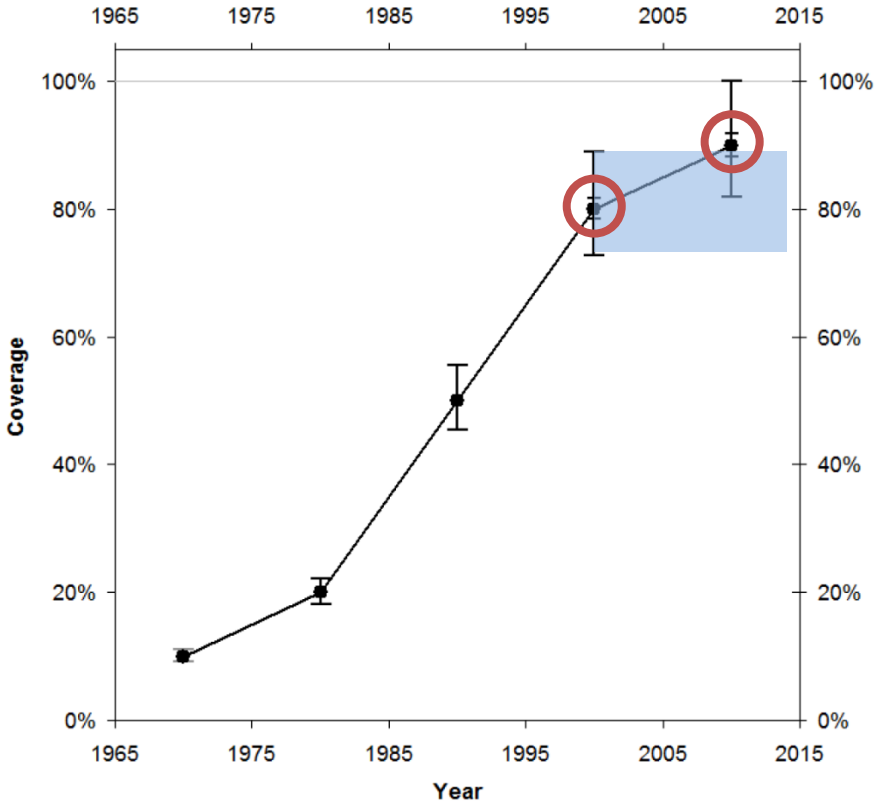
Assessing and Improving the Accuracy of Target Population Estimates for Immunization Coverage

Target accuracy* and high coverage

- As coverage rises, coverage estimates become increasingly sensitive to errors in target population estimates
- Ex. Impact of 10% error in estimation of target population with different coverage levels

True values			Estimates	
Target Population	Vaccin-ations	Coverage	Target Population	Coverage
100	10	10%	90-110	9-11%
100	20	20%	90-110	18-22%
100	50	50%	90-110	45-56%
100	80	80%	90-110	73-89%
100	90	90%	90-110	82-100%



*Accuracy = closeness of an estimate to the unknown true value it represents

Immunization target populations

- **Live births** → birth doses
- **Surviving infants** → for first year of age doses

*Surviving infants = live births * (1 - infant mortality rate)*

- Other **ages** → for booster doses, HPV, influenza…
- Other **target groups** → health workers, high-risk groups

Sources for target population

- **Civil Registration** and Vital Statistics (CRVS)
  - births and death registration
- Census & **projections**
  - More accurate for national than subnational level
  - projections decrease in accuracy over time
- **Registration** of population (within or outside health sector)
  - If within health sector, accuracy depends on overall access to health and reporting system
  - Particular case: **Electronic Immunization Registries** (EIRs)
- **Other** – estimates, modelled, example: using satellite images and counts

Assessing accuracy

Steps to assess target population (1)

1. Define period: 5-10 years data
2. Compare EPI target with other sources (ex. World Population Prospects, WorldPop, National Stats Office data)
   - Flag differences ≥10%
3. Calculate annual growth rate
   - Flag differences ≥10%
4. Compare Implied Mortality Rates (IMR) with other sources (ex. WPP, World Development Indicators, data from surveys)
   - Flag differences ≥20%
5. Compare national targets (ex. births) with sum of subnational targets
   - Flag if national births ≠ ∑ of subnational births

Assessing accuracy

Compare EPI target with other sources

	Births (000)				Surviving Infants (000)		
Year(s)	EPI	WPP	Ratio	WPP IMR	EPI	WPP	Ratio
2000	883	1,001	0.88	62.2	883	939	0.94
2001	897	991	0.91	59.4	897	932	0.96
2002	1,063	979	1.09	56.7	1,035	924	1.12
2003	1,078	966	1.12	54.1	1,051	914	1.15
2004	1,099	952	1.15	51.6	1,027	902	1.14
2005	1,118	937	1.19	49.2	1,045	891	1.17
2006	1,138	923	1.23	46.9	1,064	880	1.21
2007	1,158	911	1.27	44.6	1,083	870	1.24
2008	1,179	901	1.31	42.2	1,102	863	1.28
2009	1,068	894	1.19	39.9	1,013	858	1.18
2000-09	10,681	9,455	1.13	-	10,200	8,973	1.14

Overall difference of >10%

Overall difference of >10%

Assessing accuracy
Calculate annual growth rate

- Growth rate of national births could be calculated as:

$$Growth\ Rate = \left(\frac{Births\ in\ Year\ 2}{Births\ in\ Year\ 1}\right) - 1$$

Based on data from several countries with accurate births data, >10% annual fluctuation of growth rate likely indicate errors in the target estimate

Years	BCG	DTP1	DTP3	MCV	Pol3
2000-2001	1.6	1.6	1.6	1.6	1.6
2001-2002	18.5	15.4	15.4	15.4	15.4
2002-2003	1.4	1.5	1.5	1.5	1.5
2003-2004	1.9	-2.3	-2.3	-2.3	-2.3
2004-2005	1.7	1.8	1.8	1.8	1.8
2005-2006	1.8	1.8	1.8	1.8	m
2006-2007	1.8	1.8	1.8	1.8	m
2007-2008	1.8	1.8	1.8	1.8	m
2008-2009	-9.4	-8.1	-8.1	-8.1	m

Assessing accuracy

Check implied Infants Mortality Rates (IMR)

Year	IIMR DTP1	IIMR DTP3	IIMR MCV	WPP IMR
2000	0	0	-319	62
2001	0	0	0	59
2002	123	123	123	57
2003	123	123	123	54
2004	123	123	123	49
2005	120	120	120	47
2006	109	109	109	45
2007	81	81	81	42
2008	81	81	81	42
2009	80	80	80	40

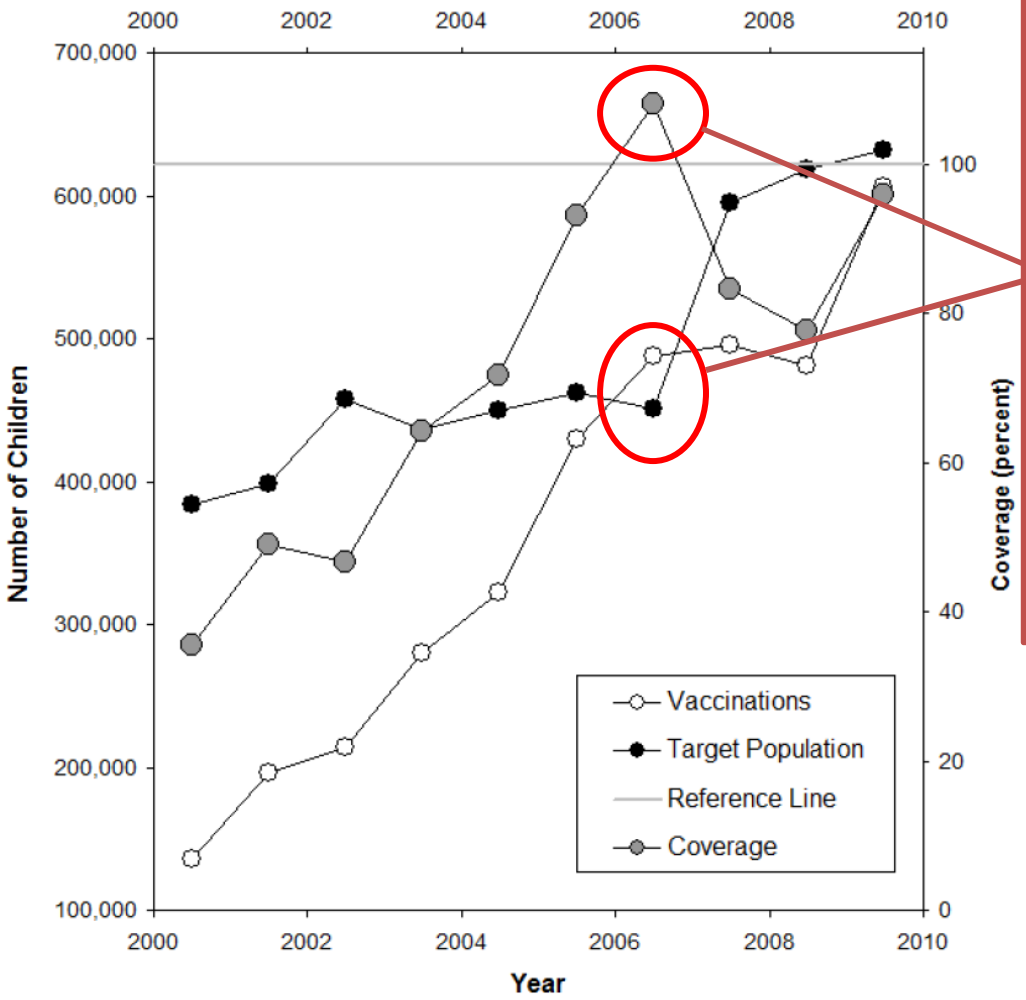
Negative value is impossible

Implied IMR is much higher (>20%) than WPP estimates

It suggests that estimates for surviving infants were not available/used

Assessing accuracy

Plotting and analysing time series

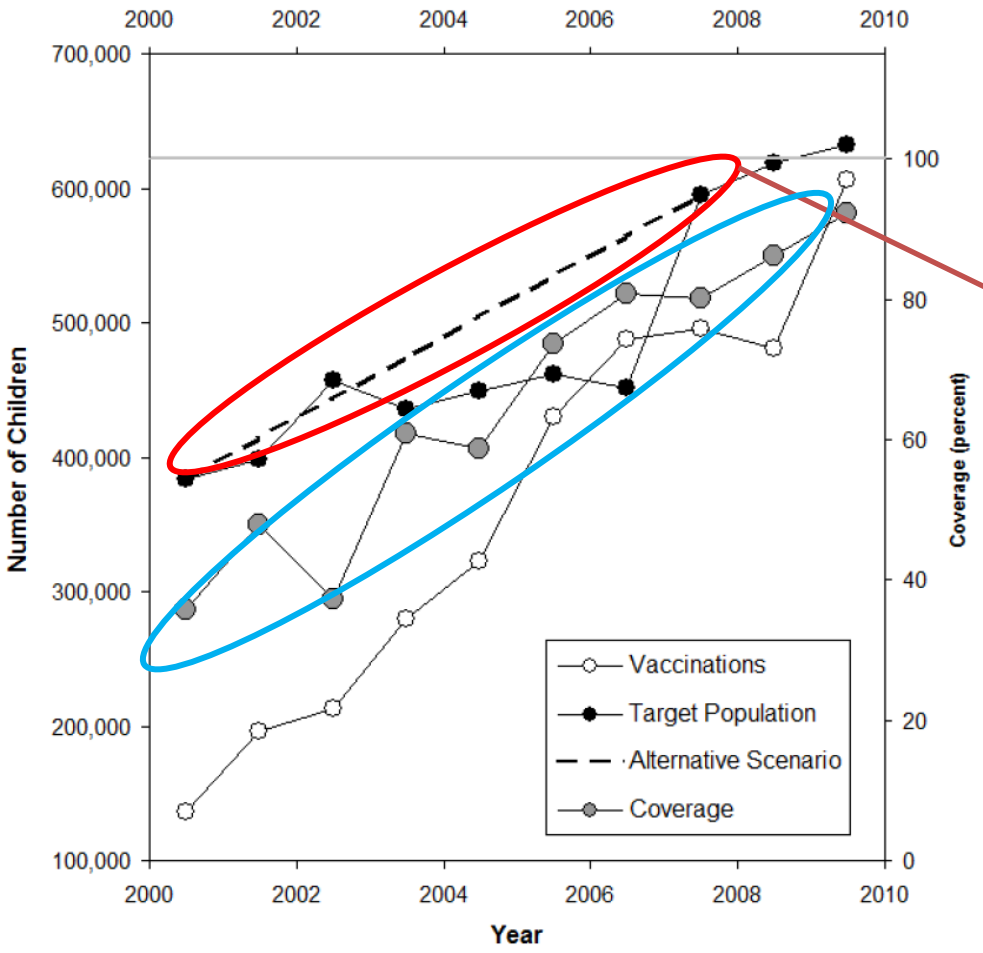


Coverage >100%

- Vaccinations trend seems plausible
- Overall target trend seems not plausible:
  - Given the vaccination trend, 2002-2006 population growth seems underestimated

Assessing accuracy

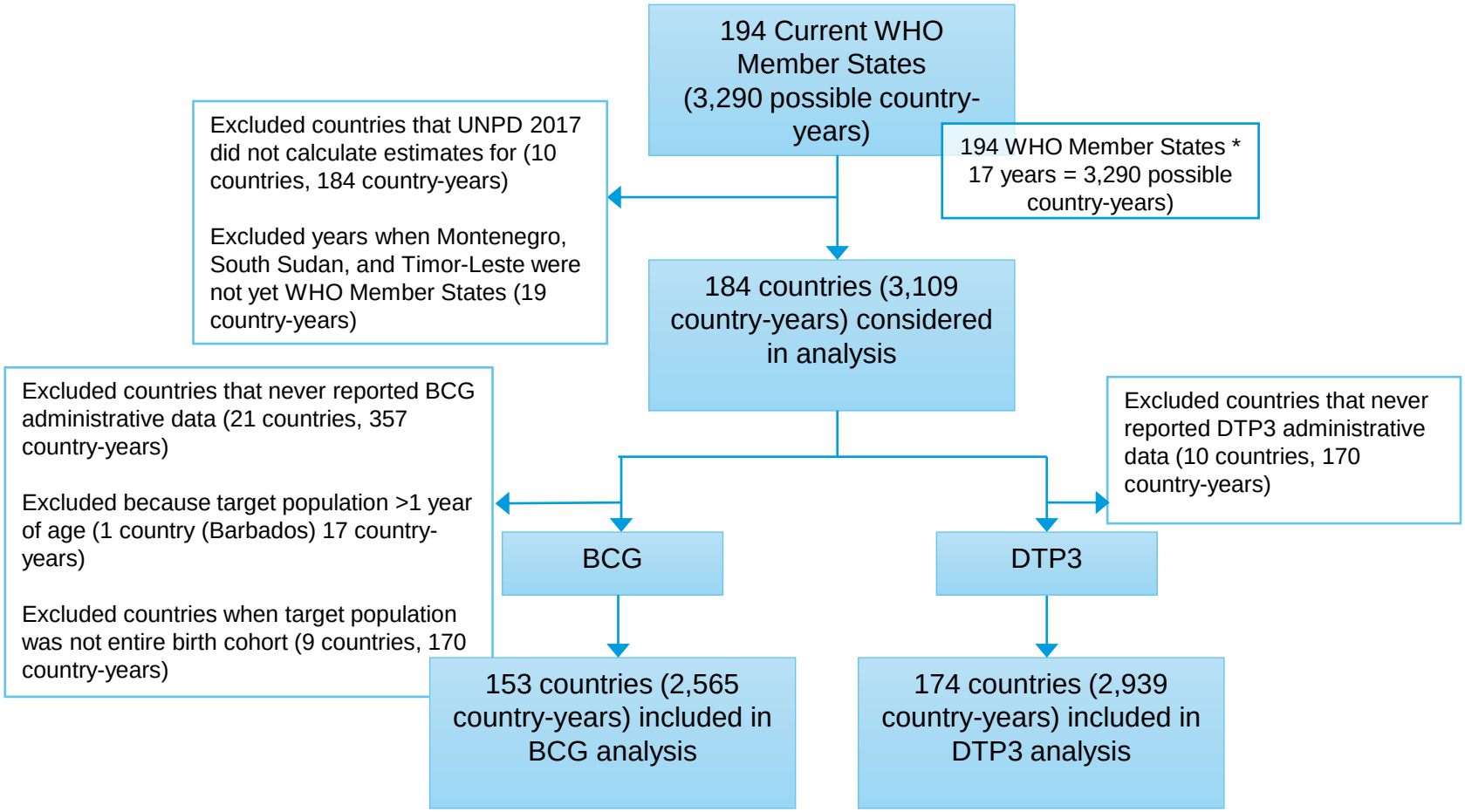
Plotting and analysing time series



- Linear interpolation of target population from 2000 to 2007 values, provides a more plausible coverage trend, without outliers
- Investigation on method used to estimate target population in 2001-2006 should be conducted to better understand limitations/errors of target population

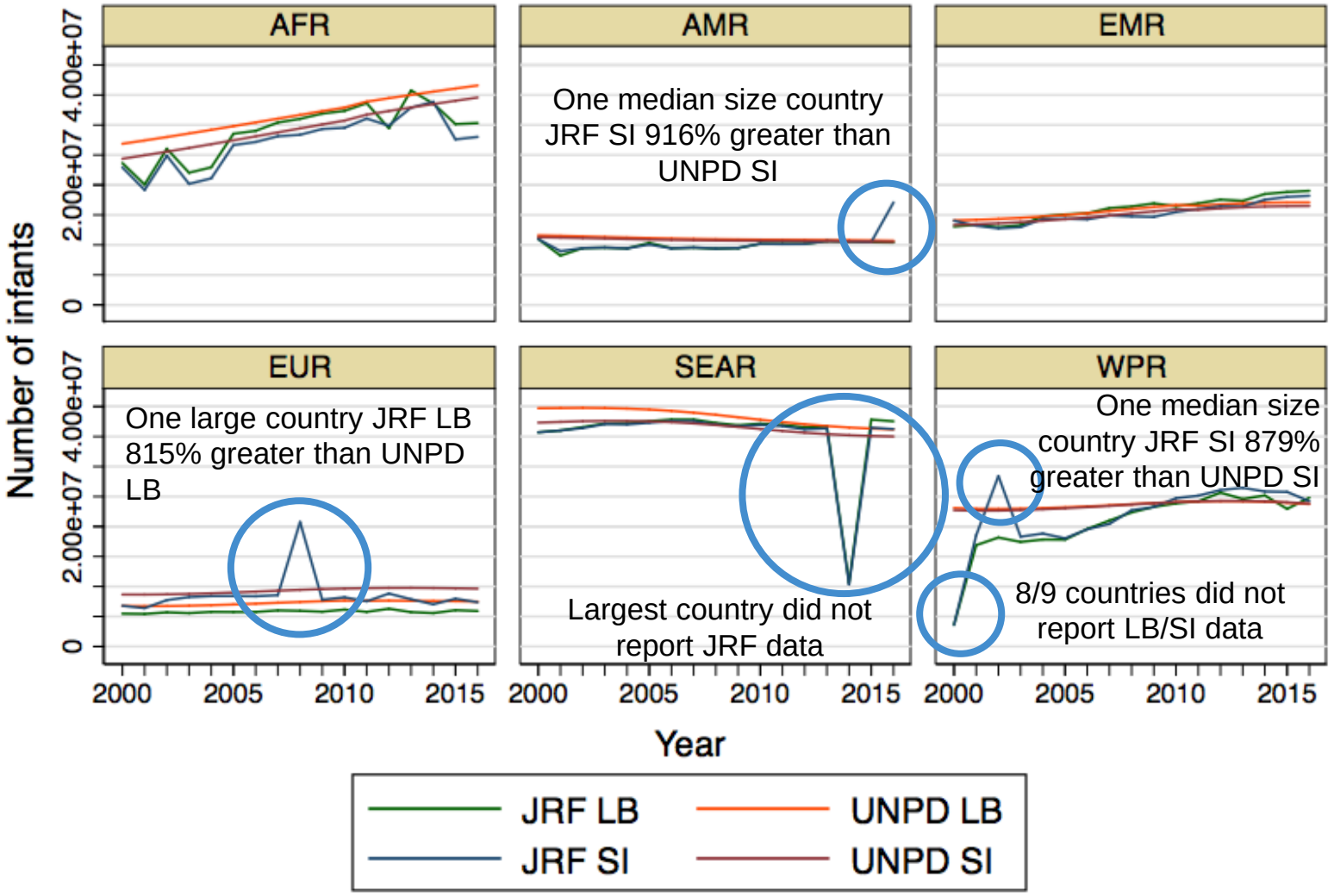
Published Analysis

Assessing reported BCG and DTP3 data from 2000 to 2016



Source: World Health Organization. (2015). Assessing and Improving the Accuracy of Target Population Estimates for Immunization Coverage. Working draft.

Regional number of LB and SI reported through JRF compared to UNPD 2017 estimates



Checklist for Assessing Accuracy

Following recommendations in the *WHO Denominator Guide*

Indicator		Country-Years		Countries	
		N reported data points	N observations	N reported countries	N observations
Reported LB missing	Any year	2565	194 (8%)	153	62 (41%)
	For 5 or more years	-	-	153	12 (8%)
	For 10 or more years	-	-	153	5 (3%)
Reported SI missing	Any year	2939	274 (9%)	174	81 (47%)
	For 5 or more years	-	-	174	20 (11%)
	For 10 or more years	-	-	174	7 (4%)

Checklist for Assessing Accuracy

Following recommendations in the *WHO Denominator Guide*

Indicator		Country-Years		Countries	
		N reported data points	N observations	N reported countries	N observations
Year-to-year difference in reported live births (LB)	>5%	2158	550 (25%)	151	141 (93%)
	>10%	2158	253 (12%)	151	100 (66%)
Year-to-year difference in reported surviving infants (SI)	>5%	2407	621 (26%)	173	162 (94%)
	>10%	2407	274 (11%)	173	120 (69%)
Year-to-year difference in reported BCG coverage	>5%	2137	788 (37%)	151	120 (79%)
	>10%	2137	423 (20%)	151	104 (69%)
Year-to-year difference in reported DTP3 coverage	>5%	2366	815 (34%)	170	144 (85%)
	>10%	2366	460 (19%)	170	116 (68%)

Checklist for Assessing Accuracy

Following recommendations in the *WHO Denominator Guide*

Indicator		Country-Years		Countries	
		N reported data points	N observations	N reported countries	N observations
Reported BCG coverage >100%	Any year	2358	271 (11%)	151	66 (44%)
	For 5 or more years	-	-	151	23 (15%)
	For 10 or more years	-	-	151	8 (5%)
Reported DTP3 coverage >100%	Any year	2625	166 (6%)	172	59 (34%)
	For 5 or more years	-	-	172	11 (6%)
	For 10 or more years	-	-	172	2 (1%)

Checklist for Assessing Accuracy

Following recommendations in the *WHO Denominator Guide*

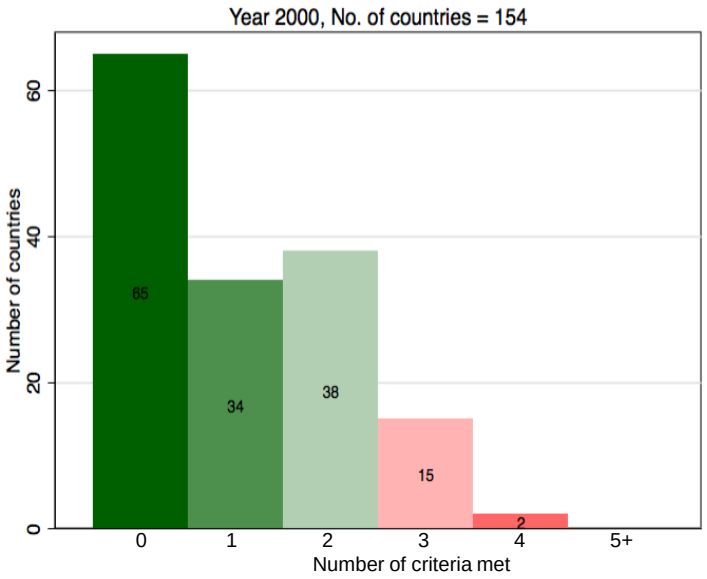
Indicator		Country-Years		Countries	
		N reported data points	N observations	N reported countries	N observations
Negative implied IMR	Any year	2345	204 (9%)	153	49 (32%)
	For 5 or more years	-	-	153	17 (11%)
	For 10 or more years	-	-	153	4 (3%)
Reported DTP3 target population different from DTP1 target population	Any year	2416	245 (10%)	168	69 (41%)

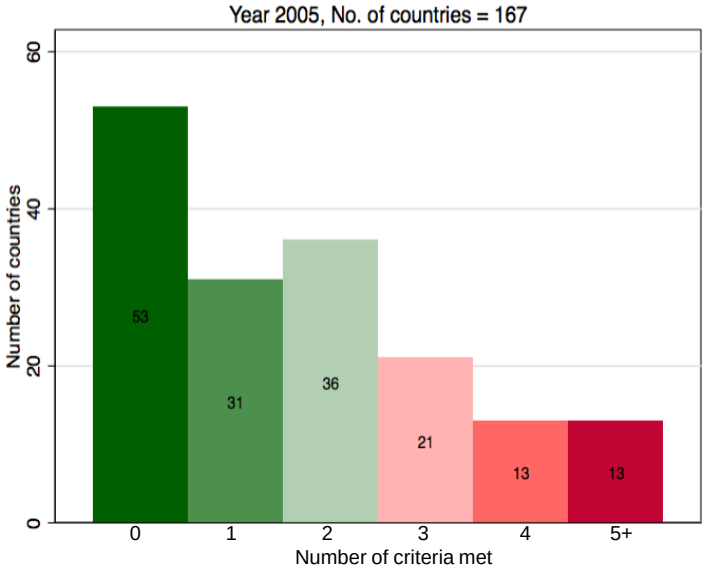
Checklist for Assessing Accuracy

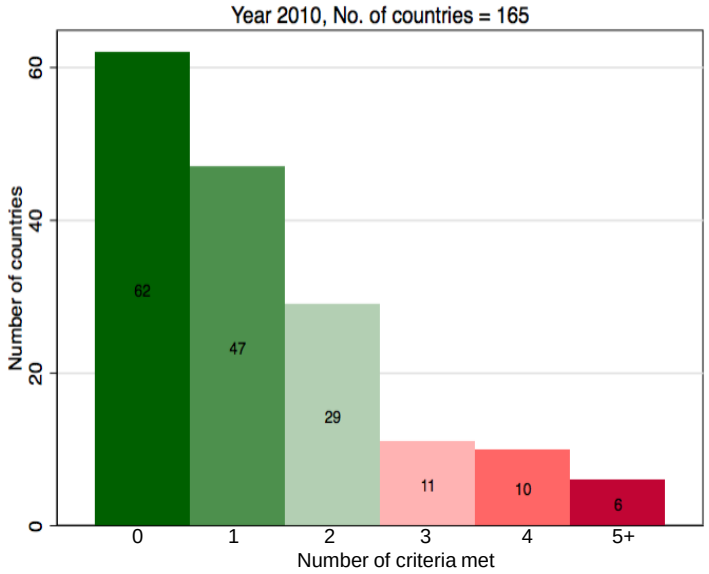
Following recommendations in the *WHO Denominator Guide*

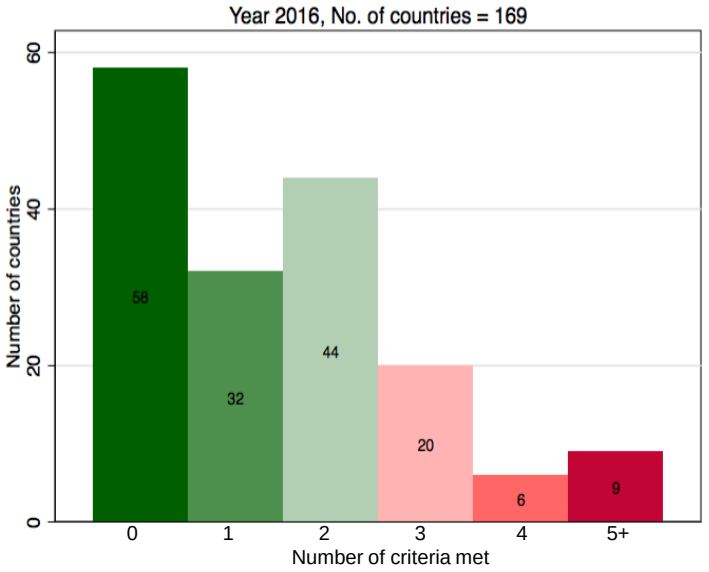
Indicator		Country-Years		Countries	
		N reported data points	N observations	N reported countries	N observations
Difference >10% between country BCG denominator and UN live birth estimate	Any year	2371	880 (37%)	153	126 (82%)
	For 5 or more years	-	-	153	81 (53%)
	For 10 or more years	-	-	153	37 (24%)
Difference >10% between DTP3 denominator and UN surviving infant estimate	Any year	2665	899 (34%)	174	135 (78%)
	For 5 or more years	-	-	174	80 (46%)
	For 10 or more years	-	-	174	35 (20%)

Distribution of countries by number of accuracy criteria flagged









Assessing accuracy

Check documentation on EPI targets data

- Method of calculation of immunization coverage: Aggregation "**by cohort**" or "**by time period**"
  - Aggregation by **time period** → target population is the number of births or children reaching age 1 year during a calendar year and number of vaccinations are the vaccinations administered during the same year
  - Aggregation "**by cohort**" → number of births are children born in a calendar year, but surviving infants are those who reach age 1 year in the following calendar year and the vaccinations may occur during the year of birth or the following year(depending on the month when the child was born)
    - Usually possible if there is an **electronic immunization registry** or if surveys are used

Two indicators for HPV vaccine coverage

Programme coverage

Coverage according to the national schedule and the programme's eligibility criteria for each calendar year.

Main estimation challenges:

- **Denominator** definition varies (across countries and over time)
  - Countries differ in strategies and age targets
  - Multicohort strategies (MAC) over multiple years
  - Programmatic changes over time
  - Source of Denominator (UN population, National data, School data)

Coverage by age 15 years

By 15

% girls turning 15 years of age in the reporting year that started vaccination at any time between 9 and 14 years of age

Main estimation challenges:

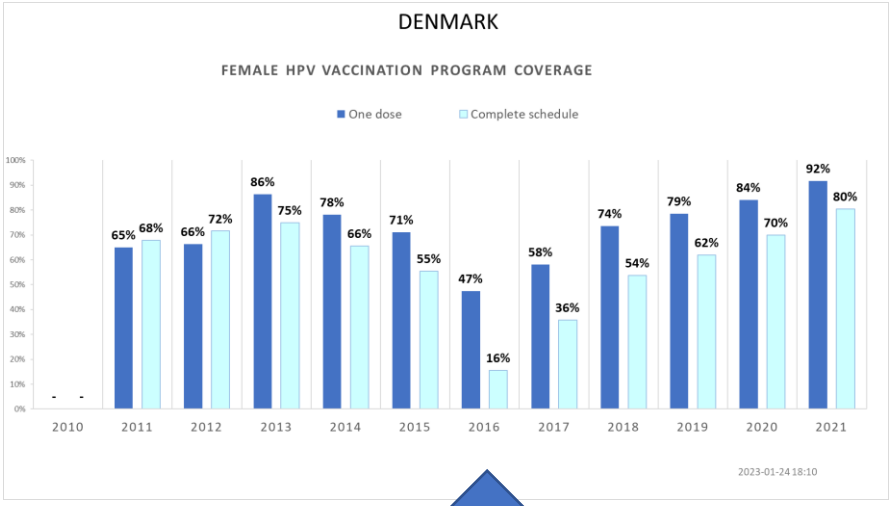
Numerator:

- accumulates data from several years back (up to 6 years)
- No data from the reporting year.

HPV – Coverage - Example from Denmark

Denmark Programme design:
Health Facility delivery
Invitation sent to each 12 yr old Girl and Boy
+ catch-up opportunities until 18 yr

PROGRAMME COVERAGE

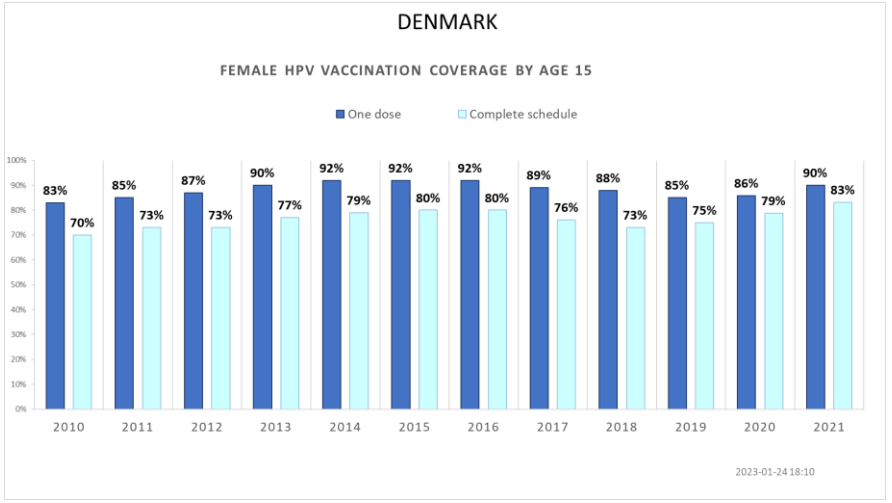


Coverage at age 12

Vaccination crisis

recovery

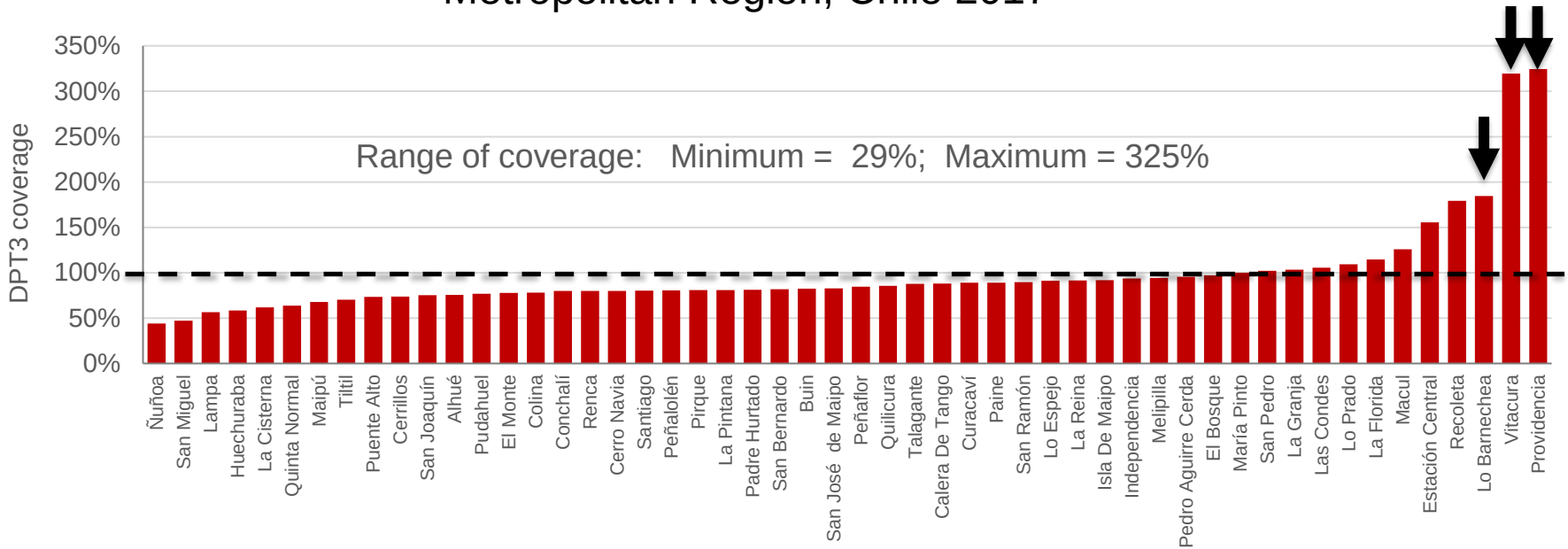
BY 15 COVERAGE



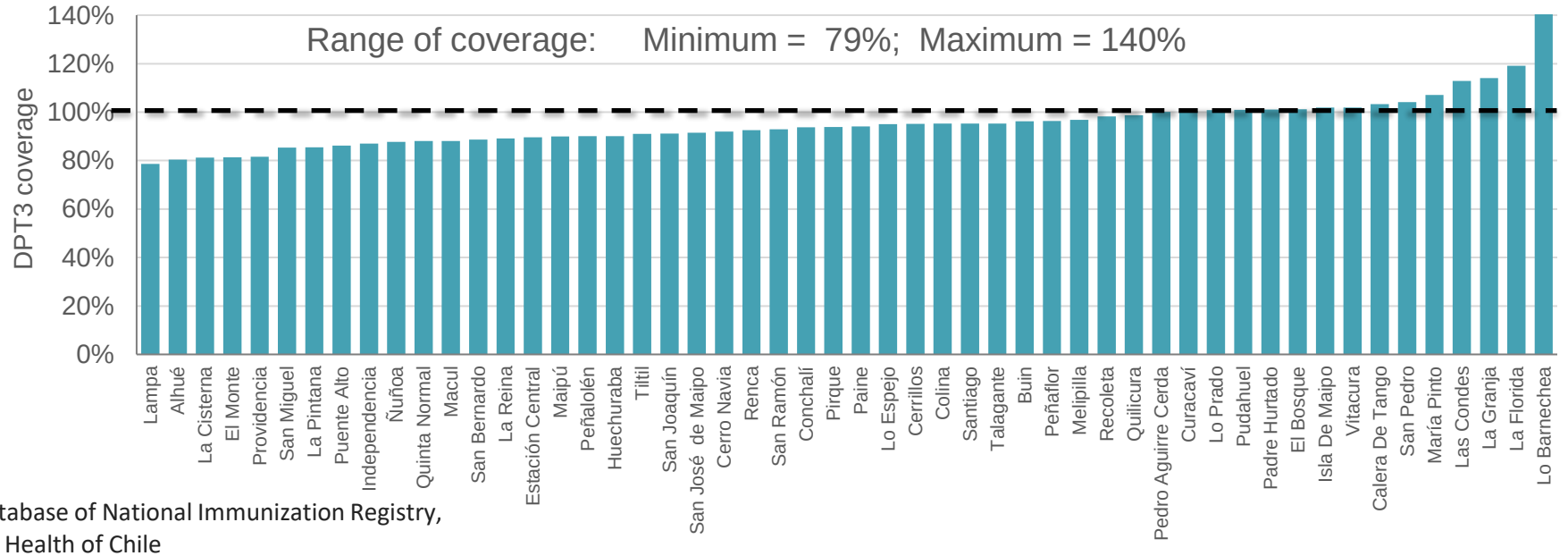
Primary cohort vacc + catch-up strategies

Comparison of DPT3 coverage among children <12 months using two different numerators: place of residence and place of vaccination. Metropolitan Region, Chile 2017

Numerator = place of vaccination

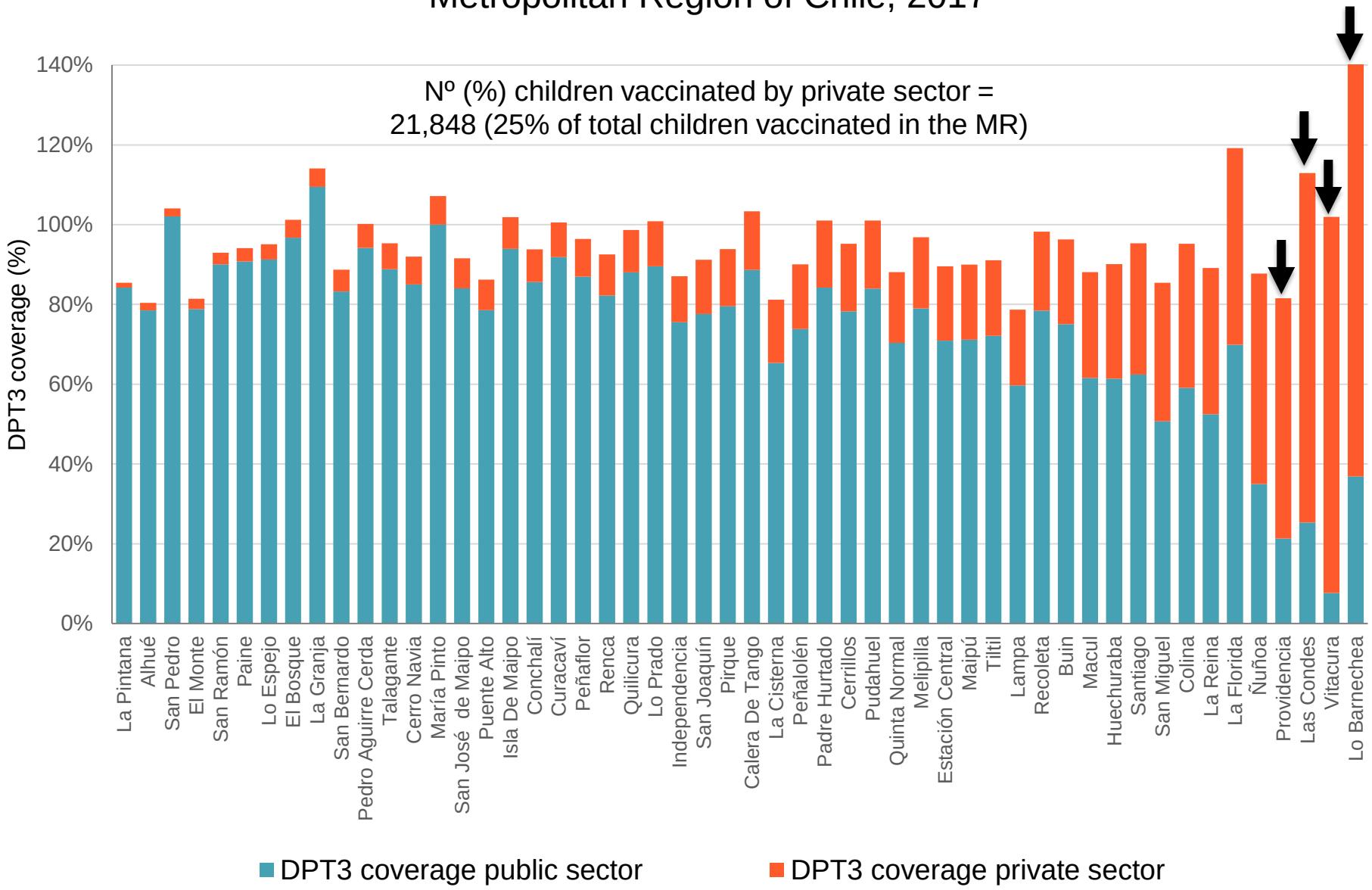


Numerator = place of residence



Source: Database of National Immunization Registry, Ministry of Health of Chile

Proportion of DPT3 coverage among children <12 months by sector of vaccination (public and private) by commune. Metropolitan Region of Chile, 2017



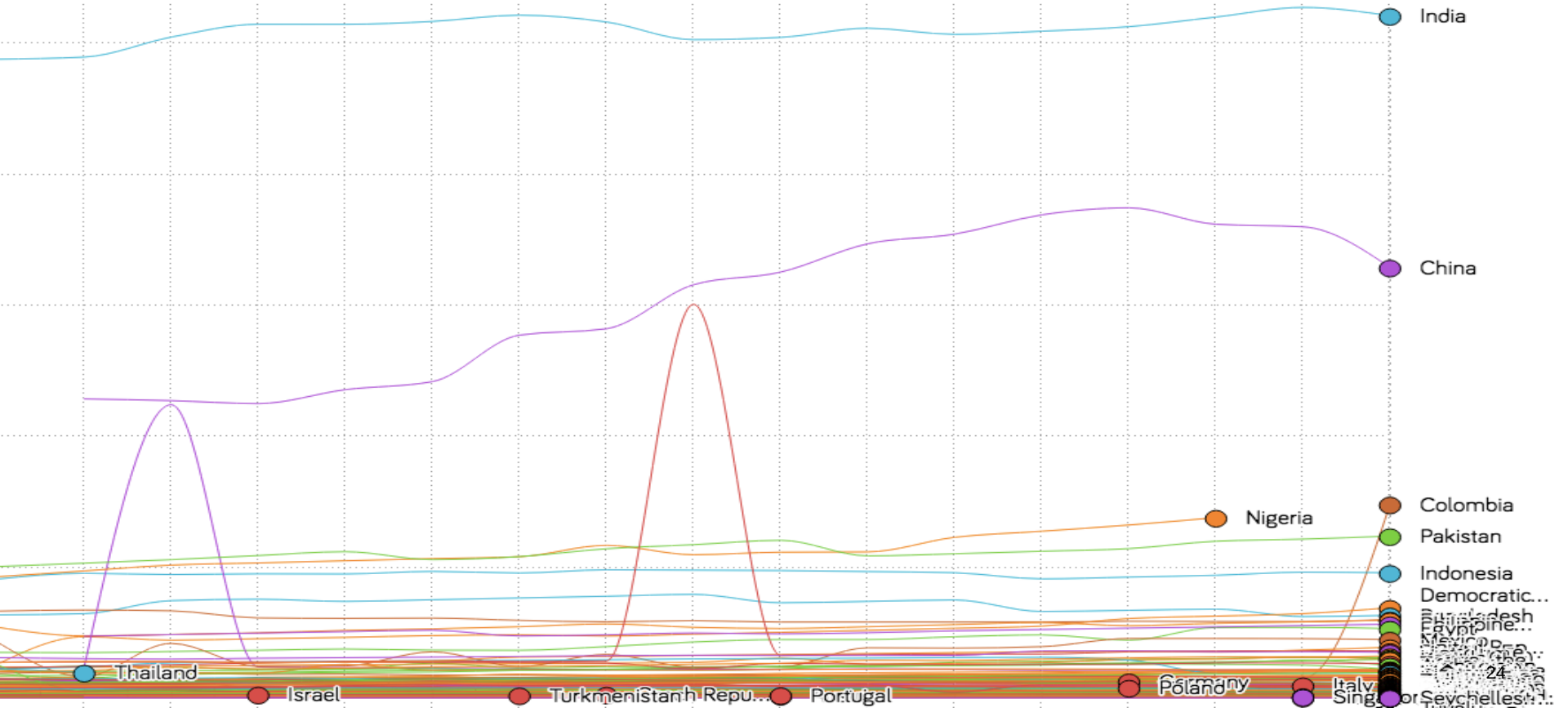
Source: Database of National Immunization Registry, Ministry of Health of Chile

Summary

Estimating a target population is challenging, and more so with high coverage

There are options, but it is important to understand data limitations

What other ways could we try to assess accuracy of denominator data?



World Health Organization

EXTRA SLIDES

Considerations on sources of population data

- CRVS
  - must be complete for birth (and death) registration
  - For subnational births use place of birth to extract denominator for BCG and place of residence for other antigens
- Census projections
  - Proper demographic methods must be applied (ex. indirect method to adjust crude birth rate, etc)
  - They should not be obtained through fixed “conversion factor” to projections of total population
  - Poorer for subnational areas and poorer for older census
  - May be available only for age groups, 5-years periods, 1st/2nd administrative level

Assessing accuracy

Aggregation “by cohort” or “by time period” are similar only in stationary populations (births and deaths are constant)

Aggregation by time period with changing denominator (ex. increase of births in Vietnam, during the year of the dragon)