


# Hospitalisations for emergency-sensitive conditions in Germany during the COVID-19 pandemic: insights from the German-wide Helios hospital network

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## ABSTRACT

**Background** While there are numerous reports that describe emergency care during the early COVID-19 pandemic, there is scarcity of data for later stages. This study analyses hospitalisation rates for 37 emergency-sensitive conditions in the largest German-wide hospital network during different pandemic phases.

**Methods** Using claims data of 80 hospitals, consecutive cases between 1 January and 17 November 2020 were analysed and compared with a corresponding period in 2019. Incidence rate ratios (IRRs) comparing the two periods were calculated using Poisson regression to model the number of hospitalisations per day.

**Results** There was a reduction in hospitalisations between 12 March and 13 June 2020 (coinciding with the first pandemic wave) with 32 807 hospitalisations (349.0/day) as opposed to 39 379 (419.0/day) in 2019 (IRR 0.83, 95% CI 0.82 to 0.85,  $p < 0.01$ ). During the following period (14 June–17 November 2020, including the start of second wave), hospitalisations were reduced from 63 799 (406.4/day) in 2019 to 59 910 (381.6/day) in 2020, but this reduction was not as pronounced (IRR 0.94, 95% CI 0.93 to 0.95,  $p < 0.01$ ). During the first wave hospitalisations for acute myocardial infarction, aortic aneurysm/dissection, pneumonitis, paralytic ileus/intestinal obstruction and pulmonary embolism declined but subsequently increased compared with the corresponding periods in 2019. In contrast, hospitalisations for sepsis, pneumonia, obstructive pulmonary disease and intracranial injuries were reduced during the entire observation period.

**Conclusions** There was an overall reduction of absolute hospitalisations for emergency-sensitive conditions in Germany during the first 10 months of the COVID-19 pandemic with heterogeneous effects on different disease categories. The increase in hospitalisations for acute myocardial infarction, aortic aneurysm/dissection and pulmonary embolism requires attention and further studies.

## INTRODUCTION

While there are numerous reports that describe emergency calls,<sup>1</sup> ED visits<sup>2</sup> and hospital admissions<sup>3–6</sup> for several medical and surgical conditions during the early COVID-19 pandemic (first wave), there is scarcity of data during later pandemic stages (ie, the second wave, and the period between waves). In addition, a comprehensive overview

## Key messages

### What is already known on this subject

► There has been a reduction in ED visits and hospital admissions for several emergent medical and surgical conditions during the early COVID-19 pandemic (first wave).

### What this study adds

► Using claims data of 80 German-wide Helios hospitals, we found an absolute overall reduction of hospitalisations for emergency-sensitive conditions in Germany during the COVID-19 pandemic until mid-November 2020 with heterogeneous effects on different disease categories. While hospitalisations for sepsis, pneumonia, obstructive pulmonary disease and intracranial injuries were reduced during the entire observation period, there was an increase in hospitalisations for acute myocardial infarction, aortic aneurysm/dissection, pneumonitis, paralytic ileus/intestinal obstruction and pulmonary embolism after the first wave compared with the corresponding period in 2019.

covering previously defined emergency-sensitive conditions<sup>7</sup> is also missing.

With this study, we wish to complement previous reports by providing and comparing hospitalisation data for patients with emergency-sensitive conditions hospitalised in a large German-wide hospital network during different phases of the pandemic.

## METHODS

### Study cohort

We performed a retrospective analysis of claims data of 80 Helios hospitals in Germany. The Helios hospital group operates metropolitan and regional acute care hospitals ranging from basic to maximum care, outpatient clinics and prevention centres across Germany (<https://www.helios-gesundheit.de/>). Patients have free choice of healthcare providers independent of insurance status. Helios hospitals provide inpatient care to about 1.2 million patients annually that corresponds to about 7% of all hospitalisations in Germany.



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**Table 1** Emergency hospital admissions in the German-wide Helios hospital network during the COVID-19 pandemic

|   | Deficit period |                  |                     |         | Resumption period |                  |                     |         |
|---|----------------|------------------|---------------------|---------|-------------------|------------------|---------------------|---------|
|   | n              | Daily admissions | IRR (95% CI)        | P value | n                 | Daily admissions | IRR (95% CI)        | P value |
| <b>Total</b>  |                |                  |                     |         |                   |                  |                     |         |
| 2019  | 39379          | 418.9            |                     |         | 63799             | 406.4            |                     |         |
| 2020  | 32807          | 349.0            | 0.83 (0.82 to 0.85) | <0.01   | 59910             | 381.6            | 0.94 (0.93 to 0.95) | <0.01   |
| <b>Sepsis (A41)</b>   |                |                  |                     |         |                   |                  |                     |         |
| 2019  | 2326           | 24.7             |                     |         | 4194              | 26.7             |                     |         |
| 2020  | 1228           | 13.1             | 0.53 (0.49 to 0.57) | <0.01   | 2263              | 14.4             | 0.54 (0.51 to 0.57) | <0.01   |
| <b>Volume depletion (E86)</b>   |                |                  |                     |         |                   |                  |                     |         |
| 2019  | 1630           | 17.3             |                     |         | 3180              | 20.2             |                     |         |
| 2020  | 1264           | 13.4             | 0.78 (0.72 to 0.83) | <0.01   | 2985              | 19.0             | 0.94 (0.89 to 0.99) | 0.01    |
| <b>Delirium, not induced by alcohol and other psychoactive substances (F05)</b>         |                |                  |                     |         |                   |                  |                     |         |
| 2019  | 391            | 4.2              |                     |         | 687               | 4.4              |                     |         |
| 2020  | 286            | 3.0              | 0.73 (0.63 to 0.85) | <0.01   | 570               | 3.6              | 0.83 (0.74 to 0.93) | <0.01   |
| <b>Acute myocardial infarction (I21) and other acute ischaemic heart disease (I24)*</b> |                |                  |                     |         |                   |                  |                     |         |
| 2019  | 2690           | 28.6             |                     |         | 4273              | 27.2             |                     |         |
| 2020  | 2534           | 27.0             | 0.94 (0.89 to 0.99) | 0.03    | 4568              | 29.1             | 1.07 (1.03 to 1.11) | <0.01   |
| <b>Pneumonia (J18)</b>  |                |                  |                     |         |                   |                  |                     |         |
| 2019  | 2876           | 30.6             |                     |         | 3743              | 23.8             |                     |         |
| 2020  | 2141           | 22.8             | 0.74 (0.70 to 0.79) | <0.01   | 3194              | 20.3             | 0.85 (0.81 to 0.89) | <0.01   |
| <b>Other chronic obstructive pulmonary disease (J44)</b>                                |                |                  |                     |         |                   |                  |                     |         |
| 2019  | 2945           | 31.3             |                     |         | 4129              | 26.3             |                     |         |
| 2020  | 1901           | 20.2             | 0.65 (0.61 to 0.68) | <0.01   | 3235              | 20.6             | 0.78 (0.75 to 0.82) | <0.01   |
| <b>Pneumonitis due to solids and liquids (J69)</b>                                      |                |                  |                     |         |                   |                  |                     |         |
| 2019  | 406            | 4.3              |                     |         | 660               | 4.2              |                     |         |
| 2020  | 351            | 3.7              | 0.86 (0.75 to 0.99) | 0.04    | 745               | 4.8              | 1.13 (1.02 to 1.25) | 0.02    |
| <b>Paralytic ileus and intestinal obstruction without hernia (K56)</b>                  |                |                  |                     |         |                   |                  |                     |         |
| 2019  | 1165           | 12.4             |                     |         | 1894              | 12.1             |                     |         |
| 2020  | 1041           | 11.1             | 0.89 (0.82 to 0.97) | <0.01   | 2035              | 13.0             | 1.07 (1.01 to 1.14) | 0.02    |
| <b>Cellulitis (L03)</b>   |                |                  |                     |         |                   |                  |                     |         |
| 2019  | 659            | 7.0              |                     |         | 1236              | 7.9              |                     |         |
| 2020  | 510            | 5.4              | 0.77 (0.69 to 0.87) | <0.01   | 1123              | 7.2              | 0.91 (0.84 to 0.98) | 0.02    |
| <b>Acute renal failure (N17)</b>  |                |                  |                     |         |                   |                  |                     |         |
| 2019  | 1192           | 12.7             |                     |         | 1886              | 12.0             |                     |         |
| 2020  | 943            | 10.0             | 0.79 (0.73 to 0.86) | <0.01   | 1749              | 11.1             | 0.93 (0.87 to 0.99) | 0.02    |
| <b>Intracranial injury (S06)</b>  |                |                  |                     |         |                   |                  |                     |         |
| 2019  | 3439           | 36.6             |                     |         | 5959              | 38.0             |                     |         |
| 2020  | 2739           | 29.1             | 0.80 (0.76 to 0.84) | <0.01   | 5066              | 32.3             | 0.85 (0.82 to 0.88) | <0.01   |

ICD-10 codes for the emergency-sensitive conditions are provided in parentheses.<sup>7</sup> Shown are conditions with significant changes in both periods while the remaining diseases are summarised in online supplemental table S1.

\*According to the Panel on Emergency-Sensitive Conditions,<sup>7</sup> disease categories are based on primary diagnosis. We have summarised acute myocardial infarction (I21) and other acute ischaemic heart disease (I24) as well as cerebral infarction (I63) and unspecified stroke (I64) since case volume for I24 and I64 was <10.

ICD-10, International Statistical Classification of Diseases and Related Health Problems; IRR, incidence rate ratio.

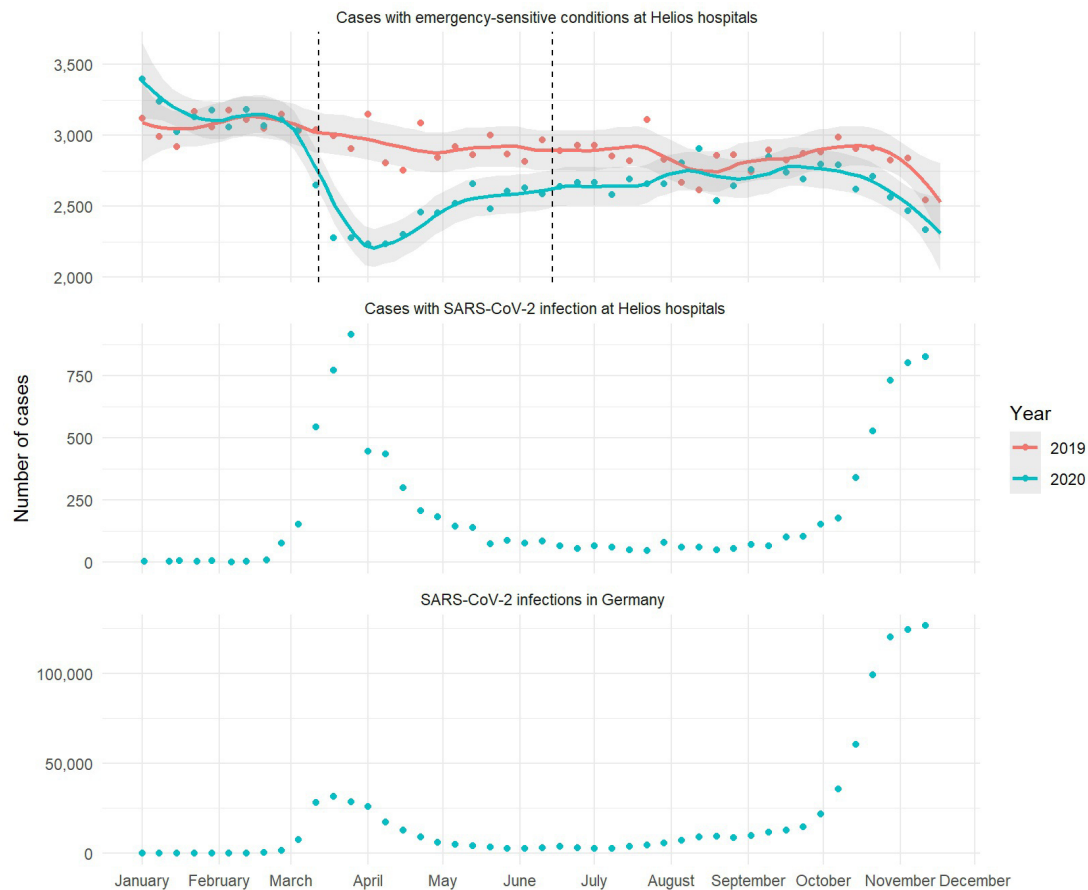
Consecutive cases with an emergent hospital admission between 1 January and 17 November 2020 (study period) were analysed and compared with a corresponding period covering the same weeks in 2019 (control period). Cause-specific hospitalisations were defined based on the primary discharge diagnosis according to International Statistical Classification of Diseases and Related Health Problems (German Modification) codes for 37 mortality-related emergency-sensitive conditions according to the Panel on Emergency-Sensitive Conditions (table 1, online supplemental table 1).<sup>7</sup> Cases with confirmed COVID-19 infection (U07.1) were not excluded from this analysis. For a description of the German Diagnosis Related Groups system, please see online supplemental file 1.

Due to the retrospective study of anonymised data, informed consent was not obtained. Patients and/or the public were not

involved in the design, conduct, reporting or dissemination of this research.

### Data analysis

Administrative data were extracted from QlikView (QlikTech, Radnor, Pennsylvania, USA). Incidence rates for admissions were calculated by dividing the cumulative number of admissions by the number of days in each time period. Incidence rate ratios (IRRs) comparing the study period with the control period were calculated using Poisson regressions to model the number of daily hospitalisations with one model per condition and phase (ie, 37×2 models). Inferential statistics were based on generalised linear mixed models (GLMMs) specifying hospitals as a random factor. For all Poisson models, we performed tests for



**Figure 1** Total weekly hospital admissions for emergency-sensitive conditions (upper panel), weekly hospitalisations of cases with SARS-CoV-2 infections at Helios hospitals (middle panel) and weekly new SARS-CoV-2 infections in Germany (lower panel). Smooth curves for weekly admission rates were fitted via Locally Weighted Scatterplot Smoothing with a degree of smoothing of  $\alpha=0.25$ . Grey areas represent 95% CIs. A 2020 deficit period starting at the first the day with non-overlapping 95% CIs and ending at the last day with non-overlapping intervals was defined. The first day at which the intervals are overlapping again was defined as the start of the resumption period (dotted vertical lines).

overdispersion by calculating the sum of squared Pearson residuals and comparing it with the residual df.

We report IRR together with 95% CIs for the comparisons of the two periods and p values for the interactions. For the calculation of ORs, we used logistic GLMMs with logit link function. For all tests, we used R (V.3.6.1) and applied a two-tailed 5% error criterion for significance.

## RESULTS

During the 2020 study period (deficit and resumption phase combined), there was a total of 453 082 emergent inpatient hospitalisations (1407.1/day) and 17 813 ambulatory ED visits (55.3/day), significantly less than 484 368 (1504.2/day; IRR 0.94, 95% CI 0.93 to 0.94,  $p<0.01$ ) and 31 306 (97.2/day, IRR 0.57, 95% CI 0.56 to 0.58,  $p<0.01$ ), respectively, seen in 2019. This decrease was also evident when comparing 2020 cases with years prior to 2019 (online supplemental table 2). Median case volume per hospital decreased from 4718 (IQR 1835–9107) to 4040 (1678–8115) for inpatient hospitalisations and from 183 (78–282) to 136 (70–239) for ambulatory ED visits.

Hospital inpatient admissions for emergency-sensitive conditions, cases with SARS-CoV-2 infections at Helios hospitals and daily new SARS-CoV-2 infections in Germany are depicted in figure 1 and per hospital in online supplemental figure 1. There was a reduction in hospitalisations between 12 March and 13 June 2020 coinciding with the first pandemic wave. During this

period, there were 32 807 hospitalisations (349.0/day) including 286 PCR-confirmed COVID-19 cases compared with 39 379 (418.9/day) in 2019 (IRR 0.83, 95% CI 0.82 to 0.85,  $p<0.01$ ). During the observational period 14 June–17 November 2020 which included the start of the second infection wave, emergency-sensitive hospitalisations were reduced from 63 799 (406.4/day) in 2019 to 59 910 (381.6/day) in 2020 including 436 COVID-19 cases, (IRR 0.94, 95% CI 0.93 to 0.95,  $p<0.01$ ) but this reduction was not as pronounced as during the first infection wave.

Hospitalisations for the individual emergency-sensitive conditions stratified for both periods show a heterogeneous pattern (table 1 and online supplemental table 1). Hospitalisations for sepsis, pneumonia, obstructive pulmonary disease and intracranial injuries as primary diagnoses were reduced during the entire pandemic, even including COVID-19 cases. Similarly, when expanding the definition of pneumonia (J18) to include all severe acute respiratory infections (J09–J22, excluding hospital-acquired infections U69.0), IRR was 0.76 (95% CI 0.74 to 0.78,  $p<0.01$ ) in the first wave and 0.97 (95% CI 0.94 to 0.99,  $p<0.01$ ) in the June–November period. In contrast, there was an increase in hospitalisations for acute myocardial infarction (IRR 1.07, 95% CI 1.03 to 1.11,  $p<0.01$ ), aortic aneurysm and dissection (IRR 1.21, 95% CI 1.02 to 1.44,  $p=0.03$ ), pneumonitis (IRR 1.13, 95% CI 1.02 to 1.25,  $p=0.02$ ), paralytic ileus/intestinal obstruction (IRR 1.07, 95% CI 1.01 to 1.14,  $p=0.02$ ) and

**Table 2** In-hospital mortality for emergency-sensitive conditions

| Year   | Deficit period |                     |         | Resumption period |                     |         |
|--|----------------|---------------------|---------|-------------------|---------------------|---------|
|  | Proportion (n) | OR (95% CI)         | P value | Proportion (n)    | OR (95% CI)         | P value |
| <b>Sepsis</b>  |                |                     |         |                   |                     |         |
| 2019   | 10.5% (229)    |                     |         | 10.1% (392)       |                     |         |
| 2020   | 26.3% (303)    | 3.05 (2.52 to 3.68) | <0.01   | 24.5% (505)       | 2.90 (2.51 to 3.36) | <0.01   |
| <b>Other disorders of fluid, electrolyte and acid–base balance</b> |                |                     |         |                   |                     |         |
| 2019   | 4.7% (18)      |                     |         | 5.1% (44)         |                     |         |
| 2020   | 3.8% (13)      | 0.80 (0.38 to 1.65) | 0.55    | 3.0% (26)         | 0.57 (0.34 to 0.93) | 0.03    |
| <b>Heart failure</b>   |                |                     |         |                   |                     |         |
| 2019   | 5.6% (330)     |                     |         | 5.2% (447)        |                     |         |
| 2020   | 6.9% (344)     | 1.26 (1.08 to 1.47) | <0.01   | 5.7% (496)        | 1.11 (0.97 to 1.27) | 0.11    |
| <b>Pneumonia</b>   |                |                     |         |                   |                     |         |
| 2019   | 6.7% (183)     |                     |         | 6.4% (228)        |                     |         |
| 2020   | 9.2% (186)     | 1.42 (1.15 to 1.75) | <0.01   | 6.1% (185)        | 0.96 (0.78 to 1.17) | 0.67    |
| <b>Other chronic obstructive pulmonary disease</b>                 |                |                     |         |                   |                     |         |
| 2019   | 3.1% (86)      |                     |         | 3.1% (121)        |                     |         |
| 2020   | 4.5% (81)      | 1.48 (1.09 to 2.02) | 0.01    | 3.3% (101)        | 1.06 (0.81 to 1.39) | 0.66    |
| <b>Respiratory failure, not elsewhere classified</b>               |                |                     |         |                   |                     |         |
| 2019   | 28.8% (49)     |                     |         | 29.5% (75)        |                     |         |
| 2020   | 44.2% (53)     | 1.95 (1.20 to 3.20) | <0.01   | 35.4% (97)        | 1.31 (0.91 to 1.89) | 0.15    |
| <b>Vascular disorders of intestine</b>                             |                |                     |         |                   |                     |         |
| 2019   | 20.7% (57)     |                     |         | 22.2% (93)        |                     |         |
| 2020   | 21.7% (60)     | 1.06 (0.71 to 1.60) | 0.77    | 16.2% (73)        | 0.68 (0.48 to 0.95) | 0.02    |
| <b>Other diseases of digestive system</b>                          |                |                     |         |                   |                     |         |
| 2019   | 5.1% (27)      |                     |         | 6.3% (56)         |                     |         |
| 2020   | 8.6% (38)      | 1.75 (1.06 to 2.95) | 0.03    | 6.8% (56)         | 1.09 (0.74 to 1.60) | 0.67    |

Shown are conditions with significant changes in at least one period while the remaining diseases are summarised in online supplemental table S2.

Based on 183 803 cases (93.8%). We excluded cases with discharge due to hospital transfer or unspecified reason. Proportion of excluded cases was stable ranging between 5.9% and 6.5% per year and period.

pulmonary embolism (IRR 1.14, 95% CI 1.06 to 1.23,  $p < 0.01$ ) after the first infection wave compared with the corresponding period in 2019.

Tests for the Poisson models showed that overdispersion was not present in the analyses.

In-hospital mortality was affected in several conditions (table 2), but remained unchanged in the majority (online supplemental table 2).

## DISCUSSION

This study was performed in the largest German-wide hospital network by analysing emergency admissions in general and for emergency-sensitive conditions from claims data. This comprehensive list<sup>7</sup> has been suggested for the assessment of the acute care system but modifications (eg, expansion of definitions for unspecified pneumonia, J18) may be warranted.<sup>8</sup>

We found an initial reduction in several emergency-sensitive conditions including myocardial infarction, heart failure, diabetes mellitus and pancreatitis that corresponded with the initiation of national public health emergency measures, and this decline persisted for several weeks. These findings are in agreement with previous studies.<sup>2–6</sup> The reasons for this are unclear. On the one hand, there may be a true reduction in the incidence of emergencies as a result of lower physical or psychological stress, improved medication adherence, diminished air pollution, traffic, and infectious disease transmission, or better outpatient care delivery models. In fact, the consistently lower rates of exacerbation of respiratory conditions or traumatic intracranial injuries support this hypothesis. On the other hand, it is possible that patients were reluctant to seek medical

attention due to fear of contagion at the hospital. In addition, the emphasis on social distancing might have inappropriately persuaded patients to avoid in-person medical care. While this reduction was pronounced during the first wave and affected multiple conditions, hospitalisations for the majority of those resumed to previous year levels during later pandemic phases.

Of special concern is the increased incidence of hospitalisations for acute myocardial infarction, aortic aneurysm and dissection as well as pulmonary embolism after the first infection wave compared with the corresponding period in 2019. While the former may be a result of reduced cardiovascular care during the early pandemic,<sup>5 6</sup> the latter could also be associated with preceding COVID-19 infections.<sup>9</sup> If the increased incidence of hospitalisations for acute myocardial infarction, aortic dissection and pulmonary embolism is a signal for a rising incidence of those conditions in the population, this could at least in part explain the observed excess mortality in Germany between late July and mid-October 2020.<sup>10</sup> Those signals require attention and further studies.

In the majority of conditions, in-hospital mortality remained unchanged during the study period, but in several, such as sepsis, pneumonia and heart failure, mortality increased. While the former may at least in part be attributed to preceding or undetected SARS-CoV-2 infections, the latter has been shown to associate with increased case severity.<sup>11</sup>

There are several limitations to this study. Health insurance claims data are created for administrative, financial and reimbursement purposes but not research. Nevertheless, it is frequently used for answering questions about healthcare utilisation and healthcare surveillance. Due to hospital acquisitions



and changes in infrastructures, the composition of the hospital network is constantly evolving. As a result, a limited number of hospitals or wards might exhibit null count for some period and hence slightly bias some estimators. However, our estimations are based using GLMM with the hospital as a random factor. Thanks to this approach, the impact on the estimated effects is reduced because of shrinkage to the population mean, meaning that the most extreme patterns have the least impact. While this study focused on previously defined emergency-sensitive conditions,<sup>7</sup> other diseases and emergency care pathways were not studied in detail which could offer additional insights. In addition, our study ended in November 2020, and we do not know whether subsequent surges had similar effects. Finally, the observed changes of in-hospital mortality are of interest but a detailed analysis of this observation is beyond the scope of the present study.

In summary, there was an absolute overall reduction of emergent hospitalisations and ED visits in Germany during the first 10 months of the COVID-19 pandemic with heterogeneous effects on different disease categories. The increase in hospitalisations for acute myocardial infarction, aortic aneurysm/dissection, pneumonitis, paralytic ileus/intestinal obstruction and pulmonary embolism after the first infection wave compared with the corresponding period in 2019 requires attention and further studies.

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**Contributors** The authors confirm contribution to the paper as follows: study conception and design—AB and RK; data collection—AM-H and RK; data analysis—SH and VP; draft manuscript preparation—AB. All authors reviewed the results, made critical revisions and approved the final version of the manuscript.

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