BMJ Open

Effect of the COVID-19 pandemic on maternal healthcare indices in Southern Iran: an interrupted time series analysis

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To cite: Yadollahi P, Zangeneh N, Heiran A, *et al*. Effect of the COVID-19 pandemic on maternal healthcare indices in Southern Iran: an interrupted time series analysis. *BMJ Open* 2022;**12**:e059983. doi:10.1136/bmjopen-2021-059983

► Prepublication history for this paper is available online. To view these files, please visit the journal online (http://dx.doi.org/10.1136/bmjopen-2021-059983).

Received 14 December 2021
Accepted 03 October 2022

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ABSTRACT

Objectives Epidemics are anticipated to influence the coverage of health services. We assessed the impact of the COVID-19 pandemic on maternal healthcare indices and care providers' performance.

Setting 1801 maternal healthcare centres under the auspices of Shiraz University of Medical Sciences, Shiraz, Southern Iran.

Participants Approximately 63 000 pregnant women.

Primary and secondary outcome measures In this prospective ecological study, interrupted time series analysis was used to model and compare the trend of maternal healthcare indices before and after the COVID-19 pandemic announcement.

Results The results showed a significant drop in count of preconception healthcare visits, first routine laboratory tests, first trimester prenatal care, first trimester sonography, prenatal screening for birth defects at weeks 11–13, prenatal care visits at weeks 16–20, second routine laboratory tests, second trimester sonography, prenatal care visits at weeks 24–30, prenatal care visits at weeks 31–34, postpartum care visits at days 10–15 and postpartum care visits at days 30–42 with the start of the COVID-19 pandemic (–50% (95% CI –48.68% to –51.36%), –19.67% (95% CI –22.12% to –17.15%), –25.88% (95% CI –28.46% to –23.21%), –23.84% (95% CI –26.26% to –21.34%), –20.16% (95% CI –23.01% to –17.20%), –18.53% (95% CI –21.25% to –15.71%), –28.63% (95% CI –31.03% to –26.14%), –27.48% (95% CI –30.07% to –24.79%), –31.08% (95% CI –33.43% to –28.61%), –31.84% (95% CI –34.35% to –29.23%), 32.55% (95% CI –35.12% to –29.89%) and –39.28% (95% CI –41.59% to –36.88%), respectively). Nevertheless, the trend in coverage of these services showed recovery in the subsequent months (8.36%, 10.55%, 5.74%, 8.01%, 4.40%, 5.06%, 11.20%, 7.58%, 7.38%, 7.80%, 9.59% and 9.61% per month, respectively).

Conclusions Using ecological data during the COVID-19 pandemic era, we observed a 'level change and slope change' as the major pattern of interruption of maternal healthcare coverage, indicating a possible indirect effect rather than a causative relationship. Such relative predictability might assist with future pandemic planning.

STRENGTHS AND LIMITATIONS OF THIS STUDY

- ⇒ We performed a large-scale ecological study on approximately 63 000 pregnant women.
- ⇒ We studied both prenatal and postpartum healthcare coverage and maternal outcomes.
- ⇒ The interrupted time series models were limited to eight preinterruption and seven postinterruption time points; that is, assessing the seasonality was impossible in this study.
- ⇒ Our data were restricted to a single province in Iran, known for its high performance in healthcare services at the national level; hence, the results might not be generalisable to other regions.

INTRODUCTION

Health service coverage, especially maternal care, constantly changes in response to emerging crises. These changes are especially noticeable during an infectious disease pandemic.[1–3] The most recent infectious disease to become a pandemic is COVID-19, which emerged in late 2019 and is caused by SARS-CoV-2. Governments and health policymakers have sought to launch programmes to tackle this pandemic's emerging direct and indirect effects. A study on the 2014 Ebola virus outbreak in West Africa showed that the indirect effects of the outbreak were more significant than the outbreak itself.[4] Therefore, it is essential to maintain the healthcare framework, ensure access to adequate food and redistribute healthcare infrastructures (health workers, equipment and facilities) to respond to the influx of patients with COVID-19.[4,5]

Pregnant women are a key focus of health systems. Although a low overall risk of severe illness, it appears that pregnant women are at an increased risk for severe illness from COVID-19 compared with non-pregnant women, particularly in the third trimester.[6,7] WHO has suggested that crowded clinics should be avoided and the chance of transmission should be minimised in low-risk pregnancies. On the other hand, prenatal

Table 1 Maternal healthcare indices

Count of	A. Preconception care visit B. First routine lab tests C. First trimester prenatal care (6–10 weeks) visit D. First trimester sonography (<14 weeks) E. Prenatal screening for birth defects (11–13 weeks) F. Prenatal screening for birth defects (15–17 weeks) G. 16–20 weeks' prenatal care visit H. Second routine lab tests I. Second trimester sonography (18–22 weeks) J. 24–30 weeks' prenatal care visit K. 31–34 weeks' prenatal care visit L. 38 weeks' prenatal care consultation M. Day 1–3 postpartum care visit N. Day 10–15 postpartum care visit O. Day 30–42 postpartum care visit P. Abortions or ectopic pregnancies
Percentage of	Q. Home birth R. Emergency on-the-road delivery S. Maternal death

care for high-risk pregnancies and women in their third trimester should be prioritised and applied with minor modifications.[8] Accordingly, a group working on reproductive health in crises (Inter-Agency Working Group) published a technical package for maternity services during the COVID-19 pandemic in July 2020.[9]

In previous epidemics, health systems sought to maintain health services, the success of which was limited.[10] A 2014 study of the Ebola virus outbreak estimated that prenatal care, family health, delivery services and postpartum care coverage decreased by 23%, 6%, 8% and 13%, respectively. The reasons for these reductions were fear of the Ebola virus in medical centres, distrust in the health system and rumours about the source of the disease.[11] Similarly, during the 2003 severe acute respiratory syndrome outbreak in Taiwan, outpatient care and inpatient care services decreased by 23.9% and 35.2%, respectively.[12] In addition, simulation models of influenza epidemics have predicted a reduction in health service coverage.[13] In another study of the Ebola epidemic, prenatal care visits decreased by 41%, only recovering to 63% of the pre-Ebola levels. The same pattern was also observed for the count of deliveries; despite a relative postepidemic improvement, pre-epidemic levels were not reached at the time of the study.[14]

During the COVID-19 pandemic, some evidence indicates changes in prenatal and postpartum care. For example, Rabbani *et al*[15] showed that about one-third of pregnant women in Saudi Arabia missed their antenatal care visit during the COVID-19 pandemic. In addition, in a study from six healthcare facilities in Kenya, Landrian *et al*[16] reported that pregnant women had significantly higher odds of delay in antenatal care visits during the COVID-19 pandemic. On the other hand, a study from 11 rural primary healthcare clinics in South Africa showed that lockdown strategies significantly decreased daily counts of child healthcare visits, but did not affect daily counts of antenatal care, postnatal care and family planning visits.[17]

Such declines in health service coverage are probably due to the dramatic changes in healthcare systems. These changes include the divergence of resources and bias towards COVID-19 management measures; redistribution of health services, budget and manpower; financial barriers because of job cuts and damaged monetary and banking systems; physical restrictions to accessing services; and fear of infection and long-term separation. Accordingly, maternal healthcare indices might drop dramatically in the context of the COVID-19 pandemic.

In this study, we sought to assess the impact of the COVID-19 pandemic on maternal healthcare indices and care providers' performance in health centres under the auspices of Shiraz University of Medical Sciences (SUMS), Shiraz, Southern Iran.

MATERIALS AND METHODS

Study design

As a potential spin-off of administrative data linkage, we conducted an ecological study on the impact of the declaration of the COVID-19 pandemic on maternal healthcare indices in Southern Iran.

The target data were the aggregated data of all pregnant women who resided in the regions under cover of SUMS, Fars province, Southern Iran, from 22 June 2019 to 21 September 2020. Individuals' data were not used. This population received maternal healthcare services from 1801 maternal healthcare centres, comprising 1489 local public health centres and auxiliary nurse and midwifery health centres and 312 district community health centres in 31 counties.

Data repository

A list was acquired from the Department of Health, SUMS, Shiraz, Iran, which included the ID numbers of

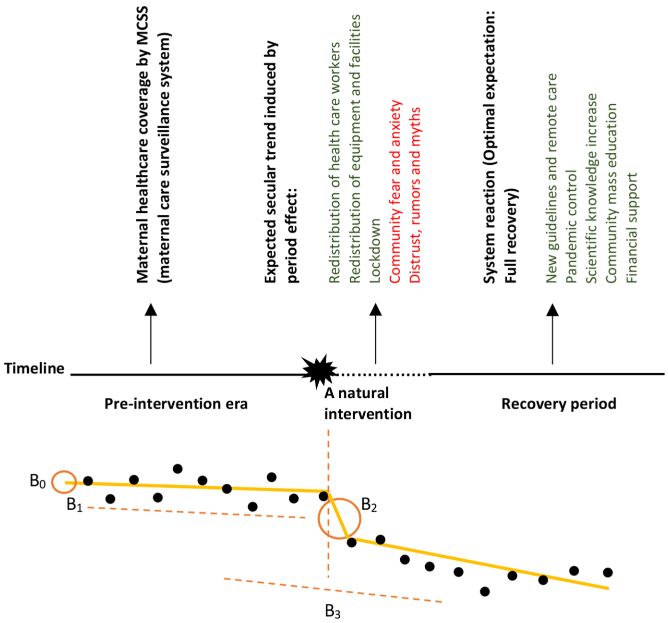

Figure 1 Effects of a natural interruption on maternal healthcare coverage and its implication on using the interrupted time series models

the target population. The target data were the aggregated (ecological) monthly counts or percentages of 19 maternal healthcare indices (ie, visit or outcome) (table 1). We acquired these data from the monthly reports of the 'Integrated Health System' (in Persian: 'Samaneh Yekparche-ye Behdashti') repository—an electronic health record system established 5 years ago.

Primary and secondary outcome measures

The primary outcome of our study was the immediate shock induced by the COVID-19 pandemic on maternal healthcare indices. The secondary outcome was the trend of these indices before and after the crisis began, that is, 8 months before (from 22 June 2019 to 19 February 2020) and 7 months after the COVID-19 pandemic was announced locally (from 20 February 2020 to 21 September 2020).

Statistical analysis

For data handling, Microsoft Excel (Microsoft Office Professional Plus (2016), Microsoft Excel: V.16.0.4549.1000. Santa Rosa, California: Microsoft) data entry software was used. Data were described using the mean and the 95% CI. A p value ≤0.05 was considered statistically significant.

To assess the primary and secondary outcomes, time series models were applied using 'Statistical Software for Data Science (Stata)' (Stata (2017), Stata Statistical Software: Release 15. College Station, Texas: StataCorp). Because of the anticipated decline in healthcare indices by an interrupting cause, we were expected to observe different time segments with different slopes before and after the declaration of the COVID-19 pandemic. Therefore, we used interrupted time series models. In addition, based on existing evidence on previous epidemics and knowledge of the interruption, we expected that the interruption would impact the outcome with no lag, leading to a level change; then, because of the recovery actions of the health surveillance system, the postinterruption trend would differ compared with the preinterruption period (impact model, figure 1). Moreover, the segmented Poisson regression was selected since each dependent variable was constituted from the counts of care delivered in a month. The interrupted time series models require at least three independent variables[18]:

$$Y_t = \beta_0 + \beta_1 T + \beta_2 X_t + \beta_3 \left(T - T_i\right) X_t$$

where:

- β_0 estimates the *base level* of the dependent variable at the beginning of the series.
- β_1 estimates the *base trend or slope* of the dependent variable during the given T months, seasons, years, etc (preinterruption time segment; 8 months before the COVID-19 pandemic was announced in the region).
- β_2 estimates the *change in the level* of the dependent variable in the first month (a month after the COVID-19 pandemic was announced) of the postinterruption time segment.
- β_3 estimates the *change in trend or slope* (difference in the slopes) in the postinterruption time segment (7 months after the COVID-19 pandemic was announced) in comparison with the base trend according to the time interruption interaction (TX_t).
- $\beta_1 + \beta_3$ estimates the trend or slope of the dependent variable in the postinterruption time segment.
- T is the time (day, week, month, season, year, etc) elapsed by the beginning of the series.
- X_t is a dummy variable to determine preinterruption and postinterruption time segments.
- $T - T_i$ is equal to the time elapsed by the beginning of the interruption.
- Y_t is the dependent variable (count of care delivered in a month).

To assess the autocorrelation, we visually inspected the Poisson regression plots for the underlying trend and outliers. Also, to investigate the residual autocorrelation, the residuals were plotted against time points, which showed data were randomly distributed (no residual autocorrelation). Furthermore, Poisson regression is prone to overconfidence in the estimates (ie, the artificially small statistical significance, lower p values, incorrect estimation of the SEs) because of the potential overdispersion of the data. To address this issue, we adjusted to a quasi-Poisson model by adding the scale (×2) parameter, which allows the variance to be proportional rather than equal to the mean.[19]

The point interruption day was set as 20 February 2020 (equivalent to the first day of the last month of the solar Hijri calendar), when the first case of COVID-19 was officially announced in Shiraz, the capital of the Fars province. We used monthly values as the unit of time periods for interrupted time series analysis on the aggregated values. We assumed that the announcement of the

COVID-19 pandemic was the sole sudden interruption or event that affected healthcare service coverage during the study period.

The outputs of segmented Poisson regression include three coefficients (β_1, β_2 and β_3). β_1 represents the predicted proportional change in the base level of an outcome (β_0) per month over the eight preinterruption months. β_2 represents the estimated change in the level of an outcome by the first month after the interruption (ie, a month after the COVID-19 pandemic was announced). By summing β_1 with β_3, the predicted proportional change in the outcome per month over the seven postinterruption months was calculated. Also, β_3 represents the difference between the preinterruption and postinterruption time segments for each outcome.[18 19]

Patient and public involvement

No patient involved.

RESULTS

A range of 20 830–23 710 pregnant women per month was recorded by 1801 maternal healthcare centres during the 15-month study period, from 22 June 2019 to 21 September 2020, which yielded a total of approximately 63 000 pregnancies. Table 2 shows changes induced by the COVID-19 pandemic in the trend of various maternal healthcare indices.

A significant rise in preconception healthcare visits was recorded before the COVID-19 pandemic (β_1=5.36% (95% CI 4.97% to 5.76%) per month, p<0.001), which dropped remarkably with the start of the pandemic (β_2=−50% (95% CI −48.68% to −51.36%), p<0.001). However, it started to recover in the subsequent months (β_1+β_3=8.36% per month) (figure 2A).

With the start of the COVID-19 pandemic, trends in the counts of first routine laboratory tests, first trimester prenatal care, first trimester sonography and prenatal screening for birth defects at weeks 11–13 fell significantly (β_2=−19.67% (95% CI −22.12% to −17.15%), −25.88% (95% CI −28.46% to −23.21%), −23.84% (95% CI −26.26% to −21.34%) and −20.16% (95% CI −23.01% to −17.20%); p=0.001, p<0.001, p<0.001 and p<0.001, respectively). Then, they started to recover in the next months (β_1+β_3=10.55%, 5.74%, 8.01% and 4.40% per month, respectively) (figure 2B–E).

A significant decreasing pattern was observed in prenatal screening for birth defects at 15–17 weeks before the COVID-19 pandemic (β_1=−3.85% (95% CI −4.56% to −3.15%) per month, p<0.001). After announcing the first cases of COVID-19, this parameter showed a non-significant increase (β_2=4.87% (95% CI −0.40% to 10.42%), p=0.07), which continued in the subsequent months (β_1+β_3=9.49% per month) (figure 2F).

With the emergence of COVID-19, trends in the counts of prenatal care visits at 16–20 weeks, second routine laboratory tests and second trimester sonography dropped significantly (β_2=−18.53% (95% CI −21.25% to −15.71%), −28.63% (95% CI −31.03% to −26.14%) and −27.48% (95% CI −30.07% to −24.79%); p<0.001, p<0.001 and p<0.001, respectively). Then, they increased in the next months (β_1+β_3=5.06%, 11.20% and 7.58% per month, respectively) (figure 2G–I).

Again, with the onset of the COVID-19 pandemic, trends in the counts of prenatal care visits at 24–30 weeks, at 31–34 weeks and on the 38th week significantly fell (β_2=−31.08% (95% CI −33.43% to −28.61%), −31.84% (95% CI −34.35% to −29.23%) and −21.93% (95% CI −25.91% to −18.76%); p<0.001, p<0.001 and p<0.001, respectively). Then, while the first two parameters increased in the next months (β_1+β_3=7.38% and 7.80% per month, respectively), the last parameter fell further with the continuation of the COVID-19 pandemic (β_1+β_3=−4.08% per month) (figure 2J–L).

For postpartum care visits at days 1–3, 10–15 and 30–42, we observed a decreasing trend before the COVID-19 pandemic (β_1=−5.80% (95% CI −6.43% to −5.16%), −2.12% (95% CI −2.63% to −1.62%) and −1.84% (95% CI −2.32% to −1.23%) per month; p<0.001, p<0.001 and p<0.001, respectively). The pandemic exerted a shock to these values at its onset (β_2=32% (95% CI 26.09% to 38.19%), −32.55% (95% CI −35.12% to −29.89%) and −39.28% (95% CI −41.59% to −36.88%); p<0.001, p<0.001 and p<0.001, respectively), but a recovery was noted in the subsequent months for the last two parameters (β_1+β_3=9.59% and 9.61% per month, respectively), as well as a further increase for the first parameter (β_1+β_3=18.82% per month) (figure 2M–O).

Rates or percentages of abortion or ruptured ectopic pregnancy, home birth, emergency on-the-road delivery and maternal death were stable before COVID-19 and were not significantly changed by the onset of the COVID-19 pandemic (β_2=42.32% (95% CI −85.52% to 142.21%), −50.04% (95% CI: NA) and 85.17% (95% CI: NA); p=0.748, p=0.825 and p=0.971, respectively), except for the rate of abortion or ruptured ectopic pregnancy (β_2=−23.20% (95% CI −30.56% to 15.06%), p<0.001). No significant difference was found between the preinterruption and postinterruption time segments (p=0.901, p=0.877 and p=0.946, respectively), except for the rate of abortion or ruptured ectopic pregnancy (p=0.012) (figure 2P–S).

DISCUSSION

We learnt from previous outbreaks and epidemics of this millennium that healthcare service coverage is prone to experiencing a secular trend following a specific interruption ('*period effect*'). The magnitude and duration of this change in coverage are associated with several factors, including redistribution of health staff and facilities, the introduction of unusual nationwide policies (eg, lockdown, community fear and phobia) and the ability to tackle and manipulate distrust, rumours and myths ('*social context and population behaviors*') among people, exerted mainly by mass media. A comprehensive

Table 2 Interrupted time series analysis of trends in the counts of maternal healthcare indices in Fars province, Southern Iran, using the announcement of the COVID-19 pandemic as the interruption

	Baseline level	Preinterruption trend		Level change by interruption		Postinterruption trend change	
Variable	**B_0 (95% CI)**	**β_1 (95% CI)**	**P value**	**β_2 (95% CI)**	**P value**	**β_3 (95% CI)**	**P value**
Preconception care visit (n)	5132 (5031 to 5235)	5.36% (4.97 to 5.76)	<0.001	−50% (−48.68 to −51.36)	<0.001	3% (2.35 to 3.66)	<0.001
First routine lab tests (n)	5062 (4953 to 5174)	−1.35% (−1.78 to −0.92)	<0.001	−19.67% (−22.12 to −17.15)	<0.001	9.20% (8.44 to 9.98)	<0.001
First trimester prenatal care (6–10 weeks) visit (n)	3934 (3838 to 4032)	−0.84% (−1.33 to −0.35)	0.001	−25.88% (−28.46 to −23.21)	<0.001	4.90% (4.03 to 5.77)	<0.001
First trimester sonography (<14 weeks) (n)	4538 (4435 to 4643)	−0.77% (−1.23 to −0.22)	0.001	−23.84% (−26.26 to −21.34)	<0.001	7.24% (6.44 to 8.04)	<0.001
Prenatal screening for birth defects (11–13 weeks) (n)	3608 (3516 to 3702)	−0.80% (−1.21 to −0.29)	0.002	−20.16% (−23.01 to −17.20)	<0.001	3.60% (2.72 to 4.50)	<0.001
Prenatal screening for birth defects (15–17 weeks) (n)	2020 (1948 to 2093)	−3.85% (−4.56 to −3.15)	<0.001	4.87% (−0.40 to 10.42)	0.07	5.64% (4.39 to 6.91)	<0.001
16–20 weeks' prenatal care visit (n)	4302 (4201 to 4405)	−1.38% (−1.85 to −0.91)	<0.001	−18.53% (−21.25 to −15.71)	<0.001	3.68% (−2.86 to 4.52)	<0.001
Second routine lab tests (n)	4531 (4427 to 4638)	−1.83% (−2.29 to −1.27)	<0.001	−28.63% (−31.03 to −26.14)	<0.001	9.87% (9.01 to 10.74)	<0.001
Second trimester sonography (18–22 weeks) (n)	4027 (3929 to 4127)	−1.32% (−2.21 to −1.23)	<0.001	−27.48% (−30.07 to −24.79)	<0.001	6.26% (5.36 to 7.17)	<0.001
24–30 weeks' prenatal care visit (n)	4194 (4095 to 4295)	−0.96% (−1.43 to −0.48)	<0.001	−31.08% (−33.43 to −28.61)	<0.001	6.42% (5.55 to 7.29)	<0.001
31–34 weeks' prenatal care visit (n)	3727 (3633 to 3822)	−1.21% (−1.72 to −0.71)	<0.001	−31.84% (−34.35 to −29.23)	<0.001	6.59% (5.65 to 7.53)	<0.001
38 weeks' prenatal care consultation (n)	2184 (2111 to 2259)	−2.92% (−3.59 to −2.25)	<0.001	−21.93 (−25.91 to −18.76)	<0.001	−1.16 (−2.85 to − 0.29)	0.016
Postpartum care visit (1–3 days) (n)	2639 (2556 to 2725)	−5.80% (−6.43 to −5.16)	<0.001	32% (26.09 to 38.19)	<0.001	13.02% (11.89 to14.17)	<0.001
Postpartum care visit (10–15 days) (n)	3782 (3687 to 3881)	−2.12% (−2.63 to −1.62)	<0.001	−32.55% (−35.12 to −29.89)	<0.001	7.47% (6.49 to 8.45)	<0.001
Postpartum care visit (30–42 days) (n)	3915 (3818 to 4014)	−1.84% (−2.32 to −1.23)	<0.001	−39.28% (−41.59 to −36.88)	<0.001	6.77% (5.78 to 7.76)	<0.001
Abortion or ectopic pregnancy (n)	438 (407 to 471)	0.35% (−1.08 to 1.76)	0.637	−23.20% (−30.56 to −15.06)	<0.001	3.10% (0.68 to 5.58)	0.012
Home birth (%)	0.97% (−0.85 to 2.98)	−2.72% (−30.72 to 35.71)	0.869	42.32% (−83.52 to 142.21)	0.748	−3.20% (−42.50 to 61.91)	0.901
Emergency on-the-road delivery (%)	0.08% (NA, 2.45)	9.63% (−49.09 to 144.65)	0.840	−50.04% (NA, NA)	0.825	−11.88% (−87.56 to 61.62)	0.877
Maternal death (%)	0.01% (NA, NA)	−19.53% (−88.95, NA)	0.921	85.17% (NA, NA)	0.971	28.88% (NA, NA)	0.946

NA, not available.

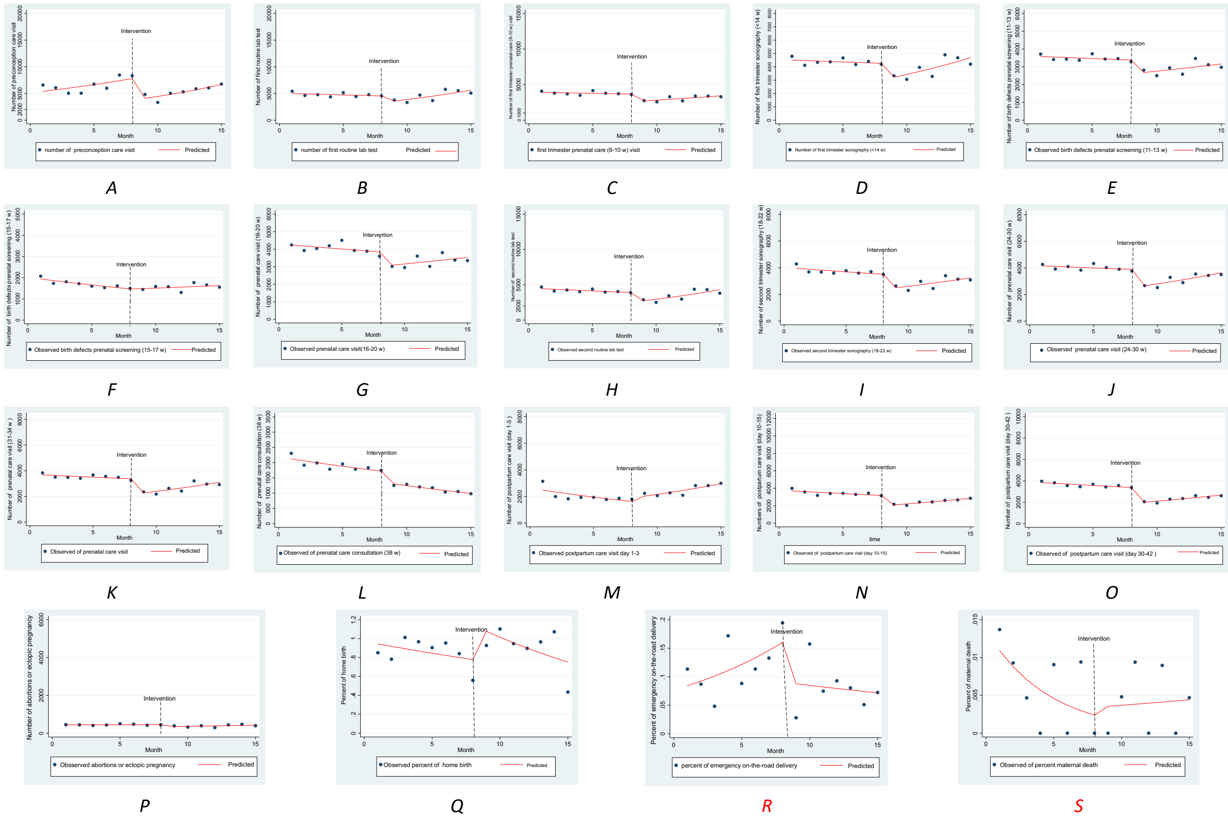

Figure 2. Interrupted time series plots of trends in count of maternal healthcare indices in southern Iran using COVID-19 pandemic as the intervention [count of (A) preconception care visit, (B) first routine lab test, (C) first trimester prenatal care (6-10 *w*) visit, (D) first trimester sonography (<14 *w*), (E) birth defects prenatal screening (11-13 *w*), (F) birth defects prenatal screening (15-17 *w*), (G) 16-20 *w* prenatal care visit, (H) second routine lab test, (I) second trimester sonography (18-22 *w*), (J) 24-30 *w* prenatal care visit, (K) 31-34 *w* prenatal care visit, (L) 38 *w* prenatal care consultation, (M) day 1-3 postpartum care visit, (N) day 10-15 postpartum care visit, (O) day 30-42 postpartum care visit, and (P) abortions or ectopic pregnancy, and percent of (Q) home birth, (R) emergency on-the-road delivery and (S) maternal death.]; *note on X axis: pre-intervention interval was from June, 2019 to February, 2020; point intervention day was set as February 20, 2020; post-intervention interval was from February, 2020 to September, 2020.*

Figure 2 Interrupted time series plots of trends in the counts of maternal healthcare indices in Southern Iran using the COVID-19 pandemic as the intervention: (A) preconception care visit; (B) first routine lab tests; (C) first trimester prenatal care (6–10 weeks) visit; (D) first trimester sonography (<14 weeks); (E) prenatal screening for birth defects (11–13 weeks); (F) prenatal screening for birth defects (15–17 weeks); (G) 16–20 weeks' prenatal care visit; (H) second routine lab tests; (I) second trimester sonography (18–22 weeks); (J) 24–30 weeks' prenatal care visit; (K) 31–34 weeks' prenatal care visit; (L) 38 weeks' prenatal care consultation; (M) day 1–3 postpartum care visit; (N) day 10–15 postpartum care visit; (O) day 30–42 postpartum care visit; (P) abortions or ectopic pregnancies; (Q) home birth (percentage); (R) emergency on-the-road delivery (percentage); and (S) maternal death (percentage). On the x-axis, the preintervention interval was from June 2019 to February 2020, the point intervention day was set as 20 February 2020 and the postintervention interval was from February 2020 to September 2020.

action plan together with adequate resources in a resilient health system ('*optimal scenario*') is expected to break this secular trend ('*system reaction*'). By controlling the outbreak and epidemic, it is possible to return the postinterruption health indices to their preinterruption (baseline) levels. Of note, a considerable recovery gap may persist depending on resources. As expected, similar patterns have been reported for reproductive and maternal healthcare service coverage in previous outbreaks and epidemics and the current COVID-19 pandemic.[14 20–25] However, most prior studies did not yield comprehensive information pertaining to trends in the related indices.

In the present study, a secular trend was seen in most maternal healthcare indices, which was exaggerated further with the shock announcement of the COVID-19 pandemic. Nonetheless, almost all of the measured indices started to recover after a gap of 1–2 months. In this context, an important question arises: can these changes affect maternal and neonatal outcomes?

What determines maternal and fetal outcomes includes the characteristics of the underlying agent (direct), the ability of the health system to cope and provide an adequate response and the public's reaction (indirect). A great heterogeneity (up to 100-fold difference) is reported for maternal-newborn outcomes across high and low-income countries.[26] While outcomes of pregnant women with COVID-19 are mixed in different studies,[27–29] a recently published meta-analysis revealed that though maternal and fetal outcomes (maternal death, stillbirth, ruptured ectopic pregnancy and maternal depression) have worsened during the pandemic, the amount of recourse has significantly modulated some of these outcomes globally. In other words, it appears that the direct effect (the underlying agent) is probably not the cause of poor outcomes, for which the indirect effect might be responsible.[23]

In line with Sustainable Development Goals related to maternal health, the Iranian maternal care surveillance system (MCSS) immediately established its task force to prevent disruption of maternal healthcare services as a top priority while withstanding COVID-19 health shocks. For example, telecommunication and self-monitoring protocols were devised and management guidelines and educational programmes were developed, with intensive care unit admissions and high-risk subjects at the centre of attention. The action plan is described in detail by Changizi and coauthors.[30] In this regard, we showed that rates of abortion or ruptured ectopic pregnancy, home birth, emergency on-the-road delivery and maternal death did not increase with the onset of the COVID-19 pandemic or in the following 7 months.

It is worth noting that a portion of these secular trends should also be attributed to the MCSS decisions rather than the direct or indirect effects of the pandemic. For example, reductions in antenatal and postnatal care face-to-face visits were suggested in low-risk pregnancies[7 31 32]; hence, it would be plausible to observe a secular trend without any significant change in outcomes.[24] Noticeably, WHO suggested prioritising and providing third trimester prenatal care (because of the risk of preterm labour and birth, hypertensive disorders, bleeding events, fetal malpresentation, etc) and high-risk pregnancy care with minor modifications.[7] We found that the rate of 24–30 and 31–34 weeks' prenatal care visits in the third trimester declined immediately after the interruption. Still, they significantly rebounded with an upward trend during the COVID-19 pandemic. Surprisingly, the count of prenatal care visits on the 38th week of gestation showed a postinterruption downward trend. Although our data cannot explain the exact reason behind this phenomenon, one can hypothesise that such a postinterruption decrease might result from an unknown intervention (policy, etc) or insufficient preinterruption time points.

Our study had at least two major limitations. First, Penfold and Zhang state that a minimum of eight time point measurements are required for both time segments before and after the interruption to assess changes robustly, although interrupted time series analysis would be possible with a smaller number of time vectors.[20] Also, an interrupted time series analysis usually should deal with confounding effects such as seasonality. While we could not acquire more data, assessing seasonality was inaccurate and impossible with only eight preinterruption and seven postinterruption time points. Nonetheless, the nature of our outcome variables might be less prone to seasonal changes, and there were no other noticeable time-varying confounders during the study period that could potentially influence the outcome. Second, our data were restricted to a single province in Iran, known for its high performance in healthcare services at the national level; hence, the results might not be generalisable to other regions.

CONCLUSION

We performed a large-scale ecological study in Southern Iran to assess the change in maternal healthcare indices due to the COVID-19 pandemic. Our study showed that most maternal healthcare indices sharply declined with the announcement of the COVID-19 pandemic but soon started to recover after a gap of 1–2 months. However, our data showed no significant changes in maternal outcomes.

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Funding The present article was financially supported by the Shiraz University of Medical Sciences (grant number: 99-01-08-23662).

Competing interests None declared.

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

Patient consent for publication Not applicable.

Ethics approval The study protocol was approved by the Ethics Committee of Shiraz University of Medical Sciences (code: IR.SUMS.REC.1399.1039).

Provenance and peer review Not commissioned; externally peer reviewed.

Data availability statement Data are available upon reasonable request. Data will be shared on request to the corresponding author with the third party's permission.

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