

Assessing quality of childbirth care provided by skilled health personnel in Exemplar countries

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Supplementary Table 1: Data sources for 39 included indicators by country

Construct	Indicator Full Name	Indicator Short Name	Indicator Type	Country	Data Source	Source Year
Education	Scores from the assessment of pre-service training curricula against ICM criteria	preservice_score_pct	Proportional	Nepal	Assessment conducted by study team members	2023
				Senegal	Assessment conducted by study team members	2023
				Zambia	Assessment conducted by study team members	2023
Education	Proportion of pre-service training curricula that last at least 3 years	preservice_3yrs_pct	Proportional	Nepal	Assessment conducted by study team members	2023
				Senegal	Assessment conducted by study team members	2023
				Zambia	Assessment conducted by study team members	2023
Continuing Professional Development	Presence of a compulsory continued professional development program or system for SHP for childbirth care	compulsory_continued_education	Binary	Nepal	Key informant interviews (KIIs) conducted by study team members - Credit points system for continuing professional development [CPD] (both <u>NMC</u> and <u>NNC</u>)	2020
				Senegal	KIIs conducted by study team members	2023
				Zambia	KIIs conducted by study team members	2023
Continuing Professional Development	Proportion of SHP for childbirth care who received in-service training related to intrapartum care from MOH in the last 5 years	in_service_training_pct	Proportional	Nepal	Service Provision Assessments (SPA)	2021
				Senegal	SPA	2019
				Zambia	(Not provided)	-
Regulation	Presence of a national education regulation system for SHP for childbirth care	education_system	Binary	Nepal	KIIs conducted by study team members	2023
				Senegal	Desk review conducted by study team members	2023
				Zambia	Desk review conducted by study team members	2023

Construct	Indicator Full Name	Indicator Short Name	Indicator Type	Country	Data Source	Source Year
Regulation	Presence of a formal process for licensing, relicensing, and registration for SHP for childbirth care	licensing_process	Binary	Nepal	KIIs conducted by study team members	2023
				Senegal	Desk review conducted by study team members	2023
				Zambia	Desk review conducted by study team members	2023
Service Delivery	Proportion of childbirth care services provided free of charge in public health facilities as part of universal health coverage	ipc_free_pct	Proportional (mixed format)	Nepal	1. 2020 NHSSP III. Review of the Aama program and Free Delivery Incentive in Nepal 2. 2019 FWD NHSSP.Rapid Assessment of Aama 3. Service Tracking Survey 2013 4. SMNH-ROAD MAP 2030-SGOP, pg219	Various
				Senegal	Reproductive Health Standards and Procedures Policy Document	2018
				Zambia	Desk review conducted by study team members	2023
Service Delivery	Proportion of staff trained in birth delivery services	staff_trained_pct	Proportional (mixed format)	Nepal	SPA	2021
				Senegal	SPA	2019
				Zambia	Harmonised Health Facility Assessment (HHFA)	2022
Service Delivery	Proportion of facilities offering normal delivery services	delivery_facilities_pct	Proportional	Nepal	SPA	2021
				Senegal	SPA	2019
				Zambia	Harmonised Health Facility Assessment (HHFA)	2022
Service Delivery	Proportion of facilities offering Cesarean section services	csection_facilities_pct	Proportional	Nepal	SPA	2021
				Senegal	SPA	2019
				Zambia	Harmonised Health Facility Assessment (HHFA)	2022

Construct	Indicator Full Name	Indicator Short Name	Indicator Type	Country	Data Source	Source Year
Service Delivery	Proportion of facilities having a referral system with access to transportation	referral_system_pct	Proportional (mixed format)	Nepal	NHSSP	2022
				Senegal	KIIs conducted by study team members	2023
				Zambia	KIIs conducted by study team members	2023
Service Delivery	Proportion of facilities offering normal delivery that have intrapartum care guidelines available	guidelines_facilities_pct	Proportional	Nepal	SPA	2021
				Senegal	SPA	2019
				Zambia	Harmonised Health Facility Assessment (HHFA)	2022
Health Workforce	Percent achievement of WHO target for nurse/midwife density	nurse_midwife_density_pct	Proportional	Nepal	Desk review conducted by study team members	2023
				Senegal	MoH/ Human Resources Directorate/Human Resources Statistical Directory	2022
				Zambia	Desk review conducted by study team members	2023
Medical Products, Vaccines, and Technologies	Proportion of facilities with: 1. An emergency transport system or ambulance services in place 2. Electricity available 24/7 3. Running water and soap 4. Communication equipment (landline/mobile phone) 5. Computer with Internet access 6. Personal protective equipment (PPE) available 7. Partographs available 8. Sterile delivery pack available 9. Essential drugs in stock: oxytocin 10. Essential drugs in stock: magnesium sulphate 11. Essential drugs in stock: misoprostol	1. transport_pct 2. electricity_pct 3. soap_water_pct 4. comms_equipment_pct 5. computer_internet_pct 6. ppe_pct 7. partographs_pct 8. sterile_pack_pct 9. oxytocin_pct 10. magnesium_sulphate_pct 11. misoprostol_pct 12. tetracycline_pct 13. chlorhexidine_pct 14. gentamicin_pct 15. ceftriaxone_pct 16. amoxicillin_pct	Proportional	Nepal	SPA	2021
				Senegal	SPA	2019
				Zambia	Harmonised Health Facility Assessment (HHFA)	2022

Construct	Indicator Full Name	Indicator Short Name	Indicator Type	Country	Data Source	Source Year
	12. Essential drugs in stock: Tetracycline eye ointment 13. Essential drugs in stock: 4% chlorhexidine gel 14. Essential drugs in stock: injectable gentamicin 15. Essential drugs in stock: ceftriaxone powder 16. Essential drugs in stock: amoxicillin suspension					
Financing	Current national health expenditure as percentage of GDP	che_as_pct_gdp	Proportional	Nepal	World Health Organization Global Health Observatory	2021
				Senegal	MOH Health Account Report	2022
				Zambia	World Health Organization Global Health Observatory	2021
Information, Monitoring, and Evaluation Systems	Proportion of facilities submitting reports regularly on Health Management Information System (HMIS)	regular_hmis_reports_pct	Proportional (mixed format)	Nepal	SPA	2021
				Senegal	KIIs conducted by study team members	2023
				Zambia	KIIs conducted by study team members	2023
Information, Monitoring, and Evaluation Systems	Proportion of facilities with functional HMIS	hmis_functional_pct	Proportional (mixed format)	Nepal	SPA	2021
				Senegal	KIIs conducted by study team members	2023
				Zambia	KIIs conducted by study team members	2023
Leadership and Governance	Presence of a chief nurse/midwife in the executive leadership team of the MOH	chief_nurse_in_moh	Binary	Nepal	Ministry of Health and Population, Organization Structure and Department of Health Services Staff Profile	2024
				Senegal	KIIs conducted by study team members	2019
				Zambia	KIIs conducted by study team members	2022

Construct	Indicator Full Name	Indicator Short Name	Indicator Type	Country	Data Source	Source Year
Leadership and Governance	Presence of a national maternal, newborn, and child health (MNCH) strategy document that is no more than 5 years old	MNCH_strategy	Binary	Nepal	Nepal Safe Motherhood and Newborn Health Road Map 2030	2019
				Senegal	Politique, Normes & Protocoles des Services de Sante de la Reproduction et Survie de l'Enfant	2018
				Zambia	KIIs conducted by study team members	2023
Leadership and Governance	Presence of a national human resources for health policy where MNCH workforce is included, and the policy is no more than 5 years old	HR_MNCH_strategy	Binary	Nepal	NHSSP Human Resources for Health Nepal Country Profile	2013
				Senegal	Annuaire Statistique des Ressources Humaines	2022
				Zambia	KIIs conducted by study team members	2023
Realization of behaviors illustrating quality of care	Proportion of facilities that received supervision in the recent 3-6 months regarding childbirth care	recent_supervision_pct	Proportional	Nepal	SPA	2021
				Senegal	SPA	2019
				Zambia	Harmonised Health Facility Assessment (HHFA)	2022
Realization of behaviors illustrating quality of care	Proportion of facilities initiating breastfeeding for newborns within 1 hour after birth	breastfeed1_pct	Proportional	Nepal	SPA	2021
				Senegal	SPA	2019
				Zambia	Harmonised Health Facility Assessment (HHFA)	2022
Realization of behaviors illustrating quality of care	Proportion of facilities offering skin to skin contact for newborns after birth	skin_pct	Proportional	Nepal	SPA	2021
				Senegal	SPA	2019
				Zambia	Harmonised Health Facility Assessment (HHFA)	2022
Realization of behaviors illustrating quality of care	Proportion of facilities offering visual and auditory privacy	privacy_pct	Proportional	Nepal	SPA	2021
				Senegal	SPA	2019
				Zambia	Harmonised Health Facility Assessment (HHFA)	2022

Supplementary Table 2: Description of sensitivity analysis categories, and sensitivity analysis scenarios within each category

	SENSITIVITY ANALYSIS 1: Managing zero values				SENSITIVITY ANALYSIS 2: Managing uniform binary variables								SENSITIVITY ANALYSIS 3: Managing mixed format data (e.g. binary and proportion)			
Problem	Zero (converted from "No" in binary indicators) will make the geometric mean 0. We need to convert 0 to 0.01 or 0.001, but which one is more appropriate?				Uniform binary indicators are the six indicators that had "Yes" from all subnational regions in all three countries. They offer little predictive power as all values are the same, but we would like to consider how we can include this data.								Seven indicators with different formats of values between countries – Nepal had proportions, but Senegal and Zambia had "Yes" for all provinces. What is the best way to include these mixed format indicators?			
Approach	Test conversion to 0.01 and compare to conversion to 0.001				Test inclusion of indicators as is, compared to introducing small amount of random variance to uniform variables, compared to exclusion of indicators								Test inclusion of mixed format indicators via keeping Nepal's proportions, or by converting Nepal's values to "Yes"/1			
Findings	Out of the 26 indicators that went into the analysis, about 8 moved places noticeably (moved 5+ ranks) in the weight ranking after changing from 0.01 to 0.001. Most values of the SHP indices decreased; the decrease was more obvious for Senegal and Zambia which had more "No"/zeros.				After adding the indicators as is, 10 of the previous 26 indicators changed ranking noticeably. Values of the SHP index increased slightly, especially in Senegal and Zambia. After changing the values to have random variance, we do not see much change in the ranking of the indicators or SHP indices.								After converting only YES to 100%, 13 of the previous 32 indicators changed ranking noticeably. All SHP indices increased, especially for Senegal and Zambia. After converting all values to 100%, the ranking of the indicators changed again. SHP indices decreased slightly compared to the standard scenario, especially for Senegal and Zambia.			
Decision	0.001 was used in the model (analysis scenario 3)				Uniform indicators were not included in the model (analysis scenario 1)								Mixed format variables were included with Nepal's original proportions (analysis scenario 2)			
Analysis scenarios	1	2	3	4	1	2	3	4	5	6	7	8	1	2	3	4
	Non-linear optimization (geometric mean with 0)	Non-linear optimization (geometric mean with 0.01)	Non-linear optimization (geometric mean with 0.001)	Non-linear optimization (geometric mean with 0.0001)	Removed uniform variables from the model	Include uniform variables as they are	Include uniform variables after introducing random variance to the values	Introduced random noise to uniform variables	Introduced random noise at 0.5 intensity	Introduced random noise at 1 intensity	Dropping all uniform variables	Introduced random noise that mimics other variable's variance	Excluded variables with differential format of values	Included variables with differential format of values after converting YES to 100%	Included variables with differential format of values after converting all non-zero responses to 100%	Refined a few uniform indicators, eliminated those that remained uniform

Supplementary Table 3A: Ranks of indicators across 16 sensitivity analyses

Full indicator names are included in Supplementary Table 1. Lower ranking represents higher weighting; higher ranking represents lower weighting.

	SENSITIVITY ANALYSIS 1: Managing zero values				SENSITIVITY ANALYSIS 2: Managing uniform binary variables								SENSITIVITY ANALYSIS 3 Managing mixed format data (e.g. binary and proportion)			
Analysis scenario number	1	2	3	4	1	2	3	4	5	6	7	8	1	2	3	4
Indicator Name																
amoxicillin	3	12	26	10	26	7	7	23	13	27	17	28	7	9	9	4
breastfeed	18	7	17	7	17	29	29	13	16	14	24	14	29	22	36	16
ceftriaxone	16	22	23	24	23	28	28	37	37	37	29	8	28	25	25	27
che_as_pct_gdp	13	14	16	13	16	13	13	40	41	12	13	16	13	17	4	20
chief_nurse_in_moh						22	22	28	34	6		6	22	30	30	25
chlorhexidine	1	6	5	25	5	6	6	17	21	28	36	25	6	7	7	7
comms_equipment_pct	6	5	12	18	12	19	19	35	35	38	27	36	19	28	21	32
compulsory_continued_education	15	2	1	1	1	4	4	4	4	1	1	1	4	1	1	1
computer_internet_pct	2	26	7	23	7	10	10	33	33	32	30	44	10	18	15	19
csection_facilities_pct	19	9	13	5	13	5	5	8	9	9	32	11	5	5	6	11
delivery_facilities_pct	8	18	24	3	24	21	21	9	10	43	7	12	21	26	14	5
education_system	21	4	4	4	4	3	3	2	2	4	23	4	3	3	2	2
electricity_pct	12	8	3	20	3	25	25	10	11	15	9	35	25	14	13	3
gentamicin	17	16	8	16	8	11	11	43	43	5	8	43	11	35	34	9
guidelines_facilities_pct								32	31	40	33	40				
hmis_functional								41	29	31	34	32		11	35	31
HR_MNCH_strategy								29	40	22		37				24
in_service_documents						12	26	25	28	44		33	12	6	31	
in_service_training								42	42	25	18	27		36	12	34
ipc_free								39	27	30	11	31		15	29	37

ipc_guidelines_implemented						20	20	19	19	29		39	20	4	38	35
ipc_providers_paid						2	12	24	23	19		10	2	34	32	
licensing_process	20	1	2	2	2	1	1	1	1	3	2	2	1	2	5	6
magnesium_sulphate_pct	7	17	10	19	10	14	14	6	7	39	3	5	14	24	17	8
misoprostol_pct	22	25	21	11	21	31	31	14	14	35	5	22	31	20	39	22
MNCH_strategy								12	6	10		20				36
nurse_midwife_density_pct	10	11	9	22	9	9	9	11	22	21	28	17	9	10	10	26
oxytocin_pct	4	10	6	6	6	8	8	7	8	8	10	9	8	37	11	10
partographs_pct	5	15	11	14	11	18	18	20	3	23	4	24	18	32	24	18
ppe_pct	23	20	18	8	18	24	24	16	20	18	25	23	24	8	16	29
preservice_3yrs_pct								22	18	17	21	21				28
preservice_score	24	23	22	12	22	23	23	27	38	26	15	30	23	19	33	21
privacy	14	13	20	21	20	27	27	30	25	41	16	41	27	27	28	12
providers_educated						30	17	3	32	7		7	30	12	22	
providers_licensed						17	2	38	39	36		26	17	13	23	
recent_supervision_pct								18	17	16	31	19				
referral_system								34	5	34	14	29		39	18	33
regular_hmis_reports								5	26	20	26	34		21	8	30
skin-to-skin	11	19	14	15	14	26	30	21	12	2	19	3	26	38	20	14
soap_water_pct	9	3	19	17	19	16	16	15	15	13	20	15	16	23	26	15
staff_trained								36	36	33	22	38		33	27	38
sterile_pack_pct								26	24	24	12	18				13
supportive_supervision														31	3	17
tetracycline	26	24	15	26	15	32	32	44	44	42	35	42	32	29	37	39
transport_pct	25	21	25	9	25	15	15	31	30	11	6	13	15	16	19	23

Supplementary Table 3B: Average, standard deviation, range, and count of indicators across 16 sensitivity analyses, sorted by average rank across sensitivity analyses

Indicator	Average Rank	Standard Deviation of Rank	Range of Ranks	Total Count of Indicator in Analyses	Rank in primary analysis
compulsory_continued_education	2.9	3.5	14.0	16	1
licensing_process	3.3	4.7	19.0	16	2
education_system	5.5	6.5	21.0	16	3
chlorhexidine	7.4	10.6	35.0	16	17
oxytocin_pct	9.8	7.5	33.0	16	14
csection_facilities_pct	10.3	7.0	27.0	16	10
magnesium_sulphate_pct	13.4	8.9	36.0	16	9
amoxicillin	14.3	8.9	25.0	16	5
electricity_pct	14.4	9.3	32.0	16	4
nurse_midwife_density_pct	14.6	6.9	19.0	16	27
soap_water_pct	16.1	5.3	23.0	16	18
partographs_pct	16.1	8.0	29.0	16	8
delivery_facilities_pct	16.6	10.2	40.0	16	6
MNCH_strategy	16.8	11.9	30.0	5	36
supportive_supervision	17.0	14.0	28.0	3	Not included
che_as_pct_gdp	17.1	9.7	37.0	16	12
ipc_providers_paid	17.6	11.9	32.0	9	Not included
skin-to-skin	17.8	9.3	36.0	16	19
providers_educated	17.8	11.2	29.0	9	Not included
transport_pct	18.7	7.4	25.0	16	35
breastfeed	19.3	8.3	29.0	16	20
sterile_pack_pct	19.5	6.1	14.0	6	15
ppe_pct	19.6	5.8	21.0	16	29
gentamicin	19.9	14.3	38.0	16	11
computer_internet_pct	19.9	12.1	42.0	16	13

recent_supervision_pct	20.2		15.0	5	23
preservice_3yrs_pct	21.2	3.9	11.0	6	28
regular_hmis_reports	21.3	10.2	29.0	8	31
chief_nurse_in_moh	22.5	9.6	28.0	10	26
comms_equipment_pct	22.6	10.8	33.0	16	30
misoprostol_pct	22.8	9.1	34.0	16	25
providers_licensed	23.4	12.6	37.0	9	Not included
preservice_score	23.8	6.3	26.0	16	7
in_service_documents	24.1	12.1	38.0	9	Not included
ipc_guidelines_implemented	24.3	10.9	35.0	10	Not included
privacy	24.3	8.7	29.0	16	16
referral_system	25.8	12.0	34.0	8	22
ceftriaxone	26.1	7.5	29.0	16	24
ipc_free	27.4	9.8	28.0	8	38
in_service_training	29.5	11.0	30.0	8	34
HR_MNCH_strategy	30.4	7.9	18.0	5	21
hmis_functional	30.5	8.7	30.0	8	32
tetracycline	32.1	9.3	29.0	16	37
staff_trained	32.9	5.7	16.0	8	39
guidelines_facilities_pct	35.2	4.4	9.0	5	33

Supplementary Table 4: Population and institutional delivery rate for each province/region in Nepal, Senegal, and Zambia included in the analysis

Country	Province / Region	Population*	Institutional Delivery Rate**
Nepal	Koshi	4,972,021	81.5%
	Madhesh	6,126,288	66.8%
	Bagmati	6,084,042	88.3%
	Gandaki	2,479,745	87.7%
	Lumbini	5,124,225	84.4%
	Karnali	1,694,889	72.4%
	Sudurpashchim	2,711,270	86.8%
Senegal	Dakar	3,732,284	98.9%
	Diourbel	1,801,991	94.2%
	Fatick	870,361	91.5%
	Kaffrine	703,555	85.4%
	Kaolack	1,155,433	93.1%
	Kédougou	184,275	87.6%
	Kolda	796,582	88.5%
	Louga	1,032,645	93.8%
	Matam	706,037	81.7%
	Saint-Louis	1,063,532	85.9%
	Sédhiou	553,005	81.6%
	Tambacounda	841,518	85.6%
	Thiès	2,105,707	97.3%
	Ziguinchor	662,179	96.3%
Zambia	Central	2,261,336	78.4%
	Copperbelt	2,768,192	92.2%
	Eastern	2,462,682	92.8%
	Luapula	1,519,478	90.6%
	Lusaka	3,093,617	92.2%
	Muchinga	922,213	83.0%
	Northern	1,623,853	74.2%
	Northwestern	1,278,357	90.0%
	Southern	2,388,091	82.1%
	Western	1,375,604	77.5%

***Population sources & years:** Nepal – National Population and Housing Census 2021; Senegal - 2019 Census, National Agency for Statistics and Demography of Senegal ; Zambia – 2022 Census of Population and Housing

****Institutional delivery rate sources & years:** 2021 Demographic and Health Surveys (DHS) in Nepal, 2023 DHS in Senegal, and 2018 DHS in Zambia

Supplementary Table 5: Full list of proposed indicators

Indicator Number	Category	Indicator name	Data source if indicator was included (n/a if not included in analysis)
1	Education/training	Intrapartum care providers are educated to national and international standards of practice (%)	n/a
2	Education/training	Pre-service training curriculum mapping score (%)	Assessment conducted by study team members
3	Education/training	Pre-service training programs that are at least 3 years long (%)	Assessment conducted by study team members
4	Regulation	Intrapartum care providers fulfil the registration, licensing and relicensing as required at national level (%)	n/a
5	Regulation	Functioning national education regulation system(s) is/are in place	KIIs/desk review conducted by study team members
6	Regulation	Formal process for licensing and relicensing are in place	KIIs/desk review conducted by study team members
7	Continuing professional development (training)	The provision of opportunities for continuing education and training to maintain and upgrade intrapartum care competencies (e.g., in-service training) (%)	n/a
8	Continuing professional development (training)	Does a system of compulsory continued professional development exist? (Yes/No)	KIIs conducted by study team members
9	Continuing professional development (training)	Do (or did) MOH offer any in-service training related to intrapartum care? (e.g., in the last 5 or 10 years)	Service Provision Assessment (SPA)
10	Continuing professional development (training)	Who are responsible for in-service training?	n/a
11	Continuing professional development (training)	Are any policy documents available which outline in-service requirements?	n/a
12	Service delivery	Childbirth care is provided free of charge in public facilities (part of UHC) (%)	Desk review conducted by study team members
13	Service delivery	Staff trained in delivery service	SPA (Nepal, Senegal), Harmonised Health Facility Assessment (HHFA) (Zambia)
14	Service delivery	Facilities offering normal delivery service (%)	SPA (Nepal, Senegal), HHFA (Zambia)
15	Service delivery	Facilities offering C-section (%)	SPA (Nepal, Senegal), HHFA (Zambia)
16	Service delivery	Intrapartum guidelines are implemented	SPA (Nepal, Senegal), HHFA (Zambia)
17	Service delivery	A referral system is in place with access to transportation	KIIs/desk review conducted by study team members
18	Service delivery	Which intrapartum care providers are considered part of an "integrated team of MNH professionals"	n/a
19	Service delivery	percent of facilities offering normal delivery with guidelines for childbirth care	n/a

20	Service delivery	Number of maternity beds per 1000 pregnant women	n/a
21	Health workforce	Nurses/midwives per 10 000 population	Desk review conducted by study team members
22	Health workforce	Density of nurse/ midwives against national target	Desk review conducted by study team members
23	Health workforce	Midwives per 10,000 population	n/a
24	Health workforce	Midwives per 1,500 women of reproductive age	n/a
25	Health workforce	Obstetricians per 10,000 population	n/a
26	Health workforce	Doctors per 10 000 population (specialist medical practitioner ISCO 2212)	n/a
27	Health workforce	Rural/urban and public/private distribution of intrapartum care providers per 10 000 population	n/a
28	Information systems	Number of district MPDSR hospitals	n/a
29	Information systems	Number of hospitals with MPDSR	n/a
30	Information systems	National and/or sub-national MPDSR systems in place	n/a
31	Information systems	Facilities with regular HMIS reporting	SPA (Nepal), KIs conducted by study team members (Senegal, Zambia)
32	Information systems	Number of public facilities	n/a
33	Information systems	Functional Health Management Information Systems (HMIS)	n/a
34	Medical products, vaccines and technologies	Transport system in place (ambulance services) including emergency transport in all facilities (%)	SPA (Nepal, Senegal), HHFA (Zambia)
35	Medical products, vaccines and technologies	Electricity service is available 24/7 in all facilities (%)	
36	Medical products, vaccines and technologies	Running water and soap available in all facilities (%)	
37	Medical products, vaccines and technologies	Communication equipment (landline/mobile phone) in all facilities (%)	
38	Medical products, vaccines and technologies	Computer with Internet access in all facilities (%)	
39	Medical products, vaccines and technologies	PPE available (medical masks, gloves, eye protection, gowns) in all facilities (%)	
40	Medical products, vaccines and technologies	Partographs available in all facilities (%)	
41	Medical products, vaccines and technologies	Sterile delivery pack available in all facilities (%)	

42	Medical products, vaccines and technologies	Essential drugs in stock: oxytocin in all facilities (%)	
43	Medical products, vaccines and technologies	Essential drugs in stock: magnesium sulphate in all facilities (%)	
44	Medical products, vaccines and technologies	Essential drugs in stock: misoprostol in all facilities (%)	
45	Medical products, vaccines and technologies	Blood sufficiency	n/a
46	Medical products, vaccines and technologies	Essential drugs in stock: Tetracycline eye ointment in all facilities (%)	SPA (Nepal, Senegal), HHFA (Zambia)
47	Medical products, vaccines and technologies	Essential drugs in stock: 4% chlorhexidine gel in all facilities (%)	
48	Medical products, vaccines and technologies	Essential drugs in stock: Injectable gentamicin in all facilities (%)	SPA (Nepal, Senegal), HHFA (Zambia)
49	Medical products, vaccines and technologies	Essential drugs in stock: Ceftriaxone powder for injection in all facilities (%)	
50	Medical products, vaccines and technologies	Essential drugs in stock: Amoxicillin suspension in all facilities (%)	
51	Financing	Intrapartum care providers are paid regularly (e.g., monthly) (%)	n/a
52	Financing	Current health expenditure (CHE) as percentage of gross domestic product (GDP) (%)	World Health Organization Global Health Observatory (Nepal, Zambia), MOH Health Account Report (Senegal)
53	Leadership and governance	Full time government Chief Nurse/Midwife Officer in MoH (yes, no, other)	Ministry of Health and Population, Organization Structure and Department of Health Services Staff Profile (Nepal), KIIs conducted by study team members (Senegal, Zambia)
54	Leadership and governance	Was a national strategy for MNCH issued in the last 5 years?	Safe Motherhood and Newborn Health Road Map 2030 (Nepal), Politique, Normes & Protocoles des Services de Sante de la Reproduction et Survie de l'Enfant (Senegal), KIIs conducted by study team members (Zambia)
55	Leadership and governance	Was a national human resources strategy issued in the last 5 years that includes MNCH workforce planning?	NHSSP Human Resources for Health Nepal Country Profile (Nepal), Annuaire Statistique des Ressources Humaines (Senegal), KIIs conducted by study team members (Zambia)
56	Realization of behaviors illustrating quality of care	Initiate breastfeeding within 1 hour (%)	SPA (Nepal, Senegal), HHFA (Zambia)
57	Realization of behaviors illustrating quality of care	Skin to skin contact (%)	SPA (Nepal, Senegal), HHFA (Zambia)
58	Realization of behaviors illustrating quality of care	Visual and auditory privacy (%)	SPA (Nepal, Senegal), HHFA (Zambia)
59	Realization of behaviors illustrating quality of care	Recent supervision of staff (%)	SPA (Nepal, Senegal), HHFA (Zambia)

Supplementary Table 6: Additional details about health facility assessment secondary data sources

	2021 Service Provision Assessment	2019 Enquête Continue sur la Prestation des Services de Soins de Santé	2021/2022 Harmonised Health Facility Assessment
Country	Nepal	Senegal	Zambia
Inclusion in DHS program	Yes	Yes	No
Study lead	Nepal Ministry of Health and Population (MoHP) and New ERA and support from USAID, FCDO, UNFPA	Agence Nationale de la Statistique et de la Démographie et le Ministère de la Santé et de l'Action Sociale, with TA from ICF International and support from USAID, UNFPA, UNICEF, Micronutrient Initiative, World Bank	Conducted by Zambia Ministry of Health (MoH), with support from WHO, Global Fund, and Johns Hopkins
Dates of data collection	January 2021 to September 2021	April 2019 to February 2020	November 2021 to January 2022
Sample size and sampling strategy	- Stratified random sample of 1,633 health facilities selected via equal probability systematic sampling with sample allocation 97% of sampled facilities - Master list of all facilities was provided by MoHP, including 7,598 health facilities; 5,681 facilities were included in the survey sample, and 1,917 health facilities were not eligible (polyclinics or hospitals with stand-alone specialized services)	- Sample of 361 health facilities selected 95% response rate	- Census of all health facilities, with a 96.4% response rate - Assessed 3,179 facilities out of the 3,321 health facilities that formed up the HHFA facility list - HHFA facility list was created based on MoH DHIS2 system and Master Facility List
National/subnational representativeness	- Included all active health facilities, both governmental and non-governmental, across provinces and facility levels - Sample stratification involved separating health facilities by facility type within each province. - Sample allocation featured a power allocation across provinces in order to achieve comparable survey precision.	Included all active health facilities, both public and private, across provinces and facility levels	Included public and private facilities from all provinces, across all facility levels, and rural/urban status

Supplementary Table 7A: Key informant interviews in Nepal

Group	Number of interviews	Position and/or Professional Qualifications
Government bodies	5	Senior position, Ministry of Health and Population, Family Welfare Division
		Senior position, Ministry of Health and Population, Health Coordination Division
		Senior position, Ministry of Health and Population, Nursing and Social Security Division
		Senior position, Ministry of Health and Population, National Health Training Center
		Senior position, Ministry of Health and Population, Management Division (HMIS ^a)
Educational institutions	9	Head of Bachelor in Nursing Program at a school of health sciences (School A)
		Head of Bachelor in Midwifery Program at a school of health sciences (School A)
		Senior position, maternity hospital associated with school of health sciences (School B)
		Head of Bachelor in Midwifery Program, maternity hospital associated with school of health sciences (School B)
		Head of Bachelor in Midwifery Program at a school of health sciences (School C)
		Head of Obstetrics and Gynecology Department at a school of health sciences (School C)
		Head of Medical Doctorate in General Practice Program at a school of health sciences (School D)
		Head of Bachelor in Midwifery Program at a school of health sciences (School D)
		Dean of a school of health sciences (School E)
International organizations and external development partners	7	USAID ^b , Staff involved with monitoring and DHS and MICS
		New Era, Staff involved with monitoring and DHS and MICS
		UNICEF ^c , Staff involved with monitoring and DHS and MICS
		UNICEF ^c , MNH focal point
		WHO ^d , MNH focal point
		UNFPA ^e , MNH focal point
		NHSSP ^f , MNH focal point
Regulatory bodies	2	Senior position, Nepal Nursing Council
		Senior position managing standards and accreditation, Medical Education Commission
Professional organizations	1	Senior position, Midwifery Society of Nepal

^a HMIS: Health Management Information System

^b USAID: United States Agency for International Development

^c UNICEF: United Nations Children's Fund

^d WHO: World Health Organization

^e UNFPA: United Nations Population Fund

^f NHSSP: Nepal Health Sector Support Programme

Supplementary Table 7B: Key informant interviews in Senegal

Group	Number of interviews	Position and/or Professional Qualifications
Central and regional government organizations responsible for maternal and newborn health	4	Senior position, National MNCH ^a division, DSME ^b
		Senior position, National MNCH ^a division, DSME ^b
		Two senior leaders responsible for training, National human resources division, DRH ^c
	2	Two regional chief medical officers, MCR ^d
	4	Regional government reproductive health coordinators, from four different regions
National government organizations responsible for maternal and newborn health data	3	Senior position, National MNCH ^a Division, DSME ^b
		Senior position, National Agency for Statistics and Demography, ANSD ^e
		Senior position, National Division of Planning, Research, and Statistics, DPRS ^f
Educational institutions	4	Training manager at a public university
		Manager at a private training institution (School A)
		Dean at a private training institution (School B)
		Training manager at Regional Centre for Training, Research, and Advocacy in Reproductive Health, CEFORP ^g
Technical and financial partners	5	Senior position, Midwifery program at UNFPA ^h
		Senior position, Health Specialist, UNICEF ⁱ
		Senior position, WHO ^j
		Senior position, USAID MOMENTUM ^k ,
		PRESSMN3 Project Lead, JICA ^l
Professional associations	3	Senegalese Association of Gynecology and Obstetrics, ASGO ^m
		National Association of State Midwives of Senegal, ANSFES ⁿ
		National Association of State Nurses of Senegal, ANIIDES ^o

a. MNCH : Maternal, newborn, and child health

b. DSME: Direction de la Santé de la Mère et de l'Enfant

- c. DRH: Direction des Ressources Humaines
- d. MCR: Médecins-chefs de région
- e. ANSD: Agence nationale de la statistique et de la démographie
- f. DPRS: Direction de la Planification, de la Recherche et des Statistiques
- g. CEFORP: Centre Régional de Formation, de Recherche et de Plaidoyer en Santé de la Reproduction
- h. UNFPA: United Nations Population Fund
- i. UNICEF: United Nations Children's Fund
- j. WHO: World Health Organization
- k. USAID MONENTUM: United States Agency for International Development
- l. JICA: Japanese International Cooperation Agency
- m. ASGO: Association Sénégalaise de Gynécologie-Obstétrique
- n. ANSFES: Association Nationale des Sages-Femmes d'Etat du Sénégal
- o. ANIIDES: Association Nationale des Infirmiers et Infirmières Diplômés d'Etat du Sénégal

Supplementary Table 7C: Key informant interviews in Zambia

A total of 25 interviews were conducted in Zambia. The study included 6 public, 3 private and 2 faith-based training institutions. The team did a purposive sample of training facilities in Eastern, Copperbelt, Lusaka and Northwestern provinces, and targeted 1-3 interviews per institution, generally including the principal tutor, additional tutor, or the program head

Group	Number of interviews	Position and/or Professional Qualifications
Educational Institutions	3	Principal tutor and 2 tutors, training school in Eastern Province (School A)
	3	Principal tutor and 2 tutors, training school in Eastern Province (School B)
	3	Principal tutor and 2 tutors, training school in Southern Province (School C)
	2	Training school in Copperbelt Province (School D)
	1	Training school in Copperbelt Province (School E)
	2	Training school in Northwestern Province (School F)
	1	Head of obstetrics and gynecology, Training school in Lusaka (School G)
	4	Interviews with tutors and managers at additional training schools
Government	1	Ministry of Health Department of Nursing Services
	2	Two provincial nursing officers
Regulatory bodies	1	Nursing and Midwifery Council of Zambia (NMCZ)
	2	Registration officer and examination officer, Health Professional Council of Zambia (HPCZ)

Supplementary Table 8: Desk Review Items

Country	Title	Author	Journal
Nepal	Task shifting and innovative medical education - moving outside the box to serve rural Nepal	Zimmerman M	Journal of the Nepal Medical Association
	A Distance Blended Learning Program to Upgrade the Clinical Competence of District Non-doctor Anesthesia Providers in Nepal	Shristi Shah, Stephen Knoble, Oliver Ross & Stephen Pickering	World Journal of Surgery
	Comparison of midwifery-led and consultant-led maternity care for low risk deliveries in Nepal	T Geetha Rana, Rashmi Rajopadhyaya, Binod Bajracharya, Manju Karmacharya and David Osrin	Health Policy and Planning
	Onsite midwife-led birth units (OMBUs) for care around the time of childbirth: a systematic review	Qian Long, Emma R Allanson, Jennifer Pontre, Özge Tunçalp, George Justus Hofmeyr, Ahmet Metin Gülmezoglu	BMJ Global Health
	Determinants of Maternal Health and Family Planning Service Coverage in Nepal: Modelling of Routine Data	Ministry of Health and Population Department of Health Services	
	The quality of skilled birth attendants in Nepal: High aspirations and ground realities	Ruma Rajbhandari, Shovana Rai, Sejal Hathi, Rita Thapa, Indra Rai, Anil Shrestha	PLOS One
	Analysis of maternal and newborn training curricula and approaches to inform future trainings for routine care, basic and comprehensive emergency obstetric and newborn care in the low- and middle-income countries: Lessons from Ethiopia and Nepal	Gaurav Sharma, Yordanos B Molla, Shyam Sundar Budhathoki, Million Shibeshi, Abraham Tariku, Adhish Dhungana, Bindu Bajracharya, Goitam G Mebrahtu, Shilu Adhikari, Deepak Jha, Yunis Mussema, Abeba Bekele, Neena Khadka	PLOS One
	Nick Simons Institute 2021-22 Annual Report		
	Assessment of facility and health worker readiness to provide quality antenatal, intrapartum and postpartum care in rural Southern Nepal	Tsering P Lama, Melinda K Munos, Joanne Katz, Subarna K Khatry, Steven C LeClerq and Luke C Mullany	BMC Health Services Research
	Facilitating learning for auxiliary nurse midwives around maternal mental health in Southern Nepal	Ireland, J., Havelock, D., Lawrie, A. Ghimire, S.	Journal of Midwifery Association of Nepal
	Nick Simons Institute 2020-21 Annual Report		
	On-site clinical mentoring as a maternal and new-born care quality improvement method: evidence from a nurse cohort study in Nepal	Sophie Goyet, Swaraj Rajbhandari, Valerie Broch Alvarez, Aida Bayou, Sirjana Khanal and Tara Nath Pokhrel	BMC Nursing
	Quality care during labour and birth: a multi-country analysis of health system bottlenecks and potential solutions	Gaurav Sharma, Matthews Mathai, Kim E Dickson, Andrew Weeks, G Justus Hofmeyr, Tina Lavender, Louise Tina Day, Jiji Elizabeth Mathews, Sue Fawcus, Aline Simen-Kapeu, Luc de Bernis	BMC Pregnancy & Childbirth
	Nepal Safe Motherhood and Newborn Health Road Map 2030	Family Welfare Division Ministry of Health and Population	
	Strategy for Skilled Health Personnel and Skilled Birth Attendants 2020-2025	Ministry of Health and Population Department of Health Services Family Welfare Division	
	The professional role of skilled birth attendants' in Nepal – A phenomenographic study	Solveig Wahlström, Margereth Björklund, Berit Munck	Sexual and Reproductive Healthcare
	Using behavioural science to explore impact and implementation of obstetric anaesthesia training in Tanzania, Nepal and Bangladesh: a qualitative evaluation study with obstetric anaesthesia providers	Nimarta Dharni, Lucie M. T. Byrne-Davis, Evans Sanga, Jo Hart, Amir Babu Shrestha, Tara Gurung, Ravi R. Shrestha, Pradip R. Vaidya, Amir Hossain, Maytinee Lilaonitkul, David Snell, Alex Barrett-Chapman, Isabeau Walker & Eleanor R. Bull	
	A Monitoring and Evaluation Plan for the Core Competencies of Skilled Birth Attendants in Nepal	Roberta Goldstein	SIT Digital Collections

Nepal	Assessing the Quality of Skilled Birth Attendants in Rural Nepal	Nick Simons Institute	
	Where midwives are not yet recognised: A feasibility study of professional midwives in Nepal	Malin Upper Bogren, Edwin van Teijlingen, Marie Berg	Midwifery
	How effective is the follow-up and enhancement program (FEP) in retaining clinical knowledge and skills of skilled birth attendants (SBAs) and improving Their working environment in rural Nepal?	Nick Simons Institute	
	National Policy on Skilled Birth Attendants	Ministry of Health and Population Department of Health Services Family Welfare Division	
	Report on Hospital-Based Maternal and Perinatal Death Surveillance and Response Training in three Western Regions	Government of Nepal Ministry of Health Department of Health Services	
	Skilled birth attendance: What does it mean and how can it be measured? A clinical skills assessment of maternal and child health workers in Nepal	M. Carlough,T, M. McCallb	International Journal of Gynecology & Obstetrics
	An insight into two decades of Skilled Birth Attendants in Nepal	Shreyashi Aryal, Samata Nepal	Frontiers in Global Women's Health
	Bachelor of Midwifery Curriculum 2016	Kathmandu University School of Medical Sciences	
	Annual Report Department of Health Services 2018/19	Government of Nepal Ministry of Health Department of Health Services	
	HMIS Indicators 2070	Government of Nepal Ministry of Health Department of Health Services	
	HMIS Indicators 2075	Government of Nepal Ministry of Health Department of Health Services	
	PCL Midwifery Curriculum 2018	Council for Technical Education and Vocational Training	
Zambia	Cavendish University Clinical Scientist B.C.Sc Curriculum 2011	Cavendish University	
	BSc Degree In Clinical Medicine Curriculum	Zambia Royal Medical University Faculty Of Health Sciences	
	BSc in Midwifery Curriculum	University of Zambia School of Nursing Sciences	
	Diploma in Clinical Medical Sciences Curriculum 2015	Ministry Of Health Chainama College Of Health Sciences	
	Diploma in Nursing Curriculum (In-Service)	Nursing and Midwifery Council of Zambia	
	Curriculum for the Diploma in Clinical Medicine	University of Zambia School of Medicine	
	Registered Nurse Midwifery Curriculum 2015	General Nursing Council of Zambia	
	Enrolled Nurse Midwifery Curriculum 2015	General Nursing Council of Zambia	
	MB ChB Curriculum 2010	University of Zambia School of Medicine	
	Diploma in Nursing Curriculum Revised 2022	Nursing and Midwifery Council of Zambia	
	Registered Midwifery DEM curriculum	General Nursing Council of Zambia	
	Classification Of Higher Education Institutions In Zambia Higher Education Act No 4 of 2013, Statutory Instrument No. 25 of 2016	Higher Education Authority	
	People at the Centre (PeaCe) Health Program Facility Baseline Report Southern Province 2021	Zambia Ministry of Health	
	Professional Regulatory Framework	General Nursing Council of Zambia	

Zambia	List of Private Training Institutions	Health Professions Council of Zambia
	List of Public Training Institutions	Health Professions Council of Zambia
	2022 to 2026 National Health Strategic Plan	Zambia Ministry of Health
	National Human Resources For Health Strategic Plan 2018-2024	Zambia Ministry of Health
	NMCZ Register For Higher Education Institutions Approved To Offer Nursing And Midwifery Programmes January 2023	Nursing and Midwifery Council of Zambia
	Reproductive, Maternal, Newborn, Child And Adolescent Health And Nutrition Communication And Advocacy Strategy 2018-2021	Zambia Ministry of Health
	National Health Policy 2012	Zambia Ministry of Health
	2022—2024 Zambia RMNCAH-N Investment Case	Zambia Ministry of Health
	Zambia Standards and Guidelines for Quality Assurance in Higher Education (ZSG-QA)	Higher Education Authority
	Zambia National Health Strategic Plan 2017 – 2021	Zambia Ministry of Health
Senegal	Analyse situationnelle : Résultat de l'enquête Dans le cadre du Projet de Renforcement des Soins de Santé Maternelle et Néonatale Phase 3	Ministère de la Santé et de L'Action Sociale, JICA
	Documentation du processus de mise en œuvre du modele du projet de renforcement des soins de sante maternelle et neonatale (PRESSMN)	Ministère de la Santé et de L'Action Sociale, JICA
	Directives nationales de la surveillance des décès maternels et riposte (SDMR) a travers la surveillance intégrée des maladies et riposte (SIMR)	Ministère de la Santé et de L'Action Sociale
	Diverse pre-service midwifery education pathways in Cambodia and Malawi: A qualitative study utilising a midwifery education pathway conceptual framework	Sarah Neal, Martha Bokosi, Dorothy Lazaro, Sreytouch Vong, Andrea Nove, Sarah Bar-Zeev, Sally Pairman, Erin Ryan, Petra ten Hooper-Bender, Caroline SE Homer
	Four-year integrated nursing and midwifery competency-based curriculum: prototype curriculum for the African region	WHO
	La liste des écoles privées de santé membres du COSEPS répartie par région version 2022	Ministère de la Santé et de L'Action Sociale
	Orientations stratégiques mondiales de l'OMS pour les soins infirmiers et obstétricaux	WHO
	Plan de formation en vue de la mise en œuvre du curriculum adopte par l'OOAS pour la formation des infirmiers et des sages femmes de l'espace CEDEAO	Ministère de la Santé et de L'Action Sociale
	Programme de formation licence sage femme	Ministère de la Santé et de L'Action Sociale
	Programme de formation LSIO infirmier	Ministère de la Santé et de L'Action Sociale
	Prototype de cursus de trois ans basé sur les compétences pour la formation initiale des sages-femmes de la région afrique	WHO
	Evaluation de la formation des sages-femmes d'etat au Senegal rapport technique	Ministère de la Santé et de L'Action Sociale
	Final report on pre-service education for nurses and midwives in Senegal	Ministère de la Santé et de L'Action Sociale
	Regional Competency Assessment Tool for Midwifery Educators and Midwives	WHO

Senegal	Loi n° 2017-14 du 20 janvier 2017 relative à l'exercice de la Profession de Sage-femme au Sénégal et portant création de l'Ordre des Sages-femmes et des Maïeuticiens	Ministère de la Santé et de L'Action Sociale	
	Politique, normes & protocoles des services de sante de la reproduction et survie de l'enfant	Ministère de la Santé et de L'Action Sociale	
	Cadre réglementaire professionnel régional à l'usage des infirmiers et des sages-femmes	WHO	
	Guide de gestion du travail d'accouchement de l'OMS: manuel d'utilisation	WHO	
	Liste OMS de contrôle pour la sécurité de l'accouchement guide de mise en œuvre	WHO	
	Midwifery education, regulation and association in the Democratic Republic of Congo (DRC) – current state and challenges	Malin Bogren, Britou Ndela, Carla Toko & Marie Berg	Global Health Action
	The state of the health workforce in the WHO African Region 2021	WHO	
	Evaluation rapide de la disponibilité, de l'utilisation et de la qualité des soins obstétricaux et néonataux d'urgence au Sénégal 2015 - 2016	Ministère de la Santé et de L'Action Sociale	
	Evaluation des besoins en soins obstétricaux et néonataux d'urgence au Sénégal 2012-2013	Ministère de la Santé et de L'Action Sociale	

Supplementary Table 9A: Senegal Technical Working Group

Number of participants in brackets

National government	• Support and Monitoring Unit for the National Health and Social Development Plan (1) • Maternal and Child Health Department (2) • Planning, Research, and Statistics Department, Health and Social Information System Division (1) • Human Resources Department, Training Division (1)
Regional government	• Medical region chiefs (2)
Educational institutions & training centres	• National School of Health and Social Development (1) • Program Leads at University of Cheikh Anta Diop de Dakar (2) • Center for Training and Research in Reproductive Health (1)
Professional associations	• National Association of State Midwives of Senegal (1) • National Association of State Nurses of Senegal (1)
Technical and Financial Partners	• WHO (1) • UNICEF (1) • UNFPA (1) • USAID (1) • JICA (1) • KOICA (1)

Supplementary Table 9B: Nepal Technical Working Group

Number of participants in brackets

National government	• Family Welfare Division (11) • HMIS Statistical Officer (1) • National Health Training Centre (1)
Technical and financial partners	• World Vision International (1) • WHO-FWD

Supplementary Table 9C: Zambia Technical Working Group

Number of participants in brackets

National government	• Ministry of Health (5)
Educational institutions	• University of Zambia (2) • Other (1)
Technical and financial partners	• Jhpiego/MOMENTUM (1)

Supplementary Table 10: Completed STROBE Statement—checklist of items that should be included in reports of observational studies

	Item No.	Recommendation	Page No.	Relevant text from manuscript
Title and abstract	1	(a) Indicate the study’s design with a commonly used term in the title or the abstract	5, 2	- Multi-country, Mixed-methods study - A conceptual framework, new estimate of effective coverage and indicator assessment
		(b) Provide in the abstract an informative and balanced summary of what was done and what was found	2	Accordingly, lower effective coverage levels reveal that mothers and newborns are receiving far less essential care than official statistics may portray. This work presents a novel approach to measure one of the most challenging concepts in global health, providing standardized routine monitoring for the most constrained settings.
Introduction				
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	3, 4, 5, 6	- However, recent increases in SHP coverage do not appear to be consistently translating into proportionate reductions in maternal and neonatal mortality. - SHP is a relatively simplistic and subjective indicator that faces challenges both in terms of how it is measured and what the measurement captures. - To date, no approach has been proposed to measure the quality of care delivered by SHP in a way that can be replicated comparably across countries, nor combined with estimates of utilization to measure overall effective coverage.
Objectives	3	State specific objectives, including any prespecified hypotheses	5	Our objective was therefore to describe and measure the quality of childbirth care provided by SHP in Nepal, Senegal, and Zambia at the subnational level.
Methods				
Study design	4	Present key elements of study design early in the paper	5	This study used a multi-country, mixed-methods design; this manuscript presents the cross-country quantitative analyses Our approach involved developing a new conceptual framework and an improved measurement method based on the 2018 SHP definition and the concept of effective coverage established by Shengelia et al.
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	5, 28, 29, 33	- Nepal, Senegal, and Zambia - We then gathered all available data , as (i.e., provinces in Nepal and Zambia and regions in Senegal) 2021 Service Provision Assessment in Nepal, the 2019 Enquête Continue sur la Prestation des Services de Soins de Santé in Senegal, and the 2021/2022 Harmonised Health Facility Assessment in Zambia - Technical working groups were consulted two to three times over the course of the project (Oct 2022 – Jan 2023, March-April 2023, and June-August 2024)
Participants	6	(a) Cross-sectional study—Give the eligibility criteria, and the sources and methods of selection of participants	28, 29	- Primary data collection was conducted to complement secondary data, including pre-service training curriculum assessments and key informant interviews (KIIs). - KIIs (24, 25, and 25 KIIs in Nepal, Senegal, and Zambia, respectively) were conducted with government officials at national, regional, and local levels; representatives of pre-service education institutions; international organizations

				implementing partners; and professional associations to further complete gaps in the data. • Key informants were chosen through purposive sampling based on experienced professional leaders and a high degree of involvement in SHP education and training programs, MNH policy making, or MNH data collection.
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	30, 31, 32	• ENMR was selected as an outcome variable for this analysis, to incorporate a measure of health burden that is preventable by effective coverage of SHP. • Based on the 2018 SHP definition, we created a conceptual framework that lays out the theory of what contributes to the effectiveness of SHP. • We proposed an initial list of candidate indicators linked to the constructs in the conceptual framework, then gathered data on as many candidate indicators as possible. • Ultimately, 39 of the 59 indicators were used in the analysis. • Figure 1: Conceptual framework for effectiveness of SHP based in 2018 SHP definition with 39 indicators included in analysis
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	8, 27, 28, 30	• Indicator sources include health facility surveys (25 indicators), KIIs and desk reviews (9 indicators), a combination of these two sources (3 indicators), pre-service training curricula assessments (1 indicator), World Health Organization Global Health Observatory (1 indicator). • We then gathered all available data at the first administrative level of country subdivisions (i.e., provinces in Nepal and Zambia and regions in Senegal) to populate a corresponding dataset as completely as possible among those candidate indicators. This process began with existing secondary datasets, namely the 2021 Service Provision Assessment in Nepal, the 2019 Enquête Continue sur la Prestation des Services de Soins de Santé in Senegal, and the 2021/2022 Harmonised Health Facility Assessment in Zambia. • Primary data collection was conducted to complement secondary data, including pre-service training curriculum assessments and key informant interviews (KIIs). • The sources for subnational ENMR were from the most recent DHS available at the time of analysis: DHS 2022 in Nepal, DHS 2019 in Senegal, and DHS 2018 in Zambia
Bias	9	Describe any efforts to address potential sources of bias	30,31	• <i>Justified choosing ENMR as the outcome, while acknowledging that other outcomes (NMR in the first day, MMR, cause-specific outcomes) might be more directly dependent on quality but are rarer and more variable at subnational level.</i> • <i>Performed multiple sensitivity analyses (different variable sets, formulations, and handling of zeros) to assess how sensitive the composite index was to modelling decisions, finding that the central tendency of results pointed to the same conclusion as the primary analysis.</i> • <i>Explicitly described data availability and quality limitations, including infrequent and incomplete routine data (SPA, SARA, DHS and other sources), exclusion of 20 indicators due to missing or uniform data, and underrepresentation of specialist workforce and hospital infrastructure.</i>

				• <i>Noted that commonly used data sources (SPA, SARA, DHS) are themselves subject to bias and recommended replication with more sites and more widely validated indicators to assess the stability and generalisability of estimates.</i>
Study size	10	Explain how the study size was arrived at	27, 28	• As part of the EGH program, Nepal, Senegal, and Zambia were selected as positive outliers for improvement in neonatal mortality, maternal mortality, and DTP vaccine coverage; in-depth selection criteria for these countries in past Exemplars studies are described elsewhere • all available data at the first administrative level of country subdivisions (i.e., provinces in Nepal and Zambia and regions in Senegal) • <i>Three study countries were chosen to allow piloting and validation of a new measurement approach across diverse health systems and data environments, while maintaining feasibility given project scope and time</i>
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	30	• All indicators were converted into proportions, ranging from 0 to 1. • Observations with a value of zero were converted to 0.001 • We also excluded indicators that had any missing values across subnational areas in any of the three countries, and those with zero variance across all three countries
Statistical methods	12	(a) Describe all statistical methods, including those used to control for confounding	31	• We developed a novel approach to estimate the quality of childbirth care by applying concepts from latent variable theory to the above indicators. We computed a composite index for quality of childbirth care at the subnational level by calculating the weighted geometric mean of the available indicators, equation 1... package “stats” to perform NLO.
		(b) Describe any methods used to examine subgroups and interactions		• n/a
		(c) Explain how missing data were addressed	30	• We also excluded indicators that had any missing values across subnational areas in any of the three countries, and those with zero variance across all three countries • Ultimately, 39 of the 59 indicators were used in the analysis
		(d) <i>Cross-sectional study</i> —If applicable, describe analytical methods taking account of sampling strategy		• n/a
		(e) Describe any sensitivity analyses	32	• Our team constructed sixteen scenarios within three broad types of sensitivity analyses to determine the impact of methodological decisions on model outputs: 1) Managing zero values – four scenarios; 2) Managing uniform binary variables – eight scenarios; 3) Managing mixed format data (e.g. binary and proportion) – four scenarios. • <i>Full sensitivity analyses in supplementary materials</i>
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	28	• KIs (24, 25, and 25 KIs in Nepal, Senegal, and Zambia, respectively) were conducted • <i>Other questions not relevant for study design – secondary data was used</i> • <i>Information about sample size of secondary data sources in supplementary materials</i>
		(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		• <i>List of study participants available in supplementary materials</i>
		(b) Indicate number of participants with missing data for each variable of interest		• n/a
Outcome data	15*	<i>Cross-sectional study</i> —Report numbers of outcome events or summary measures		• Subsection titled “Effective SHP coverage estimates”
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	7, 9	• The NLO algorithm generated unit-less weights for 39 indicators. Although the absolute value of the weights is uninteresting to interpret, their relative values reflect how well they uniquely predict ENMR. These weights ranged from 0.018 to 0.036, as shown in Figure 3. Five indicators had a weight above 0.03, and four indicators had weights below 0.02, with the remaining middle 29 indicators displaying little variability. The five highest weighted indicators (most predictive of ENMR) are: Presence of a national compulsory continued professional development system, Presence of a national licensing, relicensing and registration system, Presence of a national education regulation system, Proportion of health facilities with electricity available at all times • Figure 4 compares crude SHP coverage and effective SHP coverage linear regression results, both using ENMR as an outcome variable. As shown in Panel A, crude SBA has almost no correlation with ENMR at the subnational level in these three countries (slope = -2.33, R² <0.01). Effective SHP coverage was confirmed to have a stronger relationship with ENMR, shown in Panel B, (slope = -33, R²=0.18).
		(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

		Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	8	Crude SHP coverage as measured by the DHS and our calculated effective SHP coverage were plotted for all 29 provinces/regions across the three Exemplar countries, as presented in Figure 4. Crude SHP levels ranged from 84% to 100% in Senegal, from 50% to 77% in Nepal, and from 30% to 79% in Zambia. Comparatively, our analysis suggests that the subnational effective SHP coverage ranges from 18% to 30% in Senegal, 25% to 43% in Nepal, and 12% to 35% in Zambia.
Discussion				
Key results	18	Summarise key results with reference to study objectives	9-11	This analysis demonstrates that, even in Exemplar settings, quality of childbirth care provided by skilled health personnel (SHP) is often a larger barrier than coverage (i.e. quantity) to reducing to maternal and newborn mortality. While this analysis only focused on Nepal, Senegal and Zambia, it implies that other low- and middle-income countries (LMICs) may face more severe gaps in quality care, because these Exemplar countries represent some of the highest-performing health systems among LMICs (32,35–37). We estimate that between 12% to 43% of live births were attended by a SHP with adequate quality of care to avert preventable mortality, compared to a range from 30% to 100% of births attended by any SHP at all.
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	13,14	- the choice of ENMR as the outcome against which to weigh indicators - Data availability and quality are also challenges, as data are limited in their ability to track the range of signals of quality, and are only collected intermittently. - As such, many of the indicators in this analysis depended on unique reports, assessments and data sources that are not typically in the public domain, which may present a barrier to replicating this analysis in other settings or validating the exact results herein.
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	9, 12, 14	- While this analysis only focused on Nepal, Senegal and Zambia, it implies that other low- and middle-income countries (LMICs) may face more severe gaps in quality care, because these Exemplar countries represent some of the highest-performing health systems among LMICs - If such a substantial quality gap is detectable in Exemplar countries, then the global disconnect between increasing SHP coverage rates and plateauing mortality rates may well be explained by stagnating quality of care.
Generalisability	21	Discuss the generalisability (external validity) of the study results	14	- this analysis offers valuable insight into an ongoing global health challenge, specific estimates that may aid decision-making in three countries, and an approach to measuring the quality and effective coverage that is both valid and replicable. - It further identifies several simplified indicators that could be employed for routine monitoring, thereby reducing reliance on complex statistical methods.

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	15	This work received funding from the Bill & Melinda Gates Foundation, Gates Ventures, the Global Financing Facility, the United Nations Population Fund, and the United Nations Children's Fund. The WHO MoNITOR (Mother and Newborn Information for Tracking Outcomes and Results) Advisory Group and Gates Ventures participated in the study conceptualization and design and Gates Ventures participated in the analysis and synthesis of results. Remaining funders of the study had no role in study design, data collection, data analysis, data interpretation, or writing of the report.

Supplementary Table 11: Completed GATHER Statement—Guidelines for Accurate and Transparent Health Estimates Reporting



Checklist of information that should be included in new reports of global health estimates

Item #	Checklist item	Reported on page #
Objectives and funding		
1	Define the indicator(s), populations (including age, sex, and geographic entities), and time period(s) for which estimates were made.	8
2	List the funding sources for the work.	15
Data Inputs		
<i>For all data inputs from multiple sources that are synthesized as part of the study:</i>		
3	Describe how the data were identified and how the data were accessed.	28
4	Specify the inclusion and exclusion criteria. Identify all ad-hoc exclusions.	29, 30
5	Provide information on all included data sources and their main characteristics. For each data source used, report reference information or contact name/institution, population represented, data collection method, year(s) of data collection, sex and age range, diagnostic criteria or measurement method, and sample size, as relevant.	22, 28, Supplementary Table 1, Supplementary Table 6
6	Identify and describe any categories of input data that have potentially important biases (e.g., based on characteristics listed in item 5).	Supplementary Table 6
<i>For data inputs that contribute to the analysis but were not synthesized as part of the study:</i>		
7	Describe and give sources for any other data inputs.	Supplementary Table 5
<i>For all data inputs:</i>		
8	Provide all data inputs in a file format from which data can be efficiently extracted (e.g., a spreadsheet rather than a PDF), including all relevant meta-data listed in item 5. For any data inputs that cannot be shared because of ethical or legal reasons, such as third-party ownership, provide a contact name or the name of the institution that retains the right to the data.	Data available in Code Ocean capsule https://codeocean.com/capsule/4055409/tree
Data analysis		
9	Provide a conceptual overview of the data analysis method. A diagram may be helpful.	Extended Data Figure 7

10	Provide a detailed description of all steps of the analysis, including mathematical formulae. This description should cover, as relevant, data cleaning, data pre-processing, data adjustments and weighting of data sources, and mathematical or statistical model(s).	28-32
11	Describe how candidate models were evaluated and how the final model(s) were selected.	31, 32, Supplementary Tables 2 and 3
12	Provide the results of an evaluation of model performance, if done, as well as the results of any relevant sensitivity analysis.	32, Supplementary Tables 2 and 3
13	Describe methods for calculating uncertainty of the estimates. State which sources of uncertainty were, and were not, accounted for in the uncertainty analysis.	n/a
14	State how analytic or statistical source code used to generate estimates can be accessed.	34, Data available in Code Ocean capsule https://codeocean.com/capsule/4055409/tree
Results and Discussion		
15	Provide published estimates in a file format from which data can be efficiently extracted.	Data available in Code Ocean capsule https://codeocean.com/capsule/4055409/tree
16	Report a quantitative measure of the uncertainty of the estimates (e.g. uncertainty intervals).	n/a
17	Interpret results in light of existing evidence. If updating a previous set of estimates, describe the reasons for changes in estimates.	9-11
18	Discuss limitations of the estimates. Include a discussion of any modelling assumptions or data limitations that affect interpretation of the estimates.	13,14

This checklist should be used in conjunction with the GATHER statement and Explanation and Elaboration document, found on gather-statement.org

Stevens GA, Alkema L, Black RE, Boerma JT, Collins GS, Ezzati M, et al. Guidelines for accurate and transparent health estimates reporting: The GATHER statement. Lancet. 2016. doi: [http://dx.doi.org/10.1016/S0140-6736\(16\)30388-9](http://dx.doi.org/10.1016/S0140-6736(16)30388-9)