Body mass index, height, weight, arm circumference, and mortality in rural Bangladeshi women: a 19-y longitudinal study[1–3]

Victoria Hosegood and Oona MR Campbell

ABSTRACT

Background: Studies in Western populations report a J- or U-shaped relation between body mass index (BMI; in kg/m^2) and mortality, in which persons with extremes of BMI experience increased mortality. In contrast, little is known about populations in developing countries, where nutritional status is lower.

Objective: The objective was to examine the association between BMI and mortality in Bangladeshi women.

Design: A cohort of 1888 rural Bangladeshi women (mean age: 27.9 y) was followed over 19 y. Height, weight, arm circumference, fertility, and socioeconomic data were obtained between 1975 and 1979. Mortality, loss-to-follow-up, and additional socioeconomic data were identified by the demographic surveillance system of the International Centre for Health and Population Research, Bangladesh. Proportional hazards regression was used to examine the relation between BMI and all-cause mortality.

Results: The association between BMI and mortality was reverse J-shaped. After adjustment for socioeconomic indicators, the risk of dying was highest in women with BMIs in the lowest 10% of the decile distribution (< 16.39) and lowest in women with intermediate (11–89% range of the decile distribution) BMIs (16.39–20.71). Women with BMIs in the highest 10% of the distribution (> 20.71) had slightly elevated mortality (NS) compared with those with intermediate BMIs. Age and education were strongly associated with mortality. Women without schooling had a risk of mortality 4 times that of women with ≥ 1 y of schooling.

Conclusions: A woman's BMI relative to the BMI distribution in the local population may be a better predictor of mortality than is absolute BMI. The contribution of education in reducing mortality supports development programs aimed at increasing women's education. *Am J Clin Nutr* 2003;77:341–7.

KEY WORDS Anthropometry, Bangladesh, mortality, nutrition, women, health, education

INTRODUCTION

The relation between body mass index (BMI) and other indexes of nutritional status and mortality is widely debated. Most studies in Western populations report a J- or U-shaped relation between BMI (in kg/m^2) and all-cause mortality in both men and women; very lean and obese persons experience higher risks of death than do those with intermediate BMIs (1–7). A few studies show a positive linear relation (8, 9). The interpretation of such data is constrained by methodologic limitations, notably inadequate adjustment for smoking, early mortality, and weight-loss stemming from preexisting illness at recruitment (10, 11).

Most studies of Western populations examined cohorts with high proportions of overweight and obesity (BMI > 25). Little is known about the relation between body weight and mortality in adults in settings where nutritional status is markedly lower than in the West (7). In Bangladesh, a 1992 cross-sectional survey of rural women aged < 50 y reported an average BMI of 18.9 (12). This compares with a BMI of 24.5 in a US cohort of women aged 15–64 y in 1960 (5). All BMIs in the Bangladeshi study overlap with the lowest one-third of BMIs in a study of Swedish women (13). It is postulated that low BMIs are associated with increased morbidity, reduced physical activity and work capacity, poor pregnancy outcomes, and increased mortality (14–17). Populations in developing countries may also differ in their causes of death, health service provision and use, and behavioral and physiologic characteristics. However, supporting evidence is rare, partly because longitudinal data sets from developing countries are scarce (7).

This study describes the mortality risk associated with nutritional status among rural Bangladeshi women. It also examines the role of socioeconomic and demographic factors in modifying the relation between BMI and mortality and compares the results with those in developed countries.

METHODS

The International Centre for Health and Population Research, Bangladesh (ICDDR,B) has maintained a Demographic Surveillance System (DSS) in the Matlab district since1966. Matlab is ≈55 km southeast of Dhaka and is typical of many rural areas of Bangladesh. The DSS covers a population of ≈200 000 (18). All individuals have unique identifiers; all births, deaths, marriages, and migrations are recorded. Nutritional status,

[1] From the Centre for Population Studies (VH) and the Department of Infectious and Tropical Diseases (OMRC), London School of Hygiene and Tropical Medicine.

[2] Supported by the Medical Research Council (United Kingdom) and the Wellcome Trust (VH) and by the UK Department for International Development (OMRC).

[3] Address reprint requests to V Hosegood, Centre for Population Studies, London School of Hygiene and Tropical Medicine, 49-51 Bedford Square, London WC1B 3DP, United Kingdom. E-mail: vicky.hosegood@lshtm.ac.uk.

Received October 4, 2001.
Accepted for publication March 19, 2002.

socioeconomic, and survival data were obtained by linking several ICDDR,B data sets.

Nutritional status

Anthropometric data were obtained from the Determinants of Natural Fertility Study (DNFS), which collected height, arm circumference, and monthly weight and fertility outcomes for 2445 married women aged 10–59 y from 1975 to 1979. All subjects were weighed with the use of identical balance scales while wearing light clothing but not shoes. The methods used are described in detail elsewhere (19). The study sought to update anthropometric and pregnancy data every month during a subject's enrollment. This article analyzes a subsample of 1888 women with a measure of height and at least one nonpregnancy measure of weight; 93% of the women had more than one weight measure. If a subject had multiple weight observations, a mean nonpregnancy weight was calculated to adjust for seasonal variation. The anthropometric measures and socioeconomic status of the 557 women excluded from these analyses were not significantly different from those of the total sample.

BMI, calculated as weight (kg) divided by height squared (m), was categorized by quartiles (0–24%, 25–49%, 50–74%, and 75–100%) and deciles (0–10%, 11–89%, and 90–100%).

Vital status

All subjects in the DNFS were also registered in the Matlab DSS, which routinely reports all deaths and migration events in the surveillance population. The DSS, therefore, provided exact dates of deaths and out-migration from the time of the women's enrollment in the DNFS until July 1993 (ICDDR,B, 1994). The vital status of women who had permanently migrated from the area during the follow-up period was not known, and these subjects were censored in the analysis. Within 12 mo of death being recorded, a paramedic conducted a verbal autopsy interview with the family of the deceased. The verbal autopsy method used was not adequate to allow classification of all causes of death and, consequently, a large proportion of deaths are unclassified (20).

Women's characteristics

Individual and household-level socioeconomic indicators were available from the DNFS and a socioeconomic census conducted by ICDDR,B in 1982 (18). The variables of religion, distance to water, and land owned relate to the household level and were collected from household respondents directly. When variables were available from both sources, the more complete DNFS data were used. Age was used as a continuous variable. Other variables were categorized as shown in **Table 1**.

Statistical analyses

Cox's proportional hazards models (21) were used to analyze the association between mortality and anthropometry after adjustment for other determinants. In addition to the anthropometric variables, 13 individual and household-level variables were explored as potential confounders: age, education, religion, husband's occupation, distance to water, dimension of house, items owned, land owned, cows owned, boats owned, size of family, source of drinking water, and wall material. Cox's models provide estimates of hazard ratios, their SEs, and *P* values. Likelihood ratio (LR) tests were used to test the models' statistical significance.

TABLE 1
Summary statistics of women from the Determinants of Natural Fertility Study

	No. of subjects (%)	$\bar{x}$ ± SD (range)
Age		27.5 ± 9.1 (10–57)
10–14 y	93 (4.0)	
15–19 y	494 (21.3)	
20–29 y	739 (31.9)	
30–39 y	716 (30.9)	
≥ 40 y	272 (11.8)	
Religion		
Muslim	2052 (88.7)	
Hindu	262 (11.3)	
Parity		3.96 ± 3.17 (0–19)
0	383 (16.6)	
1–2	544 (23.5)	
3–7	1020 (44.1)	
≥8	367 (15.9)	
Education level		
None	1767 (76.4)	
1–5 y	471 (20.3)	
6–15 y	76 (3.3)	
Husband's occupation		
High level	935 (40.4)	
Low level	1373 (59.3)	
Missing	6 (0.3)	
Distance to water		
< 14 m	801 (34.6)	
≥ 14 m	1394 (60.2)	
Missing	119 (5.1)	
Land owned[1]		
0 acres	590 (25.5)	
1–4 acres	600 (25.9)	
5–12 acres	493 (21.3)	
≥ 13 acres	584 (25.2)	
Missing	47 (2.0)	
Height (cm)	2202 —	147.9 ± 5.2 (119.5–165.4)
Weight (kg)	1999 —	40.5 ± 4.6 (22.2–61.2)
Arm circumference (mm)	2050 —	21.9 ± 1.5 (16.6–24.7)
BMI (kg/m^2)	1888 —	18.5 ± 1.8 (10.5–25.6)

[1] 1 acre = 4046.86 m^2.

RESULTS

Between the time of enrollment in the DNFS and July 1993, 102 (5.4%) of the 1888 women died and 261 (13.8%) migrated out of the study area and were lost to follow-up. The mean duration of follow-up was 15.6 y (range: 0.1–18.5 y). The mortality profile showed predominantly infectious rather than chronic diseases. The most common causes of deaths were respiratory disease and tuberculosis (14%); liver, ulcer, and hepatic disease (14%); and diarrhea, dysentery, and cholera (9%). Other causes of death were each < 8% of the total, and 10% of all deaths could not be classified.

The DNFS population is described in Table 1. The mean age of the women at enrollment was 27.5 y. The mean (± SD) height was 147.9 ± 5.2 cm, weight was 40.5 ± 4.6 kg, and BMI was 18.5 ± 1.8.

The relation between BMI and all-cause mortality by quartile and decile categories is shown in **Table 2**. Both categorizations show a reversed J-shaped pattern, with the highest mortality observed for women in the lowest quartile or decile of BMI. The relation between BMI and mortality was significant in both

TABLE 2
BMI and all-cause mortality risk: hazard ratios (HRs) from bivariate analyses

	No. who died	No. who survived	No. censored	HR	SE (*P*)	LR statistic (*P*)[1]
BMI categorized by quartiles						
Quartile cutoff and BMI						
<25%, <17.30[2]	38	376	58	1.00	—	—
25–49%, 17.30–18.41	27	385	63	0.70	0.18 (0.153)	—
50–74%, 18.42–19.61	14	397	60	0.36	0.11 (0.001)	—
75%, >19.61	23	367	80	0.61	0.16 (0.06)	12.17 (0.006)
BMI categorized by 10% and 90% deciles						
Decile cutoff						
≤10%, <16.39[2]	24	142	23	1.00	—	—
10–89%, 16.39–20.71	69	1234	207	0.35	0.12 (0.001)	—
≥90%, >20.71	9	149	31	0.37	0.14 (0.01)	16.63 (0.001)

[1] Likelihood ratio (LR) test statistic for $\beta = 0$ or HR = 1.00.
[2] Reference category.

categorizations. Weight was also significantly associated with mortality. However, because it was strongly correlated with BMI, we reported the BMI because it adjusted weight for height. Height was not significantly associated with mortality (**Table 3**), although arm circumference grouped as decile categories was (**Table 4**).

Age and socioeconomic factors also had a significant effect on the risk of mortality (**Table 5**). Older women, Hindu women, and women with no education, with smaller houses, who had to travel further for water, whose husbands had lower level occupations, and who owned fewer items were more likely to die. Land owned, cows owned, boats owned, size of family, source of drinking water, and wall materials were not significantly associated with mortality or nutritional status and, therefore, are not shown.

Because age is such an important determinant of mortality, its potential role as a confounder in the relation between socioeconomic status and mortality was examined (data not shown). Although husband's occupational status was higher among the older women and education was higher among the younger women, the association between socioeconomic indicators and mortality after adjustment for age remained significant and similar to the crude associations. Height and arm circumference were not independent predictors of mortality in the multivariate analysis.

Hazard models that included BMI and the individual and household-level socioeconomic factors are shown in **Table 6**. Complete data on all covariates were available for 1816 women. After adjustment, age and education were the most important predictors of mortality. Religion was of borderline significance, but the other socioeconomic variables were not significant. BMI maintained an independent reverse J-shaped relation with mortality after adjustment for other variables. The BMI associated with the lowest significant risk was that in the intermediate range (16.39–20.71), where women were 0.45 times less likely to die (95% CI: 0.27, 0.73) than were those with a BMI of < 16.39. After adjustment, the topmost decile or quartile of BMI was not significantly different from the reference category. The LR statistic indicated the extent to which models including BMI improve the prediction of mortality compared with models containing only socioeconomic and demographic factors, and both were significant. Decile groupings of BMI were a significant addition but quartiles were not (*P* = 0.009 and 0.08, respectively; LR test).

Illness-induced weight loss before recruitment could overestimate the mortality risk in persons with low BMIs. This was assessed by excluding deaths in the first 4 y of follow-up. The observed pattern for the association between BMI and mortality remained the same as that for the full follow-up period, with

TABLE 3
Height and all-cause mortality risk: hazard ratios (HRs) from bivariate analyses

	No. who died	No. who survived	No. censored	HR	SE	LR statistic (*P*)[1]
Height categorized by quartiles						
Quartile cutoff and height						
<25%, <1.440[2]	35	385	70	1.00	—	—
25–49%, 1.441–1.479	31	484	101	0.72	0.18	—
50–74%, 1.480–1.512	24	461	73	0.60	0.16	—
75%, 1.513	29	439	70	0.75	0.19	4.01 (0.26)
Height categorized by 10% and 90% deciles						
Decile cutoff and height						
≤10%, <1.415[2]	19	177	26	1.00	—	—
11–89%, 1.416–1.549	89	1414	258	0.60	0.10	—
≥90%, 1.545	11	178	30	0.58	0.25	2.34 (0.31)

[1] Likelihood ratio (LR) test statistic for $\beta = 0$ or HR = 1.00.
[2] Reference category.

TABLE 4
Arm circumference and all-cause mortality risk: hazard ratios (HRs) from bivariate analyses

	No. who died	No. who survived	No. censored	HR	SE	LR statistic (P)[1]
Arm circumference categorized by quartiles						
Quartile cutoff and arm circumference						
<25%, <21.0[2]	40	463	61	1.00	—	—
25–49%, 21.0–22.0	30	412	72	0.84	0.20	—
50–74%, 22.1–23.0	19	380	77	0.57	0.16	—
75%, >23.0	23	407	66	0.66	0.17	5.14 (0.16)
Arm circumference categorized by 10% and 90% deciles						
Decile cutoff and arm circumference						
≤10%, <20.0[2]	22	162	27	1.00	—	—
11–89%, 20.0–24.1	83	1337	221	0.48	0.11 (0.002)	—
≥90%, >24.1	7	163	28	0.34	0.16 (0.01)	9.79 (0.007)

[1] Likelihood ratio (LR) test statistic for $\beta = 0$ or HR = 1.00.
[2] Reference category.

women in the lowest BMI deciles having the highest mortality. The hazards ratios (after adjustment for age and socioeconomic status) in the 11–89% group changed from 0.45 for the 1–17 y follow-up to 0.51 for the 5–17 y follow-up; in the ≥90% group, they changed from 0.55 for the 1–17 y follow-up to 0.70 for the 5–17 y follow-up. In both instances, the risk in the intermediate group (11–89%) was significantly lower than the risk in the ≤10% group, but the smaller sample size meant that the P value of the LR statistic with the 5–17-y model was 0.068, which was of borderline statistical significance.

The study included 61 young married women aged 10–14 y who may not have reached their maximal adult height. However, only one of these women died during the follow-up period. Recalculation of the models excluding these women did not significantly alter the hazard ratios (data not shown).

DISCUSSION

To our knowledge, this study is the first to report on the association between BMI and mortality in women from developing countries whose nutritional status is considerably lower than that of women in Europe or the United States. Low BMI, together with older age and lack of education, was significantly associated with increased mortality.

In addition to presenting data that are scarce in developing countries, an important strength of this study is the quality of the

TABLE 5
Age and socioeconomic indicators: hazard ratios (HRs) from bivariate models and models adjusted for age

Variable	No. who died	No. who survived	No. censored	Bivariate models HR	SE (P)	LR statistic (P)[1,2]
Age	126	1861	327	1.05	0.01 (0.001)	20.86 (0.001)
Religion						
Muslim	106	1710	236	1.00	—	—
Hindu	20	151	91	1.70	0.41 (0.03)	4.18 (0.04)
Education						
Yes	16	443	88	1.00	—	—
No	110	1418	239	2.11	0.56 (0.005)	9.34 (0.002)
Education level						
0 y	110	1418	239	1.00	—	—
1–5 y	15	388	68	0.51	0.14 (0.01)	—
≥6 y	1	55	20	0.23	0.23 (0.1)	10.08 (0.006)
Dimension of house						
0–17 m^2	58	606	109	1.00	—	—
≥18 m^2	67	1215	210	0.59	0.12 (0.008)	6.75 (0.009)
Distance to water						
<14 m	34	642	125	1.00	—	—
≥14 m	90	1156	148	1.48	0.30 (0.05)	3.81 (0.05)
Husband's occupation						
High level	34	736	165	1.00	—	—
Low level	92	1120	161	1.80	0.36 (0.003)	9.32 (0.002)
Items owned						
≥11	33	627	123	1.00	—	—
0–10	92	1196	196	1.47	0.30 (0.05)	3.80 (0.05)

[1] Likelihood ratio (LR) test statistic for $\beta = 0$ or HR = 1.00.
[2] Model adjusted for age, entered as a continuous variable.

TABLE 6
Hazard ratios (HRs) for BMI, age, education, and all-cause mortality risk from adjusted analyses

	Crude HR	Adjusted HR	(95% CI)	LR statistic (P)[1]
BMI categorized by quartiles				
Quartile cutoff and BMI				
<25%, 17.3[2]	1.00	1.00	—	—
25%, 17.3–18.41	0.74	0.82	(0.50, 1.37)	—
50%, 18.42–19.61	0.38[3]	0.46	(0.25, 0.87)	6.86 (0.08)
75%, >19.61	0.65	0.89	(0.52, 1.52)	—
Age	—	1.04	(1.02, 1.06)[3]	—
No education	—	4.12	(1.69, 10.38)[3]	—
BMI categorized by 10% and 90% deciles (n = 1816)[4]				
Decile cutoff and BMI				
≤10%, <16.39[2]	1.00	1.00	—	—
11–89%, 16.39–20.71	0.34	0.45	(0.27, 0.73)[3]	9.44 (0.009)
≥90%, >20.71	0.38	0.55	(0.25, 1.22)	—
Age	—	1.04	(1.02,1.07)[3]	—
No education	—	4.23	(1.70,10.49)[3]	—

[1] Likelihood ratio (LR) test statistic for $\beta = 0$ or HR = 1.00.
[2] Reference category.
[3] $P < 0.05$.
[4] Adjusted for covariates: age, education level, religion, husband's occupation, distance to water, dimension of the house, and the number of items owned (categories as described in Table 5).

anthropometric and demographic data. Direct anthropometric measurements avoided recall errors (5, 22), adjustments were made for pregnancy-related weight changes, and seasonal weight fluctuations (average: ≈1 kg/y; 19) were controlled by using summary weight measurements. Reliable prospective demographic data (dates of death and out-migration) and socioeconomic variables were available from the Matlab DSS. The 17-y follow-up period was sufficiently long to permit analysis of possible bias from early mortality due to subclinical disease (11). Finally, this study was able to describe a general population with low BMIs because smoking and alcohol use by women in rural Bangladesh are negligible and, thus, are unlikely to be confounders or effect-modifiers of the BMI-mortality association (6, 11, 23).

Despite these advantages, the data also have several limitations. The relatively small initial cohort size, young age profile, and exclusion of women with incomplete data led to analyses based on few deaths. This constrained the statistical power, particularly when early mortality was adjusted for. In addition, the quality of the cause-of-death classification and the small sample size did not permit analyses of BMI and causes of death.

The relation between BMI and mortality seen in Bangladesh is similar to the relation observed in most other studies in this field, all of which showed a nadir of mortality risk in BMIs of intermediate levels (2, 5, 22, 24). Women in the lowest 10% decile of BMI were 2.2 times more likely to die during the follow-up period than were women in the 11–89% range of the BMI decile distribution. Women in the top 90% decile were 1.8 times more likely to die than were women in the lowest group (NS). However, the observed reverse J-shape distribution for the quartile groups was slightly different from the J-shape observed in other studies. In this cohort, an upward increase in mortality was apparent only in the uppermost quartile and was only marginally significant. In studies of populations with higher BMIs, increased mortality was reported in the 3rd and 4th quartiles (3, 9, 22, 25). A comparison of the mortality risks associated with BMI quartiles in this Bangladeshi study with those observed in a 29-y cohort study of US white women is depicted in **Figure 1** (5).

Bangladesh is one of the world's poorest countries, with food insecurity, poor health care, low levels of education in males and females, and high rates of landlessness (18, 26). The rural Bangladeshi women in this study had an average BMI of 18.5, an average weight of 40.5 kg, and an average height of 147.5 cm. These distributions are similar to those observed in other studies of rural Bangladeshi women in the 1980s and 1990s (16, 18, 27) but differ markedly from, for example, those of a US cohort in which the mean BMI in white and black women is 24.5 and 27.7, respectively (3). None of the women in this study were obese, whereas 25% of white women and 46% of black women in the Charleston Heart Study were obese, ie, had a BMI ≥ 27.3 (3); in contrast, none of the women in the present study were obese.

There is considerable debate about the appropriateness of international standards for BMI. In the present study, the lowest mortality was observed in women with BMIs of 16.39–20.71 and in

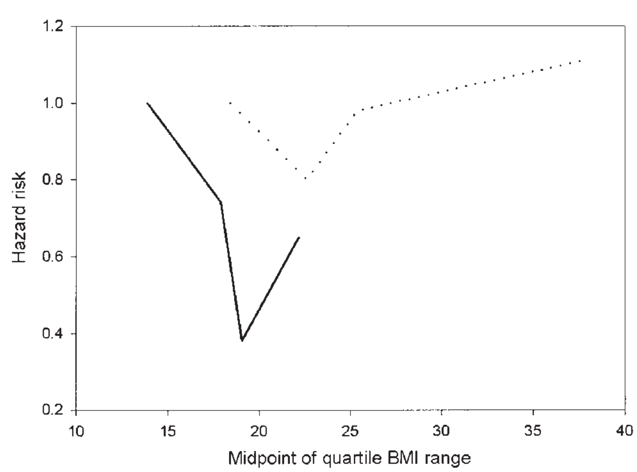

FIGURE 1. Association between the hazard risk of mortality and BMI quartiles for 1816 Bangladeshi women (—) and 697 white women aged 20–96 y from the United States (- - -; modified from reference 5).

the quartile grouping with BMIs of 18.42–19.61. These levels are considerably lower than the World Health Organization's recommendations of 20–25 (10). In addition, some of the women with the lowest mortality had BMIs below the 18.9 cutoff for chronic energy deficiency. A comparison of our results with those of populations with very different nutritional and health status suggests that the level of a woman's BMI relative to the distribution of BMI in the local population may be a better predictor of mortality than is absolute BMI. James (28) used Indian data to suggest that at low BMIs, sufficient energy intake to provide for the basal metabolic rate may offset the risks associated with low BMIs. Studies in the United Kingdom that compared women from different ethnic groups found that women of South Asian and Afro-Caribbean descent are more susceptible to complications of obesity at any given BMI than are women of European descent (29, 30). South Asians have a higher prevalence of an insulin resistance syndrome than do other ethnic groups, which is associated with higher rates of central obesity, coronary heart disease, and mortality. However, although there may be important differences between populations in the BMIs that are associated with the lowest mortality risk, on the basis of the small sample in the present study we would not argue that such low BMIs be adopted as reference standards for Bangladeshi women.

Other measures of nutritional status, namely height and arm circumference, did not show independent effects. Height was not significant, even in the bivariate analysis. This is surprising given the finding in Western literature that height is an important predictor (13, 31, 32). Arm circumference was a significant predictor in the bivariate but not in the multivariate model. More work is also needed in developing countries to relate nutritional status to other outcome measures, including cause-specific mortality, illness, physical activity, and reproductive function. Although women with intermediate BMIs as low as those observed in the present study are relatively protected against mortality, there was no information on their experience of illness and disability. Such studies are easier to conduct than are mortality studies because they require shorter follow-up periods and smaller sample sizes. The mechanisms by which low BMI affects mortality are unclear, and further exploration of the interrelation among basal metabolic rate, energy intake, energy expenditure, BMI, and other indicators of body composition is also required (27, 28).

Finally, the results show that age, education, and other socioeconomic factors were strong predictors of mortality, although only age and education had statistically significant independent effects in the multivariate models. The 4-fold increase in the risk of death for women with no schooling was striking. Such data from developing countries are rare because education level is not collected as part of the routine vital registration of deaths. Mostafa and van Ginneken (33) recently presented Matlab data showing that among women aged <60 y, mortality rates decreased from 505.9/1000 women for those with no education to 259.3/1000 women for those with ≥ 5 y of education. It was shown previously that the higher a woman's education level, the higher her children's probability of survival (34); it is noteworthy that education level also plays an important role in women's survival. The magnitude of this effect of education level also puts the more modest effect of BMI into context.

In conclusion, we observed a reverse J-shaped relation between BMI and mortality. The level of BMI associated with the lowest mortality was considerably lower than that found in populations in developed countries. This finding indicates that relative BMI may be more important than absolute BMI in predicting mortality. Mortality risk is strongly associated with age and, perhaps more importantly in intervention programs, with education.

We foremost thank the ICDDR,B for providing access to these unique data sets, particularly Mike Strong for his advice and support of the study. We also thank Sharon Huttly and Tom Marshall for valuable suggestions during the analysis phase and Anna-Maria Vanneste for providing tireless assistance, particularly for providing additional cause-specific mortality data and for reviewing the PhD thesis.

REFERENCES

1. Lew E, Garfinkel L. Variations in mortality by weight among 750 000 men and women. J Chronic Dis 1979;32:563–76.
2. Rissanen A, Knekt P, Heliovaara M, Aromaa A, Reunanen A, Maatela J. Weight and mortality in Finnish women. J Clin Epidemiol 1991;44:787–95.
3. Stevens J, Keil JE, Rust P, Tyroler H, Davis C, Gazes P. Body mass index and body girths as predictors of mortality in black and white women. Arch Intern Med 1992;152:1257–62.
4. Wienpahl J, Ragland D, Sidney S. Body mass index and 15 y mortality in a cohort of black men and women. J Clin Epidemiol 1990;43:949–60.
5. Dorn JM, Schisterman EF, Winkelstein WJ, Trevisan M. Body mass index and mortality in a general population sample of men and women. Am J Epidemiol 1997;146:919–31.
6. Sidney S, Friedman G, Siegelaub A. Thinness and mortality. Am J Public Health 1987;77:317–22.
7. Yuan J-M, Ross RK, Gao Y-T, Yu MC. Body weight and mortality: a prospective evaluation in a cohort of middle-aged men in Shanghai, China. Int J Epidemiol 1998;27:824–32.
8. Lee I, Manson J, Hennekens C, Willett W. Body weight and mortality: a 27-y follow-up of middle-aged men. JAMA 1993;270:2823–8.
9. Lindsted K, Tonstad S, Kuzma J. Body mass index and patterns of mortality among Seventh-day Adventist men. Int J Obes 1991;15:397–406.
10. Kushner RF. Body weight and mortality. Nutr Rev 1993;51:127–36.
11. Manson JE, Stampfer MJ, Hennekens CH, Willett WC. Body weight and longevity. A reassessment. JAMA 1987;257:353–8.
12. BRAC-ICDDR,B. Socio-economic development and health. A joint BRAC-ICDDR,B research project. Baseline Survey Matlab, 1992. Dhaka, Bangladesh: ICDDR,B, 1994.
13. Peck A, Vagero D. Adult body height, self perceived health and mortality in the Swedish population. J Epidemiol Community Health 1989;43:380–4.
14. Garcia M. Assessing the linkage between low body mass index and morbidity in adults: evidence from 4 developing countries. Eur J Clin Nutr 1994;48:S90–7.
15. Kusin J, Kardjati S, Renqvist U. Maternal body mass index: the functional significance during reproduction. Eur J Clin Nutr 1994;48:56–67.
16. Pryer J. Body mass index and work-disabling morbidity: results from a Bangladeshi case study. Eur J Clin Nutr 1993;47:653–7.
17. Naidu A, Rao N. Body mass index: a measure of the nutritional status in Indian populations. Eur J Clin Nutr 1994;48:S131–40.
18. Faveau V. Matlab: women, children and health. Dhaka, Bangladesh: Pioneer Printing Press, 1994.
19. Huffman SL, Wolff M, Lowell S. Nutrition and fertility in Bangladesh: nutritional status of nonpregnant women. Am J Clin Nutr 1985;42:725–38.
20. Zimiki S, Nahar L, Sarder AM, D'Souza S. Demographic surveillance system—Matlab. Cause of death reporting in Matlab. In: ICDDR B, ed. Source book of cause-specific mortality rates 1975–1981. Vol 13. Dhaka, Bangladesh: ICDDR,B, 1985.
21. Parmer M, Machin D. Survival analysis. A practical approach. Chichester, United Kingdom: John Wiley and Sons, 1995.

22. Folsom A, Kaye S, Sellers T, et al. Body fat distribution and 5-y risk of death in older women. JAMA 1993;269:483–7.
23. Fitzgerald A, Jarrett R. Body weight and coronary heart disease mortality: an analysis in relation to age and smoking habit: 15 y follow-up data from the Whitehall Study. Int J Obes Relat Metab Disord 1992;16:119–23.
24. Singh P, Lindsted K, Fraser G. Body weight and mortality among adults who never smoked. Am J Epidemiol 1999;150:1152–64.
25. Manson J, Colditz G, Stampfer M, et al. A prospective study of obesity and risk of coronary heart disease in women. N Engl J Med 1990;322:882–9.
26. Wood G. Bangladesh: whose ideas, whose interests? London: Intermediate Technology Publications, 1994.
27. Vinoy S, Rosetta L, Mascie-Taylor C. Repeated measurements of energy intake, energy expenditure and energy balance in lactating Bangladeshi mothers. Eur J Clin Nutr 2000;54:579–85.
28. James W. Introduction: the challenge of adult chronic energy deficiency. Eur J Clin Nutr 1994;48:S1–9.
29. McKeigue P, Shah B, Marmot M. Relation of central obesity and insulin resistance with high diabetes prevalence and cardiovascular risk in South Asians. Lancet 1991;337:382–6.
30. Pomerleau J, McKeigue P, Chaturvedi N. Factors associated with obesity in South Asian, Afro-Caribbean and European women. Int J Obes Relat Metab Disord 1999;23:25–33.
31. Leon D, Davey Smith G, Shipley M, Strachan D. Adult height and mortality in London: early life, socioeconomic confounding, or shrinkage? J Epidemiol Community Health 1995;49:5–9.
32. Waaler H. Height, weight and mortality. The Norwegian experience. Acta Med Scand 1984;679(suppl):1–59.
33. Mostafa G, van Ginneken J. Trends in and determinants of mortality in the elderly population of Matlab, Bangladesh. Soc Sci Med 2000; 50:763–71.
34. Cleland J, van Ginneken J. Maternal education and child survival in developing countries: the search for pathways of influence. Soc Sci Med 1988;12:1357–68.