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Vaccine preventable diseases: Time to re-examine global surveillance data?

Adam MacNeil[a,*], **Vance Dietz**[a], **Thomas Cherian**[b]

[a] Global Immunization Division, Centers for Disease Control and Prevention, Atlanta, GA, USA

[b] Department of Immunization, Vaccines and Biologicals, World Health Organization, Geneva, Switzerland

Abstract

While data driven estimates of the global burden of disease for some vaccine preventable diseases (VPDs) are limited, aggregate case numbers of VPDs are reported annually by country in the Joint Reporting Form (JRF). We examined pertussis surveillance data in the JRF, and vaccine coverage estimates, in comparison to measles, which is a priority disease for elimination and eradication efforts and is supported by the WHO Global Measles and Rubella Laboratory Network. In 2012, highest pertussis case numbers and incidence were reported from high income countries with high vaccine coverage, discordant with countries that had low vaccine coverage. Use of laboratory diagnostics for pertussis cases varied among countries. In contrast, highest reported numbers of measles cases and incidences tended to occur in low income countries. These observations imply poor quality global surveillance data for some VPDs, limiting capacity for monitoring global epidemiology or making vaccination policy decisions. Efforts are needed to improve the availability of quality surveillance data for all VPDs.

Keywords

Surveillance; Pertussis; Measles; Vaccine preventable disease; Data

1. Introduction

Global or multi-national surveillance standards exist for numerous vaccine preventable diseases (VPDs) including polio, measles, yellow fever, and rotavirus, as well as some vaccine preventative causes of invasive bacterial disease, meningitis, and encephalitis [1–6]. While the geographic scope and sensitivity of these surveillance systems may differ, use of consistent case definitions, standardized core variables, laboratory networks, and performance indicators allow for evaluation of surveillance data quality. Based on these, it is possible to draw conclusions about the epidemiology of disease, which in turn can be used for program monitoring and making vaccine policy decisions.

* Corresponding author at: The Centers for Disease Control and Prevention, 1600 Clifton Road NE, MS A-04, Atlanta, GA 30333, USA. Tel.: +1 404 639 8169. aho3@cdc.gov (A. MacNeil).

By contrast, the availability of reliable surveillance data for some VPDs – notably, pertussis, diphtheria, and tetanus – is limited and lacks the surveillance and laboratory standardization of other priority diseases. From a global perspective, annual number of reported VPD cases are provided by member countries to the World Health Organization (WHO) and the United Nations Children's Fund (UNICEF) in the Joint Reporting Form (JRF). These numbers are meant to represent all cases, including clinically, epidemiologically and laboratory confirmed cases [7]. The JRF also requests reporting of the number of cases for which laboratory testing was performed and the number of cases which were laboratory confirmed.

Pertussis is highly transmissible and incidence rates continue to be high; transmission is presumed to occur in all regions of the world. Measles has received significant attention among international partners because of elimination and mortality reduction efforts [2]. In addition, measles surveillance is supported by the WHO Global Measles and Rubella Laboratory Network, which serves >180 countries and follows standardized laboratory procedures for confirming suspected cases [8]. To better understand the current surveillance data quality situation for pertussis, as a typical VPD, in comparison to measles, which has a well-established global surveillance system, we compared surveillance data for these two diseases from the same sources.

2. Methods

In the JRF, 3 fields are collected pertaining to each VPD: total cases (including clinically, epidemiologically, and laboratory confirmed), number of cases tested by laboratory investigation, and number of cases confirmed by laboratory investigation [7]. For both pertussis and measles, we examined completeness of reporting data for all countries and graphically evaluated incidence per country, with WHO/UNICEF estimates of coverage with three doses of diphtheria-tetanus-pertussis (DPT) vaccine (DTP3 coverage) (for pertussis) and the first dose of measles vaccine (MCV1 coverage) (for measles) [9] among <1 year olds for member states in 2012 (updated, as of July 13, 2013) [7], and World Bank Gross National Income per capita, Atlas method (GNI) [10]. Annual incidence was calculated as the number cases reported on the JRF divided by the WHO population estimate for the associated country [11]. Because of strong outlier data, we additionally examined in-detail countries with high case counts, incidence, and lowest vaccine coverage, for pertussis and measles. To account for potential annual fluctuations due to periodic outbreaks, we similarly examined incidence over a 5 year time period (2008–2012). Finally, to assess the consistency in the reporting of laboratory-based surveillance for pertussis, we evaluated completeness of pertussis data for number of cases tested by laboratory investigation, and number of cases confirmed by laboratory investigation, as well as the consistency of these numbers with total cases reported.

3. Results

Among 194 member states, 34 did not provide data on pertussis cases and an additional 52 reported zero pertussis cases during 2012. In contrast, only 11 countries did not provide measles surveillance data in 2012. Although 62 countries reported zero cases of measles, many of these are nations documented to have met their measles elimination targets.

The 2012 country-level incidence of pertussis was compared with DTP3 coverage and GNI (Fig. 1). Interestingly, many countries with high relative incidence of reported pertussis were countries with high DTP3 coverage. Similarly, many of the countries with high incidence had high GNI. When similar plots were examined for measles (Fig. 2), there was not a clear trend between reported measles incidence and vaccine coverage. However, in contrast to pertussis, high measles incidence occurred almost exclusively in countries with low GNI; this difference between pertussis and measles is particularly apparent among outlying (high) incidence countries on these graphs.

Based on these observations, we further examined country-specific data for countries with highest case counts, incidence, and lowest vaccine coverage. For pertussis, highest reported case counts and incidence rates in 2012 tended to occur in high income countries (Tables 1a and 1b), as demonstrated by gross national income per capita (GNI) among the 10 counties with highest pertussis counts (median GNI = $22,450) and highest pertussis incidence (median GNI = $30,620). However, countries with the lowest estimated DTP3 coverage were more likely to be low income countries (Table 1c). For instance, median GNI among the 10 countries with lowest estimated DTP3 coverage was $740. Highest reported pertussis incidence from 2008 to 2012 commonly occurred in high income countries with high DTP3 coverage (median GNI of 10 countries with highest pertussis incidence = $28,310; median estimated DTP3 coverage = 94%, in the mid-point year of 2010) (Table 1d).

As with the DTP3 coverage rates, lowest MCV1 coverage rates tended to occur in lower income countries (median GNI among the 10 countries with lowest coverage = $760); however, in contrast with pertussis, the highest measles case counts and incidence rates were in less-developed countries (median GNI among 10 highest case count countries = $1450; median GNI among 10 highest incidence countries = $3500) (Tables 2a, 2b, and 2c), suggesting that functional measles surveillance systems are in place among low income countries. Similarly, over the 5 year time period of 2008–2012, highest reported measles incidence tended to occur among low income countries (median GNI of 10 countries with highest measles incidence = $1170) (Table 2d).

In the 2012 JRF, 45 countries reported having performed laboratory testing for at least one suspected pertussis case. In the section for aggregate number of laboratory-confirmed cases, 162 of 194 countries provided information (including zero cases), among which 58 listed at least one laboratory-confirmed case (4 countries reported having tested at least one suspect case, but did not report any laboratory confirmed pertussis cases, and 17 countries reported having laboratory-confirmed cases, but listed zero cases or had absent data on the number of cases tested). Sixteen of the 58 countries with laboratory-confirmed pertussis cases had the same number of total and laboratory-confirmed pertussis cases, suggesting that only laboratory-confirmed cases were reported on the JRF. Five countries reported a larger number of laboratory-confirmed cases than total pertussis cases. Among the ten countries with the highest total reported pertussis cases in 2012 (Table 1a), one country did not provide any information in the section for reporting laboratory-confirmed cases, five countries listed zero laboratory-confirmed cases, and four countries reported having laboratory-confirmed pertussis cases. Taken together, these observations suggest that pertussis surveillance data reported on the JRF represents a mix of clinical and laboratory confirmed cases, with reporting standards varying among countries.

4. Discussion

The country-level discordance between pertussis incidence and DTP3 coverage, and limited sensitivity (86 of 194 countries provided no data or reported zero pertussis cases), suggests poor quality pertussis surveillance data reported using the JRF. This is supported by the observation that high pertussis incidence is common in high income countries, which may be related to the availability of increased resources for disease detection and reporting. The comparison of country-level disease data for the entire population with estimated DTP3 coverage must be undertaken with caution. Estimates of vaccination coverage among children <1 year of age are indicative of population immunity of a limited age cohort, and may not be representative of the entire population. Additionally, as the number of cases deceases, as is the case for measles in many countries, there may be an increased effort to detect all cases. However, measles surveillance data from a comparable source are suggestive of a functional global surveillance system, including in low-income countries, and are more consistent with global monitoring efforts and surveillance standards [2,8].

The WHO case definition for pertussis has two classifications: a clinical case, based only on clinical symptoms, and a laboratory-confirmed case, although the clinical symptoms as well as the laboratory tests used for confirmation may vary among countries [12]. In many countries, the total number of pertussis cases reported in the 2012 JRF was larger than the number of laboratory-confirmed cases; however, a small proportion of countries reported the same number of total and laboratory-confirmed pertussis cases, which points toward exclusive use of the laboratory-confirmed case definition and possible underestimation of the burden of disease. This underscores the variability in the use of case definitions and lack of data standardization for pertussis data in the JRF. Finally, the observation that many of the countries with high reported pertussis incidence did not provide any information on laboratory confirmation, although many of these higher income countries presumably have diagnostic laboratory capacity, prevents us from drawing conclusions about the reporting criteria used for many pertussis cases reported through the JRF.

We opted to focus our analysis on pertussis surveillance data, in comparison to measles. This decision was based on the estimated burden of global disease [13], transmissibility of *Bordetella pertussis* among humans, as well as the fact that pertussis epidemiology is one of determinants of the primary immunization schedule. Pertussis data are generally reported as aggregate numbers of cases, as is the case of diphtheria and tetanus, in comparison to measles, in which case-based reporting commonly occurs. Hence, it is likely that the reporting of the three diseases may have similar issues.

Why should we care about surveillance data quality for VPDs such as pertussis? First, surveillance data are crucial for monitoring disease incidence and for assessing the performance of the immunization program. Disease outbreaks serve as an opportunity to identify susceptible pockets or communities with low population immunity that may be missed through routine monitoring of vaccination coverage alone. These data are also critical for informing immunization policies and strategies, including the number and timing of immunization doses, as well as better understanding the severity of illnesses and whether additional public health interventions are warranted.

Currently, data on some VPDs reported through the JRF are insufficient for assessing epidemiologic trends or for informing immunization policies or strategies. Because of uncertainties about the quality of reported data, as well as the absence of more detailed information on disease epidemiology (such as the age and geographic distribution of cases), aggregate reports of pertussis cases in the JRF are not routinely used for global monitoring. Previous estimates of global pertussis burden have relied on mathematical models, in contrast to direct use of surveillance data [13]; however, the limitation of these models and the absence of high quality, representative, epidemiologic data from low and middle income countries is well recognized.

Recently there has been a resurgence of pertussis in several industrialized countries with well-performing surveillance and reporting systems, most of which use acellular pertussis vaccine. This has led to questions about waning immunity of these vaccines and the need for additional booster doses [14–18]. The observations in this report may partially be explained by the use of acellular pertussis in these countries. Importantly, the poor quality global surveillance data for pertussis makes it difficult to derive firm conclusions on the use of acellular pertussis vaccine or the need for additional booster doses.

Previous strategies have discussed the need for improving surveillance for all VPDs [19]. Challenges exist for improving surveillance data quality for some VPDs. Active surveillance and available laboratory diagnostic capacity are lacking in many countries [20]. Furthermore, variation in disease presentation and differences in case definitions may impact the sensitivity, specificity, and comparability of surveillance data among countries [12,21]. We encourage further discussion and exploration among agencies and member countries to improve the quality, and effective use of VPD surveillance data, in order to inform policy decisions and ensure proper immunization program monitoring, as well as to consider implementing outbreak investigation, with laboratory confirmation, to better describe the local disease epidemiology and allow more informed decisions on vaccine policies and strategies.

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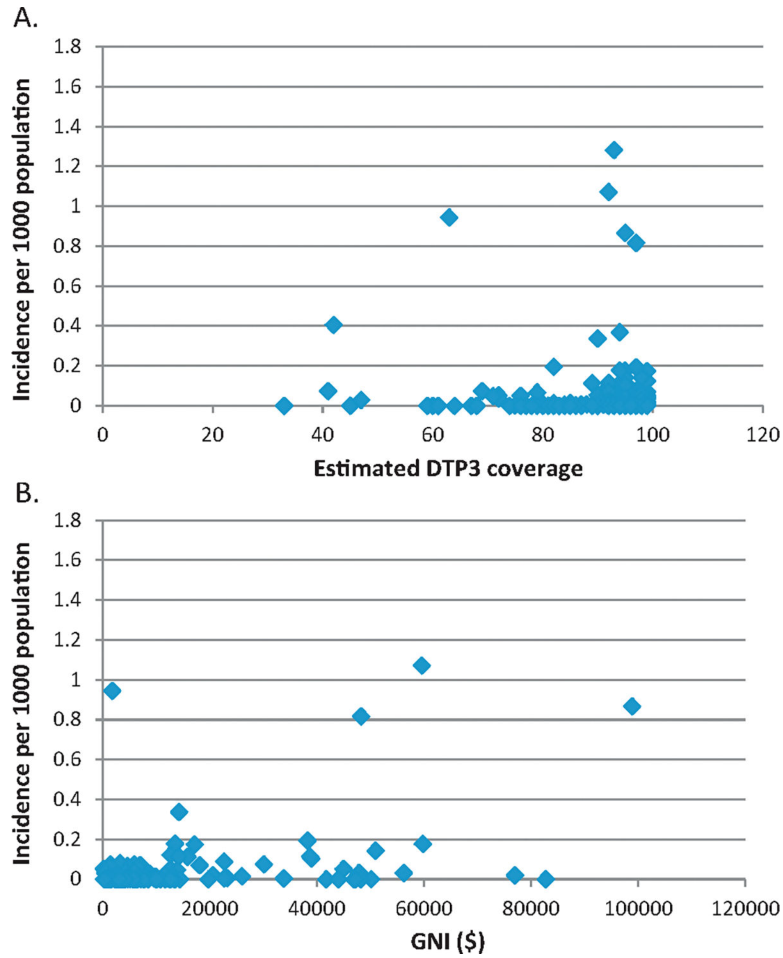

Fig. 1.

Country-level pertussis incidence per 1000 population, 2012, in comparison to estimated DTP3 coverage, 2012 (A) and GNI ($), 2012 (B).

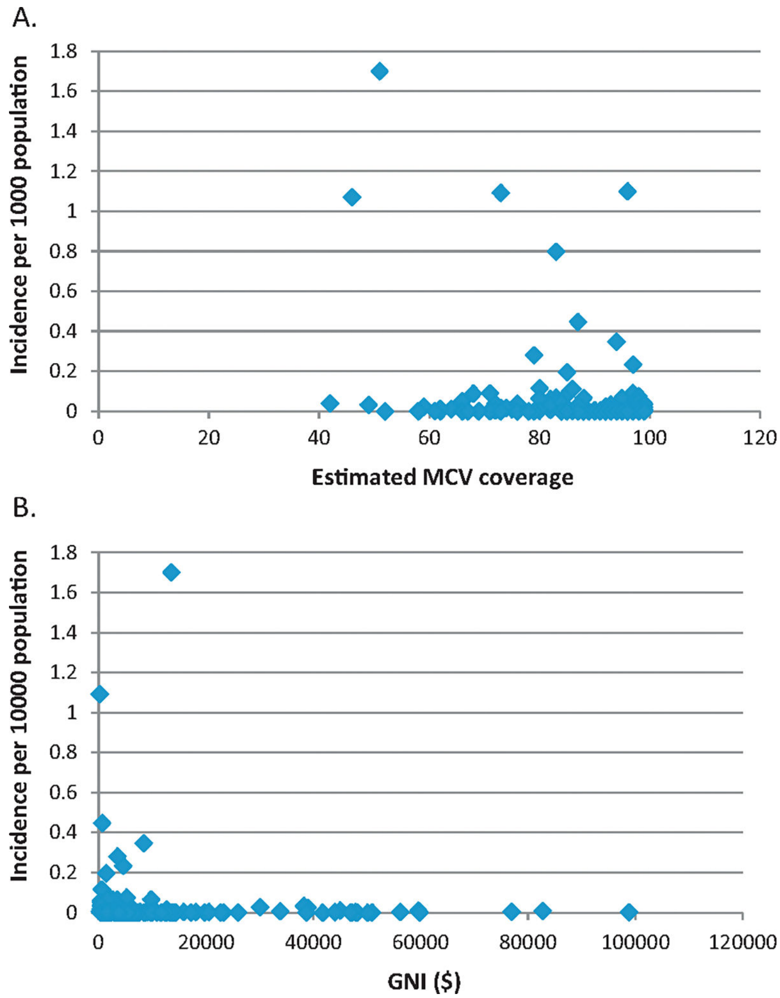

Fig. 2.

Country-level measles incidence per 1000 population, 2012, in comparison to estimated MCV coverage, 2012 (A) and GNI ($), 2012 (B).

Table 1a

Countries with the highest pertussis case counts, as reported on 2012 JRF.

Country	Pertussis case count, 2012 JRF	Annual pertussis incidence, per 1000 population[a]	Estimated DTP3 coverage[b], 2012	GNI, ($), 2012[c]
India	**44,154**	0.036	72 (85)	1530
Australia	**23,855**	1.07	92 (92)	59,570
Netherlands	**13,552**	0.82	97 (97)	48,250
United Kingdom of Great Britain and Northern Ireland	**11,980**	0.19	97 (97)	38,250
Nigeria	**11,628**	0.07	41 (57)	1430
Russian Federation	**7220**	0.05	97 (97)	12,700
Papua New Guinea	**6472**	0.94	63 (63)	1790
Chile	**5762**	0.37	90 (90)	14,280
New Zealand	**5598**	1.28	93 (93)	30,620*
Canada	**4845**	0.14	95 (95)	50,970

Table 1b

Countries with the highest annual incidence of pertussis, 2012.

Country	Pertussis case count, 2012 JRF	Annual pertussis incidence, per 1000 population[a]	Estimated DTP3 coverage[b], 2012	GNI, ($), 2012[c]
New Zealand	5598	**1.28**	93 (93)	30,620*
Australia	23,855	**1.07**	92 (92)	59,570
Papua New Guinea	6472	**0.94**	63 (63)	1790
Norway	4231	**0.87**	95 (95)	98,860
Netherlands	13,552	**0.82**	97 (97)	48,250
Somalia	3784	**0.41**	42 (61)	NA
Israel	2730	**0.37**	94 (NA)	28,930*
Chile	5762	**0.34**	90 (90)	14,280
Yemen	4699	**0.20**	82 (82)	1110*
United Kingdom of Great Britain and Northern Ireland	11,980	**0.19**	97 (97)	38,250

Table 1c

Countries with the lowest estimated DTP3 coverage, 2012.

Country	Pertussis case count, 2012 JRF	Annual pertussis incidence, per 1000 population[a]	Estimated DTP3 coverage[b], 2012	GNI, ($), 2012[c]
Equatorial Guinea	0	0	**33 (41)**	13,560
Nigeria	11,628	0.07	**41 (57)**	1430
Somalia	3784	0.41	**42 (61)**	NA
Syrian Arab Republic	4	<0.01	**45 (64)**	2610†
Chad	Not reported		**45 (72)**	740
Central African Republic	124	0.03	**47 (59)**	490
South Sudan	Not reported		**59 (68)**	650
Guinea	Not reported		**59 (99)**	460
Haiti	0	0	**60 (81)**	760
Ethiopia	Not reported		**61 (83)**	410

Table 1d

Countries with the highest pertussis incidence, 2008–2012.

Country	Total pertussis case count, 2008–2012 JRF	Annualized pertussis incidence, 2008–2012, per 1000 population[a]	Estimated DTP3 coverage[b], 2010	GNI, ($), 2010[c]
Australia	140,160	**1.26**	92 (92)	46,320
Norway	20,930	**0.86**	93 (93)	86,850
Papua New Guinea	18,978	**0.55**	56 (70)	1300
Netherlands	38,053	**0.46**	97 (97)	48,580
Estonia	3036	**0.45**	94 (94)	14,150
New Zealand	8708	**0.40**	93 (93)	28,310
Switzerland	14,300	**0.37**	96 (96)	73,350
Israel	9670	**0.26**	94 (NA)	27,270
Somalia	8300	**0.18**	45 (64)	NA
Slovenia	1695	**0.17**	96 (96)	23,910

The bold value represents the column which was used to select the countries that are listed in the table.

[a]Annual incidence is calculated as the number of pertussis cases reported on the 2012 JRF [7] divided by the WHO population estimate for the associated country [11] (In Table 1d, the 5 year total incidence was divided by 5, to represent average annual incidence).

[b]UNICEF/WHO estimate of DTP3 coverage [9]. Numbers in parentheses represent country official figures on theJRF.

[c]GNI = World Bank Gross National Income percapita, Atlas method [10] (*estimate from 2011, †estimate from 2010).

Table 2a

Countries with the highest measles case counts, as reported on 2012 JRF.

Country	Measles case count, 2012 JRF	Annual measles incidence, per 1000 population[a]	Estimated 1st dose measles coverage[b]	GNI ($), 2012[c]
Democratic Republic of the Congo	**72,029**	1.09	73 (84)	220
India	**18,668**	0.02	74 (85)	1530
Indonesia	**15,489**	0.06	80 (84)	3420
Ukraine	**12,746**	0.28	79 (79)	3500
Somalia	**9983**	1.07	46 (49)	NA
Sudan (the)	**8523**	0.20	85 (85)	1450
Pakistan	**8046**	0.05	83 (89)	1260
Romania	**7450**	0.35	94 (94)	8420
Burkina Faso	**7362**	0.45	87 (87)	670
Nigeria	**6447**	0.04	42 (78)	1430

Table 2b

Countries with the highest annual incidence of measles, 2012.

Country	Measles case count, 2012 JRF	Annual measles incidence, per 1000 population[a]	Estimated 1st dose measles coverage[b]	GNI ($), 2012[c]
Equatorial Guinea	1190	**1.70**	51 (34)	13,560
Nauru	11	**1.10**	96 (96)	
Democratic Republic of the Congo	72,029	**1.09**	73 (84)	220
Somalia	9983	**1.07**	46 (49)	NA
Djibouti	709	**0.80**	83 (83)	NA
Burkina Faso	7362	**0.45**	87 (87)	670
Romania	7450	**0.35**	94 (94)	8420
Ukraine	12,746	**0.28**	79 (79)	3500
Angola	4458	**0.23**	97 (97)	4580
Sudan (the)	8523	**0.20**	85 (85)	1450

Table 2c

Countries with the lowest estimated 1st dose measles coverage, 2012.

Country	Measles case count, 2012 JRF	Annual measles incidence, per 1000 population[a]	Estimated 1st dose measles coverage[b]	GNI ($), 2012[c]
Nigeria	6447	0.04	**42 (78)**	1430
Somalia	9983	1.07	**46 (49)**	NA
Central African Republic	141	0.03	**49 (65)**	490
Equatorial Guinea	1190	1.70	**51 (34)**	13,560
Vanuatu	0	0	**52 (94)**	3080
Guinea	6	<0.01	**58 (99)**	460
Haiti	0	0	**58 (66)**	760
Mali	341	0.02	**59 (85)**	660
Syrian Arab Republic (the)	13	<0.01	**61 (78)**	2610†
South Sudan	1952		**62 (70)**	650

Table 2d

Countries with the highest measles incidence, 2008–2012.

Country	Total measles case count, 2008–2012 JRF	Annualized measles incidence, 2008–2012, per 1000 population[a]	Estimated 1st dose measles coverage[b], 2010	GNI, ($), 2010[c]
Malawi	118,790	**1.59**	93 (93)	340
Burkina Faso	65,246	**0.79**	92 (63)	600
Democratic Republic of the Congo	223,756	**0.68**	74 (87)	190
Bulgaria	24,412	**0.65**	97 (97)	6320
Namibia	7379	**0.65**	75 (75)	4430
Somalia	28,490	**0.61**	46 (68)	NA
Equatorial Guinea	1704	**0.49**	51 (51)	9840
Zambia	30,050	**0.46**	96 (97)	1080
Lesotho	2839	**0.26**	85 (70)	1170
Iraq	36,344	**0.23**	75 (89)	4380

The bold value represents the column which was used to select the countries that are listed in the table.

[a] Annual incidence is calculated as the number measles cases reported on the JRF [7] divided by the WHO population estimate for the associated country [11] (In Table 2d, the 5 year total incidence was divided by 5, to represent average annual incidence).

[b] UNICEF/WHO estimate of 1st dose measles-containingvaccine coverage [9]. Numbers in parentheses represent country official figures on the JRF.

[c] GNI = World Bank Gross National Income percapita, Atlas method [10] (†estimate from 2010).