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Effective coverage of maternal and child health services in Cambodia from 2005 to 2014

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Abstract

Objective To investigate effective, quality-adjusted, coverage and equity of maternal and child health (MCH) services to assess progress in improving quality of care in Cambodia.

Design A secondary statistical analysis using the three most recent (2005, 2010, 2014) Demographic and Health Surveys.

Setting Cambodia.

Participants 53155 women aged 15-49 years old and 23242 children under 5 years old across the three surveys.

Outcome measures We estimated crude coverage, effective coverage, and equity in effective coverage for five MCH services over time: antenatal care (ANC), facility delivery, and sick childcare for diarrhea, pneumonia, and fever. Quality was defined by the proportion of care seekers who received a set of interventions during health care visits. Effective coverage was estimated by combining crude coverage and quality. Equity was assessed using wealth quintiles, area of residence, and maternal education over time.

Results In 2014, average crude coverage was 80.1% (range 75.6% - 84.6%) for maternal care and 59.1% (range 55.5% - 61.3%) for sick child care. Average effective coverage was 56.4% (range 32.8% - 80.1%) for maternal health care and 29.6% (range 11.5% - 51.5%) for sick child care. Between 2005 and 2014, effective coverage improved for all five services, with the biggest increase (74%) for facility delivery. Effective coverage for curative sick child care – predominantly delivered by loosely regulated private health care providers – remains low. The poorest and less educated women experienced a greater improvement in effective coverage.

Conclusions Effective coverage has generally improved in Cambodia; however, most of the improvement was seen for maternal care. Substantial efforts remain to improve quality of curative sick child care. Policymakers should focus on improving effective coverage, and not only crude coverage, to achieve the health-related SDGs by 2030.

Strengths and limitations of this study

- This study included nationally representative population data to estimate effective, quality-adjusted, coverage and equity of maternal and child health services.
- This study used three waves (2005, 2010, and 2014) of surveys to observe the temporal change in outcome variables.
- Since this study used cross-sectional data, the findings do not establish a cause and effect relationship.

Introduction

Sustainable Development Goal (SDG) 3 aims to achieve universal health coverage (UHC), by ensuring access to quality essential health services by 2030.(1) Despite substantial improvement in access to healthcare services, quality of care remains poor and variable across low- and middle-income countries (LMICs).(2–5) The Lancet Global Health Commission on High Quality Health Systems in the SDG era (i.e., the HQSS Commission) estimated that high quality health systems could save one million newborn deaths annually.(4) Vulnerable groups, including the poor and the less educated, tend to receive worst quality of care.(5–7) Thus, quality improvement needs to be a central pillar of UHC.

An increasing body of evidence recommends a shift from tracking 'crude' or 'contact' coverage to 'effective' coverage,(5–8) defined as the proportion of a population in need of a service that resulted in a positive health outcome from the service.(9) Several studies have shown that effective coverage tends to be lower than crude coverage.(7,10,11) This indicates that many patients who come in contact with the health system are not treated according to standards of care.

Cambodia is a lower-middle income country located in Southeast Asia with a population of 16.72 million people.(12) Since the late 1990's, the country has experienced consistent economic growth and a reduction in poverty rates.(13) In the past decades, the Cambodian government has focused on increasing utilization of maternal and child health (MCH) services. From 2000 to 2014, Cambodia reduced its under-5 mortality rate by two-thirds and the maternal mortality ratio by one-half.(14)

However, in order to achieve the health-related SDGs by 2030, maternal mortality must be reduced by an additional 60% and under-five mortality by an additional 30%. Using Global Burden of Disease data in 2016, Kruk et al found that deaths due to poor quality care were twice as high as deaths due to non-utilization of healthcare services in Cambodia.(15) To avert these additional maternal and child deaths, quality improvement is needed. The first step is to monitor progress during the MDG era.

To our knowledge, no study has assessed the effective, quality-adjusted, coverage of MCH services in Cambodia. Past research has mostly focused on the utilization of MCH services.(16–18) Thus, this study estimates the effective coverage of five MCH services and equity in effective coverage using data from 2005 to 2014.

Methods

Data sources

We used data from the Cambodia Demographic and Health Surveys (CDHS) to examine changes in crude coverage, effective coverage, and equity in effective coverage of maternal and child health services over time. The three most recent waves – 2005, 2010, 2014 - of CDHS were

included. The CDHS is a nationally representative, population-based, cross-sectional survey carried out every 4 to 5 years.(14) Our population of interest included all women of reproductive age (15-49 years old) who had at least one birth in the past five years preceding each survey wave, and children under five years old living in residential households. The CDHS collects data on a wide range of health services including across the MCH continuum of care. Sampling strategies and methodology have been described elsewhere.(19)

Measures

Crude coverage

Crude coverage was calculated by the proportion of women or children who needed health care (due to true or perceived needs) and who sought care at health facilities. We estimated crude coverage for five MCH services: antenatal care (ANC), delivery, and care for diarrhea, pneumonia, and fever. Antenatal care was defined as the proportion of women with at least one live birth in the five years preceding the survey who reported at least four ANC visits for their most recent birth. Delivery care was defined as the proportion of women who gave birth in the five years preceding the survey and who delivered at a health facility including all public and private facilities (excluding those who gave birth at home and undefined locations).

Care for diarrhea, pneumonia, and fever were defined, respectively, as the proportion of children who had diarrhea, symptoms of pneumonia (a cough accompanied by short, rapid breathing and difficulty breathing as a result of a problem in the chest), or fever, in the two weeks preceding the survey for whom advice or treatment was sought from a health facility including all public and private facilities except pharmacies and traditional healers.

Effective coverage

Based on the calculation used by Arsenault et al(7) and Hategeka et al(6), we estimated effective coverage as:

$$EC = Q*U/N$$

Where EC is effective coverage, Q is quality of MCH services, U is utilization of MCH services, and N is need for MCH services. Since the CDHS had only a few indicators to estimate the quality of services, the effective coverage estimates reported in this study should be considered an upper limit of the quality of MCH services.

Quality indicators were identified based on four reports: the HQSS Commission's framework(4), the WHO recommendations on antenatal care for a positive pregnancy experience(20), the National Strategy for Reproductive and Sexual Health of Cambodia 2017-2020(21), and the WHO standards for improving the quality of care for children and young adolescents in health facilities.(22)

Quality-adjusted ANC was estimated by the proportion of women who received at least four ANC visits and reported receiving five basic services at any point during ANC: their blood pressure was measured, a urine and a blood sample was collected, they were give or bough iron

tablets or syrup, and they were counseled on potential complications to look out for during pregnancy. Quality-adjusted delivery care was defined as the proportion of women who delivered at a health facility and who reported that someone examined them or asked questions about their health before being discharged.

Quality-adjusted care for diarrhea was defined as the proportion of children who sought care at a health facility for diarrhea and who received oral rehydration therapy (ORT) from a special packet, pre-packaged or from a homemade fluid. Quality-adjusted care for pneumonia was defined as the proportion of children who visited a health facility for suspected pneumonia and who received antibiotics (pills, syrup or injection). Quality-adjusted care for fever was defined as children who sought care at a health facility and received a blood test for suspected malaria.

Equity in effective coverage

Equity in effective coverage of five MCH services was assessed according to household wealth quintile, area of residence (urban vs. rural) and the woman's education level as provided by the CDHS. The wealth index is calculated based on a household's ownership of selected assets, such as televisions and bicycles; housing construction materials; and types of water access and sanitation facilities.(23) The wealth index is divided into five quintiles (lowest – Q1, second – Q2, middle – Q3, fourth -Q4, and highest – Q5) based on a continuous scale of relative wealth in the country.(23) The women's education was combined into three levels (no education, primary, and secondary or higher).

Statistical analysis

We estimated crude coverage, effective coverage, and equity in effective coverage for the five MCH services in 2005, 2010 and 2014. Data for child pneumonia care was not available in 2005.

Two additional analyses were conducted. First, we estimated the crude and effective coverage in 2000 to observe the trend in the last two decades. However, due to the age of the data, we excluded the 2000 data from the main analysis (**supplemental table 1**). Second, we used postpartum checkup after discharge to estimate effective coverage for childbirth and compare with the results from the main analysis (**supplemental table 2 and supplemental figure 1**).

All analyses were adjusted for the survey design (clustering, stratification, and survey weights) except the equiplots due to a limitation of the statistical software package. Stata SE Version 16.0 was used for all analyses.

Patient and public involvement

Patients and/or the public were not involved in the design, or conduct, or reporting, or dissemination plans of this research.

Results

Description of the study population

A total of 53,155 women of reproductive age (15-49 years old) were included across the three survey waves. The proportion of women who gave birth within the 5 years preceding the survey slightly decreased from 34.9% in 2005 to 34.0% in 2014. Most women lived in rural areas and completed primary education (**table 1**). In total, 23,242 children under 5 years were included. Fever was the most prevalent child illness, with 27.1% of children suffering from fever in the two weeks prior to the survey in 2014 (**table 1**).

Overall crude and effective coverage

In 2014, average crude and effective coverage were 80.1% and 56.4%, respectively, for maternal health care (ANC and delivery), and 59.1% and 29.6% for sick child care (care for child diarrhea, pneumonia, and fever) (**table 1**). For maternal health care, effective coverage increased by 21.0% and 22.8% from 2005 to 2010 and 2010 to 2014, respectively (**table 1**). For sick childcare, effective coverage increased by 13.4% and 4.5% from 2005 to 2010 and 2010 to 2014, respectively (**table 1**). Estimates for crude and effective coverage for each indicator can be found in **supplemental table 1**. Delivery had the highest effective coverage at 80.1% in 2014 (**supplemental table 1**). Meanwhile, fever for sick child health service showed the lowest effective coverage at 2.3% in 2005 (**supplemental table 1**).

Maternal health care

Figure 1 shows a continuous increase in crude and effective coverage for ANC and facility delivery from 2005 to 2014. In 2014, 80.1% of women who delivered at a facility had a postnatal check before getting discharged and around half of women who had four ANC visits received the five basic services during their pregnancy. Effective coverage was improved across the wealth quintile, area of residence, and women's education level for both maternal health care services. Few women (4.7%) in the lowest wealth quintile received a postnatal check in 2005; however, 60.9% of them received the same service in 2014 (**figure 2**). The proportion of women from rural areas who received the five basic services during ANC increased by 13-folds from 2005 to 2014, from 2.2% to 29.6% (**figure 2**).

Sick child care

Figure 3 shows the trend in crude and effective coverage for the three sick child health services. Overall, crude and effective coverage for sick child care did not improve as much as for maternal care. The proportion of children with diarrhea who received ORS and the proportion with fever who received a malaria test almost remained the same from 2010 to 2014 (**figure 3**). The inequity gap in women's education level was narrowed for suspected pneumonia from 2010 to 2014 (**figure 4**). The proportion of children who received oral solutions for diarrhea was greater in rural compared to urban areas in 2014 (**figure 4**). Inequity gap in wealth quintile and education level for diarrhea and pneumonia appeared to be reversed in 2014 compared to previous years (**figure 4**).

Table 1 - Characteristics of the study sample in Cambodia from 2005 to 2014.

Survey, year	2005	2010	2014
	N (%)	N (%)	N (%)
Number of households	14243	15667	15825
Women (age 15-49)	16823	18754	17578
Women who gave birth within 5 years of the survey	5865 (34.9%)	6472 (34.5%)	5973 (34.0%)
Residence			
Urban	2973 (17.7%)	3936 (21.0%)	3251 (18.5%)
Rural	13851 (82.3%)	14819 (79.0%)	14328 (81.5%)
Education			
No education	3270 (19.4%)	2974 (15.9%)	2251 (12.8%)
Primary	9389 (55.8%)	9265 (49.4%)	8281 (47.1%)
Secondary and higher	4165 (24.8%)	6516 (34.7%)	7047 (40.1%)
Wealth quintile			
Lowest	3018 (17.9%)	3389 (18.1%)	3144 (17.9%)
Second	3165 (18.8%)	3517 (18.7%)	3314 (18.9%)
Middle	3246 (19.3%)	3595 (19.2%)	3381 (19.2%)
Fourth	3308 (19.7%)	3827 (20.4%)	3613 (20.6%)
Highest	4089 (24.3%)	4429 (23.6%)	4128 (23.5%)
Maternal health care			
Crude coverage of antenatal care and facility delivery (mean, range)	25.1% (23.2%-27.0%)	58.1% (56.8% – 59.4%)	80.1% (75.6% – 84.6%)
Effective coverage of antenatal care and facility delivery (mean, range)	12.6% (4.7% – 20.5%)	33.6% (16.2% – 51.1%)	56.4% (32.8% – 80.1%)
Children (age <5)	7789	8200	7253
Children who had diarrhea 2 weeks prior to the survey	1420 (18.2%)	1161 (14.2%)	902 (12.4%)
Children who had pneumonia 2 weeks prior to the survey	2224 (28.6%)	1741 (21.2%)	1531 (21.1%)
Children who had fever 2 weeks prior to the survey	2576 (33.1%)	2194 (26.8%)	1968 (27.1%)
Care for sick children			
Crude coverage of diarrhea, pneumonia, and fever (mean, range)	45.3% (41.1% – 47.8%)	69.1% (58.9% – 75.5%)	59.1% (55.5% – 61.3%)
Effective coverage of diarrhea, pneumonia, and fever (mean, range)[a]	11.7% (2.3% – 21.1%)	25.1% (10.3% – 37.3%)	29.6 % (11.5% – 51.5%)

[a]Effective coverage for pneumonia in 2005 was not included due to missing data in CDHS.

Discussion

In this study, we estimated crude coverage, effective coverage, and equity in effective coverage for five MCH services to assess progress in improving quality of health care in Cambodia from 2005 to 2014. We found that improvements in effective coverage were greater for maternal health services (ANC and facility delivery), than for curative services for sick children (diarrhea, pneumonia, and fever). Vulnerable women, including the poor, rural residents, and less educated, experienced a greater improvement in effective coverage for facility delivery than ANC. Inequity gaps appeared to have been reversed for diarrhea and pneumonia over time, where children from rural households received higher quality care than children from urban households.

Effective coverage improved for all five MCH services from 2005 to 2014, but improvements were greater for maternal health than for curative care for children. We also found a reverse inequity gap for sick child care – children from the poorest, less educated households and from rural areas, appeared to be more likely to receive ORS for diarrhea and antibiotics for pneumonia than children from richer, more educated households and urban residents. Most curative care is delivered by an extensive network of loosely regulated private health-care providers in Cambodia while the public sector is the predominant provider of preventive care and health promotion activities.(13,24) According to the 2014 CHDS, 65% of care for child diarrhea, fever or cough took place in the private sector.(14) Private providers – mostly small practices, pharmacies or single-person practitioners - are also more prevalent in urban areas.(13) The regulation of private providers in Cambodia remains a challenge where many operate without government accreditation.(13) Our results indicate that the quality gaps may be largest in the private sector in Cambodia.

The increase in care seeking among poorer households could also have been influenced by the Health Equity Fund (HEF). The HEF, launched in 2000, is Cambodia's largest financial protection scheme, covering the poorest one-fifth of the national population and aims to increase access to government health facilities.(25) Since then, the utilization of maternal and child health services significantly increased among HEF-supported patients, particularly the facility deliveries.(14,26) Yet, only 1 in 2 children received proper treatments at facilities. Only half of women received all five basic health services during their ANC visits.

From 2005 to 2014, the proportion of women who delivered at health facilities quadrupled. During the MDG era, several programs have focused on improving maternal and newborn health including those led by the national government and international aid agencies, including the Korea Foundation for International Healthcare (KOFIH). Since 2013, KOFIH has implemented an integrated MCH program to improve the quality, availability, and accessibility of maternal and child healthcare services in the Battambang province by training health care providers, supporting transportation for referral system and improving healthcare infrastructures, etc.(27) These programs may have been effective in improving both the utilization and quality of delivery care. In 2014, 69% of deliveries took place in the public sector and 85.8% of births were attended by a midwife or a doctor.(14) Nonetheless, we found a large gap in postpartum care before and after discharge which highlights missed opportunities for high-quality delivery care

(**supplemental table 2 and supplemental figure 1**). A meta-analysis found that receiving antenatal to postnatal care could reduce the risk of combined neonatal, perinatal, and maternal mortality by 15%.(28) The Cambodian Ministry of Health recommends four postnatal checks, one before and three after discharge.(21) Despite these recommendations, mothers rarely return to the facilities after they get discharged. Inadequate transportation and long distances to health facilities might discourage women to return to the facilities after getting discharged. More outreach efforts like home visits, promotion of postnatal care during the antenatal period and at delivery are needed to ensure a continuum of delivery care for both mothers and newborns.

We found the largest difference (65.1%) between crude and effective coverage for children with fever in 2010. Effective coverage (blood test for suspected malaria) only improved by 1.1% from 2010 to 2014. This small increase in coverage might have resulted in a dramatic reduction in malaria related deaths in Cambodia. In 2018, no malaria related deaths was reported for the first time in the country's history.(29) The percentage of malaria cases significantly fell from 61% in 2015 to 27% in 2018.(29) This promising improvement could have reduced the number of blood tests for suspected malaria cases.

Effective coverage lags behind crude coverage in Cambodia, indicating a need for improving the quality of MCH care. Similar or even lower levels of effective coverage have been found in other countries. Across 91 LMICs, effective coverage for ANC ranged from 53.8% on average in low-income countries, to 93.3% in upper-middle-income countries.(7) In Rwanda, only 40.2% of women who gave birth in a facility in 2015 received a check-up before discharge while this estimate was almost the double (80.1%) in Cambodia.(6) Quality-adjusted coverage for ANC (women who had at least 4 ANC visits and received at least 11 quality focuses intervention items) was about a half in Myanmar (14.6%) compared to Cambodia (32.8%).(30) In Haiti, an average effective coverage for curative sick childcare, including taking history, testing, and managing care, was 11.8% in 2013 while this estimate was almost tripled (29.7%) in Cambodia.(10) Leslie et al found that effective coverage, providers' adherence to evidence-based care guidelines, for sick childcare was 37% in 8 LMICs between 2007 and 2015.(31)

This study includes several limitations. First, the quality measures are not inclusive as they included only a limited number of recommended items that should be completed during MCH services. For instance, effective coverage for childbirth included only one item: checkup before discharge. Many other components of care are required for high-quality delivery care included a positive user experience (respectful, patient-centered delivery care) and high-quality intrapartum technical care. In addition, quality for sick child care was measured by whether the child received an appropriate treatment (ORS for diarrhea, antibiotics for suspected pneumonia, and blood test for suspected malaria) but the survey did not ask whether the healthcare providers explained the proper treatment instructions to the caregivers or conveyed their diagnosis. Given these limited measures, our quality estimates should be regarded as an upper bound of quality, a starting point for estimating quality-adjusted coverage rather than a definite estimate. Thus, better quality measures - user experience, competent care, and timeliness of care - are needed. More studies need to go beyond utilization of care and investigate health system quality.

Second, although we included the most recent CDHS surveys, our latest data points are from 2014. The CDHS announced an upcoming 2020-21 survey. Future studies should estimate the effect of the COVID-19 pandemic on effective coverage in Cambodia.(32)

Third, DHS data is self-reported by caregivers which is subject to recall bias. Women tend to report less accurately about care related to more complex diseases such as pneumonia (33) but they report better for more invasive procedures such as a blood test. (34) To address reporting biases, other studies on quality of care have linked household surveys with facility assessments.(35) In 2008, Cambodia implemented the Service Availability and Readiness Assessment (SARA), a national health facility assessment.(36) Future studies should try to link different types of surveys to provide a more comprehensive picture of health system quality in Cambodia.

Conclusion

Despite the substantial improvement in maternal and child outcomes in the past decades in Cambodia, efforts are needed to improve quality of care. As Cambodia strives to meet the health-related SDGs by 2030, focusing on effective coverage will be important more than ever to address the residual maternal and child mortality. Our study also highlights the need for better regulation and quality improvement efforts among the private sector. To our knowledge, this is the first study providing sound evidence of the quality of care in Cambodia over time. Health system strengthening efforts need to go beyond just improving the utilization of care and start focusing on the content of care and patients' experience. The COVID-19 pandemic has shown the need for resilient, high-quality health systems more than ever. Thus, Cambodia needs to seize this moment to shift its attention and funding towards building a high-quality health system.

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Competing interests

The authors declare that they have no competing interests.

Contributions

MKK, SEK, CA were involved in the conceptualization and interpretation of findings and helped draft the manuscript. MKK and SAK conducted data analysis. JHW and CEK helped draft the manuscript.

Patient consent for publication

Not required

Ethics approval

Since this study uses publicly available data, an ethical approval was not needed.

Data sharing statement

Data are available upon request and available online from www.measuredhs.com

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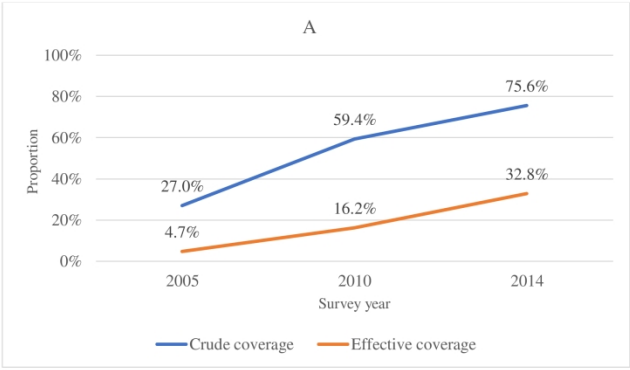
Figure Legend:

Figure 1 – Line graphs

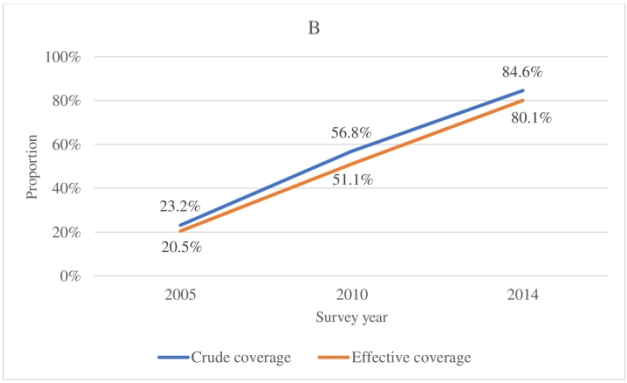
Figure 2 – Equiplots

Figure 3 – Line graphs

Figure 4 – Equiplots



A. Antenatal care (at least four visits)



B. Facility delivery

Figure 1. Crude and effective coverage of maternal health care in Cambodia from 2005 to 2014. (A) at least 4 antenatal care (ANC) visits; (B) facility delivery.

Footnote: Effective coverage for antenatal care was estimated by the proportion of women who received at least four ANC visits and reported receiving five basic services at any point during ANC: their blood pressure was measured, a urine and a blood sample was collected, they were give or bough iron tablets or syrup, and they were counseled on potential complications to look out for during pregnancy. Effective coverage for facility delivery was defined as the proportion of women who delivered at a health facility and who reported that someone examined them or asked questions about their health before being discharged.

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Figure 1 - Line graphs

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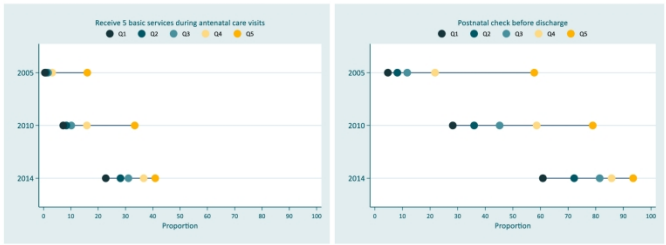
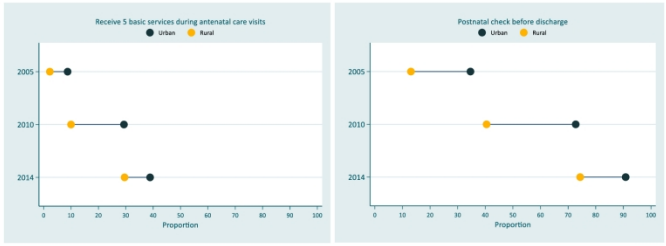
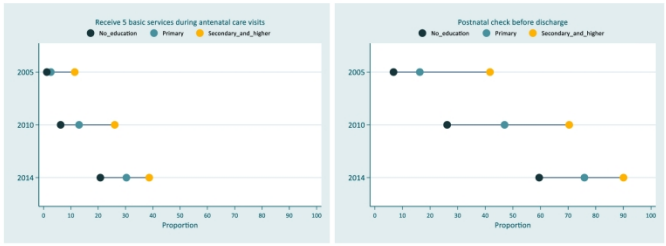


A. Wealth quintile



B. Area of residence (urban vs rural)



C. Women's education (no education, primary, and secondary and higher)

Figure 2. Equity in effective coverage of maternal health in Cambodia from 2005 to 2014 across 1) wealth quintile 2) area of residence (urban vs rural) 3) women's education (no education, primary, and secondary and higher)

1

Figure 2 - Equiplots

215x279mm (300 x 300 DPI)

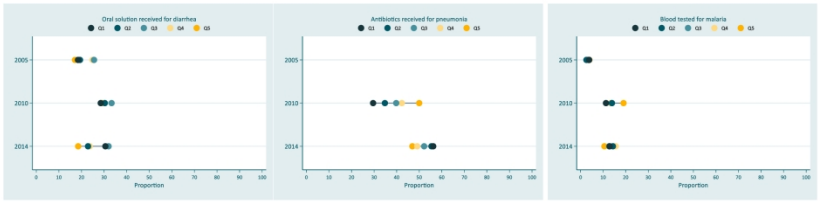
Figure 3. Crude and effective coverage of care for child health in Cambodia from 2005 to 2014. (A) diarrhea; (B) pneumonia; (C) fever.

Footnote: Data for effective coverage of pneumonia in 2005 were missing. Effective coverage for diarrhea was defined as the proportion of children who sought care at a health facility for diarrhea and who received oral rehydration therapy (ORT) from a special packet, pre-packaged or from a homemade fluid. Effective coverage for pneumonia was defined as the proportion of children who visited a health facility for pneumonia and who received antibiotics (pills, syrup, or injection). Effective coverage for fever was defined as children who sought care at a health facility and received a blood test for suspected malaria.

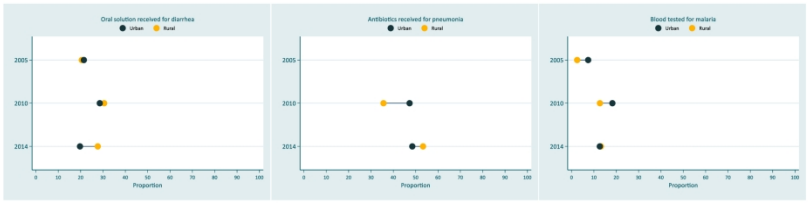
1

Figure 3 - Line graphs

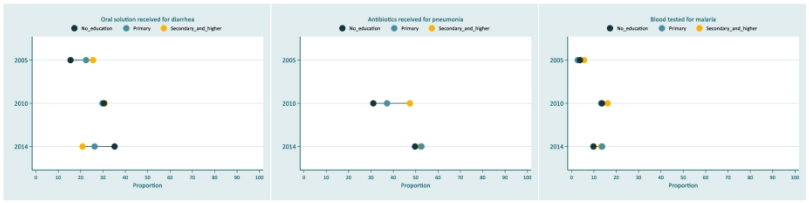
279x215mm (300 x 300 DPI)



A. Wealth quintile



B. Area of residence (urban vs rural)



C. Women's education (no education, primary, and secondary and higher)

Figure 4. Equity in effective coverage of child health in Cambodia from 2005 to 2014 across 1) wealth quintile 2) area of residence (urban vs rural) 3) women's education (no education, primary, and secondary and higher).

Footnote: Data for effective coverage of pneumonia in 2005 were missing.

1

Figure 4 - Equiplots

215x279mm (300 x 300 DPI)

Supplementary file

Effective coverage of maternal and child health in Cambodia from 2005 to 2014

Min Kyung Kim, Soon Ae Kim, Ju Hwan Oh, Chae Eun Kim, Catherine Arsenault

Supplemental table 1. Crude and effective coverage of maternal and child health in Cambodia from 2000 to 2014.

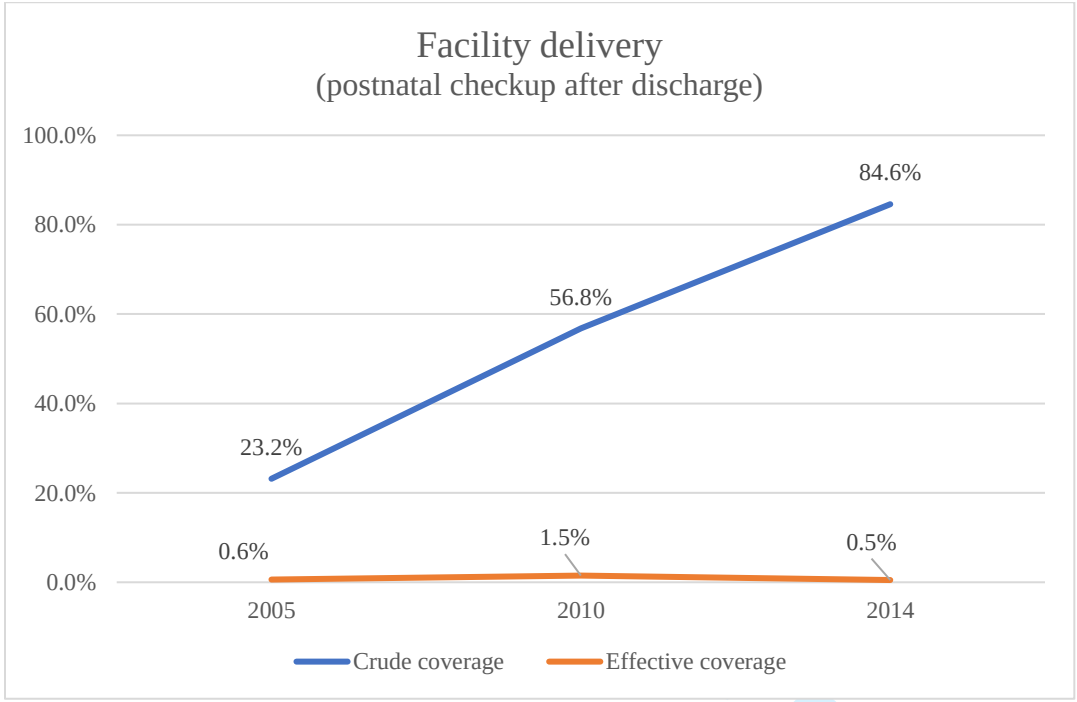
Survey, year	2000		2005		2010		2014	
	Mean	(95% CI)	Mean	(95% CI)	Mean	(95% CI)	Mean	(95% CI)
Antenatal care								
Crude coverage	8.9%	(7.8 - 10.3)	27.0%	(24.7 - 29.5)	59.4%	(57.0 - 61.7)	75.6%	(73.6 - 77.5)
Effective coverage	1.3%	(1.0 - 1.9)	4.7%	(3.7 - 6.0)	16.2%	(14.8 - 17.7)	32.8%	(30.8 - 34.9)
Facility delivery								
Crude coverage	11.0%	(9.3 - 13.8)	23.2%	(20.5 - 26.1)	56.8%	(54.1 - 59.4)	84.6%	(82.4 - 86.5)
Effective coverage	--	--	20.5%	(18.0 - 23.2)	51.1%	(48.53 - 53.7)	80.1%	(77.9 - 82.2)
Diarrhea								
Crude coverage	21.6%	(18.8 - 24.8)	41.1%	(37.5 - 44.8)	58.9%	(55.2 - 62.6)	55.5%	(50.9 - 60.0)
Effective coverage	7.8%	(6.8 - 9.7)	21.1%	(18.3 - 24.1)	27.7%	(24.3 - 31.3)	26.0%	(21.8 - 30.6)
Pneumonia								
Crude coverage	35.1%	(32.2 - 38.1)	46.9%	(43.7 - 50.2)	72.9%	(69.7 - 75.9)	61.3%	(57.4 - 65.0)
Effective coverage	30.4%	(27.7 - 33.2)	--	--	37.3%	(34.0 - 40.8)	51.5%	(47.5 - 55.5)
Fever								
Crude coverage	34.1%	(31.4 - 36.9)	47.8%	(44.6 - 51.1)	75.5%	(72.6 - 78.1)	60.6%	(57.3 - 63.8)
Effective coverage	--	--	2.3%	(1.7 - 3.1)	10.3%	(8.7 - 12.2)	11.5%	(9.5 - 13.9)

Note: -- Data are not available; effective coverage for facility delivery in 2000 and sick childcare for fever in 2000 and sick childcare for pneumonia in 2005.

Supplemental table 2. Crude and effective coverage of facility delivery (postnatal checkup after discharge) in Cambodia from 2005 to 2014

Survey, year	**2005**		**2010**		**2014**	
	Mean	(95% CI)	Mean	(95% CI)	Mean	(95% CI)
Facility delivery						
Crude coverage	23.2%	(20.5 - 26.1)	56.8%	(54.1 - 59.4)	84.6%	(82.4 - 86.5)
Effective coverage	0.6%	(0.4 - 0.9)	1.5%	(1.1 - 2.0)	0.5%	(0.3 - 0.8)

Note: Postnatal checkup after discharge is a question asked whether the mother was checked after getting discharge from the health facilities.



Supplemental figure 1. Crude and effective coverage of facility delivery (postnatal checkup after discharge) in Cambodia from 2005 to 2014.

Note: Effective coverage for facility delivery was defined as the proportion of women who delivered at a health facility and who reported that someone examined them or asked questions about their health after being discharged.

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Measuring effective coverage of maternal and child health services in Cambodia: a retrospective analysis of Demographic and Health Surveys from 2005 to 2014

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Abstract

Objective To investigate effective, quality-adjusted, coverage and inequality of maternal and child health (MCH) services to assess progress in improving quality of care in Cambodia.

Design A retrospective secondary analysis using the three most recent (2005, 2010, 2014) Demographic and Health Surveys.

Setting Cambodia.

Participants 53155 women aged 15-49 years old and 23242 children under 5 years old across the three surveys.

Outcome measures We estimated crude coverage, effective coverage, and inequality in effective coverage for five MCH services over time: antenatal care (ANC), facility delivery, and sick childcare for diarrhea, pneumonia, and fever. Quality was defined by the proportion of care seekers who received a set of interventions during health care visits. Effective coverage was estimated by combining crude coverage and quality. We used equiplots and risk ratios, to assess patterns in inequality in MCH effective coverage across wealth quintile, urban-rural, and women's education levels and over time.

Results In 2014, crude and effective coverage were 80.1% and 56.4%, respectively for maternal health services (ANC and facility delivery) and 59.1% and 26.9%, respectively for sick childcare (diarrhea, pneumonia, and fever). Between 2005 and 2014, effective coverage improved for all services, but improvements were larger for maternal health care than for sick child care. In 2014, poorer children were more likely to receive ORS for diarrhea than children from richer households. Meanwhile, women from urban areas were more likely to receive a postnatal check before getting discharged.

Conclusions Effective coverage has generally improved in Cambodia but efforts remain to improve quality for all MCH services. Our results point to substantial gaps in curative care, a large share of which is provided by unregulated private providers in Cambodia. Policymakers should focus on improving effective coverage, and not only crude coverage, to achieve the health-related Sustainable Development Goals by 2030.

Strengths and limitations of this study

- This study included nationally representative population data to estimate effective, quality-adjusted, coverage and inequality of maternal and child health services.
- This study used three waves (2005, 2010, and 2014) of surveys to observe the temporal changes in coverage, quality, and inequality.
- The study is limited by the type of measures included in the Demographic and Health Surveys to assess quality.

Introduction

The sustainable Development Goal (SDG) 3 aims to achieve universal health coverage (UHC), by ensuring access to quality essential health services by 2030.(1) Despite substantial improvement in access to healthcare services, quality of care remains poor and variable across low- and middle-income countries (LMICs).(2–5) The Lancet Global Health Commission on High Quality Health Systems in the SDG era (i.e., the HQSS Commission) estimated that high quality health systems could save one million newborn deaths annually.(4) Vulnerable groups, including the poor and the less educated, tend to receive worst quality of care.(5–7) Thus, quality improvement needs to be a central pillar of UHC.

An increasing body of evidence recommends a shift from tracking 'crude' or 'contact' coverage to 'effective' coverage,(5–9) defined as the proportion of a population in need of a service that resulted in a positive health outcome from the service.(10) Recent literature have shown a gap between crude and effective coverage ranged from 40% to 60% in LMICs.(7,11,12) This indicates that many patients who come in contact with the health system are not treated according to standards of care.

Cambodia is a lower-middle income country located in Southeast Asia with a population of 16.72 million people.(13) Since the late 1990's, the country has experienced consistent economic growth and a reduction in poverty rates.(14) In the past decades, the Cambodian government has focused on increasing utilization of maternal and child health (MCH) services. From 2000 to 2014, Cambodia reduced its under-5 mortality rate from 124 to 35 per 1,000 live births and the maternal morality ratio from 437 to 170 per 100,000 live births.(15) Increased in facility deliveries and child vaccination programs have substantially reduced these maternal and child deaths during the Millennium Development Goals (MDGs) era.(16,17)

However, in order to achieve the health-related SDGs by 2030, maternal mortality must be reduced by an additional 60% and under-five mortality by an additional 30%. Using Global Burden of Disease data in 2016, Kruk et al found that deaths due to poor quality care were twice as high as deaths due to non-utilization of healthcare services in Cambodia.(18) Moreover, inequality in accessing maternal and child care services across geographic locations, urban-rural residents, and wealth quintile was observed in Cambodia.(19,20) To avert these additional maternal and child deaths, a high-quality equitable healthcare services is needed. The first step is to monitor progress during the MDG era.

To our knowledge, no study has assessed the effective, quality-adjusted, coverage of MCH services in Cambodia. Past research has mostly focused on the utilization of MCH services.(21–23) Thus, this study estimates the effective coverage of five MCH services and inequality in effective coverage using data from 2005 to 2014.

Methods

Data sources

This is a secondary statistical analysis using data from the Cambodia Demographic and Health Surveys (CDHS) to examine changes in crude coverage, effective coverage, and inequality in effective coverage of maternal and child health services over time. The three most recent waves – 2005, 2010, 2014 - of the CDHS were included. The CDHS is a nationally representative, population-based, cross-sectional survey carried out every 4 to 5 years.(15) Our population of interest (N) included all women of reproductive age (15-49 years old) who had at least one live birth in the past five years preceding each survey wave for maternal care, and all children under five years old living in residential households for sick childcare visits. The CDHS collects data on a wide range of health services including across the MCH continuum of care. Sampling strategies and methodology have been described elsewhere.(24)

Measures

Crude coverage

Crude coverage was calculated by the proportion of women or children who needed health care (due to true or perceived needs) and who sought care at health facilities. We estimated crude coverage for five MCH services: antenatal care (ANC), delivery, and care for diarrhea, pneumonia, and fever. Antenatal care was defined as the proportion of women with at least one live birth in the five years preceding the survey who reported at least four ANC visits for their most recent birth. Delivery care was defined as the proportion of women who gave birth in the five years preceding the survey and who delivered at a health facility including all public and private facilities (excluding those who gave birth at home and undefined locations).

Care for diarrhea, pneumonia, and fever were defined, respectively, as the proportion of children who had diarrhea, symptoms of pneumonia (a cough accompanied by short, rapid breathing and difficulty breathing as a result of a problem in the chest), or fever, in the two weeks preceding the survey for whom advice or treatment was sought from a health facility including all public and private facilities except pharmacies and traditional healers.

Effective coverage

Based on the calculation used by Arsenault et al(7) and Hategeka et al(6), we estimated effective coverage as:

$$EC = Q*U/N$$

Where EC is effective coverage, Q is quality of MCH services, U is utilization of MCH services, and N is need for MCH services. Since the CDHS had only a few indicators to estimate the quality of services, the effective coverage estimates reported in this study should be considered an upper limit of the quality of MCH services.

Quality of care was defined based on four reports: the HQSS Commission's framework(4), the WHO recommendations on antenatal care for a positive pregnancy experience(25), the National Strategy for Reproductive and Sexual Health of Cambodia 2017-2020(26), and the WHO standards for improving the quality of care for children and young adolescents in health facilities.(27)

Quality-adjusted ANC was estimated by the proportion of women who received at least four ANC visits and reported receiving five basic services at any point during ANC: their blood pressure was measured, a urine and a blood sample were collected, they were given or bought iron tablets or syrup, and they were counseled on potential complications to look out for during pregnancy. Quality-adjusted delivery care was defined as the proportion of women who delivered at a health facility and who reported that someone examined them or asked questions about their health before being discharged. Quality-adjusted care for diarrhea was defined as the proportion of children who sought care at a health facility for diarrhea and who received oral rehydration therapy (ORT) from a special packet, pre-packaged or from a homemade fluid. Quality-adjusted care for pneumonia was defined as the proportion of children who visited a health facility for suspected pneumonia and who received antibiotics (pills, syrup or injection). Quality-adjusted care for fever was defined as children who sought care at a health facility and received a blood test for suspected malaria. Detailed indicator definitions are shown in **supplemental table 1**.

Inequality in effective coverage of MCH services

Inequalities in effective coverage of five MCH services was assessed using three measures of socioeconomic position: household wealth quintile, area of residence (urban vs. rural) and the woman's education level as provided by the CDHS.(15) The wealth index, provided by the CDHS, is calculated based on a household's ownership of selected assets, such as televisions and bicycles; housing construction materials; and types of water access and sanitation facilities.(28) The wealth index is divided into five quintiles (lowest – Q1, second – Q2, middle – Q3, fourth - Q4, and highest – Q5) based on a continuous scale of relative wealth in the country.(28) Details on the calculation of the wealth index can be found elsewhere.(29) The women's education was combined into three levels (no education, primary school only, and secondary or higher education).

Statistical analysis

We first used descriptive statistics to estimate crude coverage and effective coverage for the five MCH services in 2005, 2010 and 2014. Data for child pneumonia care was not available in 2005. Line graphs were used to present the trends in national averages over time for each health service. Second, we assessed inequalities in effective coverage visually using equiplots across wealth quintiles, maternal education, and area of residence (urban vs rural).

Three additional sub-analyses were conducted. First, we estimated the crude and effective coverage in 2000 to observe the trend in the last two decades. However, due to the age of the data, we excluded the 2000 data from the main analysis (**supplemental table 2**). Second, we

used logistic regressions and postestimation commands to estimate risk ratios (RR) in effective coverage in 2014 between the top and bottom categories of each measure of socioeconomic position (wealth quintiles, education and urban residence) (**supplemental table 3**). Statistical code for RR calculation is publicly available on GitHub repository: https://github.com/mkkim1/RiskRatio_Cambodia.git. Third, we used postpartum checkup after discharge to estimate effective coverage for childbirth and compare with the results from the main analysis (**supplemental table 4 and supplemental figure 1**).

All analyses, including logistic regressions, were adjusted for the survey design (clustering, stratification, and survey weights) except the equiplots due to a limitation of the statistical software package. Stata SE Version 16.0 was used for all analyses.

Patient and public involvement

Patients and/or the public were not involved in the design, or conduct, or reporting, or dissemination plans of this research.

Results

Description of the study population

A total of 53,155 women of reproductive age (15-49 years old) were included across the three survey waves. The proportion of women who gave birth within the 5 years preceding the survey slightly decreased from 34.9% in 2005 to 34.0% in 2014. Most women lived in rural areas and completed primary education (**table 1**). In total, 23,242 children under 5 years were included. Fever was the most prevalent child illness, with 27.1% of children suffering from fever in the two weeks prior to the survey in 2014 (**table 1**). High prevalence of fever could be explained by the high burden of malaria along the national borders including in the western provinces of Battambang and Pailin.

Overall crude and effective coverage

In 2014, average crude and effective coverage were 80.1% and 56.4%, respectively, for maternal health care (ANC and delivery), and 59.1% and 29.6% for sick child care (care for child diarrhea, pneumonia, and fever) (**table 1**). For maternal health, effective coverage increased by 21.0% and 22.8% from 2005 to 2010 and 2010 to 2014, respectively (**table 1**). For sick childcare, effective coverage increased by 13.4% and 4.5% from 2005 to 2010 and 2010 to 2014, respectively (**table 1**). Estimates for crude and effective coverage for each indicator can be found in **supplemental table 2**. Delivery had the highest effective coverage at 80.1% in 2014 (**supplemental table 2**). Meanwhile, effective coverage for fever had the lowest effective coverage at 2.3% in 2005 (**supplemental table 2**).

Maternal health care

Figure 1 shows a continuous increase in crude and effective coverage for ANC and facility delivery from 2005 to 2014. In 2014, 80.1% of women who delivered at a facility had a postnatal check before being discharged and around half of women who had four ANC visits received the five basic services during their pregnancy. Effective coverage in maternal health care services improved even among the poorest. For example, in 2005 only 4.7% of women in the lowest wealth quintile received a postnatal check; while this increased to 60.9% in 2014 (**figure 2**). The proportion of women from rural areas who received the five basic services during ANC increased by 13-folds from 2005 to 2014, from 2.2% to 29.6% (**figure 2**). Inequalities also appeared to be reduced according to the equiplots. However, socioeconomic inequalities in effective coverage remained in 2014. Women in the richest wealth quintile in Cambodia were 1.7 times more likely to receive all five services during ANC visits (RR = 1.7, 95% CI = 1.5, 2.0) compared to the poorest and they were 1.4 times more likely to receive a postnatal check before discharge (RR = 1.4, 95% CI = 1.4, 1.5) (**supplemental table 3**).

Sick child care

Figure 3 shows the trend in crude and effective coverage for sick child care. Overall, crude and effective coverage for sick child care did not improve as much as for maternal care between 2005 and 2014. The proportion of children with diarrhea who received ORS and the proportion with

fever who received a malaria test remained almost the same between 2010 and 2014 (**figure 3**). The proportion of children who received ORS for diarrhea was higher in the poorest groups.

In 2014, children in the richest quintile were 0.6 times less likely to receive ORS when seeking care for diarrhea (RR = 0.6, 95% CI = 0.4, 0.9), compared to children from the poorest households (**figure 4 and supplemental table 3**). Similarly, children of most educated mothers were 0.5 times less likely to receive ORS for diarrhea (RR = 0.5, 95% CI = 0.3, 0.8) compared to those with no formal education (**supplemental table 3**).

Table 1 - Characteristics of the study sample in Cambodia from 2005 to 2014.

Survey, year	2005	2010	2014
	N (%)	N (%)	N (%)
Number of households	14243	15667	15825
Women (age 15-49)	16823	18754	17578
Women who gave birth within 5 years of the survey	5865 (34.9%)	6472 (34.5%)	5973 (34.0%)
Residence			
Urban	2973 (17.7%)	3936 (21.0%)	3251 (18.5%)
Rural	13851 (82.3%)	14819 (79.0%)	14328 (81.5%)
Education			
No education	3270 (19.4%)	2974 (15.9%)	2251 (12.8%)
Primary	9389 (55.8%)	9265 (49.4%)	8281 (47.1%)
Secondary and higher	4165 (24.8%)	6516 (34.7%)	7047 (40.1%)
Wealth quintile			
Lowest	3018 (17.9%)	3389 (18.1%)	3144 (17.9%)
Second	3165 (18.8%)	3517 (18.7%)	3314 (18.9%)
Middle	3246 (19.3%)	3595 (19.2%)	3381 (19.2%)
Fourth	3308 (19.7%)	3827 (20.4%)	3613 (20.6%)
Highest	4089 (24.3%)	4429 (23.6%)	4128 (23.5%)
Maternal health care			
Crude coverage of antenatal care and facility delivery (mean, range)	25.1% (23.2%-27.0%)	58.1% (56.8% – 59.4%)	80.1% (75.6% – 84.6%)
Effective coverage of antenatal care and facility delivery (mean, range)	12.6% (4.7% – 20.5%)	33.6% (16.2% – 51.1%)	56.4% (32.8% – 80.1%)
Children (age <5)	7789	8200	7253
Children who had diarrhea 2 weeks prior to the survey	1420 (18.2%)	1161 (14.2%)	902 (12.4%)
Children who had pneumonia 2 weeks prior to the survey	2224 (28.6%)	1741 (21.2%)	1531 (21.1%)
Children who had fever 2 weeks prior to the survey	2576 (33.1%)	2194 (26.8%)	1968 (27.1%)
Care for sick children			
Crude coverage of diarrhea, pneumonia, and fever (mean, range)	45.3% (41.1% – 47.8%)	69.1% (58.9% – 75.5%)	59.1% (55.5% – 61.3%)
Effective coverage of diarrhea, pneumonia, and fever (mean, range)[a]	11.7% (2.3% – 21.1%)	25.1% (10.3% – 37.3%)	29.6 % (11.5% – 51.5%)

[a]Effective coverage for pneumonia in 2005 was not included due to missing data in CDHS.

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Discussion

In this study, we estimated crude coverage, effective coverage, and inequality in effective coverage for five MCH services to assess progress in improving quality of health care in Cambodia from 2005 to 2014. We found that improvements in effective coverage were greater for maternal health services (ANC and facility delivery), than for curative services for sick children (diarrhea, pneumonia, and fever). Vulnerable women, including the poor, rural residents, and less educated, experienced a greater improvement in effective coverage for facility delivery than ANC. Inequality gaps appeared to have been reversed for diarrhea and pneumonia over time, where children from rural households received higher quality care than children from urban households.

Effective coverage in sick child care did not improve as much as for maternal health services. We also found a pro-poor distribution for sick child care – children from the poorest, less educated households and from rural areas, appeared to be more likely to receive ORS for diarrhea and antibiotics for pneumonia, than children from richer, more educated households and urban areas. Most curative care in Cambodia is delivered by an extensive network of loosely regulated private health-care providers while the public sector is the predominant provider of preventive care and health promotion activities.(14,30) According to the 2014 CDHS, 65% of care for child diarrhea, fever or cough took place in the private sector.(15) Private providers – mostly small practices, pharmacies or single-person practitioners - are also more prevalent in urban areas.(14) The regulation of private providers in Cambodia remains a challenge where many operate without government accreditation.(14) The Cambodia National Strategic Plan 2017-2020 revealed inadequate education of health professionals as an important impediment to improving the quality of health services.(31) Since our results point to large quality gaps in the private sector, the Cambodian government should regulate private healthcare providers for their curative clinical practice to ensure that patients receive quality care.

The increase in care seeking among poorer households could also have been influenced by the Health Equity Fund (HEF). The HEF, launched in 2000, is Cambodia's largest financial protection scheme, covering the poorest one-fifth of the national population and aims to increase access to government health facilities.(32) Since then, the utilization of maternal and child health services significantly increased among HEF-supported patients, particularly the facility deliveries.(15,33) Yet, only 1 in 2 children received proper treatments at facilities. Only half of women received all five basic health services during their ANC visits.

From 2005 to 2014, the proportion of women who delivered at health facilities quadrupled. During the MDG era, several programs have focused on improving maternal and newborn health including those led by the national government and international aid agencies, including the Korea Foundation for International Healthcare (KOFIH). Since 2013, KOFIH has implemented an integrated MCH program to improve the quality of maternal and child healthcare services in the Battambang province by training healthcare workers - upgrading the skills of new midwives and training on partograph.(34) The Government Midwifery Incentive Scheme started in 2006 aimed to increase the facility deliveries by paying midwives and other trained health personnel

with cash incentives based on the number of live births they attend in public health facilities.(35) These programs may have been effective in improving both the utilization and quality of delivery care. According to the 2014 CDHS report, 69% of deliveries took place in the public sector and 85.8% of births were attended by a midwife or a doctor.(15) Nonetheless, we found a large gap in postpartum care before and after discharge which highlights missed opportunities for high-quality delivery care (**supplemental table 4 and supplemental figure 1**). A meta-analysis found that receiving antenatal to postnatal care could reduce the risk of combined neonatal, perinatal, and maternal mortality by 15%.(36) The National Strategy for Reproductive and Sexual Health in 2017-2020 recommends four postnatal checks, one before and three after discharge.(26) Despite these recommendations, mothers rarely return to the facilities after they get discharged. Inadequate transportation and long distances to health facilities might discourage women to return to the facilities after getting discharged. More outreach efforts like home visits, promotion of postnatal care during the antenatal period and at delivery are needed to ensure a continuum of delivery care for both mothers and newborns.

We found the largest difference (65.1%) between crude and effective coverage for children with fever in 2010. Effective coverage (blood test for suspected malaria) only improved by 1.1% from 2010 to 2014. This small increase in coverage might have resulted in a dramatic reduction in malaria related deaths in Cambodia. In 2018, no malaria related deaths was reported for the first time in the country's history.(37) The percentage of malaria cases significantly fell from 61% in 2015 to 27% in 2018.(37) This promising improvement could have reduced the number of blood tests for suspected malaria cases.

Effective coverage lags behind crude coverage in Cambodia, indicating a need for improving the quality of MCH care. Similar or even lower levels of effective coverage have been found in other countries. Across 91 LMICs, effective coverage for ANC ranged from 53.8% on average in low-income countries, to 93.3% in upper-middle-income countries.(7) In Rwanda, only 40.2% of women who gave birth in a facility in 2015 received a check-up before discharge while this estimate was almost the double (80.1%) in Cambodia.(6) Quality-adjusted coverage for ANC (women who had at least 4 ANC visits and received at least 11 quality focuses intervention items) was about a half in Myanmar (14.6%) compared to Cambodia (32.8%).(38) In Haiti, an average effective coverage for curative sick childcare, including taking history, testing, and managing care, was 11.8% in 2013 while this estimate was almost tripled (29.7%) in Cambodia.(11) Leslie et al found that effective coverage, providers' adherence to evidence-based care guidelines, for sick childcare was 37% in 8 LMICs between 2007 and 2015.(39) About 3 in 10 children received ORS in Vietnam (30.0%) and Cambodia (26.0%) in 2014.(40)

This study includes several limitations. First, the quality measures are not inclusive as they included only a limited number of recommended items that should be completed during MCH services. For instance, effective coverage for childbirth included only one item: checkup before discharge. Many other components of care are required for high-quality delivery care included a positive user experience (respectful, patient-centered delivery care) and high-quality intrapartum technical care. In addition, quality for sick child care was measured by whether the child received an appropriate treatment (ORS for diarrhea, antibiotics for suspected pneumonia, and

blood test for suspected malaria) but the survey did not ask whether the healthcare providers explained the proper treatment instructions to the caregivers or conveyed their diagnosis. Given these limited measures, our quality estimates should be regarded as an upper bound of quality, a starting point for estimating quality-adjusted coverage rather than a definite estimate. Thus, better quality measures - user experience, competent care, and timeliness of care - are needed. More studies need to go beyond utilization of care and investigate health system quality.

Second, although we included the most recent CDHS surveys, our latest data points are from 2014. The CDHS announced an upcoming 2020-21 survey.(41) The Global Financing Facility estimated that service disruptions during the COVID-19 pandemic could have the potential to leave 313,900 children without oral antibiotics for pneumonia and 77,600 women without access to facility deliveries.(42) In Laos, antenatal care and postnatal care declined by an estimated 10% and 9%, respectively, immediately after the declaration of the pandemic.(43) Future studies should estimate the effect of the COVID-19 pandemic on effective coverage in Cambodia.

Third, DHS data is self-reported by caregivers which is subject to recall bias. Women tend to report less accurately about care related to more complex diseases such as pneumonia (44) but they report better for more invasive procedures such as a blood test. (45) To address reporting biases, other studies on quality of care have linked household surveys with facility assessments.(46) In 2008, Cambodia implemented the Service Availability and Readiness Assessment (SARA), a national health facility assessment.(47) Future studies should try to link different types of surveys to provide a more comprehensive picture of health system quality in Cambodia. Fourth, the findings are applicable only to the study country.

Conclusion

Despite the substantial improvement in maternal and child outcomes in the past decades in Cambodia, efforts are needed to improve quality of care. As Cambodia strives to meet the health-related SDGs by 2030, focusing on effective coverage will be important more than ever to address the residual maternal and child mortality. Additionally, inequalities across socioeconomic status need to be addressed to achieve equitable quality healthcare. Our study recommends policies to improve regulation and quality improvement efforts among the private sector where curative services for sick childcare are often provided. To our knowledge, this is the first study providing sound evidence of the quality of care in Cambodia over time. Health system strengthening efforts need to go beyond just improving the utilization of care and start focusing on the content of care and patients' experience. The COVID-19 pandemic has shown the need for resilient, high-quality health systems more than ever. Thus, Cambodia needs to seize this moment to shift its attention and funding towards building a high-quality health system.

Funding

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Competing interests

The authors declare that they have no competing interests.

Contributions

MKK, SEK, CA were involved in the conceptualization and interpretation of findings and helped draft the manuscript. MKK and SAK conducted data analysis. JHW and CEK helped draft the manuscript.

Patient consent for publication

Not required

Ethics approval

Since this study uses publicly available data, an ethical approval was not needed.

Data sharing statement

Data are available upon reasonable request. The data on the selected maternal and child health indicators were taken from the women's and children's questionnaire of the DHS surveys, and the data set is available on request after registering as a user (https://dhsprogram.com/Data/).(48)

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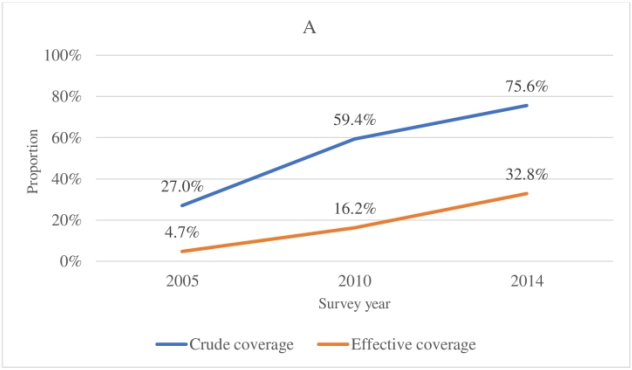
Figure Legend:

Figure 1 – Line graphs

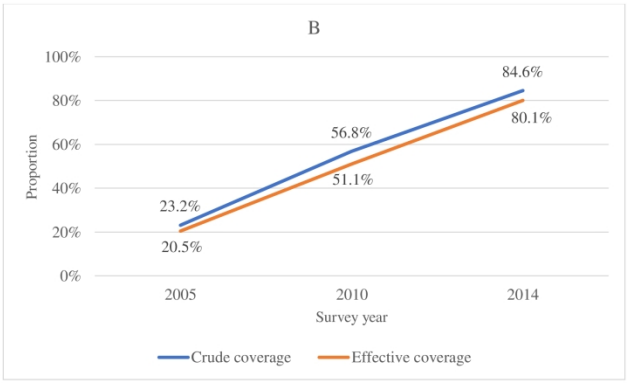
Figure 2 – Equiplots

Figure 3 – Line graphs

Figure 4 – Equiplots



A. Antenatal care (at least four visits)



B. Facility delivery

Figure 1. Crude and effective coverage of maternal health care in Cambodia from 2005 to 2014. (A) at least 4 antenatal care (ANC) visits; (B) facility delivery.

Footnote: Effective coverage for antenatal care was estimated by the proportion of women who received at least four ANC visits and reported receiving five basic services at any point during ANC: their blood pressure was measured, a urine and a blood sample was collected, they were give or bough iron tablets or syrup, and they were counseled on potential complications to look out for during pregnancy. Effective coverage for facility delivery was defined as the proportion of women who delivered at a health facility and who reported that someone examined them or asked questions about their health before being discharged.

1

Figure 1 - Line graphs

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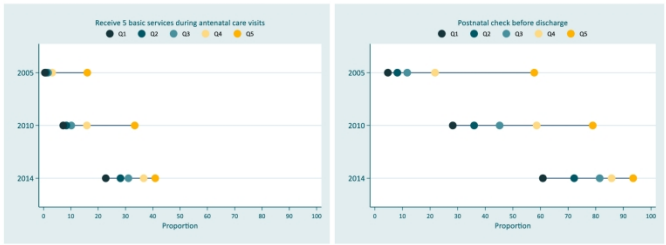
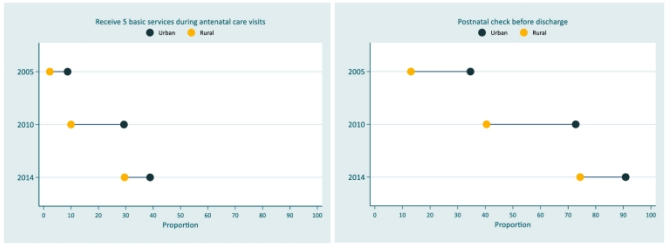
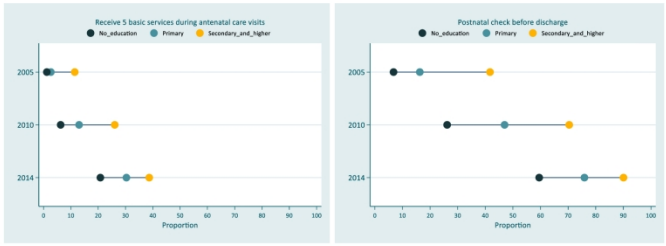


A. Wealth quintile



B. Area of residence (urban vs rural)



C. Women's education (no education, primary, and secondary and higher)

Figure 2. Equity in effective coverage of maternal health in Cambodia from 2005 to 2014 across 1) wealth quintile 2) area of residence (urban vs rural) 3) women's education (no education, primary, and secondary and higher)

1

Figure 2 - Equiplots

215x279mm (300 x 300 DPI)

Figure 3. Crude and effective coverage of care for child health in Cambodia from 2005 to 2014. (A) diarrhea; (B) pneumonia; (C) fever.

Footnote: Data for effective coverage of pneumonia in 2005 were missing. Effective coverage for diarrhea was defined as the proportion of children who sought care at a health facility for diarrhea and who received oral rehydration therapy (ORT) from a special packet, pre-packaged or from a homemade fluid. Effective coverage for pneumonia was defined as the proportion of children who visited a health facility for pneumonia and who received antibiotics (pills, syrup, or injection). Effective coverage for fever was defined as children who sought care at a health facility and received a blood test for suspected malaria.

1

Figure 3 - Line graphs

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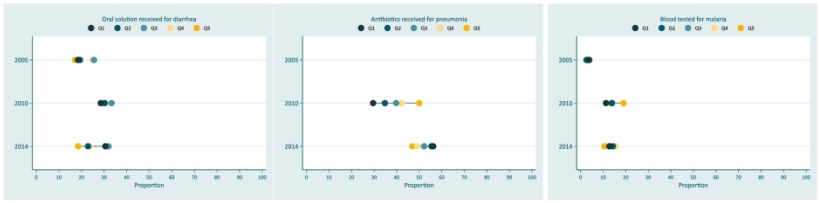
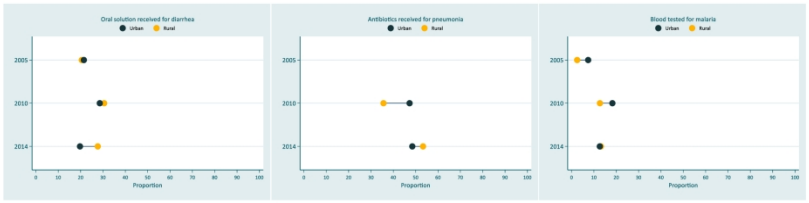
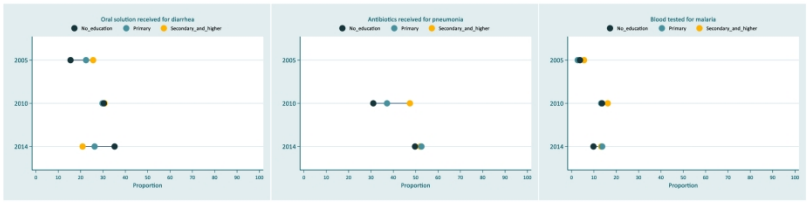


A. Wealth quintile



B. Area of residence (urban vs rural)



C. Women's education (no education, primary, and secondary and higher)

Figure 4. Equity in effective coverage of child health in Cambodia from 2005 to 2014 across 1) wealth quintile 2) area of residence (urban vs rural) 3) women's education (no education, primary, and secondary and higher).

Footnote: Data for effective coverage of pneumonia in 2005 were missing.

1

Figure 4 - Equiplots

215x279mm (300 x 300 DPI)

Supplementary file

Measuring effective coverage of maternal and child health services in Cambodia: a retrospective analysis of Demographic and Health Surveys from 2005 to 2014

Min Kyung Kim, Soon Ae Kim, Ju Hwan Oh, Chae Eun Kim, Catherine Arsenault

Supplemental table 1. Indicator definitions and measurement strategy for crude coverage, effective coverage, and inequality, Cambodia Demographic Health Surveys

Indicators	Type	Measurement	DHS measurement
OUTCOME VARIABLES			
1. Antenatal care (ANC)			
Crude coverage: Women with a recent live birth within 5-years prior to each survey wave and received at least 4 times ANC services from skilled providers	Binary	0. No, < 4 visit(s) 1. Yes, ≥ 4 visits	Q412: How many times did you receive antenatal care during this pregnancy?
Effective coverage: Women with a recent live birth within 5-years prior to each survey wave and received at least 4 times ANC services and 5 key components of ANC from a health provider, which include: 1) blood pressure monitoring, 2) iron supplementation, 3) counsel about pregnancy complications, 4) urine testing, and 5) blood testing	Binary	0. No 1. Yes, received all the four services	Q413: As part of your antenatal care during this pregnancy, were any of the following done at least once? a) Was your blood pressure measured? b) Did you give a blood sample? c) Did you give a urine sample? q421: During this pregnancy, were you given or did you buy any iron tablets or iron syrup? Q414: During (any of) your antenatal care visit(s), were you told about things to look out for that might suggest problems with the pregnancy?

Indicators	Type	Measurement	DHS measurement
2. Facility delivery			
Crude coverage: Women with a recent live birth within 5-years prior to each survey wave and delivered their last baby at the health facilities	Binary	0. No 1. Yes, delivered at the facilities (excluding home and unspecified locations) Skilled birth attendant includes general practitioner, obstetrician, nurse, midwife and village midwife	Q434: Where did you give birth to (NAME)?
Effective coverage: Women with a recent live birth within 5-years prior to each survey wave received postnatal care for their newborn before getting discharged	Binary	0. No 1. Yes	Q436: After you gave birth to (NAME), did anyone check on your baby health while you were still in the facility?
3. Sick child - diarrhea			
Crude coverage: All children under 5 years reported to have had symptoms in the 2 weeks before the survey and seek treatment from health facility	Binary	0. No 1. Yes, from health facility (excluding pharmacies)	Q611: Did you seek advice or treatment for the diarrhea from any source? Q612: Where did you seek advice or treatment?
Effective coverage: All children under 5 years reported to have had symptoms in the 2 weeks before the survey and seek treatment and received oral rehydration therapy (ORT)/increased fluids from health facility or provider	Binary	0. No 1. Yes, received ORS / a pre-packaged / ORS/homemade fluid	Q615: Was (NAME) given any of the following at any time since (NAME) started having the diarrhea: a) A fluid made from a special packet called [LOCAL NAME FOR ORS PACKET]? b) A pre-packaged ORS liquid? c) A government-recommended homemade fluid?
4. Sick child – pneumonia			
Crude coverage: All children under-5 years reported to have had symptoms in the 2 weeks before the survey and	Binary	0. No 1. Yes, from facility (excluding pharmacies)	Q620. Where did you seek advice or treatment for pneumonia? Q625. Where did you seek advice or treatment?

Indicators	Type	Measurement	DHS measurement
were taken to a medical facility for treatment			
Effective coverage: All children under-5 years reported to have had symptoms in the 2 weeks before the survey and received antibiotic pills, syrup, or injections	Binary	0. No 1. Yes, antibiotic drugs / PILL/SYRUP (J) INJECTION/IV (K)	Q630. What drugs did (NAME) take?
5. Sick child – fever			
Crude coverage: All children under 5-years reported to have had symptoms in the 2 weeks before the survey and were taken to a medical facility for treatment	Binary	0. No 1. Yes, from facility (excluding pharmacies)	Q618. Has (NAME) been ill with a fever at any time in the last 2 weeks? Q625. Where did you seek advice or treatment?
Effective coverage: All children under 5-years reported to have had symptoms in the 2 weeks and had blood taken from finger or heel for testing	Binary	0. No 1. Yes	[no question available in the DHS survey but the data are available]
MEASURES OF SOCIOECONOMIC POSITION			
Wealth index	Categorical ordinal	0. Poorest / least wealthy 1. Poor 2. Middle 3. Rich 4. Richest / wealthiest	The wealth index is a composite measure of a household's cumulative living standard. The wealth index is calculated using easy-to-collect data on a household's ownership of selected assets, such as televisions and bicycles; materials used for housing construction; and types of water access and sanitation facilities. The wealth index is presented in the DHS Final Reports and survey datasets as a background characteristic.
Education	Categorical ordinal	0. Primary/lower 1. Secondary 2. Tertiary/higher	Q107: Have you ever attended school? Q108: What is the highest level of school you attended: primary, junior high, senior high, academy or university?

Indicators	Type	Measurement	DHS measurement
			Q109: What is the highest (grade/year) you completed at that level?
Residency	Binary	0. Rural 1. Urban	Q5: Urban/rural (identified by interviewers)

Supplemental table 2. Crude and effective coverage of maternal and child health in Cambodia from 2000 to 2014.

Survey, year	2000		2005		2010		2014	
	Mean	(95% CI)	Mean	(95% CI)	Mean	(95% CI)	Mean	(95% CI)
Antenatal care								
Crude coverage	8.9%	(7.8 - 10.3)	27.0%	(24.7 - 29.5)	59.4%	(57.0 - 61.7)	75.6%	(73.6 - 77.5)
Effective coverage	1.3%	(1.0 - 1.9)	4.7%	(3.7 - 6.0)	16.2%	(14.8 - 17.7)	32.8%	(30.8 - 34.9)
Facility delivery								
Crude coverage	11.0%	(9.3 - 13.8)	23.2%	(20.5 - 26.1)	56.8%	(54.1 - 59.4)	84.6%	(82.4 - 86.5)
Effective coverage	--	--	20.5%	(18.0 - 23.2)	51.1%	(48.53 - 53.7)	80.1%	(77.9 - 82.2)
Diarrhea								
Crude coverage	21.6%	(18.8 - 24.8)	41.1%	(37.5 - 44.8)	58.9%	(55.2 - 62.6)	55.5%	(50.9 - 60.0)
Effective coverage	7.8%	(6.8 - 9.7)	21.1%	(18.3 - 24.1)	27.7%	(24.3 - 31.3)	26.0%	(21.8 - 30.6)
Pneumonia								
Crude coverage	35.1%	(32.2 - 38.1)	46.9%	(43.7 - 50.2)	72.9%	(69.7 - 75.9)	61.3%	(57.4 - 65.0)
Effective coverage	30.4%	(27.7 - 33.2)	--	--	37.3%	(34.0 - 40.8)	51.5%	(47.5 - 55.5)
Fever								
Crude coverage	34.1%	(31.4 - 36.9)	47.8%	(44.6 - 51.1)	75.5%	(72.6 - 78.1)	60.6%	(57.3 - 63.8)
Effective coverage	--	--	2.3%	(1.7 - 3.1)	10.3%	(8.7 - 12.2)	11.5%	(9.5 - 13.9)

Note: -- Data are not available; effective coverage for facility delivery in 2000 and sick childcare for fever in 2000 and sick childcare for pneumonia in 2005.

Supplemental table 3. Risk ratios in effective coverage of five maternal and child health services between richest and poorest, least and most educated and urban vs. rural residents, Cambodia Demographic and Health Survey 2014

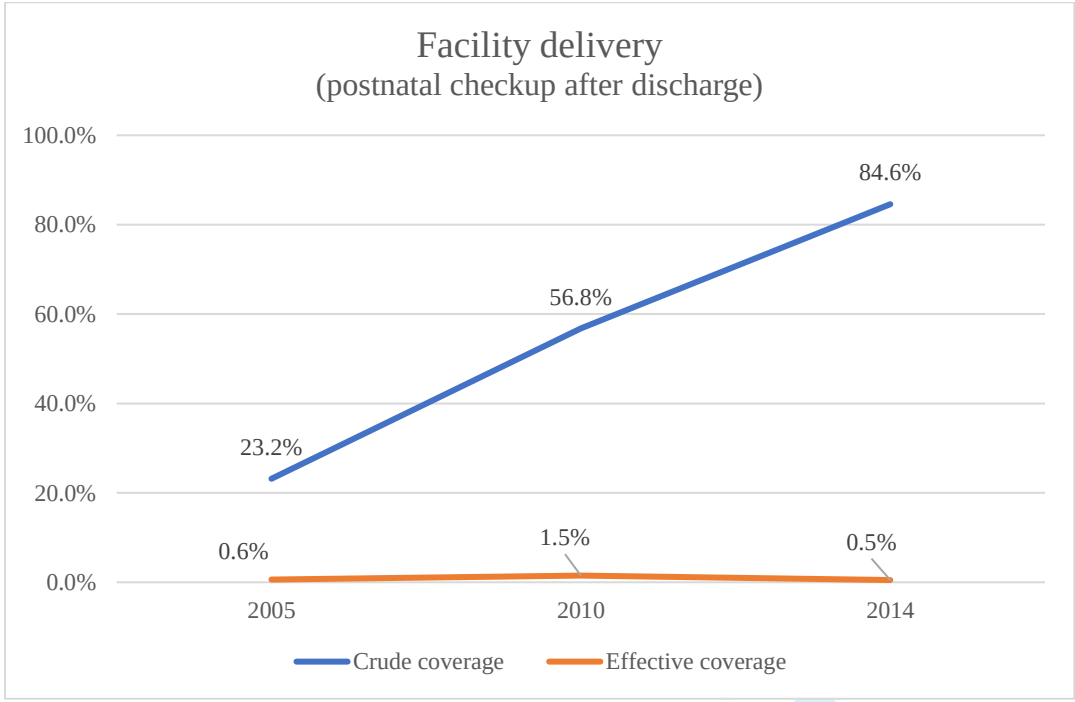
	Wealth quintile (Q5 vs. Q1)		Urban-rural area		Women's education levels (Secondary or higher education vs. no education)	
Indicators	RR	(95% CI)	RR	(95% CI)	RR	(95% CI)
Received 5 basic services during ANC visits	1.7***	(1.5 - 2.0)	1.5***	(1.3 – 1.6)	1.9***	(1.6 – 2.2)
Postnatal check before discharge	1.4***	(1.4 - 1.5)	1.2***	(1.2 – 1.2)	1.4***	(1.3 – 1.5)
Oral solution received for diarrhea	0.6*	(0.4 – 0.9)	0.8	(0.5 – 1.2)	0.5**	(0.3 – 0.8)
Antibiotics received for pneumonia	0.9	(0.8 – 1.1)	0.8*	(0.7 – 0.9)	1.0	(0.8 – 1.2)
Blood tested for malaria	0.8	(0.5 – 1.1)	0.8	(0.6 – 1.2)	1.3	(0.8 – 2.0)

Note: P<0.001***, P<0.01**, and P<0.05*. RR = Risk Ratio, CI = Confidence Interval; The RR is the ratio in effective coverage between top and bottom sub-groups: socioeconomic status – wealthiest quintile vs poorest quintile; urban and rural areas; and secondary or higher education vs. no education. RR>1 indicates pro-rich distribution (higher effective coverage in the top group); RR<1 indicates pro-poor distribution (higher effective coverage in the lower sub-groups; RR=1 suggest an equal distribution in the effective coverage indicator.

Supplemental table 4. Crude and effective coverage of facility delivery (postnatal checkup after discharge) in Cambodia from 2005 to 2014

Survey, year	**2005**		**2010**		**2014**	
	Mean	(95% CI)	Mean	(95% CI)	Mean	(95% CI)
Facility delivery						
Crude coverage	23.2%	(20.5 - 26.1)	56.8%	(54.1 - 59.4)	84.6%	(82.4 - 86.5)
Effective coverage	0.6%	(0.4 - 0.9)	1.5%	(1.1 - 2.0)	0.5%	(0.3 - 0.8)

Note: Postnatal checkup after discharge is a question asked whether the mother was checked after getting discharge from the health facilities.



Supplemental figure 1. Crude and effective coverage of facility delivery (postnatal checkup after discharge) in Cambodia from 2005 to 2014.

Note: Effective coverage for facility delivery was defined as the proportion of women who delivered at a health facility and who reported that someone examined them or asked questions about their health after being discharged.

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STROBE Statement—Checklist of items that should be included in reports of *cross-sectional studies*

	Item No	Recommendation	Page/line numbers where relevant information can be found
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	Page 2, lines 30
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	Page 2, lines 42-48
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	Page 3, lines 62-92
Objectives	3	State specific objectives, including any prespecified hypotheses	Page 3, lines 93-96
Methods			
Study design	4	Present key elements of study design early in the paper	Page 4, line 99
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	Page 4, lines 99-108
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants	Page 4, lines 101-106
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	Pages 4-5, lines 109-151
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	Pages 4-5, lines 97-162
Bias	9	Describe any efforts to address potential sources of bias	Page 4, lines 107-108
Study size	10	Explain how the study size was arrived at	
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	Page 4, lines 125-132
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	Pages 5-6, lines 163-181
		(*b*) Describe any methods used to examine subgroups and interactions	N/A
		(*c*) Explain how missing data were addressed	N/A
		(*d*) If applicable, describe analytical methods taking account of sampling strategy	N/A
		(*e*) Describe any sensitivity analyses	Pages 5-6, lines 169-

			178
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	Page 7, lines 186-195
		(b) Give reasons for non-participation at each stage	N/A
		(c) Consider use of a flow diagram	N/A
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	Page 7, lines 186-153
		(b) Indicate number of participants with missing data for each variable of interest	N/A
Outcome data	15*	Report numbers of outcome events or summary measures	Pages 7-8, lines 196-230
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	Pages 7-8, lines 197-200, 205-208, 219-222
		(*b*) Report category boundaries when continuous variables were categorized	N/A
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	N/A
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	Pages 7-8, lines 201-203, 209-217, 223-227
Discussion			
Key results	18	Summarise key results with reference to study objectives	Pages 9-10, lines 231-240
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	Pages 11-12, lines 305-332
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	Pages 10-11, lines 241-304
Generalisability	21	Discuss the generalisability (external validity) of the study results	Page 12, line 332
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	Page 12, lines 347-349

*Give information separately for exposed and unexposed groups.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at

http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

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Measuring effective coverage of maternal and child health services in Cambodia: a retrospective analysis of Demographic and Health Surveys from 2005 to 2014

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Abstract

Objective To investigate effective, quality-adjusted, coverage and inequality of maternal and child health (MCH) services to assess progress in improving quality of care in Cambodia.

Design A retrospective secondary analysis using the three most recent (2005, 2010, 2014) Demographic and Health Surveys.

Setting Cambodia.

Participants 53155 women aged 15-49 years old and 23242 children under 5 years old across the three surveys.

Outcome measures We estimated crude coverage, effective coverage, and inequality in effective coverage for five MCH services over time: antenatal care (ANC), facility delivery, and sick childcare for diarrhea, pneumonia, and fever. Quality was defined by the proportion of care seekers who received a set of interventions during health care visits. Effective coverage was estimated by combining crude coverage and quality. We used equiplots and risk ratios, to assess patterns in inequality in MCH effective coverage across wealth quintile, urban-rural, and women's education levels and over time.

Results In 2014, crude and effective coverage were 80.1% and 56.4%, respectively for maternal health services (ANC and facility delivery) and 59.1% and 26.9%, respectively for sick childcare (diarrhea, pneumonia, and fever). Between 2005 and 2014, effective coverage improved for all services, but improvements were larger for maternal health care than for sick child care. In 2014, poorer children were more likely to receive ORS for diarrhea than children from richer households. Meanwhile, women from urban areas were more likely to receive a postnatal check before getting discharged.

Conclusions Effective coverage has generally improved in Cambodia but efforts remain to improve quality for all MCH services. Our results point to substantial gaps in curative sick child care, a large share of which is provided by unregulated private providers in Cambodia. Policymakers should focus on improving effective coverage, and not only crude coverage, to achieve the health-related Sustainable Development Goals by 2030.

Strengths and limitations of this study

- This study included nationally representative population data to estimate effective, quality-adjusted, coverage and inequality of maternal and child health services.
- This study used three waves (2005, 2010, and 2014) of surveys to observe the temporal changes in coverage, quality, and inequality.
- The study is limited by the type of measures included in the Demographic and Health Surveys to assess quality.

Introduction

The sustainable Development Goal (SDG) 3 aims to achieve universal health coverage (UHC), by ensuring access to quality essential health services by 2030.(1) Despite substantial improvement in access to healthcare services, quality of care remains poor and variable across low- and middle-income countries (LMICs).(2–5) The Lancet Global Health Commission on High Quality Health Systems in the SDG era (i.e., the HQSS Commission) estimated that high quality health systems could save one million newborn deaths annually.(4) Vulnerable groups, including the poor and the less educated, tend to receive worst quality of care.(5–7) Thus, quality improvement needs to be a central pillar of UHC.

An increasing body of evidence recommends a shift from tracking 'crude' or 'contact' coverage to 'effective' coverage,(5–9) defined as the proportion of a population in need of a service that resulted in a positive health outcome from the service.(10) Recent literature have shown a gap between crude and effective coverage ranged from 40% to 60% in LMICs.(7,11,12) This indicates that many patients who come in contact with the health system are not treated according to standards of care.

Cambodia is a lower-middle income country located in Southeast Asia with a population of 16.72 million people.(13) Since the late 1990's, the country has experienced consistent economic growth and a reduction in poverty rates.(14) In the past decades, the Cambodian government has focused on increasing utilization of maternal and child health (MCH) services. From 2000 to 2014, Cambodia reduced its under-5 mortality rate from 124 to 35 per 1,000 live births and the maternal morality ratio from 437 to 170 per 100,000 live births.(15) Increased in facility deliveries and child vaccination programs have substantially reduced these maternal and child deaths during the Millennium Development Goals (MDGs) era.(16,17)

However, in order to achieve the health-related SDGs by 2030, maternal mortality must be reduced by an additional 60% and under-five mortality by an additional 30%. Using Global Burden of Disease data in 2016, Kruk et al found that deaths due to poor quality care were twice as high as deaths due to non-utilization of healthcare services in Cambodia.(18) Moreover, inequality in accessing maternal and child care services across geographic locations, urban-rural residents, and wealth quintile was observed in Cambodia.(19,20) To avert these additional maternal and child deaths, a high-quality equitable healthcare services is needed. The first step is to monitor progress during the MDG era.

To our knowledge, no study has assessed the effective, quality-adjusted, coverage of MCH services in Cambodia. Past research has mostly focused on the utilization of MCH services.(21–23) Thus, this study estimates the effective coverage of five MCH services and inequality in effective coverage using data from 2005 to 2014.

Methods

Data sources

This is a secondary statistical analysis using data from the Cambodia Demographic and Health Surveys (CDHS) to examine changes in crude coverage, effective coverage, and inequality in effective coverage of maternal and child health services over time. The three most recent waves – 2005, 2010, 2014 - of the CDHS were included. The CDHS is a nationally representative, population-based, cross-sectional survey carried out every 4 to 5 years.(15) Our population of interest (N) included all women of reproductive age (15-49 years old) who had at least one live birth in the past five years preceding each survey wave for maternal care, and all children under five years old living in residential households for sick childcare visits. The CDHS collects data on a wide range of health services including across the MCH continuum of care. Sampling strategies and methodology have been described elsewhere.(24)

Measures

Crude coverage

Crude coverage was calculated by the proportion of women or children who needed health care (due to true or perceived needs) and who sought care at health facilities. We estimated crude coverage for five MCH services: antenatal care (ANC), delivery, and care for diarrhea, pneumonia, and fever. Antenatal care was defined as the proportion of women with at least one live birth in the five years preceding the survey who reported at least four ANC visits for their most recent birth. Delivery care was defined as the proportion of women who gave birth in the five years preceding the survey and who delivered at a health facility including all public and private facilities (excluding those who gave birth at home and undefined locations).

Care for diarrhea, pneumonia, and fever were defined, respectively, as the proportion of children who had diarrhea, symptoms of pneumonia (a cough accompanied by short, rapid breathing and difficulty breathing as a result of a problem in the chest), or fever, in the two weeks preceding the survey for whom advice or treatment was sought from a health facility including all public and private facilities except pharmacies and traditional healers.

Effective coverage

Based on the calculation used by Arsenault et al(7) and Hategeka et al(6), we estimated effective coverage as:

$$EC = Q*U/N$$

Where EC is effective coverage, Q is quality of MCH services, U is utilization of MCH services, and N is need for MCH services. Since the CDHS had only a few indicators to estimate the quality of services, the effective coverage estimates reported in this study should be considered an upper limit of the quality of MCH services.

Quality of care was defined based on four reports: the HQSS Commission's framework(4), the WHO recommendations on antenatal care for a positive pregnancy experience(25), the National Strategy for Reproductive and Sexual Health of Cambodia 2017-2020(26), and the WHO standards for improving the quality of care for children and young adolescents in health facilities.(27)

Quality-adjusted ANC was estimated by the proportion of women who received at least four ANC visits and reported receiving five basic services at any point during ANC: their blood pressure was measured, a urine and a blood sample were collected, they were given or bought iron tablets or syrup, and they were counseled on potential complications to look out for during pregnancy. Quality-adjusted delivery care was defined as the proportion of women who delivered at a health facility and who reported that someone examined them or asked questions about their health before being discharged. Quality-adjusted care for diarrhea was defined as the proportion of children who sought care at a health facility for diarrhea and who received oral rehydration therapy (ORT) from a special packet, pre-packaged or from a homemade fluid. Quality-adjusted care for pneumonia was defined as the proportion of children who visited a health facility for suspected pneumonia and who received antibiotics (pills, syrup or injection). Quality-adjusted care for fever was defined as children who sought care at a health facility and received a blood test for suspected malaria. Detailed indicator definitions are shown in **supplemental table 1**.

Inequality in effective coverage of MCH services

Inequalities in effective coverage of five MCH services was assessed using three measures of socioeconomic position: household wealth quintile, area of residence (urban vs. rural) and the woman's education level as provided by the CDHS.(15) The wealth index, provided by the CDHS, is calculated based on a household's ownership of selected assets, such as televisions and bicycles; housing construction materials; and types of water access and sanitation facilities.(28) The wealth index is divided into five quintiles (lowest – Q1, second – Q2, middle – Q3, fourth - Q4, and highest – Q5) based on a continuous scale of relative wealth in the country.(28) Details on the calculation of the wealth index can be found elsewhere.(29) The women's education was combined into three levels (no education, primary school only, and secondary or higher education).

Statistical analysis

We first used descriptive statistics to estimate crude coverage and effective coverage for the five MCH services in 2005, 2010 and 2014. Data for child pneumonia care was not available in 2005. Line graphs were used to present the trends in national averages over time for each health service. Second, we assessed inequalities in effective coverage visually using equiplots across wealth quintiles, maternal education, and area of residence (urban vs rural). Finally, we used risk ratios (RR), to compare effective coverage in 2014 between the top and bottom categories of each measure of socioeconomic position (wealth quintiles, education, and urban residence). We used logistic regressions to model the log odds of effective coverage and transformed the coefficients into marginal predicted risks using postestimation commands to calculate the risk

ratio. We used the *logistic, margins,* and *nlcom* commands in STATA version 16.0.(30) Statistical code for RR calculation is publicly available on a GitHub repository: https://github.com/mkkim1/RiskRatio_Cambodia.git.

Two additional sub-analyses were conducted. First, we estimated the crude and effective coverage in 2000 to observe the trend in the last two decades. However, due to the age of the data, we excluded the 2000 data from the main analysis (**supplemental table 2**). Indicators to estimate effective coverage for facility delivery and sick childcare for fever were not available in 2000. Second, we used postpartum checkup after discharge to estimate effective coverage for childbirth and compare with the results from the main analysis (**supplemental table 3 and supplemental figure 1**).

All analyses, including logistic regressions, were adjusted for the survey design (clustering, stratification, and survey weights) except the equiplots due to a limitation of the statistical software package. Stata SE Version 16.0 was used for all analyses.

Patient and public involvement

Patients and/or the public were not involved in the design, or conduct, or reporting, or dissemination plans of this research.

Results

Description of the study population

A total of 53,155 women of reproductive age (15-49 years old) were included across the three survey waves. The proportion of women who gave birth within the 5 years preceding the survey slightly decreased from 34.9% in 2005 to 34.0% in 2014. Most women lived in rural areas and completed primary education (**table 1**). In total, 23,242 children under 5 years were included. Fever was the most prevalent child illness, with 27.1% of children suffering from fever in the two weeks prior to the survey in 2014 (**table 1**). High prevalence of fever could be explained by the high burden of malaria along the national borders including in the western provinces of Battambang and Pailin.

Overall crude and effective coverage

In 2014, average crude and effective coverage were 80.1% and 56.4%, respectively, for maternal health care (ANC and delivery), and 59.1% and 29.6% for sick child care (care for child diarrhea, pneumonia, and fever) (**table 1**). For maternal health, effective coverage increased by 21.0% and 22.8% from 2005 to 2010 and 2010 to 2014, respectively (**table 1**). For sick childcare, effective coverage increased by 13.4% and 4.5% from 2005 to 2010 and 2010 to 2014, respectively (**table 1**). Estimates for crude and effective coverage for each indicator can be found in **supplemental table 2**. Delivery had the highest effective coverage at 80.1% in 2014 (**supplemental table 2**). Meanwhile, effective coverage for fever had the lowest effective coverage at 2.3% in 2005 (**supplemental table 2**).

Maternal health care

Figure 1 shows a continuous increase in crude and effective coverage for ANC and facility delivery from 2005 to 2014. In 2014, 80.1% of women who delivered at a facility had a postnatal check before being discharged and around half of women who had four ANC visits received the five basic services during their pregnancy. Effective coverage in maternal health care services improved even among the poorest. For example, in 2005 only 4.7% of women in the lowest wealth quintile received a postnatal check; while this increased to 60.9% in 2014 (**figure 2**). The proportion of women from rural areas who received the five basic services during ANC increased by 13-folds from 2005 to 2014, from 2.2% to 29.6% (**figure 2**). Inequalities also appeared to be reduced according to the equiplots. However, socioeconomic inequalities in effective coverage remained in 2014. Women in the richest wealth quintile in Cambodia were 1.7 times more likely to receive all five services during ANC visits (RR = 1.7, 95% CI = 1.5, 2.0) compared to the poorest and they were 1.4 times more likely to receive a postnatal check before discharge (RR = 1.4, 95% CI = 1.4, 1.5) (**table 2**).

Sick child care

Figure 3 shows the trend in crude and effective coverage for sick child care. Overall, crude and effective coverage for sick child care did not improve as much as for maternal care between 2005 and 2014. The proportion of children with diarrhea who received ORS and the proportion with

fever who received a malaria test remained almost the same between 2010 and 2014 (**figure 3**). The proportion of children who received ORS for diarrhea was higher in the poorest groups.

In 2014, children in the richest quintile were 0.6 times less likely to receive ORS when seeking care for diarrhea (RR = 0.6, 95% CI = 0.4, 0.9), compared to children from the poorest households (**figure 4 and table 2**). Similarly, children of most educated mothers were 0.5 times less likely to receive ORS for diarrhea (RR = 0.5, 95% CI = 0.3, 0.8) compared to those with no formal education (**table 2**).

Table 1 - Characteristics of the study sample in Cambodia from 2005 to 2014.

Survey, year	2005	2010	2014
	N (%)	N (%)	N (%)
Number of households	14243	15667	15825
Women (age 15-49)	16823	18754	17578
Women who gave birth within 5 years of the survey	5865 (34.9%)	6472 (34.5%)	5973 (34.0%)
Residence			
Urban	2973 (17.7%)	3936 (21.0%)	3251 (18.5%)
Rural	13851 (82.3%)	14819 (79.0%)	14328 (81.5%)
Education			
No education	3270 (19.4%)	2974 (15.9%)	2251 (12.8%)
Primary	9389 (55.8%)	9265 (49.4%)	8281 (47.1%)
Secondary and higher	4165 (24.8%)	6516 (34.7%)	7047 (40.1%)
Wealth quintile			
Lowest	3018 (17.9%)	3389 (18.1%)	3144 (17.9%)
Second	3165 (18.8%)	3517 (18.7%)	3314 (18.9%)
Middle	3246 (19.3%)	3595 (19.2%)	3381 (19.2%)
Fourth	3308 (19.7%)	3827 (20.4%)	3613 (20.6%)
Highest	4089 (24.3%)	4429 (23.6%)	4128 (23.5%)
Maternal health care			
Crude coverage of antenatal care and facility delivery (mean, range)	25.1% (23.2%-27.0%)	58.1% (56.8% – 59.4%)	80.1% (75.6% – 84.6%)
Effective coverage of antenatal care and facility delivery (mean, range)	12.6% (4.7% – 20.5%)	33.6% (16.2% – 51.1%)	56.4% (32.8% – 80.1%)
Children (age <5)	7789	8200	7253
Children who had diarrhea 2 weeks prior to the survey	1420 (18.2%)	1161 (14.2%)	902 (12.4%)
Children who had pneumonia 2 weeks prior to the survey	2224 (28.6%)	1741 (21.2%)	1531 (21.1%)
Children who had fever 2 weeks prior to the survey	2576 (33.1%)	2194 (26.8%)	1968 (27.1%)
Care for sick children			
Crude coverage of diarrhea, pneumonia, and fever (mean, range)	45.3% (41.1% – 47.8%)	69.1% (58.9% – 75.5%)	59.1% (55.5% – 61.3%)
Effective coverage of diarrhea, pneumonia, and fever (mean, range)[a]	11.7% (2.3% – 21.1%)	25.1% (10.3% – 37.3%)	29.6 % (11.5% – 51.5%)

[a]Effective coverage for pneumonia in 2005 was not included due to missing data in CDHS.

Table 2. Risk ratios in effective coverage of five maternal and child health services between richest and poorest, least and most educated and urban vs. rural residents, Cambodia Demographic and Health Survey 2014

	Wealth quintile (Q5 vs. Q1)		Urban-rural area		Women's education levels (Secondary or higher education vs. no education)	
Indicators	RR	(95% CI)	RR	(95% CI)	RR	(95% CI)
Received 5 basic services during ANC visits	1.7***	(1.5 - 2.0)	1.5***	(1.3 – 1.6)	1.9***	(1.6 – 2.2)
Postnatal check before discharge	1.4***	(1.4 - 1.5)	1.2***	(1.2 – 1.2)	1.4***	(1.3 – 1.5)
Oral solution received for diarrhea	0.6*	(0.4 – 0.9)	0.8	(0.5 – 1.2)	0.5**	(0.3 – 0.8)
Antibiotics received for pneumonia	0.9	(0.8 – 1.1)	0.8*	(0.7 – 0.9)	1.0	(0.8 – 1.2)
Blood tested for malaria	0.8	(0.5 – 1.1)	0.8	(0.6 – 1.2)	1.3	(0.8 – 2.0)

Note: P<0.001***, P<0.01**, and P<0.05*. RR = Risk Ratio, CI = Confidence Interval; The RR is the ratio in effective coverage between top and bottom sub-groups: socioeconomic status – wealthiest quintile vs poorest quintile; urban and rural areas; and secondary or higher education vs. no education. RR>1 indicates pro-rich distribution (higher effective coverage in the top group); RR<1 indicates pro-poor distribution (higher effective coverage in the lower sub-groups; RR=1 suggest an equal distribution in the effective coverage indicator.

Discussion

In this study, we estimated crude coverage, effective coverage, and inequality in effective coverage for five MCH services to assess progress in improving quality of health care in Cambodia from 2005 to 2014. We found that improvements in effective coverage were greater for maternal health services (ANC and facility delivery), than for curative services for sick children (diarrhea, pneumonia, and fever). Vulnerable women, including the poor, rural residents, and less educated, experienced a greater improvement in effective coverage for facility delivery than ANC. Inequality gaps appeared to have been reversed for diarrhea and pneumonia over time, where children from rural and poorer households received higher quality care than children from urban households.

Effective coverage in sick child care did not improve as much as for maternal health services. We also found a pro-poor distribution for sick child care – children from the poorest, less educated households and from rural areas, appeared to be more likely to receive ORS for diarrhea and antibiotics for pneumonia, than children from richer, more educated households and urban areas. This could be because poorer children were relatively sicker but may also point to differences in quality between the types of providers used. Most curative care in Cambodia is delivered by an extensive network of loosely regulated private health-care providers while the public sector is the predominant provider of preventive care and health promotion activities.(14,31) According to the 2014 CDHS, 65% of care for child diarrhea, fever or cough took place in the private sector.(15) Private providers – mostly small practices, pharmacies or single-person practitioners - are also more prevalent in urban areas.(14) The regulation of private providers in Cambodia remains a challenge where many operate without government accreditation.(14) The Cambodia National Strategic Plan 2017-2020 revealed inadequate education of health professionals as an important impediment to improving the quality of health services.(32) Since our results may point to large quality gaps in the private sector, the Cambodian government should regulate private healthcare providers for their curative clinical practice to ensure that patients receive quality care.

The increase in care seeking among poorer households could also have been influenced by the Health Equity Fund (HEF). The HEF, launched in 2000, is Cambodia's largest financial protection scheme, covering the poorest one-fifth of the national population and aims to increase access to government health facilities.(33) Since then, the utilization of maternal and child health services significantly increased among HEF-supported patients, particularly the facility deliveries.(15,34) Yet, only 1 in 2 children received proper treatments at facilities. Only half of women received all five basic health services during their ANC visits.

From 2005 to 2014, the proportion of women who delivered at health facilities quadrupled. During the MDG era, several programs have focused on improving maternal and newborn health including those led by the national government and international aid agencies, including the Korea Foundation for International Healthcare (KOFIH). Since 2013, KOFIH has implemented

an integrated MCH program to improve the quality of maternal and child healthcare services in the Battambang province by training healthcare workers - upgrading the skills of new midwives and training on partograph.(35) The Government Midwifery Incentive Scheme started in 2006 aimed to increase the facility deliveries by paying midwives and other trained health personnel with cash incentives based on the number of live births they attend in public health facilities.(36) These programs may have been effective in improving both the utilization and quality of delivery care. According to the 2014 CDHS report, 69% of deliveries took place in the public sector and 85.8% of births were attended by a midwife or a doctor.(15) Nonetheless, we found a large gap in postpartum care before and after discharge which highlights missed opportunities for high-quality delivery care (**supplemental table 3 and supplemental figure 1**). A meta-analysis found that receiving antenatal to postnatal care could reduce the risk of combined neonatal, perinatal, and maternal mortality by 15%.(37) The National Strategy for Reproductive and Sexual Health in 2017-2020 recommends four postnatal checks, one before and three after discharge.(26) Despite these recommendations, mothers rarely return to the facilities after they get discharged. Inadequate transportation and long distances to health facilities might discourage women to return to the facilities after getting discharged. More outreach efforts like home visits, promotion of postnatal care during the antenatal period and at delivery are needed to ensure a continuum of delivery care for both mothers and newborns.

We found the largest difference (65.1%) between crude and effective coverage for children with fever in 2010. Effective coverage (blood test for suspected malaria) only improved by 1.1% from 2010 to 2014. This small increase in coverage might have resulted in a dramatic reduction in malaria related deaths in Cambodia. In 2018, no malaria related deaths was reported for the first time in the country's history.(38) The percentage of malaria cases significantly fell from 61% in 2015 to 27% in 2018.(38) This promising improvement could have reduced the number of blood tests for suspected malaria cases.

Effective coverage lags behind crude coverage in Cambodia, indicating a need for improving the quality of MCH care. Similar or even lower levels of effective coverage have been found in other countries. Across 91 LMICs, effective coverage for ANC ranged from 53.8% on average in low-income countries, to 93.3% in upper-middle-income countries.(7) In Rwanda, only 40.2% of women who gave birth in a facility in 2015 received a check-up before discharge while this estimate was almost the double (80.1%) in Cambodia.(6) Quality-adjusted coverage for ANC (women who had at least 4 ANC visits and received at least 11 quality focuses intervention items) was about a half in Myanmar (14.6%) compared to Cambodia (32.8%).(39) In Haiti, an average effective coverage for curative sick childcare, including taking history, testing, and managing care, was 11.8% in 2013 while this estimate was almost tripled (29.7%) in Cambodia.(11) Leslie et al found that effective coverage, providers' adherence to evidence-based care guidelines, for sick childcare was 37% in 8 LMICs between 2007 and 2015.(40) About 3 in 10 children received ORS in Vietnam (30.0%) and Cambodia (26.0%) in 2014.(41)

This study includes several limitations. First, the quality measures are not inclusive as they included only a limited number of recommended items that should be completed during MCH services. For instance, effective coverage for childbirth included only one item: checkup before

discharge. Many other components of care are required for high-quality delivery care included a positive user experience (respectful, patient-centered delivery care) and high-quality intrapartum technical care. In addition, quality for sick child care was measured by whether the child received an appropriate treatment (ORS for diarrhea, antibiotics for suspected pneumonia, and blood test for suspected malaria) but the survey did not ask whether the healthcare providers explained the proper treatment instructions to the caregivers or conveyed their diagnosis. Given these limited measures, our quality estimates should be regarded as an upper bound of quality, a starting point for estimating quality-adjusted coverage rather than a definite estimate. Thus, better quality measures - user experience, competent care, and timeliness of care - are needed. More studies need to go beyond utilization of care and investigate health system quality.

Second, although we included the most recent CDHS surveys, our latest data points are from 2014. The CDHS announced an upcoming 2020-21 survey.(42) The Global Financing Facility estimated that service disruptions during the COVID-19 pandemic could have the potential to leave 313,900 children without oral antibiotics for pneumonia and 77,600 women without access to facility deliveries.(43) In Laos, antenatal care and postnatal care declined by an estimated 10% and 9%, respectively, immediately after the declaration of the pandemic.(44) Future studies should estimate the effect of the COVID-19 pandemic on effective coverage in Cambodia.

Third, DHS data is self-reported by caregivers which is subject to recall bias. Women tend to report less accurately about care related to more complex diseases such as pneumonia (45) but they report better for more invasive procedures such as a blood test. (46) To address reporting biases, other studies on quality of care have linked household surveys with facility assessments.(47) In 2008, Cambodia implemented the Service Availability and Readiness Assessment (SARA), a national health facility assessment.(48) Future studies should try to link different types of surveys to provide a more comprehensive picture of health system quality in Cambodia. Fourth, the findings are applicable only to the study country.

Conclusion

Despite the substantial improvement in maternal and child outcomes in the past decades in Cambodia, efforts are needed to improve quality of care. As Cambodia strives to meet the health-related SDGs by 2030, focusing on effective coverage will be important more than ever to address the residual maternal and child mortality. Additionally, inequalities across socioeconomic status need to be addressed to achieve equitable quality healthcare. Our study recommends policies to improve regulation and quality improvement efforts among the private sector where curative services for sick childcare are often provided. To our knowledge, this is the first study providing sound evidence of the quality of care in Cambodia over time. Health system strengthening efforts need to go beyond just improving the utilization of care and start focusing on the content of care and patients' experience. The COVID-19 pandemic has shown the need for resilient, high-quality health systems more than ever. Thus, Cambodia needs to seize this moment to shift its attention and funding towards building a high-quality health system.

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Competing interests

The authors declare that they have no competing interests.

Contributions

MKK, SEK, CA were involved in the conceptualization and interpretation of findings and helped draft the manuscript. MKK and SAK conducted data analysis. JHW and CEK helped draft the manuscript.

Patient consent for publication

Not required

Ethics approval

Since this study uses publicly available data, an ethical approval was not needed. The original survey implemented obtained ethical approvals for data collection; the Demographic and Health Surveys Program (https://dhsprogram.com/data/available-datasets.cfm) approved our data access request to conduct the study.

Data sharing statement

Data are available upon reasonable request. The data on the selected maternal and child health indicators were taken from the women's and children's questionnaire of the DHS surveys, and the data set is available on request after registering as a user (https://dhsprogram.com/Data/).

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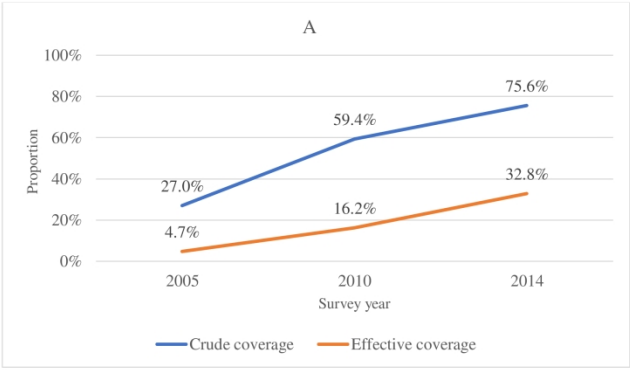
Figure Legend:

Figure 1 – Line graphs

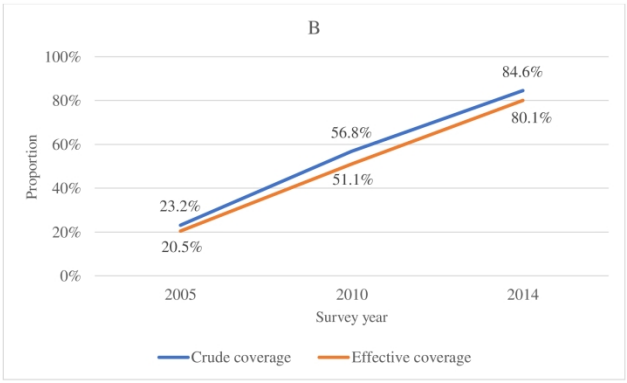
Figure 2 – Equiplots

Figure 3 – Line graphs

Figure 4 – Equiplots



A. Antenatal care (at least four visits)



B. Facility delivery

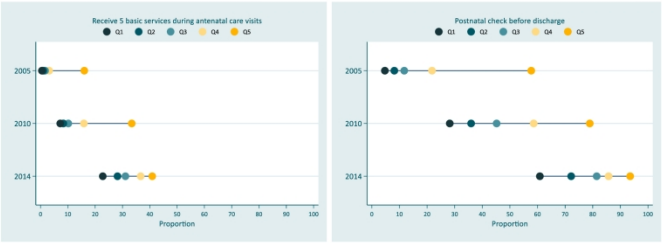
Figure 1. Crude and effective coverage of maternal health care in Cambodia from 2005 to 2014. (A) at least 4 antenatal care (ANC) visits; (B) facility delivery.

Footnote: Effective coverage for antenatal care was estimated by the proportion of women who received at least four ANC visits and reported receiving five basic services at any point during ANC: their blood pressure was measured, a urine and a blood sample was collected, they were give or bough iron tablets or syrup, and they were counseled on potential complications to look out for during pregnancy. Effective coverage for facility delivery was defined as the proportion of women who delivered at a health facility and who reported that someone examined them or asked questions about their health before being discharged.

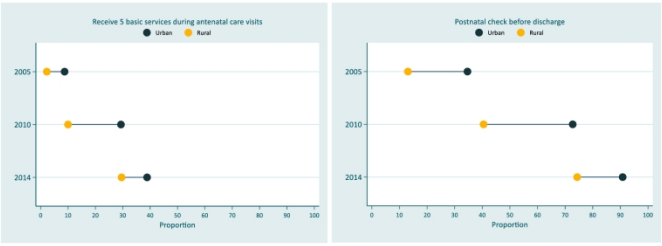
1

Figure 1 - Line graphs

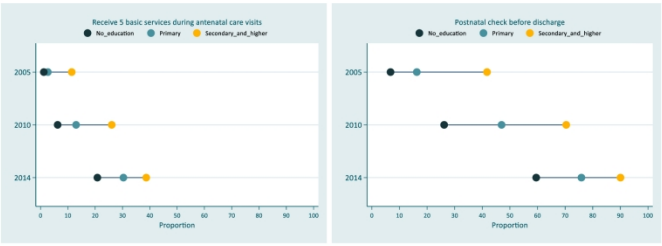
215x279mm (300 x 300 DPI)



A. Wealth quintile



B. Area of residence (urban vs rural)



C. Women's education (no education, primary, and secondary and higher)

Figure 2. Equity in effective coverage of maternal health in Cambodia from 2005 to 2014 across 1) wealth quintile 2) area of residence (urban vs rural) 3) women's education (no education, primary, and secondary and higher)

1

Figure 2 - Equiplots

215x279mm (300 x 300 DPI)

Figure 3. Crude and effective coverage of care for child health in Cambodia from 2005 to 2014. (A) diarrhea; (B) pneumonia; (C) fever.

Footnote: Data for effective coverage of pneumonia in 2005 were missing. Effective coverage for diarrhea was defined as the proportion of children who sought care at a health facility for diarrhea and who received oral rehydration therapy (ORT) from a special packet, pre-packaged or from a homemade fluid. Effective coverage for pneumonia was defined as the proportion of children who visited a health facility for pneumonia and who received antibiotics (pills, syrup, or injection). Effective coverage for fever was defined as children who sought care at a health facility and received a blood test for suspected malaria.

1

Figure 3 - Line graphs

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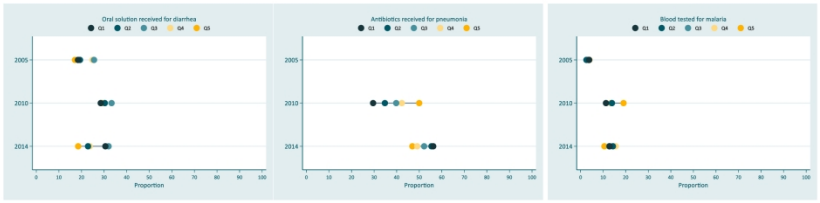
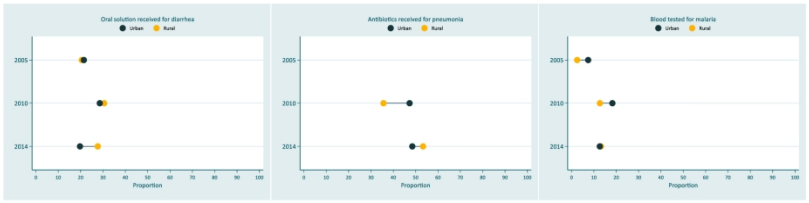
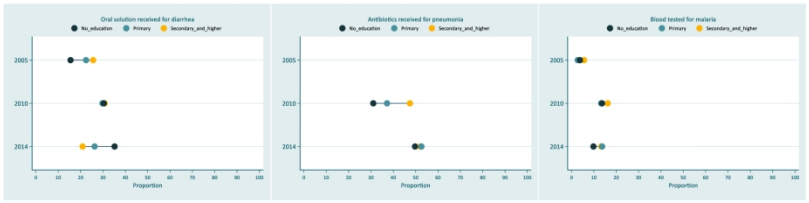


A. Wealth quintile



B. Area of residence (urban vs rural)



C. Women's education (no education, primary, and secondary and higher)

Figure 4. Equity in effective coverage of child health in Cambodia from 2005 to 2014 across 1) wealth quintile 2) area of residence (urban vs rural) 3) women's education (no education, primary, and secondary and higher).

Footnote: Data for effective coverage of pneumonia in 2005 were missing.

1

Figure 4 - Equiplots

215x279mm (300 x 300 DPI)

Supplementary file – second round

Measuring effective coverage of maternal and child health services in Cambodia: a retrospective analysis of Demographic and Health Surveys from 2005 to 2014

Min Kyung Kim, Soon Ae Kim, Ju Hwan Oh, Chae Eun Kim, Catherine Arsenault

Supplemental table 1. Indicator definitions and measurement strategy for crude coverage, effective coverage, and inequality, Cambodia Demographic Health Surveys

Indicators	Type	Measurement	DHS measurement
OUTCOME VARIABLES			
1. Antenatal care (ANC)			
Crude coverage: Women with a recent live birth within 5-years prior to each survey wave and received at least 4 times ANC services from skilled providers	Binary	0. No, < 4 visit(s) 1. Yes, ≥ 4 visits	Q412: How many times did you receive antenatal care during this pregnancy?
Effective coverage: Women with a recent live birth within 5-years prior to each survey wave and received at least 4 times ANC services and 5 key components of ANC from a health provider, which include: 1) blood pressure monitoring, 2) iron supplementation, 3) counsel about pregnancy complications, 4) urine testing, and 5) blood testing	Binary	0. No 1. Yes, received all the four services	Q413: As part of your antenatal care during this pregnancy, were any of the following done at least once? a) Was your blood pressure measured? b) Did you give a blood sample? c) Did you give a urine sample? q421: During this pregnancy, were you given or did you buy any iron tablets or iron syrup? Q414: During (any of) your antenatal care visit(s), were you told about things to look out for that might suggest problems with the pregnancy?

Indicators	Type	Measurement	DHS measurement
2. Facility delivery			
Crude coverage: Women with a recent live birth within 5-years prior to each survey wave and delivered their last baby at the health facilities	Binary	0. No 1. Yes, delivered at the facilities (excluding home and unspecified locations) Skilled birth attendant includes general practitioner, obstetrician, nurse, midwife and village midwife	Q434: Where did you give birth to (NAME)?
Effective coverage: Women with a recent live birth within 5-years prior to each survey wave received postnatal care for their newborn before getting discharged	Binary	0. No 1. Yes	Q436: After you gave birth to (NAME), did anyone check on your baby health while you were still in the facility?
3. Sick child - diarrhea			
Crude coverage: All children under 5 years reported to have had symptoms in the 2 weeks before the survey and seek treatment from health facility	Binary	0. No 1. Yes, from health facility (excluding pharmacies)	Q611: Did you seek advice or treatment for the diarrhea from any source? Q612: Where did you seek advice or treatment?
Effective coverage: All children under 5 years reported to have had symptoms in the 2 weeks before the survey and seek treatment and received oral rehydration therapy (ORT)/increased fluids from health facility or provider	Binary	0. No 1. Yes, received ORS / a pre-packaged / ORS/homemade fluid	Q615: Was (NAME) given any of the following at any time since (NAME) started having the diarrhea: a) A fluid made from a special packet called [LOCAL NAME FOR ORS PACKET]? b) A pre-packaged ORS liquid? c) A government-recommended homemade fluid?
4. Sick child – pneumonia			
Crude coverage: All children under-5 years reported to have had symptoms in the 2 weeks before the survey and	Binary	0. No 1. Yes, from facility (excluding pharmacies)	Q620. Where did you seek advice or treatment for pneumonia? Q625. Where did you seek advice or treatment?

Indicators	Type	Measurement	DHS measurement
were taken to a medical facility for treatment			
Effective coverage: All children under-5 years reported to have had symptoms in the 2 weeks before the survey and received antibiotic pills, syrup, or injections	Binary	0. No 1. Yes, antibiotic drugs / PILL/SYRUP (J) INJECTION/IV (K)	Q630. What drugs did (NAME) take?
5. Sick child – fever			
Crude coverage: All children under 5-years reported to have had symptoms in the 2 weeks before the survey and were taken to a medical facility for treatment	Binary	0. No 1. Yes, from facility (excluding pharmacies)	Q618. Has (NAME) been ill with a fever at any time in the last 2 weeks? Q625. Where did you seek advice or treatment?
Effective coverage: All children under 5-years reported to have had symptoms in the 2 weeks and had blood taken from finger or heel for testing	Binary	0. No 1. Yes	[no question available in the DHS survey but the data are available]
MEASURES OF SOCIOECONOMIC POSITION			
Wealth index	Categorical ordinal	0. Poorest / least wealthy 1. Poor 2. Middle 3. Rich 4. Richest / wealthiest	The wealth index is a composite measure of a household's cumulative living standard. The wealth index is calculated using easy-to-collect data on a household's ownership of selected assets, such as televisions and bicycles; materials used for housing construction; and types of water access and sanitation facilities. The wealth index is presented in the DHS Final Reports and survey datasets as a background characteristic.
Education	Categorical ordinal	0. Primary/lower 1. Secondary 2. Tertiary/higher	Q107: Have you ever attended school? Q108: What is the highest level of school you attended: primary, junior high, senior high, academy or university?

Indicators	Type	Measurement	DHS measurement
			Q109: What is the highest (grade/year) you completed at that level?
Residency	Binary	0. Rural 1. Urban	Q5: Urban/rural (identified by interviewers)

Supplemental table 2. Crude and effective coverage of maternal and child health in Cambodia from 2000 to 2014.

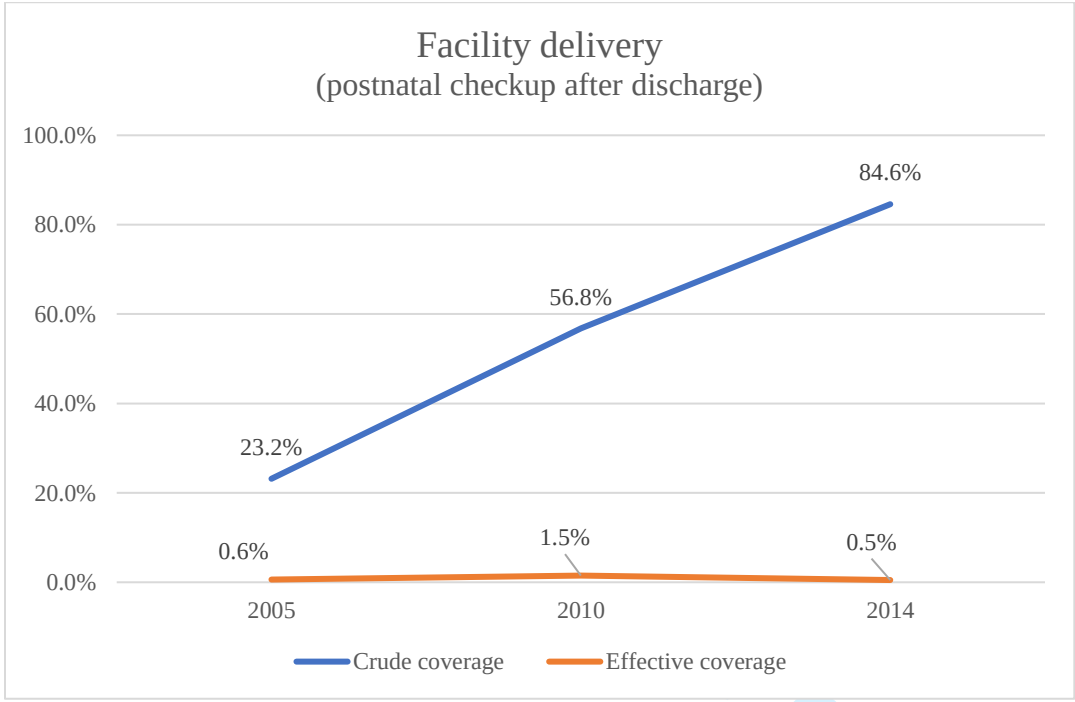
Survey, year	2000		2005		2010		2014	
	Mean	(95% CI)	Mean	(95% CI)	Mean	(95% CI)	Mean	(95% CI)
Antenatal care								
Crude coverage	8.9%	(7.8 - 10.3)	27.0%	(24.7 - 29.5)	59.4%	(57.0 - 61.7)	75.6%	(73.6 - 77.5)
Effective coverage	1.3%	(1.0 - 1.9)	4.7%	(3.7 - 6.0)	16.2%	(14.8 - 17.7)	32.8%	(30.8 - 34.9)
Facility delivery								
Crude coverage	11.0%	(9.3 - 13.8)	23.2%	(20.5 - 26.1)	56.8%	(54.1 - 59.4)	84.6%	(82.4 - 86.5)
Effective coverage	--	--	20.5%	(18.0 - 23.2)	51.1%	(48.53 - 53.7)	80.1%	(77.9 - 82.2)
Diarrhea								
Crude coverage	21.6%	(18.8 - 24.8)	41.1%	(37.5 - 44.8)	58.9%	(55.2 - 62.6)	55.5%	(50.9 - 60.0)
Effective coverage	7.8%	(6.8 - 9.7)	21.1%	(18.3 - 24.1)	27.7%	(24.3 - 31.3)	26.0%	(21.8 - 30.6)
Pneumonia								
Crude coverage	35.1%	(32.2 - 38.1)	46.9%	(43.7 - 50.2)	72.9%	(69.7 - 75.9)	61.3%	(57.4 - 65.0)
Effective coverage	30.4%	(27.7 - 33.2)	--	--	37.3%	(34.0 - 40.8)	51.5%	(47.5 - 55.5)
Fever								
Crude coverage	34.1%	(31.4 - 36.9)	47.8%	(44.6 - 51.1)	75.5%	(72.6 - 78.1)	60.6%	(57.3 - 63.8)
Effective coverage	--	--	2.3%	(1.7 - 3.1)	10.3%	(8.7 - 12.2)	11.5%	(9.5 - 13.9)

Note: -- Data are not available; effective coverage for facility delivery in 2000 and sick childcare for fever in 2000 and sick childcare for pneumonia in 2005.

Supplemental table 3. Crude and effective coverage of facility delivery (postnatal checkup after discharge) in Cambodia from 2005 to 2014

Survey, year	**2005**		**2010**		**2014**	
	Mean	(95% CI)	Mean	(95% CI)	Mean	(95% CI)
Facility delivery						
Crude coverage	23.2%	(20.5 - 26.1)	56.8%	(54.1 - 59.4)	84.6%	(82.4 - 86.5)
Effective coverage	0.6%	(0.4 - 0.9)	1.5%	(1.1 - 2.0)	0.5%	(0.3 - 0.8)

Note: Postnatal checkup after discharge is a question asked whether the mother was checked after getting discharge from the health facilities.



Supplemental figure 1. Crude and effective coverage of facility delivery (postnatal checkup after discharge) in Cambodia from 2005 to 2014.

Note: Effective coverage for facility delivery was defined as the proportion of women who delivered at a health facility and who reported that someone examined them or asked questions about their health after being discharged.

Measuring effective coverage of maternal and child health services in Cambodia: a retrospective analysis of Demographic Health Surveys from 2005 to 2014

Min Kyung Kim, Soon Ae Kim, Juhwan Oh, Chae Eun Kim, Catherine Arsenault

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STROBE Statement—Checklist of items that should be included in reports of *cross-sectional studies*

	Item No	Recommendation	Page/line numbers where relevant information can be found
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	Page 2, lines 30
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	Page 2, lines 42-48
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	Page 3, lines 62-92
Objectives	3	State specific objectives, including any prespecified hypotheses	Page 3, lines 93-96
Methods			
Study design	4	Present key elements of study design early in the paper	Page 4, line 99
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	Page 4, lines 99-108
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants	Page 4, lines 101-106
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	Pages 4-5, lines 109-151
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	Pages 4-5, lines 97-162
Bias	9	Describe any efforts to address potential sources of bias	Page 4, lines 107-108
Study size	10	Explain how the study size was arrived at	
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	Page 4, lines 125-132
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	Pages 5-6, lines 163-181
		(*b*) Describe any methods used to examine subgroups and interactions	N/A
		(*c*) Explain how missing data were addressed	N/A
		(*d*) If applicable, describe analytical methods taking account of sampling strategy	N/A
		(*e*) Describe any sensitivity analyses	Pages 5-6, lines 169-

			178
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	Page 7, lines 186-195
		(b) Give reasons for non-participation at each stage	N/A
		(c) Consider use of a flow diagram	N/A
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	Page 7, lines 186-153
		(b) Indicate number of participants with missing data for each variable of interest	N/A
Outcome data	15*	Report numbers of outcome events or summary measures	Pages 7-8, lines 196-230
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	Pages 7-8, lines 197-200, 205-208, 219-222
		(*b*) Report category boundaries when continuous variables were categorized	N/A
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	N/A
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	Pages 7-8, lines 201-203, 209-217, 223-227
Discussion			
Key results	18	Summarise key results with reference to study objectives	Pages 9-10, lines 231-240
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	Pages 11-12, lines 305-332
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	Pages 10-11, lines 241-304
Generalisability	21	Discuss the generalisability (external validity) of the study results	Page 12, line 332
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	Page 12, lines 347-349

*Give information separately for exposed and unexposed groups.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at

http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.