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Too Early, Too Late: Timeliness of Child Vaccination in the Philippines

Valerie Gilbert Ulep and Jhanna Uy

CONTACT US:

RESEARCH INFORMATION DEPARTMENT
Philippine Institute for Development Studies

18th Floor, Three Cyberpod Centris - North Tower
EDSA corner Quezon Avenue, Quezon City, Philippines

publications@mail.pids.gov.ph
(+632) 8877-4000

https://www.pids.gov.ph

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PHILIPPINE INSTITUTE FOR DEVELOPMENT STUDIES

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Abstract

The Philippine Expanded Program for Immunization has focused primarily on immunization coverage as their metric for performance. However, an equally important indicator of effective vaccine delivery remains unmeasured – the *timeliness* of administration. National Expanded Programs on Immunization should aim for both high immunization coverage levels and timely administration of vaccines – not early, not late. In this paper, we estimated the coverage and timeliness of routine childhood vaccination in the Philippines from 1993 to 2017 using six rounds of the National Demographic Health Survey. The major findings of the study are: *(a)* coverage for routine childhood vaccination fluctuated over the last 25 years, a trend not usually observed in most other countries like those in ASEAN. In 2014, the basic vaccination coverage in the Philippines dipped to 65%, the lowest level since 1990; (*b)* the provision of routine childhood vaccination is predominantly public; about 95% of vaccinated children obtained their vaccines from public facilities despite the large and increasing number of private facilities; *(c)* a large percentage of children, albeit vaccinated, had untimely administration. The percentage of timely administration among vaccinated children ranged from 38% to 65%. Only 10% had complete and timely basic vaccination. Overall, the Philippine EPI has shown inconsistent performance in both coverage and timeliness in the past two decades. The findings are critical inputs to a more comprehensive assessment of the EPI. It should provide insights in streamlining the delivery and financing mechanism of the EPI to rapidly expand coverage and to promote timely vaccination.

Keywords: Expanded Program for Immunization, coverage, timeliness, Philippines

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Too early, too late: Timeliness of child vaccination in the Philippines[1]

Valerie Gilbert Ulep and Jhanna Uy[2]

I. Introduction

Vaccination has made the most significant contribution to the prevention of infectious diseases in the past century. Immunization prevents 3 to 5 million deaths due to vaccine-preventable diseases (VPD) every year worldwide (WHO, 2019). The Expanded Program on Immunization (EPI) was introduced and led by the World Health Organization (WHO) in 1974 to promote universal immunization for children, especially in developing countries. Six VPDs were initially targeted by the EPI as part of routine basic vaccination: tuberculosis, poliomyelitis, diphtheria, whooping cough, tetanus, and measles. As of 2018, about 85% to 90% of children across the globe have received all six basic vaccines (WHO & UNICEF, 2019).

The expanded program on immunization in the Philippines

The EPI has a long history in the Philippines. Since its inception in 1976, it has been one of the major public health programs of the Department of Health (DOH). Its mission is to ensure that infants and families have access to safe and effective vaccines to protect them against common by serious vaccine-preventable diseases. The EPI is mandated by law through Republic Act no. 10152 of 2011 to provide free routine vaccination for 11 diseases. The vaccination schedule for children is summarized in Table 1.

Table 1. Philippine national immunization schedule for children 0 to 12 months of age

Vaccine / Antigen	Disease	Doses	Schedule
BCG (Bacillus Calmette–Guerin)	Tuberculosis	1	Birth (within 24 hours)
HepB	Hepatitis B	1	Birth (within 24 hours)
Pentavalent vaccine (DPT-HepB -HiB)	Diphtheria, tetanus and pertussis Hepatitis B Hemophilus influenzae type B Meningitis	3	6 weeks, 10 weeks, 14 weeks
OPV (Oral polio vaccine)	Poliomyelitis	3	6 weeks, 10 weeks, 14 weeks
IPV (Inactivated polio vaccine)		1	14 weeks
PCV (Pneumococcal conjugate vaccine)	Pneumococcal infections (e.g. meningitis)	3	6 weeks, 10 weeks, 14 weeks
MCV (Measles containing vaccine) and MMR (Measles, mumps, rubella)	Measles, mumps, rubella	2	9 months, 1 year

Source: Philippine Foundation for Vaccination

[1] This study will be an input to a more comprehensive assessment of the National Immunization Program (EPI) funded by the Department of Health (Philippines).

[2] Research Fellow and Supervising Research Specialist, respectively, VU and JU are both first co-authors.

The implementation of EPI occurs in a devolved health system where health services, including disease prevention, are decentralized to local government units (LGUs). The DOH serves mainly as advisory and regulatory body to LGUs whilst providing technical support, capacity building, resources, and supplemental immunization campaigns as needed. The DOH centrally procures all vaccines required for EPI operations nationwide and oversees the vaccine supply chain. Since 2013 DOH has provided LGUs with the disposable supplies needed for vaccination (Department of Health, 2019; Coe, Gergen, & Vilcu, 2017). The LGUs cover operational expenses to deliver immunization services free-of-charge at rural health units (RHUs), barangay health centers (BHCs), and public hospitals.

The EPI has achieved significant milestones in vaccination targets. The Philippines eliminated polio in 2000 and maternal and neonatal tetanus in 2017. Since the passing of the Sin Tax Law or Republic Act 10351 of 2012, the EPI has received a massive infusion of funds that has only grown steadily: from PHP 2 billion in 2013 to PHP 7 billion in 2018, approximately a 200% increase in budget over the 5 years (Department of Health, 2019). It has used these funds to expand the program by introducing new or underutilized vaccines such as the pneumococcal vaccine in 2012 and the Japanese encephalitis vaccine in March 2019 for most affected areas.

Despite significant achievements, the Philippine government has struggled to maintain vaccination coverage levels and to reach its medium-term national target of fully immunizing of 95% of all children.[3] The government has never achieved 90% coverage for basic vaccination. The country also experienced large declines in vaccination coverage in recent years. Consequently, the incidence of vaccine-preventable diseases such as measles, pertussis, and diphtheria have dramatically increased.[4]

The timeliness of vaccine administration

The DOH has traditionally focused on coverage to assesses its performance, i.e., the proportion of children who have received vaccines at a certain age, regardless of the timing of administration. The National Objectives for Health (NOH), an official document that outlines medium-term health system targets of the DOH, only includes vaccination coverage as an indicator of the EPI's success (DOH, 2018). An equally important criteria to assess the EPI's performance, which has remained largely unmeasured in the Philippines, is the *timeliness* of vaccine administration based on the national immunization schedule. Coverage and timeliness - albeit related - are separate issues. High vaccination coverage does not necessarily mean timely vaccination, and focus on high coverage may mask low

[3]The National Objectives for Health (2017-2022) targets that 95% of children will be fully immunized by 2022 from 62% in 2013.

[4]The Philippines had a measles outbreak that started in late 2017 and lasted until mid-2019, affecting five regions. There were 55,777 cases and 676 deaths from January 2018 to 11 May 2019.

levels of timeliness (Adetifa, Boniface, Mutuku, Bwanaali, & Mukumi, 2018; Tsega, et al., 2016; Masters, Wagner, & Boulton, 2019).

Immunization coverage is a measure of *completion* of the immunization schedule, but it only translates to protection against disease if effective vaccines are delivered in a *timely manner within the recommended ages*. Delayed administration of vaccines increases a child's duration at risk for VPDs (Grant, et al., 2003; Kolos, Menzies, & McIntyre, 2007; von Kries, Bohm, & Windfhur, 1997), while vaccines that are administered too early may result in weak or sub-optimal immune response that decreases the ability of the vaccines to prevent disease (Ober, Salmon, Orenstein, deHart, & Halsey, 2009; Feikema, Kleven, Washington, & Barker , 2000).

In this study, we examine immunization coverage and the extent of timely vaccination among Filipino children in the last 25 years (1993-2017) for the following vaccines considered to be a part of routine basic vaccination for children: birth dose of Bacillus Calmette-Guerin (BCG), Oral Polio Vaccine (OPV), Diphtheria Pertussis and Tetanus (DPT), and measles vaccine. We are the first to estimate the timeliness of vaccine administration in the Philippines using various rounds of the National Demographic and Health Survey, a nationally representative household survey.

II. Methods

Study Design, Data Sources, and Population

We utilized secondary data from the six rounds of the Philippine National Demographic and Health Survey (NDHS) - 1993, 1998, 2003, 2008, 2013, and 2017. The NDHS is a nationally representative cross-sectional survey of households. All women of reproductive age within households were interviewed and asked about any children born in the past five years prior to the survey. Information collected by the PHDS include (1) household wealth quintile, (2) child's date of birth, and (3) child immunization history based on either vaccination cards or mother's recall for the last two children born. Dates of vaccine administration were available for children with vaccination cards.

Because the NDHS does not have data beyond 2017, we supplemented our analyses with data from WHO/UNICEF Estimates of National Immunization Coverage (WUENIC). WHO/UNICEF estimates vaccine coverage annually by reviewing a country's administrative data from service providers and national surveys with data on vaccination (e.g. NDHS, Multiple Indicator Cluster Survey), adjusting and calibrating the data as needed for recall bias and consistency among data sources and local trends (Burton, et al., 2009). To note, NDHS and WUENIC estimates are thus not perfectly comparable because of the differences in methodological approach.

Definitions of Coverage and Timeliness

We assessed vaccine coverage and timeliness of administration for 4 vaccines that have comprised routine basic vaccination since the Philippine started its EPI's in 1976: BCG (birth dose), OPV (3 doses), DPT (3 doses), and measles (first of two doses) vaccine (Table 2).

Table 2. Philippine national immunization schedule for children aged 0 to 12 months

Vaccine / Antigen	Recommended age range
BCG	Birth - 2 weeks
OPV 1, DPT 1	6 weeks - 8 weeks
OPV 2, DPT 2	10 weeks - 16 weeks
OPV 3, DPT 3	14 weeks - 24 weeks
MCV or MMR 1	9 months - 12 months

Coverage was defined as the proportion of children aged 12 to 24 months who were immunized with each vaccine as recorded in vaccination cards or as reported by mother's recall regardless of the timing of immunization. Similarly, basic vaccination coverage measures the proportion of children aged 12 to 24 months who were recorded or reported by mother's to have received all 8 doses as listed in Table 2. We restricted to this age group to ensure that all children included in the analyses would have had the opportunity to receive all routine basic vaccines for children 0 to 12 months.

To evaluate the timeliness of vaccine administration, we calculated the age at immunization in days as the difference between the date of birth and date of immunization as recorded in child vaccination cards. Only children with vaccination cards have dates of immunization, so estimates from this sample are restricted to those with cards. Moreover, prior to the 2017 survey round, the NDHS did not capture a child's day of birth. We thus assumed that a child's day of birth fell in the middle of the month to be conservative.

Immunization was considered timely if a child received the vaccine according to the national immunization schedule's recommended age range for the vaccine and dose (Table 2). Vaccination was early if the vaccine was given prior to the minimum recommended age and delayed if given after the maximum recommended age. For example, three children who received their OPV3 dose at 10 weeks, 20 weeks, and 30 weeks are considered to have early, timely, and delayed OPV3 immunization, respectively. We thus defined our indicator for timeliness as the proportion of immunized children who received their vaccine on time or within the recommended age range.

Data Analyses

To examine trends in coverage, we used pooled NDHS data to calculate coverage for each vaccine and all basic vaccines for birth cohorts born from 1990 to 2016. WUENIC data for 1980 to 2018 was used to benchmark immunization coverage in the Philippines to the global average and ASEAN countries.

The proportion of timely administration for each vaccine and all basic vaccines as a set was determined for each NDHS round. Among those who had untimely vaccination, we calculated the number of days administration was early or delayed by taking the difference between the child's age at immunization and the minimum and maximum age for the dose, respectively. To better understand the distribution of ages at which children were immunized in different NDHS rounds, we utilized the non-parametric Kaplan Meier (KM) method to estimate unadjusted cumulative coverage for a vaccine at any given age. The event of interest was vaccination and the primary outcome is time in weeks the child received the vaccine (i.e., child's age at immunization in weeks). Observations were censored if the following occurred: (1) child received the vaccine (the event), (2) child has not been vaccinated but was younger than the assessed age (e.g. child was only 2 weeks old at the time of interview and so does not provide information past 2 weeks for assessments at 3 weeks or beyond), or (3) the observation period ended (156 weeks or 36 months) without the child receiving the vaccine. The KM method is useful because it allows utilization of the data for all children, regardless of age. The method adjusts and accounts for the possibility that the younger children who do not meet the minimum recommended ages for a vaccine may not have had had the opportunity to be vaccinated at the time of the survey interview – and that they could have possibly gotten vaccinated after (i.e., right censoring).

To examine patterns by socio-economic status, we disaggregated coverage and timeliness indicators for each vaccine and NDHS survey round by household wealth quintile (top 20% richest, middle 20%, and bottom 60%) Lastly, we also examined where children obtained their vaccines using data from the 2017 NDHS which asked mothers whether their child received their last vaccine from a private or public facility.

III. Results

a. Coverage

Across all time periods, vaccine doses administered at birth to early weeks of life (e.g., BCG, DPT1, and OPV1) had higher coverage compared to doses scheduled to be administered at later ages such as the first dose of the measles vaccine at 9 to 12 months (Figure 1). Moreover, data in all time periods show that around 20% to 25% of children do not complete all three doses each for OPV and DPT.

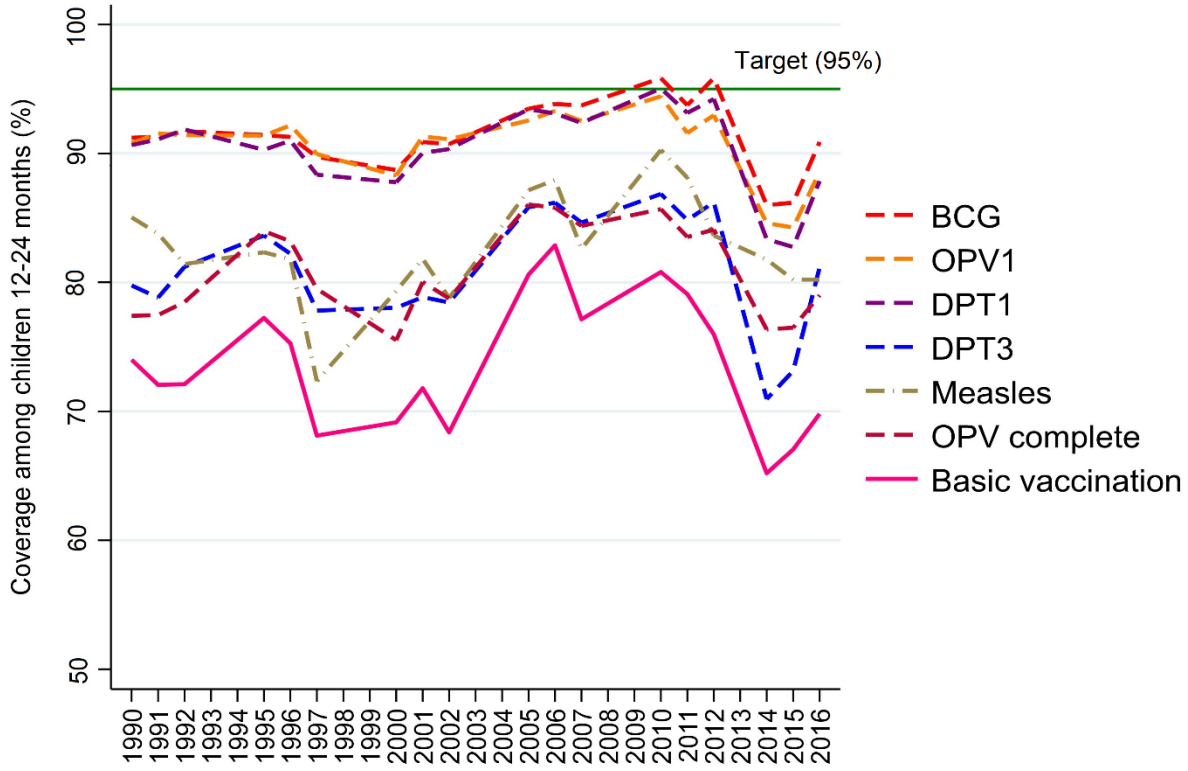

Figure 1: Vaccine by birth cohort in the Philippines, 1990-2016
Data source: Analysis of National Demographic and Health Surveys (various rounds)
Note: Estimates were interpolated for missing cohort periods

From 1990-2016, immunization coverage in the country was characterized by large fluctuations or periods when coverage increased then declined (Figure 2). In 2002, immunization coverage started to steadily increase for all vaccines and was sustained until 2012. In this decade, child vaccination for BCG, DPT1, and OPV1 reached the target of 95% coverage. However, a large decline started in 2013, and our results suggest that basic vaccination coverage dipped to 65% in 2014, the lowest level since 1990. There was a slight recovery in 2016 where 70% of children aged 12 to 24 months had completed all basic vaccinations.

Additional data from WHO / UNICEF for 2017 and 2018 suggests that the gains in 2016 might not have been sustained as DPT3 coverage dropped significantly from 2016 to 2017 and 2018 (Figure 2). Figure 2 compares the immunization coverage for DPT3 in the Philippines with the global average. Here, we present only DPT3 because it is most commonly used antigen for cross-country analysis. From 1980 to 2012, the Philippines has consistently had DPT3 coverage levels above the global average. In the early years of EPI (1980 to 1983), Philippine DPT3 coverage was actually more than twice that of global DPT3 coverage. The Philippines, however, has not kept pace, and in 2013, the Philippine DPT3 coverage was lower than the global average. In 2017, Philippine DPT3 coverage was even lower than some of the poorest countries in the world such as Burundi (90%), Malawi (92%), and Liberia (84%).

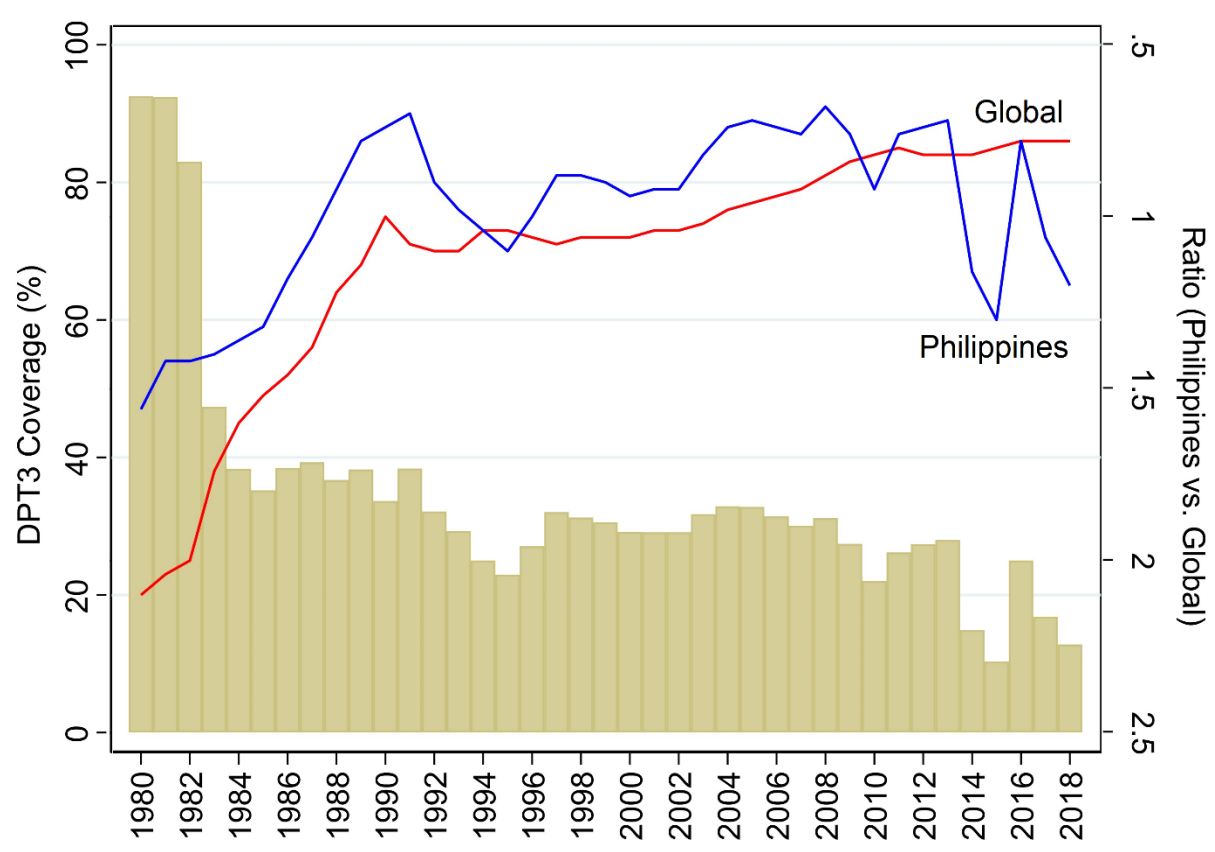

Figure 2. DPT3 Coverage in the Philippines and Globally, 1980-2018[5]

Data source: WHO/UNICEF estimates

[5] To note, estimates in Figure 1 and 2 may not be perfectly comparable. The former uses our calculations from the NDHS. The latter uses the latest WHO/UNICEF modelled estimates.

Among ASEAN countries, the Philippines had the lowest DPT3 coverage in 2018. Most countries in the region have demonstrated large improvements in coverage in the last 40 years (Figure 3). Thailand, Singapore, and Malaysia have sustained high DPT3 coverage (>90%). Meanwhile the Philippines, Vietnam, Lao, and Indonesia, registered large fluctuations over the years.

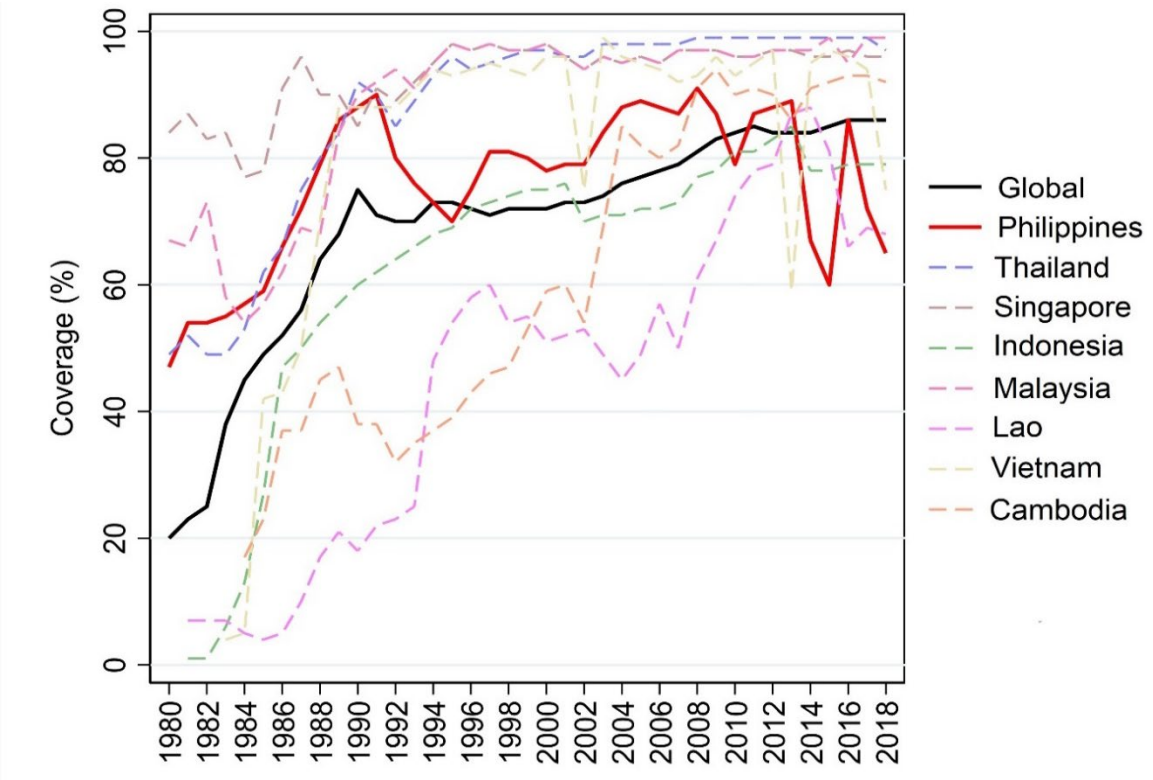

Figure 3. DPT3 Coverage in the Philippines and other ASEAN countries, 1980-2018[6]
Data source: WHO/UNICEF estimates

b. Timeliness

Table 3 shows coverage vis-a-vis timeliness of administration across the six NDHS survey rounds.

In the 2017 NDHS, depending on the type of vaccine and dose, the percentage of vaccinated children with timely administration ranged from 38% to 67%. For example, of those children with immunized with OPV1, only 40% were administered according to schedule while 55% were delayed and 5% were early. The median duration of OPV1 early and delayed administration was 7 days and 19 days, respectively.

In general, the timeliness of vaccine administration was highest for BCG and vaccines scheduled to be administered at later ages (i.e. OPV3, DPT3, and measles). It also appears that though the coverage for later doses in a vaccine series (i.e. OPV, DPT) were lower, these doses were timelier, but at the same time, those who were vaccinated late had longer delays. Take the case of the DPT series in 2017: The

[6] To note, estimates in Figure 1 and 2 may not be perfectly comparable. The former uses our calculations from the NDHS. The latter uses the latest WHO/UNICEF modelled estimates.

coverage of DPT1 was 86%, timely vaccination was 38%, and median delay was 23 days. In contrast, the coverage of DPT3 was 79%, timely vaccination was 65%, but median delay was 62 days.

Figure 4 shows the cumulative coverage per vaccine over child's age in weeks for each of the six NDHS rounds. A reference line is included to delineate the recommended ages of administration. From the 1993 to 2017 rounds, the timeliness of BCG (12.9% to 64.6%), OPV1 (16.8% to 39.5%), and DPT1 (16.4% to 37.5%) improved significantly, as evidenced by how the red curves are shifted to the left of other years within the recommended vaccination schedule. The other vaccine doses have shown only moderate improvements in timeliness which have plateaued or even slightly decreased in in 2017.

Table 3. Coverage and timeliness of vaccines included in basic vaccination, 1993-2017, Philippines

Vaccine and Dose	NDHS Round	Coverage among 12-24 months (%)	Timely (%)	Early		Late	
				%	Median (days)	%	Median (days)
BCG (birth dose)	1993	91.3	12.9	-	-	87.1	51
	1998	90.8	16.5	-	-	83.5	39
	2003	90.7	18.7	-	-	81.3	39
	2008	93.9	24.5	-	-	75.5	25
	2013	95.3	42.1	-	-	57.9	22
	2017	89.4	64.6	-	-	35.4	25
OPV 1	1993	91.2	16.8	8.8	7	74.3	27
	1998	91.7	21.3	10.4	8	68.3	19
	2003	91.2	21.2	10.8	7	68.0	23
	2008	92.8	27.2	9.9	6	62.9	16
	2013	93.1	27.6	9.3	7	63.1	13
	2017	87.3	39.5	5.2	7	55.3	19
OPV 2	1993	86.1	43.6	4.9	6	51.4	39
	1998	88.1	51.0	6.3	8	42.7	28
	2003	87.4	49.5	5.5	7	45.0	39
	2008	90.2	58.3	5.1	6	36.6	25
	2013	89.1	60.6	6.0	7	33.4	24
	2017	85.8	61.1	2.8	7	36.1	37
OPV 3	1993	77.9	55.9	2.7	7	41.4	61
	1998	81.7	64.0	4.5	7	31.5	43
	2003	79.9	60.4	3.0	5	36.6	54
	2008	84.9	69.4	3.9	7	26.7	40
	2013	83.9	70.3	3.9	6	25.8	43
	2017	78.4	66.8	1.6	5	31.6	50
DPT 1	1993	91.2	16.4	8.8	7	74.8	27
	1998	90.3	20.6	9.0	7	70.4	21
	2003	90.1	21.6	10.3	7	68.1	22
	2008	92.7	27.4	9.9	6	62.7	17
	2013	94.1	27.7	9.0	7	63.3	13
	2017	86.0	37.5	5.7	8	56.8	23
DPT 2	1993	87.6	45.2	4.8	6	50.0	40
	1998	87.1	49.3	5.2	7	45.5	30
	2003	86.1	50.9	5.2	7	43.9	35

	2008	89.9	58.8	5.1	6	36.1	25
	2013	91.4	60.4	6.0	7	33.6	29
	2017	82.3	58.4	2.5	10	39.1	45
DPT 3	1993	79.5	56.5	2.6	7	40.9	55
	1998	80.5	62.1	3.5	6	34.4	48
	2003	78.6	61.8	2.9	4	35.3	49
	2008	85.1	69.5	3.8	6	26.7	40
	2013	85.5	70.7	3.4	6	25.9	43
	2017	78.8	64.5	1.3	7	34.2	62
Measles	1993	82.5	67.3	20.2	10	12.5	123
(first	1998	78.9	67.1	22.8	12	10.1	73
dose)	2003	80.2	64.4	25.1	11	10.5	70
	2008	84.8	68.1	24.1	7	7.8	82
	2013	85.2	71.4	18.9	8	9.7	72
	2017	80.1	67.1	15.4	73	17.5	27

Data source: National Demographic and Health Survey (various rounds)

Overall, among children who were immunized with all 8 vaccine doses, only 10.6% had timely basic vaccination in 2017 (Table 4). This was a big improvement compared to the baseline of 2.1% in 1993.

Table 4. Basic vaccination coverage and timeliness, 1993-2017, Philippines

NDHS Round	Coverage among 12-24 months (%)	All vaccines Timely (%)
1993	71.9	2.1
1998	72.6	2.1
2003	69.8	2.6
2008	79.3	5.3
2013	77.2	9.3
2017	69.4	10.6

Source: National Demographic and Health Survey (various rounds)

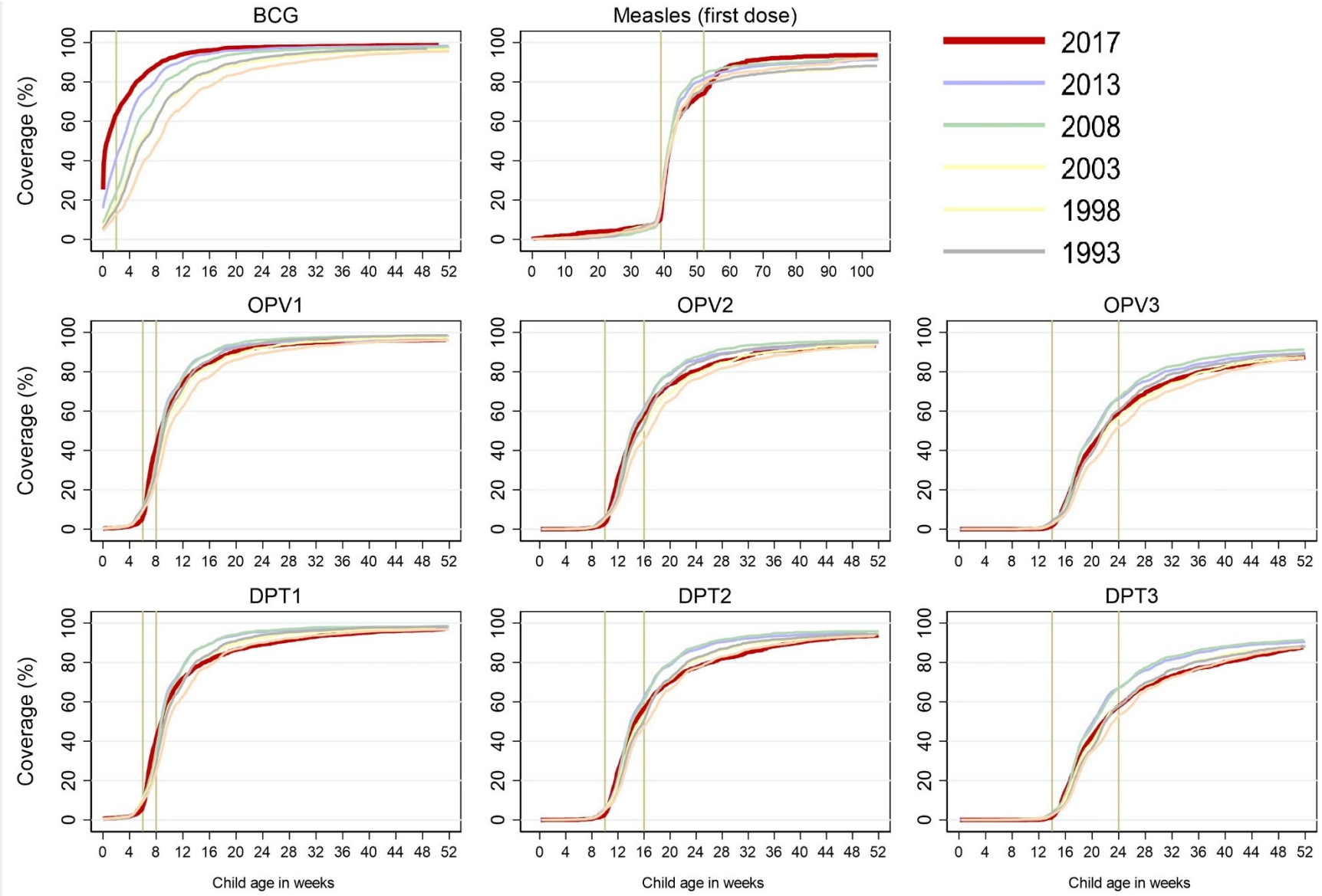

Figure 4. Cumulative coverages, by survey round (1993-2017)

c. Coverage and Timeliness by Socio-economic status

Disaggregating national statistics reveals disparities across socio-economic status (SES) for immunization. coverage. Across all survey rounds, the top 20% had higher coverages for all vaccines and doses compared to the poorest 60%. In the 2017 round, basic vaccination coverage among the richer SES groups (top 20% and middle 20%) was 75%, higher than the 60% coverage in the bottom 60% (Figure 4). The top 20% actually had coverages above the national targets of 95% coverage for BCG, OPV1, OPV2, DPT1, and DPT2 – except for the 2017 round where their coverage for these vaccines dipped to 90% - 93% (Table 5). From the 2013 to 2017 NDHS rounds, basic vaccination coverage declined in all socio-economic groups. The decline, however, was conspicuously large among the rich.

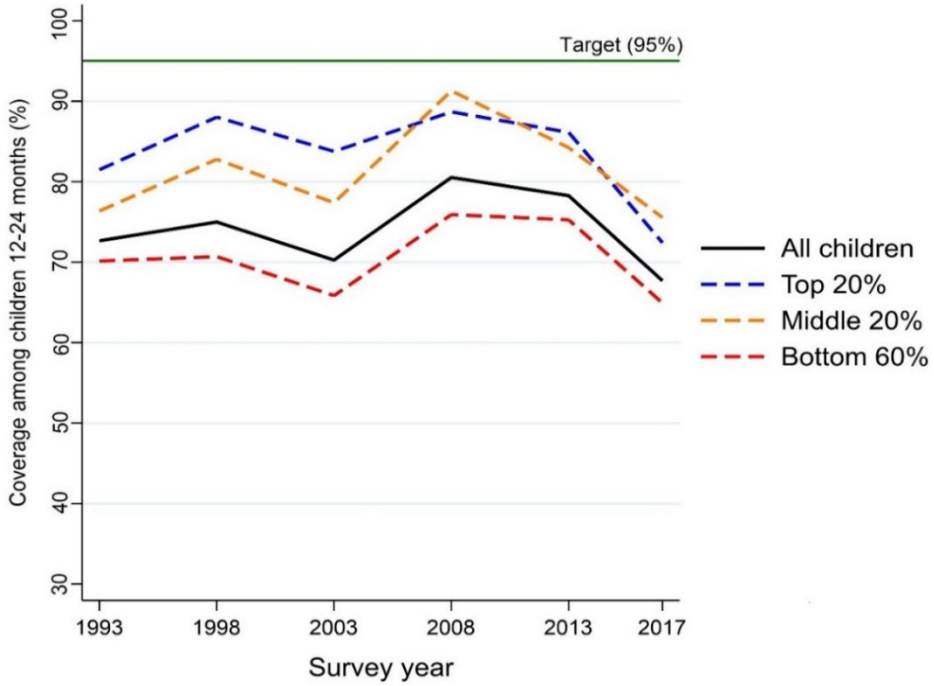

Figure 5. Vaccination coverages, by socio-economic status by survey year
Source: Analysis of National Demographic and Health Surveys (various rounds)

For both the richest and poorest households, only the timeliness of immunization for BCG, OPV1, and DPT1 improved significantly across time, while other vaccine doses have shown only moderate improvements. This is consistent with the aggregate statistics presented in the previous section.

In general, the percentage of children with timely vaccination is slightly pro-rich, except for BCG where the gap for timeliness between SES groups is most prominent (Table 5). Children of the top 20% richest households were much more likely to receive the BCG birth dose within the recommended schedule of birth to 2 weeks. In 2017, for example, the timeliness of BCG administration for the children of the top 20% was 83.2% while it was only 58.6% for children of the bottom 60%. There are, however, only slight differences in the level of timeliness between the rich (top 20%) and the poor (bottom 60%) for the other vaccines and doses.

Overall, however, the timeliness of administration all vaccines and doses included as part of routine basic immunization is very low regardless of SES. In 2017, only 10.5% of children from the top 20% and 9.2% of children from the bottom 60% had all their vaccines and doses administered on time.

Table 5. Coverage and Timeliness of basic vaccination by socio-economic status, 1993-2017, Philippines

Vaccine and Dose	NDHS Year	Top 20%		Bottom 60%	
		Coverage (%)	Timely (%)	Coverage (%)	Timely (%)
BCG (birth dose)	1993	97.5	21.8	89.5	10.5
	1998	98.1	25.0	88.0	14.4
	2003	96.1	36.1	89.0	13.7
	2008	98.4	33.6	91.9	21.1
	2013	99.4	61.2	93.9	35.5
	2017	93.1	83.2	87.9	58.6
OPV 1	1993	97.7	18.1	89.0	15.7
	1998	98.7	27.8	88.9	20.1
	2003	97.9	25.3	89.1	19.5
	2008	96.9	32.4	90.6	24.4
	2013	95.2	28.9	92.1	25.0
	2017	93.8	49.2	85.3	36.1
OPV 2	1993	94.8	45.5	83.1	42.7
	1998	97.4	56.1	84.8	48.9
	2003	95.3	52.2	84.7	47.4
	2008	96.6	57.4	87.1	55.1
	2013	94.5	60.5	87.1	58.4
	2017	93.4	60.4	83.5	60.3
OPV 3	1993	88.4	58.7	75.2	54.2
	1998	91.6	66.3	77.8	62.4
	2003	89.1	63.4	76.4	58.9
	2008	93.0	64.6	81.3	68.4
	2013	91.5	68.8	81.0	68.2
	2017	81.8	75.3	76.4	64.0
DPT 1	1993	97.1	18.2	89.4	14.9
	1998	98.5	27.5	87.0	19.2
	2003	97.3	27.0	87.7	19.4
	2008	98.6	31.6	90.1	24.8
	2013	98.1	28.5	92.7	25.2
	2017	93.0	46.9	83.3	34.1
DPT 2	1993	95.9	51.1	85.1	43.9
	1998	96.7	56.3	83.3	46.4
	2003	96.5	54.5	82.7	47.9
	2008	97.1	58.4	86.5	55.8
	2013	96.9	58.7	89.1	58.5
	2017	90.3	54.6	79.2	58.2
DPT 3	1993	89.2	62.2	76.8	54.7
	1998	91.8	67.3	76.1	59.4
	2003	89.6	65.8	74.6	59.9

	2008	93.0	65.6	81.4	68.2
	2013	92.7	68.5	82.6	68.8
	2017	88.4	67.6	74.9	62.9
Measles (first dose)	1993	85.3	60.6	81.1	68.2
	1998	91.0	47.7	75.4	70.4
	2003	89.3	59.5	78.2	66.0
	2008	91.4	56.5	81.1	72.2
	2013	91.4	66.0	82.6	71.9
	2017	85.9	56.0	77.2	68.3
Basic vaccination (all doses)	1993	78.3	3.6	70.0	1.6
	1998	85.1	3.3	68.9	1.5
	2003	80.4	4.3	66.8	1.9
	2008	86.6	5.4	75.1	4.0
	2013	85.8	12.4	74.0	7.0
	2017	74.4	10.5	65.7	9.2

Source: National Demographic and Health Survey (various rounds)

Using data from the 2017 NDHS, we also examined where children obtained their vaccines. Routine immunization seems to be predominantly delivered in the public sector as around 95% of children received their last vaccination at public facilities. Children of richer households (top 20%) were more likely to have gotten their vaccines at private facilities; while households of lower SES tended to obtain their vaccines from the public sector (see Figure 6). This is especially pronounced for OPV3 and DPT2 where at least half of the top 20% relied on private facilities.

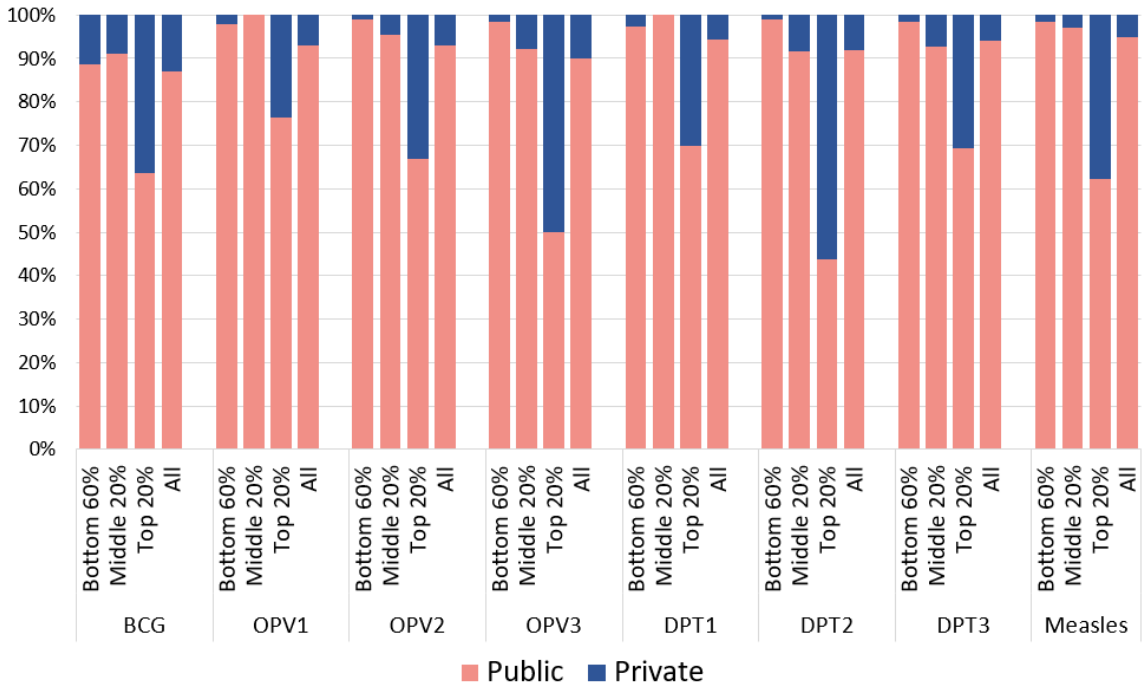

Figure 6. Facility of last immunization by vaccine/dose and socio-economic status, 2017
Source: National Demographic and Health Survey (various rounds)

IV. Discussion

In this paper, we estimated the coverage and timeliness of administration of basic routine vaccines in the Philippines in the last 25 years (1993-2017) using National Demographic Health Surveys. Traditionally, the performance of the Philippine EPI has been focused on coverage. However, we present that the timeliness of vaccination is also an important metric to evaluate the overall performance of the Philippine EPI.

Basic vaccination coverage has never reached 95%.

The goal of any EPI is to expand and maintain basic vaccine coverage at levels high enough to confer most of the population, especially children, with immunity to common and serious vaccine-preventable diseases. The Philippines reached its highest basic vaccination coverage of 80% in 2016. This plummeted to 65% in 2014, the lowest level in the last 25 years.

Immunization coverage in past two decades was characterized by large fluctuations.

Immunization coverage for specific vaccines and basic vaccination has been remarkably unstable over time. There were periods when the coverage increased then declined. In contrast, many other countries

in the world, like our neighbors in ASEAN, have successfully increased and maintained their vaccine coverage levels.

A large number children, though vaccinated, had untimely immunization.

In 2017 and depending on the time of vaccine, only 38% to 65% of immunized children had timely administration within the recommended age ranges of the national immunization schedule. More alarming is that, overall, among children who were immunized with all 8 vaccine doses considered, only 11% had timely basic vaccination.

The concept of timeliness is not new in the health sector. It is a critical domain of health care quality that countries should aim and measure as one of the primary goals of a health system is to reduce 'unnecessary waiting time and harmful delays for those who receive care and for those who give it' (Institute of Medicine, 2001). National immunization schedules are determined by accounting for local disease epidemiology, and they have an underlying goal of eliciting immunity in children before they are exposed to infectious diseases (Shetty, Chaudhuri, & Sabella, 2019). Immunizing too early or too late decreases the ability of the vaccines to prevent targeted diseases.

The timeliness of administration has been an emerging issue in many national EPIs. Epidemiologic studies show that untimely vaccination is a risk factor for vaccine-preventable diseases (Grant, et al., 2003; Kolos, Menzies, & McIntyre, 2007; von Kries, Bohm, & Windfhur, 1997). Untimely vaccination has been the cause of infectious disease outbreaks in several countries with high immunization coverage. An et al (2016) linked Vietnam's 2013 measles epidemic with a low proportion of children with timely vaccination. Similarly, despite having a vaccine coverage of more than 95% for measles, countries like China, Israel, and Russia have had measles outbreaks due to untimely vaccination (Ni, Xiong, Li, Yu, & Qian, 2015; Rubin & Ignatyev, 2008; Anis, et al., 2009). Other studies demonstrate the non-specific effects of timely vaccination. Delayed Bacillus Calmette-Guerin (BCG), for instance, is associated with lower child survival (Brieman, et al., 2004).

Crude comparison of our timeliness estimates with other recent studies in other countries suggests that except for the measles vaccine, the proportion of children receiving untimely vaccination is relatively large in the Philippines (Table 6).

Table 6. Timeliness of vaccination coverage in the Philippines compared to other countries

Vaccine / Antigen	**Philippines (2017)**	**Kenya** (Adetifa, et al 2018)	**Senegal** (Mbengue, et al., 2017)	**Malaysia** (Abidin, Juni, & Ibrahim, 2017)	**Norway** (Walton , et al., 2017)
GDP per capita (2010 US$)*	3,000	1,200	1,500	12,100	92,000
BCG	65%	80%	88%	-	--
OPV 1	40%	-	74%	-	80%
OPV 2	61%	-	75%	-	74%

OPV 3	67%	50%	73%	-	60%
DPT 1	38%	-	74%	76%	80%
DPT 2	58%	-	76%	66%	74%
DPT 3	65%	82%	73%	58%	60%
Measles 1	67%	28%	-	65%	59%

* Source: World Bank

Although differences in immunization coverage are large, there are only slight differences in the level of timeliness between the rich (top 20%) and the poor (bottom 60%).

The percentage of children with timely vaccination is slightly pro-rich, but the degree of inequality is negligible. This could imply that once the children "get in" the EPI system, there is not that big of a difference in the efficiency of service delivery for immunization because majority of children in all socio-economic groups rely on the public sector. This is with the exception of BCG, which are birth doses received at place of delivery – of which the rich are more likely to get at hospitals.

Potential Drivers of the Philippine EPI's weak performance.

The performance of the Philippine EPI has been inconsistent as manifested by the considerably low and unstable immunization coverage over the years and the high level of untimely vaccination.

In general, drivers of vaccination coverage and timeliness may be categorized into three: demand-related, supply-related, and contextual factors (Figure 7). The demand-side culminates in parent/caregiver intent to vaccinate, which is determined by the socio-economic and demographic characteristics of the household. Supply-factors manifest as facility readiness, which is determined by the availability of supplies, human resources, funds, and capital. Contextual factors facilitate or make it difficult for parents/caregivers to access the program, such as geographic distance, financial affordability, and cultural acceptability of immunization services.

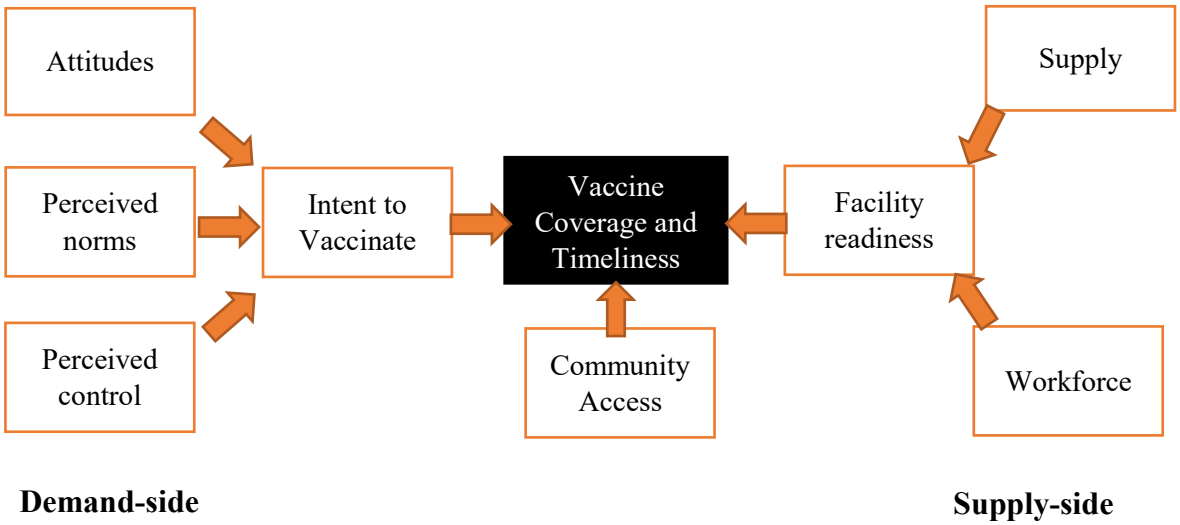

Figure 7. Framework summarizing determinants of vaccine coverage and timeliness (Masters, Wagner, & Boulton, 2019; Phillips, Dieleman, Lim, & Jessica, 2017)

Supply-side. Fluctuations in immunization coverage could be a symptom of perennial supply-side inefficiencies which also affect the timeliness of vaccines delivery at frontline health facilities. For health facilities to have a sufficient supply of safe and effective vaccines, the entire supply chain from procurement to logistics of the cold chain must be functional and efficient. Countries that experienced shortages and delays have had low levels of timely vaccination. For example, Santibanez, Santoli, & Barker (2006) and Stolkey, et al. (2004) show that shortages of DPT and measles vaccines in 2001 and 2012 had resulted in high levels of untimely and under-coverage in the United States.

Innovations and the redesign of vaccine supply chains are increasingly necessary as current supply chains are growing outdated and unable to deliver both basic and newly introduced vaccines to an increasingly larger population (World Health Organization, 2014). In a country where 95% of children obtain vaccines from government health facilities, a glitch in any of the stages of the supply chain such as bureaucratic bottlenecks may have a large repercussions on immunization coverage and timeliness. Currently, the DOH centrally procures and manages the supply chain (i.e., storage, distribution, handling, and stock management, and logistics) until the vaccines reach government-run health facilities. The private sector plays a limited role in vaccine provision, and the DOH EPI only delivers vaccines to public facilities, despite the large and growing number of private facilities.

Demand-side. Possible root causes and drivers of weak performance are complex and cannot be solely attributed to implementation problems on the side of DOH, local governments, or health facilities. Demand-related factors such attitudes and practices of parents and caregivers towards vaccination are equally important in vaccine uptake and timeliness of administration.

The large decline in immunization coverage in some periods could be also a reflection of changing demand-related factors. For example, immunization coverage sharply declined from 2016 to 2018,

which coincided with the staggering decline in vaccine confidence during the same period. The confidence in vaccines plummeted from 93% "strongly agreeing" that vaccines are important in 2015 to 32% in 2018 (Larson, Hartigan-Go, & De Figeuredo, 2018). To note, coverage declined in socio-economic groups, but the decline was more prominent among the top 20%. The large decline among the richest quintile strengthens our hypothesis on the role of demand-related factors. While unvaccinated children are more likely to come from low-income households, recent studies indicate that vaccine hesitancy and refusal in more prominent in richer groups that have access to vaccinations (Malia, 2018)

Moreover, data from other countries show that there have growing number of parents practicing "alternative vaccination schedules" because of vaccine hesitancy (Offit & Moser, 2009; Hough-Telford, et al., 2016).[7] These parents/caregivers generally do not oppose vaccines, but they want to choose the timing of administration, which is typically on a later date (Dempsey, et al. 2011).[8] This scenario could explain high immunization coverage, but low level of timeliness.

V. Conclusions and Recommendations

National Expanded Programs on Immunization should aim for both high immunization coverage levels and timely administration of vaccines – not early, not late. The Philippine EPI has shown inconsistent results in both coverage and timeliness in the past two decades.

We outlined potential reasons of the weak performance that warrants closer examination. The findings of the study are inputs to a more comprehensive assessment of the Philippine EPI. The central insight of initial results from this paper is that without large investments and reforms in the current system of delivery and health promotion for immunization, universal coverage targets will remain quixotic, at best.

Specifically, for the supply-side, the program should consider re-designing the vaccine supply chain. Some countries in South Africa have had relatively successfully shifts from state-run supply chain management, which is proven to be highly inefficient, to innovative modalities such as private sector outsourcing (Lyndon, Raubenheimer, Arnot-Kruger, & Zaffran, 2015; Prosser, et al., 2017). The EPI should also consider the feasibility of expanding the service delivery channel to private facilities. In the Philippines, half of health facilities are privately-owned; the large network of private facilities can be

[7]The Strategic Advisory Group of Experts on Immunization (SAGE) defines vaccine hesitancy as "delay in acceptance or refusal of vaccines despite availability of vaccination services. Vaccine hesitancy is complex and context specific, varying across time, place and type of vaccines. It is influenced by factors such as complacency, convenience and confidence." (Strategic Advisory Group of Experts on Immunization, 2014)

[8]About 2% of parents in the United States refused all immunizations but another 12% deliberately followed an alternative schedule. About 8% followed the Miller or Sears schedule but the others derived their own schedule. Another 28% thought that a delayed schedule would be safer (Dempsey, et al., 2011)

use as mechanism to rapidly expand coverage and promote timely vaccination. The expansion of service delivery to the private sector, however, entails shifting the current health financing modality of the EPI.

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