Trend of adjusted antenatal care visits on pregnant women and neonatal during the COVID-19 pandemic: Findings from a three districts survey in 2021

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ABSTRACT

Sustainable health development efforts amid infectious disease outbreaks such as Coronavirus disease 2019 (COVID-19) require a resilient maternal health system. With cases rising globally and across Asia, Indonesia faces significant disruptions in essential services. A critical research gap exist in utilizing adjusted time-series analysis to isolated pandemic impact from seasonal variation in urban Indonesia. This study evaluates trends in antenatal care (ANC) visits (January 2019–December 2020) at three Community Health Centres in Makassar: Bara-Baraya, Jongaya and Batua using Interrupted Time Series (ITS) analysis. Findings reveal a significant decline in visits during the second and third quarters of 2020, primarily due to transmission fears. We suggest integration of telemedicine and home visits to maintain continuity of care. Although focused on urban Makassar, these results are an important reference for health and offer applicable solutions for other developing countries facing resource constraints. This study emphasizes the need for inclusive prevention strategies to protect maternal health in urban and rural areas in low- to middle-income countries during systemic health crises.

ABSTRAK

Upaya pengembangan kesehatan berkelanjutan di tengah wabah penyakit menular seperti COVID-19 memerlukan sistem kesehatan ibu yang tangguh. Dengan kasus yang terus meningkat secara global dan di seluruh Asia, Indonesia menghadapi gangguan signifikan pada layanan esensial. Terdapat kesenjangan penelitian kritis dalam memanfaatkan analisis time-series yang disesuaikan untuk memisahkan dampak pandemi dari variasi musiman di Indonesia perkotaan. Studi ini mengevaluasi tren kunjungan perawatan antenatal (ANC) (Januari 2019– Desember 2020) di tiga Pusat Kesehatan Masyarakat (Puskesmas) di Makassar: Bara-Baraya, Jongaya dan Batua menggunakan analisis Interrupted Time Series (ITS). Temuan menunjukkan penurunan signifikan dalam kunjungan selama kuartal kedua dan ketiga tahun 2020, terutama disebabkan oleh kekhawatiran akan penularan. Kami menyarankan integrasi telemedisin dan kunjungan rumah untuk menjaga kelangsungan perawatan. Meskipun berfokus pada Makassar perkotaan, hasil ini menjadi acuan penting bagi kesehatan dan menawarkan solusi yang dapat diterapkan bagi negara-negara berkembang lain yang menghadapi keterbatasan sumber daya. Studi ini menekankan perlunya strategi pencegahan inklusif untuk melindungi kesehatan ibu di daerah perkotaan dan pedesaan di negara-negara berpendapatan rendah hingga menengah selama krisis kesehatan sistemik.

GRAPHICAL ABSTRACT
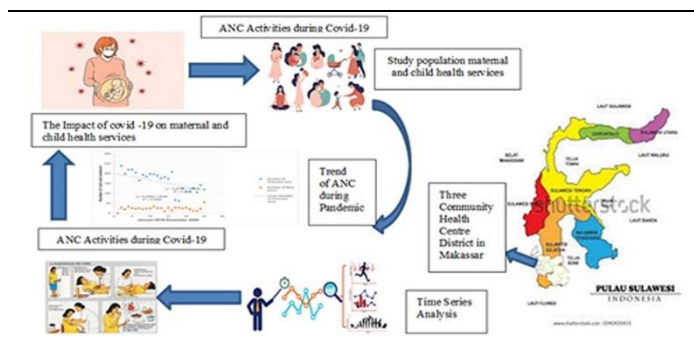
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INTRODUCTION

Maternal and child health services, including examinations during pregnancy, birth, and after birth, are becoming widely discussed topics among earlier scholars (Central Bureau Statistic, 2019). However, maternal morbidity and mortality rates are still different and quite varied in some areas. The ratio of maternal mortality and access to health services in densely populated areas is even significantly lower than others due to disparities in healthcare facility access (Provincial Health Office, 2019; Tounkara et al. 2023).

Moreover, the continuity of these essential maternal services faced an unprecedented global threat. The exponential increase in COVID-19 cases globally (reaching millions of cases by mid-2020) and across Asia has become essential. In Indonesia, where cases surged significantly in early 2020, the implementation of government policies subsequently (Chu et al., 2022; Eurosurveillance Editorial Team, 2020; Kotlar et al., 2021; Thompson et al., 2025). Therefore, the occurrence of COVID-19 pandemic in Indonesia prompted adjustments to health service guidelines for maternal care, including pregnant women's antenatal and newborns services (Indonesia Ministry Health, 2020).

Disruptions in antenatal care services during the pandemic caused lower utilization rates, which have led to an increase in adverse pregnancy outcomes such as miscarriage, premature birth, low birth weight, and fetal death (Ariani et al. 2022). Moreover, during the COVID-19 pandemic, the frequency decreased to only two visits. In response to this, community health centers have facilitated virtual communication between health workers to overcome antenatal and postnatal care visit restrictions, including the organization of online classes.

Therefore, this study aimed to investigate the disparities in maternal and child health outcomes as well as access to health services in different areas of Makassar, particularly province of South Sulawesi, Indonesia. Analysis was carried out to assess how various factors influenced healthcare usage over time and examine the availability as well as accessibility of maternal health services, including antenatal care, childbirth services, and postnatal, across different areas. The assessment was performed using an interrupted time series method to identify trends in the number of targets and the extent of coverage. Based on previous studies, interrupted time series produced an analysis that provided a basis for longitudinal observations, enabling comparisons of pre-period and post-period visual plots and graphs, thereby facilitating policymakers' understanding of the results (Lang'At et al. 2019). In comparison, this study used data on antenatal care collected over some time (annually) to inform current decisions and planning based on long-term investigations. The results were expected to be used by policymakers to improve service quality, particularly during the pandemic. Additionally, the use of coordinated health services were measured and monitored to encourage efforts to optimize public health outcomes and to reduce inequality health access toward universal health coverage in achieving expected targets..

METHODS

Study design and participation

This study applied a stratified random sampling approach based on population density (high-, medium-, and low-density strata) to select study sites from the total public health centers (Puskesmas) in Makassar City (N = 47). Three Community Health Centers were selected as study sites: Antang, Jongaya, and Bara-Baraya. The study used longitudinal time-series data of Antenatal Care (ANC) visits extracted from midwives' medical records over a 24-month period (January 2019–December 2020). This period covered both the pre-pandemic and pandemic phases, allowing the assessment of changes in service utilization associated with COVID-19. In this study, the term "adjusted" refers to the statistical processing of raw ANC visit counts using seasonal decomposition (deseasonalization) and moving-average smoothing, with the aim of separating the pandemic-related effect from expected seasonal patterns and irregular fluctuations.

Population and sample criteria

The study population comprised all pregnant women who utilized ANC services at public health facilities in Makassar City. The analytical sample was derived from ANC visit records of pregnant women who received services at the preselected Community Health Centers (Antang, Jongaya, and Bara-Baraya) during the study period (January 2019–December 2020). Eligibility was based on the availability of complete ANC visit records and documented service utilization spanning the defined observation period. Records were excluded for pregnant women with pre-existing medical comorbidities and for those with confirmed active COVID-19 infection during the

Table 1
The number of pregnant women who received antenatal care visits and gave birth

Community Health Centers	Antenatal care		Number of Birth	
	2019	2020	2019	2020
Bara-Barayya	2151	1534	313	287
Jongaya	949	952	280	224
Batua	2760	1851	174	132

study period, as indicated in the medical records.

Study variables

This study used several variables, including antenatal visits and the number of births between 2019 and 2020. The antenatal care was measured, namely the total number of registered antenatal care visits per quarter at three selected community health centers, as taken from routine monitoring records. No subjective cut-off point was applied; this measure represents a direct count of officially recorded events. Meanwhile, the independent variable, time/intervention, was determined by a critical cut-off point (t0) separating the pre- and post-intervention phases, based on the onset of measurable pandemic impact. The time variable (t) was treated as a sequential and continuous variable, with data collected quarterly over two years, resulting in eight periods (t = 1 to t = 8). Elements were selected based on a basic examination of the pregnant woman's condition, including gestational age at the time of visit to the Community Health Centre.

Data analysis

The SPSS program version 23 facilitated the process. Data were analysed using the Interrupted Time Series (ITS) framework to evaluate shifts in Antenatal Care (ANC) visit trends. To isolate the impact of the pandemic from natural temporal variations, the raw data underwent seasonal decomposition using an additive model to generate deseasonalized counts. Additionally, a four-period moving average was applied to smooth irregular fluctuations and highlight long-term trends. These statistical adjustments allowed for a rigorous comparison of level and slope changes between the pre-pandemic (2019) and pandemic (2020) periods, ensuring that the observed changes were attributable to the pandemic intervention rather than seasonal or random variations.

Ethical Consideration

Before collecting the data, ethics approvals were obtained under the Institutional Review Board of the Faculty of Medicine and Health Sciences, Universitas Muhammadiyah Makassar No.016/UM.PKE/X/43/2021. Also, this study obtained approvals from each of the Head Community Health Centers, and it was deemed to use secondary data and a low-risk observational study.

RESULTS
Baseline characteristics

To achieve the objectives of this study, analysis started by collecting a simple data set, containing observation information from January 2019 to December 2020. Data were generated on more than 5860 pregnant women in 2019 and 4337 in 2020. These samples were representative of three selected community health centers who received antenatal care services and gave birth during 2019 to 2020, as shown

Table 2
Time series forecasting on antenatal care visit of community health center of Bara- Barayya

t	Years	Months	Visits	MA (4)[a]	Baseline CMA(4)	Y^t/CMA[b] S^t, I^t	S^t	Y^t / St Deseasonalize	T[c]
1	Year 1	1	658				1.13	582	600,42
2		2	591				1.13	523	-26,753
3		3	577	523	523	1.10	0.83	695	0.000
4		4	564	503	503	1.12	1.16	486	0.000
5	Year 2	1	566	489	489	1.16	1.13	501	0.000
6		2	256	471	471	0.54	1.13	227	0.000
7		3	600	448			0.83	723	0.000
8		4	368				1.16	317	0.000

Note: [a] MA, Moving Average; [b] CMA, Centre Moving Average; [c] T, Time

Table 3

Time series forecasting on antenatal care visit of community health center of Jongaya

t	Years	Months	Visits	MA (4)[a]	Baseline CMA(4)	Y^t/CMA[b] S^t, I^t	S^t	Y^t/St Deseasonalize	T[c]
1	Year 1	1	646				1.24	521	686,605
2		2	667				0.96	695	-28,235
3		3	753	576	576	1.31	1.18	638	0.000
4		4	694	566	566	1.23	0.7	991	0.000
5	Year 2	1	650	550	550	1.18	1.24	524	0.000
6		2	356	509	509	0.7	0.96	371	0.000
7		3	422	463			1.18	358	0.000
8		4	423				0.7	604	0.000

Note: [a] MA, Moving Average; [b] CMA, Centre Moving Average; [c] T, Time

in Table 1. All community health centers have the same services and wide coverage, ensuring the same quality and standard.

Antenatal care measurement

Information about antenatal care services activities for each month was carefully recorded and accumulated during data collection. The samples were selected based on their gestational age and antenatal visit schedule. This led to the assumption that pregnant women recorded early in the year had an early gestational age. Meanwhile, the number of births per month was derived from maternity records. The records were matched with their antenatal care visits and examination services during pregnancy. Women who had given birth were accumulated targeted for each community health centre.

Trend of adjusted antenatal care visits

This prognosis can be observed through a graph created with a line chart using markers. The graph presents detailed information to observe the variations of visits. In this graph, the horizontal axis is labeled with actual years and quarters, with each year divided into four quarters for individual community health center. This arrangement allows for visual presentation of seasonality and trend of visits within two years as one component. The overall direction of these graphs is called the trend component. The final component is a regular component or seasonal component.

The analysis showed the trend of visits in scatter plots (see Figure 1), indicating what happens to one variable when another is modified. As the month progressed, the number of visits also showed a decrease, particularly in certain months of increasing outbreak events. All scatter plots showed negative trends, particularly in the Jongaya community health center, with an R2 value of 0.0001. This suggested that only 0.01% of the variance in the dependent variable could be explained by the independent variable(s) in the model. However, independent variable did not explain much of the variation in the dependent variable.

Antenatal care visits before and during the pandemic have remained stable (Table 4). The first quarter's visits were almost the same as in two years. Specifically, the first year in four quarters showed many visits, a trend that lasted until the first quarter of the second year. In the second quarter, the number of visits decreased by approximately 50%, which continued in the third quarter. Meanwhile, the fourth quarter saw a slight increase, as presented in (Table 3). This study also showed how visits moved through time and could be projected or extrapolated into the future. Moreover, the results showed that the trend of

Table 4

Time series forecasting on antenatal care visit of community health center of Batua

t	Years	Months	Visits	MA (4)[a]	Baseline CMA(4)	Y^t/CMA[b] S^t, I^t	S^t	Y^t/St Deseasonalize	T[c]
1	Year 1	1	209				1.13	185	1,826,462
2		2	156				1.13	138	-390,772
3		3	211	178	178	1.19	0.91	232	0.000
4		4	204	173	173	1.18	1.08	189	0.000
5	Year 2	1	190	176	176	1.08	1.13	168	0.000
6		2	110	169	169	0.65	1.13	97	0.000
7		3	144	161			0.91	158	0.000
8		4	199				1.08	184	0.000

Note: [a] MA, Moving Average; [b] CMA, Centre Moving Average; [c] T, Time

Figure 1
Scatter plot of antenatal care and new-borns in three community health centers
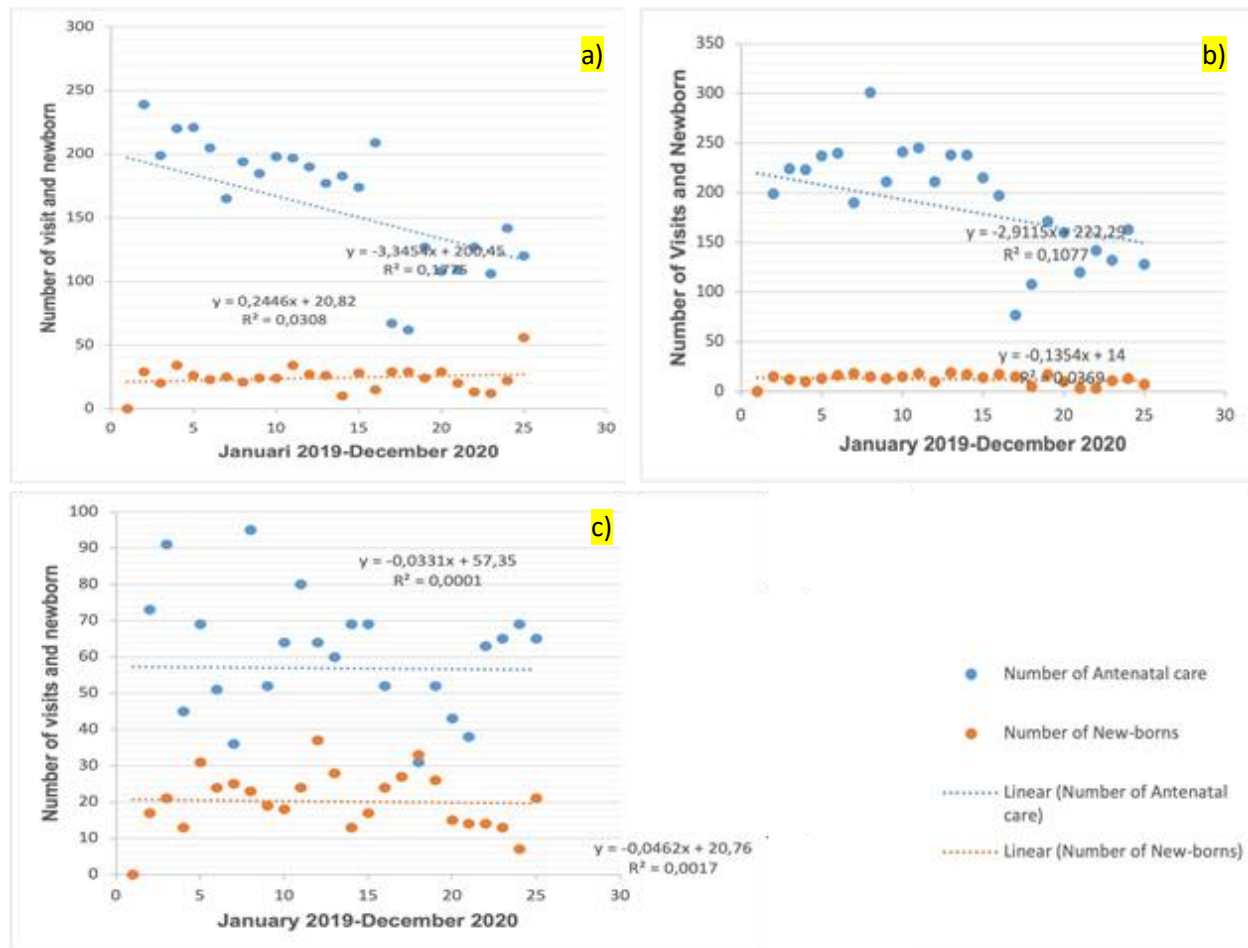
Note: a) Bara-Barayya; b) Batua; c) Jongaya

examination visits followed the pattern of pandemic events and did not experience any significant decrease (Table 2).

DISCUSSION

The impact of policy changes during the COVID-19 pandemic

The COVID-19 pandemic, which started in 2020 and continued into early 2022, significantly impacted antenatal and new-borns care services. This global health crisis showed the need for adaptable and resilient healthcare systems (Fridell et al. 2020). To address the problem, three basic strategies have been used by health systems throughout the world to quickly scale up health system infrastructure. These included building new treatment facilities, transforming public spaces, and rearranging already-existing medical facilities to accommodate patients

with COVID-19 (Haldane V et al. 2021). Therefore, the purpose of this study was to evaluate how well Indonesia's prenatal care services performed during the COVID-19 pandemic. Based on the results, service consumption patterns found were classified as episodic and unpredictable. It is crucial to note that the first study examined the number of visits and births per month.

A significant increase in demand for healthcare services during the pandemic, coupled with a shift in workforce focus towards emergency response, likely contributed to disruptions in routine healthcare services. The pandemic's reverberations extended to both access and quality of care, with maternal and child health services, encompassing perinatal care, immunization programs, and facility deliveries, experiencing significant disruptions across numerous nations(Kikuchi et al., 2024). Similarly,

perinatal care quickly and drastically changed (Downey et al. 2022; Vermeulen et al. 2022). The epidemic has shown that, despite differences in national capacities, investments in increasing the number and quality of health workers are essential to anticipate better and address future pandemics (Haldane et al. 2021). The challenge of low staffing levels and unequal geographic distribution, shortages of sufficient personal protective equipment (PPE), restricted testing capacity, inadequate training, social attacks and discrimination, and poor mental health are faced by health workforce during COVID-19 (World Health Organization, 2020). Therefore, promoting preventive measures, such as keeping a physical distance, washing hands frequently, and using proper breathing method (World Health Organization, 2020) . This method can help keep vulnerable individuals out of the hospital unnecessarily.

To prevent significant disruption to maternal health services during future public health emergencies, evidence-based prevention should be integrated into health policy. Previous research has identified the effectiveness of telemedicine and virtual consultations in maintaining continuity of care and minimizing the risk of infection in low-risk pregnancies (Drummond et al., 2024). In addition, community-based interventions, such as home visits by midwives and the establishment of "green zones" (COVID-free zones) in health facilities, have been shown to restore public confidence and service utilization (Golden et al., 2024). Moreover, the implementation of mHealth applications can facilitate remote monitoring and appointment scheduling to avoid crowds at clinics (Safo et al., 2025). These preventive measures are crucial to ensure that maternal and neonatal health remains a priority even amid a systemic health crisis (World Health Organization & Human Reproduction Programme, 2024).

Disruption and adaptation in antenatal care services during the pandemic

In prenatal care, there is an increasing concern regarding the use of healthcare services during the COVID-19 pandemic. Recent studies have shown a connection between fewer prenatal care visits and poorer health outcomes for both mothers and new-borns. This study shown that there is a potential rise in complicated pregnancies and the need for critical care during deliveries when in the case of fewer prenatal visits and more hospital births (Goyal et al. 2021). The decline in prenatal care visits during the pandemic has the potential to undermine decades of progress in improving maternal and newborn health outcomes.

The implication is insufficient prenatal monitoring, particularly in cases of high-risk pregnancies where prompt referral and intervention are necessary. Meanwhile, pregnant women with conditions like multiple pregnancies, hypertensive disorders of pregnancy, and prior caesarean sections should be immediately recognized and given the proper care in antenatal period (Murewanhema et al. 2023). The results identified a correlation between a higher number of antenatal care visits, particularly during the third trimester of pregnancy, and a lower likelihood of death among new-borns. Compared to women receiving sufficient care, those with intensive care did not have a higher risk of prenatal mortality (Singh et al. 2021; Manjavidze et al. 2020).

This study did not determine the cause of the observed decrease in visits. However, it hypothesized that COVID-19 pandemic made pregnant women afraid, anxious, and even fierce when trying to access healthcare facilities (Miskeen et al. 2024). Similarly, the potential opportunities, such as the convenience of online consultations, could be among contributing factors (Wu H et al. 2020). By offering online resources like educational programs, video calls, and conferencing platforms, pregnant women can access general gestational information, mental health consultations, and antenatal care education, which impact the diagnosis and treatment of pregnancy issues (Wu et al. 2020; Thirugnanasundralingam et al. 2023). These not only allow for convenient learning but also facilitate monitoring for potential pregnancy complications like pre-eclampsia (Wu et al. 2020), although further studies are recommended. Additionally, investigations are needed to determine if there was an influence on prenatal care scheduling, as suggested by some previous studies (Peahl et al. 2021).

After the analysis conducted in this study, the factors causing decreases and similarities between both trends were not identified. Moreover, the fear of transmission of COVID-19 pandemic was assumed to cause poor attendance at antenatal care. It was also assumed that online consultation was more flexible and provided solutions rather than visiting health service facilities. Additionally, online consultation could reduce unnecessary hospital visits and limit potential risks of infection among vulnerable group during the COVID-19 pandemic.

This study showed the statistical analyses of standard regression models. The results showed that the observations were independent. In time series data,

this assumption is often violated due to autocorrelation, a phenomenon where consecutive observations are more similar to each other. In many epidemiological datasets, autocorrelation is largely explained by underlying factors such as seasonality. Therefore, residual autocorrelation is rarely a problem after correcting for the variables. The result emphasized that the study could not show predictable numbers for one or two years (one year before, one year after) ahead since the observations were short enough, two years during the COVID-19 pandemic. This study is similar to the previous report, where trends probably only fluctuated due to the rise in outbreak (Wilhelm et al. 2019).

Due to the outbreak, this study was conducted within short timeframe. The inability to forecast particular data observation periods further limited exact projections. In this context, healthcare systems must fund proactive initiatives and provide ongoing services in times of emergency to manage problems in the future. Although vulnerabilities were identified, the pandemic catalyzed the exploration and implementation of innovative solutions. To ensure sustained accessibility of essential maternal and child health services, particularly during public health emergencies, a multi-pronged method is necessary. There is need for continuous investments in strengthening healthcare infrastructure, upskilling the workforce, and leveraging technological advancements.

CONCLUSIONS

In conclusion, this study showed variations in the association, with some centers having a negative trend. These findings underscored the significance of recognizing local contexts and customizing interventions to address the unique challenges faced by different communities. Localized disruptions such as these in maternal and child health services can trigger a series of adverse consequences, including increased rates of maternal and neonatal mortality, higher rates of preterm births, and a greater incidence of infectious diseases stemming from reduced vaccination coverage. These results suggested that the COVID-19 pandemic disrupted access to essential maternal and child health services, potentially impacting maternal and neonatal health outcomes. This study also provided valuable insights into the challenges and opportunities faced by local healthcare providers and pregnant women in the specific areas covered in Indonesia. The findings contribute to public health by informing the development of focused public health interventions designed to lessen the pandemic's adverse effects on maternal and child health outcomes. By pinpointing the most affected areas and populations, public health authorities can improve resource allocation and implement evidence-based strategies. These strategies will aim to improve access to care and encourage positive health behaviors. Furthermore, while this study focuses on urban Makassar, the observed disruptions provide a critical cautionary tale for rural regions and other developing nations, highlighting the universal need for resilient maternal health frameworks that can withstand future pandemic-scale shocks.

AUTHORS' CONTRIBUTIONS
Juliani Ibrahim: Conceptualization; Methodology; Writing—original draft. Yoko Takahata: Investigation; Writing—review & editing. Sukaeni Ibrahim: Data curation; Writing & editing.

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COMPETING INTERESTS
The authors confirm that all of the text, figures, and tables in the submitted manuscript work are original work created by the authors and that there are no competing professional, financial, or personal interests from other parties.

REFERENCES
Ariani N. Antenatal care services utilization during COVID-19 second wave attack in Pasuruan, Indonesia. (2022). *J Med Life*,15(1):7–14. https://doi.org/10.25122/jml-2021-0238.

Fridell M, Edwin S, von SJ, Saulnier DD. (2020). Health system resilience: what are we talking about? A scoping review mapping characteristics and keywords. I*nt J Health Policy Manag*, 1;9(1):6–16. https://doi.org/10.1093/ije/dyw098.

Central Bureau Statistic. South Sulawesi Province in Figures. (2019). https://sulsel.bps.go.id/publication/2019/08/16/990caae13d6f4c5d743e852b/provinsi-sulawesi-selatan-dalam-angka-2019.html.

Chu, Dinh Toi, Suong Mai Vu Ngoc, Hue Vu Thi, Yen Vy Nguyen

Thi, Thuy Tien Ho, Van Thuan Hoang, Vijai Singh, and Jaffar A. Al-Tawfiq. (2022). "COVID-19 in Southeast Asia: Current Status and Perspectives." *Bioengineered* 13(2):3797–3809.

Downey LE, Gadsden T, Del V, Vilas R, Peiris D, Jan S. (2022). The impact of COVID-19 on essential health service provision for endemic infectious diseases in the South-East Asia region: A systematic review. *The Lancet Regional Health-Southeast Asia*,1:100011. https://doi.org/10.1016/j.

Drummond, Nora, Joanne Bailey, Christina Majszak, and Ruth Zielinski. (2024). "Implementation of Virtual Antenatal and Postnatal Urgent Midwifery Visits: Evaluation of a Quality Improvement Initiative." *International Journal of Environmental Research and Public Health* 21(7). https://www.doi.org/10.3390/ijerph21070903

Eurosurveillance Editorial Team. (2020). "Note from the Editors: World Health Organization Declares Novel Coronavirus (2019-NCoV) Sixth Public Health Emergency of International Concern." *Euro Surveillance : Bulletin Europeen Sur Les Maladies Transmissibles = European Communicable Disease Bulletin* 25(5). https://www.doi.org/10.2807/1560-7917.ES.2020.25.5.200131e

Fridell M, Edwin S, von SJ, Saulnier DD. (2020). Health system resilience: what are we talking about? A scoping review mapping characteristics and keywords. *Int J Health Policy Manag*, 1;9(1):6–16. https://doi.org/10.15171/ijhpm.2019.71

Golden, Bethany N., Shaimaa Elrefaay, Monica R. McLemore, Amy Alspaugh, Kimberly Baltzell, and Linda S. Franck. (2024). "Midwives' Experience of Telehealth and Remote Care: A Systematic Mixed Methods Review." *BMJ Open* 14(3). https://www.doi.org/10.1136/bmjopen-2023-082060

Goyal M, Singh P, Singh K, Shekhar S, Agrawal N, Misra S. (2021). The effect of the COVID-19 pandemic on maternal health due to delay in seeking health care: Experience from a tertiary center. *International Journal of Gynecology and Obstetrics*, 152(2):231–5. https://doi.org/10.1002/ijgo.13457

Haldane V, Foo C, Abdalla SM, Jung AS, Tan M, Wu S. (2021). Health systems resilience in managing the COVID-19 pandemic: lessons from 28 countries. *Nature Medicine Nature Research*, 27:964–80. https://doi.org/10.1038/s41591-021-01381-y.

Indonesia Ministry Health. (2020). *Protocol of Healthy Mothers and New Baby Born Services During Pandemic COVID-19*. https://infeksiemerging.kemkes.go.id/download/

Kikuchi K, Yi S, Nanishi K, Yasuoka J. (2024). Challenges of Maternal and Child Health after the COVID-19 Pandemic. *Frontiers Media SA*, 2024. (Frontiers Research Topics). https://doi.org/10.3389/978-2-8325-4385-6.

Kotlar, Bethany, Emily Gerson, Sophia Petrillo, Ana Langer, and Henning Tiemeier. (2021). "The Impact of the COVID-19 Pandemic on Maternal and Perinatal Health: A Scoping Review." *Reproductive Health* 18(1).

Lang'At E, Mwanri L, Temmerman M. (2019). Effects of implementing free maternity service policy in Kenya: An interrupted time series analysis. B*MC Health Serv Res*. 19(1). https://doi.org/10.1186/s12913-019-4462-x.

Manjavidze T, Rylander C, Egil Skjeldestad F, Kazakhashvili N, Anda EE. (2020). The impact of antenatal care utilization on admissions to neonatal intensive care units and perinatal mortality in Georgia. *PLoS One,* 1;15 (12 December). https://doi.org/10.1371/journal.pone.0242991.

Miskeen E. (2024). Utilization of Antenatal Care Services Within the Context of COVID-19, Security Challenges, and an Unstable Healthcare System at Primary Health Care Centers. *Int J Womens Health*, 16:737–47. https://doi.org/10.2147/IJWH.S435894.

Murewanhema G, Mpabuka E, Moyo E, Tungwarara N, Chitungo I, Mataruka K. (2023) Accessibility and utilization of antenatal care services in sub-Saharan Africa during the COVID-19 pandemic: *A rapid review*, 50:496–503. https://doi.org/10.1111/birt.12719.

Peahl AF and Howell JD. (2021). The evolution of prenatal care delivery guidelines in the United States. *American Journal of Obstetrics and Gynecology Mosby Inc.* 224:339–47. https://doi.org/10.1016/j.ajog.2020.12.016

Provincial Health Office. South Sulawesi FY. South Sulawesi Provincial Health Office Performance Report (LKOJ). https://e-renggar.kemkes.go.id/file_performance/1-199003-2tahunan-488.pdf

Safo, Kwame S., Daniel Opoku, Richard A. Bonney, Clement K. Serchim, and Kofi A. Mensah. (2025). "Potential Effects of Whatsapp on Maternal Health Services Uptake during COVID-19: A Cross-Sectional Study in Ghana." *BMC Health Services Research* 25(1). https://doi.org/10.1186/s12913-025-12245-3

Singh A, Jain P, Singh N, Kumar S, Bajpai P, Singh S. (2021). Impact of COVID-19 pandemic on maternal and child health services in Uttar Pradesh. *India J Family Med Prim Care*, 10(1). https://doi.org/10.4103/jfmpc.jfmpc_1550_20

Thompson, Madeline, Amanda K. Buttery, Shu Xin Oh, Macy Chan, Byung Hyun Lee, Tomoharu Iino, Yu Chun Alice Wang, and Chris Clarke. (2025). "Risk Factors for Severe COVID-19 Outcomes in the Asia-Pacific Region: A Literature Review." *Frontiers in Public Health* 13

Tounkara M, Sangho O, Beebe M, Whiting-Collins LJ, Goins RR, Marker HC.(2022). Geographic Access and Maternal Health Services Utilization in Sélingué Health District, Mali. *Matern Child Health J*, 26(3):649–5. https://doi.org/10.1007/s10995-021-03364-4

Thirugnanasundralingam K, Davies-Tuck M, Rolnik DL, Reddy M, Mol BW, Hodges R. (2023). Effect of telehealth-integrated antenatal care on pregnancy outcomes in Australia: an interrupted time-series analysis. *Lancet Digit Health*, https://doi.org/10.1016/S2589-7500(23)00151-6.

Vermeulen J, Bilsen J, Buyl R, Smedt D, Gucciardo L, Faron G. (2022). Women's experiences with being pregnant and becoming a new mother during the COVID-19 pandemic. *Sexual and Reproductive Healthcare*, 1;32. https://doi.org/10.1016/j.srhc.2022.100728

Wilhelm JA and Helleringer S. (2019). Utilization of non-Ebola health care services during Ebola outbreaks: A systematic review and meta-analysis. *J Glob Health*, 9(1). https://doi.org/10.7189/jogh.09.010406.

World Health Organization. (2020) Health workforce policy and management in the context of the COVID-19 pandemic response Interim guidance. https://iris.who.int/bitstream/handle/10665/337333/WHO-2019-nCoV-health_workforce-2020.1-eng

World Health Organization, and Human Reproduction Programme. 2024. *Roadmap for Research on Maternal and Perinatal Health in the Context of Epidemic Threats*.

Wu H, Sun W, Huang X, Yu S, Wang H, Bi X. (2020). Online antenatal care during the COVID-19 pandemic: Opportunities and challenges. *Journal of Medical Internet Research*, 22. https://doi.org/10.2196/19916