SUPPLEMENT TO VOLUME 73, 1995, OF THE

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OF THE WORLD HEALTH ORGANIZATION
DE L'ORGANISATION MONDIALE DE LA SANTE

THE SCIENTIFIC JOURNAL OF WHO • LA REVUE SCIENTIFIQUE DE L'OMS

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A WHO COLLABORATIVE STUDY

RLD HEALTH ORGANIZATION, GENEVA • ORGANISATION MONDIALE DE LA SANTE, GENEVE

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Participants, institutions and countries

Project Analyst:

Dr A. Kelly, Trinity College, Dublin, Ireland.

World Health Organization:

Dr P.M. Shah and Dr M. Belsey, Maternal and Child Health and Family Planning, Division of Family Health, WHO, Geneva, Switzerland.

Dr M. de Onis and Dr A. Pradilla, Nutrition Unit, Division of Food and Nutrition, WHO, Geneva, Switzerland.

U.S. Agency for International Development (USAID):

Dr M.A. Anderson, Office of Health, Bureau for Global Program, Field Support and Research, USAID, Washington DC, USA.

Consultants:

Dr M. Kramer, McGill University, Montreal, Canada, and Dr J. Haas, Cornell University, Ithaca, NY, USA.

Report Editor:

Dr J. Kevany, Trinity College, Dublin, Ireland.

Investigators for country studies:[a]

Argentina:	*Dr J.M. Belizán*, Mr E. Bergel and Mrs L. Campodónico, Centro Rosarino de Estudios Perinatales, Rosario, Argentina.
Colombia:	*Dr H. Rey*, Dr E.I. Ortiz, Dr L. Fajardo and Dr A. Pradilla, Universidad del Valle, Cali, Colombia.
Cuba:	*Dr U. Farnot*, Dr É. Diaz and Dr D. Fresneda, Hospital America Arias, La Havana, Cuba.
Egypt:	*Dr A. Kirksey* and Dr Hsiu-Chen Wang, Department of Food and Nutrition, Purdue University, West Lafayette, IN, USA.
The Gambia:	*Dr T.J. Cole*, Dr F.A. Foord, Dr M. Watkinson, Dr W.H. Lamb and Dr R.G. Whitehead, MRC Dunn Nutrition Unit, Cambridge, England.
Guatemala:	*Dr T. González-Cossío* and Dr H.L. Delgado, Institute of Nutrition of Central America and Panama (INCAP), Guatemala.
India:	*Dr L. Raman*, Dr K. Visweswar Rao, Dr K. Adinarayana, Dr A. Rawal, Dr N. Vasumathi, Dr C.H. Parvati, Dr G. Vasanthi, Dr C.S. Aruna, Dr P.V. Subhalaxmi, Dr T. Srinivasachary and Dr V. Padma, National Institute of Nutrition, Hyderabad, India.
Indonesia:	*Dr M.A. Husaini*, Dr Y.K. Husaini, Dr Sandjaja, Dr D. Kartono, Dr A.B. Jahari, Dr Barizi and Dr D. Karyadi, Nutrition Research and Development Centre, Bogor, Indonesia.
Kenya:	*Dr C. Neumann*, Dr L. Ferguson, And Dr N.O. Bwibo, University of California Los Angeles, School of Public Health, Los Angeles, CA, USA.

[a] Countries are listed in alphabetical order. The names of the principal investigators are in italics. The studies from Argentina, Cuba and Guatemala are not reported in the Annex.

Malawi: *Dr D. Pelletier*, Dr M. Arimond, Dr F.C. Johnson, Dr E. Liang, Dr J. Low, Dr P. Mvula, Dr L. Msukwa, Dr U. Ramakrishnan, Dr J. Ross and Dr K. Simler, Cornell Food and Nutrition Policy Program, Cornell University, Ithaca, New York, USA.

Mexico: *Dr J.R. Backstrand*, Department of Nutritional Sciences, University of Connecticut Health Center, Farmington, CT, USA.

United Kingdom: *Dr M. Hall*, Aberdeen Maternity Hospital, Aberdeen, Scotland.

USA/NCPP: *Dr S.M. Garn* and Dr T.V.E. Sullivan, Nutrition Unit, School of Public Health, Department of Anthropology and Center for Human Growth & Development, University of Michigan, MI, USA.

USA/CDC: *Dr I. Kim*, National Center for Chronic Disease Prevention and Health Promotion, Centers for Disease Control and Prevention, Atlanta, GA, USA.

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Data from the Nigeria study were provided by WHO with the agreement of the original investigator, Professor K. Harrison. Similarly, data from an Irish study were provided through the Department of Statistics, Trinity College, Dublin, Ireland.

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PREFACE

The health of women is central to the successful social and economic development of the family and the community. It determines the well-being of the mother, the fetus, the infant and the child, and in turn the health and reproductive capacity of the next generation's mothers. The individual's diet and nutrition reserves in the body provide the substrate for the physiological systems that permit normal health and successful reproduction. Inadequate maternal diets and reduced nutritional reserves impede normal fetal growth and development and limit the physical, mental and social functions that are critical to reproduction and motherhood. Overt or subclinical malnutrition in both general and specific forms introduces for the woman, the fetus and the infant a significant risk of illness, disability and death.

The assessment of nutritional status is important at several levels. It is critical for monitoring and quantifying risk in populations and their subgroups for policy and programme development. It is also an important adjunct in the management of care by detecting abnormality in both the pre-reproductive and reproductive phases of women's lives. Thus, the assessment of nutrition provides means for identifying individuals or groups in need of intervention programmes and for evaluating their response to service inputs. Assessment of nutritional status is an important feature of antenatal care and therefore must be feasible at the most peripheral level of the health care system. The mother who follows the progress of her own pregnancy is the first-level observer. The primary health worker and the traditional birth attendant usually have personal experience and some formal training which permits them to quantify informal observations and make simple decisions on the need for additional care or referral.

Assessment procedures for guiding care should be simple, effective, acceptable and inexpensive, and the indicators derived from them should be readily understood, interpreted and acted upon. As resources are limited and interventions must be targeted to those with the greatest need, the indicators must be accurate, reliable, sensitive and specific; they should be able to detect those who need assistance and reassure those who do not. Assessments must be performed consistently well, using the minimum of technical resources, independently of who is carrying it out. This is not always possible in practice; different cadres and different individuals within cadres will vary in their capacity to carry out such assessments accurately. Similarly, individuals of the same capacity and cadre can perform differently as a result of the technical resources and equipment available to them.

Finally, the level at which the assessment procedure signals the need to intervene must be set, taking into account the available resources. The threshold for action is determined not only in biological and probability terms, but also in terms of the numbers that can be effectively assisted. In an ideal world, all levels of risk should receive any necessary intervention to cover the worst possible outcome, even if this results in substantial wastage. To minimize waste, however, the limited resources in developing countries must be conserved for those who apparently have the highest level of risk for an adverse outcome to the mother or the child. This implies that certain levels of risk will have to be ignored on the grounds that the probability of a serious adverse outcome is less and therefore scarce resources would probably be wasted.

An international meeting on the selection and use of maternal anthropometric indicators for screening and monitoring pregnancy and its outcomes was held in the Pan American Health Organization (PAHO), Washington DC, in April 1990 under the sponsorship of WHO, USAID, PAHO, and MotherCare. Subsequently a small group of participants met to consider the requirements for, and the practical issues concerned with planning and implementing a meta-analysis of existing databases in order to examine the performance of selected indicators on a global basis. Following this meeting, the Maternal and Child Health and Family Planning Unit and the Nutrition Unit of WHO, Geneva, assumed responsibility for the project and jointly developed a research proposal and allocated funds. The proposal was also submitted to USAID for consideration in the context of existing joint work in this area, and subsequently received generous support. Within a few months of the Washington meeting a substantial number of key investigators had been identified and contacted, and they agreed to collaborate in: (i) undertaking a secondary analysis of their data, and (ii) providing a copy of the original data to WHO for purposes of the meta-analysis. This supplement to the Bulletin of the World Health Organization *reports the findings of the meta-analysis concerning the usefulness of commonly employed indicators for*

selected infant and maternal outcomes and complications of pregnancy. It also proposes a short list of preferred indicators that should be of particular relevance to programme managers and health workers in different primary health care settings.

The usefulness of the findings of this study will only be demonstrated in the future through their wide application in practical situations under various conditions. Information collected systematically from different programmes should verify the recommendations made on the basis of this meta-analysis. Apart from their acceptability and feasibility, these recommendations will have to be confirmed by the more efficient use of resources and improvements in routine maternal, fetal and infant health indicators. This task for service directors working in collaboration with national and international agencies will provide the basis for a comprehensive review of experience in the future.

Résumé

Anthropométrie maternelle et issues de la grossesse: étude collective de l'OMS

La santé des femmes est au centre du développement social et économique de la famille et de la communauté. Elle détermine le bien-être de la mère, du fœtus, du nourrisson et de l'enfant, lesquels détermineront à leur tour la santé et l'aptitude à la reproduction de la nouvelle génération de mères. L'alimentation individuelle et les réserves de l'organisme sont le support des systèmes physiologiques qui permettent une santé normale et une reproduction accomplie. Un régime alimentaire insuffisant chez la mère et une diminution des réserves de l'organisme nuisent à la croissance et au développement du fœtus et limitent les fonctions physiques, mentales et sociales qui jouent un rôle capital dans la reproduction et la maternité. Une malnutrition patente ou infraclinique, sous sa forme générale ou sous une de ses formes spécifiques, entraîne pour la femme, le fœtus et le nourrisson un risque élevé de maladie, d'incapacité et de décès.

Les méthodes d'évaluation de l'état nutritionnel doivent être simples, efficaces, acceptables et peu coûteuses, et les indicateurs qui en dérivent doivent être faciles à comprendre, à interpréter et à modifier. Comme les ressources sont limitées et que les interventions doivent être ciblées sur les groupes qui en ont le plus besoin, les indicateurs doivent être exacts, fiables, sensibles et spécifiques; ils doivent permettre d'identifier les personnes qui ont besoin d'une assistance et de rassurer les autres. L'évaluation doit être d'une qualité régulière, avec un minimum de ressources techniques, quel que soit l'exécutant. En pratique, cela n'est pas toujours possible; différents cadres et différentes personnes à l'intérieur d'un même cadre, différeront dans leur aptitude à effectuer une telle évaluation avec exactitude. De même, des personnes ayant les mêmes aptitudes et provenant du même cadre peuvent obtenir des résultats différents selon les ressources techniques et le matériel dont elles disposent.

Enfin, il faut fixer le niveau auquel une méthode d'évaluation signale la nécessité d'une intervention, en tenant compte des ressources disponibles. Le seuil d'action est déterminé non seulement selon des critères biologiques et statistiques, mais également en fonction du nombre de personnes qui peuvent bénéficier efficacement de l'assistance. Dans l'idéal, les personnes de tous les niveaux de risque devraient recevoir toute intervention nécessaire pour éviter l'issue la plus défavorable, même si cette façon de faire entraîne un gaspillage de ressources important. Pour réduire ce gaspillage au minimum, les faibles ressources dont disposent les pays en développement doivent être réservées pour les personnes qui ont apparemment le risque le plus élevé d'issue défavorable pour la mère ou l'enfant. Cela implique que certains niveaux de risques doivent être négligés, en tenant compte du fait que la probabilité d'une issue défavorable est plus faible en de tels cas et que des ressources déjà faibles seraient probablement gaspillées.

Une réunion internationale sur la sélection et l'utilisation d'indicateurs anthropométriques maternels pour l'étude et la surveillance de la grossesse et de son issue a eu lieu à l'Organisation panaméricaine de la Santé (OPS), à Washington, en avril 1990, sous le parrainage de l'OMS, de l'OPS, de l'USAID et de MotherCare. La réunion avait pour principal objet d'identifier des indicateurs anthropométriques appropriés en vue d'une utilisation sur le terrain. A la suite de cette consultation, il a été décidé de procéder à une méta-analyse des séries de données existantes sur l'anthropométrie maternelle et les issues de la grossesse. Ce projet avait pour objectif de déterminer dans quelle mesure les données anthropométriques sont utiles et efficaces pour prédire les issues de la grossesse chez la mère et l'enfant (y compris les complications de la grossesse, du travail, de l'accouchement et du post-partum) dans différents pays et d'établir des courbes de référence spécifiques pour la prise de poids maternelle au niveau des populations, comme outils de surveillance de la grossesse au niveau communautaire et individuel.

Vingt-cinq séries de données en provenance de 20 pays ont été rassemblées et réanalysées et les résultats des différentes études ont été regroupés dans une méta-analyse. Les issues de la grossesse étaient, pour le nourrisson: faible poids de naissance, retard de croissance intra-utérin et prématurité, et pour la mère: accouchement assisté, toxémie gravidique et hémorragie du post-partum. Les indicateurs anthropométriques étudiés étaient la taille de la mère, le périmètre brachial, le poids avant grossesse et le poids atteint au bout de 20, 28 et 36 emaines ainsi que diverses prises de poids entre certains stades de la grossesse. L'indice de Quételet a également été examiné à ces divers moments. Les sous-groupes

de mères jugées à risque particulier d'issue indésirable, par exemple celles dont la taille était inférieure à la moyenne ou le poids inférieur au poids moyen avant grossesse, ont été examinés séparément.

La méta-analyse a été divisée en deux étapes. Dans la première, les odds ratios ont été spécifiés pour chaque indicateur en fonction des six issues considérées, et dans la deuxième, les indicateurs ayant des odds ratios souhaitables aux fins de dépistage dans différentes conditions d'utilisation ont été évalués. Les odds ratios ont été basés sur la fréquence de l'issue dans le quartile inférieur de la distribution de l'indicateur par rapport à sa fréquence dans le quartile supérieur; on a pu ainsi identifier le degré de risque par rapport à l'optimum dans le cadre considéré plutôt que par rapport à une norme absolue. Les indicateurs ayant les odds ratios les plus élevés ont été ensuite évalués afin de déterminer leur utilité en tant qu'instrument de dépistage par rapport à des critères prédéterminés: spécificité >0,7 et sensibilité >0,35 dans 40% ou plus des études regroupées dans la méta-analyse.

Issues fœtales

Les indicateurs du poids atteint entre le poids avant grossesse et 32 à 36 semaines montrent des odds ratios élevés pour le faible poids de naissance et le retard de croissance intra-utérin; ces rapports augmentent lorsqu'on les calcule pour les sous-groupes anthropométriques définis. L'odds ratio le plus élevé (4,0) correspond au poids atteint au bout de 24 à 28 semaines pour le retard de croissance intra-utérin lorsque cet indicateur est appliqué aux femmes de poids avant grossesse inférieur à la moyenne. Les indicateurs n'ont présenté que des odds ratios faibles et irréguliers en ce qui concerne la prématurité. Les quatre indicateurs concernant le poids atteint répondaient aux critères de dépistage pour le faible poids de naissance, alors que le poids atteint avant grossesse, au bout de 20 semaines et au bout de 36 semaines répondait aux critères pour le retard de croissance intra-utérin. Le poids avant grossesse et l'indice de Quételet répondaient aux critères de dépistage pour le faible poids de naissance. Du point de vue des services, cela suppose qu'une pesée réalisée avant la grossesse, ou au début de la grossesse, puis au bout de 20 ou 28 semaines est un indicateur utile du risque de faible poids de naissance et de retard de croissance intra-utérin et constitue un signal d'alarme suffisamment précoce pour montrer la nécessité d'une intervention.

Issues maternelles

Dans l'ensemble, les indicateurs ont une relation beaucoup plus faible avec les issues maternelles. La taille maternelle en tant que facteur prédictif de l'accouchement assisté a présenté l'odds ratio positif le plus élevé (1,6) mais ne répondait aux critères de dépistage que dans 5 études sur 13 (38%). Pour les deux autres issues, la plupart des indicateurs avaient un odds ratio de 1 au maximum, ce qui montrait un risque neutre ou réduit d'issue défavorable associé au quartile inférieur. Le faible poids maternel et la faible prise de poids sont associés au retard de croissance intra-utérin et sont donc susceptibles de réduire le risque d'accouchement assisté. Comme l'hémorragie du post-partum est associée à un travail difficile et prolongé, ces indicateurs peuvent également montrer un risque réduit pour cette issue. En revanche, la toxémie gravidique est associée à une prise de poids rapide en fin de grossesse et ce sont donc les valeurs du quartile supérieur qui sont associées à une augmentation du risque. Il est clair que ces indicateurs de "risque négatif" ne peuvent pas être utilisés pour exclure le risque d'issues défavorables graves, bien qu'ils puissent plaider en faveur de l'avantage, déjà perçu par la mère, de ne pas "manger pour deux" pendant la grossesse.

Les indicateurs sélectionnés sur la base de leurs odds ratios et de leur capacité de dépistage ont ensuite été jugés du point de vue de leur aptitude à être utilisés dans diverses conditions de prestations de services de santé, notamment dans le cadre des soins de santé primaire. L'étude a examiné trois limitations fréquentes de la prestation efficace de soins primaires:

— la fréquence des contacts avec la mère: visite unique ou visites multiples;
— l'existence de matériel (balances);
— l'étendue des services: couverture, enregistrement et compétences.

Les indicateurs fœtaux sélectionnés ont été examinés dans le cadre de ces limites pour identifier lesquels doivent être choisis dans différentes conditions de prestations de services de santé. Lorsqu'on ne dispose pas de balance, la taille et le périmètre brachial sont les seuls indicateurs utilisables pour le faible poids de naissance et le retard de croissance intra-utérin, bien qu'ils ne répondent pas aux critères

de sélection définis pour l'étude. Lorsqu'on dispose de balances et qu'un enregistrement précoce des mères est la norme, des pesées réalisées au bout de 20, 28 et 36 semaines sont des indicateurs valides du faible poids de naissance et du retard de croissance intra-utérin; lorsque les soins à la mère sont disponibles en permanence, le poids avant grossesse et l'indice de Quételet sont également valides pour le faible poids de naissance, le retard de croissance intra-utérin et la prématurité. Aucun des indicateurs utilisant la prise de poids ne satisfait aux critères de l'analyse pour les odds ratios, de sorte que des pesées multiples ne présentent pas d'avantages. Il est clair que la prise de poids est un outil simple et utile de surveillance de la santé générale pendant la grossesse, mais il ne s'agissait pas d'un critère de sélection dans le cadre de cette étude.

L'efficacité, du point de vue du programme, des indicateurs dérivés de cette analyse devrait être démontrée par l'amélioration des mesures classiques de l'issue de la grossesse, du point de vue de la santé maternelle, fœtale et infantile, et par l'utilisation plus efficace des ressources. Il incombera au directeur des services, en collaboration avec les organismes nationaux et internationaux, de procéder à un examen complet de ces effets à long terme, au cours des années qui viennent.

CONTENTS

1. Introduction

A workplan on maternal nutrition for WHO's Maternal and Child Health, Family Planning and Nutrition programmes was developed in 1988 in response to requests from the World Health Assembly. There was a clearly defined need to provide guidance to national health services on practical ways of assessing women's nutritional status, particularly in relation to reproduction. Numerous studies had previously investigated indicators based on maternal anthropometry for purposes of predicting infant and, less frequently, maternal outcomes of pregnancy. Indicators such as maternal height, pre-pregnancy weight, gestational weight gain, and mid-upper-arm circumference received considerable attention as proxy measures of current or past nutritional status, which in turn bear directly or indirectly on pregnancy outcome, particularly in relation to infant birth weight.

Krasovec & Anderson (*1*) summarized the deliberations of a recent international meeting on this topic and identified programme and research issues in the use of individual indicators as well as providing an up-to-date literature review. The international meeting identified two areas of maternal anthropometry as priorities for further investigation:

— the lack of definitive recommendations on preferred indicators for specific pregnancy outcomes in different primary health care settings;

— the consistency of performance of individual indicators in different populations and under varying operational conditions.

As part of the WHO workplan it was therefore decided: (*a*) to test the performance of selected indicators in predicting various pregnancy risks for both infant and mother, and (*b*) if indicators were found to have a useful predictive role, to develop suitable reference values for screening and monitoring. One immediate application for these reference values would to be expand the WHO prototype home-based maternal records (*2*) to include monitoring of nutritional status. A joint agreement to finance the workplan was signed between WHO and USAID that led to complementary funds being made available by USAID during 1988–92.

Scope of the project

Various studies conducted in different settings have identified a range of potentially useful indicators. Under study conditions, with reliable equipment and trained personnel, these have reportedly demonstrated good predictive value. Unfortunately, such study conditions are not widespread in routine service operations and thus actual performance may be significantly poorer than expected. There is therefore a need to provide sound technical advice on the utility and feasibility of selected anthropometric indicators for routine application in primary health care, especially in circumstances where resources are limited. This concern led to a jointly sponsored WHO/PAHO/USAID/MotherCare conference on maternal anthropometry (23–25 April 1990), which focused specifically on identifying appropriate anthropometric indicators for field application. The conference discussed in detail the strengths and weaknesses of single anthropometric indicators such as maternal height, weight, gestational weight gain, arm circumference, body mass index, and weight-for-height in relation to both maternal and fetal outcomes (*3*). This meeting was immediately followed by a further consultation under the auspices of WHO/PAHO (26–27 April 1990), in collaboration with USAID/MotherCare, to address the practical issues of developing a framework for the re-analysis of existing data sets in order to permit a comprehensive assessment of the available evidence. A decision was taken to proceed with a large-scale secondary analysis of data, followed by a meta-analysis of existing data sets on maternal anthropometry and pregnancy outcomes. The meeting also assisted in the identification of appropriate data sets and endorsed the proposal to contact investigators and request their support in re-analysing their data according to a standard protocol.[a] Arising from these analyses, practical guidance would be offered to health planners and field workers on the expected performance of selected indicators.

Rationale for analysis strategy

The decision to undertake a re-analysis of existing data, as distinct from undertaking a multicentre prospective study, was dictated by three considerations:

— the existence of a sufficient number of suitable data sets to permit the project objectives to be met;

— the lower cost of re-analysis of existing data compared with launching a new multicentre prospective study; and

[a] *Protocol for secondary data analysis of existing data bases on maternal anthropometry.* WHO Nutrition Unit and Programme of Maternal and Child Health and Family Planning, Geneva, 1990.

— the timely availability of findings compared with those of a large-scale prospective study.

The concomitant drawback to this analysis strategy was that no control could be exercised over the design of the original studies which, as with all secondary or meta-analyses, could prove problematic in interpreting the results. Two measures tended to minimize this problem: first, studies were selected on the basis of predetermined standards to ensure their validity and comparability (see Chapter 2); second, a detailed study protocol was provided to collaborators to encourage a uniform approach. Investigators were also asked to supply a copy of their data to WHO so that uniform preparations (including definitions and exclusions) were applied, and a common set of analyses was performed using the same statistical software. The individual study results were then subjected to a formal meta-analysis as reported below.

Project objectives

The objectives of this meta-analysis are:

— to test to what degree anthropometric measurements are useful and efficient in predicting maternal and child outcomes of pregnancy (including complications during pregnancy, labour and delivery, as well as postpartum) in different country settings;

— to determine the quantitative association of specific indicators and combinations of indicators and risk for mother and infant;

— to develop specific reference curves for maternal weight gain (or weight gain-for-height or arm circumference) for populations with different characteristics, as tools to monitor pregnancy in the community and home.

Outcomes investigated

Most studies concentrate on the infant outcomes (e.g., birth weight, survival, and perinatal or neonatal growth) and the majority of studies had information relating to one or more of these. This project seeks feasible predictors of both maternal and infant outcomes, so particular efforts were made to identify data sets that included pregnancy complications (e.g., assisted delivery, pre-eclampsia, cephalopelvic disproportion), as well as postpartum problems (e.g., haemorrhage). The outcomes listed in Table 1 were expected to be common to a number of national studies as they are routinely noted in a clinical setting. In fact it was found that only the items in italics were reported in a sufficient number of studies for investigation in this phase of the project. The remaining outcomes, and possibly others, will form part of the ongoing research as the data bank expands.

Core indicators

Kramer (*4*) provided a review of the many factors having a known or potential bearing on selected fetal outcomes, including genetic, constitutional, demographic, obstetric and nutritional variables. While information on these factors is important in a clinical setting, the present work focuses specifically on maternal nutrition. In defining a minimal set of such indicators, the constraints of service coverage, availability of proper equipment and the training level of the health worker provide an operational framework. Table 2 summarizes the indicators felt to be practicable for each combination. The column headings indicate the operational limitations by cross-classifying equipment availability (scales vs. no scales) with service coverage and worker training (service constraints). The row categories reflect the frequency of antenatal visits and hence the use of the measure-

Table 1: **List of maternal and fetal outcomes of interest**[a]

Stage	Outcomes/complications
Pregnancy	*Pre-eclampsia*[b]
	Eclampsia
Labour/delivery	*Prolonged labour*
	Assisted delivery (forceps/vacuum extraction)
	Cephalo-pelvic disproportion
	Caesarean section
Postpartum	*Postpartum haemorrhage*
	Maternal mortality
	Maternal anthropometry
Fetus	*Low birth weight*
	Intrauterine growth retardation
	Preterm birth
	Mortality: peri- and neonatal
Newborn	Anthropometric measures

[a] For purposes of both the analysis and the recommendations a distinction has been made between low birth weight (LBW) and intrauterine growth retardation (IUGR). The former is defined by WHO as a birth weight less than 2500 grams, and is very widely used as a recognized poor outcome for the infant, resulting in an elevated risk of morbidity and mortality. However, the LBW definition does not take account of the gestational age of the infant, whereas IUGR does. An infant is defined as IUGR if its birth weight is less than the 10th centile of a suitable weight-for-gestational age reference. This is felt to provide a clearer indication of the problem and avoid the confounding effect of birth weight with preterm birth. Data from Williams et al. (*5*) were used to establish a common fetal growth reference for purposes of the meta-analysis. For the secondary analysis, all investigators reported on LBW, but often employed a local definition of IUGR. IUGR is at present more often found in the scientific and research literature, while LBW continues as the most common measure of poor fetal outcome in the operational context worldwide. It was felt that a report on the analysis of LBW, IUGR, and preterm birth would be of special value.

[b] Items in italics were the only ones reported in a sufficient number of studies for investigation in this phase of the project.

Table 2: **Framework for maternal anthropometric indicator analysis**

Service delivery constraints:	Scales available (I) None	Scales available (II) Some	No scales available (III) None	No scales available (IV) Some
A	Early in pregnancy[a]	Late in pregnancy[a]	Early in pregnancy	Late in pregnancy
Single measurement				
SCREENING	— MUAC[b] — Height — Weight attained	— MUAC — Height — Weight attained	— MUAC — Height	— MUAC — Height
B	Throughout pregnancy	Late in pregnancy	Early in pregnancy	Not applicable
Multiple measurements				
SCREENING or MONITORING	Δ Weight[c] Δ MUAC Height	Δ Weight Δ MUAC Height	Δ MUAC	

[a] Access to the mother 'early in pregnancy' would imply contact during the 1st trimester or even pre-pregnancy. Access 'late in pregnancy' implies contact at around 30 weeks or later.
[b] Mid-upper-arm circumference.
[c] The symbol Δ is used to denote change in the measurement during pregnancy. Although listed in **B** as a potential indicator for use in monitoring, MUAC was found to change very little, if at all, during pregnancy for the data analysed. Height will not change during pregnancy (unless the mother is still physically maturing) and it may be conveniently recorded at any point of contact with the mother.

Notes on Table 2

(i) Service delivery constraints entail considerations of coverage, availability of appropriate equipment, quality of staff training, etc. The assumption is made that if coverage and quality are very limited, then service contact prior to pregnancy is unlikely and pre-pregnancy weight cannot be determined. Similarly multiple contacts with the mother are unlikely in such circumstances, so the assessment of gestational weight gain will not be possible.

(ii) In **A** and **B** above, it must be appreciated that the choice of study indicators does not imply that these are appropriate to detect 'responders' to any one of a number of possible interventions (e.g., dietary supplementation, or referral to a better equipped centre).

ment, i.e., for screening or monitoring. The cells list the measurements considered feasible under the combination of circumstances. To illustrate, if service constraints are poor and coverage is low (columns II and IV), it is likely that mothers may be seen only once before delivery and, that too, relatively late in pregnancy. In these circumstances, maternal height, arm circumference and, if scales are available, the attained weight are the only practical measurements (cells A II and A IV).[b] If there are fewer service constraints and service coverage is high, it is likely that contacts will occur on several occasions throughout pregnancy and multiple measurements are possible (cells B I and B III). The purpose is to report on the utility of the listed indicators (and combinations of these) in a way that reflects the structure of Table 2. This should permit the service provider to identify the circumstances pertaining locally and consider the corresponding options. Global experiences in relation to the current use of these core indicators are discussed in detail in the recent PAHO report (*1*) and are summarized in a WHO publication (*3*).

As is evident from Table 2, each indicator can potentially be measured at various times during pregnancy, depending on timing and frequency of contact with the health service. These service contacts may be conveniently categorized as pre-pregnancy, first antenatal visit (at whatever gestational age), and subsequent visits. Therefore, information may be obtained for a given indicator in the possible combinations shown in Table 3.

Project stages

(i) The protocol to assist investigators in the re-analysis of their data was developed at the World Health Organization between June and July 1990, and was subsequently reviewed and revised.

(ii) Some 55 investigators were identified and contacted (August to December 1990) and asked to provide a detailed description of their study for review by a WHO panel. The submissions received

[b] This is not to preclude the possibility of other circumferences (e.g., head and calf) or skinfold thicknesses, etc.; however, irrespective of merit, these are less commonly employed now and are not considered in this report.

Table 3: **Key indicators and time at which these may be measured**

Measurement	Frequency	Maternal indicator	Abbreviation
Height	Any time before or during pregnancy	1. Height	HT
Arm circumference	Pre-pregnancy and change during pregnancy	2. Mid-upper-arm circumference	MUAC
Weight	Pre-pregnancy and attained weight during pregnancy	3. Pre-pregnancy weight	WTpp
		4. Attained weight by month 5	WT/5
		5. Attained weight by month 7	WT/7
		6. Attained weight by month 9	WT/9
Weight gain	Weight change during pregnancy	7. Weight gain: month 5 to 7	WTg/5–7
		8. Weight gain: month 5 to 9	WTg/5–9
		9. Weight gain: month 7 to 9	WTg/7–9
		10. Weight gain: pre-pregnancy to month 5	WTg/pp–5
		11. Weight gain: pre-pregnancy to month 7	WTg/pp–7
		12. Weight gain: pre-pregnancy to month 9	WTg/pp–9
Body mass index (BMI)	Pre-pregnancy and attained BMI during pregnancy	13. Pre-pregnancy BMI	BMIpp
		14. Attained BMI by month 5	BMI/5
		15. Attained BMI by month 7	BMI/7
		16. Attained BMI by month 9	BMI/9
In mothers with low maternal height:			
Weight	Pre-pregnancy and attained weight during pregnancy	17. Pre-pregnancy weight	WTpp(HT)
		18. Attained weight by month 5	WT/5 (HT)
		19. Attained weight by month 7	WT/7(HT)
		20. Attained weight by month 9	WT/9(HT)
Weight gain	Weight change during pregnancy	21. Weight gain: month 5 to 7	WTg/5–7(HT)
		22. Weight gain: month 5 to 9	WTg/5–9(HT)
		23. Weight gain: month 7 to 9	WTg/7–9(HT)
		24. Weight gain: pre-pregnancy to month 5	WTg/pp–5(HT)
		25. Weight gain: pre-pregnancy to month 7	WTg/pp–7(HT)
		26. Weight gain: pre-pregnancy to month 9	WTg/pp–9(HT)
In mothers with low pre-pregnancy weight:			
Weight	Attained weight during pregnancy	27. Attained weight by month 5	WT/5(WT)
		28. Attained weight by month 7	WT/7(WT)
		29. Attained weight by month 9	WT/9(WT)
Weight gain	Weight change during pregnancy	30. Weight gain: month 5 to 7	WTg/5–7(WT)
		31. Weight gain: month 5 to 9	WTg/5–9 (WT)
		32. Weight gain: month 7 to 9	WTg/7–9(WT)
		33. Weight gain: pre-pregnancy to month 5	WTg/pp–5(WT)
		34. Weight gain: pre-pregnancy to month 7	WTg/pp–7(WT)
		35. Weight gain: pre-pregnancy to month 9	WTg/pp–9(WT)

were used to judge if the study was suitable for inclusion in this project. Several previously agreed considerations determined this, including study design and data quality. A number of the prerequisites are discussed in the study protocol, and are commented upon in Chapter 2.

(iii) Grants were awarded to the selected collaborators between November 1990 and June 1991. In all, 8 studies were supported at this stage by WHO; a further 11 studies had previously been supported by WHO or its Regional Offices. Finally, secondary analysis of the remaining studies was undertaken by