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Trends in Repeated Cardiopulmonary Resuscitation and Short-Term Outcomes after In-Hospital Cardiac Arrest: A Nine-Year Code Blue Registry Study

Loui Kamel Alsulimani
King Abdulaziz University
Taha Masri
tmasri@kau.edu.sa

King Abdulaziz University Hospital
Safinaz M Alshiakh
King Abdulaziz University
Ibrahim Abdu Asiri
King Abdul Aziz University Hospital
Abdullah Mohammad Alghamdi
King Abdulaziz University
Mutasem S. Almehayawi
King Abdulaziz University
Shafiqa Mohammed Jaber AlSharif
King Abdulaziz University
Hasan M. Alshamrani
King Abdulaziz University

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Abstract

Background

Repeated cardiopulmonary resuscitation (CPR) may indicate persistent instability and an increased risk of unfavorable outcomes following in-hospital cardiac arrest. This study evaluated temporal patterns, patient-group differences, and associations between repeated CPR and short-term outcomes over nine years.

Methods

This retrospective registry-based study analyzed aggregated monthly Code Blue data from King Abdulaziz University Hospital, Saudi Arabia, between January 2017 and December 2025. Outcomes included repeat-CPR rate, survival after the first CPR attempt, survival beyond 24 hours, and in-hospital mortality. We compared outcomes across pre-COVID (2017–2019), COVID (2020–2022), and post-COVID (2023–2025) periods and among adult, pediatric, and neonatal groups using nonparametric tests. Spearman correlations assessed temporal and outcome relationships.

Results

Among 108 monthly observations, mean repeat-CPR, initial survival, 24-hour survival, and mortality rates were 29.57%, 64.07%, 45.17%, and 60.35%, respectively. Initial survival differed across periods ($p < 0.001$) and was higher pre-COVID than during COVID and post-COVID. Mortality also differed across periods ($p < 0.001$) and was lower post-COVID than during both earlier periods. Repeat-CPR and 24-hour survival rates did not differ significantly across periods. All outcomes differed among patient groups ($p < 0.001$. Pediatric patients had the highest initial and 24-hour survival, whereas adults had the highest repeat-CPR and mortality rates. Repeat CPR correlated negatively with 24-hour survival ($\rho=-0.230$) and positively with mortality ($\rho = 0.357$); initial survival correlated positively with 24-hour survival ($\rho = 0.660$; all $p < 0.001$).

Conclusions

CPR outcomes varied across temporal periods and patient groups. Higher repeat-CPR rates were associated with poorer short-term outcomes, supporting population-specific monitoring and strengthened post-resuscitation care.

Introduction

In-hospital cardiac arrest (IHCA) remains a major clinical challenge and is associated with substantial morbidity and mortality among hospitalized patients (1). Despite advances in cardiopulmonary

resuscitation (CPR), early recognition systems, and post-cardiac-arrest care, outcomes vary considerably across institutions and patient populations (2). Return of spontaneous circulation (ROSC) represents an essential first step in successful resuscitation; however, initial resuscitation success does not necessarily translate into sustained survival (3). A substantial proportion of patients who initially respond to CPR experience early clinical deterioration, recurrent cardiac arrest, or death during the post-resuscitation period (4). Consequently, evaluating IHCA outcomes should extend beyond immediate ROSC to include recurrent resuscitation, early survival, and mortality (5).

Repeated CPR following an initial resuscitation episode represents a particularly important clinical event. Recurrent arrest may indicate persistent physiological instability, incomplete reversal of the precipitating cause, severe underlying disease, or progression of post-cardiac-arrest syndrome(6, 7). Previous patient-level studies have reported that recurrent IHCA is associated with substantially poorer survival than a single arrest episode (8). Nevertheless, survival after recurrent arrest remains possible, and the prognostic implications of repeated CPR may vary according to the patient population, underlying disease, timing of recurrence, and institutional resuscitation practices (9). Longitudinal evaluation of repeated CPR alongside immediate and short-term outcomes may therefore provide clinically valuable information about the overall performance of hospital resuscitation systems (10, 11).

IHCA outcomes may also change over time and differ across clinical populations. The coronavirus disease 2019 (COVID-19) pandemic introduced major changes in healthcare delivery, including altered patient case mix, increased clinical severity, infection-control requirements, workforce pressures, and potential delays in emergency response (12, 13). Studies examining IHCA during the pandemic have reported variable findings, reflecting differences in healthcare systems, patient characteristics, COVID-19 status, and study periods(13). Furthermore, adult, pediatric, and neonatal cardiac arrests represent clinically distinct conditions(14). These groups differ in arrest etiology, underlying disease, physiological reserve, initial cardiac rhythm, location of arrest, and response to resuscitation. Comparison across these populations may therefore help identify group-specific outcome patterns and quality-improvement priorities (15).

Although previous investigations have examined individual predictors of IHCA survival, fewer studies have evaluated repeated CPR, initial resuscitation success, early survival, and mortality simultaneously over an extended period encompassing the pre-pandemic, pandemic, and post-pandemic eras. Long-term institutional registries provide an opportunity to characterize these patterns and identify outcomes that warrant focused clinical review. Therefore, this study examined nine years of institutional Code Blue registry data from 2017 through 2025. We compared repeat-CPR rate, survival after the first CPR attempt, survival beyond 24 hours, and mortality across the pre-COVID, COVID, and post-COVID periods and among adult, pediatric, and neonatal patient groups. We also evaluated temporal trends and relationships among these CPR outcomes. We hypothesized that CPR outcomes would differ across study periods and patient groups and that higher repeat-CPR rates would be associated with less favorable short-term outcomes.

Methods

Study Design and Setting

This retrospective, registry-based observational study was conducted at King Abdulaziz University Hospital, a tertiary care teaching hospital in Jeddah, Saudi Arabia. Data were obtained from the institutional Code Blue registry and monthly cardiopulmonary resuscitation audit reports covering the nine years from January 2017 through December 2025. The requirement for informed consent to participate was waived by the same committee.

Ethics approval

The study was conducted in accordance with the ethical principles of the Declaration of Helsinki. Ethical approval was obtained from the Research Ethics Committee of the Faculty of Medicine, King Abdulaziz University Hospital, Jeddah, Saudi Arabia (reference no. 123 – 26; approval date: February 19, 2026; National Committee of Bioethics registration no. HA-02-J-008). The committee classified the study as a non-interventional retrospective record review. Data were analyzed in aggregated form, and the analytical dataset contained no directly identifiable patient information.

Study Population

All Code Blue activations requiring CPR during the study period were eligible for inclusion. Events were classified into adult, pediatric, and neonatal groups according to the institutional Code Blue registry. Code Blue activations that did not require CPR were not included. Monthly observations with missing information for a specific outcome were excluded only from analyses involving that outcome; available data for the remaining outcomes were retained.

Data Source and Study Variables

Aggregated monthly data were extracted from the institutional Code Blue registry and corresponding CPR audit reports. The extracted variables included the total number of CPR events, the number of patients requiring repeated CPR, survival after the first CPR attempt, survival beyond 24 hours following CPR, and in-hospital mortality.

Repeated CPR was defined as more than one CPR episode. Survival after the first CPR attempt was defined as the achievement of return of spontaneous circulation. Survival beyond 24 hours was defined as remaining alive for more than 24 hours following CPR. In-hospital mortality was defined as death during the index hospitalization following CPR. Each outcome rate was calculated using the corresponding denominator specified in the institutional registry.

The unit of analysis was the monthly institutional observation. For subgroup analyses, observations were classified into adult, pediatric, and neonatal groups according to the institutional registry. For temporal analyses, the study period was divided a priori into three phases: pre-COVID (2017–2019), COVID era (2020–2022), and post-COVID (2023–2025).

Statistical Analysis

Data were analyzed using IBM SPSS Statistics version 25.0 (IBM Corp., Armonk, NY, USA). The distributions of continuous outcome variables were assessed using the Shapiro–Wilk test. Because the outcome variables were not normally distributed, nonparametric statistical methods were used. Continuous variables were summarized as mean ± standard deviation (SD) together with median and interquartile range (IQR), whereas categorical variables were summarized as frequencies and percentages where applicable.

Differences in repeat-CPR rate, survival after the first CPR attempt, survival beyond 24 hours, and in-hospital mortality across the pre-COVID, COVID, and post-COVID periods were assessed using the Kruskal–Wallis H test. The same method was used to compare CPR outcomes among adult, pediatric, and neonatal groups. When the overall Kruskal–Wallis test was statistically significant, Dunn's post hoc pairwise comparisons with Bonferroni adjustment were performed to identify specific group differences while controlling for multiple comparisons.

The magnitude of between-group differences was quantified using epsilon-squared (ε^2) effect sizes. Temporal associations between calendar year and CPR outcomes, as well as relationships among CPR outcome variables, were evaluated using Spearman's rank correlation coefficient (ρ).

Annual trends in repeat CPR rate, survival after first CPR, survival beyond 24 hours, and mortality were presented graphically. Outcomes were also visualized according to patient group and study period. All statistical tests were two-sided, and $p < 0.05$ was considered statistically significant.

Results

Overall Descriptive Analysis

The primary analysis included 108 monthly institutional observations from January 2017 to December 2025. Overall, the mean repeat CPR rate was 29.57 ± 18.09%, with a median of 28.80% (IQR: 20.00–40.00%), indicating that about one-third of patients required repeat CPR. The mean survival rate following the first CPR attempt was 64.07 ± 24.13%, with a median of 67.21% (IQR: 50.00–80.00%), suggesting that nearly two-thirds of patients initially achieved return of spontaneous circulation. The mean survival beyond 24 hours was 45.17 ± 23.62%, with a median of 42.50% (IQR: 32.50–57.40%), indicating that fewer than half of the patients survived beyond the first 24 hours after resuscitation. The overall mortality rate was 60.35 ± 24.59%, with a median of 63.00% (IQR: 48.05–80.00%), reflecting a relatively high mortality burden among patients undergoing CPR. The relatively wide standard deviations

and interquartile ranges indicate substantial month-to-month variability in CPR outcomes across the nine-year study period, reflecting temporal changes in patient case mix, clinical characteristics, and healthcare delivery (Table 1).

Table 1
Overall descriptive statistics of monthly CPR outcomes, 2017–2025

Variable	Mean ± SD	Median (IQR)
Repeat CPR Rate (%)	29.57 ± 18.09	28.80 (20.00–40.00)
Survival After 1st CPR (%)	64.07 ± 24.13	67.21 (50.00–80.00)
Survival Beyond 24 h (%)	45.17 ± 23.62	42.50 (32.50–57.40)
Mortality Rate (%)	60.35 ± 24.59	63.00 (48.05–80.00)

Values represent distributions of monthly institutional outcome rates. CPR, cardiopulmonary resuscitation; IQR, interquartile range; SD, standard deviation.

Comparison of CPR Outcomes across study periods

Repeat-CPR rate did not differ significantly across the pre-COVID, COVID, and post-COVID periods ($\chi 2 = 4.692$, $p = 0.096$, $\varepsilon 2 = 0.006$). Although the COVID era had the highest mean rank, the effect size was negligible. Survival after the first CPR attempt differed significantly across the three periods ($\chi 2 = 22.009$, $p < 0.001$, $\varepsilon 2 = 0.045$). The pre-COVID period had the highest mean rank, although the overall effect size was small. Bonferroni-adjusted pairwise comparisons showed that initial survival was higher during the pre-COVID period than during the COVID era (mean difference, 11.93 percentage points; 95% CI, 5.40–18.47; adjusted $p < 0.001$) and the post-COVID period (mean difference, 12.27 percentage points; 95% CI, 5.75–18.79; adjusted $p < 0.001$). Initial survival did not differ significantly between the COVID and post-COVID periods (adjusted $p = 1.000$). Survival beyond 24 hours did not differ significantly across the three study periods ($\chi 2 = 3.777$, $p = 0.151$, $\varepsilon 2 = 0.004$). The effect size was negligible, and none of the Bonferroni-adjusted pairwise comparisons was statistically significant.

In-hospital mortality differed significantly across the three periods ($\chi 2 = 20.756$, $p < 0.001$, $\varepsilon 2 = 0.042$), although the effect size was small. Mortality was lower during the post-COVID period than during the pre-COVID period (mean difference, 10.78 percentage points; 95% CI, 4.08–17.47; adjusted $p < 0.001$) and the COVID era (mean difference, 10.47 percentage points; 95% CI, 3.78–17.17; adjusted $p = 0.001$). Mortality did not differ significantly between the pre-COVID and COVID periods (adjusted $p = 1.000$).

Overall, study-period differences were observed for survival after the first CPR attempt and in-hospital mortality, whereas repeat-CPR rate and survival beyond 24 hours remained comparable. The omnibus comparisons are presented in Table 2, outcome distributions across the three periods are shown in Fig. 3A–D, and complete Bonferroni-adjusted pairwise comparisons are provided in Supplementary Table S1.

Table 2
Comparison of monthly CPR outcomes across study periods

Outcome Variable	Pre-COVID Mean Rank	COVID Era Mean Rank	Post-COVID Mean Rank	χ^2	p-value	ε^2
Repeat CPR Rate	230.98	234.34	204.67	4.692	0.096	**0.006**
Survival After 1st CPR	266.29	203.52	207.09	22.009	< 0.001	**0.045**
Survival Beyond 24 Hours	240.27	211.23	223.60	3.777	0.151	**0.004**
Mortality Rate	244.94	245.52	186.03	20.756	< 0.001	**0.042**

Values for the three study periods are mean ranks. Comparisons were performed using the Kruskal–Wallis H test. Pre-COVID: 2017–2019; COVID era: 2020–2022; post-COVID: 2023–2025. CPR, cardiopulmonary resuscitation; ε2, epsilon-squared effect size. Statistically significant p-values are shown in bold.

Comparisons among adult, pediatric, and neonatal groups

All four CPR outcomes differed significantly among adult, pediatric, and neonatal groups (all $p < 0.001$; Table 3). Group differences were moderate for repeat-CPR rate ($\varepsilon^2 = 0.115$), small for survival after the first CPR attempt ($\varepsilon^2 = 0.073$), and large for survival beyond 24 hours ($\varepsilon^2 = 0.175$) and in-hospital mortality ($\varepsilon^2 = 0.169$). Adults had higher repeat-CPR rates than pediatric patients (mean difference, 10.44 percentage points; 95% CI, 4.17–16.70; adjusted $p < 0.001$) and neonates (mean difference, 10.16 percentage points; 95% CI, 3.83–16.49; adjusted $p < 0.001$). Repeat-CPR rate did not differ significantly between pediatric patients and neonates (adjusted $p = 1.000$).

Table 3
Comparison of monthly CPR outcomes among adult, pediatric, and neonatal groups

Outcome Variable	Adults mean Rank	Pediatrics mean Rank	Neonates mean Rank	χ^2	*p*-value	ε^2
Repeat CPR Rate	218.22	150.00	142.46	40.524	< 0.001	0.115
Survival After First CPR Rate	157.73	209.16	146.45	26.638	< 0.001	0.073
Survival Beyond 24 Hours Rate	127.59	226.47	155.47	61.012	< 0.001	0.175
Mortality Rate	221.94	120.72	174.86	59.280	< 0.001	0.169

Values for the three patient groups are mean ranks. Comparisons were performed using the Kruskal–Wallis H test. CPR, cardiopulmonary resuscitation; ε2, epsilon-squared effect size. Statistically significant p-values are shown in bold.

Survival after the first CPR attempt was higher among pediatric patients than among adults (mean difference, 9.93 percentage points; adjusted $p = 0.010$) and neonates (mean difference, 15.68 percentage points; adjusted $p < 0.001$). No significant difference was observed between adults and neonates (adjusted $p = 0.263$). Survival beyond 24 hours was higher among pediatric patients than among adults (mean difference, 23.61 percentage points; adjusted $p < 0.001$) and neonates (mean difference, 19.02 percentage points; adjusted $p < 0.001$). Adults and neonates did not differ significantly in survival beyond 24 hours (adjusted $p = 0.463$).

In-hospital mortality was higher among adults than among pediatric patients (mean difference, 25.70 percentage points; 95% CI, 17.80–33.59; adjusted $p < 0.001$) and neonates (mean difference, 12.96 percentage points; 95% CI, 5.09–20.84; adjusted $p < 0.001$). Mortality was also higher among neonates than among pediatric patients (mean difference, 12.73 percentage points; 95% CI, 4.98–20.48; adjusted $p < 0.001$).

Collectively, pediatric patients demonstrated the most favorable survival outcomes, whereas adults had the highest repeat-CPR and mortality rates. Outcome distributions by patient group are shown in Fig. 2A–D, and complete Bonferroni-adjusted pairwise comparisons are provided in Supplementary Table S2.

Temporal trends and correlations among CPR outcomes

Correlation analysis demonstrated weak negative associations between study year and repeat CPR rate ($\rho = -0.112$, $p = 0.018$), survival after the first CPR attempt ($\rho = -0.206$, $p < 0.001$), and mortality rate ($\rho = -0.187$, $p < 0.001$). In contrast, no significant correlation was observed between study year and survival beyond 24 hours ($\rho = -0.071$, $p = 0.130$), indicating that longer-term survival remained relatively stable throughout the study period despite temporal fluctuations in other CPR outcomes.

Among the CPR outcome measures, survival after the first CPR rate showed a strong positive correlation with survival beyond 24 hours ($\rho = 0.660$, $p < 0.001$), suggesting that higher rates of initial resuscitation success were associated with improved short-term survival. Repeat CPR rate was weakly negatively correlated with survival beyond 24 hours ($\rho = -0.230$, $p < 0.001$) and weakly positively correlated with mortality rate ($\rho = 0.357$, $p < 0.001$), indicating that patients requiring repeated resuscitation were less likely to survive beyond 24 hours and more likely to experience mortality. Furthermore, survival beyond 24 hours showed a strong negative correlation with the mortality rate ($\rho = -0.662$, $p < 0.001$), indicating that higher 24-hour survival was associated with substantially lower mortality (Table 4).

Table 4
Spearman correlations between calendar year and monthly CPR outcomes

Variables	Spearman's ρ	p-value
Year vs Repeat-CPR Rate	−0.112	0.018
Year vs Survival After 1st CPR attempt	−0.206	< 0.001
Year vs Survival Beyond 24 hours	−0.071	0.130
Year vs In-hospital Mortality	−0.187	< 0.001
Survival After 1st CPR vs Survival Beyond 24 h Rate	0.660	< 0.001
Repeat-CPR Rate vs Survival Beyond 24 h Rate	−0.230	< 0.001
Repeat-CPR Rate vs Mortality Rate	0.357	< 0.001
Survival Beyond 24 hours vs In-hospital Mortality	−0.662	< 0.001

Correlations were calculated using monthly institutional outcome rates. All tests were two-sided. CPR, cardiopulmonary resuscitation; ρ, Spearman rank-correlation coefficient. Statistically significant p-values are shown in bold.

Collectively, these findings suggest that successful initial resuscitation is strongly associated with improved short-term survival, whereas repeated CPR is associated with poorer clinical outcomes. Despite changes in several CPR-related measures over time, survival beyond 24 hours showed no significant temporal trend.

Annual outcome patterns

Annual trends in CPR outcomes are presented in Fig. 1A–D. Repeat-CPR rates fluctuated throughout the study period, with higher numerical values during the COVID era followed by lower values during the post-COVID period (Fig. 1A). Survival after the first CPR attempt was highest during the pre-COVID period and remained below pre-COVID levels during the COVID and post-COVID periods (Fig. 1B). Survival beyond 24 hours fluctuated without a consistent increasing or decreasing pattern (Fig. 1C). In-hospital mortality increased numerically during the COVID era and subsequently decreased during the post-COVID period (Fig. 1D).

Discussion

This nine-year Code Blue registry study identified important temporal and patient-group differences in repeated CPR and short-term outcomes following in-hospital cardiac arrest. Four principal findings emerged. First, survival after the first CPR attempt was significantly higher during the pre-COVID period than during both the COVID and post-COVID periods, whereas survival beyond 24 hours remained comparable across the three periods. Second, in-hospital mortality was significantly lower during the post-COVID period than during the pre-COVID and COVID periods. However, the small effect sizes indicate that study period accounted for only a modest proportion of the observed variability. Third,

pediatric patients demonstrated the most favorable survival outcomes, whereas adults had the highest repeat-CPR and mortality rates. The mean monthly repeat-CPR rate was approximately 30%, indicating that repeated resuscitation constituted a substantial component of the institutional CPR burden. Although the mean initial survival rate was approximately 64%, mean survival beyond 24 hours was approximately 45%. This difference highlights the clinical vulnerability of patients during the early post-cardiac-arrest period. Previous studies have similarly demonstrated that achievement of return of spontaneous circulation (ROSC) does not necessarily translate into sustained survival because outcomes after in-hospital cardiac arrest are influenced by arrest etiology, initial rhythm, CPR duration, comorbidities, arrest location, and post-cardiac-arrest care (16, 17). These findings emphasize that institutional assessment of resuscitation performance should not be limited to ROSC (18).

Survival after the first CPR attempt was significantly higher during the pre-COVID period than during the COVID and post-COVID periods. No significant difference was observed between the COVID and post-COVID periods, suggesting that initial resuscitation success had not returned to its pre-COVID level during the first three post-COVID years. Several factors may have contributed to lower initial survival during the COVID era, including changes in patient case mix and illness severity, infection-control requirements, workforce pressures, and potential delays in recognizing cardiac arrest or initiating resuscitation. Studies of IHCA among patients with COVID-19 have generally reported low ROSC and survival rates, although outcomes have varied across hospitals and patient populations (19–21).

An important feature of the results is the divergence between initial survival and in-hospital mortality during the post-COVID period. Survival after the first CPR attempt remained lower than during the pre-COVID period, whereas mortality decreased. These outcomes represent different stages of the clinical pathway and may therefore follow different temporal trajectories. This divergence reinforces the importance of evaluating multiple outcomes rather than using ROSC alone as an indicator of resuscitation-system performance (22, 23). Nevertheless, the present findings do not establish that repeated CPR independently caused mortality(24).

Survival after the first CPR attempt was positively associated with survival beyond 24 hours. Although clinically expected, this finding reinforces the importance of successful initial resuscitation for sustained early survival (25). However, the difference between initial and 24-hour survival also indicates that ROSC alone is insufficient to ensure a favorable outcome (26).

All four CPR outcomes differed significantly among adult, pediatric, and neonatal groups. The more favorable pediatric outcomes are consistent with previous reported higher survival to hospital discharge among children than adults following pulseless IHCA, despite differences in initial rhythm distributions (27). Differences between adult and pediatric outcomes may reflect variation in arrest etiology, underlying disease, physiological reserve, monitored status, initial rhythm, and arrest location(28). Neonatal resuscitation is distinct from adult and pediatric IHCA, due to differences in arrest mechanisms, physiology, diagnoses, and pathways. Outcomes shouldn't be seen as just an age-based

middle ground. Understanding neonatal patterns requires analysis of arrest setting, etiology, gestational age, and diagnoses. (29, 30).

The decline in initial survival and mortality highlights the need for cautious interpretation of temporal findings. It has several implications for quality improvement. First, repeat CPR can serve as a surveillance indicator; high rates may benefit from case reviews to identify recurrent deterioration or gaps in monitoring. Second, the gap between initial survival and survival beyond 24 hours underscores the importance of post-arrest stabilization and preventing recurrent arrests. Third, differences among adult, pediatric, and neonatal groups suggest that CPR performance should be monitored separately for each group rather than as a single hospital-wide measure.

Strengths and limitations

This study has several strengths. It included nine consecutive years of institutional data, encompassed the pre-COVID, COVID, and post-COVID periods, and evaluated multiple stages of the resuscitation pathway. The inclusion of adult, pediatric, and neonatal groups provided a broad institutional perspective. Furthermore, assessment of repeated CPR alongside initial survival, 24-hour survival, and mortality allowed outcomes to be examined beyond immediate resuscitation success.

Several limitations should be acknowledged. First, this was a retrospective, single-center study, which may limit generalizability to institutions with different populations and resuscitation systems. Second, the analysis was based on aggregated monthly registry observations. Consequently, the relationships among repeat CPR, survival, and mortality cannot establish individual-level causality or independent prognostic effects. Third, the study could not adjust for potentially important confounders, including age within each group, comorbidities, arrest etiology and location, initial rhythm, monitored status, CPR duration, response times, illness severity, treatment limitations, or post-resuscitation care. Fourth, individual COVID-19 status was unavailable; therefore, the study-period comparisons reflect temporal rather than infection-specific effects. Fifth, the study evaluated 24-hour survival and in-hospital mortality but did not include survival to a standardized longer-term time point, neurological outcomes, or functional status. Finally, changes in registry practices, clinical protocols, staffing, and case mix over the nine-year period may have contributed to the observed patterns.

Conclusion

This nine-year Code Blue registry study demonstrated temporal and patient-group differences in CPR outcomes. Survival after the first CPR attempt was highest during the pre-COVID period, whereas in-hospital mortality was lowest during the post-COVID period. Repeat-CPR and 24-hour survival rates remained comparable across study periods. Pediatric patients experienced the most favorable short-term outcomes, while adults had the highest repeat-CPR and mortality rates. At the monthly institutional level, higher repeat-CPR rates were associated with lower 24-hour survival and higher mortality, whereas initial resuscitation success was positively associated with sustained early survival. These findings

support population-specific monitoring of CPR outcomes and highlight repeated resuscitation and post-cardiac-arrest care as priorities for institutional quality improvement.

Declarations

Ethics approval and consent to participate:

This study was conducted in accordance with the ethical principles of the Declaration of Helsinki. Ethical approval was obtained from the Research Ethics Committee of the Faculty of Medicine, King Abdulaziz University Hospital, Jeddah, Saudi Arabia (reference no. 123 – 26; approval date: February 19, 2026; National Committee of Bioethics registration no. HA-02-J-008). The committee classified the study as a non-interventional retrospective record review and waived the requirement for informed consent to participate. Data were analyzed in aggregated form, and the analytical dataset contained no directly identifiable patient information.

Consent for publication:

Not applicable. The manuscript does not contain identifiable individual patient information, images, or other identifying material.

Competing interests:

The authors declare no competing interests.

Patient consent for publication

The requirement for informed consent was waived by the Research Ethics Committee of the Faculty of Medicine, King Abdulaziz University Hospital, Jeddah, Saudi Arabia, because this was a non-interventional retrospective record review. Data were analyzed in aggregated form, and the analytical dataset contained no directly identifiable patient information.

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Clinical trial number

not applicable.

Contributors

Taha Masri: Conceptualization, methodology, formal analysis, investigation, data curation, visualization, writing—original draft, writing—review and editing, and project administration.

Loui Kamel Alsulimani: Conceptualization, methodology, validation, supervision, and writing—review and editing.

Safinaz M. Alshiakh: Methodology, investigation, data curation, and writing—review and editing.

Ibrahim Abdu Asiri: Investigation, resources, data curation, and writing—review and editing.

Abdullah Mohammad Alghamdi: Methodology, validation, and writing—review and editing.

Mutasem S. Almehayawi: Investigation, validation, and writing—review and editing.

Shafiqa Mohammed Jaber AlSharif: Investigation, validation, and writing—review and editing.

Hasan M. Alshamrani: Investigation, data curation, project administration, and writing—review and editing.

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Author Contribution

Taha Masri: Conceptualization, methodology, formal analysis, investigation, data curation, visualization, writing—original draft, writing—review and editing, and project administration.Loui Kamel Alsulimani: Conceptualization, methodology, validation, supervision, and writing—review and editing.Safinaz M. Alshiakh: Methodology, investigation, data curation, and writing—review and editing.Ibrahim Abdu Asiri: Investigation, resources, data curation, and writing—review and editing.Abdullah Mohammad Alghamdi: Methodology, validation, and writing—review and editing.Mutasem S. Almehayawi: Investigation, validation, and writing—review and editing.Shafiqa Mohammed Jaber AlSharif: Investigation, validation, and writing—review and editing.Hasan M. Alshamrani: Investigation, data curation, project administration, and writing—review and editing.All authors reviewed and approved the final manuscript and agreed to be accountable for the integrity and accuracy of the work.

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Data availability:

Data supporting the findings of this study are available from the corresponding author upon reasonable request, subject to institutional and ethical restrictions.

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Figures

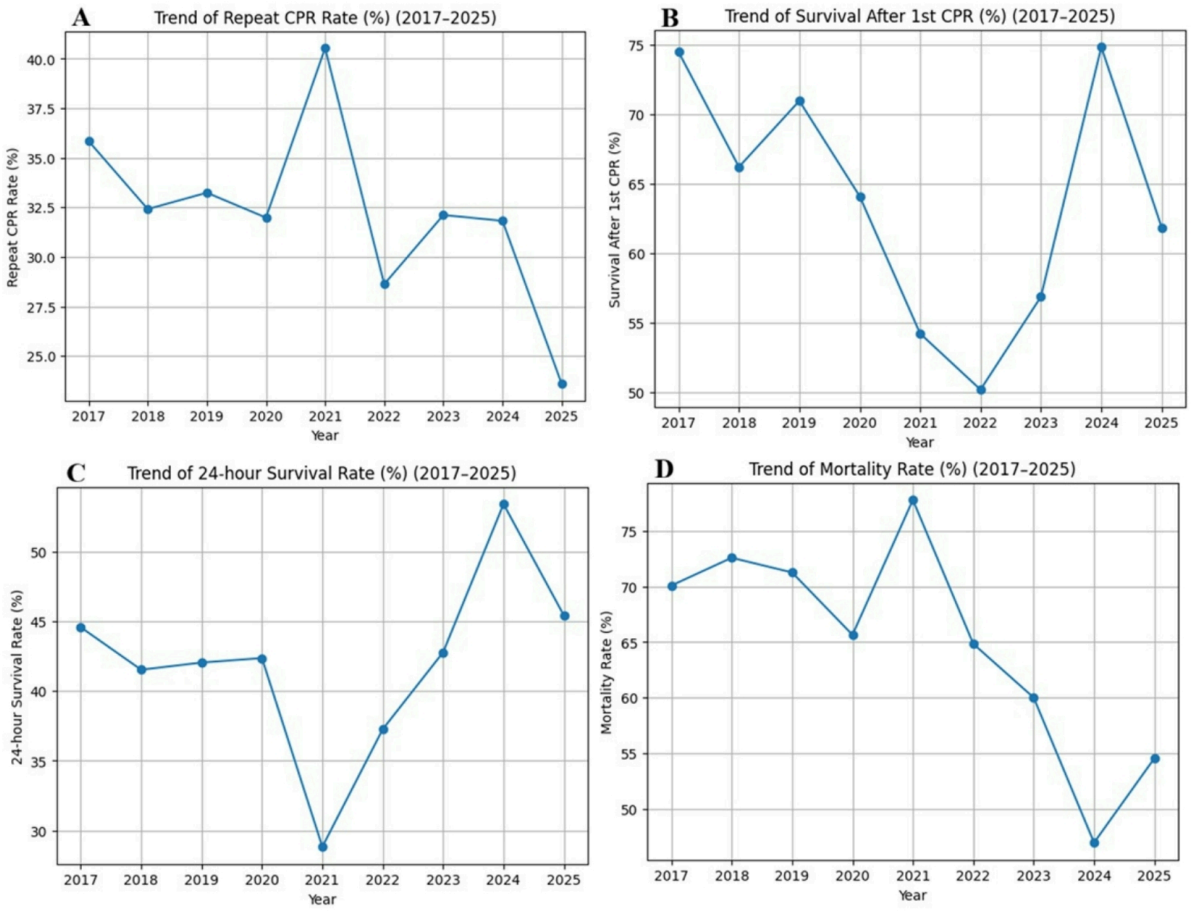


Figure 1

Annual trends in CPR outcomes from 2017 through 2025.
(A) Repeat-CPR rate; (B) survival after the first CPR attempt; (C) survival beyond 24 hours; and (D) in-hospital mortality. Shaded vertical regions indicate the pre-COVID (2017–2019), COVID (2020–2022), and post-COVID (2023–2025) periods.

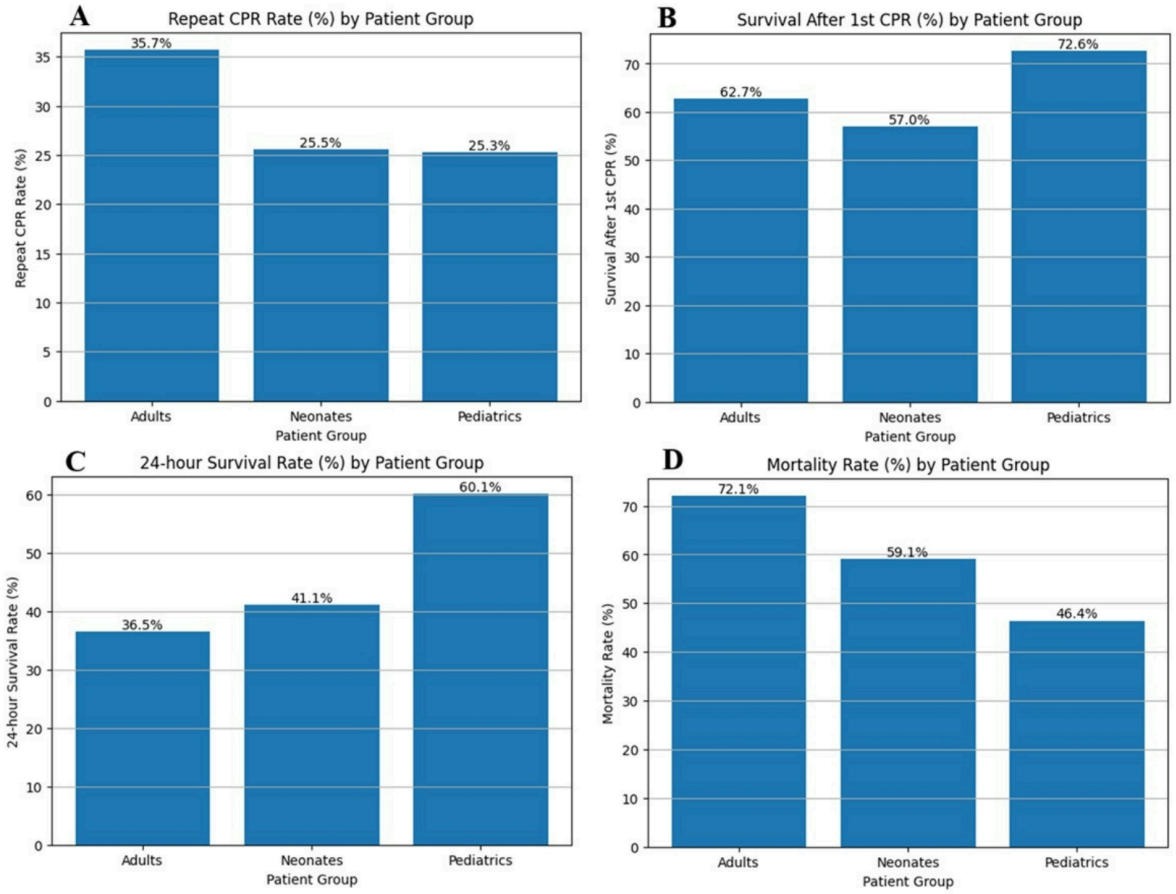


Figure 2

CPR outcomes by patient group.

Distributions of (A) repeat-CPR rate, (B) survival after the first CPR attempt, (C) survival beyond 24 hours, and (D) in-hospital mortality among adult, pediatric, and neonatal groups.

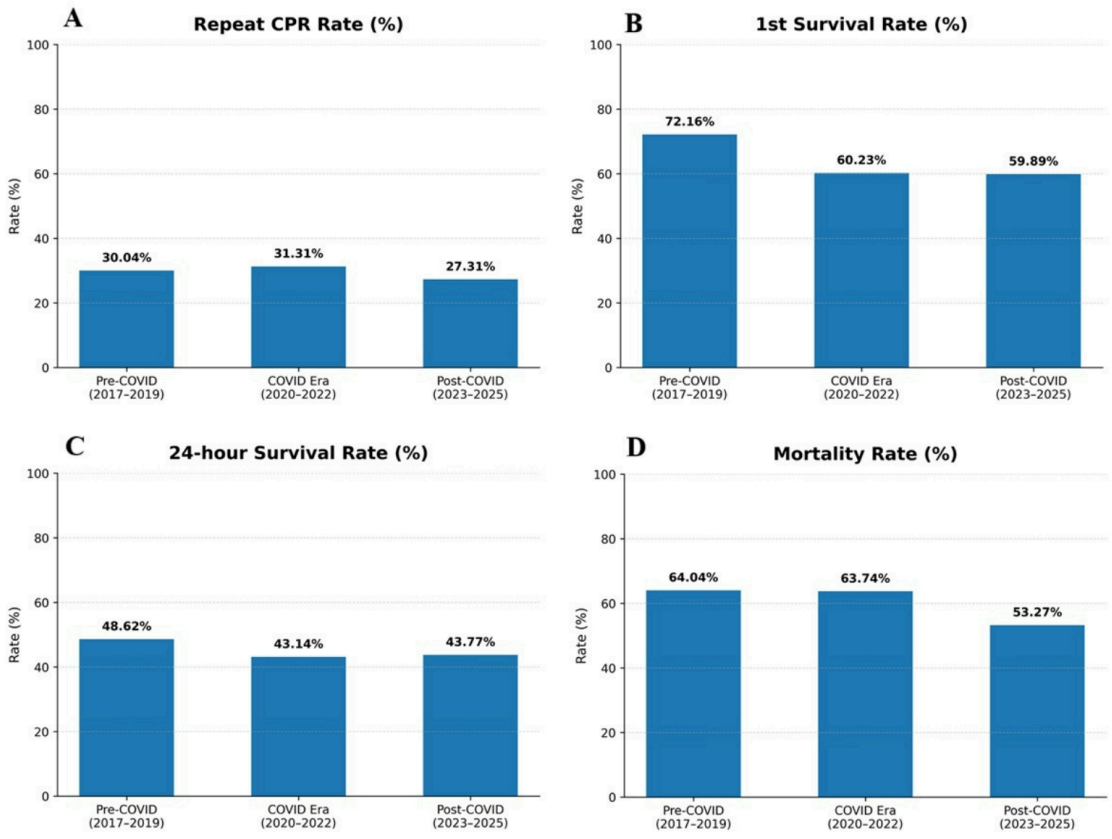


Figure 3

CPR outcomes across the pre-COVID, COVID, and post-COVID periods.
Distributions of (A) repeat-CPR rate, (B) survival after the first CPR attempt, (C) survival beyond 24 hours, and (D) in-hospital mortality. Overall comparisons were performed using the Kruskal–Wallis H test.

Supplementary Files

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- Supplementarymaterial.docx