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Presentation of Data

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Growth is the result of interplay between genetic and environmental factors. Though the matter is still debatable, evidence to date indicates that most of the differences in growth (i.e., height, weight) between children from developed and developing nations, result from differences related to the environment and not to racial origins (Guzmán, 1968; Habicht *et al.*, 1974). Consequently, growth reflects the adequacy of dietary, principally proteins and calories, and health conditions; or more generally, it reflects nutritional status.

This chapter is limited to a discussion of the kinds of growth assessment surveys and their uses, with attention being devoted to techniques and manners of presenting data. The presentation is organized around three kinds of growth assessments: cross-sectional surveys, longitudinal studies, and surveillance. As Table I shows, the basic distinction between them has to do with who is being measured and with what frequency. Though the actual collection procedures are essentially the same in all cases, the sampling procedures as shown in Table I are unique in each case because fundamentally different questions are being asked.

1. Cross-Sectional Surveys

Cross-sectional surveys are one-time approaches in which populations are measured usually over as short a period as possible. Such surveys are cheap, easy to conduct, and, of course, take less time to execute and analyze than longitudinal studies.

A matter of concern for all growth evaluations, but particularly with cross-sectional surveys because of time constraints, is the selection of the study

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Table 1. Types of Growth Assessment

Cross-sectional survey	All or a representative sample of a population are measured once
Longitudinal studies	The same individuals are measured at two or more points in time
Surveillance	Selected members of a population, not necessarily the same individuals, are measured at two or more points in time

sample. The aim is often not to measure the universe, be it a region or a town, but a given portion of it. Needless to say, if one is to generalize, the sample measured must be representative, as communities selected for reasons of ease and convenience frequently are not. If not all individuals within a town are to be measured, a random sample should be selected from a proper frame. This ideal situation contrasts with a frequent pattern in which those who are measured are those who "show up" to be measured.

Cross-sectional surveys have a variety of potential uses, the most common one being to evaluate the nutritional status of populations. One example of this is the INCAP/OIR nutritional status assessment of Central America (INCAP, 1971). In this survey the investigators were interested principally in two general aspects: (a) relative comparisons between groups to identify communities, regions, or countries with better or worse nutritional status, and (b) comparison of each of the groups of concern with reference standards to quantify deviations from normal. Both of these concerns require comparison of two or more populations.

There are many approaches to comparing two populations: direct comparison of means through *t*-tests or other appropriate tests when the distribution is skewed; direct plotting of cases against a percentile distribution; and calculation of the percentage of cases below a certain value. It is the dictates of the survey which determine what techniques to use. For instance, a government may be interested in estimating the extent of severe growth retardation in various regions of the country, in which case the percentage of children falling below an unacceptable value would be the desired statistic.

A second usage of cross-sectional surveys is to screen individuals to select those at greatest immediate risk of death. Recent history has seen the application of such surveys in the war-devastated areas of Biafra and Bangladesh, where international relief organizations wanted to direct their resources to individuals, particularly children, most depleted and in need of food (Sommer and Lowenstein, 1975). In both regions, the QUAC stick indicator, which consists of comparing the arm circumference of a test child to that of a normal child of the same height, was utilized. This indicator, like other indicators derived from the comparison of test and normal children in terms of labile measurements such as weight, muscle circumference, and skinfold relative to stable measurements of length or width of the skeleton, evaluates current nutritional status and is age independent. The basic assumption in the rationale of these indicators is that in normal children of a given skeletal length or width, there is a tolerable range in labile tissue and that marked deviations from this represent abnormality, where severe body depletion and obesity represent the extremes. Data of this kind are, therefore, usually reported in terms of how many subjects fall above or below a chosen criterion.

Cross-sectional surveys may also be utilized to construct standards of growth if children are measured at fixed ages (Luna-Jaspe *et al.*, 1970). Such data are ideal for estimating means and variances or percentiles of growth at specific ages. Moreover, subtracting means at two different ages will yield adequate estimates of the mean growth increments. To estimate variability of increments, however, longitudinal data must be utilized. Cross-sectional data on children not measured at specific ages are not recommended for constructing standards of growth, for these data do not allow for adequate estimates of variability at fixed ages. For the same reason, percentile charts should not be constructed if children are not measured at the same age.

A fourth general category of studies for which cross-sectional surveys are useful is the investigation of factors related to growth. Because of the very nature of surveys, such a research design can at best only inform about associations and not about cause-effect relationships. Examples of such studies include the relationship between familial and socioeconomic factors related to growth (Rawson and Valverde, 1976). In some cases, the investigators are not interested in causes but the indicators of risk. Examples of these latter studies include the identification of the maternal anthropometric characteristics that best predict low birth weight or infant mortality (Lechtig *et al.*, 1976) with the aim of selecting women with such traits as recipients of more than normal attention.

2. *Longitudinal Evaluations*

By convention "longitudinal" has come to mean "during (part of) the life of." Thus, longitudinal evaluations are those in which data are collected at various times on the same individuals. As with simple surveys, the intent of this may be to evaluate the health status of an individual, to establish norms of growth, or to study the growth process itself. By far the most widespread collection of longitudinal data is for purposes of monitoring the growth of an individual child in view of two major types of questions.

The first question, and the most significant medically, is whether the child is growing adequately. In particular, the interest is upon successive changes, with the idea of identifying a period of relatively higher stress through a faltering in the rate of growth (Marsden and Marsden, 1964). This in turn implies some standard for comparison and a way to look for differences. The most common clinical technique is the plotting of serial measures of either height or weight against age on a chart which already shows the standard.

Another common procedure is to calculate differences (i.e., the change itself) and to make a direct numerical comparison with standards of change. In both instances, comparisons may be absolute, "the child's growth is faltering," or relative, "he's always been short for his age; he's even shorter than you'd expect given his parents height," but in both cases the outcome is essentially a yes/no answer to the question of whether the child is currently doing "ok." If the answer is no, then some immediate cause is sought.

The second question, though less important medically, is one very frequently asked, namely, "what will the child's adult stature be." This can be done roughly by obtaining a child's current percentile, assume that his adult percentile will be the same, and then convert the latter percentile to absolute height. Alternatively, predictive regression equations that utilize age, anthropometric measurements, and skeletal age may be used if more precision is required (Walker, 1974).

Deriving standards for change is a somewhat tricky business since it cannot be done from cross-sectional data: the rate of growth is not necessarily smooth and, unlike the mean change, the distribution of changes cannot be inferred from the separate distributions of attained values. The most obvious example is the adolescent spurt, which every child undergoes, but which is not reflected in the steady rise of average height during the adolescent years (Tanner, 1962). Thus longitudinal standards imply longitudinal studies from which to derive the estimates of change.

Longitudinal assessments are preferred for investigations of the growth process itself. Measurements of the rate of growth, for instance, can be related to whatever other factors are of interest (Gopalan *et al.*, 1973). As in the case of assessing individual histories, the comparison may be absolute, "the better fed children grew more," or relative, "the impact of supplemental feeding on growth is greater between the ages of 1 and 3 years than in later ages." Finally, for some studies the appropriate variable may be more truly longitudinal, as for example the age of maximal growth spurt of parameters derived from fitting a curve (Johnston *et al.*, 1976).

3. *Surveillance*

The term "surveillance" originates from the French *surveiller*, meaning to keep a very close watch with the intent of control. Thus, for governments and technical agencies which have in recent years become increasingly concerned with the nutritional status as an indicator of social well-being, surveillance is not an isolated activity but an integral part of the formulation and execution (which includes evaluation) of policy. Because of the diversity of interests and nonuniformity of the conditions in different areas, this calls for different approaches and methodologies. In this context surveillance relates to measurements on sequential samplings of populations. The information collected in the initial point in time in the observation process may be used as a reference baseline for evaluation in the time sequence.

A joint FAO/UNICEF/WHO Expert Committee (WHO, 1976) has defined nutritional surveillance as a continuous process with the following objectives:

1. To describe changes in the nutritional status of populations with particular references to subgroups identified as being at risk.
2. To provide information that will contribute to the analyses of causes and associated factors for the selection of preventive measures.
3. To promote decisions by governments concerning priorities and allocation of resources to meet the needs of normal development and emergencies.
4. To enable predictions of the probable evolution of nutritional problems.
5. To monitor nutritional programs and evaluate their effectiveness.

Clearly, information from different fields (production, consumption, income, ecology, and health status, among others) is needed to fulfill these objectives. In this chapter, however, we limit considerations to growth data as it may contribute to a surveillance effort. Furthermore, considerations of growth data are limited to the use and presentation of selected anthropometric measurements, in the context of nutritional surveillance within an epidemiological frame, and for the evaluation of the impact of interventions. For these purposes, the data in a given time sequence may or may not originate from the same individuals, although to be of real value, it must originate from the same population—the target of surveillance.

The use of anthropometric measurements in nutritional surveillance within an epidemiological frame, in general, relates to the evaluation of shifts in the distribution of anthropometric characteristics in a population. In turn, the population groups for surveillance may be selected intentionally because of ease of access and high risk to malnutrition; the behavior through time of results derived from observations made in the selected population then serves as indicators of change in the nutritional situation of an area, country, or region. In this context, shifts in the distribution of a given anthropometric characteristic or index can be documented and identified using a time series of means and standard deviations presented in a set of conventional tables and/or graphs. In Japan, for example, graphs of the age-sex-specific average heights and weights of schoolchildren over a sequence of years (Nakayama and Arima, 1965) have been used successfully to depict secular trends (increasing) in height and weight and have also served to document changes in such trends (decreasing), particularly in the case of weight, during World War II.

When the distribution of the measurements of the characteristics used in the surveillance exercise is approximately normal, and interest is on the population as a whole, corresponding means and standard deviations can be used successfully as appropriate indicators for evaluating change over time. However, the distribution of the measurements used in surveillance very often is not normal (e.g., skinfolds) or interest is focused on a particular group (such as low-birth-weight babies) within the population. In this case, the conceptually appropriate presentation is a sequential set of frequency distributions or, equivalently, a time series of tables of selected percentile values of the variable of interest. This approach can be cumbersome and difficult. The important point, however, is that the evaluation of shifts in time of a complete frequency distribution can be made by being sensitive to the shifts in points of greatest interest in the distribution. The procedure may be simplified by selecting arbitrary points in the original distribution of measurements and following through time the behavior of the study population in terms of these selected reference points. One example of this approach is the sequential calculation of the percentage of newborn children with low birth weight (<2.5 kg), or else the percentage of children who fall below a reference line traced on a growth chart. The former is useful in predicting changes in mortality in children, and the latter helps in estimating changes in the magnitude of the malnutrition problem (Lechtig *et al.*, 1976; INCAP, 1971). The difficult feature in such schemes relates to the definition of appropriate reference points for calculation of the percent figures and the establishment of the levels of the percent figures required to trigger action.

The procedures described can be used also for the purpose of evaluating changes in nutritional status as a result of the natural process of development. An example from Guatemala (Guzmán, 1975) illustrates the presentation of data in both tabular and graphic forms. In this case, observations on the height and weight of children from a specific public school and an orphanage in metropolitan Guatemala were compared in the time extremes of a 20-year time interval. In other words, the same locations, but with different individuals, were compared at the beginning and end of the 20-year time lapse considered. A numerical table (Table II) and graph (Fig. 1) prepared with data from the study in reference, illustrate the usefulness of this scheme of presenting anthropometric data in the detection of changes over long periods of time and contrasting such changes in different population groups.

The sequential recording of indices, such as we have described, will define

Table II. Mean Differences in Height for Male Children from an Orphanage and a Public School in Guatemala City, 1952–1972[a]

	Orphanage		Public school	
Age (years)	Λ Height (cm)	Percent change	Λ Height (cm)	Percent change
8	−1.07 ± 1.99	−0.9	6.17 ± 1.86	5.3
9	−1.90 ± 1.58	−1.5	10.91 ± 1.35	9.2
10	−0.40 ± 1.86	−0.3	10.96 ± 1.37	8.9
11	−0.95 ± 1.97	−0.7	4.80 ± 1.47	3.6
12	0.91 ± 2.78	0.7	7.76 ± 1.74	5.8
13	−1.40 ± 2.08	1.0	6.95 ± 1.58	5.0
14	−3.50 ± 2.07	−2.4	3.38 ± 2.77	2.3
All ages	−1.19 ± 0.80	−0.9	7.28 ± 0.60	5.7

[a] Λ Height = mean height 1972 − mean height 1952. Percent change relative to age-sex-specific height in 1952.

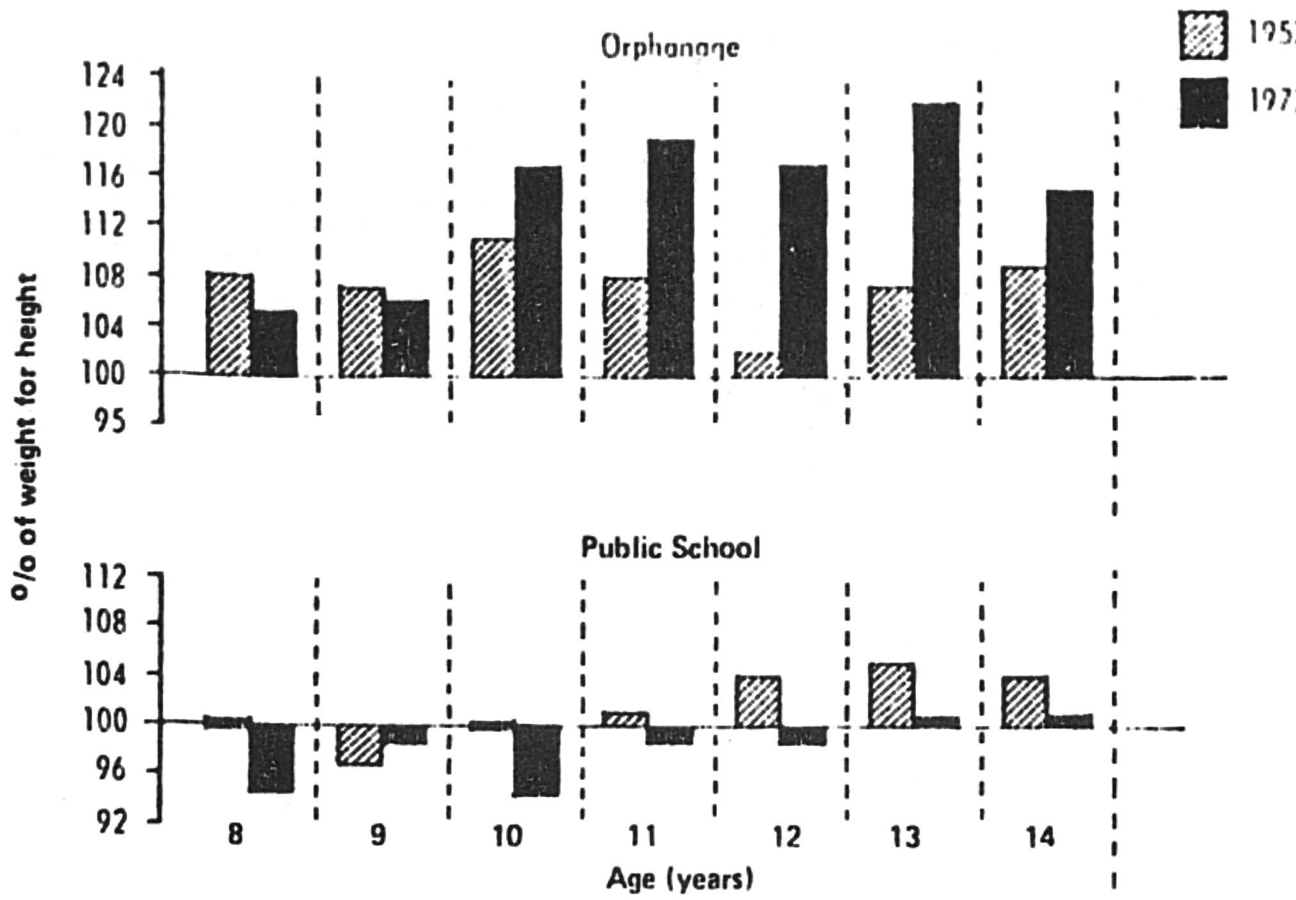

Fig. 1. Evolution of weight for height in male children from an orphanage and a public school in Guatemala City, 1952 and 1972.

trends, and reasonable predictions of expected behavior of the indices are possible from such trends, provided they do not project too far into the future.

Of particular usefulness in the evaluation of the impact of interventions is an adaptation of techniques used for industrial quality control (Bennett and Franklin, 1954). Using this scheme control charts with expected steady state behavior of anthropometric characteristics in a given population can be constructed. These charts can then be used for plotting and displaying graphically the behavior through time of selected anthropometric characteristics. Departures from the steady state can be detected in the time intervals specified for recording measurements. This scheme is particularly suited for application in centers that provide health services—mother and child care centers and maternity wards in hospitals, for example. Additionally, the control charts may provide a basis for an early warning system for deteriorating nutritional conditions. The value of control charts in surveillance systems merits research and exploration of practicability.

4. General Comment

We have now completed a review of the analysis and presentation of the data arising from the three major types of growth monitoring: survey, longitudinal study, and surveillance. Such growth data are utilized for nutritional assessment and are collected to assess either individuals or populations as a whole. Moreover data may be collected for use by public health planners, researchers, physicians and medical care auxiliaries, or other interested parties. Finally, data may be collected with an intent to detect acute malnutrition, assess chronic status, or study the growth process itself. Who the data are about, who will use it, and why they want it affect both the kind of data collected and its form of presentation. In this connection, Jelliffe has provided clear and useful guidelines for different ways of presenting data (Jelliffe, 1966, pp. 198–204) and also for the preparation of reports (Jelliffe, 1966, pp. 172–175).

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