Did Political Division and Stockouts Reduce Covid-19 Vaccine Take-Up in Low Income Countries? Evidence from Sierra Leone

By FATU E. CONTEH, RACHEL GLENNERSTER, SAMANTHA HORN, DESMOND M.KANGBAI, ANNE KARING AND SARAH SHAUKAT*

The mass rollout of a novel adult vaccine in the midst of a pandemic required people around the world to place considerable trust in their governments' recommendations and vaccine delivery processes. Vaccine supply disruption risked undermining faith in the process. We use data on the universe of Covid-19 vaccines in Sierra Leone to answer two questions. First, whether the relationship between support for Covid-19 vaccination and support for the party in power holds in a low income environment (Sierra Leone) where trust in vaccines is traditionally high. Second, whether interruptions to vaccine supply reduced take up of second doses.

A correlation between self reported support for Covid-19 vaccines and support for the party in power holds in many high and middle income countries even when the parties in power have very different political ideologies (Goodwin et al., 2022; Halimatusa'diyah and Durriyah, 2022; Yuen, 2022). While Low-Income Countries (LICs) have relatively high trust in vaccines, low trust in central government hindered efforts to control the West Africa Ebola epidemic. We find take-up of Covid-19 vaccines among adults is 18 percentage points lower in areas where Temne (the ethnicity associated with the main opposition party) is the largest ethnicity. We find this disparity is not specific to Covid-19. Temne areas have lower childhood vaccination rates both when the Temne-associated party is in and out of power nationally.

LICs faced highly intermittent Covid-19 vaccine supply as a result of India's vaccine export ban and HICs tendency to donate vaccines at short notice when they were about to expire. The disruptin could reduce long-run vaccine take-up by undermining faith in the vaccine program or create scarcity value and increase long-run demand (Cannon, Goldsmith and Roux, 2019). We estimate the impact of stockouts by comparing the second dose take-up among those whose second dose due date fell just before and after Sierra Leone experienced a stockout of the AstraZeneca vaccine. We find the stockout did not have a statistically significant impact on second dose take-up.

* Conteh: Innovations for Poverty Action, Sierra Leone (email: fatuconteh@ramlabs.org); Glennerster: University of Chicago (email: rglennerster@uchicago.edu); Horn: Carnegie Mellon University (email: samihorn@cmu.edu); Kangbai: Ministry of Health and Sanitation, Sierra Leone (email: desmakay@yahoo.com); Karing: University of Chicago (email: akaring@uchicago.edu); Shaukat: Tufts University (email: sarah.shaukat@tufts.edu).

I. Covid-19 Vaccines in LICs and Sierra Leone

In mid-November 2022, 24% of the population in LICs had received at least one Covid-19 vaccine, compared to 79% in HICs (Our World in Data, 2022). In Sierra Leone, the vaccine rate was 35% overall and 68% for those over 18.

As with other LICs, the initial barrier to take-up in Sierra Leone was supply. Sinopharm vaccines arrived in Sierra Leone in February 2021 followed by AstraZeneca in March. People aged 70 and over, health workers, and people aged 40 and over in key professions were eligible. Eligibility was extended to people aged 30 and over in June 2021, 18 and over in July, and 12 and over in December. AstraZeneca, J&J and Sinopharm were the main vaccines used by adults with 12-18 year-olds exclusively offered Pfizer once they were eligible.

Originally only available in major hospitals, by March 2022 there were nearly 500 vaccine centers with at least one in all 164 chiefdoms. Despite this, as of November 2021, the average rural Sierra Leonean had to travel 1.5 hours each way to receive a vaccine (Mobarak et al., 2022). From August 23, 2021, the government organized "surges" in which health workers visited communities with vaccines and encouraged vaccination.

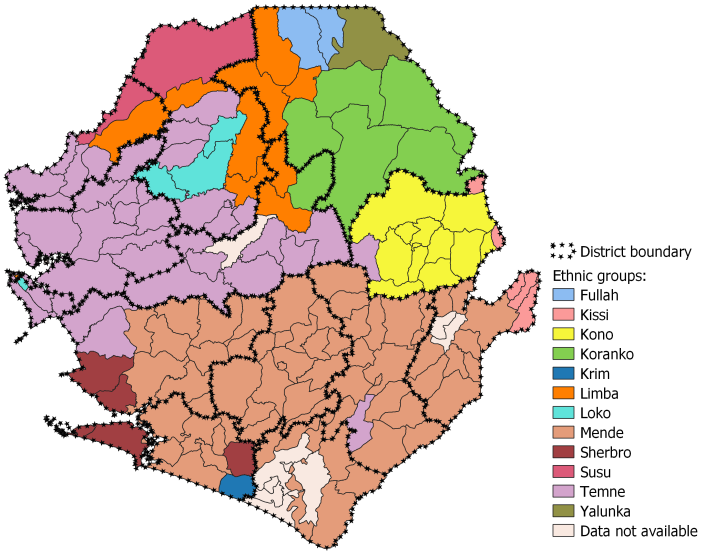

FIGURE 1. CHIEFDOMS AND MAJORITY ETHNIC GROUPS IN SIERRA LEONE

II. Ethnicity and Covid-19 Vaccine Take-up

We utilize data from Sierra Leone's Ministry of Health and Sanitation (MoHS) database of Covid-19 vaccinations which records over 3.7 million doses administered to roughly 2.8 million people over 22 months from March 2021 to December 2022. Data includes clinic, vaccine type, age, occupation, gender, name, address, and phone number. Data on the number of health centers per chiefdom comes from the MoHS. Including this control helps alleviate concerns that differential vaccination rates reflect differential access.

Using data from the 2004 census, we calculate the largest ethnicity in each of Sierra Leone's chiefdoms (Figure 1). The three largest ethnicities are Mende (based in the south and linked with the ruling Sierra Leone Peoples Party (SLPP)), Temne (mainly in the north and associated with the All Peoples Congress (APC) who were in power from 2007-2018) and Kono (based in the east and a politically swing ethnicity). We use the 2015 census data, multiplied by the general population growth rate, to get the chiefdom population and, thus our vaccination rate per chiefdom.[1].

Ethnicity tightly predicts voting in Sierra Leone. In 2007, 92 percent of the variation in people's vote could be predicted by their ethnicity (Casey, Kamara and Meriggi, 2021). To investigate the relationship between political division and Covid-19 vaccine take-up, we estimate the following OLS equation:

$$(1) \quad Y_c = \beta_0 + \beta_1 Temne_c + \beta_2 Kono_c + \beta_3 Other\_Ethnicities_c + \beta_4 Health\_Centers_c + \beta_5 Urban_c + \varepsilon_c$$

where the outcome, Y_c, represents the proportion of people vaccinated with Covid-19 first dose in chiefdom c. $Temne_c$, $Kono_c$, and $Other\_Ethncities_c$ are binary variables that equal one if the respective ethnicity is the largest in a chiefdom. There are 73 Mende (base group), 44 Temne, 12 Kono, and 36 other ethnicity chiefdoms.[2] $Health\_Centers_c$ is a continuous variable and refers to the number of health centers in a chiefdom. $Urban_c$ is a binary variable indicating if a chiefdom is urban. Standard errors are clustered at the district level (the level of health administration). To account for the small number of clusters (16 districts), we present wild cluster bootstrapped p-values. Because the capital – Western Area Urban (WAU) – is ethnically very mixed, we test sensitivity to excluding it.

To examine if the relationship between support for the party in power and vaccine

[1] 2015 population data come from the Directorate of Science, Technology, and Innovation (DSTI) public portal (DSTI, 2019)

[2] In Table A1, we show that our findings stay consistent if we do not club the other ethnicities together.

TABLE 1—ETHNICITY AND PROPORTION VACCINATED IN A CHIEFDOM

	Covid-19 vaccination					Child Immunization (Measles)	
	During first 6 months (Mar - Sep 2021)		During first 12 months (Mar 2021 - Mar 2022)			During SLPP government (2018 - 2019)	During APC government (2012 - 2013)
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Proportion vaccinated w/ Covid-19 first dose	Proportion vaccinated w/ Covid-19 first dose	Proportion vaccinated w/ Covid-19 first dose	Proportion vaccinated w/ Covid-19 first dose	Proportion vaccinated w/ Covid-19 first dose ($\geq 18 years$)	Proportion vaccinated w/ measles first dose	Proportion vaccinated w/ measles first dose
Temne	-0.025	-0.030	-0.063	-0.057	-0.180	-0.039	-0.054
	(0.008)	(0.008)	(0.034)	(0.030)	(0.070)	(0.016)	(0.028)
	[0.036]	[0.006]	[0.075]	[0.080]	[0.049]	[0.055]	[0.064]
Kono	-0.042	-0.041	-0.122	-0.125	-0.319	-0.087	-0.064
	(0.007)	(0.007)	(0.021)	(0.023)	(0.043)	(0.010)	(0.017)
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.028]
Other ethnicities	-0.027	-0.027	-0.059	-0.050	-0.133	-0.061	-0.088
	(0.009)	(0.009)	(0.040)	(0.038)	(0.065)	(0.026)	(0.040)
	[0.009]	[0.013]	[0.256]	[0.264]	[0.051]	[0.078]	[0.046]
Mende Mean	0.068	0.068	0.298	0.298	0.523	0.956	0.885
Number of health centers	✓	✓	✓	✓	✓	n/a	n/a
Urban Dummy	✓	✓	✓	✓	✓	✓	✓
Year Fixed Effects	n/a	n/a	n/a	n/a	n/a	✓	✓
Drop Western Area Urban	✗	✓	✗	✓	✓	✓	✓
Observations	164	156	164	156	136	312	312

Notes: Each column reports results for a single OLS regression of the dependent variable listed in the column heading on the variables listed in the row headings, a binary variable indicating if the chiefdom is urban, the number of health centers (if relevant), and indicators for the year (if relevant). Columns 1 and 3, include observations from Western Area Urban (WAU) in others they are dropped. Standard errors clustered at the district level in parentheses. Wild cluster bootstrapped p-values in square brackets.

takeup is Covid-19 specific, we investigate the relationship between childhood immunization and ethnicity. This also allows us to test whether regional patterns of vaccine takeup change with the party in power. . We estimate the following OLS equation using data from MoHS:

$$(2) \quad Y_{ct} = \beta_0 + \beta_1 Temne_c + \beta_2 Kono_c + \beta_3 Other\_Ethnicities_c + \beta_4 Year_t + \beta_5 Urban_c + \varepsilon_{ct}$$

where the outcome, Y_{ct}, is the proportion of children vaccinated with measles first dose in chiefdom c in year t. We consider two pre-Covid-19 periods: during the ruling party's (SLPP's) government in 2018 and 2019 and during the government of the main opposition party (APC) pre-Ebola in 2012 and 2013. We include year-fixed effects, and the rest of the variables are as defined for Equation 1.

Compared to chiefdoms where Mendes are the largest ethnicity, non-Mende chiefdoms have a lower proportion of people receiving at least one dose of Covid-19 vaccine. In the first 6 months, Temne and Kono areas saw 2.5 and 4.2 percentage points lower vaccine rates, respectively (Column 1 Table 1). The differential rises to 6.3 and 12.2 percentage points by March 2022 and is even higher if calculated as a proportion of those aged 18 and above (Table 1, Columns 3 and 5).[3]

However, this relationship does not only hold for Covid-19 vaccination. We see a similar relationship for childhood immunization: Temne areas have lower childhood vaccination rates both when the Temne-associated party (APC) is in and out of power at a national level (Columns 6 and 7, Table 1).

[3]To capture people's willingness to go out of their way to get vaccinated, we focus our analysis on the first 6 and 12 months. Even when including months with widespread vaccine outreach (since March 2022), non-Mende chiefdoms continue to have a lower proportion of adults vaccinated with Covid-19 first dose, albeit statistically insignificant based on the wild cluster bootstrapped p-values (Table A2, Column 8).

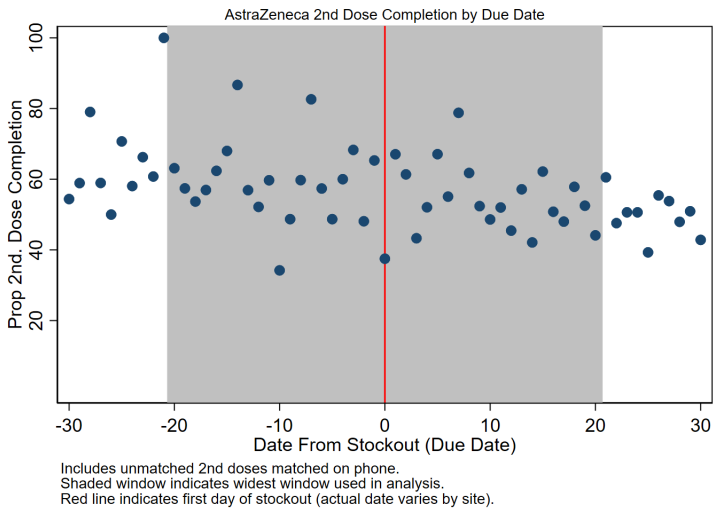

FIGURE 2. SECOND DOSE COMPLETION BY DUE DATE

TABLE 2—STOCKOUTS

	(1) 2nd Dose (14 days)	(2) 2nd Dose (21 days)	(3) 2nd Dose (14 days)	(4) 2nd Dose (21 days)
Stockout	-0.015	−0.018	0.013	−0.001
	(0.073)	(0.041)	(0.120)	(0.083)
	[0.737]	[0.688]	[0.926]	[0.993]
Days	-0.001	−0.001	−0.003	−0.002
	(0.006)	(0.002)	(0.008)	(0.004)
Mean of Outcome	0.56	0.56	0.56	0.56
Observations	2176	3484	1832	3140
Buffer	✗	✗	3 days	3 days

Each column reports results for a single OLS regression of the dependent variable listed in the column heading on the variables. Text in parentheses represents number of days on either side of stockout included in observations. Clustered SEs at site-level in parentheses. In square brackets, we report the wild cluster bootstraped p-values Buffer indicates the removal of observations on the date of the stockout, and within the specified number of days on each side of the stockout

III. Stockouts and Second Dose Take-Up

For our stockout analysis we rely on matched first and second doses. When patient data is entered immediately on-site, as it was in large clinics with data managers, patients were issued a vaccine card which included an ID and the due date for the second shot (if any). At other sites data was entered offsite with a delay. The first and second doses were linked in the database when a patient had an ID or a data manager looked them up using their phone number. Otherwise, they were recorded as an unlinked second dose.

While there were multiple instances of AstraZeneca stockouts, we analyse a stockout in July 2021 as other stockouts overlap with policy changes to a greater degree (including changes in age eligibility), surge events (large-scale efforts to increase vaccinations).

We use data from a subset of vaccination sites with high volumes allowing for good linking of first and second doses. Specifically, sites were selected based on the volume of AstraZeneca given in the month prior to the stockout, the proportion of entries with mobile phone numbers (phone numbers allow for matching first and second doses if ID is missing), and the proportion of second doses without a corresponding first dose entry (correlated with backlogs in data

entry). Many sites depleted their supply prior to the date of expiry. The start of site-level stockout is set to when first doses of AstraZeneca fall consistently to zero [4] The end of the stockout is the first date after August 1 where there are in excess of 10 first doses over a 3 day period.

The date of the stockout could not have been predicted by patients at the time the first dose was received, minimizing the ability of individuals to select out of the stockout differentially. The stockout delayed the timing of 2nd dose take-up. Among individuals with due dates during the stockout who eventually received the vaccine (in our study sample) 93% received the vaccine only after the stockout was completed.

Figure 2 shows the daily second dose completion, aggregated across sites, by the due date relative to stockout. It shows a slight decline in the percentage of people getting second doses over time but no discontinuity at the start of the stockout (red line).

In regression from we investigate the impact of stockouts using a linear probability model of the form:

$$(3) \quad Y_{ijt} = \beta_0 + \beta_1 Stockout_{ijt} + \beta_2 Days_{it} + \beta_3 Days_{it}^2 + X_i + \alpha_t + \delta_j + \varepsilon_{ijt}$$

where the outcome, Y_{ijt}, is a binary variable indicating whether an individual i received a second dose at site j at time t. $Stockout_{ijt}$ is a binary variable indicating whether an individual is due during the stockout, $Days_{it}$ and $Days_{it}^2$ are measures of the time (in days and days squared) between the stockout (measured at the site level) and the individuals due date (0 is the first day of stockout, negative values are before stockout, and positive values are during the stockout), X_i is a vector of individual-level covariates (sex, age, occupation dummies, pre-existing health conditions), α_t is a vector of time controls (day of week indicators, day mandates are announced, or Eid), and δ_j are site level fixed effects. Standard errors are clustered at the site level, and as we use only 5 high volume sites with high quality data, we also present wild cluster bootstrapped p-values. We show time windows of 14 and 21 days on either side of the stockout (Table 2 Columns 1 and 2 respectively). The window is chosen to balance the increase in observations arising from a wider time window and potential imbalance in individual characteristics due to changes in the types of people who get vaccinated over time. Results are robust to excluding the two days before and after the stockout start ("buffer" in Columns 3 and 4). A negative coefficient on Days and Days squared reflects declining rate of second dose take- up over time. The coefficient on the stockout is close to 0 (between -0.11 and 1.3 percentage point change in second dose take-up) and not statistically significant. In other words, having to delay receiving a second dose because of the stockout did not reduce take-up of second doses. Results are relatively consistent with specifications where the outcome is receiving the second doses within 100 days of the due date, and if we estimate the relationship using all vaccination sites.

[4]Formally the earliest date between June 1 and August 1 where either there are three or more days where no first doses are received, or a three day period where below five doses are received).

IV. Conclusion

As with many other countries, we see a relationship between a regions long-term association with the party in power (proxied by ethnicity or language), and take-up of the Covid-19 vaccine. A year since the start of Covid-19 vaccination, chiefdoms where the majority of the population are Temne (the ethnic group associated with the main opposition) have a 18 percentage point lower take-up of Covid-19 adult vaccines compared to an average take-up of 52% in Mende chiefdoms. However, this is not a Covid-19 specific pattern. Temne areas had lower childhood vaccination rates pre-Covid and even when the Temne associated party is in power. This suggests caution is needed when interpreting evidence of the politicization of Covid-19 vaccines on the basis of Covid-19 vaccination rates on their own. Second, we find that those who experienced vaccine stockouts at the time they were due for Covid-19 vaccines were just as likely as those not experiencing stockouts to eventually receive their second dose, even though they had to wait longer to receive it. This is not because everyone turned up for the second dose, with only about half of those impacted and not impacted by stockouts receiving a second dose. Intermittent supply is likely to have had other negative impacts: in Sierra Leone for

example large scale campaigns to promote the vaccine were delayed until there was sufficient supply for fear of stocking demand that could not be met.

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APPENDIX

TABLE A1—ALL ETHNICITIES AND PROPORTION VACCINATED IN A CHIEFDOM

	Covid-19 vaccination					Child Immunization (Measles)	
	During first 6 months (Mar - Sep 2021)		During first 12 months (Mar 2021 - Mar 2022)			During SLPP government (2018 - 2019)	During APC government (2012 - 2013)
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Proportion vaccinated w/ Covid-19 first dose	Proportion vaccinated w/ Covid-19 first dose	Proportion vaccinated w/ Covid-19 first dose	Proportion vaccinated w/ Covid-19 first dose	Proportion vaccinated w/ Covid-19 first dose ($\geq 18 years$)	Proportion vaccinated w/ measles first dose	Proportion vaccinated w/ measles first dose
Temne	-0.025	-0.030	-0.060	-0.054	-0.171	-0.039	-0.054
	(0.009)	(0.008)	(0.035)	(0.031)	(0.072)	(0.017)	(0.028)
	[0.042]	[0.006]	[0.089]	[0.091]	[0.056]	[0.055]	[0.064]
Loko	-0.042	-0.042	-0.139	-0.133	-0.284	0.027	0.078
	(0.014)	(0.015)	(0.046)	(0.044)	(0.085)	(0.024)	(0.049)
	[0.021]	[0.029]	[0.045]	[0.062]	[0.049]	[0.440]	[0.427]
Sherbro	-0.016	-0.016	-0.059	-0.055	-0.095	-0.148	-0.177
	(0.009)	(0.009)	(0.036)	(0.032)	(0.065)	(0.079)	(0.136)
	[0.115]	[0.113]	[0.477]	[0.439]	[0.250]	[0.524]	[0.524]
Limba	-0.017	-0.015	0.036	0.062	0.131	-0.056	-0.144
	(0.020)	(0.022)	(0.080)	(0.083)	(0.120)	(0.030)	(0.028)
	[0.556]	[0.600]	[0.736]	[0.554]	[0.423]	[0.181]	[0.000]
Kissi	-0.046	-0.045	-0.194	-0.188	-0.314	0.027	0.039
	(0.010)	(0.010)	(0.030)	(0.029)	(0.057)	(0.028)	(0.067)
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.507]	[0.507]
Kono	-0.042	-0.041	-0.122	-0.126	-0.318	-0.087	-0.064
	(0.007)	(0.007)	(0.021)	(0.024)	(0.044)	(0.010)	(0.017)
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.039]
Susu	-0.010	-0.009	-0.015	-0.009	-0.142	-0.101	-0.269
	(0.008)	(0.009)	(0.026)	(0.024)	(0.045)	(0.060)	(0.031)
	[0.278]	[0.299]	[0.607]	[0.739]	[0.022]	[0.469]	[0.003]
Fullah	-0.033	-0.033	-0.055	-0.049	-0.155	-0.054	-0.110
	(0.007)	(0.008)	(0.021)	(0.019)	(0.045)	(0.012)	(0.017)
	[0.001]	[0.006]	[0.003]	[0.003]	[0.012]	[0.000]	[0.000]
Krim	-0.063	-0.063	-0.215	-0.211	-0.351	-0.079	-0.148
	(0.007)	(0.007)	(0.018)	(0.016)	(0.044)	(0.012)	(0.017)
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
Yalunka	0.003	0.003	-0.136	-0.130	-0.265	-0.061	-0.084
	(0.007)	(0.007)	(0.020)	(0.018)	(0.045)	(0.012)	(0.017)
	[0.685]	[0.665]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
Koranko	-0.033	-0.033	-0.033	-0.028	-0.197	-0.115	-0.072
	(0.012)	(0.012)	(0.026)	(0.024)	(0.066)	(0.013)	(0.037)
	[0.038]	[0.060]	[0.253]	[0.309]	[0.045]	[0.000]	[0.135]
Mende Mean	0.068	0.068	0.298	0.298	0.523	0.956	0.885
Number of health centers	✓	✓	✓	✓	✓	n/a	n/a
Urban Dummy	✓	✓	✓	✓	✓	✓	✓
Year Fixed Effect	n/a	n/a	n/a	n/a	n/a	✓	✓
Drop Western Area Urban	✗	✓	✗	✓	✓	✓	✓
Observations	164	156	164	156	136	312	312

$*p < .10, **p < .05, ***p < .01$; Standard errors clustered at the district level in parentheses. In square brackets, we report the wild cluster bootstraped p-values. The analysis is at the chiefdom level, the third-level units of administration in Sierra Leone.

TABLE A2—ETHNICITIES AND PROPORTION VACCINATED IN A CHIEFDOM INCLUDING TILL DATE DATA

	Covid-19 vaccination							
	During first 6 months (Mar - Sep 2021)		During first 12 months (Mar 2021 - Mar 2022)			Full duration (Mar 2021 - Dec 2022)		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Proportion vaccinated w/ Covid-19 first dose	Proportion vaccinated w/ Covid-19 first dose	Proportion vaccinated w/ Covid-19 first dose	Proportion vaccinated w/ Covid-19 first dose	Proportion vaccinated w/ Covid-19 first dose ($\geq$ 18*years*)	Proportion vaccinated w/ Covid-19 first dose	Proportion vaccinated w/ Covid-19 first dose	Proportion vaccinated w/ Covid-19 first dose ($\geq$ 18*years*)
Temne	-0.025	-0.030	-0.063	-0.057	-0.180	-0.016	-0.011	-0.184
	(0.008)	(0.008)	(0.034)	(0.030)	(0.070)	(0.067)	(0.067)	(0.111)
	[0.036]	[0.006]	[0.075]	[0.080]	[0.049]	[0.830]	[0.872]	[0.161]
Kono	-0.042	-0.041	-0.122	-0.125	-0.319	-0.068	-0.072	-0.361
	(0.007)	(0.007)	(0.021)	(0.023)	(0.043)	(0.029)	(0.033)	(0.069)
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.059]	[0.100]	[0.025]
Other ethnicities	-0.027	-0.027	-0.059	-0.050	-0.133	-0.031	-0.019	-0.120
	(0.009)	(0.009)	(0.040)	(0.038)	(0.065)	(0.058)	(0.056)	(0.095)
	[0.009]	[0.013]	[0.256]	[0.264]	[0.051]	[0.602]	[0.758]	[0.235]
Mende Mean	0.068	0.068	0.298	0.298	0.523	0.429	0.429	0.749
Number of health centers	✓	✓	✓	✓	✓	✓	✓	✓
Urban Dummy	✓	✓	✓	✓	✓	✓	✓	✓
Drop Western Area Urban	✗	✓	✗	✓	✓	✗	✓	✓
Observations	164	156	164	156	136	164	156	136

Notes: Each column reports results for a single OLS regression of the dependent variable listed in the column heading on the variables listed in the row headings, a binary variable indicating if the chiefdom is urban and the number of health centers. In Columns 1, 3 and 6, the sample includes observations from Western Area Urban (WAU) while in all other columns observations from WAU are not included in the sample. Standard errors clustered at the district level in parentheses. Wild cluster bootstrapped p-values in square brackets.