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Effects of the COVID-19 pandemic on sales of sexual and reproductive health products: an ecological study of pharmacies in Kenya

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ABSTRACT

Objectives To examine how sales of sexual and reproductive health (SRH) products varied among pharmacies in Kenya using administrative data, leveraging natural variation in the COVID-19 pandemic and accompanying policy restrictions between 2019 and 2021.
Design and setting Ecological study of pharmacies in Kenya.
Participants 761 pharmacies using the Maisha Meds product inventory management system (capturing 572 916 products sold).
Outcomes Sales quantity, price and revenue of SRH products sold per pharmacy per week.
Results COVID-19 deaths were associated with a −2.97% (95% CI −3.82%, −2.11%) decrease in sales quantity, a 1.09% (95% CI 0.44%, 1.72%) increase in sales price and a −1.89% (−1.00%, −2.79%) decrease in revenues per pharmacy per week. Results were similar when considering new COVID-19 cases (per 1000) and the Average Policy Stringency Index. Results differed substantially between individual SRH products—a large decrease in sales quantity in pregnancy tests, injectables and emergency contraception, a modest decrease in condoms and no change in oral contraception. Sales price increases were similarly varied; four of the five most sold products were revenue neutral.
Conclusions We found a robust negative association between SRH sales at pharmacies in Kenya and COVID-19 reported cases, deaths and policy restriction. Although our data cannot definitively point to reduced access, existing evidence from Kenya regarding unchanged fertility intentions, increases in unintended pregnancies and reported reasons for non-use of contraceptives during COVID-19 suggests a prominent role of reduced access. While policymakers may have a role in sustaining access, their role may be limited by broader macroeconomic problems, such as global supply chain disruptions and inflation, during supply shocks.

STRENGTHS AND LIMITATIONS OF THIS STUDY

⇒ This study uses a large, comprehensive data set on sales and pricing of sexual and reproductive health (SRH) products (n=572 916 products sold across 761 pharmacies) in Kenya.
⇒ This study disaggregates SRH access outcomes by specific product type.
⇒ This study cannot compare differences in sales for SRH products against other products sold at pharmacies.
⇒ The study cannot separately identify the impact of COVID-19 and subsequent policy restrictions due to the overlap in timing of these events.

had disproportionate impacts on women, affecting both their professional and personal lives.[2] At work, women faced higher levels of unemployment and a greater burden of child and elder care during the pandemic that further shrank their employment opportunities.[3–6] Disproportionately represented in the medical workforce, women were often at higher risk of COVID-19 infection.[6 7] At home, women experienced increased gender-based violence exacerbated by COVID-19's detrimental impacts on financial stability, access to support services, household tensions and limitation of stress-relieving activities.[8] Further, COVID-19-induced policy restrictions were associated with a decline in mental health[9] and an increase in food insecurity for women in particular.[10–12]

These gender disparities are further exacerbated in low and middle-income countries, where women are less protected by (relatively less generous) social safety net policies since they often work in the informal sector.[5] The COVID-19 pandemic experience is also different and potentially extended for women in low and middle-income countries due to different trajectories of the pandemic, influenced by lower vaccine coverage.[5] In Kenya,

INTRODUCTION
Background
The COVID-19 pandemic and mitigation efforts led to shelter-in-place and lockdown orders, closed businesses and created economic hardship globally.[1] This has

for example, women living in low-income informal settlements experienced disproportionate impacts in terms of food insecurity, accessing necessary healthcare and being a victim of household violence during the COVID-19 pandemic.[13]

Among the various impacts of the COVID-19 pandemic on women, one particularly concerning impact is the reduction in access to sexual and reproductive health (SRH) products and services, an unintended consequence of pandemic-induced business closures and mobility restrictions. Women's reproductive rights are under threat worldwide,[14 15] and the COVID-19 pandemic serves as an example for understanding the consequences of restricting access to critical SRH services and products; limited access to SRH products and services such as contraceptives and HIV prevention leaves women at increased risk for unintended pregnancy and HIV. The COVID-19 pandemic threatens to exacerbate existing gender disparities and contribute to the rising threat to women's reproductive rights, especially among those in low and middle-income countries, and widen the gender gap among those in extreme poverty over the next decade.[16] With fewer options to access SRH products and services when regular retail locations are closed (such as mail or delivery services), women in low and middle-income countries may have especially high levels of unmet need for SRH products and services.[17 18] In Kenya, for example, there was a large-scale disruption of SRH services as governments converted health facilities into quarantine centres, closed many primary care facilities and reassigned healthcare workers to the COVID-19 pandemic response.[19]

Objectives

To better understand how COVID-19 impacted access to vital SRH services and products, as well as to lay the groundwork for efforts to improve access for vulnerable women now and in future public health crises, we examined how sales of SRH products varied over time among pharmacies in Kenya using the Maisha Meds point-of-sales system, a tablet-based platform used by some pharmacies in Kenya. Tracking point-of-sales pharmacy data provides insight into demand for SRH products and services when other SRH services were less accessible during the pandemic.

Specifically, we conducted an ecological study to examine how the COVID-19 pandemic and its subsequent policy restrictions impacted pharmacy sales of SRH products in Kenya. Kenya experienced over 300 000 cases and 5000 deaths over the course of five COVID-19 waves between 2019 and 2021.[20] The country implemented and relaxed various policy restrictions over this period, similar to many other low and middle-income countries during the pandemic. Leveraging the variation in timing between COVID-19 deaths and corresponding policies, along with the rich sales data from over 700 Kenyan pharmacies, we estimated the association between COVID-19 deaths, corresponding policies and sales of SRH products from

pharmacies using the Maisha Meds system. We hypothesise that both the COVID-19 pandemic and subsequent pandemic mitigation policies reduced pharmacy sales of SRH products.

METHODS

Data

We combined epidemiological data on the COVID-19 pandemic in Kenya with administrative data tracking the national policy response and point-of-sales pharmacy data from Maisha Meds from March 2020 to December 2021 for this analysis.

COVID-19 cases and deaths

We compiled COVID-19 case and mortality data from WHO's Coronavirus (COVID-19) Dashboard.[20] Between 1 and 21 March 2020, the dashboard's case and death data were collected via official communications governed by the International Health Regulations[21] as well as from official Ministries of Health and social media account communications. After 21 March 2020, the case and death data were collected from aggregate data reported to WHO on a daily basis. Case and death data were laboratory confirmed according to WHO's case definitions[22]—with the exception of some regional reporting definitions. The counts reflect the date that the case or death was reported—rather than when symptoms first began. The number of new cases and deaths was aggregated at a weekly level by calendar week (Sunday to Saturday) for subsequent analysis.

COVID-19 policy restrictions

To estimate exposure to COVID-19 policy restrictions in Kenya, we used data on the timing and level of policy restrictions from the Oxford COVID-19 Government Response Tracker (OxCGRT).[23] This data set has previously been used to examine COVID policy responses and their relation to epidemiological data,[24] unemployment in the USA,[25] global production and supply chains,[26] airline investor volatility,[27] among many other outcomes.

The OxCGRT provides comprehensive daily COVID-19 policy restriction rankings for 21 different policy indicators such as workplace closures and facial coverings for 184 countries, including Kenya. Rankings for each policy indicator are a measure of how strict the policy is on a given day and are based on publicly available information added by over 400 Oxford-affiliated volunteers around the globe who frequently update the data set. These volunteers participate in trainings and weekly meetings to make sure the policy indicator rankings are consistent and properly reviewed by another volunteer, especially because these discrete rankings are specific to each indicator. Additional details around how the OxCGRT is compiled are available elsewhere.[23]

The OxCGRT's rankings for each policy indicator are further aggregated into the following categorised indices: stringency, government response, containment

and health, and economic support (online supplemental table S1). Each policy indicator ranking is averaged and then normalised to account for the differences in scales of the indicator rankings, resulting in a subindex score between 0 and 100, with lower numbers reflecting less restrictive policies and higher numbers indicating more restrictive policies.[23] Each index is then calculated by taking simple averages of the subindex scores of the relevant indicators.[23] For example, the Stringency Index, the index used to compute our primary measure of interest, is the average of the subindex scores of the indicators about containment and closure policies and public information campaigns.[23] We then averaged this Stringency Index by calendar week (Sunday to Saturday) to form the Average Stringency Index, our primary measure of interest.

As robustness checks, we additionally considered the subindices focused on (1) how governments responded to COVID-19 across all policy indicators (government response), (2) 'lockdown'-style restrictions and investments in healthcare and vaccines (containment/health) and (3) income support and debt relief (economic support) (online supplemental table S1). We also examined five of these COVID-19 policy indicators in depth: stay at home (C6), gathering restrictions (C4), workplace closing (C2), school closing (C1) and movement restrictions (combining C7 internal movement and C8 international travel controls) (online supplemental figure S1). Additional details on how these policy indicators were defined are available in online supplemental table S2.

Point-of-sales pharmacy data
We obtained sales data from the Maisha Meds point-of-sales and inventory management system capturing 572 916 SRH products sold across 761 pharmacies in Kenya between January 2019 and December 2021. This included pharmacies across the country, with pharmacies from the three largest cities accounting for 39% of pharmacies (Nairobi (11%), Mombasa (6%), Kisumu (22%)). Facilities recorded a mean (SD) of 338 (439) transactions per month (across all products, including non-SRH products). We received 14 months of data before the COVID-19 pandemic and 22 months of data during the COVID-19 pandemic. Data included a time stamp for each point-of-sales transaction and unique identifiers for the specific sale and pharmacy involved. We also received data on the product name, brand name, sales price and sales quantity. All prices were recorded in Kenyan shillings (Ksh; approximately Ksh100=US$1 during the study period).

First, we calculated the quantity of all SRH products sold per pharmacy per calendar week. This included all items that pharmacies categorised under SRH in the Maisha Meds system, such as different types of contraception, pregnancy tests and medication commonly used during pregnancy and menstruation supplies and medication. There are 31 specific SRH products covered in our data set. Next, we calculated the mean sales price and revenue (aggregated value of products sold) of all SRH products

per pharmacy per calendar week. To examine sales at the product level, we repeated this calculation for each of the five most sold SRH products separately. For the product-level analysis, we combined all individual products sold across all brands and dosages (eg, emergency contraceptive pill).

Analysis
First, we constructed a timeline of the number of COVID-19 cases and policy restrictions by week between March 2020 and December 2021 to examine how the two varied over time.

Second, we calculated descriptive statistics on pharmacy sales quantity, price and revenue. We stratified by before/during the COVID-19 period (using 1 March 2020 as the cut-off point) and tested the significance of differences in means using linear regressions of a post-March 2020 dummy variable on each (logged) outcome, clustering SEs at the pharmacy level. We used the logged outcomes for analysis since each of the untransformed outcomes was highly skewed to the right. We repeated this analysis for each of the five most sold products (emergency contraception, condoms, oral contraception, pregnancy test, injectables).

Third, we estimated log-linear regression models of new COVID-19 deaths (continuous) on sales quantity, sales price and revenue per pharmacy per week. We controlled for pharmacy and calendar week fixed effects—robustly accounting for both pharmacy-specific variation and secular time trends—and clustered SEs at the pharmacy level. We interpreted the regression results as percentage changes in the outcome variable by exponentiating the coefficients and subtracting 1. We estimated the same models using COVID-19 cases (continuous) and the Average Stringency Index, respectively, as the independent variable instead. We repeated the regression analysis for each of the five most sold products individually to understand whether the relationship between COVID-19 and sales and pricing outcomes differed by product.

We conducted a series of robustness checks testing alternative definitions of COVID-19 exposure and policy restrictions, alternative model specifications for the regression analysis and alternative inclusion criteria for our sample of pharmacies. First, we repeated the regression analysis using two alternative definitions of COVID-19 exposure, including (1) considering all time periods after March 2020 as exposed (ie, pre/post COVID-19 binary variable); and (2) defining COVID-19 exposure based on infection waves 1–5 in Kenya taken from previous literature, respectively. In the first alternative, we used a dummy variable for post-March 2020 as the independent variable. In the second alternative, we used a dummy variable for COVID-19 wave as the independent variable, using specific dates in the literature to define when Kenya was experiencing a COVID-19 wave or not. In addition, we repeated the regression analysis using three subindices and five specific COVID-19 policy restrictions as alternative definitions of COVID-19 policy
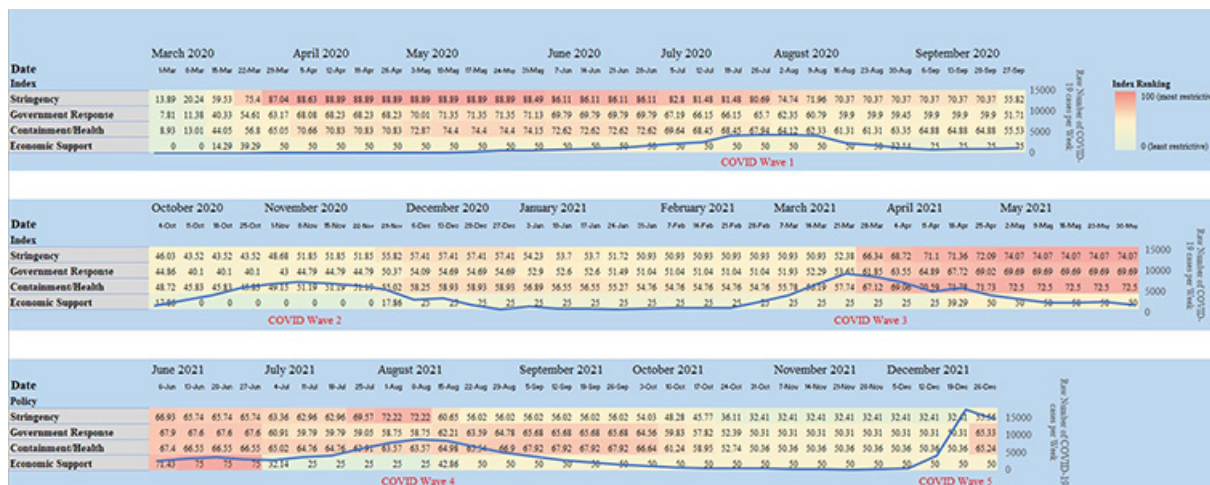
Figure 1 Timeline of Kenya COVID-19 policies and number of new cases per week (March 2020 to December 2021). The line graph plots the number of new COVID-19 cases per week from WHO's Coronavirus (COVID-19) Dashboard. Values of the Policy Stringency Index (and subindices) from the Oxford COVID-19 Government Response Tracker (OxCGRT) are presented in each row and colour coded by restrictiveness (red is most restrictive, yellow is least restrictive).

restrictions. Second, we tested alternative model specifications including lagged deaths and more flexible functional forms to account for delayed reactions and fluctuations in case severity and the government's implementation of new control measures. Specifically, we estimated three separate models adding each subsequent week's lag onto the cumulative model (from 1 to 3 weeks' lags, an approximation for the length of reporting lags), and included quadratic and cubic terms for COVID-19 deaths. The sensitivity analysis using lagged deaths and more flexible functional forms only included pharmacy fixed effects instead of two-way fixed effects as in the main analysis to avoid over controlling for temporal variation. Third, we repeated the regression analysis using a restricted sample of pharmacies that recorded at least one sale both before and after March 2020 to reduce potential concerns around selection bias among pharmacies that only recorded sales either before or during the COVID-19 pandemic.

Patient and public involvement
Patients were not involved in the design of this study.

RESULTS
Figure 1 presents a timeline of COVID-19 cases and policy restrictions in Kenya between March 2020 and December 2021. Kenya experienced five distinct waves of COVID-19: June to September 2020 (wave 1); October 2020 to January 2021 (wave 2); March to May 2021 (wave 3); July to September 2021 (wave 4); and December 2021 to February 2022 (wave 5)—this is reflected by the sharp increase in the number of cases per week during these periods and aligns with other COVID wave definitions.[28] The COVID-19 Policy Stringency Index varied between 13.9 and 88.9 over the study period and was negatively correlated with the number of cases per week (r=−0.234), but high case levels were not always followed/accompanied by strict policy restrictions. For example, the Policy Stringency Index was relatively low (45–58) during wave 2 despite Kenya experiencing high case levels.

Table 1 presents descriptive statistics on sales of SRH products over the study period (n=33 242 pharmacy–week combinations). Pharmacies sold a mean of 14 SRH products per pharmacy per week (SD=13). Mean sales quantities were 7% lower during the COVID-19 pandemic (14.74

Table 1 Descriptive statistics on sales of sexual and reproductive health products

Per shop per week	Overall (n=33 242)		Before March 2020 (n=12 425)		After March 2020 (n=20 817)		Difference	
	Mean (SD)	25th, 75th percentiles	Mean (SD)	25th, 75th percentiles	Mean (SD)	25th, 75th percentiles	Levels (P value)	%
Sales quantity	14.12 (13.35)	19, 41	14.74 (13.77)	5, 20	13.75 (13.09)	5, 19	−0.99* (0.034)	−7
Sales price (Ksh)	226 (782)	93, 186	210 (645)	91, 175	236 (853)	95, 193	26.82*** (0.000)	13
Revenue (Ksh)	2279 (3149)	650, 2890	2252 (3006)	660, 2850	2295 (3231)	640, 2920	43.11 (0.165)	2

*P<0.05, **p<0.01, ***p<0.001. P values from linear regressions of a post-March 2020 dummy variable on each (logged) outcome, clustering SEs at the pharmacy level. Data from sales of 572 916 products from 761 pharmacies between January 2019 and December 2021 (33 242 pharmacy–week combinations with at least one sale of sexual reproductive health products). ~Ksh100=US$1.

Table 2 Descriptive statistics on sales of emergency contraception, condoms, oral contraception, pregnancy tests and injectable contraceptives

Per shop per week	Overall (n=33 242)		Before March 2020 (n=12 425)		After March 2020 (n=20 817)		Difference	
	Mean (SD)	25th, 75th percentiles	Mean (SD)	25th, 75th percentiles	Mean (SD)	25th, 75th percentiles	Levels (P value)	%
Sales quantity								
Emergency contraception	6.09 (6.51)	2, 9	6.05 (6.43)	2, 8	6.11 (6.55)	1, 9	0.07 (0.148)	−1
Condoms	4.45 (5.23)	1, 6	4.64 (5.42)	1, 7	4.34 (5.12)	1, 6	−0.29 (0.516)	−6
Oral contraception	2.18 (2.70)	0, 3	2.21 (2.71)	0, 3	2.16 (2.70)	0, 3	−0.05 (0.964)	−2
Pregnancy test	2.12 (3.06)	0, 3	2.59 (3.14)	0, 4	1.84 (2.97)	0, 3	−0.75 (0.423)	−29
Injectable contraceptives	1.36 (4.01)	0, 1	1.26 (2.76)	0, 1	1.41 (4.60)	0, 2	0.15 (0.829)	12
Sales price (Ksh)								
Emergency contraception	74 (222)	25, 82	69 (240)	25, 77	76 (210)	26, 85	7.14*** (0.000)	10
Condoms	34 (373)	3, 38	29 (79)	4, 35	37 (467)	3, 39	7.25*** (0.000)	25
Oral contraception	19 (90)	0, 21	18 (80)	0, 20	19 (96)	0, 22	0.74*** (0.000)	4
Pregnancy test	39 (481)	0, 14	42 (485)	0, 17	36 (479)	0, 13	−6.01** (0.005)	−14
Injectable contraceptives	19 (95)	0, 16	18 (113)	0, 14	19 (82)	0, 17	1.49** (0.003)	8
Revenue (Ksh)								
Emergency contraception	867 (1025)	200, 1200	841 (1011)	200, 1160	883 (1032)	200, 1240	42.22** (0.002)	5
Condoms	417 (833)	40, 520	414 (732)	40, 510	418 (888)	30, 520	3.88 (0.146)	1
Oral contraception	222 (498)	0, 790	222 (629)	0, 280	223 (400)	0, 290	0.80*** (0.001)	0
Pregnancy test	229 (1920)	0, 200	255 (1634)	0, 220	214 (1770)	0, 170	−40.55** (0.003)	−16
Injectable contraceptives	185 (532)	0, 200	183 (609)	0, 200	187 (480)	0, 200	3.70* (0.013)	2

*P<0.05, **p<0.01, ***p<0.001. P values from linear regressions of a post-March 2020 dummy variable on each (logged) outcome, clustering SEs at the pharmacy level. Data from sales of 572 916 products from 761 pharmacies between January 2019 and December 2021 (33 242 pharmacy–week combinations with at least one sale of sexual reproductive health products). ~Ksh100=US$1.

before March 2020, 13.75 afterwards, p=0.034). The mean sales price was Ksh226 (~US$2; SD=782). Sales prices were 13% higher during the COVID-19 pandemic (Ksh210 before March 2020, Ksh236 afterwards, p<0.001). On average, pharmacies earned Ksh2279 (~US$22; SD=3149) in revenue per pharmacy per week. This did not differ significantly between before and during the COVID-19 pandemic—pharmacies did not earn less revenue from SRH products despite the decrease in SRH sales quantities as pharmacies responded by increasing the sales price of SRH products.

The five most commonly sold products were emergency contraception (35% of all SRH products sold); condoms (26%); oral contraception (13%); pregnancy tests (12%); and injectable contraceptives (8%) (online supplemental table S3). Table 2 presents descriptive statistics on sales of these five products. Differences in sales quantity, sales price and revenue before and during COVID-19 were not uniform across all five products. While sales quantities minimally decreased for emergency contraception (−1%, p=0.148), condoms (−6%, p=0.516) and oral contraception (−2%, p=0.964), they decreased substantially for pregnancy tests (−29%, p=0.423) and *increased* for injectable contraceptives (12%, p=0.829). Sales prices increased for emergency contraception (10%, p<0.001),

condoms (25%, p<0.001), oral contraception (4%, p<0.001) and injectable contraceptives (8%, p=0.003), but decreased for pregnancy tests (−14%, p=0.005). Overall, these trends resulted in modest increases in revenue for emergency contraception (5%, p=0.002), condoms (1%, p=0.146), oral contraception (0%, p=0.001) and injectable contraceptives (2%, p=0.013) but a substantial decrease for pregnancy tests (−16%, p=0.003). For each product, pharmacies appeared to increase sales prices roughly in proportion to the decrease in sales quantities in a revenue-neutral manner, with the exception of pregnancy tests, where sales quantity, price and revenue all decreased substantially, and injectable contraceptives, where sales quantity, price and revenue all increased.

Table 3 presents results from log-linear regressions of COVID-19 and policy restrictions on sales per pharmacy per week. Models 1–3 use (1) new COVID-19 deaths, (2) new COVID-19 cases (per 1000 persons) and (3) Average Stringency Index (0–100) as the independent variable, respectively. Controlling for pharmacy and week, COVID-19 deaths were associated with a −2.97% decrease in sales per pharmacy per week (95% CI −3.82%, −2.11%). Each new COVID-19 case (per 1000 persons) was associated with a −3.83% decrease in sales quantity per pharmacy per week (95% CI −4.93%, −2.73%).

Table 3 Impact of COVID-19 and policy restrictions on sales of sexual and reproductive health products

	COVID-19 severity		COVID-19 policy restrictions
Outcomes (per pharmacy per week)	1 Number of COVID-19 deaths	2 COVID-19 cases (per 1000)	3 Average Stringency Index
a. SRH sales quantity	−0.0301*** (−0.0390, −0.0213)	−0.0391*** (−0.0506, −0.0277)	−0.0182*** (−0.0234, −0.0131)
b. SRH sales price (Ksh)	0.0108*** (0.0044, 0.0171)	0.0140*** (0.0057, 0.0222)	0.0053** (0.0016, 0.0090)
c. SRH revenue (Ksh)	−0.0191*** (−0.0283, −0.0100)	−0.0248*** (−0.0367, −0.0130)	−0.0131*** (−0.0183, −0.0079)

Coefficients and 95% CIs in parentheses. Separate log-linear regressions of (1) number of COVID-19 deaths; (2) new COVID-19 cases (per 1000 persons); and (3) Policy Stringency Index (0–100) on (a) sales quantity, (b) sales price and (c) revenue per pharmacy per week. All models control for pharmacy and week fixed effects and cluster SEs at the pharmacy level. *P<0.05, **p<0.01, ***p<0.001.
SRH, sexual and reproductive health.

Similarly, COVID-19 deaths and new COVID-19 cases (per 1000 persons) were associated with a 1.09% (95% CI 0.44%, 1.72%) and 1.41% (95% CI 0.57%, 2.24%) increase in sales price per pharmacy per week, respectively. COVID-19 deaths and new COVID-19 cases (per 1000 persons) were associated with a −1.89% (95% CI −1.00%, −2.79%) and −2.45% (95% CI −1.29%, −3.60%) decrease in revenues per pharmacy per week, respectively.

The results on sales quantity and sales price are robust to alternative definitions of COVID-19 exposure, including before versus after March 2020, and defining COVID-19 exposure based on waves 1–5 in Kenya based on previous literature (online supplemental table S4). Similar results on sales quantity and price hold when more flexibly modelling COVID-19 exposure by including lagged deaths (online supplemental table S5) and higher order terms (online supplemental table S6). However, the result on revenue is not robust to alternative definitions of COVID-19 exposure or more flexible forms of modelling COVID-19 exposure. Specifically, the association between the alternative definitions of COVID-19 exposure and revenue is not significant and occasionally flip in sign (online supplemental table S4). This is also the case when more flexibly modelling COVID-19 exposure by including lagged cases (online supplemental table S5) and higher order terms (online supplemental table S6). The result is robust to using a restricted sample of pharmacies that recorded at least one sale both before and after March 2020 to reduce potential concerns around selection bias among pharmacies that only recorded sales either before or during the COVID-19 pandemic (online supplemental table S7).

Table 3 also presents results from log-linear regressions of the Average Stringency Index on sales per pharmacy per week. Stringent COVID-19 policy restrictions were associated with a decrease in sales per pharmacy per week—a 1 unit increase in the Average Stringency Index was associated with a −1.80% decrease in sales (95% CI −2.31%, −1.30%). Among the subindices and individual policy restrictions, workplace closure policies and school closure policies were most strongly associated with a decrease in sales per pharmacy per week (online supplemental table S8). Similarly, COVID-19 policy restrictions were associated with a 0.53% (95% CI 0.16%, 1.72%)

increase in sales price and −1.30% (95% CI −0.79%, −1.81%) decrease in revenues per pharmacy per week.

Table 4 presents corresponding results from log-linear regressions of COVID-19 and policy restrictions on sales per pharmacy per week for the five most sold products individually. COVID-19 deaths were associated with a decrease in sales of emergency contraception (−1.20%, 95% CI −2.02%, −0.38%), condoms (−1.05%, 95% CI −1.88%, −0.21%), pregnancy tests (−1.70%, 95% CI −2.55%, −0.84%) and injectable contraceptives (−1.55%, 95% CI −2.71%, −0.37%). COVID-19 deaths were also associated with an increase in sales price for emergency contraception (1.84%, 95% CI 0.99%, 2.70%), condoms (2.17%, 95% CI 1.09%, 3.27%), oral contraception (2.86%, 95% CI 1.76%, 3.97%), pregnancy tests (1.10%, 95% CI 0.05%, 2.15%) and injectable contraceptives (3.82%, 95% CI 1.94%, 5.74%). However, COVID-19 deaths were not associated with revenues per pharmacy per week for four of the five most commonly sold products, with pregnancy tests (−0.10%, 95% CI −2.56%, −0.01%) being the exception.

The association between new COVID-19 cases and sales per pharmacy per week for each of the five most sold SRH products largely held when using COVID-19 cases (per 1000 persons) and the Average Stringency Index, respectively, as the independent variable instead. One notable exception is the negative association between the Average Stringency Index and revenues per pharmacy per week for emergency contraception (−1.00%, 95% CI −1.97%, −0.01%).

DISCUSSION
Using a unique, comprehensive data set on sales and pricing of SRH products across 700 pharmacies in Kenya, we found a robust negative association between SRH sales at pharmacies and COVID-19-reported cases, deaths and policy restrictions. Specifically, COVID-19 was associated with a decrease in SRH sales quantity, an increase in SRH sales price and a decrease in SRH-related revenue. This is an important finding with implications for access to SRH products for women as pharmacies in Kenya are a particularly important resource for obtaining these critical products.[29 30] To our knowledge, this paper is the first estimate

Table 4 Impact of COVID-19 and policy restrictions on sales of emergency contraception, condoms, oral contraception, pregnancy tests and injectable contraceptives

Per pharmacy per week	COVID-19 cases		COVID-19 policy restrictions
	1 Number of COVID-19 deaths	2 COVID-19 cases (per 1000)	3 Average Stringency Index
Emergency contraception (n=28 480)			
a. Sales quantity	−0.0121** (−0.0204, −0.0038)	−0.0157** (−0.0265, −0.0049)	−0.0125*** (−0.0173, −0.0076)
b. Sales price (Ksh)	0.0182*** (0.0099, 0.0266)	0.0237*** (0.0128, 0.0346)	0.0057* (0.0009, 0.0106)
c. Revenue (Ksh)	−0.0046 (−0.0136, 0.0043)	−0.0060 (−0.0176, 0.0056)	−0.0102* (−0.0152, −0.0051)
Condoms (n=25 530)			
a. Sales quantity	−0.0106* (−0.0190, −0.0021)	−0.0137* (−0.0247, −0.0028)	−0.0069** (−0.0119, −0.0018)
b. Sales price (Ksh)	0.0215*** (0.0108, 0.0322)	0.0279*** (0.0140, 0.0418)	0.0143*** (0.0079, 0.0206)
c. Revenue (Ksh)	−0.0016 (−0.0119, 0.0087)	−0.0021 (−0.0154, 0.0113)	−0.0012 (−0.0073, 0.0049)
Oral contraception (n=21 938)			
a. Sales quantity	−0.0017 (−0.0104, 0.0070)	−0.0022 (−0.0135, 0.0090)	−0.0018 (−0.0068, 0.0033)
b. Sales price (Ksh)	0.0282*** (0.0174, 0.0389)	0.0366*** (0.0226, 0.0506)	0.0166*** (0.0103, 0.0229)
c. Revenue (Ksh)	0.0094 (−0.0007, 0.0194)	0.0121 (−0.0009, 0.0252)	0.0040 (−0.0020, 0.0010)
Pregnancy test (n=17 658)			
a. Sales quantity	−0.0171*** (−0.0258, −0.0084)	−0.0222*** (−0.0335, −0.0110)	−0.0134*** (−0.0193, −0.0076)
b. Sales price (Ksh)	0.0109* (0.0005, 0.0213)	0.0142* (0.0007, 0.0277)	0.0046 (−0.0019, 0.0111)
c. Revenue (Ksh)	−0.0100* (−0.0199, −0.0001)	−0.0130* (−0.0259, −0.0001)	−0.0111* (−0.0181, −0.0040)
Injectable contraceptive (n=12 733)			
a. Sales quantity	−0.0156* (−0.0275, −0.0037)	−0.0202* (−0.0357, −0.0048)	−0.0084* (−0.0157, −0.0011)
b. Sales price (Ksh)	0.0375*** (0.0192, 0.0558)	0.0487*** (0.0250, 0.0725)	0.0200*** (0.0093, 0.0307)
c. Revenue (Ksh)	0.0165 (−0.0005, 0.0335)	0.0215 (−0.0006, 0.0435)	0.0069 (−0.0036, 0.0174)

Coefficients and 95% CIs in parentheses. Separate log-linear regressions of (1) number of COVID-19 deaths; (2) new COVID-19 cases (per 1000 persons); and (3) Policy Stringency Index on (a) sales quantity, (b) sales price and (c) revenue per pharmacy per week. All models control for pharmacy and week fixed effects and cluster SEs at the pharmacy level. *P<0.05, **p<0.01, ***p<0.001.

of a reduction in direct sales of SRH products using a comprehensive data set covering a large population (as opposed to self-reported measures from household survey data), showing a substantial reduction in women's access to SRH products during COVID-19 through pharmacy retail channels.

Our finding complements the growing body of literature showing a reduction in access to contraception during COVID-19 in low and middle-income countries.[31] Note that our finding on its own does not necessarily imply a reduction in women's access to SRH services if COVID-19 reduced fertility and sexual behaviour and thus underlying demand for SRH services. In the USA, for example, fertility plummeted during the pandemic and later recovered as COVID-19 policy restrictions affected sexual behaviour among unmarried individuals.[32 33] In Kenya, however, fertility intentions regarding both number and timing of childbearing remained consistent before and during COVID-19 among 85% of women in a longitudinal cohort,[34] while adolescent girls and young women in a separate cohort had a 60% increased risk of being pregnant during lockdown compared with the prelockdown period.[35] Despite no overall change in contraceptive status

(adoption or discontinuation) among a separate cohort of women, 14% of women reported COVID-19-related reasons for non-use of contraceptives.[36] While our finding is theoretically consistent with both demand and supply shocks to SRH services, the totality of evidence from Kenya regarding unchanged fertility intentions, increases in unintended pregnancies and reported reasons for non-use of contraceptives suggests a prominent role of reduced access, which pharmacies contribute towards by raising prices to compensate for decreased demand.

Our vast administrative data on both sales quantities and prices also allow us to speculate on pharmacy pricing behaviour in response to COVID-19-induced market conditions. While we cannot robustly disentangle demand (customer) and supply (pharmacy) side changes without directly observing pharmacy procurement behaviour, the fact that sales price increases for each product are just enough to offset decreases in sales quantity in a revenue-neutral manner for four of the five most commonly sold products suggests deliberate pricing adjustments from pharmacies. This suggests the possibility of a negative feedback loop where pharmacies respond to negative demand shocks (induced by COVID-19 and policy

restrictions or potentially by other shocks such as conflict, climate change) by increasing prices to maintain revenues, inadvertently reducing women's access to SRH products even further. If so, policymakers should take this into serious consideration and implement social protection policies (eg, subsidies, either to customers or pharmacies or both[37]) to stop these negative feedback loops. This is extremely relevant for future pandemics across sub-Saharan Africa as well as other large shocks to market conditions, such as conflict-related disruptions. However, policymakers' ability to sustain local market supply may be limited in case of broader macroeconomic problems such as global supply chain disruptions and inflation, both of which were substantial during the COVID-19 pandemic.[26]

To our knowledge, this is also the first study that disaggregates SRH access outcomes (measured as purchased products) by specific products. We find that differences in sales quantities, sales prices and revenues before and during COVID-19 were not uniform across the five most sold products. The largest decreases in sales quantity occurred in pregnancy tests, followed by injectables and emergency contraception. On the other hand, condoms experienced a modest decrease in sales quantity and oral contraception sales did not change at all. While sales price increases (observed across all products) meant that revenues did not decrease for four of the five products, this was not the case for pregnancy tests. These differences suggest that women with different preferences for specific SRH products may experience differential effects in terms of accessing SRH. This is especially concerning as SRH products are often not substitutable. Further research into differential effects between SRH products could yield important insights. For example, the modest decrease in sales quantity of oral contraception relative to injectables could reflect the fact that oral contraception is more established with a larger base of continuing users who may be less affected than those seeking to initiate (a new form of) contraception for the first time. The large decrease in sales of pregnancy tests also warrants further research investigating whether this led to differences in fertility at the population level—either corresponding to lower birth rates or an increase in unplanned/unintended pregnancies. Our result contributes to the growing literature on fertility and sexual behaviour during COVID-19 in Kenya that currently finds no differences in fertility intentions,[34] an increase in pregnancies[35] and women reporting COVID-19-related reasons for non-use of contraceptives.[36]

Building on our current analysis, we plan to estimate the impact of COVID-19 and policy restrictions separately by exploiting the variation in epidemiological trends at the subnational level in Kenya, given the availability of subnational-level data and the large geographical spread of pharmacies in our data set. This will help us understand the relative effects of COVID-19 versus policy restrictions on SRH sales to inform policymakers when considering trade-offs between pandemic control and adverse economic and SRH impacts in the future.

Our study has several limitations. First, our COVID-19 case and death data are reliant on reported cases, which is likely to be a dramatic undercount of true cases and deaths. However, this will probably accurately capture periods of epidemic surge even if the exact magnitudes are inaccurate. Second, we are unable to compare differences in sales for SRH products against other products sold at pharmacies. We hypothesise that the former may be disproportionately affected due to women being more severely affected by COVID-19 and policy restrictions, and suggest this comparison as a promising direction for future research. Third, the external validity of our results is constrained by inherent limitations of the pharmacy sales data set. Although Maisha Meds is a leading point-of-sales and inventory management system in Kenya, pharmacies represented in the data set are skewed towards periurban and urban areas due to the system requiring at least intermittent internet access. In addition, pharmacy sales data remain a proxy for understanding access to SRH since women may or may not have received SRH services from other access points. Fourth, due to the overlap in timing between COVID-19 and subsequent policy restrictions, we are currently unable to separately identify the impact of each exposure, similar to much of the existing literature. Serrano-Alarcon *et al* (2021)[38] are a notable exception, where the authors exploit the different policy responses to COVID-19 in England and Scotland despite similar epidemiological trends to estimate impacts on mental health.

CONCLUSIONS

Our findings add to the growing literature on the impacts of COVID-19 on health systems, especially the disproportionate impact on women. Our finding from pharmacies, a highly accessible avenue for women to obtain SRH products,[29 30] is particularly concerning in the context of the diminishing reproductive rights of women across the globe, but also represents an opportunity to increase SRH product access in times of crises.[39] For example, policymakers could provide subsidies, either to consumers or pharmacies, to stop negative feedback loops where pharmacies exacerbate decreases in demand by increasing prices in an attempt to maintain revenue neutrality. These policies could further have positive spillovers on women's access to SRH products outside of times of crisis. Policymakers should consider the unintended consequences of policy restrictions to ensure that women retain access to critical SRH services during future crises. Note, however, that policymakers' role may be limited in cases of broader macroeconomic problems such as global supply chain disruptions and inflation when supply shocks are unrelated to local policy restrictions.

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