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Original Research

Epidemiology of Acute and Long-Term Outcomes of Critically Ill Pregnant Women Admitted to the Intensive Care Unit With COVID-19: A Cohort Study in Saudi Arabia

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Abstract

Background: The coronavirus disease-2019 (COVID-19) epidemic has emerged as a significant threat to global maternal health, especially with the increasing risk of serious consequences among a vulnerable population, including admission to the intensive care unit (ICU). Therefore, understanding the nature of outcomes in various populations is crucial for developing effective healthcare strategies. Thus, this study aimed to investigate the epidemiology, risk factors, and acute and long-term outcomes of COVID-19 among pregnant women in Bisha Province, Saudi Arabia. Our specific focus was on the determinants of ICU admission to ensure a thorough understanding of the impact of the disease. **Methods**: This cohort study was conducted at King Abdalla Hospital from February 2020 to January 2023. This study included 88 pregnant women with COVID-19 admitted to the ICU (cases) and 120 pregnant women with COVID-19 not admitted to the ICU (controls). Electronic medical records (EMRs) were extracted for sociological, maternity, and clinical characteristics, as well as the results. A multivariable logistic regression model was used to identify independent risk factors for ICU admission and adverse outcomes. **Results**: This indicated that advanced maternal age [>35 years; odds ratios (ORs) = 2.5; $p < 0.003$], third-trimester gestation (ORs = 3.1; $p < 0.010$), low income (ORs = 2.9; $p < 0.010$), pre-existing hypertension (ORs = 4.8; $p < 0.010$), and lower educational level (ORs = 3.6; $p < 0.010$) were significant independent predictors of ICU admission. Furthermore, survivors of ICU admission experienced 2.5 to 3.2 times greater persistence of cardiovascular, respiratory, neurological, and mental health symptoms at 12 months post-infection compared to non-ICU patients. **Conclusions**: This research has revealed a convergence of clinical and socioeconomic factors that significantly increases the likelihood of severe COVID-19 during pregnancy. The significant long-term morbidity among ICU survivors highlights the essential requirement for a comprehensive strategy. These findings can specifically help reduce risk for targeted delivery, improve healthcare access, particularly in post-COVID recovery clinics, and increase outcomes for this risk population in future epidemic responses.

Keywords: COVID-19; pregnancy; intensive care unit; maternal health; long COVID effects; short term COVID effects; Saudi Arabia

1. Introduction

The World Health Organization (WHO) defines the post-coronavirus disease-2019 (COVID-19) condition, or "Long COVID", as the continuation or onset of new symptoms 3 months after the initial severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) infection, with these symptoms lasting for at least 2 months and with no other explanation [1]. Thus, research into the impacts of COVID-19 in pregnant patients admitted to the intensive care unit (ICU) in Saudi Arabia is crucial, given the associated elevated risks [2]. Prior data have shown that women, particularly those of reproductive age, have a considerable level of post-COVID symptoms, such as fatigue and cognitive dysfunction. Moreover, the system of pregnant women is even more strained by the stresses of pregnancy and nursing. Meanwhile, a national study has shown that people who experience severe COVID-19, particularly in the ICU, are at the highest risk of long COVID; however, the epidemiology and long-term impact of this condition remain poorly understood. It is important to appreciate this burden to design appropriate follow-up care for Saudi mothers [2]. A significant percentage of pregnant women infected with COVID-19 require intensive care and respiratory support (42.3%), which leads to increased risk of ICU admission during pregnancy [1]. Fever, dyspnea, and hypoxemia are typical acute symptoms; in extreme situations, these symptoms can develop into acute respiratory distress syndrome (ARDS), which requires mechanical ventilation

[2]. Furthermore, obstetric problems such as preterm birth, preeclampsia, and higher rates of cesarean delivery are closely associated with ICU hospitalization [3,4]. In addition to many neonatal problems, infants born to moms with severe COVID-19 are more likely to experience [5]. Despite being uncommon, vertical transmission has been reported, which raises questions regarding possible long-term developmental repercussions in neonates exposed to it [4]. Long-term follow-up is also necessary because of new evidence that maternal COVID-19 may be a factor in postpartum respiratory and cardiovascular complications [6]. Pregnant women with COVID-19 have mild to moderate symptoms and are cured without serious consequences [2]. This variation emphasizes the importance of personal care in the management of COVID-19 among pregnant women [7,8], highlighting the need for risk evaluation and individualized treatment strategies. According to research, one percent of pregnant women infected with COVID-19 require acute care and complementary oxygen therapy, which is closely associated with a high risk of ICU admission [9]. Fever, cough, and dyspnea are typical acute clinical signs; in severe cases, these symptoms can progress to acute respiratory distress requiring mechanical ventilation [10]. Additionally, a higher incidence of preterm labor and a higher rate of cesarean delivery are two adverse obstetric outcomes that are frequently linked to the need for ICU hospitalization [11,12].

Long-term effects of COVID-19 on newborns, such as a higher chance of complications, including low birth weight and poorer Apgar scores, are a cause for concern. While vertical transmission is uncommon, this transmission does occur occasionally, and babies who test positive for SARS-CoV-2 may have long-term health and developmental consequences. Hence, it is important to consider the larger context of maternal health during the pandemic, including the acute and long-term effects of COVID-19 among pregnant women.

Specifically, COVID-19 in pregnant women has been linked to heightened chances of catastrophic maternal outcomes, such as ICU admissions and mechanical ventilation. To improve maternal–neonatal health outcomes and guide evidence-based therapies, this study aimed to present a thorough assessment of the acute and long-term effects of COVID-19 in severely ill pregnant women. Moreover, this study aimed to improve maternal health and clinical guidelines for future epidemic responses by combining data from Saudi Arabia and International Cohorts.

2. Materials and Methods

2.1 Study Design and Setting

This was a cohort study conducted at King Abdullah Specialized Hospital and Terry Referral Hospital in Bisha province, Saudi Arabia. This design was chosen to investigate the exposure and clinical outcomes of pregnant women who were admitted to an ICU compared with those managed without ICU care. The data for this study were derived from the electronic medical records (EMRs) of King Abdalla Hospital in Bisha Province, Saudi Arabia. This study included pregnant women with laboratory-confirmed COVID-19 who were admitted between February 2020 and January 2023. All data were retrospectively collected and anonymized, with approval from the Institutional Review Board of the University of Bisha.

2.2 Study Participants and Sampling

Pregnant women with a laboratory-confirmed positive result of SARS-CoV-2 [confirmed by reverse transcription-polymerase chain reaction (RT-PCR)] who were treated in the specified period from February 2020 to January 2023 in King Abdalla Hospital and met the inclusion criteria were enrolled.

2.2.1 Case Definition and Inclusion Criteria

Pregnant women with COVID-19 in the ICU for the treatment of severe or critical illness according to the WHO clinical progression scale (*i.e.*, requiring non-invasive or invasive mechanical ventilation, vasopressor support, and/or having severe organ dysfunction) [1].

2.2.2 Control Definition and Inclusion Criteria

Pregnant women with confirmed COVID-19 during the same period (from February 2020 to January 2023), treated on a ward, isolation unit, or as outpatients who never required ICU care at any point during the infection period.

2.2.3 Exclusion Criteria

The following subjects were not included in the study: (1) women with a positive SARS-CoV-2 result but no documented symptoms of COVID-19; (2) patients with incomplete medical records detailing the management of COVID-19 or obstetric outcomes; (3) women who discharged from the hospital against medical advice or were transferred to an outside institution before resolution of acute illness and viable assessment of outcomes.

The sample size was calculated according to previous studies [1,2]. The probability of a prominent risk factor (pre-existing hypertension) was 15% for the disease-free group and 30% for the case group. We estimated that a total of 138 participants would be needed to detect an effect size with 80% power at a two-sided alpha = 0.05. We recruited 88 cases and 120 controls to increase the statistical power and adjust for potential missing data. The same sampling procedures were used throughout the survey to identify all cases that met the selection criteria. We selected one uniform source from the population and provided detailed accounts for the time period of each sample.

2.3 Collecting Data

The statistical analysis was performed using Stata Base version 19 (2024) (StataCorp LLC, College Station, Texas, USA). Descriptive statistics and regression analysis were performed. For the variable range, accurate Fisher tests were used.

COVID-19-specific information was collected, including date of diagnosis, presence of symptoms, illness severity classified according to the WHO guidelines, therapeutic interventions (*e.g.*, oxygen therapy, corticosteroids, remdesivir), and clinical complications.

Maternal outcomes were categorized as primary and secondary measures. Primary outcomes included ICU admission, mechanical ventilation requirements, and maternal mortality; secondary obstetric outcomes comprised preeclampsia, preterm birth, mode of delivery, and postpartum hemorrhage. Newborn results included pregnancy at birth, birth weight, Apgar scores at 1 and 5 minutes, admission to the Neonatal Intensive Care Unit (NICU), and the SARS-CoV-2 RT-PCR test results for the infant. Uninsured refers to patients who did not have any form of government or private health insurance at the time of hospital admission, meaning the patients were fully responsible for all medical costs.

2.4 Short-Term and Long-Term Follow-Up Assessment

Short-term (acute) outcomes were defined as complications and clinical endpoints occurring during the initial hospitalization for COVID-19 [13]. These included the primary outcome of ICU admission, as well as secondary outcomes such as the requirement for mechanical ventilation, maternal mortality, obstetric complications (preeclampsia [14], preterm birth [15], mode of delivery [16], and postpartum hemorrhage [15]), and immediate neonatal outcomes (birth weight [16], Apgar scores [17], and NICU admission). Data for these outcomes were extracted directly from the EMRs for the admission period.

Long-term outcomes were assessed 12 months post-diagnosis through structured telephone interviews and a review of the EMRs. Symptoms were categorized into cardiovascular, respiratory, neurological, and mental health domains using a standardized questionnaire based on WHO post-COVID case definitions.

Follow-up percentages among ICU and non-ICU groups were tracked, and responders were compared with those lost to follow-up. Of the 88 ICU and 120 non-ICU patients, follow-up at month 12 was completed for 72 (81.8%) and 105 (87.5%), respectively. Loss to follow-up was mostly due to the individual becoming uncontactable (*e.g.*, unavailable phone number) or refusal to be recorded. We also compared baseline characteristics (age, income, and comorbidities) between the responders and loss-to-follow-up groups; these were not significantly different, suggesting a non-differential response. We utilized the Benjamini-Hochberg false discovery rate (FDR) correction to compare persisting symptoms among different health domains and performed diagnostic procedures for our regression model, including checks of multicollinearity [variance inflation factor (VIF)], identification of outliers (Cook's D), evaluation of model performance (area under the receiver operating characteristic, AUROC), and stability testing with bootstrap resampling (1000 times) for the coefficients.

2.5 Statistics

All statistical analyses were performed using Stata Base, version 19 (2024). Descriptive statistics were used to analyze all study variables for general characteristics (Table 1) and the comparison of sociodemographic and clinical characteristics between pregnant women with COVID-19 admitted to the ICU and those not admitted (Table 2). The normality assumption for continuous variables was assessed using the Shapiro-Wilk test and Q-Q plots. Continuous data that showed approximately normal distribution were reported as the mean $\pm$ SD and tested using independent-sample *t*-tests. Categorical variables are presented as numbers and percentages (n, %) and were compared using the Chi-square test or Fisher's exact test when the expected cell count was $<$5.

Table 1. General characteristics of the study population (n = 208).

Characteristic	Category/statistic	Value
Age (years)	Mean $\pm$ SD	31.9 $\pm$ 5.3
	Age $>$35 years, n (%)	69 (33.2%)
Gestational age (weeks)	Mean $\pm$ SD	29.9 $\pm$ 4.2
	Third trimester, n (%)	80 (38.5%)
Income level	Low income, n (%)	110 (52.9%)
	Middle/high income, n (%)	98 (47.1%)
Pre-existing conditions	Hypertension, n (%)	40 (19.2%)
	Diabetes, n (%)	20 (9.6%)
Education level	High school or lower, n (%)	60 (28.8%)
	College degree, n (%)	148 (71.2%)

n, number of participants.

Multivariable logistic regression analysis was used to identify factors associated with the primary outcomes (ICU admission) and with combined adverse maternal outcomes. The reference model included variables with a *p*-value $<$ 0.1 in the bivariate analysis or were clinically relevant, as reported in the literature [18]. The final parsimonious model was built using backward stepwise variable elimination and is described with the corresponding odds ratios (ORs), 95% CI, and *p*-value. Statistical significance was assumed for all tests with a two-tailed *p*-value less than 0.05.

Model diagnostics were performed based on multicollinearity (tested with VIF: all VIF $<$5), influential observations tested using Cook's D and DFBETAs, model performance, including AUROC, and the Hosmer-Lemeshow goodness-of-fit test. Internal validity of the model was determined by bootstrap validation (1000 runs). There were a few missing data points ($<$2%), which were addressed using a complete case analysis; a sensitivity analysis using multiple imputation did not materially alter the results.

Table 2. Comparison of sociodemographic and clinical characteristics between pregnant women with COVID-19 admitted to the ICU and those not admitted (n = 208).

Characteristic	ICU cases (n = 88)	Non-ICU controls (n = 120)	*p*-value
Age (years)			
Mean ± SD	34.5 ± 5.3	30.2 ± 4.9	<0.010
Age >35 years	45 (51.1%)	24 (20.0%)	<0.003
Gestational age (weeks)			
Mean ± SD	32.1 ± 4.2	28.5 ± 3.6	<0.010
Third trimester	50 (56.8%)	30 (25.0%)	<0.010
Socioeconomic factors			
Low income	65 (73.9%)	45 (37.5%)	<0.010
Uninsured	28 (31.8%)	12 (10.0%)	<0.010
Pre-existing conditions			
Hypertension (chronic)	30 (34.1%)	10 (8.3%)	<0.010
DM (pre-gestational)	15 (17.0%)	5 (4.2%)	<0.020
Education level			
High school or lower	40 (45.5%)	20 (16.7%)	<0.010
College degree	48 (54.5%)	100 (83.3%)	<0.010

ICU, intensive care unit; COVID-19, coronavirus disease-2019; DM, diabetes mellitus.

Table 3. Logistic regression analysis of risk factors for ICU admission among pregnant women with COVID-19.

Variable	ORs	95% CI	*p*-value
Age >35 years	2.5	1.4–4.5	<0.003
Third trimester	3.1	1.8–5.5	<0.010
Low income	2.9	1.7–4.9	<0.010
Uninsured	4.5	2.0–10.3	<0.010
Pre-existing hypertension	4.8	2.2–10.4	<0.010
Pre-existing diabetes	2.3	1.1–5.0	<0.020
High school education or lower	3.6	1.9–6.7	<0.010

OR, odds ratio. The final multivariable model was adjusted for all listed variables.

Table 4. Logistic regression analysis of factors associated with adverse outcomes in pregnant women with COVID-19.

Factors	ORs	95% CI	*p*-value
Age >35 years	2.8	1.6–5.0	<0.002
Third trimester	3.4	2.0–5.8	<0.010
Low income	3.2	1.9–5.4	<0.010
Uninsured	4.8	2.3–10.7	<0.010
Pre-existing hypertension	5.1	2.4–10.9	<0.010
Diabetes	2.6	1.2–5.6	<0.010
High school education or lower	3.9	2.1–7.3	<0.010
Multiparity (more than 2 children)	2.1	1.1–4.0	<0.030
Obesity (BMI >30 kg/m^2)	3.0	1.5–6.0	<0.004

BMI, body mass index. The final multivariable model was adjusted for all listed variables.

The final multivariable logistic regression model for ICU admission (Table 3) was adjusted for the following covariates selected a priori based on clinical relevance and bivariate analysis ($p < 0.1$): maternal age (>35 years), gestational trimester, income level, insurance status, pre-existing hypertension, pre-existing diabetes, and education level.

The final multivariable model for adverse outcomes was adjusted for the covariates in the ICU model (Table 4), with the addition of multiparity and obesity [body mass index (BMI) >30 kg/m^2], which were significant in the bivariate analysis for this broader endpoint.

Variables with a *p*-value < 0.1 in the initial bivariate analysis were considered for inclusion in the multivariable logistic regression model, along with clinically relevant factors identified in the literature.

3. Results

A total of 208 pregnant women with a mean maternal age of 31.9 years (±5.3 years) and laboratory-confirmed COVID-19 were included in this study (Table 1). The case-control analysis revealed significant clinical and socioeconomic disparities between the 88 women admitted to the ICU and the 120 non-ICU controls. Key risk factors for ICU admission identified through multivariate analysis included advanced maternal age, third-trimester infection, low income, education level and pre-existing comorbidities.

A significant portion of the participants (33.2%, n = 69) were aged 35 years or older. The mean gestational age at diagnosis was 29.9 weeks (±4.2), and 38.5% (n = 80) of participants were in the third trimester, reflecting the diversity of the pregnant population. More than half of the participants (52.9%, n = 110) were classified as having a low income. This high prevalence of low income among the participants underscores the potential socioeconomic challenges these individuals may face during pregnancy and COVID-19 infection.

Table 2 presents the data for pregnant women with COVID-19, stratified by ICU admission status. Significant differences were observed across multiple variables. The mean maternal age was significantly higher among women admitted to the ICU (34.5 ± 5.3 years) compared with those managed outside the ICU (30.2 ± 4.9 years; $p < 0.010$). Consistently, a greater proportion of ICU patients were aged >35 years (51.1% vs. 20.0%; $p < 0.003$).

Gestational age at diagnosis also differed significantly, with ICU patients presenting at a later stage of pregnancy (32.1 ± 4.2 weeks) compared to non-ICU patients (28.5 ± 3.6 weeks; $p < 0.010$). More than half of the ICU group were in the third trimester (56.8%), compared with only 25.0% of the non-ICU group ($p < 0.010$).

Marked socioeconomic disparities were observed. Low-income status was reported in 73.9% of the ICU patients versus 37.5% of the non-ICU patients ($p < 0.010$). Conversely, only 26.1% of the ICU patients belonged to the middle- or high-income category, compared with 62.5% of the non-ICU patients ($p < 0.010$).

Pre-existing medical conditions were more prevalent among patients admitted to the ICU. Pre-existing hypertension was reported in 34.1% of the ICU patients versus 8.3% of the non-ICU patients ($p < 0.010$). Similarly, diabetes mellitus (DM) was more common among ICU patients (17.0%) compared with controls (4.2%; $p < 0.020$).

Educational attainment differed significantly between groups. Nearly half (45.5%) of ICU patients had a high school education or lower, compared with 16.7% in the non-ICU group ($p < 0.010$). In contrast, 83.3% of the non-ICU group had attained a college degree, compared with 54.5% of the ICU patients ($p < 0.010$). Overall, these findings indicate that advanced maternal age, later gestational age at infection, lower income, lower educational level, and the presence of comorbid conditions, such as pre-existing hypertension and diabetes, were more common among pregnant women with COVID-19 requiring ICU admission.

The evaluation of risk factors associated with ICU admission among pregnant women with COVID-19 (Table 3). Pregnant women aged over 35 years exhibited a 2.5-fold increased risk of ICU admission (ORs = 2.5, 95% CI: 1.4–4.5; $p < 0.003$). Meanwhile, women in the third trimester had an ORs of 3.1 (95% CI: 1.8–5.5; $p < 0.010$), indicating that those in this phase of pregnancy are more than three times as likely to require ICU care. Low-income conditions were associated with an increased risk of ICU admission (ORs = 2.9, 95% CI: 1.7–4.9; $p < 0.010$), suggesting that socioeconomic inequalities could significantly affect health outcomes for pregnant women during the COVID-19 epidemic. The likelihood of ICU admission among pregnant women surged to 4.5 (95% CI: 2.0–10.3; $p < 0.010$).

The need for ICU care (ORs = 4.8, 95% CI: 2.2–10.4; $p < 0.010$) in patients with pre-existing hypertension rose dramatically, which is an essential suggestion for how to care for pregnant women. DM was associated with a higher risk of ICU admission (ORs = 2.3, 95% CI: 1.1–5.0; $p < 0.02$), indicating that women with existing health problems require close monitoring.

Women with a high school education or lower had an ORs of 3.6 (95% CI: 1.9–6.7; $p < 0.010$) for ICU admission compared to those with higher educational attainment. These findings reveal several significant risk factors for ICU admission among pregnant women with COVID-19, including older maternal age, third-trimester pregnancies, low income, pre-existing hypertension, pre-existing diabetes, and lower educational attainment. These results underscore the necessity of identifying high-risk individuals within these demographics to facilitate targeted interventions and enhance healthcare delivery amid the current epidemic.

Model diagnostics and validation: The multivariable logistic regression models demonstrated good performance and calibration. The AUROC curve for the main ICU admission model (Table 3) was 0.85 (95% CI: 0.80–0.90), representing excellent discrimination. The model was acceptably calibrated, with a non-significant Hosmer-Lemeshow goodness-of-fit test ($p = 0.42$). Internal validation by bootstrap resampling (1000 iterations) yielded an optimism-corrected AUROC of 0.84. For a model predicting any adverse outcome (Table 4), the AUROC was 0.87 (95% CI: 0.82–0.92), and this model also had good calibration (Hosmer-Lemeshow $p = 0.51$), with an optimism-corrected AUROC for the area under the curve (AUC) of 0.86 vs. Steyerberg *et al.* [19]. Impact of country on bacteremia: The population blood culture positivity rate ranged from 2 to 52% across countries. There was no multicollinearity problem in either model, as all VIF values were below 2.5. Influence of observations: influential observations were not detected using Cook's distance and DFBETAs, as no outliers were found to substantially affect the model coefficients.

The findings of the logistic regression analysis, including adverse outcomes among pregnant women with COVID-19, are summarized in Table 4. This study identified factors contributing to poor health outcomes for this population. More than 35 pregnant women exhibited high OR values (2.8; 95% CI: 1.6–5.0; $p < 0.002$), indicating a high probability of adverse outcomes. The risk of adverse results was significantly higher for women in the third trimester, 3.4 (95% CI: 2.0–5.8; $p < 0.010$). The probability of adverse outcomes was significantly higher among individuals with low incomes (ORs = 3.2, 95% CI: 1.9–5.4; $p < 0.010$). Pregnant women without insurance had a considerably increased risk of unfavorable outcomes (ORs = 4.8, 95% CI: 2.3–10.7; $p < 0.010$). With an OR of 5.1 (95% CI: 2.4–10.9; $p < 0.010$), pre-existing hypertension was a significant risk factor for adverse outcomes, suggesting that women with this condition are more than five times more likely to suffer from serious COVID-19-related problems. Similarly, an OR of 2.6 (95% CI: 1.2–5.6; $p < 0.010$) was associated with a significant increase in risk for diabetes. An OR of 3.9 (95% CI: 2.1–7.3; $p < 0.010$) was observed only among women with a high school education, suggest-

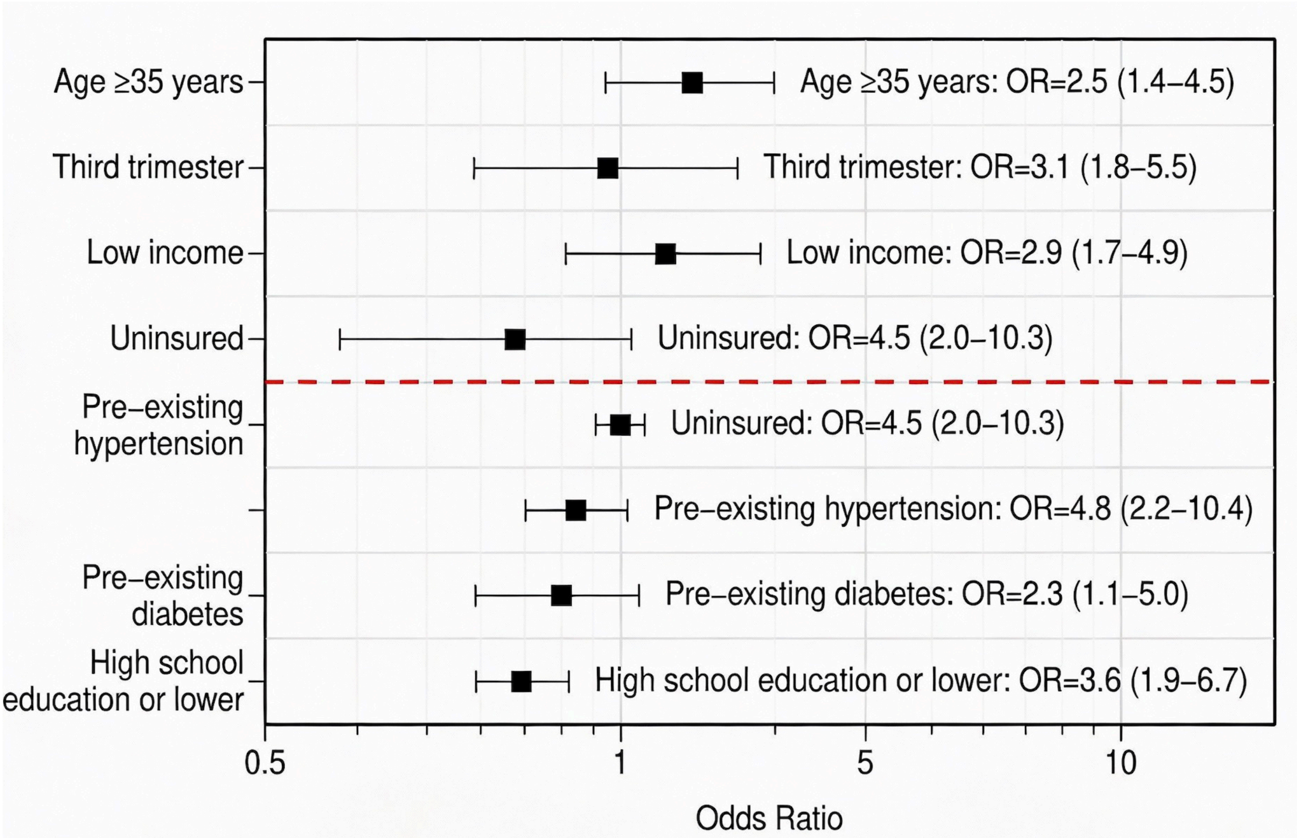

Fig. 1. ORs for associated risk factors. The red dashed line indicates no increased risk (ORs = 1).

ing that educational attainment may affect access to information about maternity care and the availability of health services during the epidemic. Having more than two children was linked to a higher likelihood of adverse outcomes (ORs = 2.1, 95% CI: 1.1–4.0; $p < 0.030$), indicating that women with COVID-19 may face more challenges following several previous pregnancies. The results also showed that obesity markedly increased the likelihood of adverse outcomes (ORs = 3.0, 95% CI: 1.5–6.0; $p < 0.004$), suggesting that pregnant women who are overweight or obese require targeted interventions. According to these data, advanced maternal age, third-trimester gestation, low income, absence of health insurance, pre-existing diabetes and pre-existing hypertension, lower education levels, multiparity, obesity, and other key characteristics are linked to worse outcomes in pregnant women with COVID-19. These results underline the need for the high-risk population to improve health outcomes and reduce issues in the pregnant population during the ongoing COVID-19 epidemic.

Significant risk factors for ICU admission are revealed by the COVID-19 results in pregnant women (Fig. 1). The likelihood of developing a serious illness requiring intensive care is much higher for women over 35, those in the third trimester, and those with lower incomes or no health insurance. Furthermore, pre-existing diseases, such as pre-existing diabetes and hypertension, were shown to increase the risk further. The robustness of these findings is further supported by the statistically significant associations ($p < 0.05$) observed across all identified risk factors. These findings highlight the critical need for focused interventions, such as improved prenatal care, easier access to healthcare, and customized public health initiatives, to reduce the serious consequences for high-risk pregnant COVID-19-infected women.

The analysis of the data in this study included visualizations of study group distributions, age-related trends, medical and socioeconomic circumstances, and risk factors for ICU admission to substantiate these conclusions. Meanwhile, future studies should examine specific issues in more detail, conduct more comprehensive statistical analyses, or introduce alternative visualizations.

Both the risk of ICU admission and the rate of complications increase significantly with increasing gestational age (Fig. 2), especially in the third trimester. Indeed, the third trimester is associated with more than twice the risk of the previous trimesters, with a risk ratio of 2.27. The risk ratios were significantly lower in the first and second trimesters. These results emphasize how crucial proactive care and careful observations are for pregnant women in advanced gestational stages who are infected with COVID-19.

Fig. 3 illustrates notable differences between pregnant women who required intensive care (ICU group) and those who did not (non-ICU group), based on a thorough exami-

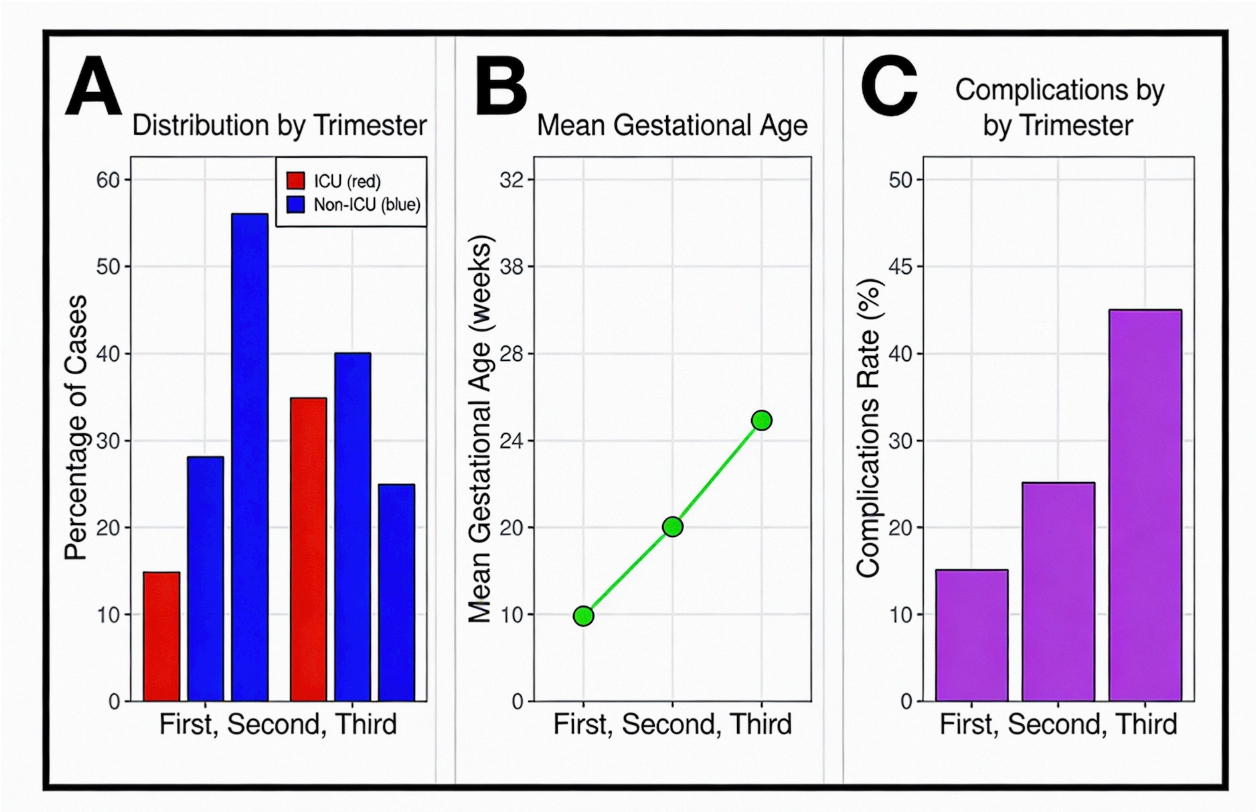

Fig. 2. The risk ratios for ICU admission by trimester. (A) Distribution of cases by trimester, comparing ICU versus non-ICU groups (percentage of cases in each trimester). (B) Mean gestational age (weeks) by trimester. (C) Complications rate by trimester.

Table 5. Comparison of persistent symptoms at 12 months between ICU and non-ICU cohorts after FDR correction.

Symptom domain	Persistence in ICU cohort, N (%)	Persistence in non-ICU cohort, N (%)	Raw *p*-value	FDR-adjusted *p*-value (q-value)
Cardiovascular	45/72 (62.5)	14/105 (13.3)	$<$0.001	$<$0.001
Respiratory	40/72 (55.6)	15/105 (14.3)	$<$0.001	$<$0.001
Neurological	38/72 (52.8)	13/105 (12.4)	$<$0.001	$<$0.001
Mental health	43/72 (59.7)	16/105 (15.2)	$<$0.001	$<$0.001

N = percetage; FDR, false discovery rate.

nation of long-term COVID-19 outcomes. These data show that patients admitted to the ICU continue to face significant symptom burdens even after a year of infection.

The ICU group was 3.19 times more likely to have long-term problems than the non-ICU patients, with the most frequent cardiovascular complications. This firmness of symptoms, even after improvement in both groups, underscores the immediate need for long-term care and targeted treatments. The overall prevalence was 2.8 times higher in the ICU cohort, as ICU patients experienced a 20.22% reduction in symptoms compared with a 28.23% reduction in the non-ICU group.

The recovery rate for respiratory symptoms was nearly twice as high among non-ICU patients (32.43%) as among ICU patients (16.78%). This significant disparity of 15.65% underscores the long-term effects of severe COVID-19 on lung function, particularly in ICU patients.

The most significant disparities in recovery between groups were noted in mental health and fatigue (16.94% and 16.43%, respectively). Across all areas, non-ICU patients showed an improvement of over 29%, whereas ICU patients continued to experience difficulties (persistence ratios of 2.68 and 2.51, respectively).

Despite being the smallest recovery gap (2.05%), neurological symptoms had one of the highest firmness ratios (2.86), suggesting long-term difficulties with nerves and cognition.

With the ICU patients recovering by just 14.38% compared to 23.38% in the non-ICU group—a 9% difference—sleep problems remained moderately persistent. This persistence of sleep problems in the ICU patients underscores the need for continued care and support even after the acute phase of the disease.

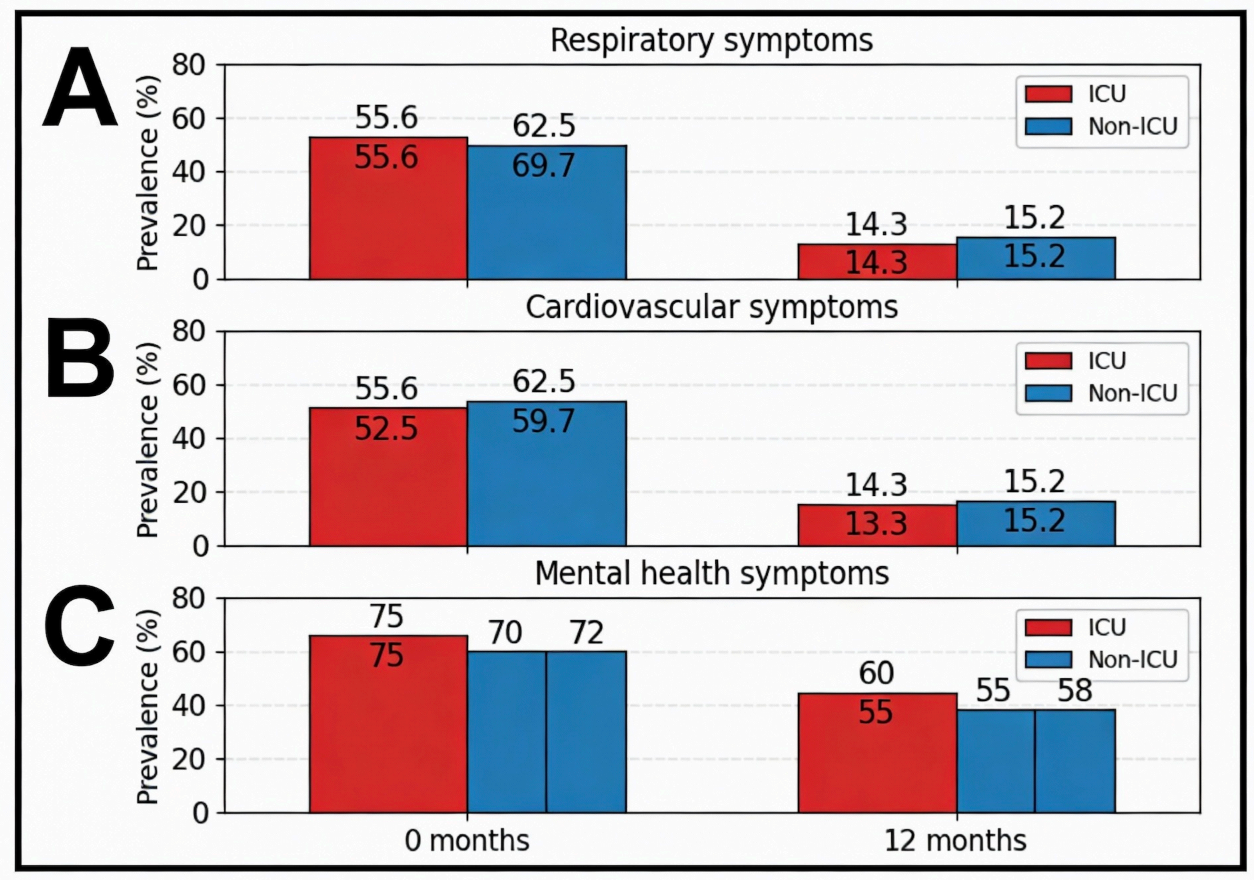

Fig. 3. Long-term outcomes of COVID-19 in pregnancy. (A) Respiratory symptom prevalence at 0 and 12 months, comparing ICU versus non-ICU groups. (B) Cardiovascular symptom prevalence at 0 and 12 months, comparing ICU versus non-ICU groups. (C) Mental health symptom prevalence at 0 and 12 months, comparing ICU versus non-ICU groups.

According to the study, patients discharged from the ICU exhibited 2.5 to 3.2 times higher symptom persistence across all health categories than those not admitted to the ICU, indicating notable differences in long-term recovery from COVID-19. The most persistent symptoms over time were neurological and cardiovascular. Nevertheless, the most essential treatment interval was noted in mental health and exhaustion, which highlights the important requirement of integrated psychological support in post-ICU care. Non-ICU patients had a frequently high recovery rate, despite improvement being observed in both groups. This underscores the need for specialized, prolonged treatment for severe COVID-19 survivors and shows how the severity of the disease at the beginning predicts long-term prognosis. According to these findings, high-risk patients should have their cardiovascular, neurological, and mental health monitored as part of risk-stratified follow-up regimens. These results emphasize critical needs for pregnant patients for exceptional care and long-term monitoring, which recur from severe COVID-19, especially those who required ICU admission. Therefore, future studies should test targeted remedies to increase recovery rates in high-risk populations.

The persistence of symptoms at 12 months post-infection across cardiovascular, respiratory, neurological, and mental health domains was assessed (Table 5). As shown in Fig. 3, patients admitted to the ICU were significantly more likely to have symptoms persisting across all domains than those not treated in an ICU. To correct for multiple comparisons among these four major symptom domains, we applied the Benjamini–Hochberg method to the FDR. Symptom persistence between the ICU and non-ICU cohorts for each domain was treated as a family of tests for the FDR adjustment. Differences in chronicity remained significant across the four health domains after FDR correction.

4. Discussion

This study provides a critical evaluation of the risk factors and consequences of ICU admission among pregnant patients with COVID-19 in the Bisha Province of Saudi Arabia. Our results clearly show that the following factors are significant and independent predictors of severe disease requiring intensive care: pre-existing comorbidities (diabetes and hypertension), third-trimester gestation, low socioeconomic status (as indicated by low income and lack

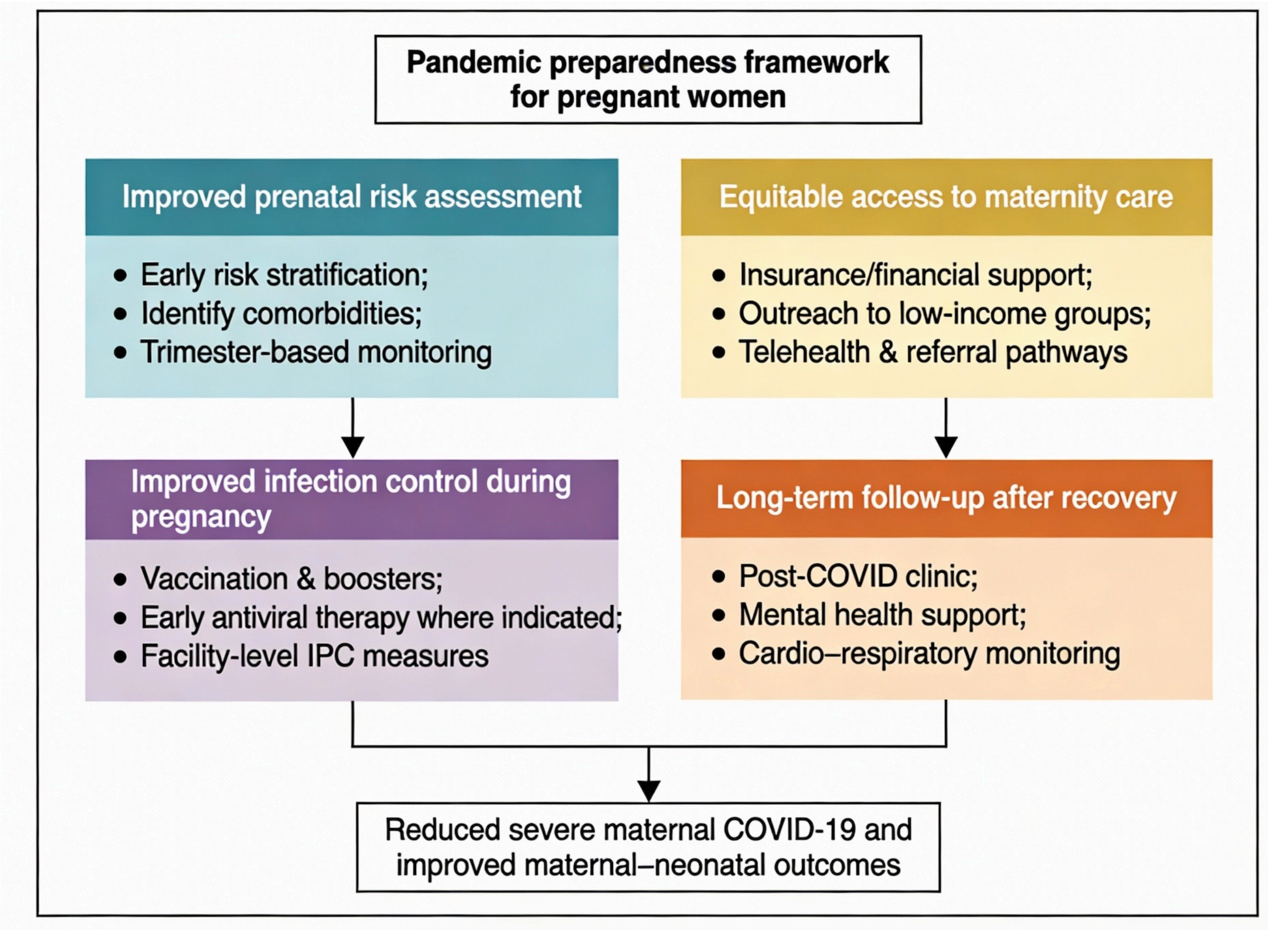

Fig. 4. A framework for implementing targeted interventions for pregnant women during pandemics.

of health insurance), advanced maternal age (>35 years), and lower educational attainment. These findings are not unique; rather, these findings align with a growing body of regional and global literature [19–21]. SARS-CoV-2 infection during pregnancy significantly worsens pre-existing health and socioeconomic vulnerabilities, as evidenced by the considerably higher ORs for being uninsured (ORs = 4.5) and for pre-existing hypertension (ORs = 4.8). This aligns with international meta-analyses that have repeatedly found socioeconomic deprivation and chronic hypertension to be strong risk factors for critical illness in pregnant populations [22,23]. Given that the third trimester is characterized by decreased functional residual capacity of the lungs, an immunomodulated state, and an elevated diaphragm due to the gravid uterus, all of which increase susceptibility to severe respiratory infections, the strong correlation with advanced gestational age is physiologically plausible [24,25]. This result aligns with research and international registries that show a disproportionate number of pregnant women in the third trimester who are admitted to ICUs [26,27]. In addition, studies from diverse socioeconomic backgrounds have shown concern about the identification of lower education as a risk factor (ORs = 3.6), which likely reflects greater differences in health literacy, access to timely prenatal care, and the capacity to follow complex public health initiatives [28,29].

After the acute period, we examined long-term outcomes and found a striking difference between the ICU and non-ICU patients. Cardiovascular, pulmonary, neurological, and mental health issues were among the symptoms that patients in critical care reported remaining present for 2.5 to 3.2 times longer at 12 months after infection. Thus, a substantial long-term morbidity burden that goes well beyond the immediate perinatal period is highlighted by the exceptionally high persistence of neurological and cardiovascular symptoms, as well as the large recovery gap in mental health and fatigue. The "long COVID" pattern in our obstetric cohort is consistent with findings in the general population, where prolonged recovery and multi-organ sequelae are predicted mainly by the initial severity of the disease [30,31]. However, the prevalence of "long COVID" during the postpartum phase adds a complex dimension and may affect important processes, such as nursing, mother–infant bonding, and family dynamics, thereby increasing the burden on public health [32,33]. Thus, psychological and psychiatric support must be urgently incorporated into standard postpartum follow-up protocols for severe COVID-19 survivors, as this area is frequently disregarded in traditional obstetric care, given the observed substantial mental health burden, which includes fatigue and likely elements of post-traumatic stress disorder from the ICU experience [34,35].

A comprehensive public health and clinical response is necessary due to the confluence of clinical and socioeconomic risk factors identified in this study. Firstly, our results strongly support prioritizing early antiviral therapy and booster vaccinations for pregnant women, particularly those with comorbidities and in the third trimester, as these interventions are safe during pregnancy and have been shown to reduce disease severity significantly [36,37]. Second, continuously increasing low-income support and promoting access to healthcare for pregnant women are strictly required, given the significant risk of socioeconomic disadvantage. To mitigate the effects, initiatives may include culturally sensitive patient education, strengthening social support networks, and access to prenatal care [38,39]. Lastly, for women recuperating from severe COVID-19, long-term follow-up data require the creation of specialized, multidisciplinary postnatal clinics that provide integrated therapy to holistically treat the neurological, mental, and cardiac consequences [40,41].

This study provides strong evidence of sufficient long-term sickness associated with severe COVID-19 during pregnancy, in addition to validating the risk variables known in settings related to Saudi Arabia. In light of the current and potential epidemic hazards, these conclusions are crucial for developing targeted interventions, informing health policy, and optimizing care for this vulnerable group.

Based on our research, we suggest a four-pillar structure for pandemic preparedness (Fig. 4): (1) improved prenatal risk assessment, (2) fair access to maternity care, (3) improved infection control during pregnancy, and (4) long-term follow-up after recovery. This comprehensive strategy prioritizes high-risk women, addressing both acute management and long-term outcomes, and ensures that the health system can protect maternal and newborn health through evidence-based, targeted interventions in the event of future medical emergency conditions.

During an epidemic, this structure provides a broad, evidence-based approach to protect the health of mothers and their embryos. This framework encompasses a comprehensive range of care, from prenatal risk evaluation to postpartum recovery, and is centered around four key interactions.

Limitations

This study has several limitations that should be considered when interpreting the findings. First, the single-center design at a tertiary care hospital in Bisha Province may limit the generalizability of the results to other regions or healthcare settings within Saudi Arabia. Second, the retrospective nature of the data collection is subject to potential biases from incomplete or inaccurate documentation in the EMRs; meanwhile, long-term outcomes were assessed via structured interviews, and recall bias remains a possible concern. Furthermore, although sufficient for the primary analysis, the sample size may have been underpowered to detect more subtle associations or rare adverse outcomes. Unmeasured confounding factors, such as detailed vaccination status, specific viral variants, or nuances in prenatal care adherence, could have influenced the results but were not accounted for in our analysis. Finally, the assessment of long-term outcomes via structured telephone interviews, while necessary for follow-up, is inherently susceptible to recall and reporting bias, which may affect the accuracy of the symptom persistence data.

5. Conclusions

This study identified a confluence of clinical and socioeconomic factors that significantly increase the risk of severe COVID-19 in pregnancy. The substantial long-term morbidity among ICU survivors underscores the critical need for a multifaceted approach. We recommend implementing targeted prenatal risk stratification, enhancing healthcare access, and establishing dedicated post-COVID recovery clinics to mitigate risks and improve outcomes for this vulnerable population in future pandemic responses.

Abbreviations

COVID-19, coronavirus disease-2019; ICU, intensive care unit; SARS-CoV-2, severe acute respiratory syndrome coronavirus 2; ARDS, acute respiratory distress syndrome; NICU, Neonatal Intensive Care Unit; RT-PCR, reverse transcription-polymerase chain reaction; EMRs, electronic medical records; IQR, interquartile range; OR, odds ratio; aOR, adjusted odds ratio; BMI, body mass index; IRB, Institutional Review Board; WHO, World Health Organization; FDR, false discovery rate; VIF, variance inflation factor; AUROC, area under the receiver operating characteristic; AUC, area under the curve; DM, diabetes mellitus.

Availability of Data and Materials

The data used in this study are available from the corresponding authors upon request.

Author Contributions

EM and AA conceived and designed the study. AMA, DA, EA, and SE were responsible for data acquisition and patient enrollment. BA performed the statistical analysis. ASH contributed to the interpretation of data and critical revision of the manuscript for important intellectual content. All authors contributed to critical revision of the manuscript for important intellectual content. All authors read and approved the final manuscript. All authors have participated sufficiently in the work and agreed to be accountable for all aspects of the work.

Ethics Approval and Consent to Participate

The study protocol was reviewed and approved by the Institutional Review Board (IRB) of University of Bisha [Ref No.: UB-RELOC H-06-BH-087/(1810.24)]. The requirement for informed consent was waived by the IRB due to the retrospective nature of the study. All patient data were handled with strict confidentiality. Data were anonymized and de-identified at the point of collection and stored on a password-protected hospital server, accessible only to the principal investigators, in compliance with the Declaration of Helsinki.

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Conflict of Interest

The authors declare no conflict of interest.

Declaration of AI and AI-Assisted Technologies in the Writing Process

During the preparation of this manuscript, the authors mainly used Grammarly, 2025 for language polishing, grammar improvement, and proofreading purposes. The AI tool was employed to enhance the clarity, readability, and grammatical accuracy of the text when the authors developed the intellectual content fully. All scientific and analytical materials, including data interpretation, conclusions, and scholars, remain the basic work of writers. The use of grammar did not affect the research method, result, or intellectual direction of study. After using this tool, the authors reviewed and edited the content as needed and take full responsibility for the content of the publication.

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