Variations in Estimates of Guatemalan Infant Mortality, Vaccination Coverage, and ORS Use Reported by Different Sources[1]

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All available estimates of rates of infant mortality, vaccination coverage (for BCG, DPT 3, polio 3, measles, and tetanus toxoid), and ORS use in Guatemala in the 1980s were identified and investigated. A large number of sources and estimates were found. Large discrepancies were also found between the estimates for a given indicator, even when the estimates were reported for the same year by the same source. For instance, reports for 1985 yielded 10 different infant mortality estimates ranging from 56.0 to 79.8 deaths per 1 000 live births; vaccination coverage estimates ranging from 30% to 60.5% for BCG, 3.5% to 34.2% for DPT 3, 3.5% to 33.5% for polio 3, 11% to 58.2% for measles, and 1% to 8.2% for tetanus toxoid; and estimated use rates of oral rehydration solution ranging from 3.5% to 7.2%. In this same vein, three Guatemalan Ministry of Health estimates of infant deaths per 1 000 live births in 1984 ranged from 52.4 to 79.8; four UNICEF estimates for 1985 ranged from 65 to 79.8; and three USAID estimates for 1987 ranged from 59 to 72. The many reasons found for this diversity point to significant problems influencing the reliability of current data.

National governments and international agencies have assigned indicators such as infant mortality, vaccination coverage, and oral rehydration use an important role in their efforts to promote child survival. Global and national targets have been set in terms of such selected indicators. Programs have been monitored and evaluated on the basis of changes in the values of these indicators. Most important, programs have been modified and donor agency financial support has been given or withheld in response to observed trends in a few important indicators. Accordingly, it is important to identify, understand, and discuss variations in the reported values of such indicators and to advise policy mak-

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ers of the risks as well as the benefits of making decisions based on apparent trends in these values.

Scientists, governments, and international agencies have used a variety of methods to estimate the values of key indicators. Each method has its strengths and weaknesses. For example, infant mortality estimates can be derived using either direct methods (calculating directly from the data) or indirect methods (calculating from a demographic model that processes the data according to accepted mathematical conventions); and they can be derived using data from various sources—vital events registration systems, surveys, or censuses. Vital events registration systems have been criticized for containing biased data, because they do not capture all births and deaths; survey data have been criticized for involving only small samples; and some estimates have been criticized for using direct rather than indirect methods (*1*). Similarly, methods employed to estimate rates of oral rehydration use have been criticized for various reasons—including adoption of nonstandard definitions of "diarrhea" and "diarrhea episode" (*2, 3*), variations in the definition of "proper" use of oral rehydration solution and the length of the recall period (*3*), and variations in the manner of questioning informants (*3*). However, little attention has been given to problems arising from the use of secondary data and perpetuation of errors found therein.

In most cases, the values retrieved from published and unpublished sources produce multiple choices regarding the "correct" value of a given indicator. Confronted with the problem of reporting a single trend for each of various selected indicators to policymakers, the authors set out to explore the reasons for the appearance of multiple and, at times, conflicting values for the indicators. This article reports all of the values discovered for rates of infant mortality, vaccination coverage, and oral rehydration use in one country, Guatemala, in the 1980s and discusses some of the theoretical and practical reasons for the observed variations in these values over time and across sources. Part of that discussion illustrates how organizations contribute to such variation by incorrectly citing, using, and reporting estimates from other sources.

METHODS

The initial data search was carried out during 1987–1988 in both Guatemala and Washington, D.C., and a second round of searching was done at both locations during 1990–1992. Besides exploring the standard reference sources, interviews were held with representatives of various private, government, and international organizations in both places (*4*).

Most of the unpublished estimates identified during the first round of data collection were verified against the original source documents during the second round, although this was not possible in a few cases. These latter estimates have been retained, but the fact that they are unverified has been noted in the data tables. In all cases efforts were made to determine the sources, definitions, and procedures used to make the estimate, as well as to find reasons for apparent inconsistencies or disagreements with other estimates. These efforts were successful in many but not all of the cases.

INFANT MORTALITY: TRENDS AND VARIATIONS

Measuring Infant Mortality

The infant mortality rate (IMR) is defined as the number of infant deaths per 1 000 live births in a specified geographic area. This rate can reflect either the ratio of infant deaths to live births occurring over a specified time period or the probability of a newborn infant dying prior to its first birthday. Theoretically, these two sorts of calculations yield the same value when the numbers of births and infant deaths are stable over time, but not when the population is growing. The time period over which data are collected may be as short as a year, but is more commonly a longer period—usually three or five years.

In practice, two general methods are used in the developing world to estimate IMR: a direct method in which births and deaths over a given time period are counted and a ratio is derived that expresses the number of infant deaths per thousand live births; and an indirect method in which information about births, deaths, migration, and other demographic factors is entered into a mathematical model to generate an estimate. Most such models generate estimates in the form of a time trend. The data needed to apply either method can come from two general types of sources: surveys (which include censuses, sample surveys, and special studies) or vital events registries.

IMRs in Guatemala

The IMR estimates found for Guatemala were derived using both methods (direct and indirect) and both types of data sources (vital events registries and surveys). In some cases the documents containing these estimates provided no information about the source of the data or the method used to derive the estimates. As might be expected, the various estimates were spread over a range of values that was rather large—so large, in fact, that an individual seeking a definitive IMR estimate for any particular point in time would find only bewilderment.

Part of this variation appears due to the technical issues cited above, including the following:

- different methods of estimation (direct and indirect);
- different sources of data (registries, censuses, and surveys);
- when employing indirect methods, use of different models and analyses of the available empirical information; and
- use of different time periods.

As in many other countries, the Guatemalan situation is further complicated because different organizations tend to engage in what amounts to poor reporting of what are essentially the same data. In particular, once a data-generating event such as a survey or census takes place, the results of that event filter into different organizations at different times, and the time of the information may be erroneously reported as the time when the organization received the data rather than the time when the data were collected. Moreover, various other timing errors of this sort can happen, the most egregious occurring when an estimate is ascribed to the year of the estimate's publication rather than to the year when the data were collected. More understandable is the attribution of a multi-year estimate to the final year or (even less objectionable) to the midpoint of the multi-year range.

Finally, because the IMR is used in a political as well as a technical context, some estimates are distorted to emphasize political objectives. Overestimates may be generated for the benefit of the donor community, as a means of stimulating additional technical and/or financial assistance; or underestimates may be generated for public consumption at home to convey the impression that conditions are improving.

Figure 1 shows all the sources and estimates of IMR in Guatemala in the 1980s that were found by this study (*5–36*). It turns out that various types of organizations provide estimates of IMR trends

Figure 1. Infant mortality rates (per 1 000 live births) in Guatemala, as reported by various sources. Arrows indicate first-level dissemination of 1987 DHS estimates, showing how these estimates influenced numbers disseminated by others.

	Source	Pre-1980	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	Post-1989
1.	BUCEN 1990 (*6*)	77.6*	–	73.2*	72.7	72.2	71.7*	69.9	68.2	66.4	64.6	–	–
2.	BUCEN 1989 (*5*)	–	–	–	–	–	–	–	–	–	–	64	–
3.	CELADE 1988 (*7*)	–	82.0	–	–	–	–	70.0	–	–	–	–	–
4.	DHS 1983 (*8*)	–	–	–	–	96	–	–	–	–	–	–	–
5.	DHS 1987 (*9*)	–86.4–					–73.4–				–	–	–
6.	DHS 1987 (*9*)			–79.1–							–	–	–
7.	DHS 1987 (*9*)			–65.3(U)–							–	–	–
8.	DHS 1987 (*9*)			–84.5(R)–							–	–	–
9.	Guat MOH 1980-1987 (*10*)	–	68.2	54.3	60.2	64.9	52.4	68.5	55.8	–	–	–	–
10.	Guat MOH 1980-1987 (*10*)	–	–	–	64.3	–	70.1	–	–	–	–	–	–
11.	Guat MOH 1987 (*11*)	–	–	–	–	–	–	–	–	51.3	–	–	–
12.	Guat MOH 1985 (*12*)	–	–	–	–	–	79.8	–	–	–	–	–	–
13.	INCAP Sent 1986 (*13*)	–	–	–	–	86.5(R)	–	77.8(R)	–	–	–	–	–
14.	PAHO 1986 (*14*)	–82.0–			–70.0–					–59.0–			–48.0–
15.	PAHO 1986 (*14*)	74.0	81.1	54.4	48.3	81.1	68.5	–	–	–	–	–	–
16.	PAHO 1990 (*15*)	–	–	–	–	–	–			–59–			
17.	PAHO 1990 (*15*)	–	80.9	53.8	64.2	65.7	65.5	56.0	56.8	56.1	43.7	–	–
18.	UNICEF State (*16–21*)	–	–	–	–	70	–	65	61	60	58	56	–
19.	UNICEF 1987 (*24*)	–	76	–	–	–	–	65	–	–	–	–	–
20.	UNICEF CAP 1986 (*25*)	–	75	–	–	–	65	79.8	–	–	–	–	–
21.	UNICEF CAP 1988 (*26*)	–	83	–	–	–	–	71	65	–	–	–	–
22.	UN/POP 1988 (*27*)	–82–			–70–					–59–			–48–
23.	UN/POP 1988 (*28*)	–	–80–		–	–	–	–	–	–	–	–	–
24.	UN/POP 1988 (*29*)	–82–			–70–					–59–			–48–
25.	USAID Child 2nd (*30*)	–	–	–	–	–	–	–	63	–	–	–	–
26.	USAID Child 3rd (*31*)	–	–	–	–	–	–	–	–	59	–	–	–
27.	USAID Child 4th (*32*)	–	–	–	–	–	–	–	–	–	73	–	–
28.	USAID Child 5th–6th (*33,34*)	–	–	–	–	–	–	–	–	72	–	–	–
29.	USAID CP (*35*)	–	77	70	–	66	63	67	68	67	79	–	–
30.	USAID/Guat 89 (*36*)	–	–	–	–		79.8	73.4	68.2	64.8	–	–	–
31.	USAID/Guat 89 (*36*)	–	–	–	–	–	80(R)	78(R)	75(R)	70(R)	–	–	–
32.	World Bank 1988 (*37*)	–	–	–	–	–	–			–65.6–			–56.1–

Notes (keyed to line numbers):

1. The figure 77.6 is for the 2-year period 1979–1980; "benchmark" years with asterisks based on vital registration data.
2. Table 8, p. 60.
3. Unverified field reporting of data.
4. Unverified field reporting of data.
5. Table 2.1, p. 7; figures for 5-year periods beginning 1 January 1977 and 1 July 1982.
6. Table 2.2, p. 9; figures for 10-year period, 1 July 1977–30 June 1987.
7. Table 2.2, p. 9; figures for 10-year period, 1 July 1977–30 June 1987. U = urban data.
8. Table 2.2, p. 9; figures for 10-year period, 1 July 1977–30 June 1987. R = rural data.
9. Unverified 1980–1986 data copied in field.
10. The two figures, copied in field for 1982 and 1984, are unexplained.
11. Infant deaths in the calendar year multiplied by 1 000, divided by live births in the calendar year, as reported in the civil register for that calendar year.
12. Unverified field reporting of data.
13. Table 18b (Trussell variant, West model); 1983 figure (86.5) based on Feeney method, 1985 figure (77.8) based on Bass method. R = rural data.

14. Vol. I, p. 392, from UN/POP 1988 (29), medium variant; figures for 5-year periods beginning mid-1975, mid-1980, mid-1985, and mid-1990 (source denotes these 5-year periods as 1975–1980, 1980–1985, etc.).
15. Vol. I, p. 394, from official government statistics (p. 177); first figure (74.0) is for 1979.
16. Vol. I, p. 53; figure for 5-year period beginning mid-1985 (source denotes this 5-year period as 1985–1990).
17. Vol. I, pp. 303, 334; 1987 and 1988 figures "provisional"; from official data in PAHO technical information system.
18. Figure for 1983 from p. 141, reference *16*; for 1985, p. 90 (*17*); for 1986, p. 64 (*18*); for 1987, p. 94 (*19*); and for 1988, p. 102 (*20*).
19. Guatemala table, no page no.; source is United Nations Population Division.
20. Unverified field reporting of data.
21. Unverified field reporting of data.
22. Table A.2; figures are for the 5-year periods beginning mid-1975, mid-1980, mid-1985, and mid-1990 (source denotes these 5-year periods as 1975–1980, 1980–1985, etc.).
23. Table 50, p. 122; figure, for 1980–1981, based on complete vital registration data and census.
24. Table 16, pp. 121–122, medium variant; figures are for the 5-year periods beginning mid-1975, mid-1980, mid-1985, and mid-1990 (source denotes these 5-year periods as 1975–1980, 1980–1985, etc.).
25. Pages 68, 86; from United Nations, *World Population Prospects: 1984* (*28*).
26. Pages 58, 70; from United Nations, *World Population Prospects: 1984* (*28*).
27. Pages 74, 88; from DHS 1987 (9).
28. References *33* (on pp. 98, 114, and 116) and *34* (on pp. 66, 86, and 89) both report the same figure; from DHS 1987 (9).
29. Figures are from the following annual reports: for 1984, FY86 report, p. 86; for 1985, FY87, p. 6; for 1986, FY88, p. 8; for 1987, FY89, p. 8; for 1988, FY90, p. 10. Figures for 1980, 1981, and 1983 (from the FY82, FY83, and FY85 reports) were copied here without verification. The FY 91 CP (p. 277) notes that all IMR estimates in the CP were obtained from the U.S. Census Bureau.
30. Based on national estimates.
31. Based on rural data (R) from the Sentinel Areas Survey (INCAP Sent 1986—*33*).
32. Page 118; the figures are for 5-year periods beginning mid-1985 and mid-1990 (source denotes these 5-year periods as 1985–1990 and 1990–1995).

in Guatemala. The Ministry of Health (MOH) furnishes annual estimates on behalf of the Government (*10, 11*). Two international organizations doing health work in Guatemala, PAHO (*14, 15*) and UNICEF (*16–26*), publish IMR estimates. The U.S. Agency for International Development (USAID) makes several of its own estimates or selects estimates from other sources (*30–36*). Other institutions publishing estimates include the World Bank (*37*), the United Nations Population Office (*27–29*), and the U.S. Census Bureau (*5–6*).

Various organizations published estimates derived from other sources. For example, the Latin American Demographic Center (CELADE) developed its own estimates based on all available sources (*7*).

In addition, several organizations published multiple estimates for the same year that disagreed with one another. For example, three 1984 MOH estimates of IMR (*10, 12*) ranged from 52.4 to 79.8, four 1985 UNICEF estimates ranged from 65 to 79.8 (*17, 24–26*), and four 1987 USAID estimates ranged from 59 to 72 (*31, 33–36*).[6]

These organizations used several different original sources of data to make their estimates of IMR. The Ministry of Health obtained the number of infant deaths and the number of live births in each calendar year from the official civil registries. The U.S. Census Bureau, U.N.

[6]Throughout this article the infant mortality rate (IMR) is reported as the number of infant deaths per 1 000 live births.

Population Office, and CELADE used indirect methods that employed official census data. In addition, use was made of several different sample surveys completed in Guatemala during the 1980s that provided useful data for estimating IMR as well as IMR estimates of their own. Specifically, two national Demographic and Health Surveys (DHS) were carried out in 1983 and 1987 (*8, 9*), and two surveys of rural sentinel villages were conducted jointly by INCAP and the Ministry of Health in 1983 and 1987 (*13, 38*). The 1983 and 1987 Demographic and Health Surveys and the 1983 INCAP/MOH survey all provided their own IMR estimates.

Figure 2 demonstrates the range of estimates encountered in this study for a single year, 1985. (That year was selected because it had the largest number of estimates and sources of any 1980s year.) The range extends from 56.0 to 79.8, a difference of nearly 24 deaths per 1 000 live births.

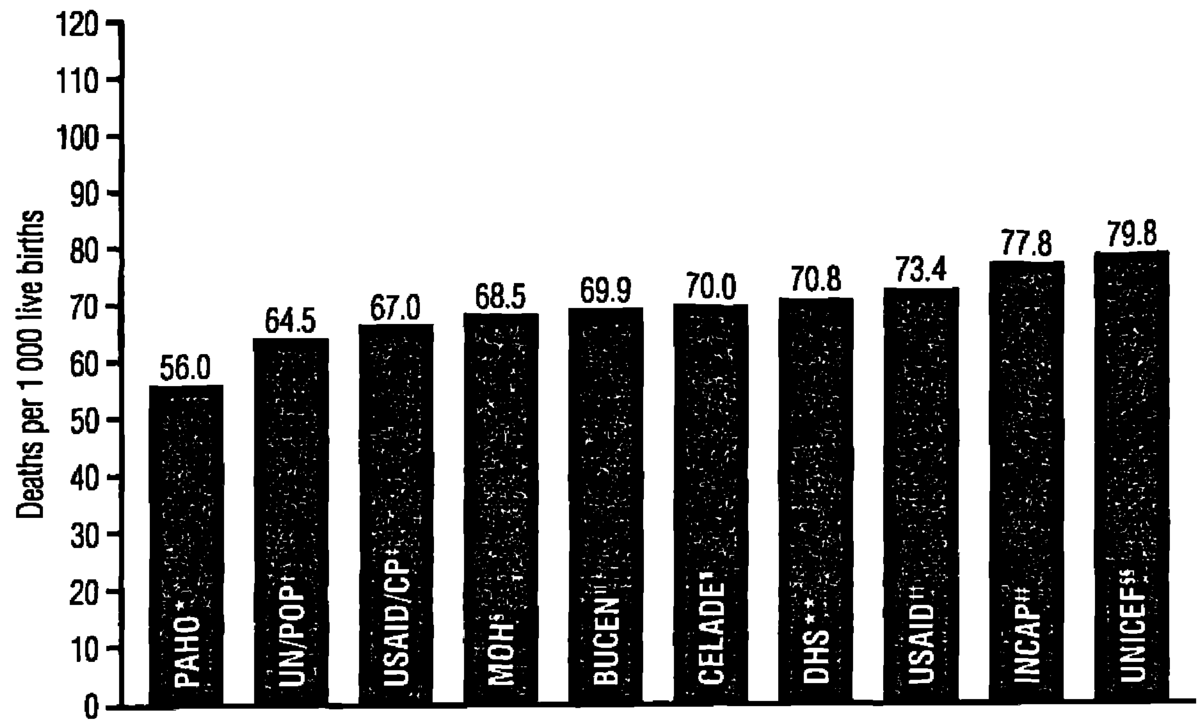
The high extreme of the 1985 range (79.8), which was drawn from UNICEF's 1986 annual report for the country, appears to have originated with a Ministry of Health study (*12*) on services to mothers and infants that was published in 1985. In fact, the same 79.8 figure is cited by three sources: the MOH mother/infant study cites it for 1984, the 1986 UNICEF country report (*25*) cites it for 1985, and the 1989 USAID/Guatemala annual report (*36*) cites it for 1984. While it is possible that the MOH mother/infant study was influenced by the 1983 sentinel villages study published in 1986 (*13*), which reported a rural IMR of 86.5 for 1983, it is unlikely that the results reported for earlier years by the 1987 Demographic and Health Survey (DHS) (*9*) were a factor in determining the 79.8 figure. The two 1985 estimates of IMR for rural populations—77.8 and 78, see Figure 1, INCAP Sent (*13*) and USAID/Guat (*36*)—are also close to the top of the range.

The low extreme of the 1985 range (56.0) was reported by PAHO in its 1990 *Health Conditions in the Americas* (*14*). According to PAHO, this figure was copied from official country statistics based solely on civil registry data, and thus was not influenced by DHS results or other special studies. Estimates obtained by indirect methods, such as those reported by the U.S. Census Bureau (*5, 6*), U.N. Population Office (*27–29*), and CELADE (*7*), fell between the two extremes of the range.

This 1985 pattern is more or less repeated throughout the decade. That is, one finds a wide range of IMRs, with estimates based on surveys and special studies (especially of rural populations) near the top of the range, estimates based on indirect methods in the middle of the range, and estimates based on direct methods toward the bottom of the range. As Figure 1 indicates, we did find exceptions to this pattern, notably the high 1983 DHS estimate of 96 (*8*) and the high PAHO estimate of 81.1 reported for both 1980 and 1983 (*14*). The reasons for these exceptions are not known.

Figure 3 displays time trends from four sources: the U.S. Census Bureau (*6*), U.N. Population Office (*29*), PAHO (*14, 15*), and the Guatemalan Ministry of Health (*10, 11*). Both the Census Bureau and the Population Office relied on indirect methods to generate these time trends; therefore, the curves tracing the two trends are relatively smooth. Clearly, the U.N. model is the more optimistic of the two. On the other hand, the MOH obtains the number of live births and infant deaths for a given calendar year as reported in the official civil registry and divides the deaths by the live births. This direct method yields a trend that is irregular and generally well below the first two estimates. The lowness of these MOH estimates appears due to large-scale underreporting of infant deaths in the civil registry, an underreporting problem clearly identified by the MOH on page

Figure 2. The range of Guatemalan infant mortality estimates found for the year 1985, showing the source of each estimate within the column.



*The PAHO estimate was reported in the 1990 edition of *Health Conditions in the Americas* (*15*). According to the publication, this estimate was obtained from the Guatemalan Ministry of Health.

†The UN/POP estimate of 1985 IMR (64.5) was derived by the authors from the two 5-year IMR estimates beginning in mid-1980 and mid-1985 in *World Population Prospects: 1988* (*29*), using a linear interpolation between the midpoints of the two 5-year estimates.

‡The USAID/CP estimate, reported in the agency's 1987 *Congressional Presentation* (*35*), is based on U.S. Census Bureau estimates.

§The MOH estimate was reported in *Anuarios Estadísticos (1980–1987)* (*10*).

‖The BUCEN estimate, reported by the U.S. Bureau of the Census printout furnished in 1990 (6), was one in a series of annual estimates.

¶The CELADE estimate was reported in *La Mortalidad en la Niñez en Centroamérica, Panamá y Belize* (*7*).

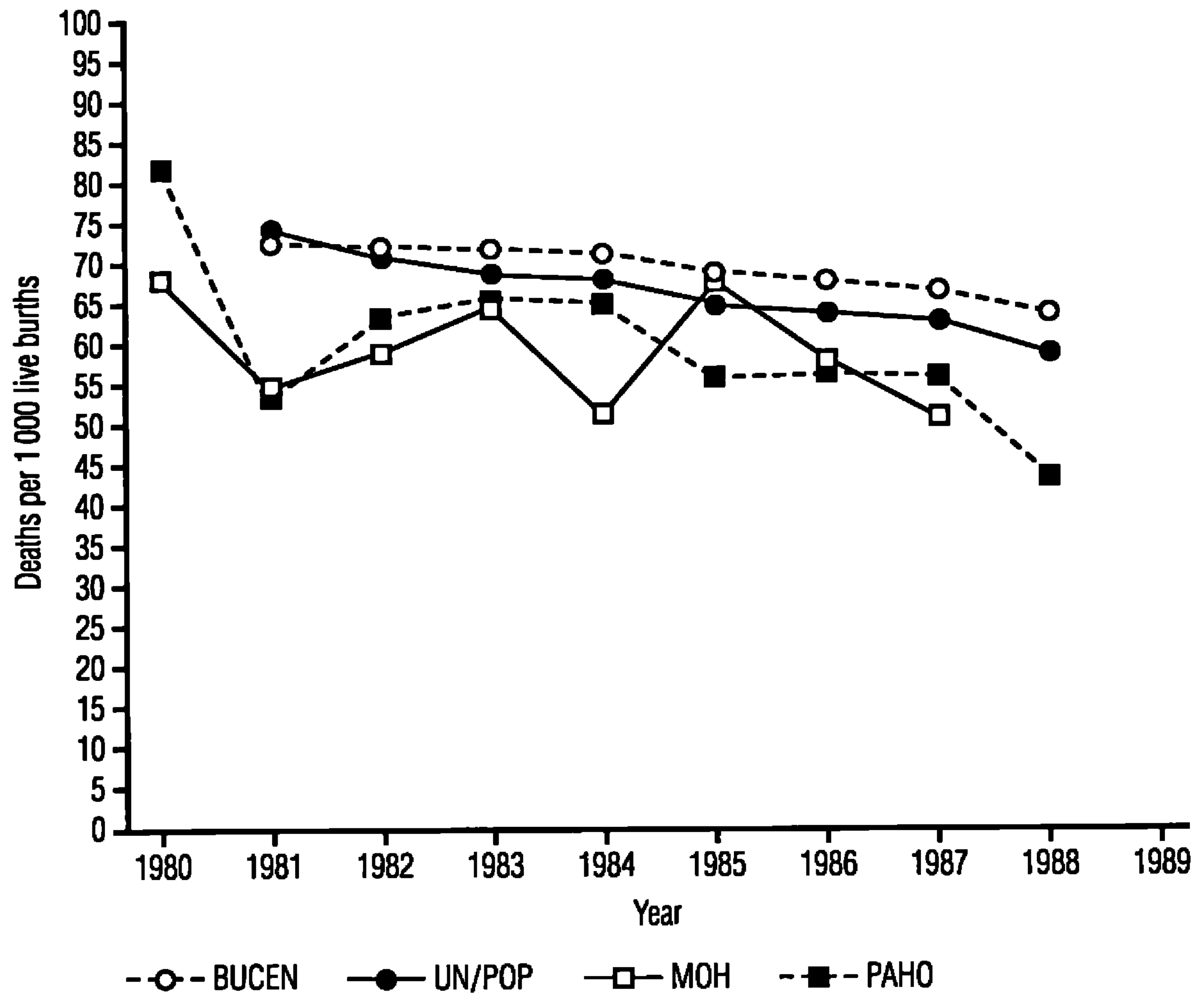
**The DHS estimate of 1985 IMR (70.8) was derived by the authors from the two 5-year IMR estimates beginning in mid-1977 and mid-1982 in *Encuesta de Planificación Familiar y Salud Maternal Infantil de Guatemala 1983: Informe Final* (*8*), using a linear extrapolation from the midpoints of the two 5-year estimates.

††This USAID estimate, reported in *USAID/Guatemala Action Plan, FY 89* (*36*), is actually the DHS (9) estimate for the 5-year period beginning in mid-1982.

‡‡The INCAP estimate, reported in *Encuesta Simplificada de Salud y Nutrición Materno-Infantil, Guatemala* (*13*), is for rural areas and is based on data obtained from the sentinel villages survey.

§§This UNICEF estimate, reported in the *1986 Annual Report* (*25*), was apparently based on a Guatemalan Ministry of Health study.

Figure 3. Guatemalan infant mortality trends in 1980–1988, as indicated by four different sources. (BUCEN = U.S. Bureau of the Census; UN/POP = United Nations Office of Population; MOH = Ministry of Health of Guatemala; PAHO = Pan American Health Organization.)



34 of its own *Anuario 1987: Guatemala en Cifras de Salud* (*11*). The reason for the irregular, almost sawtooth shape of the MOH data was not determined by the authors.

Even though the estimates of IMR reported by PAHO in *Health Conditions in the Americas* (*14, 15*) are taken directly from official Guatemala Ministry of Health statistics, they do not always match the MOH estimates reported in the annual yearbooks (*10*). In some years these estimates by the MOH and PAHO are nearly identical (e.g., 1981, 1983, 1986), while in other years they differ widely (e.g., 1980, 1984, 1985). Similarly, as seen in Figure 1, the two editions of PAHO's *Health Conditions in the Americas* (1986 edition and 1990 edition) agree in some years (e.g., 1980) and disagree in others (e.g., 1983). The reasons for these discrepancies are not known.

The indirect models used by CELADE, the U.N. Population Office, and the U.S. Census Bureau all incorporated the DHS results and other special study results into their estimates. In fact, the U.S. Census Bureau adjusted its previously published estimates for past years on the basis of more recent DHS and special study results. In its 1989 action plan (*36*), USAID/Guatemala cited both the 1983 DHS (*8*) and the 1986 INCAP sentinel villages results (*13*) as the basis for its IMR estimates for 1985 and later. The second and third USAID reports to Congress on child survival (*30, 31*) used U.N. Population Office estimates for 1986 and 1987 as their estimates for 1986 and 1987, respectively; the fourth USAID report to Congress on child survival (*32*) gave a 1988 estimate based on the 1987 DHS survey (*9*); and the fifth and sixth USAID reports to Congress on child survival (*33*, *34*) both retreated to reporting only a 1987 estimate based on the same 1987 DHS survey (*9*). (The 1987 DHS survey actually reported a single figure, 73.4, for the 5-year period beginning in mid-1982.)

UNICEF's annual country report for 1988 (*26*) cites IMRs of 71 for 1985 and 65 for 1986, an apparent recognition of the DHS results. The USAID congressional presentations (*35*) claim to obtain their IMR estimates from the U.S. Census Bureau, an example of original sources (DHS and INCAP) passing through a secondary source (Census Bureau) to influence a third source (USAID, congressional presentations). The differences between the IMRs reported by the Census Bureau (*6*) and USAID in its congressional presentations (*35*) probably reflect the Census Bureau's practice of retrospectively altering its estimates for prior years based on the latest information. Interestingly, the USAID congressional presentation for fiscal year 1990 (*35*) reported an IMR of 79 for 1988, a rate much higher than those reported for previous years and totally out of context. This anomaly could have arisen through misreporting of the 1987 DHS estimate for the 10-year period mid-1977 through mid-1987.

Figure 1 portrays first-level dissemination of the 1987 DHS results (*9*). The DHS provided national estimates of IMR for two 5-year periods (1977–1981 and mid-1982 through mid-1987), as well as urban and rural estimates for the entire 10-year period (mid-1977 through mid-1987). As noted, several sources factored the DHS results into their own estimates. In summary, it appears that the "events" of the DHS and INCAP sentinel village studies influenced the various organizations involved at different paces, but that nearly all eventually factored the data from these "events" into their computations, the two exceptions being those PAHO and MOH estimates based solely on civil registry data.

It is difficult to know which single source is most accurate. If a single estimate is required for some reason, the best data source is one of the organizations with teams of demographers who analyze new empirical data and adjust their models accordingly—such as CELADE, the U.N. Population Office, or the U.S. Census Bureau. Direct estimates reported by the Ministry of Health and PAHO are too unreliable at this stage of civil registry development in Guatemala. Some estimates, particularly those made by the U.S. Census Bureau, the U.N. Population Office, and the World Bank, should be accompanied by a date when the estimate was made as well as by dates defining the period to which the estimate applies, because they retrospectively revise prior year estimates as new information becomes available.

VACCINATION COVERAGE: TRENDS AND VARIATIONS

Measuring Vaccination Coverage of Children

Worldwide, the effort to estimate vaccination coverage rates on an annual basis has been greater than the effort to estimate other child survival indicators. This is true despite the fact that the vaccination coverage rate is not synonymous with the rate of immunization. (Vaccination does not guarantee protection, because not all vaccinations result in the seroconversion necessary to assure immunization, especially in situations where frequent breakdowns in the cold chain render vaccines ineffective.)

One reason for the extraordinary effort devoted to estimating vaccination coverage is the potential for rapid change in a given vaccination coverage rate. Every year a completely new cohort of infants must be vaccinated. Because the success in vaccinating each cohort depends on a number of short-term factors, coverage rates can and do fluctuate dramatically from one year to the next; therefore, the rate *must* be estimated anew each year.

In general, two methods of estimating vaccination coverage rates have been refined over the years: routine reporting (generating what are known as administrative estimates) and surveys.

In Central America, where reporting systems are relatively well developed, emphasis has been placed on improving the quality of routine reporting. However, special surveys carried out from time to time provide an alternative view of coverage levels that may be more representative of the entire target population and thereby serve as a check on bias found in data from routine reporting systems. Normally, ministries of health report administrative estimates, and these in turn are received and reported by international organizations such as PAHO, WHO, and UNICEF.

Administrative estimates are calculated by taking the number of vaccine doses administered to the children of a particular age group during a given time period (the numerator) and dividing it by the total number of children in that age group during that time period (the denominator). An administrative estimate is thus based on *period* data (data collected throughout a relatively long period of time, usually a year). Several factors contribute to discrepancies, and sometimes errors, in both the numerators and denominators of administrative estimates.

With respect to numerators, standard practice calls for generating annual administrative estimates of vaccination coverage from a count of vaccine doses administered to children *under one year of age* throughout a year. Typically, the health sector keeps a count of the vaccine doses administered. Some of the factors contributing to numerator variation in these administrative estimates include the following:

- Some estimates count doses sent to the field; others count doses administered as reported by the field.
- Fluctuating inventories of vaccines can significantly influence estimates based on doses sent to the field.
- With respect to doses administered, the inclusion of children vaccinated *outside* the recommended age range, especially children over one year of age, inflates the numerator and therefore the estimate of coverage. Because many countries count doses of vaccine administered without differentiating by age, this is a frequent error.
- Delays in reporting data from the periphery can delay the publication of updates by 6 to 12 months.
- Administrative estimates often include only government-administered vaccines. In that case vaccinations administered by the private sector—including private physicians and nongovernmental organizations—are not counted.

Denominators of administrative estimates are typically the estimated number of children who survive the first year of life. The number of one-year survivors is frequently obtained by subtracting an estimate of the infant deaths during the year (based on infant mortality estimated by a demographic model or taken from census projections) from an estimate of the number of live births during the year (often obtained from a vital events registration system). However, sometimes the total number of live births during the year is used rather than the number of survivors, and in other instances the number used is a midyear estimate of the 0–11.9 month population.

Some of the factors contributing to discrepancies and errors in the denominators of administrative estimates include the following:

- Use of the alternative definitions noted above (one-year survivors, live births, and midyear population) and use of alternative sources (demographic models, censuses, and vital events registration systems).
- Use of different demographic models, which produce different estimates of the IMR used to estimate the number of one-year survivors. (Demographic models typically capture relatively long-term trends and rarely reflect recent reversals in those trends.)
- Use of inappropriate partial cohorts, including cohorts that reflect the vaccination window (e.g., 9–11.9 months for measles) rather than the entire year.

In contrast to the period data used by routine reporting systems, survey estimates are based on data collected at a particular *point* in time, namely, the point in time of the survey. The recommended survey methodology for estimating vaccination coverage rates "by the first birthday" is to survey children 12 through 23.9 months of age, and to count as vaccinated only those children who were vaccinated prior to their first birthday.

In such a survey, estimates for the values of both the numerator (the number of children 12–23.9 months old at the time of the survey who were vaccinated prior to their first birthday) and the denominator (all children who were 12–23.9 months old at the time of the survey) are taken directly from the survey data. Health cards are used to determine birth dates, vaccination status, and age of the child at vaccination. In some cases, mothers' recall about the vaccination is also used.

Under the direction of the World Health Organization, a standard sampling methodology (a two-stage cluster sampling technique) has evolved for estimating vaccination coverage. (In Guatemala, no surveys that used this technique were encountered, although other more extensive health surveys that included vaccination information were found.)

Various factors, including the following, contribute to discrepancies and errors in survey-based estimates.

- Samples may not be truly representative, because limited resources frequently restrict the movement of survey teams in remote places.
- The phenomenon surveyed may be seasonal (in the case of vaccination programs, coverage rates found at one point in time may reflect recent campaigns, temporary breakdowns in the cold chain, or even the irregular pace of vaccination programs forced by rainy seasons, etc.).
- Different sample sizes and sampling techniques (e.g., cluster sampling or simple random sampling) can yield different results.
- The inclusion or exclusion from the numerator (the count of children vaccinated) of undocumented vaccinations—supported by the mother's recall but not by a vaccination card—can affect estimates.
- Data recorded on health cards may be incorrect.
- Aggregation of subnational estimates may have been done incorrectly.
- Variations occur in the age ranges of the children sampled (0–11.9 months, 12–23.9 months, 3–11.9 months, 0–59.9 months have all been used) and in the age range counted in the numerator. Surveys that include children vaccinated after their first birthday in the numerator overestimate the true rate, while surveys that sample only children under one year of age underestimate the true rate unless adjustments are made.

A number of other factors may also contribute to discrepancies and errors in vaccination coverage estimates. Programs with lower coverage rates have an opportunity to vaccinate more children than programs with higher coverage rates because they can vaccinate all the children in the current year's cohort plus many of the as yet unvaccinated children in the previous year's cohort, especially in the case of antigens given early in life. Because denominators are not adjusted to account for this, estimates relating to low-coverage programs have a potential for overestimating true coverage.

In addition, delivery methods can have a spurious effect on coverage estimates. For example, in the wake of a campaign, vaccination coverage with DPT 3 and polio 3 tend to be underreported, and coverage with DPT 1 and polio 1 tend to be overreported, because mothers tend to forget how many times their children were vaccinated.

Vaccination Coverage of Children in Guatemala

Vaccination coverage rates reported for Guatemala in the 1980s, based on both administrative and survey data, were found to have been influenced by most of the variation-producing factors noted above. Some surveys accepted the mother's recall of a vaccination, while others did not. Different sampling frames and sampling methodologies were used. Administrative estimates were found to vary with respect to (1) the time elapsing between the end of the reporting period and the time the report was actually received, (2) the population estimate (denominator) selected, and (3) the degree of rigor applied in limiting the numerator to children vaccinated prior to their first birthday.

Table 1 displays all of the data sources (*8–11, 13–21, 25, 26, 30–35, 38–45*) and the full range of measles vaccination coverage rates discovered during the investigation. The same sources provided information on BCG, DPT 3, and polio 3 vaccination coverage rates in the same years.[7] Eight different rates were derived from the 1987 Demographic and Health Survey (see table listings for DHS 1987 and DHS 1989—*9, 39*), including five for children 12–23.9 months old at the time of the survey. Line 4 in Table 1 gives the coverage reported for the 55.5% of all children surveyed in this age group *with* vaccination cards; this is the rate published in the official report of the DHS. Lines 6, 7, 8, and 9 present estimates of the overall rate (for the children in this age group without cards plus those with cards) based on different assumptions about the vaccination rate among the children without cards. (Lines 6–10 in Table 1 are from a 1989 draft document prepared by the DHS project staff—*39*.)

These coverage estimates based on different assumptions regarding coverage among children without cards illustrate how misleading published rates can be unless their assumptions are specified. Line 6 in Table 1 is the rate derived directly from the mother's recall of her child's vaccination history. (Guatemala was one of seven countries where the mother was asked for a total history—most of the early demographic and health surveys asked only whether the mother recalled her child receiving at least one vaccination.) Line 8 in Table 1 is the rate derived by assuming that children whose mothers recalled at least one vaccination were vaccinated at the same rate as the children with cards. In addition, the DHS staff analyzed the veracity of the mother's recall in the seven aforementioned surveys where the mother was asked for a total history and, based on the analysis, determined an adjustment factor to correct for recall errors. This adjustment factor lowered the coverage rates somewhat

[7]Tables containing the specific data for the other vaccines are available from the first author.

Table 1. Measles vaccination coverage rates in Guatemala, as reported by various sources.

Source	Comment	Pre-1980	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	Post-1989
DHS 1983 (*8*)	Table 13–3, p. 195; coverage of those with cards.	—	—	—	—	11.3*	—	—	—	—	—	—	—
DHS 1983 (*8*)	"	—	—	—	—	54.4§	—	—	—	—	—	—	—
DHS 1987 (*9*)	Table 2.9, p. 17; coverage of those with cards (48.7% 3–11.9 months old had cards).	—	—	—	—	—	—	—	—	12.9†	—	—	—
DHS 1987 (*9*)	Table 2.9, p. 17; coverage of those with cards (55.5% 12–23.9 months old had cards, see Table 2.10, p. 18).	—	—	—	—	—	—	—	—	68.8§	—	—	—
DHS 1987 (*9*)	Table 2.9, p. 17; coverage of those with cards (54.3% had cards).	—	—	—	—	—	—	—	—	60.8¶	—	—	—
DHS 1989 (*39*)	Table 6, column A; based on actual mother's recall of child's vaccination history.	—	—	—	—	—	—	—	—	55§	—	—	—
DHS 1989 (*39*)	Table 6, column B; assumes children without cards were vaccinated at rate of those with cards, adjusted.	—	—	—	—	—	—	—	—	54§	—	—	—
DHS 1989 (*39*)	Table 6, column C; assumes children without cards were vaccinated at rate of those with cards.	—	—	—	—	—	—	—	—	56§	—	—	—
DHS 1989 (*39*)	Derived assuming children without cards received no vaccination.	—	—	—	—	—	—	—	—	38§	—	—	—
DHS 1989 (*39*)	Table 10; method unclear but probably similar to that of the second DHS 1989 entry above.	—	—	—	—	—	—	—	—	25‡	—	—	—
Guat MOH 1980–1987 (*10*)	Data obtained from MOH yearbooks, unverified.	—	60.0**	51.6**	47.0**	12.2**	9.1**	11.0**	49.4**	—	—	—	—
Guat MOH 1987 (*11*)	Numerator of 103 276 vaccinations and denominator of 308 307 births in 1987.	—	—	—	—	—	—	—	—	33.5**	—	—	—
INCAP KAP 1987 (*38*)	Unverified field reporting of data.	—	—	—	—	—	—	—	—	70.6‖	—	—	—
INCAP KAP 1987 (*38*)	"	—	—	—	—	—	—	—	—	3.0†	—	—	—
INCAP Sent 1986 (*13*)	Rural data only, Table 29 and p. 13. Unclear whether figure includes children without cards or mother recall.	—	—	—	—	—	—	58.2§	—	—	—	—	—
INCAP Sent 1986 (*13*)	"	—	—	—	—	—	—	24.7*	—	—	—	—	—
PAHO 1986 (*14*)	Vol. 1, pp. 407–410.	—	—	8**	12**	9**	24**	—	—	—	—	—	—
PAHO 1990 (*15*)	Vol. I, p. 81, Table 20.	—	—	—	—	—	—	—	—	—	—	52**	—
UNICEF State 1986 (*16*)	Table 3, p. 137; 12% is for 1981–1983.	—	—		–12–††		—	—	—	—	—	—	—
UNICEF State 1987 (*17*)	Table 3, p. 94; 12% is for 1980–1981; 11% is for 1984–1985.	—	–12–**		—	—	–11–**		—	—	—	—	—

(cont.)

Table 1. (Continued)

Source	Comment	Pre-1980	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	Post-1989
UNICEF State 1988 (*18*)	Table 3, p. 68; 42% is for 1985–1986.	—	—	8††	—	—	—	–42–††		—	—	—	—
UNICEF State 1989 (*19*)	Table 3, p. 98; 24% is for 1986–1987.	—	—	8††	—	—	—	—	–24–††		—	—	—
UNICEF State 1990 (*20*)	Table 3, p. 80; 54% is for 1987–1988.	—	—	8††	—	—	—	—	—	–54–††		—	—
UNICEF State 1991 (*21*)	Table 3, p. 106; 52% is for 1988–1989.	—	—	8††	—	—	—	—	—	—	–52–††		—
UNICEF CAP 1986 (*25*)	Unverified field reporting of data.	—	—	—	—	12††	24††	—	—	—	—	—	—
UNICEF CAP 1988 (*26*)	"	—	—	8††	—	—	24††	23††	46††	16††	—	—	—
USAID Child (*30–34*)	1985 from *30*, p. 68; 1986 from *31*, p. 58; 1987 from *32*, p. 74; 1988 from *33*, p. 98; 1990 from *34*, p. 66 (provisional figure); all data from WHO/EPI (*40–44*).	—	—	—	—	—	—	23††	47††	24††	54††	—	68††
USAID CP (*35*)	Figures are from the following annual reports: 1985—FY89, Annex 3, p. 111; 1987—FY90, Annex 3, p. 85 and FY91, Annex 3, p. 79; 1988—FY92, Part 1, p. 760.	—	—	—	—	—	—	23††	—	55††	59††	—	—
USAID Guat HIS (*45*)	Coverage for <1-year-olds; figures based on MOH data for doses administered during the year as % of mid-year population.	—	—	—	24.3**	24.3**	27.6**	23.0**	52.1**	24.3**	55.2**	54.3**	—
USAID Guat HIS (*45*)	Coverage for <5-year-olds; figures based on MOH data for doses administered during the year as % of mid-year population.	—	—	—	11.4‡‡	12.9‡‡	10.1‡‡	48.2‡‡	73.4‡‡	63.3‡‡	64.2‡‡	51.7‡‡	—
WHO/EPI (*40–44*)	Figures from following reports: 1980–1985, WHO/EPI, dated 1/87 (*40*); 1986, WHO/EPI, 1/88 (*41*); 1987, WHO/EPI, 1/89 (*42*); 1988, WHO/EPI/GEN/89.2, 7/89 (*43*); 1989, WHO/EPI/CEIS/90.2, 7/90 (*44*); 1990 figure (68%) is provisional.	—	23††	8††	12††	9††	24††	23††	47††	24††	54††	53††	68††

*% infants 0–11.9 months old at the time of the survey who were vaccinated by the time of the survey.
†% infants 3–11.9 months old at the time of the survey who were vaccinated by the time of the survey.
‡% children 12–17.9 months old at the time of the survey who were vaccinated by their first birthday.
§% children 12–23.9 months old at the time of the survey who were vaccinated by the time of the survey.
‖% children 12–23.9 months old at the time of the survey who were vaccinated by their first birthday.
¶% children 3–59.9 months old at the time of the survey who were vaccinated by the time of the survey.
**% all infants (either mid-year population or 1-year survivors) who were vaccinated at <1 year, using administrative data.
††signifies ‖ and/or **.
‡‡% children 0–59.9 months old at the time of the survey who were vaccinated before their fifth birthday, using administrative data.

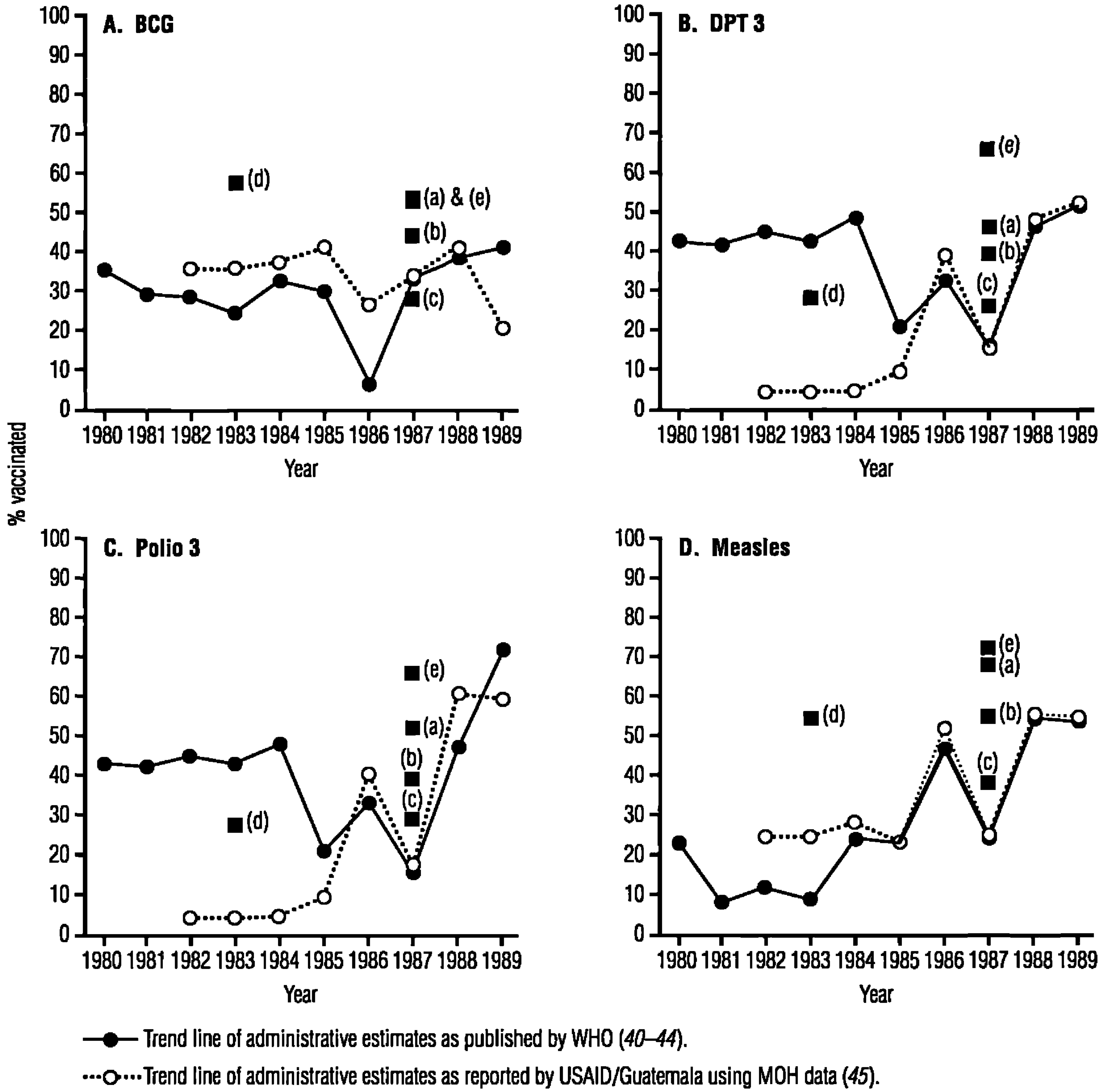
for all antigens except BCG. Line 7 shows the results of applying this adjustment factor to the line 8 estimates. Finally, line 9 shows the most pessimistic rate, which was based on an assumption that any child without a card was not vaccinated.

Figure 4 displays selected vaccination coverage rates published by WHO and reported by USAID. The trends based on the WHO numbers (solid trend line—*40–44*) are the most basic, because they have been derived from information provided by the Ministry of Health and are frequently used by other reporting agencies such as UNICEF (*16–23*) and USAID (*30–34*). A second trend line, reported by the USAID Mission in Guatemala (dotted trend line—*45*), is also based on MOH administrative data but differs substantially from the WHO-reported trend line in some years. During the first half of the decade, the WHO estimates are much higher than the USAID estimates for DPT 3 and polio 3, but lower than the USAID estimates for BCG and measles. These large discrepancies in the early part of the decade appear to be due primarily to the fact that the Ministry of Health data used by USAID/Guatemala was actually published in 1990 and therefore was subject to adjustment by the Ministry in the intervening years; whereas the data used by WHO was reported as soon after the data collection period as possible. The WHO and USAID estimates in the latter half of the decade are closer together; the small differences can be largely explained by the use of different population estimates in the denominator. The divergence of the two trend lines for BCG coverage in 1989 (41 vs 20.8) points up the instability of vaccination coverage estimates. We do not know the reason for this divergence.

The results of the national demographic and health surveys (DHS) undertaken in 1983 (*8*) and 1987 (*9*), together with the results of the 1987 KAP study (*38*), provide a useful comparison to the official figures published by WHO (*40–44*). Figure 4 includes three of the five 1987 DHS (*9, 39*) estimates made for children 12–23.9 months of age at the time of the survey (see points a, b, and c). One of these estimates (see point a) was based on the assumption that all children without cards were vaccinated at the same rate as those with cards; another one (see point b) was based on the assumption that only those children whose mothers recalled at least one vaccination were vaccinated at the same rate as the children with cards; and the third (see point c) was based on the assumption that children without cards were not vaccinated.

The graphs in Figure 4 suggest an intriguing phenomenon regarding measurement of vaccination coverage (both inside and outside Guatemala) by means of survey data (as reported by DHS and INCAP) versus administrative data (as reported by WHO). Specifically, one is tempted to jump to the conclusion that apparent 1987 vaccination coverage as determined by survey data is higher than that determined by administrative data. However, the group surveyed in 1987 was 12–23.9 months old; and so a significant part of the group was vaccinated in 1986. With the exception of the BCG trend line, the WHO administrative rates for 1986 were higher than the most pessimistic DHS estimates and only slightly lower than the middle DHS estimates that assumed the coverage of children whose mothers recalled at least one vaccination was the same as the coverage found for children with cards. Thus, the difference between the two estimates (DHS 1987 and WHO administrative) can be largely explained by differences in definition rather than differences in data. (The BCG administrative trend seems out of line with the others, with vaccination coverage falling off rather than rising in 1986. We know of no explanation for this deviation.) All four estimates reported by the

Figure 4. Vaccination coverage rates estimated by various agencies for BCG, DPT 3, polio 3, and measles vaccinations based on both administrative and survey data, 1980–1989.



Notes:

1. The WHO and USAID/Guatemala administrative estimates are the ratios of vaccines given to children under 1 year of age to estimates of the mid-year populations for the years shown.
2. All survey estimates are for the age group 12 through 23.9 months of age.

Sources:

(a) DHS (9): assuming all children without vaccination cards were vaccinated at the same rate as the children in possession of vaccination cards.

(b) DHS (39): assuming only those children whose mothers recalled at least one vaccination for their children were vaccinated at the same rate as the children in possession of vaccination cards.

(c) DHS (39): assuming all children without vaccination cards received no vaccination at all.

(d) DHS, 1983 (8): treatment of the card/recall issue unknown.

(e) KAP (38): treatment of the card/recall issue unknown.

KAP 1987 (*38*) survey for 1987 and two of the four estimates reported by the DHS 1983 (*8*) survey for 1983 are much higher than the corresponding administrative estimates for the same year, possibly because relatively high coverage rates were ascribed to children without health cards.

Tetanus Toxoid Coverage

Deriving tetanus toxoid coverage trends among women from historical data is particularly challenging, due partly to changing definitions of the coverage indicator over time and partly to the cumulative protective effect of tetanus toxoid vaccination over the course of a lifetime. These two matters are closely related.

Properly spaced, five doses of tetanus toxoid will protect a woman from tetanus and all of her newborns from neonatal tetanus throughout her childbearing years. In populations where little effort has been made to vaccinate women against tetanus, the traditional strategy adopted by health professionals has been to give two shots during the latter stages of a single pregnancy. Hence, the historical indicator used to monitor program progress is the proportion of pregnancies in which two doses are administered.

However, as the number of women receiving subsequent doses of the vaccine through repeated pregnancies increases, and as more young women who were vaccinated for DPT as children reach childbearing age, the proportion of protected newborns increases, even among mothers who may not have received the prescribed two shots during any single pregnancy. Here the traditional indicator ceases to address the relevant issue, the proportion of newborns protected against neonatal tetanus.

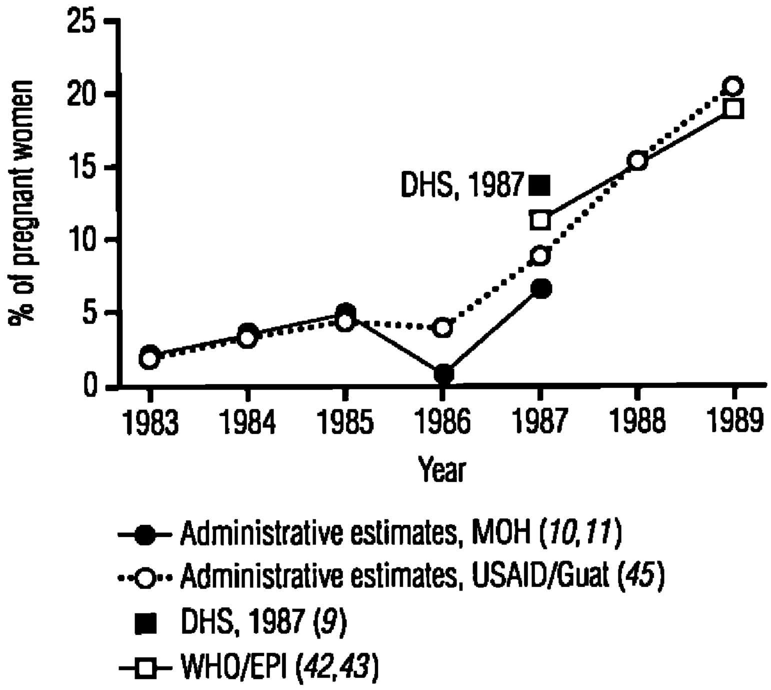
For this reason, efforts are underway worldwide to modify the neonatal tetanus indicator so that it successfully measures long-term protection. The new indicator is the proportion of newborns whose mothers have received sufficient tetanus toxoid vaccinations, properly spaced, to guarantee the newborn's protection against neonatal tetanus. In some cases this coverage has been defined as the number of properly vaccinated women of childbearing age divided by the number of childbearing women in the population. However, because the acceptance of this new indicator varies and underlying assumptions are not always made explicit, it is not always possible to determine which definition applies to a particular published rate.

As with estimates of vaccination coverage against childhood diseases, estimates of tetanus toxoid coverage are available from both administrative and survey sources; and the quality of the latter is determined by many of the same factors that determine the quality of the former. Among other things, administrative estimates are only as good as the ability of the routine reporting system to capture the number of doses given and the accuracy of the estimated number of pregnancies occurring in a given time period. Frequently the denominator is estimated by the number of live births during a period rather than the number of pregnancies, which, due to miscarriages and stillbirths, underestimates the denominator and therefore overestimates the coverage. Survey estimates are limited by the ability of mothers to recall their vaccination histories. Frequently, where children have vaccination cards mothers do not, and therefore maternal recall is especially important. Also, surveys are frequently not comparable due to the diverse ways in which vaccination histories are sought and recorded.

Thirteen different sources of estimates were found for tetanus toxoid coverage in Guatemala in the 1980s[8]; Figure 5 displays selected estimates. The DHS esti-

[8]DHS 1987 urban, rural, and total (*9*); MOH 1980–1987 (*10*); MOH 1987 (*11*); INCAP 1986 (*13*); UNICEF 1988, 1989, 1990, and 1991 (*18–21*); USAID 1985–1987 (*30–34*); USAID 1984–1989 (*45*); and WHO/EPI (*40–43*).

Figure 5. Tetanus toxoid vaccination coverage estimated by different sources that use administrative and survey data. Coverage is defined as the percentage of pregnant women in the calendar year receiving two or more doses of tetanus toxoid during the pregnancy, except in the case of the DHS estimate, where coverage is the percentage of live births in the preceding 5 years for which mothers received at least one dose during pregnancy.



mates for 1987 (*9*) reflect the percentages of births among urban, rural, and all survey respondents during the five years preceding the survey for which the mother had received at least one tetanus toxoid vaccination. Three trend lines are shown in Figure 5: estimates for 1983–1987 published by the MOH (*10, 11*); estimates for 1983–1989 reported in the USAID/Guatemala database using MOH data (*45*); and two estimates (1987 and 1989) reported by WHO/EPI (*42, 43*) that are also based on MOH data. All three define the numerator as the number of second doses given to pregnant women in the time period indicated and define the denominator as the number of live births occurring in that period.

As may be seen, the tetanus toxoid vaccination coverage rates appear quite low throughout the decade. The unexplained 1986 drop in the Ministry of Health estimates may have been due to a change in service delivery strategies, or may be an artifact of the method of computation applied by the Ministry.

ORS USE: TRENDS AND VARIATIONS

Measuring ORS Use Trends

The appropriate technology for treating watery diarrhea is administration of prepackaged oral rehydration salts (ORS) or homemade sugar-salt solutions (SSS). During the child survival initiative of the late 1980s, a distinction was made between the ORS use rate and the oral rehydration therapy (ORT) use rate, the former being limited to use of prepackaged ORS. The World Health Organization publishes both the ORS use rate and the (ORS + SSS) use rate, the latter under the heading of "ORT Use Rate."

According to the USAID Child Survival Program (*30–34*), ORT involves three aspects of diarrhea case management—the administration of either ORS or SSS, continued appropriate feeding during diarrhea, and referral of severe cases to proper medical treatment facilities. None of the ORT use rates published by WHO refer to the more complex USAID definition. Moreover, individuals and institutions citing primary data sources commonly fail to distinguish clearly between ORS, (ORS+SSS), and ORT use rates.

Both ORS and (ORS+SSS) use rates are best determined by surveys. The recommended method for inquiring about rehydration practice is to select children 0–59.9 months old who have had diarrhea in the two weeks preceding the survey and to ask their mothers what treatment was administered to these children. (This method requires rather large sample sizes to ensure finding enough children with diarrhea episodes in the two weeks preceding the survey.) Variations in how the question is posed to the mothers limit the comparability of survey results, as does the fact that some surveys use recall periods that are longer or shorter than two weeks. Overall, errors and inconsistencies arise in the rates found by the surveys for various reasons, including the following:

- different recall periods;
- different treatment of households with more than one child under 5 years old;
- sample composition differences arising from seasonal variations in the distribution of diarrhea cases;
- different questions and methods of asking questions to mothers about diarrhea and their own behavior;
- inaccurate responses by mothers who have learned how to answer the questions to please the authorities but have not changed their behavior; and
- loose handling of the distinctions between packets, proper home solutions, and improper home solutions.

WHO has developed procedures for estimating the ORS use rate from data on the number of packets available in a country during a given year. First, an estimate of diarrhea incidence is made, often from old surveys. An algebraic algorithm is then applied to estimate how many of those cases were treated with ORS, based on estimates of the availability of ORS packets in homes and health facilities. In the absence of other empirical data, these estimates are reasonable; however, factors such as the existence of packet supply backlogs or packet nonusage following distribution do not enter into the estimation procedure.

As use of oral rehydration treatment for diarrhea has become more widespread, increasing attention has been given to proper application of the technology. Studies have shown that all too often mothers use the packets but mix the solution incorrectly or fail to give adequate amounts to their children. Similarly, mothers do not always mix home solutions in the proper proportions or give adequate quantities to their children. In addition, there is always the possibility that reported increases in ORS or ORT use rates may simply reflect increased inappropriate usage, especially the giving of inadequate quantities to not very sick children. Thus, a 40% use rate is not necessarily twice as good as a 20% use rate.

In years to come, indicators of ORS and ORT use may be changed to distinguish proper application of the treatment from faulty applications. Ideally, the reported oral rehydration use rate should maximize appropriate use and minimize inappropriate use in the light of resource limitations of both the home and the government. However, because ORS and ORT use rates apply to all diarrhea episodes, not just watery diarrhea, it is unclear what the ideal use rate should be in most situations.

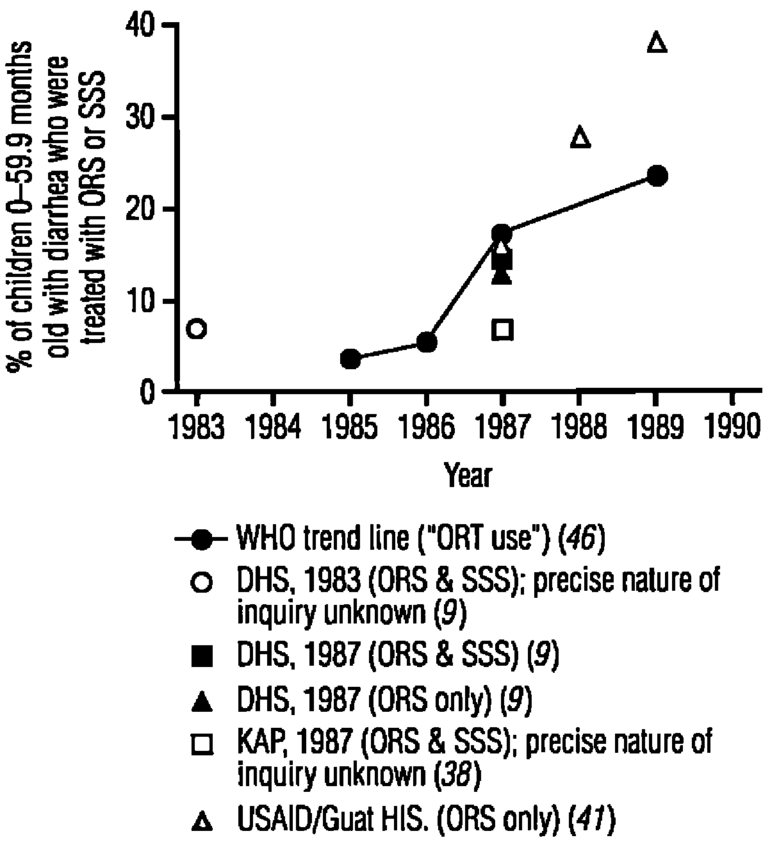
ORS Use Rates in Guatemala

In Guatemala, data are available regarding ORS and (ORS + SSS) use rates from two types of sources: the routine reporting system (as reflected in rates published by WHO—*46*) and surveys. The rates published by WHO are computed by a variety of methods depending on the data available.

Figure 6 charts most of the data available regarding ORS and (ORS + SSS) use. Table 2 contains the actual numbers, including several applying to multi-year estimates and several others applying to rural areas only that are not shown in the chart. While the apparent overall trend in (ORS + SSS) use is positive, the absolute levels of use attained by 1989 were still well below 50%.

The two 1987 DHS estimates in Figure 6 indicate the apparent gap between ORS use and (ORS + SSS) use in Guatemala. This gap does not seem very large, sug-

Figure 6. ORS and (ORS + SSS) use rates estimated by reports of different sources based on both administrative and survey data.



gesting that the primary rehydration solution used in the country is the packet. More broadly, the diversity of the various 1987 estimates appears due primarily to differences in definitions rather than differences in data, underlining the need to exhibit caution in comparing numbers unless the definitions and procedures used to derive those numbers are known to be the same.

DISCUSSION AND CONCLUSIONS

Many different published and unpublished estimates for rates of infant mortality, vaccination coverage, and ORS use were found for Guatemala in the 1980s. Counting a publication series as a single source,[9] we found 16 different sources for infant mortality; 13 sources for BCG vaccination coverage; 14 sources for DPT, polio, and measles coverage; 8 sources for tetanus toxoid coverage; and 8 sources for ORS use.

Although the reported IMR declines more or less steadily throughout the decade (see Figure 3), estimates of all vaccination coverages and ORS use remain relatively low—near or well below 50% for most of the decade. Moreover, the decade trends in vaccination coverage are not consistently favorable (see Figure 4). The coverages for BCG, DPT 3, polio 3, and measles are all approximately constant during the first half of the decade according to WHO/EPI (*40–44*) and USAID/Guat HIS (*45*) estimates, and then show oscillating patterns in the last half of the decade. Finally, DPT 3, polio 3, and measles coverages were all higher at the end of the decade than at the beginning according to both sources, while 1989 BCG coverage was higher according to WHO/EPI (*44*) but lower according to USAID/Guat HIS (*45*). Tetanus toxoid coverage and ORS use (see Figures 5 and 6) show fairly consistent upward trends according to all available sources.

The single most striking finding of the study is the diversity of the estimates reported by the different sources. Data for the single year of 1985 yielded 10 different infant mortality estimates ranging from 56.0 to 79.8 deaths per 1 000 live births, a spread of 23.8 deaths (see Figure 2). Reported BCG coverage for that same year ranged from 30% to 60.5%, DPT 3 coverage ranged from 3.5% to 34.2%, polio 3 coverage ranged from 3.5% to 33.5%, measles vaccine coverage ranged from 11% to 58.2%, and tetanus toxoid coverage ranged from 1% to 8.2%. In a similar vein, reported ORS use for 1985 ranged from 3.5% to 7.2%, for 1987 ranged from 8.7% to 17%, and for 1989 ranged from 38.3% to 69.5%. Ranges in other years were almost as large for all the indicators, although the variations in reported child-

[9]The publication series that were counted as single sources include PAHO's *Health Conditions in the Americas* (*14, 15*), UNICEF's *State of the World's Children* (*16–23*), the UNICEF Area Office for Central America and Panama *Annual Report* (*25, 26*), USAID's *Congressional Presentation: Latin America and the Caribbean* (*35*), and USAID's reports to Congress on child survival (*30–34*).

Table 2. ORT coverage rates in Guatemala for children 0–59.9 months old, as reported by various sources. ORS = prepackaged oral rehydration salts; SSS = homemade sugar-salt solution; ORT = ORS or SSS and appropriate feeding and referral.

Source	Comment	1981	1982	1983	1984	1985	1986	1987	1988	1989	Post-1989
DHS 1983 (*8*) (ORS + SSS)	Table 12–14, p. 192; episode within past week; 7.4% ORS and 1.4% SSS.	—	—	8.8	—	—	—	—	—	—	—
DHS 1987 (*9*) (ORS only)	Table 2.8, p. 16; last episode within past 2 weeks.	—	—	—	—	—	—	13.2	—	—	—
DHS 1987 (*9*) (ORS + SSS)	Calculation performed by DHS; result not published in official report.	—	—	—	—	—	—	15.9	—	—	—
INCAP KAP 1987 (*38*) (ORS + SSS)	Unverified field report from reference; last episode; 7.1% ORS and 1.6% SSS.	—	—	—	—	—	—	8.7	—	—	—
INCAP Sent 1986 (*13*) (ORS + SSS)	Rural data only; Table 33; 0–35.9 months of age; 3.5% ORS and 3.7% SSS.	—	—	—	—	7.2	—	—	—	—	—
USAID Guat 1989 (*36*) (ORS only)	Rural data only; 0–35.9 months of age; unverified field report from reference; from INCAP Sent 1986 (*13*).	—	—	—	—	3.5	3.5	—	—	—	—
USAID Guat HIS (*45*) (ORS only)	0–59.9 months of age; ORS cases treated as % of mid-year population under 5.	—	—	—	—	—	—	16.1	27.8	38.3	—
UNICEF State 1990 (*20*) (ORS only)	Table 3, pp. 80, 100; % of cases treated with ORS in under fives (1986–1987, 1989).	—	—	—	—	—	–17–		—	69.5	—
UNICEF State 1991 (*21*) (ORS + SSS)	Table 3, pp. 106, 126; % of cases treated with ORS + SSS in under fives (1987–1988).	—	—	—	—	—	—	–17–		—	—
UNICEF State 1992 (*22*) (ORS + SSS)	Table 3, p. 76; % of cases treated with ORS + SSS in under fives (1987–1989).	—	—	—	—	—	—		–24–		—
UNICEF State 1993 (*23*) (ORS + SSS)	Table 3, p. 72; % of cases treated with ORS + SSS in under fives (1987–1991).	—	—	—	—	—	—			–24–	
WHO CDD (*46*) (ORS only)	1985 figure based on household sample survey; 1987 figure is National CDD (Control of Diarrheal Diseases) Program estimate.	—	—	—	—	3.5	3.4	17.0	—	—	—
WHO CDD (*46*) ("ORT use")	1985 figure same as ORS use; 1986 figure is midpoint between (ORS + SSS) and (maximum of ORS or SSS).	—	—	—	—	3.5	5.4	17.0	—	24	—

hood vaccination coverages tended to be greater earlier in the decade (see Figure 4).

Another noteworthy point is that several organizations published multiple estimates for the same indicator in the same year. For example, three Guatemalan Ministry of Health estimates of infant mortality in 1984 ranged from 52.4 to 79.8 deaths per 1 000 live births; four UNICEF estimates of infant mortality in 1985 ranged from 65 to 79.8; and three USAID estimates of infant mortality in 1987 ranged from 59 to 72.

As already noted, an assortment of factors contributed to the diversity of the estimates—including a variety of definitions, data sources, estimation methods, and reporting methods. Many of these factors have been found in other countries and discussed by other authors (*1–3, 39, 47*). Each of the health indicators studied is a rate that includes both a numerator and denominator; and the factors causing the observed variations often contributed independently and differentially to the numerator and denominator. This phenomenon has also been found to influence the reporting of other health indicators (*48*). In general, the results of important data "events," such as a demographic and health survey, seem to find their way into most data sources eventually, but after different delays and after passing through and being interpreted by various levels of intermediate sources, a process that can introduce errors (see Figure 1).

Overall, our findings demonstrate that policy makers and evaluators need to take care when basing decisions on one or a few estimates of child survival indicators such as those examined here. While decade-long trends are reasonably consistent, shorter-term trends and absolute values can be very misleading. Organizations reporting these indicators need to exercise greater care in defining and reporting accurately and completely about both the numerators and denominators upon which their estimates are based, and to explicitly state the sources and procedures involved.

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