Public Health Classics

This section looks back to some ground-breaking contributions to public health, reproducing them in their original form and adding a commentary on their significance from a modern-day perspective. To complement this month's theme of the *Bulletin*, Mercedes de Onis reviews the 1956 paper by F. Gomez et al. on mortality in second and third degree malnutrition. The original paper is reproduced by permission of Oxford University Press.

Measuring nutritional status in relation to mortality

Mercedes de Onis[1]

In 1956, Federico Gómez and colleagues described the clinical picture preceding death and the apparent cause of death in malnourished children admitted to the Nutrition Department of the children's hospital in Mexico City (*1*). The main purpose of their article, a classic in the history of nutritional sciences, was to provide information on clinical profiles of child malnutrition and their associated risk of mortality. What made this paper a landmark contribution was the use of a simple anthropometric measurement — weight — to develop an indicator (weight-for-age) and, on this basis, a classification of varying degrees of malnutrition. To do this, Gómez and his colleagues relied on the average "theoretical weight" they had found among Mexican children (*2*). Patients were classified into three groups according to severity of malnutrition, namely, *first degree* (76–90% of the "theoretical weight" average for the child's age), *second degree* (61–75%), and *third degree* (60% and less). Their article linked this classification system to the precise health outcome — mortality — and assigned to varying degrees of malnutrition not only a clinical value but also a prognostic significance. The authors documented that the type of prognosis depended mainly on the severity of malnutrition, measured as weight deficit. Subsequently, reference to *first, second* and *third* degrees of malnutrition became common jargon not only among nutritionists, but also among others working in the field of child health. With time, the so-called "Gómez classification" (using the Harvard reference values (*3*) and different cut-off points, i.e., 80%, 70% and 60% of median) was used widely both to classify individual children for clinical referral and to assess malnutrition in communities.

The paper by Gómez et al. raised two interrelated issues that are discussed below. The first, which describes how to measure malnutrition, considers such methodological issues as selecting anthropometric indicators, choosing reference data and establishing cut-off points. The second issue concerns the relationship between malnutrition, as measured by child anthropometry, and mortality.

Measuring nutritional status

The classification developed by Gómez et al. was based on three prior selections: an anthropometric indicator, a reference population with which to compare the index child or community, and cut-off points to classify children according to variable degrees of malnutrition. Classifications developed after Gómez have all relied on these same three elements.

Anthropometric indicator

Nutritional status can be assessed using clinical signs of malnutrition, biochemical indicators and anthropometry. Inadequacies in nutritional intake eventually alter functional capacity and result in many adverse health outcomes that are distinct expressions of malnutrition's different levels of severity. Initially, children adapt to inadequate diets through reduced physical activity and slowed rates of growth. At moderate degrees of malnutrition activity and growth rates are affected to a greater degree and, in addition, signs of wasting and some biochemical abnormalities (e.g. reduction in serum albumin) begin to show. At advanced stages of severity, all linear growth ceases, physical activity is severely curtailed, body wasting is marked, and clinical signs (e.g. oedema, hair and skin changes) are noticeable. Anthropometry thus has an important advantage over other nutritional indicators: whereas biochemical and clinical indicators are useful only at the extremes of malnutrition, body measurements are sensitive over the full spectrum. In addition, anthropometric measurements are non-

[1] Medical Officer, Department of Nutrition for Health and Development, World Health Organization, 1121 Geneva 27, Switzerland (email: deonism@who.int).

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invasive, inexpensive and relatively easy to obtain. The main disadvantage of anthropometry is its lack of specificity, as changes in body measurements are also sensitive to several other factors, including intake of essential nutrients, infection, altitude, stress and genetic background.

A child's body responds to malnutrition in two ways that can be measured by anthropometry: a deceleration or cessation of growth, which over the long term results in low height-for-age or stunting; and body wasting, which is a short-term response to inadequate intakes, and commonly assessed by weight relative to height. Height-for-age and weight-for-height thus discriminate between different biological processes, unlike weight-for-age, which could be low because of stunting (short stature) and/or wasting (recent weight loss). The Gómez criteria relied exclusively on weight-for-age and hence could not discriminate between short-term and long-term forms of malnutrition. Thus, patients classified on the basis of weight-for-age criteria are a mixed group in terms of their clinical nutritional status. In post-Gómez classifications, weight-for-height has emerged as a very important indicator (*4, 5*) and, in fact, several authors have identified low weight-for-height as the indicator of choice for screening severely malnourished children who are at increased risk of dying (*6–9*).

Reference population

Anthropometric values are compared across individuals or populations in relation to a set of reference values. The choice of reference population to assess nutritional status has a significant impact on the proportion of children identified as being malnourished and, in turn, important programmatic implications for what to do about it (*10*). Much has been written about growth references, but there remain unanswered questions about the many factors that determine human growth and indeed what constitutes "normal" growth. Gómez et al. used "theoretical weights" among Mexican children (*2*), and later nutrition classification standards have followed this tradition by choosing reference values of their own. A detailed account of the different growth references used prior to the current international reference is provided elsewhere (*11*). The US National Center for Health Statistics (NCHS)/WHO international reference, in use since the late 1970s, has been found to have important technical and biological drawbacks. Consequently, WHO is conducting a multicountry study aimed at developing a new growth reference. A major innovation of this new effort is the use of an internationally constituted reference population as opposed to the strictly national samples in existing references (*12*). The extent to which the new curves differ from the current ones in shape and the spread of values around the mean will affect the relationship — established using the old reference values — between child anthropometry and functional outcomes such as mortality.

Cut-off point

Once an anthropometric indicator and a reference population have been selected, it is necessary to determine the limits of "normality". There are three classification systems for comparing a child, or a group of children, to the reference population: *Z*-scores (standard deviation scores), percentiles and percent-of-median. The Gómez classification uses the percent-of-median, which is a convenient measure if the reference population distribution has not been normalized. The percent-of-median is simpler to calculate than a *Z*-score or percentile. In the growth reference populations used prior to the NCHS/WHO reference, the curves were generally not normalized. However, in order to formulate the software version of the current reference, the original height and weight distributions were slightly modified by a normalization procedure (*13*). Since the calculation of the percent-of-median ignores the distribution of the reference population around the median, the interpretation of any given percent-of-median value varies across age and height groups. For example, depending on a child's age, 80% of the median weight-for-age can be above or below -2 *Z*-scores, resulting in different classifications of health risk. In addition, common cut-offs for percent-of-median are different for the three distinct anthropometric indicators (*5*).

Since the late 1970s WHO has recommended using the *Z*-score system because of its several advantages (*4*). For population-based applications, the software version of the NCHS/WHO reference greatly contributed to the wide acceptance of the *Z*-score concept because it simplified the handling of anthropometric data obtained from surveys and nutritional surveillance. For individual applications, however, there has been reluctance to adopt it because the *Z*-score of an *individual* child is more difficult to calculate than the percent-of-median. While field staff generally have no difficulty learning how to perform the calculation, they frequently experience difficulties with understanding the concept of the *Z*-score. It is nevertheless generally recognized that *Z*-score is the most appropriate descriptor of nutritional status for both individual and population-based applications, and health and nutrition centres are gradually switching to its use. Teaching how to use *Z*-scores, however, remains a challenge, and imaginative and simple ways need to be developed to convey this concept to health professionals.

The use of a statistically defined cut-off point (e.g. -2 *Z*-score) is not unique to anthropometry; indeed, it is widely applied in many clinical and laboratory tests. Nevertheless, it is important to bear in mind that using a cut-off-based criterion to define what is "abnormal" is somewhat arbitrary. In reality, there are not two distinct populations — one well-nourished and the other malnourished — but rather a continuous gradation of nutritional status. That is, the risk of undesirable health outcomes such as mortality does not change dramatically by simply

crossing the cut-off line: significant deterioration within the "normal" range may in fact carry greater risk. For many purposes, the best descriptor of a population's nutritional status is the mean, which in less developed environments is usually shifted to the left. This "population approach" resolves the problem of focusing solely on the severely malnourished subpopulation falling below a certain cutoff. In most instances, the mild and moderately malnourished subpopulations will be of greater importance from a public health perspective because there are many more children here than in the severely malnourished category.

Predicted risk, which drives most interventions, focuses on individuals, where the farther away from the centre of the distribution an individual is, the greater the risk of outcomes such as mortality. However, it is inadequate for nutritional interventions to be driven solely by an "individual approach", limiting nutritional support to children who fall below the accepted cut-off level. This approach tackles only the tip of the malnutrition iceberg. Ideally, both the population and individual approaches should be combined so that children who remain severely malnourished despite population-based interventions are identified and given special therapeutic attention (9).

Present practice often recommends the use of a universal cut-off point, e.g. -2 Z-score, which is very useful for population-based monitoring. However, for individual applications in screening high-risk children, cut-off points should be locally identified by taking into account: the population-specific prevalence and nature of malnutrition; the cut-off point below which children are shown to respond to specific interventions; and the availability of resources, which will ultimately determine the proportion of children that the intervention can reach.

Child anthropometry and mortality

The point made by Federico Gómez and colleagues (1) — that severe malnutrition has a significant effect on mortality — is biologically plausible and hardly ever disputed. Several other studies have documented that severely malnourished children are at a much greater risk of dying than are healthy children (14). An equally important question is, how strong is the association between mild or moderate malnutrition and the risk of child mortality? An accurate answer is important for the success of child survival programmes as the number of children with mild and moderate malnutrition is several times greater than the number who are severely malnourished (15). If mild and moderate malnutrition are strongly associated with increased mortality, efforts to reduce child mortality should be directed to improving the nutritional status of *all* children, instead of focusing primarily, or exclusively, on severely malnourished patients.

Few large prospective studies of mortality during childhood have examined this issue. The one by Chen et al. (16), who studied a cohort of Bangladeshi children (15–26 months at enrolment) for two years, has been highly influential. Their observations, which had important programmatic implications, showed a pronounced threshold effect: mortality increased with worsening nutritional status when malnutrition was severe, but mild or moderate degrees of malnutrition had little predictive power. More recently, Pelletier et al. (17, 18) reviewed 28 community-based prospective studies on the relationship between anthropometric indicators of malnutrition and child mortality. The authors reached two important conclusions. First, the accumulated results were consistent in showing that the risk of mortality was inversely related to anthropometric indicators of nutritional status and that there was an elevated risk even at mild-to-moderate levels of malnutrition. Moreover, when considering the relative proportions of severe versus mild-to-moderate malnutrition in populations, the authors showed that the majority of nutrition-related deaths were associated with mild-to-moderate, rather than severe, malnutrition. In programmatic terms, this implies that strategies focusing primarily or exclusively on severely malnourished children will be inadequate to improve child survival in any significant way. To make a substantial impact on mortality, the burden of mild and moderate malnutrition in a population must also be reduced. The second important result from the review by Pelletier et al. is the confirmation that malnutrition has a potentiating (multiplicative) effect on mortality. Malnutrition, rather than acting in a simple additive fashion, was in fact observed to multiply the number of deaths caused by infectious disease.

The substantial contribution to child mortality of *all* degrees of malnutrition is now widely recognized. As a consequence, current international efforts such as the Integrated Management of Childhood Illness strategy, which focuses on the most important causes of child death, include a number of key nutritional interventions (19). It was pioneers like Federico Gómez and his colleagues who laid the groundwork for today's approach by developing the concepts that the international nutrition community now takes for granted and continues to refine in an effort to understand better the magnitude of malnutrition and its impact on health. Those who believe that assessing nutritional status is a fundamental tool for protecting child health are indebted to this pioneering work. ■

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