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Heights of Populations — an Index of Their Nutrition and Socio-economic Development

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The conventional indices employed by economists and planners to assess the state of development of a country do not generally include any index which *directly* reflects the *quality* of its human resources. Purely economic indicators of national development such as GNP may, perhaps suffice in the case of developed countries of Europe and North America where populations have already attained near-maximal levels of health and nutrition. The major objective of the planning process in the case of such developed countries, at present, is a further increase in their economic prosperity, which has already reached levels more than adequate to meet all their basic human physiological needs. In the case of less fortunate developing countries like India, however, the primary and major objective of national planning and 'development' is (or, at least, should be) the removal of prevailing constraints posed by poverty, ill-health and undernutrition on human growth and (human) development, and, consequently, on the full expression of the genetic endowment of the population. Under the circumstances, it will be appropriate and necessary that the success (or otherwise) of the planning process in these countries is assessed by yardsticks which provide a *direct* measure of its impact on levels of human growth and human development.

Reductions in infant mortality rate and increase in life expectancy — yardsticks generally used to measure plan achievements — no doubt, do provide a measure of the overall improvement in health status. However, important and useful as these indicators are, they are no more than indices of the "state of survival" of a population. They do not tell us much about the state of health, nutrition and well-being of the survivors. What we need for this purpose is a measurement — simple, feasible and capable of application on a national scale, which will provide an indication of the status of the survivors and of the impact of national developmental programmes thereon.

It is in this context that the merits of a continuing programme of annual measurements of heights of sufficiently large and representative *population groups* across the country deserve consideration.

Height measurements have a special place as an index of socio-economic development in developing societies in which populations have yet to find full expression to their genetic potential for growth. Quantification of height deficits in such populations (through comparison of their actual height with potential height) could provide a measure of the degree of their underdevelopment. Cross-sectional studies among different segments of the society could indicate differences in their degrees of underdevelopment. Serial studies could provide indications of secular trends and of the nutritional impact of development.

Practical considerations: The facile assumption often made that "stunting" can be ignored if the subjects happen to have "appropriate weights for heights" has now been shown to be unwarranted.

Tanner (*Social Science History, Vol. 6*: 571-581, 1982) in his remarkable paper on 'The potential of auxological data for monitoring economic and social well-being' has provided a fascinating historical account which highlights the great value of height measurement as an instrument for monitoring progress with respect to the state of health, nutrition and well-being of communities. Steckel (*Historical Methods*, 16.1.1983) found a close correlation between height and per capita income in a study based on the result of 56 height studies and per capita income estimates for 20 countries. When it is recognised that "socio-economic" factors and per capita income could affect height only by mediating changes in nutritional inputs, the importance of height as a measure of nutritional status of a community will become obvious.

Biological significance of height measurements: Why are height measurements important? We will now briefly review some available evidence relevant to this question.

Tanner quotes Villerme who wrote as long ago as 1828 that: "Human height becomes greater and growth takes place more rapidly, other things being equal in proportion as the country is richer, comfort more general, houses, clothes and nourishment better, and labour, fatigue and privations during infancy and youth less; in other words, circumstances which accompany poverty delay the age at which complete stature is reached and stunt adult height."

In Japan, between 1957 and 1977, average mature height increased by 4.3 cm in males and 2.7 cm in females; age at maximum increment dropped by 0.97

years in males and 0.53 years in females. Practically all the height increase was due to increase in leg length, not in sitting height, with the result that within 20 years of economic advancement, the entire body proportions of the Japanese had changed. This is perhaps the most striking and spectacular evidence of the importance of height measurements as an index of the nutritional status of a population which parallels economic advancement; and shows that height measurement is an indicator of as much importance to the developmental economist and planner as it is the health/nutrition scientist.

There is a large body of evidence pointing to a relationship between height and mental function. Indeed, as early as 1893, William Porter (quoted by Tanner) had shown in the schools of St. Louis that pupils who were academically advanced for their age were also taller. There have been quite a few similar observations in recent years pointing to a correlation between height and IQ.

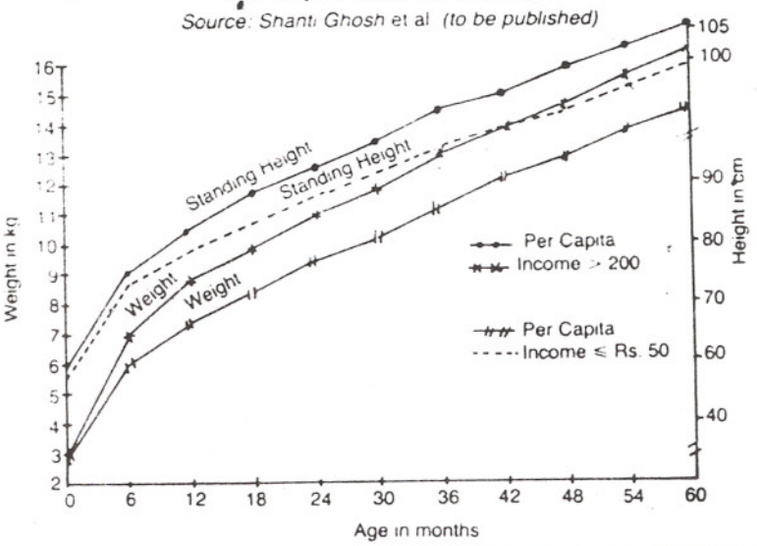
Tanner also quotes that in Norway, in a massive study in which height measurements were recorded in 1.8 million subjects over 15 years of age, it was found that mortality in those of heights 185-189 cm was half the rate with those of height 150-155 cm. A similar lower mortality among taller children less than five years old in Ghana has also been reported by Billewicz *et al* (*Annals of Human Biology* 3: 399, 1982).

Reviewing all the available evidence on height measurements and attempting an answer to the question: "Is being taller better?", Tanner concludes: "It does look, therefore, as though height indeed can be a proxy for health and for the attainment of biological potential. This is true, of course, only when comparing groups, not in comparing isolated individuals, the variation between whom is overwhelmingly due to genetic causes. But between social classes, urban and rural dwellers, the educated and uneducated, height is a useful proxy for 'aisance de vie'."

Height measurements will not only be helpful in monitoring *secular* trends in nutrition and economic status; they will also be useful in interregional and interclass comparisons of nutritional status. Height measurements could help to bring out glaring socio-economic inequalities and the consequent disparities in nutritional status among classes within countries. Bielicki *et al* (*Human Biol* 53: 543-556, 1981) showed that the sons of Polish peasants raised in villages in families containing four children were distinctly shorter than sons of professional men with small families working in large cities. Goldstein (*Human Biol.* 43: 91-111, 1971) reported a similar phenomenon in the U.K. on the basis of a national sample survey of heights of seven-year-olds in 1971.

Figure: Weights and Heights of Girls by Per Caput Income and age.

Source: Shanti Ghosh et al (to be published)



In the United Kingdom difference between the average heights of non-manual classes (class III) and labouring classes (class IV and V) has been reported by Clements and Picket in 1957 (quoted by Tanner); strangely enough, the data of the office of Population Censuses and Surveys of 1980 show that this difference still persists.

It is only with respect to Scandinavian countries — Sweden and Norway — that there is, today, convincing published evidence of absence of significant differences with respect to height as between occupational classes. The attainment of such a situation of equity and distributive justice wherein there are no striking differences with respect to nutritional status as between different occupational and income groups, must be considered as the hallmark of truly successful socio-economic development; in such a situation, even the groups with the lowest income levels are apparently able to achieve an optimal level of nutrition. Unfortunately, most developing countries are apparently still far away from this goal. Not only is the general level of health and nutrition in their populations low, there are also apparently far greater evidences of disparities among populations. Evidence of differences in height as between different occupation groups in India are unfortunately quite striking as observation that follow will show.

Indian studies: Three Indian studies covering fairly large numbers of subjects indicate the value of height as a measure of nutritional status. In these studies, height measurements (along with weight measurements) have been carried out in subjects of different socio-economic groups; it has been presumed that the dietary intake would largely parallel the socio-economic status, and in any case, as was pointed out earlier, there is no way by which socio-economic or occupational status can exert a direct metabolic effect on the body in order to influence height except through its effect on nutritional inputs. So it will be justifiable to view the observed relationship in these studies between height and economic status as in fact a relationship between height and nutritional status.

Shanti Ghosh and her colleagues (paper to be published) carried out an extensive longitudinal study on growth and development of children of different socio-economic groups, followed from birth for periods extending now to nearly 15 years. Nearly 8,200 children were covered in the study. The communities investigated ranged from the poorest (less than Rs. 50 per head per month — 1969 level) of the middle class (more than Rs. 200 per head per month — 1969 level). The longitudinal data from children belonging to those two income groups (Figure) show a clear relation-

ship between socio-economic status and heights and weights of children.

K. Satyanarayana and colleagues (*Ann. Hum. Biology* 7. 359-365, 1980) at the National Institute of Nutrition, Hyderabad, have assembled data from longitudinal observations on the heights and weights of children of different socio-economic groups in rural Hyderabad observed over a 15-year period (five to 20 years). The children belonging to their Group I with heights between M and M−2 SD of Boston Standard, mostly came from families of affluent landlords owning more than five acres of fertile land; those of their Group III were from the poorest rural households owning no land of their own, with adults being illiterate and eking out their living from seasonal agricultural wage-labour. In Table 1 some of their observations have been set out. The same table also shows data on heights and weights of children of the most affluent Indian communities as observed and reported by D. Hanumantha Rao and Gowrinath Sastry (*Ind. Jour. Med. Res.* 66. 950-956, 1977) of the same Institute, on the basis of their cross-sectional studies. The striking differences betwen the different socio-economic groups will again be obvious.

The National Nutrition Monitoring Bureau in Hyderabad, India has recently completed a study of the dietary, nutritional and anthropometric status of 32,332 subjects (12,925 adults and the rest children) drawn from 15 major cities of India (National Nutrition Monitoring Bureau Report on Urban Populations — 1975-79: National Institute of Nutrition publication, 1980). The sample households were classified into five major socio-economic categories.

The high income group (HIG) and the slum labour (SL) represented the two extreme ends of the economic spectrum, with the other three groups lying in between. The SL was the group subject to the greatest socio-economic deprivation — poor, largely illiterate or semi-literate, living in highly overcrowded and unhygienic conditions and having to depend mostly on unskilled manual labour to eke out a precarious livelihood. Their diets were decidedly lower in energy content and their children showed a higher prevalence of signs of vitamin deficiency.

The heights and weights of children and adults faithfully reflected the socio-economic gradient with the HIG at one end and SL at the other and the other groups falling in between. For the sake of convenience only part of the data from the two groups at the extreme ends (HIG and SL) have been set out in Tables 2 and 3.

Table 1

Longitudinal Studies of Growth of Indian Children of Different Socio-economic Groups

Group	Initial (5 yrs. age)		Final (20 yrs. age)	
	Ht. (cm)	Wt (kg.)	Ht. (cm)	Wt (kg.)
I Mostly from families of well-to-do landlords * (owning about 5 acres of fertile land)	104.7 (2.90)	15.3 (1.4)	167.8 (6.26)	51.5 (6.6)
III Mostly from families of agricultural labourers * on seasonal daily wages	89.2 (4.02)	11.5 (1.08)	157.8 (6.09)	44.0 (3.91)
Affluent**	108.0	18.3	171.8	59.6

*Based on * K. Satyanarayana:* Int. Cong. of Nutrition, *Brighton, 1985*
** *D. Hanumantha Rao and J. Gowrinath Sastry:* Ind. Jour. of Med. Res. *66.950. 956.*

Table 2

Heights and Weights of Children

Age (years)	Sex	Height — cm		Weight — kg	
		HIG	Slum	HIG	Slum
5	Boys	110.4	99.8	18.2	13.9
	Girls	107.6	98.7	16.2	13.6
12	Boys	144.2	132.6	30.8	25.1
	Girls	140.4	133.7	29.9	26.8
16	Boys	164.5	154.7	46.2	38.6
	Girls	156.2	148.6	43.1	39.1

Source: NNMB Report on urban populations 1975-1979 (1980). National Institute of Nutrition, Hyderabad.

Table 3

Heights and Weights of Adults

Age group	Heights (cm)		Weights (kg)	
	HIG	SL	HIG	SL
20-25 years M	166.4	161.4 (161.0-164)	50.4	46.6 (47.2-49.8)
20-25 years F	154.6	150.1 (149.4-151.9)	46.8	41.7 (41.0-44.2)
40-45 years M	166.8	161.2	66.3	48.1
40-45 years F	153.1	149.6	56.0	41.6

Figures within brackets in cols. 3 and 5 are measurements of corresponding rural groups.

Source: NNMB Report on urban populations 1975-1979 (1985) National Institute of Nutrition, Hyderabad

The poverty trap: The outstanding finding in all the three Indian studies cited above is the striking relationship between income and occupational status on the one hand and physical stature on the other. It would appear tha the more *lowly* (using the expression fo the sake of convenience) the job that a community is engaged in, the greate the degree of stunting in its children and adults. The cart-pullers, the scavengers manual labourers (including those en gaged in strenuous work), stone-cutters porters having to carry heavy loads and agricultural labourers are apparently the

ones who are most stunted and have the lowest body weights; unfortunately, these are precisely the occupation groups (not the business executives and academicians) who stand in greatest need of a sturdy body-build for optimal productivity and output and for earning a reasonable wage from their occupation.

It is unlikely that differences in height for age of the order observed in India (and possibly other developing countries) as between different income/occupation groups within the country, will be seen in developed countries. It is precisely for this reason that height measurement acquires special importance and significance as an indicator of socio-economic development in developing countries.

It is not so much the retardation of physical growth *per se* and the relatively small body size of the poor that need bother us. It is the fact that there is now mounting evidence, thanks to sophisticated functional tests which measure physical stamina and work capacity on the one hand and mental development and learning ability on the other, that impairment in physical growth (as assessed by failure to achieve the full genetic potential for the attainment of physical stature) is accompanied by varying degrees of functional incompetence. The fascinating work of Spurr *et al* in Colombia (*Am. Jour. Clin. Nutr.* 39. 452-459, 1984; *Human Biology*, 54. 553-574, 1982; *Am. Jour. Clin. Nutr.* 37. 834-847, 1983); Chavez *et al* in Mexico (*Growing Up in a Developing Community*: Inst. Nacional Nutricion, Mexico, 1982); Viteri in Guatemala (*Amino-acid Fortification of Protein Foods*. Ed. Scrimshaw & Htschull, M.I.T. Press, Cambridge, 350-375, 1971) and Satyanarayana *et al* in India (*Am. Jour. Clin. Nutr.* 30.322-325, 1977) have provided ample evidence of the functional implications of growth retardation. Indeed there is often a linear relationship between the degree of growth retardation and the degree of physical and mental functional impairment. Measurement of the degree of growth retardation thus could serve as a proxy for the assessment of functional competence.

In a longitudinal study on undernourished boys in India, Satyanarayana and colleagues (*Am. Jour. Clin. Nutr.* 32. 1769-1775, 1979) showed that the wages earned by adolescent boys employed by farmers in rural areas were significantly related to body weight and height. Men and women with better nutritional anthropometry earned 30 percent to 50 percent additional incentive money (over and above the uniform basic pay) in factories where individual incentive system based on work output was in operation.

Table 4

Maternal Height and Incidence of Low Birth Weight in Offspring

Maternal height (cm)	Income group	Incidence of L.B.W.
Less than 145 cm	Less than Rs. 50 per head per month	35.5%
More than 145 cm	–do–	24.2%
More than 145 cm	More than Rs. 200 per head per month	15.0%

Source: *Shanti Ghosh* et al.

A considerable proportion of girls in developing countries who are stunted and of low body size because of undernutrition during the crucial years of their growth and development end up with heights below 145 cm when they enter motherhood. It is now known that there is a direct relationship between stunting of the mothers and the occurrence of low birth weights in their offspring. According to the recommendations of international agencies, maternal heights below 145 cm may be considered indicative of risk of obstetric complications and low birth weight. It will be seen from the data presented in Table 4 based on a study by Shanti Ghosh *et al.* in India that a distinctly higher proportion of offspring of mothers with heights less than 145 cm were of low birth weight. In India, as in many other developing countries, more than one-third of all infants born alive are of birth weights below 2,5000 gm. It is now known that both with respect to height and weight, infants who start with the initial handicap of low birth weight apparently never fully recover from their initial handicap. Thus low birth weights in full term infants make a lasting contribution to stunting.

Stunting is the outstanding feature of so-called 'adaptation'. It is the feature that ensures that, not just this generation but the next as well, does not escape from the poverty trap. Stunted children with impaired learning abilities and schooling end up as stunted adults with low levels of productivity, educational attainment and resourcefulness and earn low incomes and thus continue to be enmeshed in the poverty trap and so unable to feed their children adequately. Stunted women beget offspring with low birth weights who start their lives with an initial handicap from which they never fully recover. Thus stunting and poverty with which it is invariably associated continue from one generation to another. To view this scenario as "acceptable adaptation" is cruel irony!

A country or community in which large segments of the population suffer from growth retardation and resultant stunting and small body size, is one in which the quality and calibre of human resources is eroded and is of substandard quality.

A community in which a considerable part of the population is stunted is usually a community with high infant and child mortality, high levels of morbidity in children, high rate of drop-outs from schools. This is also a community in which children have lost valuable time for learning skills, mothers have lost considerable part of their daily wages and health services are so overburdened with a heavy load of curative work to the point that preventive and promotive health programmes are relegated to the background.

A Programme for Use of Height Measurements as an Indicator

In view of the considerations discussed above, there would appear to be a sound case for the institution of a country-wide programme of:

- measurements of heights of children six to seven years of age in our rural schools to be repeated systematically in the same schools annually; and
- measurements of heights of adults (men and women) belonging to different occupation (and income) groups in different parts of the country to be systematically repeated once in five years.

The National Nutrition Monitoring Bureau (NNMB) at the National Institute of Nutrition, Hyderabad, has been carry-

ing out height measurements as part of its very useful, though limited, monitoring programme. The same Institute has also carried out several *ad hoc* research studies in which heights of small population groups in the country have been compared (some of these studies have been referred to in this paper). But what is envisaged in the present proposal is a much larger programme of height measurement carried out systematically on a country wide scale. If height measurements have to serve as a meaningful indicator of changing trends with respect to nutritional status of communities across the country, such measurements may have to be organised somewhat differently and conducted on a much wider scale. Such a study could very well become part of an expanded programme of operations of the National Nutrition Monitoring Bureau. It is, however, not the purpose of this paper to discuss the statistical design, and the organisational and operational details of such a study.

The most appropriate and convenient age group that could be immediately captured for large scale height surveys would be school children of the six to seven year age group — i.e. those belonging to the 1st or 2nd standard (the stage at which drop-outs are few). We have a ready-made institutional infrastructure for this purpose. According to the All-India Education Survey of 1982, there were nearly 5.6 lakh rural schools in the country, a school within a radius of 1 km of practically every village in the country. Of the estimated 55 to 60 million children in rural schools, probably between one-fourth to one-third may fall in the six to seven year age category. It is certainly not being suggested here that we should launch as ambitious a programme as that of Japan, in which *all* school children between five and 17 years have been measured for height *annually* for nearly 40 years now. In fact, it is these measurements that have provided (and continue to provide) the most convincing scientific evidence of the impact of Japan's remarkable economic recovery on the nutritional status of its people. It should at least be possible for us in this country to initiate immediately a limited programme of annual height measurements in a fair number of representative rural schools in different parts of the country. For this purpose, representative schools in each block of the country must be selected according to a proper statistical design.

It is extremely important that the persons chosen to carry out the measurements are properly trained. It will be ideal if the rural school teacher himself could be trained for this purpose. If the study is going to be limited to just one annual measurement of the child and only to six-to seven-year-olds, the time that the teacher needs to spend on this work on the entire year will be insignificant. He can be trained to record not only height but the weight of the child. Involving the teacher in the programme has its special merits. Apart from the fact that this will be an inexpensive arrangement, it is also most unlikely that we will find (or need) anybody else in the village who will be better educated and qualified to do this job. If the work is entrusted to the teacher, then it will be possible for him to so arrange the timing of the measurements that he can carry out this work in his spare time without encroaching on his teaching hours. However, the entire operation, if it is not to degenerate into an unreliable exercise, must be directed, supervised and monitored by a competent central institution with adequate expertise in nutrition, auxology, epidemiology and bio-statistics. Equipment needed for the measurement must be provided to each school, periodically calibrated and promptly replaced wherever necessary.

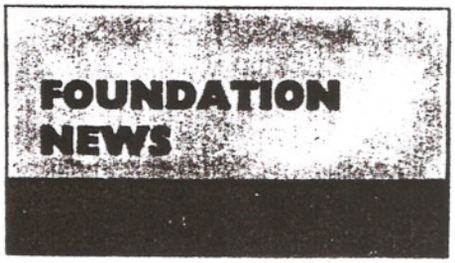
Data from each school, block, state and the entire country must be collated, properly analysed and published annually. This operation would generate a vast amount of useful data which will throw a great deal of light on the status of nutrition of our rural children at the stage when they have first ended their perilous journey through their 'pre-school' years (zero to five years). These data will also help us to indirectly evaluate the impact of our MCH and ICDS programmes on the nutritional status of our children.

In addition to measurements on school children, cross-sectional measurement of heights in adults (male and female) of different occupational classes and communities — such as landless agricultural labour in different regions of the country, white-collar and industrial labour in urban areas, Harijans and tribals could be undertaken. Such measurements may be repeated in the same population groups at five-yearly intervals. It is extremely important that the groups for these measurements are not chosen in an *ad hoc* fashion but after due consideration of their significance and importance to the national human resource base. The group chosen must be sufficiently large and representative.

Such height measurements and quantification of height deficits through comparison with an international or national standard and application of the procedure of Z scores will help us identify differences in nutritional status as between different regions, populations, groups and social classes in the country and to monitor changes over a period of time.

Concluding comments: The thoughts expressed in this paper are by no means new. The importance of height measurements has long been well-known to paediatricians and health scientists. The central point being made in this paper is that it is high time that we make effective use of this well-known, simple, feasible and relatively inexpensive indicator to monitor the impact of our national programmes on the nutritional status of our people. This is an indicator which will prove of as much use to the developmental economist and the planner as to the health/nutrition scientist. Our planners will then be able to assess their achievements on the basis of easily quantifiable and verfiable data and need not have to get lost in sterile debates arising from dubious claims as to how many "thousands" did (or did not) cross the "poverty line"!

Partly based on a paper to be presented at WIDER (U.N. University), Helsinki in July 1987.



"Nutrition Programmes in Orissa State" — by M.C. Swaminathan, Shanti Ghosh and C. Gopalan — NFI Scientific Report 5 — pp. 32. This publication contains a review of ongoing nutrition programmes in the State of Orissa, India, and suggestions for a broader strategy for nutritional improvement. Free copies can be had from the Foundation on specific request.