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Raising Awareness Among Immunization Programme Managers to the Potential Bias Resulting from the Application of Fixed Factors to Obtain Target Population Size Estimates

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Abstract: The challenges faced by many immunization programmes in understanding the size of the target population(s) for their work is seemingly well recognized, although not well documented. Despite the aid of adjustments for differences over time, inadequate information constitutes a major weakness of target population size estimates for many immunization programme managers. Because complete vital registration, the most reliable source for target population data, does not exist in the majority of the low- and middle-income countries [1,2], immunization programmes must estimate the number of children in the target population (e.g., births, surviving infants) based on counts or estimates made by local programme staff or health workers or rely on projections from the latest census data [3].

Keywords: Population size estimates, Immunization programme.

The challenges faced by many immunization programmes in understanding the size of the target population(s) for their work is seemingly well recognized, although not well documented. It is the inadequacy of the available information in this area, even with the aid of adjustments for differences over time, that constitutes a major weakness of target population size estimates for many immunization programme managers. Because complete vital registration, the most reliable source for target population data, does not exist in the majority of the low- and middle-income countries [1,2], immunization programmes must estimate the number of children in the target population (e.g., births, surviving infants) based on counts or estimates by local programme staff or health workers or rely on population projections from the latest census data [3]. Population projections are complex computations [4] that involve uncertainty and this uncertainty increases the further one is from the previous census.

In some instances, the number of live births and surviving infants (i.e., children surviving until there first birthday) is estimated by applying fixed "conversion factors" (e.g., 3%, 4%, 5%) to estimates of total population size. It is important for those using target population estimates based on the latter approach to understand the potential consequence and that a trend bias may be introduced which can influence planning and monitoring efforts over time.

Consider a hypothetical example for Country A where a total of 1,782,000 children aged <12 months are immunized with 3 doses of diphtheria and tetanus with pertussis containing vaccine (DTP_3) during 2005; given that the number of children aged <12 months (e.g., surviving infants) is 2,377,000 for Country A in 2005, the true immunization coverage level for DTP_3 vaccine during 2005 is 75%. Of course, immunization coverage is a derived measure that is computed as the number of children vaccinated during a period (during the first year of life, <12 months of age) divided by the number of children who survive to their first birthday (i.e., surviving infants). The number of surviving infants is also a derived measure, computed by applying the infant mortality rate to the number of births. In Country A, the immunization programme multiplies the total population size for the country (57,421,000) by the conversion factor 0.04 (or 4% or 40 per 1000 population) to estimate the total number of births (2,297,000). The estimated number of surviving infants (2,113,000) is obtained by applying the infant mortality rate, in this example assumed to be 80 per 1000 live births. Although true immunization coverage with DTP_3 is 75%, the estimated DTP_3 coverage is 84% (1,782,000 ÷ 2,113,000), an overestimate of 9% points that results from the application of a conversion factor that differs from the actual crude birth rate for 2005, which was 45 per 1000 population.

Utilization of fixed factors can also result in the introduction of a trend bias. Continuing with our example, the number of children immunized with DTP_3 before their first birthday increased during the period 2000 to 2015 but coverage levels remain constant at 75% (Table **1**, Example 1). Again, the immunization programme estimates the total number of births by multiplying the total population size for the country by a conversion factor of 0.04 (or 4%) and the number of surviving infants is obtained by applying the infant mortality rate (fixed here at 80 per 1000 live births). In this instance, estimated DTP_3 coverage levels decline from 90% during 2000-05 (15% points higher than the true coverage!) to 79%

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Table 1. Hypothetical Examples Demonstrating Trend Bias Introduced in Estimated Immunization Coverage Levels as a Result of Applying a Fixed Crude Birth Rate Over Time

	2000-05	2005-10	2010-15
EXAMPLE 1			
A. Number of surviving infants immunized (x 1000)	1820	1970	2104
B. Average total population (x1000)	54,953	63,452	72,623
C. "True" crude birth rate	0.048	0.045	0.042
D. "Assumed fixed" crude birth rate	0.04	0.04	0.04
E. "Assumed fixed" infant mortality rate	0.08	0.08	0.08
F. Estimated target population size … … ((B×D) - (B×D×E))	2022	2335	2673
G. Estimated DTP_3 coverage ((A ÷ F) × 100%)	90%	84%	79%
H. True target population size … … … …((B×C) - (B×C×E))	2427	2627	2806
I. True DTP_3 coverage ((A ÷ H) × 100%)	75%	75%	75%
EXAMPLE 2			
A. Average number of surviving infants immunized (x 1000)	494	575	610
B. Average total population (x1000)	15,207	17,785	20,462
C. "True" crude birth rate	0.049	0.044	0.037
D. "Assumed fixed" crude birth rate	0.04	0.04	0.04
E. Infant mortality rate	0.116	0.104	0.091
F. Estimated target population size … … ((B×D) - (B×D×E))	538	637	744
G. Estimated DTP_3 coverage ((A ÷ F) × 100%)	92%	90%	82%
H. True target population size … … … …((B×C) - (B×C×E))	659	701	688
I. True DTP_3 coverage ((A ÷ H) × 100%)	75%	82%	89%

during 2010-15. Again, true coverage levels are constant. The observed trend bias is a direct consequence of the declining crude birth rate (*ceteris paribus*) that the country has experienced over the period.

Example 2 in Table **1** demonstrates how utilization of fixed factors can mask a true increase in coverage. In this hypothetical example, the country is experiencing a decline in crude birth rate as well as a decline in infant mortality. The number of children immunized with DTP_3 is increasing over time as are true immunization coverage levels, from 75% for 2000-05 to 89% for 2010-15. Estimated coverage levels, however, decline over the period from 92% to 82% as a result of an inaccurate conversion factor to obtain the estimated number of births.

Applying fixed conversion factors as noted above assumes the appropriate conversion factor is constant over time. This assumption is much less likely to hold true in most low- and middle-income countries in 2010 than in 1980 as a result of rapid demographic changes in these countries with declining crude birth rates in more recent years (Table **2**); in Eastern Africa, for example, the median crude birth rate decreased from 45 per 1000 population (min/max: 20/52; Q1/Q3: 44/48) during 1980-85 to 38 (min/max: 13/46; Q1/Q3: 34/41) during 2005-10.

So, what options does the immunization programme manager have at his/her disposal? Ideally, immunization programme staff work closely with the staff at the national statistics office to make use of the latest population census data and population projections to obtain estimates of live births and surviving infants that more accurately translate than a fixed conversion factor. Surprisingly enough, many national statistical offices are unaware of how immunization programmes utilize population data derived from censuses and thus initiating a dialogue between the two areas is important. Immunization programme staff may also utilize population estimates and projections produced by the United Nations Population Division (UNPD). Although the UNPD estimates may not match those of the national statistics office, the UNPD estimates are readily available and are produced using a standard approach and therefore facilitate the construction of a consistent time-series of population esti-

Table 2. Crude Birth Rate Per 1000 Population from 1980-85 Through 2005-10

Major area or region	1980-1985	1985-1990	1990-1995	1995-2000	2000-2005	2005-2010
World	28	27	24	22	21	20
Africa	44	43	40	38	37	36
Eastern Africa	47	46	44	42	40	38
Middle Africa	48	48	48	47	46	43
Northern Africa	39	35	30	27	25	24
Southern Africa	35	32	28	26	25	23
Western Africa	47	45	44	42	41	40
Asia	29	28	25	22	20	19
Eastern Asia	21	22	18	15	13	12
South-Central Asia	36	34	31	28	25	24
Central Asia	32	32	29	23	21	23
Southern Asia	36	34	31	28	25	24
South-Eastern Asia	32	29	26	22	21	19
Western Asia	36	33	30	28	25	24
Europe	14	14	12	10	10	11
Latin America and the Caribbean	31	28	25	23	21	19
Northern America	15	16	15	14	14	14
Oceania	20	20	20	19	18	18

Source: United Nations, Department of Economic and Social Affairs, Population Division (2011). *World Population Prospects: The 2010 Revision,* obtained from http://esa.un.org/unpd/wpp/Excel-Data/fertility.htm on 12 February 2012.

mates, a useful characteristic for monitoring immunization coverage levels over time.

We noted at the outset that challenges with immunization target population size estimates are recognized; unfortunately sustained commitments to invest in and improve immunization and civil registration data are too often conspicuously absent from discussions on the way forward [5]. The World Health Organization is currently developing an approach to assist national immunization programmes to assess and improve estimates of target population size. It is hoped that this effort will provide immunization programmes with viable alternatives while efforts continue to raise awareness of the importance of civil registration systems among national governments and development partners [6,7].

ABBREVIATIONS

DTP3 = 3 doses of diphtheria and tetanus with pertussis containing vaccine

UNPD = United Nations Population Division

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DISCLAIMER

The findings and views expressed herein are those of the authors alone and do not necessarily reflect those of their respective institutions.

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