

# Hospital Admission Profile of Neonates for Conditions Originating in the Perinatal Period in England and Wales Between 1999–2020: An Ecological Study

Hassan Al-shehri<sup>1</sup>, Dania T Dahmash<sup>2</sup>, Niels Rochow<sup>3,4</sup>, Basma Alturki<sup>5</sup>, Danah Alrajhi<sup>5</sup>, Faisal Alayed<sup>5</sup>, Faisal Alhazani<sup>5</sup>, Hanan Alsuhbany<sup>5</sup>, Abdallah Y Naser<sup>6</sup>

<sup>1</sup>Department of Pediatrics, College of Medicine, Imam Mohammad Ibn Saud Islamic University, Riyadh, Saudi Arabia; <sup>2</sup>ISARIC Global Support Centre, Centre for Tropical Medicine and Global Health, University of Oxford, Oxford, UK; <sup>3</sup>Department of Pediatrics, Rostock University Medical Center, Rostock, 18057, Germany; <sup>4</sup>Department of Pediatrics, Paracelsus Medical University, Nuremberg, 90471, Germany; <sup>5</sup>College of Medicine, Imam Mohammad Ibn Saud Islamic University, Riyadh, Saudi Arabia; <sup>6</sup>Department of Applied Pharmaceutical Sciences and Clinical Pharmacy, Faculty of Pharmacy, Isra University, Amman, 11622, Jordan

Correspondence: Abdallah Y Naser, Department of Applied Pharmaceutical Sciences and Clinical Pharmacy, Faculty of Pharmacy, Isra University, Amman, Jordan, Tel +962 795285555, Email [abdallah.naser@iu.edu.jo](mailto:abdallah.naser@iu.edu.jo)

**Purpose:** To analyze trends of conditions originating in the perinatal period (COPP) in England and Wales between 1999 and 2020.

**Patients and methods:** An ecological study of COPP was conducted using hospital admission data from April 1999 to March 2020 from the Hospital Episode Statistics database in England and the Patient Episode Database for Wales.

**Results:** The overall hospital admission rates increased by 41.6%, from 1913 per 100,000 persons (95% CI: 1905–1922) in 1999 to 2709 (95% CI: 2700–2719) in 2020 (trend test  $p < 0.001$ ). The most common causes for neonatal admissions were disorders related to the length of gestation and fetal growth, respiratory and cardiovascular disorders specific to the perinatal period, and hemorrhagic and hematological disorders of newborns (28.8%, 27.3%, and 15.2%, respectively). Although the admission rates increased for both males and females (by 33.1% and 35.1%, respectively), hospital admission rates for all causes were higher among males compared to females ( $p < 0.05$ ).

**Conclusion:** COPP-related hospital admissions rate in England and Wales increased significantly over the past 21 years. Notably, the proportion of COPP-related hospital admissions of males was higher than females. Further studies are warranted to explore the role of gender in hospital admissions and health care for COPP.

**Keywords:** admissions, England, hospital, perinatal, United Kingdom, Wales

## Introduction

The perinatal period is defined as the period beginning from 154 days Of gestational age (22 weeks), the time when the weight Of the fetus is around 500 g, till the end of the first seven days after delivery.<sup>1</sup> The growing fetus, and eventually the neonate, are prone to multiple health problems during this period owing to inadequate antenatal care, perinatal complications, and post-natal hospital complications, which may result in significant morbidity and mortality. Globally, there are around 2 million stillbirths annually, and about 2.4 million neonatal deaths, of which, approximately three-fourths occur in the first 7 days of life. Hence, it is the responsibility of every country to guarantee excellent health care throughout gestation, enhance safe delivery practices, and provide competent post-partum care continuing beyond the perinatal period.<sup>2,3</sup> The United Nations formulated eight Millennium Development Goals (MDGs) to be achieved by the year 2015, of which two goals, the 4<sup>th</sup> and 5<sup>th</sup> – decreasing child mortality and promoting maternal health, were directly aimed at improving the conditions of maternal and perinatal care worldwide.<sup>4,5</sup> These two MDGs are interlinked

since perinatal and maternal consequences are fundamentally connected, and strategies addressing the management of one influence the results of the other, especially intrapartum care and hypertension.<sup>6–8</sup> Dedicating two out of eight MDGs to mother- and child-care highlights the extensive burden of maternal and neonatal morbidity and mortality associated with childbirth and post-natal care and the enormous variability across geographical boundaries in achieving these goals.<sup>5</sup> Accomplishing these goals require improved service delivery, and efforts at biological and treatment intervention levels.<sup>4,9</sup>

According to the United Nations Children's Fund (UNICEF), globally, the median neonatal mortality rate decreased from 36.6 per 1000 in 1990 to 17.5 per 1000 in 2019.<sup>3</sup> Despite the significant decline in perinatal and maternal mortality rates worldwide over the recent decades,<sup>10,11</sup> it is noteworthy that these changes are not uniform across the globe.<sup>2,12</sup> Every year more than 5 million babies are born in the European Union member states, of which about 8 per 1000 experience critical sensory or cognitive impairments, 22,000 deaths before their prime birthday, and 23,000 are stillborn.<sup>13,14</sup> The median preterm live birth rate in Europe was estimated to be around 7.3% and in England it is higher than 8.0%.<sup>15</sup> In England and Wales, the mortality rate during the neonatal period ( $\geq 24$  weeks of gestation) has reached 3.0% in 2019.<sup>15</sup>

In the regions of England and Wales, the fetal mortality rate is 3.8 per 1000 births. The main causative factors that complicate pregnancy and result in perinatal morbidity and mortality include congenital anomalies, preterm birth, and fetal growth restriction.<sup>2</sup> A previous study in the United States reported that 99% of all early neonatal deaths and almost 66% of late neonatal deaths were related to perinatal conditions and congenital anomalies.<sup>2</sup> Besides, a recent study that was conducted in England and Wales reported that hospital admission rate related to congenital anomalies increased in the past two decades by 4.9%.<sup>16</sup>

Notably, the percentage of preterm births has been stable, and rather increased, in several countries around the world; this trend is suggestive of the limited success in the prevention of preterm births and their complications as compared to the considerable improvement in perinatal mortality with medical interventions.<sup>17,18</sup> Consequently, the hospital admission rates are also bound to increase, putting a significant burden on the country's infrastructure and health policies.

To augment the decision-making process regarding health practices and policies for medical conditions in the perinatal period, health information, comprising of hospital admission data, is required to identify most leading cause related to COPP and develop relevant interventions, which can be further used to monitor, plan, and implement the necessary health-care measures.<sup>19</sup>

The Hospital Episode Statistics (HES) is a database that stores all data related to hospital admissions throughout England as part of the National Health Service (NHS). Studies based on the HES data reveal that infant hospital admissions have considerably increased in England, more so due to disorders arising in the early neonatal period.<sup>20</sup> Therefore, this ecological study aims to study the trend of hospital admissions due to COPP in England and Wales during the past 21 years, from 1999 to 2020.

## Methods

### Data Sources and Study Population

As previously described,<sup>21–25</sup> we conducted a retrospective ecological study using publicly available data from two central medical databases of England and Wales – the HES database in England and the Patient Episode Database for Wales (PEDW).<sup>26–28</sup> The HES database provides detailed information on hospital admissions associated with a wide range of health conditions in England, while the PEDW provides similar information for the residents of Wales.

Hospital admission data were extracted from the databases for the period between April 1999 and March 2020. The HES and PEDW databases contain hospital admission data for the COPP using its diagnostic code, the International Statistical Classification of Diseases (ICD) system P00-P96. The initial time point was set at 1999 since the databases provide records from 1999/2000 onwards. The information regarding hospital admissions retrieved from the databases included patient demographics, Clinical diagnoses, procedural details, and duration of hospital stay. Additionally, we collected the mid-year population data for the 21 years between 1999 and 2020 from the Office for National Statistics to calculate the annual hospital admission rate for COPP.

## Data Analysis

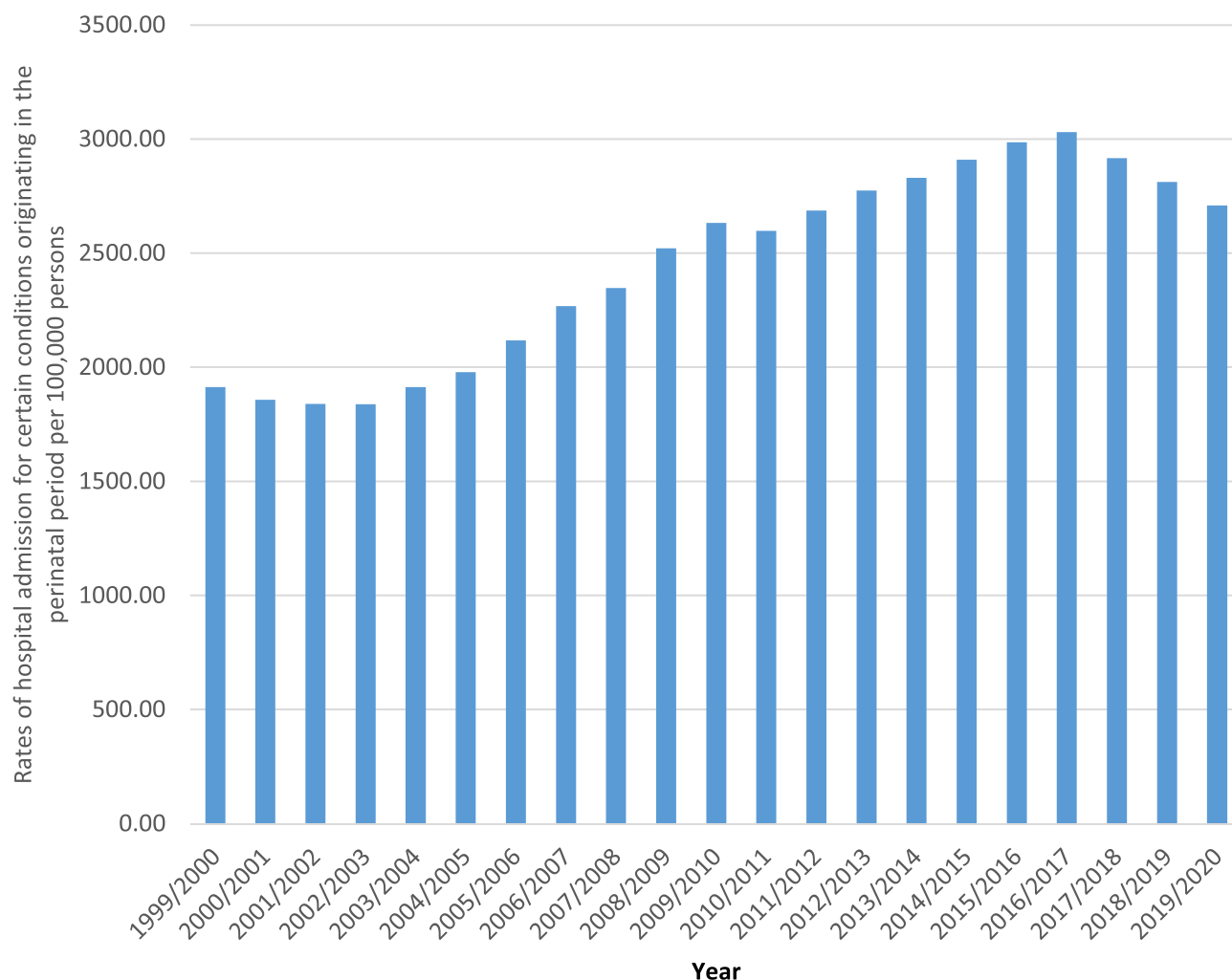
We calculated the annual admission rates for COPP with 95% confidence intervals (CIs) using the number of hospital admissions related to each COPP for the pediatric age group divided by the mid-year population for the pediatric age group of that year. The trend in hospital admissions was assessed using Poisson model. A two-sided p-value of  $<0.05$  was considered for statistical significance. All analyses were performed using SPSS version 25.0 (IBM Corp, Armonk, NY, USA).

## Results

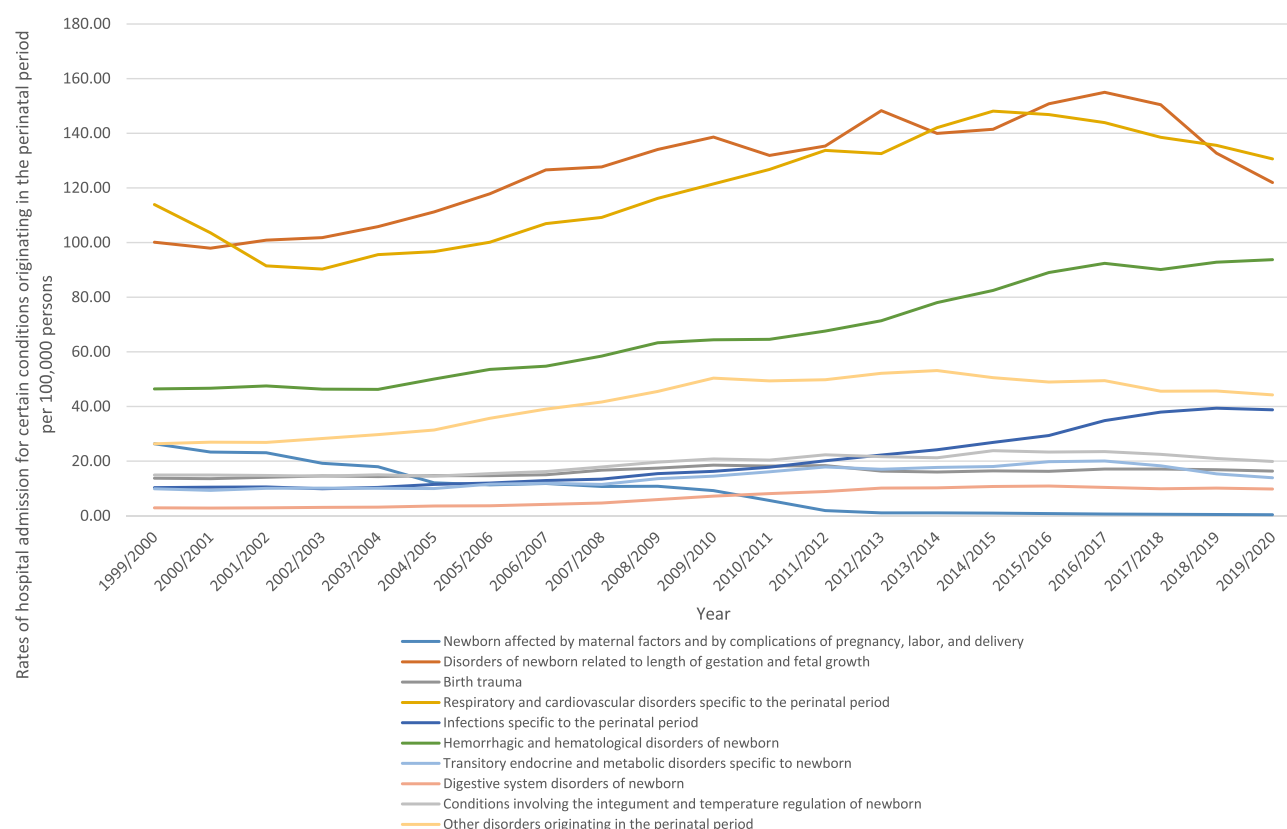
The total number of annual hospital admissions due to COPP increased by 53.5%, from 189,557 in 1999 to 291,048 in 2020, reflecting a 41.6% increase in total hospital admissions rate, from 1913.15 (95% CI: 1904.62–1921.68) in 1999 to 2709.33 (95% CI 2699.62–2719.04) in 2020 per 100,000 people (trend test:  $p < 0.001$ ) (Figure 1).

The most common causes for hospital admissions were disorders of newborns related to the length of gestation and fetal growth, respiratory and cardiovascular disorders specific to the perinatal period and hemorrhagic and hematological disorders of newborns, accounting for 28.8%, 27.3%, 15.2%, respectively, of all hospital admissions (Figure 2).

When assessing the individual causes of COPP during the past 21 years, the highest increase in hospital admissions rate was seen due to infections specific to the perinatal period, followed by digestive system disorders of the newborn, and hemorrhagic and hematological disorders of newborns, revealing a 2.9-fold, 2.6-fold, 1.1-fold increase, respectively



**Figure 1** Rates of hospital admission for COPP in England and Wales.



**Figure 2** Percentage of COPP-related hospital admission from the total number of admissions.

(Table 1). The hospital admissions rate for other disorders originating in the perinatal period, namely transitory endocrine and metabolic disorders specific to newborn, conditions involving the integument and temperature regulation of newborn, birth trauma, disorders of newborn related to the length of gestation and fetal growth, and respiratory and cardiovascular disorders specific to the perinatal period, were increased by 77.0%, 48.4%, 40.8%, 31.6%, 28.4%, and 20.8%, respectively. However, hospital admissions rate associated with maternal factors and conditions like complications of pregnancy, labor, and delivery, affecting the newborn decreased by 98.4% during this period (Table 1 and Figure 3).

A total of 5,184,939 for COPP-related hospital admission episodes were reported in England and Wales during the study period, of which, males accounted for 2,851,591 hospital admission episodes, comprising approximately 55.0% of the total number of hospital admission, with an average of 135,790 admissions per year. The hospital admission rates among females increased by 35.1%, ie, from 324.39 per 100,000 persons (95% CI: 322.24–326.55) in 1999 to 438.15 (95% CI: 435.79–440.51) in 2020. Likewise, hospital admission rates for males also increased by 33.1%, ie, from 407.22 per 100,000 persons (95% CI: 404.75–409.70) in 1999 to 542.07 (95% CI: 539.42–544.71) in 2020 (Figure 4).

## Gender-Based Comparison of Admission Rates

Hospital admission rates for all causes were higher among males compared to females (Figure 5).

## Discussion

This study aimed to elucidate the pattern of hospital admissions due to COPP in England and Wales during the past 21 years. The key findings of the study were: 1) there was an obvious increase in hospital admissions rate (41.6%) related to COPP; 2) disorders of newborns related to the length of gestation and fetal growth, respiratory and cardiovascular disorders specific to the perinatal period, and hemorrhagic and hematological disorders of the newborn were the most common causes for hospital admissions for COPP; 3) the highest increase in hospital admissions rate was seen in infections specific to the perinatal period, digestive system disorders of newborn, and hemorrhagic and hematological

**Table I** Percentage Change in the Hospital Admission Rates from 1999 to 2020 in England and Wales

Conditions	Rate of Conditions in 1999 per 100,000 Persons (95% CI)	Rate of Conditions in 2020 per 100,000 Persons (95% CI)	Percentage Change from 1999 to 2020
<b>Infections specific to the perinatal period</b> (congenital viral diseases, bacterial sepsis of newborn, other congenital infectious and parasitic diseases, and omphalitis of newborn).	53.92 (52.47–55.36)	212.17 (209.42–214.92)	293.5%
<b>Digestive system disorders of newborn</b> (other intestinal obstruction of newborn, necrotizing enterocolitis of newborn, and other perinatal digestive system disorders such as perinatal intestinal perforation, other neonatal peritonitis, neonatal hematemesis and melena due to swallowed maternal blood, noninfective neonatal diarrhea, congenital cirrhosis (of liver), peptic ulcer of newborn, newborn esophageal reflux, gestational alloimmune liver disease).	15.20 (14.43–15.97)	54.19 (52.80–55.58)	256.5%
<b>Hemorrhagic and hematological disorders of newborn</b> (newborn affected by intrauterine (fetal) blood loss, umbilical hemorrhage of newborn, intracranial nontraumatic hemorrhage of newborn, hemorrhagic disease of newborn, other neonatal hemorrhages, hemolytic disease of newborn, hydrops fetalis due to hemolytic disease, kernicterus, neonatal jaundice due to other excessive hemolysis, neonatal jaundice from other and unspecified causes, disseminated intravascular coagulation of newborn, and other perinatal hematological disorders).	244.00 (240.93–247.07)	519.82 (515.52–524.12)	113.0%
<b>Other disorders originating in the perinatal period</b> (convulsions of newborn, other disturbances of the cerebral status of newborn, feeding problems of newborn, reactions and intoxications due to drugs administered to newborn, disorders of muscle tone of newborn, and stillbirth).	138.50 (136.19–140.82)	245.20 (242.25–248.16)	77.0%
<b>Transitory endocrine and metabolic disorders specific to newborn</b> (transitory disorders of carbohydrate metabolism specific to newborn, transitory neonatal disorders of calcium and magnesium metabolism, other transitory neonatal endocrine disorders, and other transitory neonatal electrolyte and metabolic disturbances).	51.95 (50.53–53.37)	77.08 (75.42–78.74)	48.4%
<b>Conditions involving the integument and temperature regulation of newborn</b> (hypothermia of newborn, other disturbances of temperature regulation of newborn, and other conditions of integument specific to newborn).	78.07 (76.33–79.81)	109.92 (107.94–111.90)	40.8%
<b>Birth trauma</b> (intracranial laceration and hemorrhage due to birth injury, other birth injuries to central nervous system, birth injury to scalp, birth injury to skeleton, birth injury to peripheral nervous system, and other birth injuries).	68.82 (67.19–70.46)	90.58 (88.79–92.38)	31.6%
<b>Disorders of newborn related to length of gestation and fetal growth</b> (slow fetal growth and fetal malnutrition, short gestation and low birth weight, and long gestation and high birth weight).	525.74 (521.24–530.24)	675.01 (670.12–679.91)	28.4%

(Continued)

Table 1 (Continued).

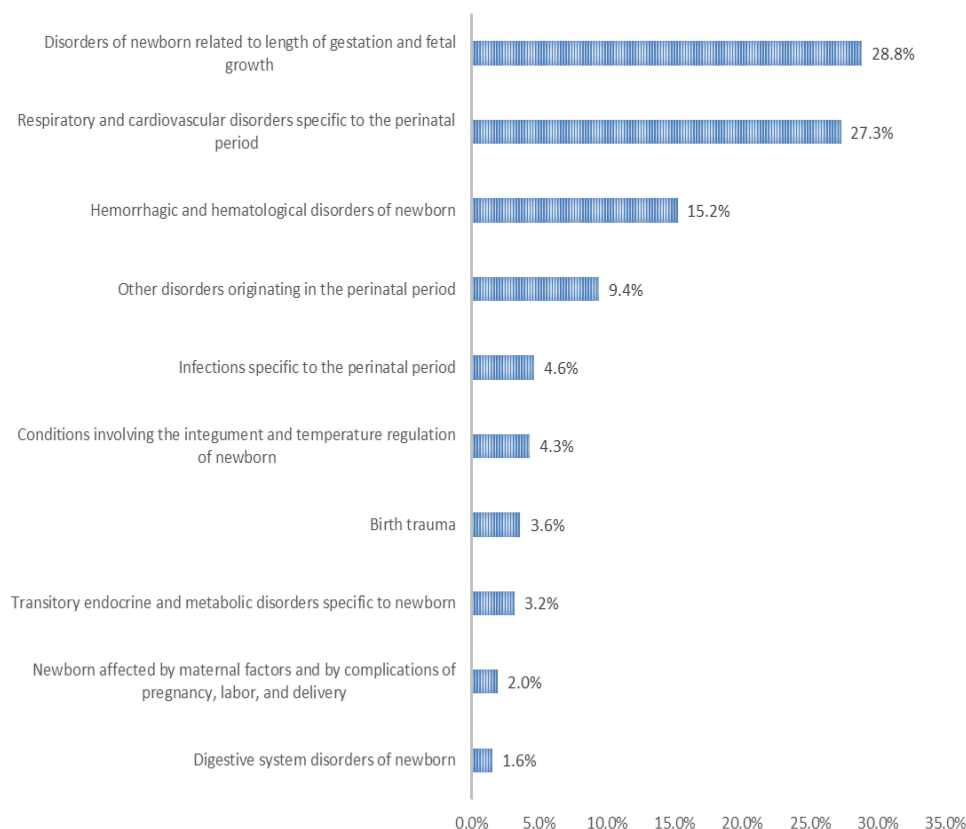
Conditions	Rate of Conditions in 1999 per 100,000 Persons (95% CI)	Rate of Conditions in 2020 per 100,000 Persons (95% CI)	Percentage Change from 1999 to 2020
<b>Respiratory and cardiovascular disorders specific to the perinatal period</b> (metabolic acidemia in newborn, respiratory distress of newborn, congenital pneumonia, neonatal aspiration, interstitial emphysema and related conditions originating in the perinatal period, pulmonary hemorrhage originating in the perinatal period, chronic respiratory disease originating in the perinatal period, other respiratory conditions originating in the perinatal period, and cardiovascular disorders originating in the perinatal period).	598.53 (593.73–603.33)	723.19 (718.12–728.25)	20.8%
<b>Newborn affected by maternal factors and by complications of pregnancy, labor, and delivery</b> (includes complications of placenta, cord and membranes and complications related to noxious substances transmitted via placenta or breast milk).	138.42 (136.11–140.74)	2.17 (1.89–2.45)	–98.4%

disorders of newborn; and 4) males contributed to more than half (55.0%) of the number of hospital admissions and admission rates for all causes were higher among males compared to females.

Despite the decrease in the annual birth rate in England and Wales in the past two decades by 14.2% from 12 per 1000 persons in 1999 to 10.3 per 1000 persons in 2020,<sup>29</sup> hospital admission rate related to COPP in our study showed an increase of 41.6% during the same period. The findings of our study are in agreement with the existing literature which has explored the impact of the changed postnatal care policies and austerity measures undertaken by the government on child care. Neonatal jaundice, a sub-category of infant hemorrhagic and hematological diseases, is one of the most prevalent causes of hospital hospitalizations. Jones et al reported that the overall hospital admissions in England increased by 6% in the year 2008, of which 39% was attributed to potentially preventable conditions related to neonatal jaundice and digestive tract conditions (mainly gastroenteritis).<sup>20</sup> They also reported that a significant proportion of this increase was seen in the first six days of life. A set of practices are recommended to minimize the risk of developing neonatal jaundice including optimal breastfeeding should be encouraged (eight to 12 feedings per day), all infants should be screened for jaundice and its risk factors, bilirubin levels should be interpreted according to the infant's age in hours, measuring bilirubin levels in all infants with jaundice in the first 24 hours after delivery, and transcutaneous bilirubin measurement is as accurate as total serum bilirubin measurement.<sup>30</sup> Newborns are susceptible to enteric infections in early life, this is mainly related to reduced local and systemic immune response, reduced gastric acidity, and absence of an adequate intestinal flora.<sup>31</sup> Other external factors include type of delivery, nutrition, hygiene habits, the supplementation with probiotics and/or prebiotic oligosaccharides in the newborn and use of antibiotics in the mother and infant.<sup>32–34</sup> Concerning gastroenteritis, multiple prevention measures could be adapted, these include recommending full and exclusive breastfeeding, which protects against intestinal infections and prevents exposure to environmental contamination, proper hand-washing hygiene, and safe disposal of human and other waste.

Another study by Rajmil et al reported on the effects of austerity measures undertaken by the European governments to tackle the economic crisis from 2005 to 2015.<sup>35</sup> They stated that higher austerity measures (example reducing expenditure and cutting funds on organisations/ministries, freezing wages, increasing taxes, developing new taxes schemes, reducing child benefits, and raising the retirement age)<sup>36</sup> led to worsening of social and health conditions of the country, with poorer low birth weight, increased infant mortality, and material deprivation of the children.<sup>35</sup>





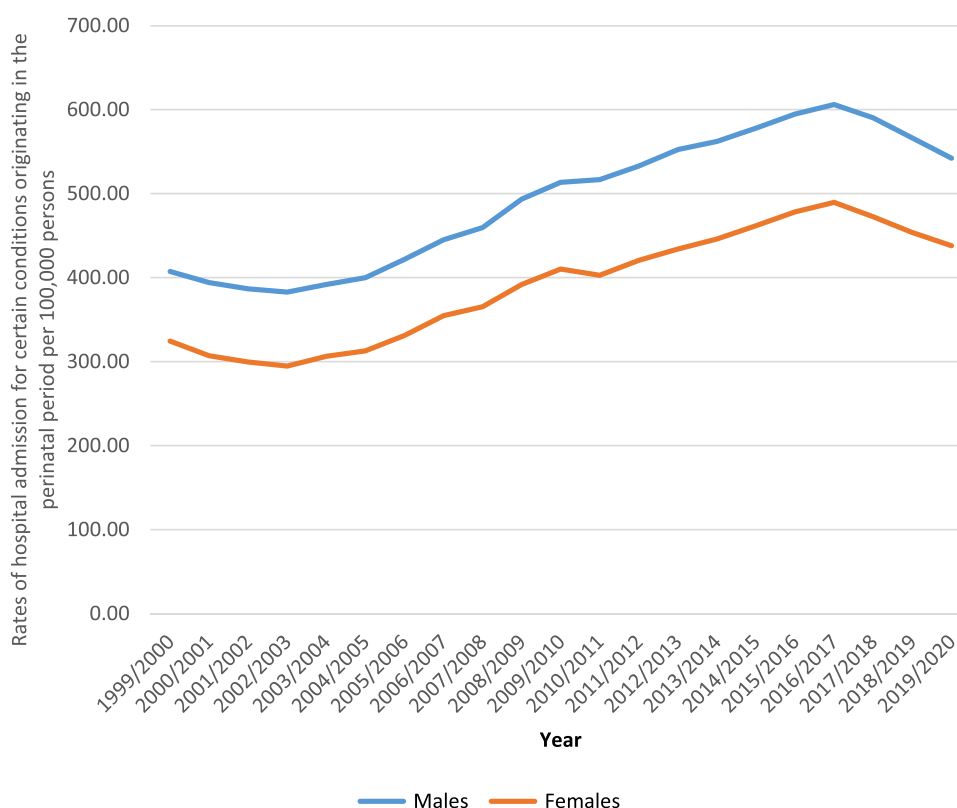
**Figure 3** Rates of hospital admission for COPP in England and Wales stratified by type between 1999 and 2020.

Notably, the EURO-PERISTAT report also discussed the effect of preterm deaths on the overall fetal and neonatal mortality rates.<sup>37</sup> These factors are of more importance in areas where medical termination of pregnancies is prohibited. They also highlighted the importance of knowing the gestational age and birth weight at the time of delivery for the obstetrician and the attending pediatrician to make decisions during the pregnancy and after delivery.

An important finding of our study was that the hospital admissions rate for newborns due to maternal factors and complications of pregnancy, labor, and delivery decreased by 98.4%. These numbers indicate the positive effects of health policies as well as improvement at the medical intervention level and hospital care of pregnant mothers, which was one of the goals of the WHO's MDG program. However, reducing the number of stillbirths and neonatal deaths remains an unachieved goal. Preconception, peri-conception, and neonatal screening, as well as basic reproductive health practices, are important reproductive healthcare services that help in the early diagnosis of abnormalities in newborns.<sup>38</sup> In recent years, early detection and screening programs, including ultrasonography, have improved. Better diagnostic procedures (such as MRI, genetic testing, fetal blood sample, direct biopsy of fetal tissue, and Non-invasive prenatal diagnosis (NIPD)) help in the early detection of neonatal abnormalities during the perinatal period (earlier than 20 weeks of pregnancy and during the first trimester),<sup>39–41</sup> allowing for early informed decision-making and reducing the risk of having newborns with unintended abnormalities.

It was also observed that the overall hospital admissions due to COPP including infections, disorders of the digestive system, and hematological disorders increased significantly over the 21 years. The increased hospital admissions in England and Wales are indicative of the increased level of awareness among caregivers and family members of the neonate to seek urgent medical help in case of any health problem. As described by Jones et al, a greater proportion of parents in England were advised to take their infant to a hospital.<sup>20</sup>

An important observation in our study was the role of gender in the hospital admissions rate in England and Wales. The majority of hospital admissions for COPP were males, and the proportion of male children admitted to hospitals for



**Figure 4** Rates of hospital admission for COPP in England and Wales stratified by gender.

each cause included in COPP were higher than females. This finding is peculiar as it may be indicative of the social impact of poor health care, and further studies are required to explore the effect of gender on health care meted out.

Additionally, the recent COVID-19 pandemic has seriously affected health care across the globe, and the results of a strained healthcare system are bound to be seen in maternal and neonatal health. Therefore, the UNICEF proposed the Every Newborn Action Plan (ENAP) to provide guidelines to all countries for preventing neonatal deaths and stillbirths and decrease morbidity by the year 2030.<sup>42</sup> The ENAP program suggests enhanced antenatal care, early and skilled neonatal care by health professionals, and special attention to small and sick newborns.

Based on our findings, we recommend implementing early identification practices that reduce the probability of complications originating in the perinatal period. Besides, educational intervention should be implemented to increase parental knowledge and awareness related to achieving optimal maternal and fetal health. These educational campaign should be started even before planning for conception. Preventive measures and practices and educational campaign should target all expected complications originating in the perinatal period and specifically should focus on disorders of newborns related to the length of gestation and fetal growth, respiratory and cardiovascular disorders specific to the perinatal period and hemorrhagic and hematological disorders of newborns. Their associated risk factors should be identified and appropriate interventions should be implemented.

Our study has several strengths. It is the first study to evaluate the rate of hospital admission for conditions originating in the perinatal period in the United Kingdom. At the same time, there were also some limitations. First, due to the nature of the data that is publicly available from these two databases, we were not able to adjust for important confounders that might influence the admission rates. The identified temporal variability could be related to potentially non-medical causes, such as updated coding guidelines. Admission data includes admission and readmission at the same time. Another important contributing confounding factor is that the duration period of the study involved COVID-19 pandemic. Because of the lockdown restrictions, hospital admissions may be affected. Therefore, our admission rates could have been overestimated.



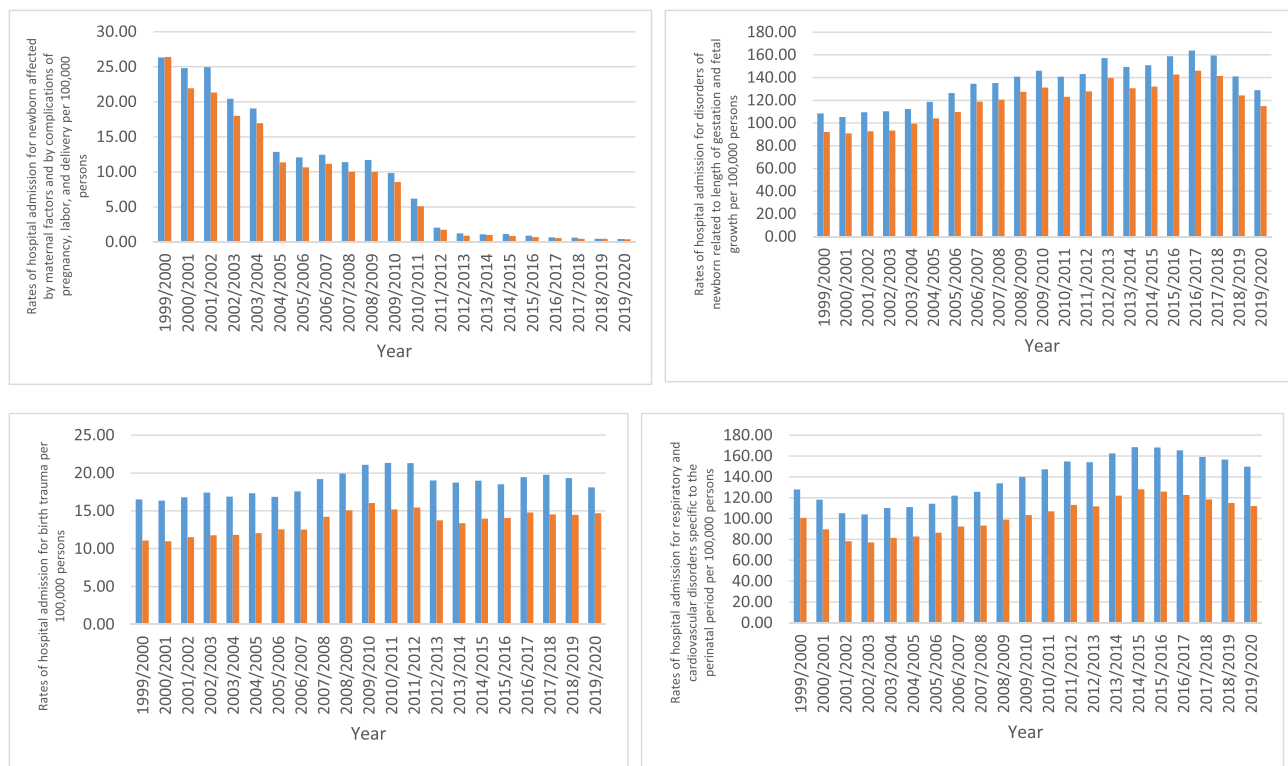


Figure 5 Continue.

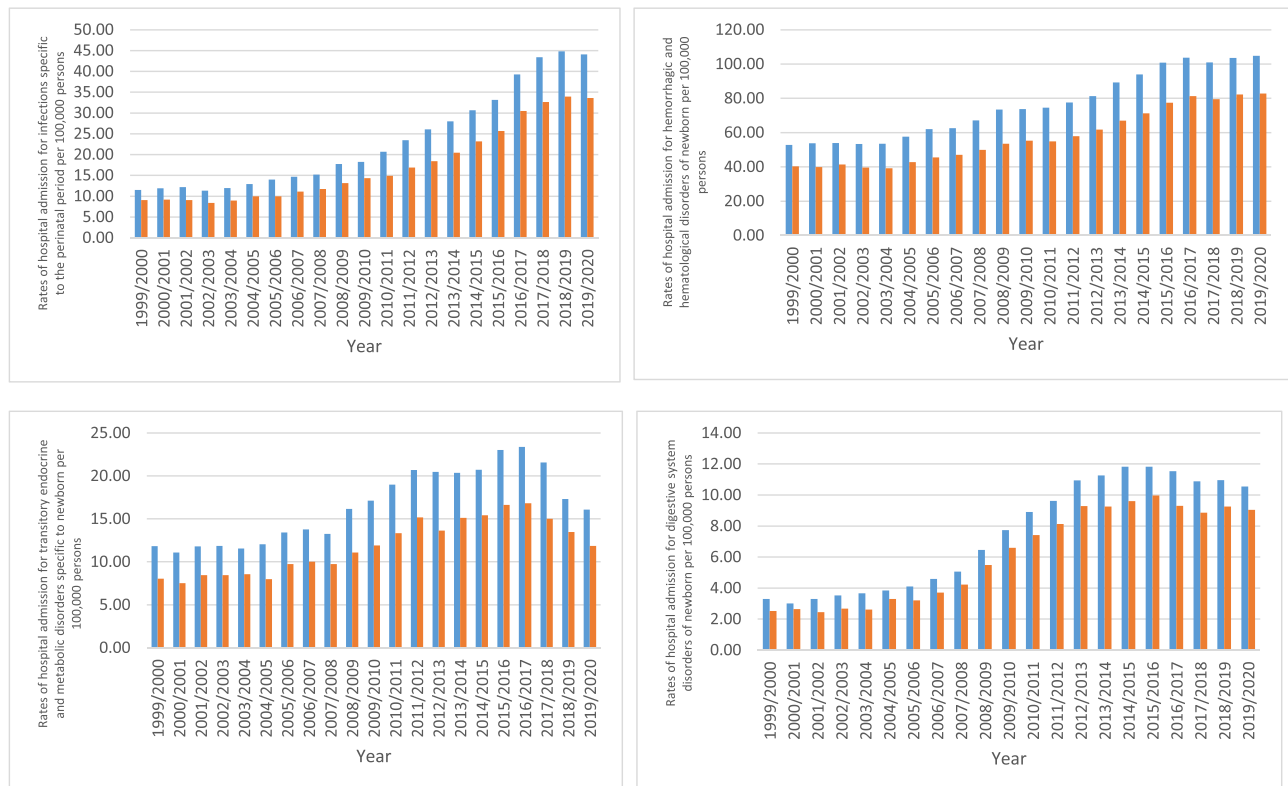
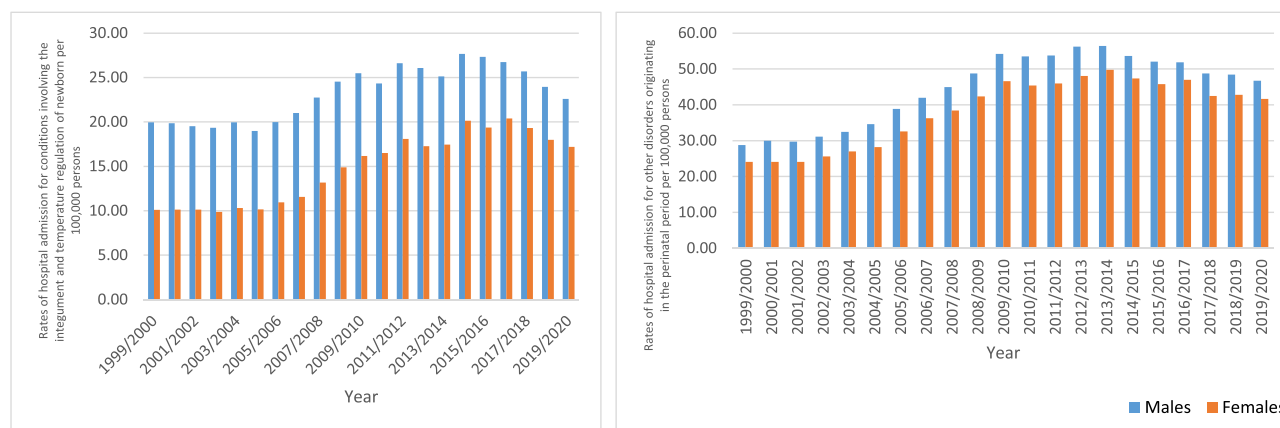


Figure 5 Continue.



**Figure 5** Hospital admission rates for COPD in England and Wales stratified by gender.

## Conclusion

Our study is an important contribution in understanding the overall trends of hospital admissions and, in turn, the status of COPD health care in England and Wales. We observed that the overall hospital admission rates due to all causes increased from 1999 to 2021, with the majority of cases being related to fetal growth and length of gestation and respiratory and perinatal cardiovascular problems. An interesting finding was the predominance of the male gender for all causes of perinatal hospital admissions. Future studies should focus on identifying the impact of gender and different socio-economic strata to understand the reach of national-level healthcare programs and policies.

## Data Sharing Statement

Publicly available datasets were analyzed in this study. This data can be found here: <http://http://content.digital.nhs.uk/hes>; <http://www.infoandstats.wales.nhs.uk/page.cfm?pid=41010&orgid=869>.

## Ethical Approval and Consent to Participate

This study used de-identified data and was considered exempt from human protection oversight by the institutional review board.

## Disclosure

The authors declare no conflicts of interest for this work.

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