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Original Article

Quality of clinical assessment and child mortality: a three-country cross-sectional study

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Abstract

This analysis describes specific gaps in the quality of health care in Central Africa and assesses the association between quality of clinical care and mortality at age 2–59 months. Regionally representative facility and household surveys for the Democratic Republic of the Congo, Cameroon and Central African Republic were collected between 2012 and 2016. These data are novel in linking facilities with households in their catchment area. Compliance with diagnostic and danger sign protocols during sick-child visits was observed by trained assessors. We computed facility- and district-level compliance indicators for patients aged 2–59 months and used multivariate multi-level logistic regression models to estimate the association between clinical assessment quality and mortality at age 2–59 months in the catchment areas of the observed facilities. A total of 13 618 live births were analysed and 1818 sick-child visits were directly observed and used to rate 643 facilities. Eight percent of observed visits complied with 80% of basic diagnostic protocols, and 13% of visits fully adhered to select general danger sign protocols. A 10% greater compliance with diagnostic protocols was associated with a 14.1% (adjusted odds ratio (aOR) 95% CI: 0.025–0.244) reduction in the odds of mortality at age 2–59 months; a 10% greater compliance with select general danger sign protocols was associated with a 15.3% (aOR 95% CI: 0.058–0.237) reduction in the same odds. The results of this article suggest that compliance with recommended clinical protocols remains poor in many settings and improvements in mortality at age 2–59 months could be possible if compliance were improved.

Keywords: Child health, quality of care

Introduction

Despite annual mortality reductions of 4.1% over the past 15 years, sub-Saharan Africa remains the region with the highest under-5 mortality rate in the world (UNICEF, 2015). Sustainable Development Goal 3 aims to end preventable deaths of newborns and children under age 5 by 2030, with all countries aiming to reduce under-5 mortality to at most 25 per 1000 live births (United Nations, 2015). Major efforts will be necessary to reach this target

Key Messages

- The results of this study show remarkably poor compliance with these diagnostic protocols for the diagnosis of children under age 5 with acute health problems.
- Using a novel data set in three Central African countries, we find that failure to comply with basic diagnostic protocols was associated with substantial excess child mortality.
- The findings highlight the need for major improvements in the quality of diagnosis and care in low-income settings.

Table 1 Analytic samples

Survey instruments	Analytic sample	N
Direct observation of clinical consultations + client exit interviews	Descriptive quality analysis	1818 sick-child visits
Direct observation of clinical consultations + household survey	Descriptive mortality analysis and regression analysis of births within 3 years in the district catchment area	13 618 live births in 68 district catchment areas
	Descriptive mortality analysis and regression analysis of births within 5 years in the district catchment area	19 671 live births in 68 district catchment areas
	Descriptive mortality analysis and regression analysis of births within 3 years in the facility catchment area	6861 live births in 459 facility catchment areas
	Descriptive mortality analysis and regression analysis of births within 5 years in the facility catchment area	10 032 live births in 459 facility catchment areas

in West and Central Africa, where an estimated 98.7 under-5 deaths occurred per 1000 live births in 2015 (You *et al.*, 2015).

Both verbal and social autopsies suggest that well over 80% of these deaths occur after children are seen by a modern medical provider (Sodemann *et al.*, 1997; de Savigny *et al.*, 2004; Källander *et al.*, 2008; Rutherford *et al.*, 2009; 2010; Willcox *et al.*, 2018). Although treatment is undoubtedly sought too late in some instances, delays in treatment seeking are unlikely to fully explain the continued high burden of child mortality. While several recent studies highlight the substantial deficiencies in various domains of quality of care, there is very little evidence directly linking the quality of healthcare services to child health outcomes (Rutherford *et al.*, 2010; Fink *et al.*, 2015; Leslie *et al.*, 2016a,b; Gage *et al.*, 2017; Sharma *et al.*, 2017). An important reason why estimates of the empirical relationship between quality of care and health outcomes are rare is the lack of population-level health data that can be directly linked to measures of the quality of clinical care received.

In this article, we explore a unique three-country data set with random samples of households in the catchment areas of each facility to assess both the quality of clinical assessments for children under age 5 and the degree to which the quality of clinical care predicts mortality at age 2–59 months in each district's catchment area.

Materials and methods

Study population and sampling

The data for this study were produced as part of ongoing Results-Based Financing projects supported by the World Bank and the Health Results Innovation Trust Fund. Detailed information on a set of facilities, as well as a random subset of households in the catchment areas of each facility, was collected. In this study, we analysed the baseline surveys from Cameroon, Central African Republic (CAR) and Democratic Republic of Congo (DRC). Survey instruments are available online (World Bank Group, 2014a,b,c; 2015; 2017a,b). Samples were representative at the subnational level: select regions in Cameroon, select prefectures in CAR and select zones areas in DRC. Sampling of facilities and households was done in a three-step sampling procedure. The World Bank selected subnational areas for the Results-Based Financing projects in discussion with the national Ministry of Health. First, facilities were randomly selected in target areas. Second, up to two enumeration areas (EAs) were randomly selected from each catchment area of selected facilities. Third, a random subset of households in the selected EAs was chosen for the household interview.

Facility assessments included facility audits, direct observations of clinical consultations, staff interviews and client exit interviews. Household surveys included in-person questionnaires centered around maternal and child health. All household surveys were restricted to households with at least one woman who had been pregnant or delivered a child within 2 years of the survey. Survey-specific sampling designs and the timing of data collection are detailed in Supplementary Table S1.

Data access was granted by the World Bank Microdata Library, and data analysis was supported by the respective country research teams. Construction of the pooled samples is detailed in Supplementary Figures S1 and S2 and summarized in Table 1.

Quality of care

The primary exposure of interest was the quality of clinical assessment in sick-child visits at facilities. As part of the facility survey, trained surveyors followed sick children of consenting caregivers throughout their facility visits and tracked healthcare providers' diagnostic procedures using a checklist. The facility survey only considered children presenting with a new condition (i.e. not follow-up or routine visit). At the end of the visit, caregivers were invited to complete an exit interview, which solicited information about perceived quality of care, cost, and prescriptions.

Based on Integrated Management of Childhood Illness (IMCI) guidelines, we identified 15 procedures that are essential to diagnosis in all sick-child visits for patients aged 2–59 months and within control of the clinician (Box 1). A full description of the selected

Table 2 Clinical assessment protocols

	Protocol	Original survey question
History taking	Inability to drink anything	Has the health worker asked if the child can drink or take breast milk?
	Cough or difficult breathing	Has the health worker asked if the child has cough or difficulty breathing?
	Diarrhoea	Has the health worker asked when the patient has diarrhea?
	Fever	Has the health worker asked if the child had a fever for the last 24 hr?
	Vomiting	Has the health worker asked if the child vomits anything he takes?
	Convulsions	Did the health worker ask if the child had convulsions?
	Ear problems	Has the health worker asked if the child has pain or discharge in the ear?
Routine examination	Weight	Has a health worker weighed the child?
	Temperature	Has a health worker taken the child temperature? Or has the health worker checked the temperature if it had not been done by an agent before?
	Pallor	Alternative wording: (1) Has the health worker checked the child's eyes or the palms of the hands, or the soles of the feet (anaemia)? (2) Does the health worker check the palms of the child's hands, or compare these against the mother's? (anaemia)
	Oedema of feet	Has the health worker looked at both feet or both ankles (oedema)?
	Skin turgor	Has the health worker checked skin pinch/folds?
	Ear examination	Did the health worker look in his ears?
	Count respirations	Has the health worker checked the respiratory rate?
	Undressed child for examination	Alternative wording: (1) Has the health worker undressed the child? (2) Does the health worker lift shirt?

'Temperature examination' is considered complete if it is conducted by either (1) a health worker prior to consultation or (2) the healthcare worker during the consultation.

procedures, underlying survey questions and details of the coding of survey items is provided in Table 2. To allow for minor protocol deviations and measurement error, we coded a visit as compliant with diagnostic protocols if at least 80% of required procedures were completed by the provider. While we would be interested in a sensitivity analysis of higher thresholds that allow for less deviations or measurement error, we are limited by increasingly small data variation at higher threshold levels. Missing information on any procedure was imputed as the mean of other procedures observed in the consultation. We also conducted a sensitivity analysis where missing items were assigned a minimum (0) or maximum (1) value.

In addition to our broad diagnostic compliance measure, we constructed a narrower measure focusing on healthcare providers' efforts to collect information on general danger signs. IMCI guidelines require clinicians to solicit a patient history of three general danger signs (continued vomiting, convulsions and inability to drink) and observe the child's energy level and convulsion status in all sick-child visits (World Health Organization, 2014). We focused the narrower measure of compliance on verbal assessment of the three general danger signs given the difficulty in measuring providers' assessment of children's energy level and convulsions status through direct observation. Henceforth, we refer to continued vomiting, convulsions and inability to drink as select general danger signs to distinguish from the set of general danger signs that includes current convulsion status and energy level. Visits were coded as compliant with select general danger sign protocols if information on continued vomiting, convulsions and inability to drink was collected by the healthcare provider.

Verifying these signs of severe disease is essential to identify potentially fatal prognoses for immediate referral; WHO uses such compliance as the top priority indicator for the evaluation of IMCI (World Health Organization, 2003). However, evidence from sub-Saharan Africa after implementation of the IMCI strategy suggests that danger signs are regularly missed in fatal cases, and healthcare providers can better identify mild than severe disease (Horwood *et al.*, 2009; Willcox *et al.*, 2018).

Both compliance measures were computed for each sick-child visit and then collapsed at the district or facility level for analytical purposes as described in detail below. Districts refer to sub-prefectures in CAR, health districts in DRC and arrondissements in Cameroon.

Mortality

The primary health outcome of interest was under-5 mortality. Given the restriction of our quality measure to patients aged 2–59 months, we restricted mortality to the same age range. Household surveys asked women with a birth or pregnancy in the last 2 years to report 10-year or full birth histories. To reduce temporal differences between the quality measurement and survival outcomes, we restricted our main analysis to children born in the 3 years prior to the survey. In cases where the month or date of birth was missing, we assumed children were born in the middle of the month and year, respectively, per international guidelines (O'Donnell *et al.*, 2007). In a sensitivity analysis, we assume that children with a missing month or date of birth were born at the beginning or end of the month and year. Children with missing year of birth were omitted from analysis.

Covariates

To describe the quality of observed sick-child visits, the following facility survey covariates were included in our analysis: survey country, provider cadre, facility level, household asset quintile and reported symptom. Country-specific asset scores were developed from caretaker-reported information using principal components analysis and quintile classification. Facility and healthcare provider types were standardized for comparison across countries. Patient symptom(s) were recorded in both direct observation of clinical consultations and caretaker exit interviews. Importantly, these symptoms have no bearing on the general IMCI protocols considered in this study, which apply to all sick-child visits.

In the mortality analysis, we include known predictors of child mortality to improve the precision of our estimates, as well as catchment-level predictors of child mortality to control for potential sources of confounding. Household-level survey covariates include the number of mother's previous live births, maternal education group (none, primary and secondary) and maternal age (15–19, 20–34 and 35–44 years), while catchment-level covariates include the average asset quintile, portion of households using improved sanitation and the portion of households using improved water source. Covariate selection was restricted by measurements available in the household surveys. Furthermore, we included fixed effects for country-province and year of birth to control for measurement differences across surveys, time trends and province-level characteristics associated with both quality and morality.

Statistical analysis

The main objective of the project was to use the linked databases to estimate empirical association between quality of care observed at facilities and mortality at age 2–59 months reported in catchment areas served by the same facilities. First, we computed diagnostic and select general danger sign binary compliance indicators for all sick-child visits and presented average compliance results by facility, provider and patient characteristics. We also stratified the probability of death among live births within 3 years of the survey by patient characteristics.

To analyse the association between quality of clinical assessment and mortality at age 2–59 months, we estimated an intention-to-treat model in which we regressed individual mortality at age 2–59 months on the unweighted average quality of clinical assessments observed in the catchment area. We estimated a multi-level logistic model with catchment area random effects to account for correlation of the residuals for live-births therein. A more detailed description of the statistical model is provided in the Supplementary Material (Section 1). Given that caregivers do not necessarily seek care at the facility to which they are administratively assigned, we aggregated quality of care at the district level in our primary analysis. Health districts are usually large and, thus, likely to contain all facilities that caregivers will typically access. In our sensitivity analysis, we also estimated the association between quality and health outcomes at the facility level; we expected these associations to be weaker due to caregivers use of facilities outside the area to which they are administratively assigned (i.e. bypassing). Given that quality of care likely changes over time due to provider attrition or behavior change, we restrict mortality to 3 years prior to the survey in our main analysis. While even shorter time windows would be desirable, sample sizes become too small to allow meaningful statistical analysis. In our sensitivity analysis, we present models using longer time windows. In addition, we estimated adjusted models in which we regressed mortality at age 2–59 months on the average compliance with each individual protocol in our sensitivity analyses. All statistical analyses were conducted in Stata/MP 15 (StataCorp, 2017).

We cannot rule out the possibility of residual confounding, so we present these results as associational evidence. There is potential for residual confounding if the measured covariates are

Table 3 Characteristics of sick-child visits observed in the facility survey

	DRC		CAR		Cameroon		All	
	n	%	*n*	%	*n*	%	*n*	%
Observations	1018		590		210		1818	
Providers	325		223		95		643	
Facilities	280		211		25		516	
Age of patient								
2–11 months	222	22	178	30	74	35	474	26
12–23 months	235	23	178	30	55	26	468	26
24–35 months	206	20	108	18	28	13	342	19
36–47 months	163	16	72	12	22	10	257	14
48–59 months	192	19	54	9	31	15	277	15
Sex of patient								
Male	568	56	322	55	107	51	997	55
Female	450	44	268	45	103	49	821	45
Literacy of caretaker								
Literate	650	64	161	27	156	74	967	53
Illiterate	368	36	429	73	54	26	851	47
Provider cadre								
Physician	196	19	6	1	44	21	246	14
Nurse	692	68	120	20	56	27	868	48
Health assistant, community health worker	N/A	N/A	437	74	34	16	471	26
Others	130	13	27	5	76	36	233	13
Facility level								
Secondary	248	24	63	11	40	19	351	19
Primary	770	76	527	89	170	81	1467	81
Reported symptom								
Fever	788	87	295	78	104	55	1187	80
Cough, difficulty breathing	326	37	123	27	80	42	529	35
Vomiting	202	22	149	33	N/A	N/A	351	26
Diarrhea	169	18	183	39	34	17	386	24
Fatigue	188	23	29	6	N/A	N/A	217	17
Others	67	7	38	8	28	14	133	8

Sample represents those children age 2–59 months seeking curative care services (illness or injury) whose caretakers consented to both direct observation of the clinical consultation and exit interview. Reported symptoms reflect those reported in both the observed clinical consultation and exit interview. Each observation corresponds to a visit in one of the sampled facilities. All means represent unweighted sample averages. Not applicable is abbreviated N/A.

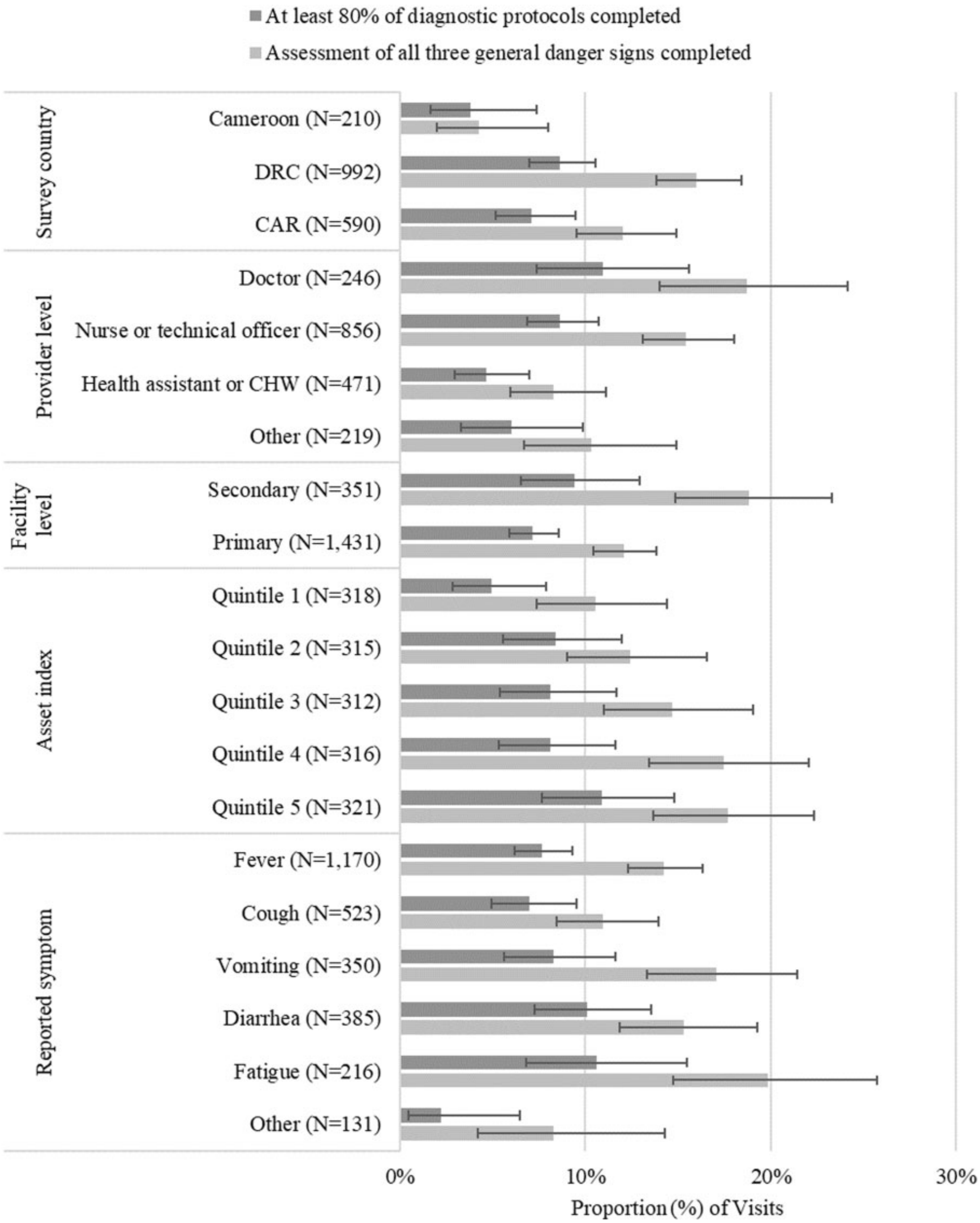

Figure 1 Average compliance by patient, provider and facility characteristics in survey year ($N = 1818$). Sample represents those children age 2–59 months seeking curative care services (illness or injury) whose caretakers consented to both direct observation of the clinical consultation and exit interview. Error bars represent 95% confidence intervals. Each observation corresponds to a visit in one of the sampled facilities. No sample weights were applied

imprecise or catchment-level confounders are unmeasured altogether. For example, it is possible that poor-quality diagnostic health services collocate with the coverage of preventive health interventions (e.g. vaccination) within provinces. Given the paucity of any preexisting evidence in this area, this associational evidence represents a novel contribution to the study of quality of care and child health outcomes.

Results

In 516 facilities, 1818 sick-child visits with 643 healthcare providers were directly observed. Table 3 presents patient, provider and facility characteristics of the sick-child visits by survey country. In the pooled sample, over half of the patients were under age 2 at the time of the clinic visit and fever was reported more than twice as often as

Table 4 Characteristics of live births within three years of the household survey ($N = 13\,618$)

	Live births		Death at age 2–59 months		Probability of death at age 2–59 months (%)
	n	%	*n*	%	
Live births	13 618				
Deaths			415		
Catchment districts	68		68		
Province	16		16		
Birth timing					
2–12 months	6022	44	54	13	0.9
13–24 months	4432	33	148	36	3.3
25–36 months	3164	23	213	51	6.7
Maternal education					
None	4530	33	190	46	4.2
Primary	5604	41	163	39	2.9
Secondary and above	3484	26	62	15	1.8
Maternal age					
15–19	1933	14	56	13	2.9
20–34	9801	72	303	73	3.1
35–49	1884	14	56	13	3.0
Live births (mother)					
0	112	1	3	1	2.7
1	2595	19	51	12	2.0
2	2842	21	77	19	2.7
3	2293	17	81	20	3.5
4	1874	14	62	15	3.3
5+	3902	29	141	34	3.6
Portion of district households using improved sanitation					
0–24%	5576	41	132	32	2.4
25–59%	2693	20	73	18	2.7
50–74%	2546	19	94	23	3.7
75–100%	2803	21	116	28	4.1
Portion of district households using improved water source					
0–24%	2725	20	69	17	2.5
25–59%	3561	26	88	21	2.5
50–74%	3681	27	126	30	3.4
75–100%	3651	27	132	32	3.6
Country					
Cameroon	3757	28	75	18	2.0
CAR	5861	43	252	61	4.3
DRC	4000	29	88	21	2.2

Sample represents those live births in catchment areas supported by direct observation of clinical consultation for children age 2–59 months seeking curative care services (illness or injury), regardless of whether the caretaker also consented to exit interview. All means represent unweighted sample averages.

any other symptom (80%). In the CAR survey, the literacy rate among caretakers (27%) was less than half that in the other two surveys (65% in DRC and 74% in Cameroon). While the dominant site of clinical consultation was primary care facilities across survey countries, the most common healthcare provider varied widely: nurses in DRC (68.6%), health assistant or community health worker in CAR (74.1%) and other health professionals in Cameroon (36.2%).

Among clinical assessments, 7.6% (SD: 26.5%) completed at least 80% of diagnostic protocols and only 14 (0.77%) followed 100% of diagnostic protocols. The proportion of observed sick-child visits in which the provider inquired about all three select general danger signs ranged from 4.3% (SD: 20.3%) in Cameroon to 16.0% (SD: 36.7%) in DRC. Information on compliance with individual procedures using mean and alternative imputation approaches for missing data is provided in Supplementary Figure S3. While this is not an evaluation, it is worth nothing that 37% ($N = 679$) of providers across all survey countries reported having been trained in IMCI.

Figure 1 shows average compliance with diagnostic and select general danger sign protocols by patient, provider and facility characteristics. On average, doctors performed better than lower-level healthcare workers, secondary facilities performed better than primary facilities and wealthier patients received higher-quality assessments than poorer patients.

For our mortality analysis, 13 618 children born within 3 years of the household survey were analysed. Table 4 shows that most children were born to mothers who either had attended primary schooling (41%) or had no education (33%); only 26% of children had a mother who had completed secondary schooling or higher. Nearly a third of children were born to mothers who had given birth to five or more children by the time of the survey. In the pooled sample, 3.0% of live births within 3 years of the household survey had died by the time of the survey. The probability of death at age 2–59 months was highest in CAR (4.3%; SD: 20.3%), followed by Cameroon (2.0%; SD 14.0%) and DRC (2.2%; SD: 14.7%).

The results from adjusted and unadjusted logistic models of mortality at age 2–59 months are presented in Table 5. In the adjusted

Table 5 Adjusted and unadjusted logistic models of death at age 2–59 months on quality indices using district catchment areas and three-year birth histories

	Death at age 2–59 months (odds ratio)			
	Unadjusted	Adjusted	Unadjusted	Adjusted
Disease diagnostic protocol compliance	0.268 (0.083–0.865) [0.028]	0.218 (0.061–0.779) [0.019]		
Select general danger sign compliance			0.245 (0.092–0.649) [0.005]	0.191 (0.067–0.549) [0.002]
Live births		1.053 (1.001–1.108) [0.047]		1.055 (1.003–1.111) [0.038]
Maternal age				
15–19		1.236 (0.900–1.696) [0.191]		1.245 (0.907–1.709) [0.176]
20–34		Ref (1.0)		Ref (1.0)
35–49		0.791 (0.561–1.115) [0.180]		0.783 (0.555–1.104) [0.163]
Maternal education				
No schooling		Ref (1.0)		Ref (1.0)
Primary		0.797 (0.628–1.012) [0.063]		0.809 (0.637–1.027) [0.081]
Secondary +		0.668 (0.473–0.943) [0.022]		0.679 (0.481–0.959) [0.028]
District: asset quintile		0.920 (0.689–1.229) [0.573]		0.928 (0.694–1.241) [0.615]
District: % improved sanitation		0.314 (0.035–2.821) [0.301]		0.195 (0.021–1.790) [0.148]
District: % improved water		3.292 (0.433–24.999) [0.249]		4.468 (0.580–34.414) [0.151]
Constant	0.036 (0.026–0.048) [0.000]	0.069 (0.023–0.206) [0.000]	0.034 (0.026–0.046) [0.000]	0.060 (0.020–0.182) [0.000]
Observations	13 618	13 618	13 618	13 618
Number of groups	68	68	68	68
Year of birth FE	No	Yes	No	Yes

All models include district catchment area random effects. All adjusted models include country-province fixed effects and year of birth dummies. Observation units are live births within 3 years of the survey. Disease diagnostic protocol compliance refers to the proportion of sick-child visits in the catchment district for which at least 80% of 15 protocols were assessed. Select general danger sign compliance refers to the proportion of sick-child visits in the catchment district for which all three select general danger signs were assessed. 95% confidence intervals are in parenthesis, and *P*-values are in brackets.

models, a shift in the percentage of visits completing at least 80% of basic diagnostic protocols from 0% to 100% (a one unit increase in compliance) was associated with a 78.2% reduction in the odds of mortality at age 2–59 months (adjusted odds ratio (aOR) 95% CI: 0.061–0.779), while a unit increment in select general danger sign compliance was associated with a 80.9% reduction in the odds of mortality (aOR 95% CI: 0.067–0.549). A more conservative 10-percentage point increment in compliance with diagnostic and select general danger sign protocols was associated with a 14.1% and 15.3% decline in the odds of mortality at age 2–59 months, respectively. Substantially increased risk was also observed for mothers under age 20, while large protective effects were found for primary and secondary schooling. Supplementary Table S2a and b presents the results of the main models with alternate date and month of birth imputation assumptions, and Supplementary Table S3a and c presents the results of the main models by survey country. Note that the Cameroon and DRC surveys may be under powered to precisely identify the quality–mortality association. The distribution of the exposure variables among catchment districts is illustrated in Supplementary Figure S4a and b.

Table 6 compares the results of sensitivity analyses, in which we expand the timeline analysed from 3 to 5 years (columns 1, 3, 4 and 6) and narrow our measurement of quality from the district to facility level (columns 2, 3, 5 and 6). Supplementary Figure S4c and d illustrates the distribution of facility-level quality. When we expand the time window alone (Table 6, columns 1 and 4), we observe

Table 6 Sensitivity analysis: adjusted logistic models of death at age 2–59 months on quality indices using different spatial coding and time windows

	Death at age 2–59 months (odds ratio)					
	(1)	(2)	(3)	(4)	(5)	(6)
Catchment area	District	Facility	Facility	District	Facility	Facility
Birth history	5 years	3 years	5 years	5 years	3 years	5 years
Disease diagnostic protocol compliance	0.313 (0.110–0.889) [0.029]	0.805 (0.324–2.001) [0.640]	1.027 (0.542–1.947) [0.935]			
Select general danger sign compliance				0.359 (0.160–0.802) [0.013]	0.564 (0.281–1.129) [0.106]	0.596 (0.369–0.961) [0.034]
Constant	0.044 (0.015–0.122) [0.000]	0.092 (0.030–0.283) [0.000]	0.083 (0.032–0.214) [0.000]	0.041 (0.015–0.116) [0.000]	0.095 (0.031–0.292) [0.000]	0.087 (0.034–0.223) [0.000]
Observations	19 671	6511	9682	19 671	6511	9682
Number of groups	68	457	458	68	457	458

All models include catchment area random effects (facility or district), country-province fixed effects and year of birth dummies, while controlling for live births ever born to the mother, maternal age (15–19, 20–34 and 35–44 years), maternal education group (none, primary and secondary), average asset quintile in the catchment area, portion of catchment households using improved sanitation and the portion of catchment households using improved water source. Observation units are live births; 350 live births were dropped from adjusted models using facility catchment areas because no deaths were observed among those born in 2015. Disease diagnostic protocol compliance refers to the proportion of sick-child visits in the catchment area for which at least 80% of 15 protocols were assessed. Select general danger sign compliance refers to the proportion of sick-child visits in the catchment area for which all three select general danger signs were assessed. 95% confidence intervals are in parenthesis, and *P*-values are in brackets.

weaker associations between district clinical quality and mortality at age 2–59 months. When we consider the expanded time window and facility-level quality (Table 6, columns 3 and 6), our estimates shrunk further. Among those, however, only the estimated association between select general danger sign compliance and mortality at age 2–59 months (Table 6, column 6) was statistically indistinguishable from a null effect: aOR 95% CI: 0.369–0.961.

Supplementary Figure S5 presents further sensitivity analyses for the main adjusted model, in which we consider the relationship between the proportion of district consultations complying with each protocol item and mortality at age 2–59 months separately. For most (11/15) protocols, the relationship is not statistically significant at the 0.05 level.

Discussion

We used a novel data set from three countries to assess the quality of clinical care received by children under age 5, as well as the relationship between average clinical quality and mortality at age 2–59 months. Overall compliance with clinical assessment guidelines was remarkably poor. Providers completed at least 12 of 15 basic diagnostic protocols (i.e. 80%) in only 8% of observed sick-child visits and assessed all three select general danger signs in only 13%, with relatively small differences across health provider cadres. IMCI training was low in these areas, and we may expect to find different results in similar areas with more trained healthcare workers. Experimental and non-experimental evidence suggests that IMCI and other trainings centered on childhood illness increase provider performance, where performance is defined by compliance with diagnostic protocols or the correct classification of sick children up to 2 years out. Even with these improvements, however, provider performance remained low in study settings (Nguyen *et al.*, 2013; Leslie *et al.*, 2016). Recent literature suggests that poor-quality child health services undermine gains in the utilization of such services, while signaling poor-quality maternal, and newborn health services too (Leslie *et al.*, 2017). More research is needed to identify the drivers of quality disparities across patient profiles suggested by this analysis.

The central result of our analysis is that failure to comply with basic diagnostic protocols is associated with substantial excess mortality at age 2–59 months. After controlling for individual, maternal and household, characteristics, we found that children faced 14.1% lower odds of mortality for every 10% increase in compliance with basic diagnostic protocols during sick-child visits at the district level, when compliance is defined as completing 80% of the recommended clinical items. We found similar associations for compliance with select general danger sign protocols, which are central to the assessment of disease severity in IMCI protocols. Although child survival is the focus of this analysis, it is important to note that better case management of non-fatal disease confers other benefits including decreased morbidity, reduced over-prescription, infectious disease control and improved utilization of and satisfaction with the health system (Audo *et al.*, 2005; Maina *et al.*, 2017).

Empirical evidence of the impact of clinical quality on child mortality has largely been limited to evaluations of the IMCI strategy; those results have been mixed to-date and fail to isolate the effect of the sub-component to improve case management (Ahmed *et al.*, 2010; Rakha *et al.*, 2013; Gera *et al.*, 2016). Cross-sectional data analyses are rare due to need for households and facilities to coincide geographically and temporally. The only such study we identified relied on strong econometric assumptions in a narrow context (Leslie *et al.*, 2016). Our results suggest that the empirical relationship between the quality of clinical assessment and child health outcomes is indeed strong. As such, health system performance measurement should emphasize quality, in addition to quantity.

These findings are particularly consequential to the structure of quality improvement interventions at a time when existing models are yet unproven or falling short. In a wide range of sub-Saharan African settings, resource-intensive models of training and supervision have demonstrated small improvements in compliance with basic clinical protocols in sick-child visits (Leslie *et al.*, 2016). The impact of alternative models, such as performance-based financing, quality improvement collaboratives and a broad range of other stand-alone strategies, on similar measures of quality processes is mixed or modest at best (Das *et al.*, 2016; Rowe *et al.*, 2018; Garcia-Elorrio *et al.*, 2019). New mechanisms for monitoring and improving clinical quality that focus on the identification of life-threatening cases for immediate referral should be explored.

The main strength of our study is direct sampling of households in the catchment areas of facilities where the quality of care was observed. Our intent-to-treat estimates take into consideration all behavioral responses of households facing high or low quality of care. By assessing quality at the district level, we mitigated potential bypassing-induced measurement error (Kruk *et al.*, 2009). Districts in the survey settings are large; the average district population is over 50 000 in CAR, around 100 000 in Cameroon, so inter-district bypassing should be small. Empirically, district-level associations were larger in magnitude compared to health facility-level analysis, which suggests that bypassing may indeed attenuate the associations observed at the facility level.

Associations observed at the district level may also be attenuated. First, it is possible that mothers underreport or misreport mortality in birth histories (Mahy, 2003). If such errors are more common in high mortality areas, our estimates would be biased towards the null. Second, any changes in quality over time would induce measurement error in the exposure and thus result in attenuation. When we broadened the sample to include more birth cohorts, we indeed found smaller effect sizes. While the observed quality of care in sick-child visits is likely biased upward due to Hawthorne effect, any such effect would be uncorrelated with mortality and not bias our regression results (Leonard and Masatu, 2010). Similar studies omit the first and second observations to minimize bias in our descriptive results, but our data structure does not provide sufficient observations per provider to apply this correction.

The results of our study suggest that focused interventions to improve compliance with IMCI guidelines may have great potential to reduce child mortality in the studied area, as well as similar settings.

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Supplementary data

Supplementary data are available at *Health Policy and Planning* online.

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