cember 1970, as noted in Sommer and Lowenstein (1975)], which was the month after severe flooding. Thus, secular changes in mortality and nutritional status may have occurred due to the usual seasonal effects, the disaster and maturation of this cohort of children (1–4-year-olds).

**Table 17** [from Alam et al. (1989)] shows that the mortality rate of children severely malnourished at baseline is higher in the 3 months after measurement than in the subsequent 3 months. Similarly, the relative risk of mortality for these children is higher in the first interval. This result is seen with each of the six indicators. However, it is not possible with the data provided to estimate the loss in predictive power, viz. sensitivity and specificity (at various cutoff points), which is incurred due to the longer follow-up period. Nor is it possible to single out the loss in power involved with a 3-month follow-up for all children as opposed to a 1-month period typically sought in most growth-monitoring programs. Similar problems exist in the other studies mentioned above, and thus it is not possible at this time to provide concrete guidance concerning the implications of changing the measurement frequency in mortality prevention programs that use growth monitoring to screen high-risk children. Although the conservative strategy would be to continue to strive for monthly measurements, this may be done at the expense of mothers' time and clinic logistics, as mentioned above, which vary in importance from one setting to another.

### *Comparing the predictive ability of anthropometric indicators*

Much of the literature on anthropometry-mortality relationships has been directed towards comparing indicators in order to identify the single indicator which is the best predictor of mortality. Of the 28 studies reviewed here, 15 of them provided data which implicitly or explicitly compared indicators in this respect. However, of these only eight employed appropriate criteria and methods for comparison, and only these studies are reviewed below.[16] Because of the large number of possible contrasts among indicators the results are considered in three stages. First, the results bearing on HA, WA and WH are described, followed by comparisons among the arm circumference-based indicators, and finally, comparisons among HA, WA and arm circumference indicators.

**Table 18** shows the final results of the eight studies that used appropriate methods of comparison. It should be noted that in all cases the follow-up period varies between 6 and 24 months, thereby ensuring that large distortions are not introduced by studies with very short follow-up intervals (e.g., 1–3 months). However, the age range covered does vary substantially across studies and, in light of the potential for age-specific effects of indicators described earlier, is a factor that must be considered in comparing across studies.

In comparing across studies and across the various comparative criteria, the most consistent observation

[16]Brownie et al. (1986) have provided a detailed critique of the methods for comparing indicators up to that point in time and have provided empirical support for the use of the alternative comparative criteria adopted in this section. Their results suggest that the single best comparative criterion is the normalized distance statistic ($d_a$), followed by the maximum sum of sensitivity and specificity (MSS). The use of "receiver operating characteristic" (ROC) curves is also highly recommended. The least satisfactory basis for comparison,

**TABLE 18**

***Comparison of height-for-age, weight-for-age, and arm circumference-based indicators in relation to mortality***[1,2]

| Study | Age range in months | Follow-up period | ROC curves: High Sp | ROC curves: Low Sp | MSS | $d_a$ |
|---|---|---|---|---|---|---|
| 1b | 12–23 | 24 mo | AC > WA > HA | WA > HA > AC | — | — |
| | 12–23 | 6 mo | AC > WA > HA | HA > AC > WA | — | — |
| 5 | 12–59 | 6 mo | AC > HA > WA | AC = WA > HA | — | — |
| 14 | 6–59 | 6 mo | AC > WA > HA | — | AC > WA > HA | AC > WA > HA |
| 17 | 6–59 | 12 mo | AC > WA > HA | WA > AC > HA | — | — |
| 1d | 12–23 | 24 mo Males | ACHT > AC > ACA > WA > HA | | ACA = WA > AC > HA | ACA > AC > WA > HA |
| | 12–23 | 24 mo Females | HA > WA > ACA > AC | | HA > WA > AC = ACA | HA > WA > ACA > AC |
| | 12–23 | 24 mo Combined | HA > AC > WA > ACA | | HA > WA > AC ≥ ACA | HA > AC > WA > ACA |

[1] Adapted from Bairagi (1981), Alam et al. (1989), Briend et al. (1989), Vella et al. (1994) and Cogill (1982). Study descriptions are provided in Table 1. [a]Studies 1b and 1d are based on the same basic data set; however, the results differ because of different methods of analysis. The indicator ranks shown here for study 1b are estimated from Figure 1 of the published report; however, the ROC curves for AC, WA, and HA intersect throughout the range of specificity analyzed. Study 1d reported quantitative estimates of the total area under each indicator's ROC curve, which forms a better basis for comparison in this case. Note: WH not shown because of its poor performance across all studies [Pelletier (1991a)].

[2] ROC = receiver operating characteristic; High SP = High specificity; Low Sp = Low specificity; MSS = maximum sum of sensitivity and specificity; $d_a$ = normalized distance statistics; AC = arm circumference; WA = weight-for height; HA = height-for-age; ACHT = arm circumference-for-height; ACA = arm circumference-for age.

is that WH is the least effective predictor of mortality (and is therefore omitted from Table 18). Although one might hypothesize that this is because WH reflects acute malnutrition and may therefore predict only short-term mortality (i.e., <6 months of follow-up), the favorable performance of AC-based indicator (which also reflects wasting) in relation to HA and WA suggests this is not the case. It may be that WH has more measurement error than AC in these studies due to compounding the independent measurement errors in weight and height and the greater susceptibility of WH to variation in levels of hydration, stomach contents, posture during measurements, etc. Another lesson from this finding is that misleading conclusions can be derived if indicators are compared on the basis of simple analysis like that portrayed in Figures 1–4. These figures suggests that WH is among the most consistent indicator across studies, but the ROC curves reveal that WH has much lower sensitivity for a given specificity than other indicators.

Apart from the relatively poor performance of WH, when the variation in the strengths of each study is taken into account, Table 18 suggests that WA is superior to HA according to all performance criteria. The two notable exceptions are the study of Bairagi et al. (1985) (which is the most difficult to interpret due to small sample sizes and confounding by seasonality) and females in the Bangladesh data from Chen et al. (1980). The latter finding does not appear to be an artefact of study design and suggests that under certain circumstances the performance of indicators may be affected by child's sex as well as age. The results for sexes combined in that study resemble those for females because of the disproportionate number of female deaths in this sample.

When the three AC-based indicators are compared according to these same performance criteria (cf. Pelletier 1991) it appears that standardizing AC with HT does not add to the predictive ability of AC. Thus, C/HT is consistently ranked poorly in such analyses, with the notable exception of males from the study by Chen et al. (1980) as reanalyzed by Cogill (1982). In addition, the results suggest that simple arm circumference (AC) is superior to AC corrected for age except among females in the data from Chen et al. (1980). The latter result may simply reflect age confounding, however, because AC increases sharply with age through 12 mo and more gradually thereafter (Frisancho 1990, Jelliffe 1966), exactly opposite to the trend in mortality with age.

Finally, Table 18 compares the AC-based indicators with HA and WA. For the criterion that is common to all studies (ROC curves), it appears that *at high specificities* simple AC is superior to HA and WA. This is true in all except the females and sexes combined in the study by Chen et al. (1980) as reanalyzed by Cogill (1982). This is not true in the range of low specificity, however, for those studies providing data in those ranges. Similar conclusions are reached based on the MSS and $d_a$ criteria, although not all studies used these performance criteria.

The possibility that the superior performance of simple AC may be due to age confounding has been directly examined by Yip and Pelletier (1994) using data from Northern Malawi. Their analysis, based on ROC analysis, confirms that simple AC outperforms WA, whereas use of age-adjusted AC produces results comparable to WA.

Thus, on the basis of the few studies for which a valid basis for comparison exists, it appears that, at extremely low cutoff points (i.e., high specificity), simple arm circumference may be superior to HA or WA in predicting mortality within the subsequent 6–24 months. It is likely that this reflects age confounding, however. The indicator results are mixed at lower specificity values (less extreme cutoff points). More important than this conclusion, however, is the fact that the ranking of indicators with respect to these technical criteria often obscures the overall similarity that exists in their performance. Few studies employed statistical tests to determine whether the observed differences in prediction are statistically significant (Brownie et al. 1986). In addition, there are suggestions that the indicator rankings may be subject to modification by such factors as the child's sex and socioeconomic status (Cogill 1982), child's age (Katz et al. 1989; Pelletier et al. 1994a) and probably seasonality and other factors. Thus, the ultimate choice of indicators should take into consideration operational characteristics of the local programs, such as the expense and logistics of performing various measurements, the validity with which these measurements can be taken in the local context and the resources available for interventions (Haas and Habicht 1990). It should also be noted that mortality prediction (screening) is only one of the objectives for taking anthropometric measurements in health programs, and that AC is not necessarily the indicator best suited to other applications such as nutrition education (Ruel 1994).

### *Attained weight versus weight change in relation to mortality*

In recent years it has become increasingly common for primary health care programs to stress indicators of weight change to complement or supplant measures of attained weight. Weight change has the theoretical advantage that it may provide early detection of growth faltering even among children whose attained weight is above conventional cutoff points for defining risk. In addition, by monitoring the change in weight rather than absolute position of the child's weight on the growth chart, it is explicitly acknowledged that

and the one most commonly employed up to that time, is relative risk.

some children may never approximate a normal position on the chart (often due to stunting in earlier years) and that attention should instead be directed towards maintaining a growth trajectory that is parallel to the normal trajectory.

Despite these theoretical advantages, the use of weight change indicators raises a number of operational and conceptual questions. First, because weight change indicators are subject to measurement errors twice (i.e., at a given visit and at a subsequent visit), the indicator has a larger proportion of false positives and negatives than a static indicator. Given that false positives imply targeting scarce intervention resources to the less needy and that false negatives imply a failure to intervene upon a child at high risk of dying, this is obviously a matter of some concern. Second, the use of weight change indicators may also be conceptually flawed depending on 1) the way in which weight change indicators are used (e.g., whether and how they are combined with static indicators), 2) the types of interventions actually available and 3) the explicit decision-making algorithm for linking indicators to interventions. For instance, it is not at all clear from the available studies that a child who is above 80% WA and shows growth faltering has a similar risk of death to a child at 60% WA who is growing parallel to the normal trajectory. It may well be reasonable to direct health education to the former, and education plus curative attention to the latter. However, it is not clear what should be done with the variety of possibilities between these two extremes. Nor is it clear whether health workers with rudimentary training can effectively distinguish between these different types of risk.

Although some of these issues must be resolved through operations research, there are two fundamental questions in relation to mortality prediction: 1) Do weight change indicators bear any relation at all to mortality risk; and 2) Do they provide significant improvement over indicators based on attained size. There are four reports in the literature that address these questions to some extent.

Of the four studies, three were able to demonstrate that the weight gain of survivors is significantly greater than that of children dying during the succeeding interval (Bairagi et al. 1985). The one negative study employed three different intervals for estimating weight change (2, 4 and 6 months) and examined this in relation to mortality in the following 12 months. However, in no case was a significant association found. Part of the problem may be that this study is limited by small sample sizes (15–23 deaths in various analyses) and is confounded by seasonality. The three studies producing positive results are reviewed below.

The Zaire study (Kasongo Project Team 1986) attempted to relate 2–4-months weight changes to mortality in the succeeding 100 days and found a weak association among 6–24-month-olds and a significant association among 25–59-month-olds. This association was only evident when large deviations in weight were considered (>0.5 WA Z-scores for older children and >1 WA Z-score for younger children). In no case was the association significant in the case of the cutoff point usually employed in actual programs (i.e., presence or absence of any weight loss). The authors conclude that, because the earlier report from this study found no association between mortality and attained weight (Kasongo Project Team 1983), then the weight change indicator is superior. However, the two analyses were performed on different subsamples (105 deaths for attained weight and 52 deaths for weight changes), thereby precluding direct comparison. Moreover the coverage of deaths in the study as a whole appears to be very low (see Table 1).

Both of the remaining studies (Briend and Bari 1989b, Yambi 1988) reported a significant association between mortality and weight change in the preceding interval, and both found that this effect is independent of attained weight in multivariate logistic regression models. The latter study also included initial weight in the model in order to control for the correlation between weight change and initial weight (a portion of which is induced by measurement error). However, that study did not include a comparison of the performance of the weight change indicator in relation to attained weight (using ROC curves, MSS and $d_a$ for instance) and, thus, it is not possible to evaluate its predictive ability against these standard criteria.

The Briend and Bari (1989b) study from Bangladesh is the only one to provide a complete analysis of the performance of weight change versus attained weight. According to all three criteria of performance ($d_a$, MSS and ROC curves) attained weight-for-age is found to be far superior to weight change as a predictor of mortality. Weight change over a 3-month period (which decreases the influence of measurement error as a proportion of the true change in weight) has a performance intermediate between weight-for-age and 1-month changes according to all three criteria. Thus, in terms of choosing a single best indicator among these three possibilities, it is clear that attained weight-for-age is the indicator of choice. Because of the compounding of measurement errors in calculating weight change, this result is even more likely to hold under actual program conditions in which measurement error is greater than in this study.

In recognition of the fact that programs may be designed to *combine* weight-for-age and weight changes for screening purposes, this study also examined the implications of this strategy. In multivariate logistic regression models, low weight-for-age (<60%) and 1-month weight changes (presence or absence of weight loss) are both found to be significant, although the odds ratio of the former is 9.7

compared with 3.7 for the latter. Both variables retain their significance even when morbidity symptoms are included in the models (measles and respiratory infections).[17] Even more telling, however, is the fact that, at any level of specificity, simple weight-for-age has higher sensitivity than 1-month weight loss alone or weight loss in combination with weight-for-age. Thus, the improved prediction of mortality (sensitivity) that is seen in logistic regression analysis is achieved at the expense of specificity. In an operational sense this implies that more deaths could be prevented by applying both indicators simultaneously; however, this would be accomplished at a higher cost to the program due to the greater number of false positives. Alternatively, if program resources are fixed, then the use of two indicators rather than simply weight-for-age may prevent *fewer* deaths, due to leakage of limited intervention resources to the less needy. In any case, this study suggests that better results could be achieved by simply raising the cutoff point of WA rather than adding weight loss to the screening protocol.

## IMPLICATIONS FOR POLICY, PROGRAMS AND RESEARCH

An important observation from this review is that the published literature reflects a much stronger concern for programmatic issues arising from the anthropometry-mortality relationship (chiefly screening) than for policy-related issues. One indication of this is the fact that the PAR estimates presented in this paper, which are of central policy importance, had to be calculated from data culled from the original reports, and this was possible with only a fraction of the studies. It is also reflected in the general lack of attention to possible confounding and effect modification, which are likewise of central importance for some policy purposes and, to some extent, for screening purposes as well. Finally, it was noted that even the analyses directed at screening issues (e.g., those comparing the performance of various anthropometric indicators) often did not employ valid or consistent performance criteria. Although these criteria were only recently developed (Brownie et al. 1986, Cogill 1982), this nonetheless represents a weakness in many studies. Despite these overall weaknesses in the literature, it is possible to identify a number of conclusions of immediate policy and programmatic relevance. These are noted below, followed by suggestions for future research.

### *Implications for policy*

The first important observation is that the fundamental relationship between anthropometric indicators and mortality is found in all studies except one (Kasongo). Second, the threshold effect reported by Chen et al. (1980) has not been found in most studies conducted since that time, including studies from the same geographic area (Matlab) and other areas of Bangladesh, Asia and Africa. An exception is the recent report from Zaire (Van Den Broeck et al. 1993) that may reflect the highly intervened communities in that study. Thus, although mortality risk does increase in an exponential fashion with decreasing levels of anthropometric status, there is nonetheless some elevated risk of mortality even in the mild-to-moderate region of most anthropometric indicators (WA, WH, and AC). This finding is counter to the notion that growth deficits in the mild-to-moderate range may represent physiological adaptations to a poor environment and do not carry any functional consequences of policy importance (Lipton 1983, Seckler 1982).

The policy importance of this latter finding is revealed by the estimates of population attributable risk, which indicate that a substantial proportion (e.g., 46–93% according to weight-for-age) of the "nutrition-related" deaths are found in the mild-to-moderate range of anthropometric indicators. Although the range of estimates for these proportions is rather wide, it is sufficient to indicate that policies designed to address the problem of severe malnutrition can aspire to prevent only a proportion of the nutrition-related deaths or total child deaths in the population. This appears to be especially important in countries outside of South Asia which have a much higher ratio of mild-to-moderate to severe malnutrition.

A related policy implication is that the cost-effectiveness of preventing nutrition-related deaths will be initially much lower and the absolute cost much higher, for policies and programs directed at the mild-to-moderate category. This is because of the much larger size of the population to be covered and the lower risk of death in this segment of the population (i.e., lower sensitivity) as compared with the severely malnourished segment. However, the failure to address this substantial number of nutrition-related deaths in the mild-to-moderate categories may limit the size of the reduction in child mortality rates for the population as a whole. It also leaves a large "reservoir" of mild-to-moderate cases from which severe cases are derived and thereby subjected to an even higher risk of death. It is likely that broader social and economic policy changes may be required to reduce mild-to-moderate malnutrition, in part because individual screening and intervention is so inefficient

[17] Although diarrhea is associated with lower weight changes, it is not associated with higher mortality in this sample and therefore does not affect these results. The authors attribute the lack of association between diarrhea and mortality to the presence of an intensive ORS program and access to one of the study's physicians for intensive care.

when dealing with relatively low risks distributed across a large proportion of the population.

An important caveat to this discussion is, of course, that it is still not clear to what extent the "anthropometry-related" deaths in these studies are truly "nutrition-related." To some extent they may be simply a function of other socioeconomic and behavioral factors being proxied by low anthropometric status. The literature is fairly convincing in suggesting that such confounding does not account for the association between *severe* malnutrition and mortality. The one study examining this issue in mild-to-moderate malnutrition found that the effects persists (and, indeed, is even stronger) within some socioeconomic strata. This latter finding requires confirmation in other populations because of the impact which variation in morbidity patterns and health care utilization may have on this result. The paper by Pelletier et al. (1994a) in this supplement addresses this issue in greater detail based on a study in Northern Malawi.

One of the provocative findings emerging from this synthesis is the observation that malnutrition acts as a potentiator of mortality (i.e., a multiplicative effect), rather than simply as another additive cause of mortality (Figures 5 and 6 and Pelletier et al. 1993). This result is fully consistent with the knowledge of a physiologic synergism between malnutrition and morbidity (Chandra 1991, Scrimshaw et al. 1968), but it has not been previously shown epidemiologically. Earlier intervention studies in Narangwal (Kielmann et al. 1978), Guatemala (Ascoli et al. 1967) and elsewhere (Gwatkin et al. 1980) have either suffered from inadequate sample sizes to demonstrate this effect or were not designed to do so. The implications for policy are as follows: 1) health interventions will have the biggest impact on mortality in the most malnourished populations; 2) nutritional changes (positive and negative) will have their biggest impact in populations with already high mortality levels and 3) the biggest impacts on mortality can be achieved by simultaneously improving health status *and* nutritional status and by targeting populations with the highest mortality rates.

These policy conclusions are not novel, but they are often undervalued, unheeded or otherwise unreflected in the policies of international agencies and governments. The present results provide added empirical support for increasing the level of the resources and attention to nutritional considerations in efforts to lower child mortality. This applies to direct interventions, as typically implemented through the health sector; however, in light of the evidence that the synergism operates over the mild-to-moderate range of malnutrition—and not just the severe range—it also reinforces the importance of explicitly considering the nutritional implications of policies and programmes in other sectors as well. The institutional mechanisms for undertaking effective policy review on an on-going basis remains one of the most difficult, but high-priority issues for attention.

Another result of immediate policy relevance is the observation that the effect of severe malnutrition on mortality is made substantially worse (four times worse) by the absence of breastfeeding (Table 14). In light of the already strong impact of severe malnutrition on mortality, the observation that it is quadrupled in the absence of breastfeeding is quite striking. This result, which does not appear to be confounded by child's age, was found in both of the studies examining this issue. Though it requires more extensive documentation, the apparent magnitude of the effect warrants immediate attention. It suggests not only that current breastfeeding programs should be maintained and strengthened, but also that special efforts should be made to ensure prolonged breastfeeding in children already severely malnourished or at high-risk for becoming so.

### *Implications for programs*

The key programmatic issues arising from this literature relate to the choice of anthropometric indicators for screening, the frequency of measurement required for effective screening, and appropriate age/sex target groups. A positive finding of the review is that, when a uniform set of performance criteria are applied to anthropometric indicators, an emerging consensus is suggested concerning the best predictors of mortality. Specifically, it appears that, with qualifications, simple arm circumference and weight-for-age are superior to other indicators. Moreover, the two studies that explicitly compared the predictive ability of attained weight versus weight change found that attained weight was the better predictor and was not significantly improved by simultaneous consideration of weight change.

The important qualifications to the above conclusions are as follows: 1) Arm circumference outperforms the others (WA and HA) only at high specificities (i.e., extreme cutoff points) and is probably confounded by age; 2) There is suggestive evidence of some sex specificity (and possibly age-specificity) in the ranking of indicators and 3) Although this result arises from a number of studies that vary in age range and length of follow-up, there have been no systematic attempts to examine these relationships over a range of follow-up periods and a range of ages. To study these issues systematically in a single study will require much larger sample sizes than previously available (to accommodate sex- and age-specific analyses), a wide age range and the ability to distinguish several follow-up intervals.

Despite the limitations in the above evidence it is relevant to note that the choice of indicators and frequency of measurement depends in large part on local considerations (logistics and the specific objectives of the program) and only in part on the technical criteria of screening efficiency (Haas and Habicht 1990). Programs designed to avert deaths in individual children, as in famines or clinic screening for acute cases, obviously require an indicator and a measurement frequency that reflect immediate risk and can be measured with reasonable ease and accuracy. The present results suggest that *for mortality prediction* AC with a low cutoff point is technically superior to WA (and both are superior to WH). This conclusion carries with it two caveats, however. First, simple AC is likely to be confounded with age if the program screens young children (<12 months) as well as old. Second, the studies giving rise to these results all employed a follow-up period of 6–24 months and, therefore, do not truly reflect the risk of death in the immediate future. There is a need to examine this issue with a much shorter follow-up period, using accepted methods for comparing indicators. Moreover, the marginal improvements in prediction using AC need to be weighed against any logistic considerations (e.g., switching from WA to AC in clinics), which vary according to local circumstances.

Programs with longer term child survival or nutritional improvement objectives (e.g., those delivering health and nutrition education) clearly do not require the same measurement frequency nor indicators of immediate risk. Here an important consideration may be the sensitivity of the indicator to recent health and nutritional conditions (to identify faltering growth early in the process rather than to prevent death per se). In this case change in WA would likely be superior to simple AC or change in AC. Unfortunately much of the literature designed to identify the single best indicator has overlooked these contextual and logistical considerations (Habicht and Pelletier 1990).

### Implications for research

The studies included in this review have three interrelated characteristics that make it difficult to draw firm conclusions on several policy and programmatic issues: small sample sizes, variation in analytical methods and the failure to collect and/or use ancillary information in the analysis. In many cases this was compounded by the tendency to focus on questions with programmatic relevance (i.e., identification of the best anthropometric indicator) rather than policy relevance, even though the same data might be applied to both types of questions. This section highlights the key issues requiring further research, some of which might be undertaken with existing data.

The first set of issues relates to the possibility of effect modification, i.e., that the relationship between anthropometric indicators and mortality may differ according to child's age or sex, length of follow-up, season of measurement and a host of other factors. On the basis of a limited number of studies, the review supports the notion that such effect modifiers do exist and that they have significant implications for policies and programs. This is seen in the case of child's age and sex, which influence the relative predictive ability of different anthropometric indicators; in length of follow-up, in which mortality prediction appears to attenuate under longer follow-up and is likely to affect some indicators more than others; in season of measurement, which modifies the risk of death in malnourished children and in breastfeeding, which diminishes the risk of death among malnourished children compared with nonbreastfed children. Unfortunately, the evidence concerning these effect modifiers is quite patchy across the studies, in part due to the three factors noted above.

Greater resolution on these issues could be obtained by reanalyzing appropriate data sets already available. At a minimum it should be possible to examine effect modification by age and sex and possibly by length of follow-up in some studies. In light of the small sample sizes, one option would be to pool the data from several studies (notably the many studies from Bangladesh, but not limited to those) and perform an integrated analysis. An advantage of reanalysis, even if pooling is not performed, would be to adopt a standard set of criteria for comparing the performance of anthropometric indicators as described by Brownie et al. (1986).

Another issue requiring further attention is the strength of the association between mild-to-moderate malnutrition and mortality. In particular, it is important to examine whether the elevated mortality risk in this segment of the population is simply because households with malnourished children have poor environmental and behavioral characteristics, which are the same characteristics giving rise to higher mortality. The analyses to date have suggested that this is not the case with severely malnourished children, but only one study has singled out the mild-to-moderate cases for similar analysis. Moreover, there is a need to consider variation in age, length of follow-up and type of anthropometric indicator in these analyses for the reasons outlined above. Given that most of the children classified as malnourished by anthropometric criteria are of the mild-to-moderate type and that these appear to account for a significant proportion of the nutrition-related deaths in a population, this issue has important policy implications. Related to this is the need to better understand the quantitative impact of malnutrition on mortality due to different types of morbidity and the biological basis for that impact. Such knowledge would help decide the most appropriate mix of nutrition- and health-related interventions at national and subnational levels, by combining information on the morbidity profile and malnutrition prevalences to estimate locally relevant population attributable risks.

The observation that a given deficit in weight-for-age among South Asian children is associated with lower mortality risk than in children from other regions is worthy of further investigation. It is consistent with earlier cross-national observations that the weight-for-age of South Asian populations is higher than expected, given their child death rates and other indicators of overall quality of life such as access to safe water, national food (calorie) availability, female literacy and infant mortality (Haaga et al. 1985).

A plausible hypothesis for these observations relates to the unusually high rate of low birthweight in South Asian populations and its effects on postnatal growth. According to the World Health Organization (W.H.O.) 31% of births from middle South Asia (including India and Bangladesh) result in low birthweight (<2,500 g), compared with 20% for the rest of Asia and 13–17% for various regions in Africa (World Health Organization 1980). Given the small stature of adult South Asian women (Eveleth and Tanner 1976), a significant proportion of this small size at birth is probably *not* attributable to poor maternal health and nutrition during pregnancy. Similarly, a significant proportion of the small size in early childhood may not reflect protein-energy malnutrition during this period. Rather, to some degree the smallness at birth and in early childhood may reflect relatively benign constitutional constraints to pre- and postnatal growth (Garn and Keating 1980, Gayle et al. 1987, Ounsted et al. 1988), which would not be expected to carry the same functional consequences in infancy and early childhood (Rasmussen et al. 1985). Research to test this hypothesis would require examination of possible interactions between birthweight and maternal characteristics (e.g., stature) as they relate to infant and child mortality.

Finally, it is worth noting that there are limitations to the policy inferences to be drawn from prospective, community-based mortality studies of the type reviewed here. In particular the demonstration that anthropometry predicts future mortality, even if unconfounded, does not mean that child growth and nutrition *must* be improved in order to reduce mortality. It may well be possible to improve health conditions and health care to the point where the incidence of disease is sharply reduced and the remaining morbidity is treated through competent health care. The evidence that malnutrition potentiates already existing mortality in a population certainly suggests that the success of health interventions would be accelerated through nutritional improvement. However, the most realistic and relevant way to estimate the role of nutrition in reducing child mortality, and the most cost-effective mix of strategies, is through intervention programs that improve nutritional and health conditions in real world settings.

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