provide infants 5–8 months old approximately 280 kcal per day from complementary foods
Provide infants 9–11 months old approximately 450 kcal per day from complementary foods
Provide children 12–24 months old approximately 750 kcal per day from complementary foods
Increase feeding frequency as the child gets older, using a combination of meals and snacks:
Feed infants 5–8 months old complementary foods 2–3 times per day
Feed infants 9–11 months old complementary foods 3–4 times per day
Feed children 12–24 months old complementary foods 4–5 times per day
Gradually increase food consistency and variety as the infant becomes older, adapting the diet to the infant's requirements and abilities:
Feed mashed and semisolid foods, softened with breastmilk, if possible beginning around 5 months of age
Feed energy-dense combinations of soft foods to infants 5–11 months old
Introduce finger foods (snacks that can be eaten by children alone) beginning around 8 months of age
Make the transition to family food at about 12 months of age
Diversify the diet to improve quality and micronutrient intake:
Feed a high-protein diet such as meat, fish, or poultry, or legumes such as lentils, beans, peas, chickpeas, or yogurt daily
Feed vitamin A–rich fruits and vegetables daily
Use only iodized salt
Practice active feeding:
Feed infants directly and assist older children when they feed themselves
Give each child a plate and a spoon, and encourage him or her to stay at the table during the mealtime
Offer favorite foods and encourage children to eat when they lose interest or have depressed appetite
Start new foods one at a time, and allow 4–7 days to observe for any possible food intolerance
Include eggs and honey in the diet only after the child completes 12 months of age
Do not offer more than two small coffee cups of juice per day, especially before meals, as it could decrease appetite
Feed slowly and patiently and minimize distractions during meals
Make mealtime a happy, pleasant time. Do not force the child to eat certain foods or finish everything on the plate
Practice frequent and active feeding during illness:
During illness increase fluid intake by more frequent breastfeeding and patiently encourage children to eat favorite foods
After illness, breastfeed and give foods more than usual and encourage children to eat more food at each sitting

ers. Data forms were checked for completeness and consistency by the interviewer and her team supervisor before being submitted for data entry. In keeping with the MGRS protocol, data were entered twice and validated by centrally prepared routines before being incorporated into the study master files [6].

Conclusions

The successful conclusion of the study required the overcoming of several particularly difficult challenges: a relatively high refusal rate, obtaining fathers' anthropometric measurements, securing the family's adherence to the feeding guidelines of the study, and locating families for the cross-sectional component of the study.

Of those eligible at screening, nearly a quarter refused to participate. In addition, almost a third of the mothers enrolled in the hospital for the longitudinal study rescinded their consent when contacted at home. This high refusal rate probably reflects the high value placed on privacy in Oman. In many cases, families were very hesitant to have people interview them at home, particularly when it involved the long-term commitment of two years. Often it was the child's father who refused consent after the mother had agreed to participate.

Participating fathers were requested to be available for at least one of the follow-up visits, but this often proved difficult and required making the adjustments described earlier. Even when they were available, some fathers would not have their measurements taken by women, a fact that increased the logistic complexity and resource costs of the study.

Adherence to the protocol's feeding recommendations was difficult for mothers working outside the home. This was common in the professional class targeted by the study. Employers were contacted and requested to support working mothers to breastfeed their infants exclusively, e.g., by granting enrolled mothers compensated time off during the day. The large households common in Oman also proved challenging, because many individuals participate in child care. It was important, therefore, to counsel both the mother and other key family members.

Locating children selected for screening for the cross-sectional component of the study proved especially difficult. Many children on the master list, especially older ones, were no longer available at the addresses provided by the Child Health Register. Extensive efforts were required to locate these children. Even after telephone contact was established, missed appointments were common and locating potential subjects' homes was often difficult. Muscat is experiencing rapid growth that has resulted in a network of unpaved roads in both new and older neighborhoods.

However, the study was successfully implemented, thanks to the collaboration of many individuals and institutions and the tenacity of the field and coordination teams.

References

1. Annual statistical report, 2001. Muscat, Sultanate of Oman: Ministry of Health, 2002.
2. Mohamed AJ, Onyango AW, de Onis M, Prakash N, Mabry RM, Alasfoor DH. Socioeconomic predictors of unconstrained child growth in Muscat, Oman. East Mediterr Health J, in press.
3. de Onis M, Garza C, Victora CG, Onyango AW, Frongillo EA, Martines J, for the WHO Multicentre Growth Reference Study Group. The WHO Multicentre Growth Reference Study: planning, study design, and methodology. Food Nutr Bull 2004;25(1)(suppl 1):S15–26.
4. de Onis M, Onyango AW, Van den Broeck J, Chumlea WC, Martorell R, for the WHO Multicentre Growth Reference Study Group. Measurement and standardization protocols for anthropometry used in the construction of a new international growth reference. Food Nutr Bull 2004;25(1)(suppl 1):S27–36.
5. Wijnhoven TMA, de Onis M, Onyango AW, Wang T, Bjoerneboe GEA, Bhandari N, Lartey A, Al Rashidi B, for the WHO Multicentre Growth Reference Study Group. Assessment of gross motor development in the WHO Multicentre Growth Reference Study. Food Nutr Bull 2004;25(1)(suppl 1):S37–45.
6. Onyango AW, Pinol AJ, de Onis M, for the WHO Multicentre Growth Reference Study Group. Managing data for a multicountry longitudinal study: experience from the WHO Multicentre Growth Reference Study. Food Nutr Bull 2004;25(1)(suppl 1):S46–52.

Implementation of the WHO Multicentre Growth Reference Study in the United States

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Abstract

The World Health Organization (WHO) Multicentre Growth Reference Study (MRGS) North American site was Davis, California. For the longitudinal cohort (0–24 months), 208 infants were enrolled between January and December 1999 from five area hospitals at which nearly all Davis women give birth. The target sample size was lower in the United States than in the other sites, because recruitment in the United States was restricted to mothers who were willing to exclusively breastfeed for at least 4 months and continue breastfeeding for at least 12 months. For the cross-sectional component, a mixed-longitudinal design was used, which required approximately 500 subjects. The subjects were recruited by going door-to-door, with the sampling scheme based on the distribution of the subjects of the longitudinal study within the city. The cross-sectional sample was recruited between January and July 2001. Major challenges during implementation were maintaining daily communication with hospital personnel and scheduling home visits.

Key words: Anthropometry, breastfeeding, child health, child nutrition, growth, growth monitoring, growth references, infant feeding practices, United States

Introduction

The World Health Organization (WHO) Multicentre Growth Reference Study (MGRS) North American site was Davis, California, in the United States. Davis is a university town. Its average educational level is high. More than 95% of mothers initiate breastfeeding, and support services for breastfeeding are available. The altitude is about 15 m. The mobility of the student population is high, but for the longitudinal study, only mothers who planned to remain in Davis for at least 24 months were included. Five hospitals collectively account for more than 95% of all births to women residing in Davis: Sutter Davis Hospital, Woodland Memorial Hospital, and three hospitals in Sacramento, California—the University of California at Davis (UC Davis) Medical Center and two Kaiser Permanente hospitals. Prior to initiating this study, the research team had had extensive experience with studies on infant nutrition and growth in the community. Thus, the study site fulfilled the criteria for inclusion in the MGRS described elsewhere in this supplement [1].

Planning phase

Study timeline and preparatory activities

The timeline of the study is summarized in figure 1. During the first two months, the study team met with representatives from the five hospitals listed above and arranged for letters to be sent to potential subjects when they registered to give birth at each hospital. Permission to recruit newborns from the hospitals and conduct specific activities was obtained from the administrators of the hospitals. Letters to the patients described the study and indicated that study personnel would visit the mothers in the hospital shortly after delivery. Members of the study team met with the physicians in charge of each hospital's maternity ward and other relevant hospital personnel to explain the logistics of the study, introduce team members, and discuss study procedures. Letters introducing the study and explaining its logistics were sent to local physicians. During the longitudinal recruitment phase of the study,

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Members of the WHO Multicentre Growth Reference Study Group and Acknowledgments are listed at the end of the first paper in this supplement (pp. S13–S14).

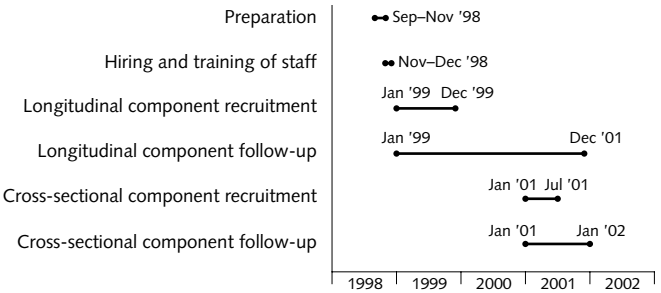

FIG. 1. Study timeline

letters were mailed to the physicians of enrolled subjects explaining the study and describing the lactation counseling services of the study.

Institutional ethical approval was obtained from the University of California Human Subjects Review Committee and the Kaiser Permanente Northern California Health Services Institutional Review Board.

Study teams

There were three study teams for the longitudinal study: the coordination, neonatal, and follow-up teams. The coordination team consisted of the site's principal investigator, three supervisors, a study secretary, and two data entry clerks. This team had the general responsibility of overseeing all study activities. Two supervisors were International Board Certified Lactation Consultants (IBCLCs). These supervisors jointly managed the neonatal team, and one of them also served as the data manager. The third supervisor was in charge of anthropometric training and supervised the follow-up team. All three supervisors served as backup data collectors for the neonatal and follow-up teams. The neonatal team, composed of two IBCLC lactation counselors and two research assistants, was responsible for screening, lactation counseling, and data collection through day 14 of each subject's participation. The follow-up team was responsible for data collection from 1 to 24 months. They referred mothers to the lactation counselors of the neonatal team as needed. This team consisted of four research assistants.

There were two teams for the cross-sectional study: one for recruitment and a second for obtaining anthropometric measurements. The recruitment team was responsible for going door-to-door to screen and enroll subjects. This team consisted of five individuals, most of whom worked part-time. The measurement team subsequently contacted each family to complete the cross-sectional visit and take the anthropometric measurements. The team consisted of three research assistants.

All members of the data collection teams had at least a four-year college degree in a related field and qualifications consistent with the duties they would perform.

Training and initial standardization

The study teams received training in accordance with the MGRS Manual of Operations. The breastfeeding observation protocol was standardized among the lactation counselors and the two IBCLC supervisors. The follow-up team was given instructions on the referral system to be used for women experiencing breastfeeding problems. The cross-sectional study recruitment personnel received instructions on the neighborhood recruitment scheme and the screening protocol.

Adaptation of study materials and procedures

The Manual of Operations was adapted to reflect the team configuration implemented at this site. A home visit was added on day 3 postpartum to optimize the successful establishment of breastfeeding, in accordance with the recommendations of the American Academy of Pediatrics [2].

Minor adaptations were made to the baseline and follow-up questionnaires. Several questions were added to document socioeconomic status. In recording educational status, the number of years of higher education was "capped" at a predetermined maximum, depending on the degree obtained. The list of potential responses to selected questions was expanded (e.g., site-specific foods for the food frequency and dietary recall questions).

Public relations activities

Study displays and informational brochures were placed in clinics and offices of physicians likely to have patients interested in the study. Study personnel visited local childbirth classes and mothers' support groups to introduce and explain the aims and procedures of the study.

The Davis, Sacramento, and UC Davis newspapers published several articles with photographs about the study, and two television segments publicizing the study were aired on local channels. The mothers and infants received a matching set of T-shirts with the local study logo as a means of thanking the participants, publicly acknowledging their participation, and

introducing the study to the wider community. Local merchants were also solicited to offer discounts and gift certificates to subjects as a means of encouraging wider community involvement.

The cross-sectional study was publicized in the local newspaper prior to the commencement of recruitment. Pediatricians were contacted and asked to encourage their patients to participate in the study. Flyers to parents were distributed through local day-care centers and kindergarten classes. A publicity table also was set up at the Davis Farmer's Market.

Implementation of the longitudinal study

Sampling strategy

All infants born during the enrollment period to mothers who planned to remain in Davis for at least 24 months were potentially eligible for the longitudinal study. Most subjects (95%) were recruited from the five hospitals listed above. Each of these hospitals was contacted daily, seven days a week, to identify potential subjects. Potential subjects were visited in the hospital within 24 hours of delivery by a member of the research team. Mothers who resided in Davis and gave birth at home or at other hospitals were also eligible to participate if the research team was notified and the mother could be reached within 24 hours after delivery. Women who planned to have a home birth were contacted prenatally via the designated midwife.

Eligibility criteria specific to the US site are shown in table 1. The target sample size for the longitudinal study at the US site was 200 (as compared with 300 in the other sites). The sample size was judged adequate based on the documented research experience in this community. This experience indicated that the desired final sample size (at least 70 infants) could be attained if recruitment was restricted to mothers who were willing to breastfeed exclusively for at least 4 months and continue breastfeeding for at least 12 months.

TABLE 1. Longitudinal study selection criteria specific to the USA site

Davis resident: mailing address in Davis or El Macero (a subdivision of Davis)
Perinatal morbidity: any condition that was serious enough for the infant to be kept in the intensive care unit for more than 24 hours led to exclusion. This included conditions such as respiratory illnesses, congenital malformations, maternal drug abuse, Down syndrome, and nervous system disorders
Intention to breastfeed: mother was willing to exclusively breastfeed for at least 4 months and continue breastfeeding for at least 12 months
Socioeconomic status: telephone in the home

Screening and enrollment of children

Informed written consent was obtained from the mother after eligibility was established. If she was unwilling or ineligible, or wanted to discuss her participation in the study with her partner, written consent was obtained for the neonatal measurements only. All newborns of interviewed mothers were measured if consent for those measurements was obtained, irrespective of enrollment in the full study. Eligible mothers wishing to postpone their decision kept the consent form until the first follow-up visit at home.

Follow-up logistics

Subjects were given the option of having home visits or going to the site's central facility. The majority preferred home visits. The neonatal team conducted home visits on days 3, 7, and 14 and at week 4 to all mothers who experienced breastfeeding problems on day 14. This allowed the lactation counselor to evaluate whether breastfeeding problems had been resolved and offer further assistance if needed. In cases where such follow-up was required, the neonatal team continued to follow the subject until week 4. Otherwise, the follow-up team initiated follow-up after the day 14 visit and conducted all home visits from four weeks to 24 months. Whenever mothers experienced breastfeeding problems after four weeks, the follow-up team contacted the neonatal team supervisor to arrange for lactation counseling. Figure 2 illustrates coordination among the teams.

The motor development assessment began at four months, according to the MGRS protocol described elsewhere in this supplement [3]. The implementation of the 12-month study visit to those who were ineligible owing to breastfeeding intention, refusal, or dropout followed the standard protocol [1]. All children who completed the study were given a certificate of completion at 24 months.

Lactation support and complementary feeding

The lactation counselors provided breastfeeding guidance to all mothers during the first 24 hours after birth and on days 3, 7, and 14, and were available for home consultations at other times. A telephone hotline was made available for emergency support seven days a week from 8 am to 5 pm. At three and six months, the mothers were contacted by telephone by one of the supervisors or lactation counselors. At three months exclusive breastfeeding was encouraged, and at six months the mother was encouraged to continue breastfeeding and given advice on complementary feeding. If a mother planned to start working outside the home and would not have the baby with her, a lactation counselor made an appointment to teach

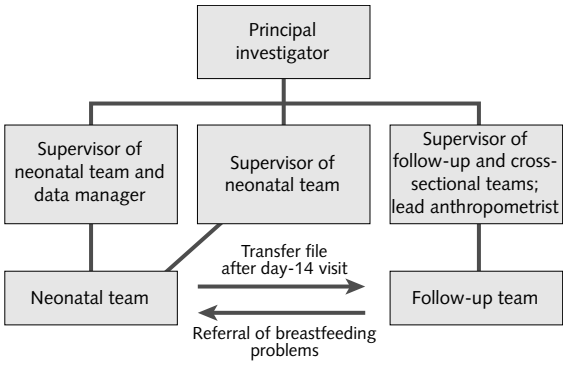

FIG. 2. Organizational and team coordination chart

her how to extract breastmilk (and, if necessary, left a breast pump with her). A counselor also contacted a mother when she experienced breastfeeding problems or the follow-up team was concerned that breastfeeding might be terminated before 12 months.

Complementary feeding guidelines were developed by the site's coordination team. Draft guidelines were sent to local pediatricians for comment and subsequently were revised based on their input (table 2). The guidelines were provided to all mothers. If a mother asked for advice on complementary feeding, the assistant referred to the guidelines but did not interfere with her physician's advice.

TABLE 2. Complementary feeding guidelines at the USA site

Introduce solids, starting with small amounts, one or two times per day and gradually increase to three meals per day by 12 months, with additional snacks as desired
The order of introduction of solids doesn't seem to matter, but start one new food at a time and allow four to seven days to watch for any reaction
Baby cereals that are iron fortified are a good source of iron and therefore are often recommended as one of the first foods.
After the transition period (when new foods are introduced), include fruits, vegetables, and high-protein foods (meat, fish, or eggs) every day. Include vitamin A–rich fruits and vegetables
Do not feed more than 8 ounces of juice per day
If there is a family history of allergies, don't feed eggs until the child is two years old, and don't feed peanuts, nuts, or fish until the child is three years old
Continue to breastfeed as often as your baby wants. If you supplement, use cow's milk formula, NOT regular cow's, goat's, or soy milk before 12 months
Start with pureed or strained foods, then mashed or finely chopped foods at 8 to 10 months, and most family food after 12 months (when more teeth are in)
Fluoride drops are recommended where nonfluoridated water is used
Iron drops are recommended for low-birthweight infants (beginning at 1 month, through 12 months)
Vitamin D supplements are recommended for dark-skinned infants or those who get insufficient sunlight
For those children who eat few or no animal products and show signs of poor appetite, a multivitamin (containing zinc) is recommended
Make mealtime a happy, pleasant experience. Do not force your child to eat certain foods or finish everything on the plate

Implementation of the cross-sectional study

Sampling strategy

The limited population of Davis and the MGRS protocol requirement to minimize subject participation in both the longitudinal and cross-sectional components required local adaptations. The cross-sectional study adopted a mixed-longitudinal design, in which each child would be measured three different times at three-month intervals. Also, because of funding delays, the cross-sectional study at the United States site could not begin until after the longitudinal study subjects began to enter the age range of the cross-sectional study (18–71 months), and for this reason the target age range was restricted to 27 to 71 months. The mixed-longitudinal design and likely attrition rates set the target sample size at 483.

The sampling strategy was based on the index household method. Index households were defined as those that had been screened for the longitudinal study. Because nearly all births to Davis mothers in 1999 were screened for the longitudinal study, this approach did not bias the sample. The city was divided into 83 neighborhoods. The number of cross-sectional study subjects to be recruited from each neighborhood was based on its number of index households. The recruiters identified each index household and went door-to-door in a clockwise direction to obtain information on the households closest to each index household. To determine the order of potential enrollment, the index households within each neighborhood were randomized. After the eligible children from the index households had been recruited, the children from nearby households were enrolled, starting with the household closest to the first index household, then the household closest to the second index household, and so on. The children in the set of next closest households were then enrolled. This continued, moving further and further from each index household, until the target number of subjects for each neighborhood was reached.

The selection criteria were consistent with the general MGRS protocol, except that children born outside of Davis were not excluded. Children enrolled in the longitudinal study were potentially eligible for the cross-sectional study, but a "cap" was placed on the percentage in the youngest age ranges that could participate in both components. The cap was based

on the estimated proportion of cross-sectional study children who, given the city's demographics, would have been in the longitudinal study. The maximum allowable percentage of longitudinal study children was 17% in the 27- to 30-month interval, 11% in the 30- to 33-month interval, and 6% in the 33- to 36-month interval. There were no longitudinal study subjects in the cross-sectional sample other than in those age groups.

If a household had more than one child who qualified, all were selected. The only exception was for siblings of subjects screened for the longitudinal study. We selected one such sibling for every third household screened for the longitudinal study that had more than one child who qualified (based on achieving a similar proportion in the cross-sectional study sample as these siblings would represent in the general population of Davis children 27–71 months of age).

Screening, enrollment, and survey logistics

The cross-sectional study recruiters went door-to-door during the daytime and early evening hours seven days a week. Flyers with a postage-paid reply form were left at homes where no contact was made. If the form was not returned, up to two additional attempts were made (at least one of which was after 5 pm or on a weekend) to find someone at home. Neighbors were also asked about whether there were any children under six in the targeted households. If at least one neighbor was sure that no child in that age range was part of that household, the household was excluded.

In each neighborhood, the five households closest to each index household were contacted initially. On the first visit, the eligible children in the index household or the next closest household were enrolled, but children in all other households were put on a waiting list until complete information was available for all five households nearest to each index household. If at this point the target number for the neighborhood had not been reached, the process was repeated with the next closest set of five households.

Standardization, quality control, and data management activities

Anthropometric standardization sessions

Initial anthropometric training was conducted by the local lead anthropometrist, whose measurement techniques were standardized against the WHO lead anthropometrist before the initiation of the study [4]. The members of the neonatal and follow-up teams participated in standardization sessions with the cosupervisors and the local lead anthropometrist.

The neonatal team standardization sessions could not be conducted in hospital newborn nurseries. Therefore, the mothers of young infants not enrolled in the longitudinal study were recruited to participate in specially conducted standardization sessions held at the site's coordination center. To ensure that the measurement techniques used with newborns did not differ from those used during standardization sessions, the lead anthropometrist observed at least one newborn measurement per week at the local hospital. During the first year of the study, neonatal team standardization sessions were held on a weekly basis for eight consecutive weeks to accumulate the data required for calculating reliability (precision and accuracy) statistics. Because the team was large, an algorithm was designed by the site statistician that permitted each infant to be measured by only four observers. This required 21 infants over a period of eight weeks, with each observer measuring 12 infants. This design allowed estimates of accuracy and precision similar to those required by the standard MGRS design [4].

The alternative algorithm described above was not required for the follow-up team. Standardization sessions were held at the coordination center or at local day-care centers. In general, five children aged 2 to 66 months were measured at each session. The data from two sessions were combined to obtain the required estimates of accuracy and precision. The accuracy and precision of each team member's measurements were reviewed after each standardization period, and corrective standardization sessions were scheduled for individuals whose measurement techniques needed improvement.

When the cross-sectional study began, the team participating in this component joined the remaining follow-up team members for anthropometric standardization sessions. Because the follow-up team helped out with the cross-sectional measurements, all personnel at that time were trained and standardized for measurement of height.

Motor development standardization sessions

To ensure standardized data collection, the sites were required to conduct regular motor development standardization sessions [3]. However, by the time the standardization protocol was finalized, the US site had nearly completed collecting motor development data. Thus, only one standardization session was held following the standardized protocol. The initial training and standardization at this site were conducted at local day-care centers prior to the initiation of data collection with the assistance of a local expert (Dr. Ernesto Pollitt).

Quality control activities

All quality control procedures in the MGRS protocol were followed [1]. During the first few weeks of the

study, the supervisors accompanied the fieldworkers on several home visits. Thereafter, random monitoring of data collection (10% of all interviews) was conducted by telephone. The supervisors served as backup data collectors and routinely observed the interviewing and measurement techniques of all study assistants.

The questionnaires were turned in to the supervisor daily and checked for completeness and consistency. Corrections were made when necessary. This sometimes required telephoning the mother or remeasuring a child. Any problems found during routine questionnaire checks were discussed at the next team meeting.

All team members attended regular staff meetings. In the longitudinal study, each team met with the supervisor weekly in the first few months and at least once every two weeks thereafter. These operational procedures provided abundant opportunities to oversee the quality of the work being performed.

Data management

After reviewing all questionnaires, the supervisors coded the responses to any open-ended questions and forwarded the forms to data clerks. The data manager conducted data cleaning and validation (e.g., checking for outliers, data entry errors, and out-of-range values), completed preliminary data analyses, and prepared the data files for transfer to the MGRS Coordinating Centre in Geneva.

Conclusions

There were several challenges in implementing the MGRS protocol at this site, particularly during the neonatal phase. First, maintaining adequate daily communication with hospital staff was sometimes difficult. It required building good working relationships and perseverance. Mothers were sometimes not receptive to being screened so soon after delivery. This required making all mothers (and their physicians) aware of the study before hospitalization. Performing infant length measurements in the hospital was sometimes difficult when the infant became agitated. The mothers were reassured that the procedure was brief and not painful. In general, the mothers needed frequent breastfeeding support and assistance, and therefore additional lactation consultants were hired. During the follow-up phase, scheduling visits was a challenge that required persistence and flexibility. For example, if mothers were working outside the home, visits were scheduled at day-care centers. In terms of overall management, the greatest challenges were scheduling standardization sessions and mastering the data management system.

References

1. de Onis M, Garza C, Victora CG, Onyango AW, Frongillo EA, Martines J, for the WHO Multicentre Growth Reference Study Group. The WHO Multicentre Growth Reference Study: planning, study design, and methodology. Food Nutr Bull 2004;25(1)(suppl 1):S15–26.
2. American Academy of Pediatrics Work Group on Breastfeeding. Breastfeeding and the use of human milk. Pediatrics 1997;100:1035–9.
3. Wijnhoven TMA, de Onis M, Onyango AW, Wang T, Bjoerneboe GEA, Bhandari N, Lartey A, Al Rashidi B, for the WHO Multicentre Growth Reference Study Group. Assessment of gross motor development in the WHO Multicentre Growth Reference Study. Food Nutr Bull 2004;25(1)(suppl 1):S37–45.
4. de Onis M, Onyango AW, Van den Broeck J, Chumlea WC, Martorell R, for the WHO Multicentre Growth Reference Study Group. Measurement and standardization protocols for anthropometry used in the construction of a new international growth reference. Food Nutr Bull 2004;25(1)(suppl 1):S27–36.