Appendix A: Methodology

Methodology of audit creation and setup

NRAP is a suite of continuous clinical audits, the oldest of which commenced in February 2017. There are four continuous secondary care audits covering the following workstreams – COPD, adult asthma, children and young people's asthma, and pulmonary rehabilitation. For further details of individual report methodology, please refer to the data analysis and methodology components of the following clinical audit reports:

> *Drawing breath* – 2021/22 (published 2023)
> *Breathing well* – 2022/23 (published 2024)
> *Catching our breath: Time for change in respiratory care* – 2023/24 (published 2025)

Please use this link to access our current reports for each workstream.

Information governance (IG) and data storage, security and transfer

The adult asthma, children and young people asthma, and COPD secondary care clinical audits operate under Section 251 approval from the Confidentiality Advisory Group (CAG) of the Health Research Authority (HRA). The reference numbers are:

> Adult asthma and COPD (joint approval held): CAG-8-06(b)/2013 (for data collected and reported within this report), and the current 23/CAG/0045 approval (for data collected from the 01 June 2023)
> Children and young people asthma: 19/CAG/0001

A record of each approval can be found at: www.hra.nhs.uk/about-the-hra/our-committees/section-251/cag-advice-and-approval-decisions (April 2013 onwards, non-research).

For more information on the audit's information governance, please visit the NRAP information governance webpage. To view the adult asthma, children and young people asthma, COPD fair processing documents, information governance frequently asked questions (FAQs) and data flow diagrams, please click on the workstream name.

Data entry

Hospitals are required to enter data via the audit programme's bespoke web-tool, created by Crown Informatics Ltd (available at www.nrap.org.uk). Guidance documentation to support participation in the audit are available to download from both the web tool (www.nrap.org.uk) and the NRAP webpages on the RCP website (https://www.rcp.ac.uk/improving-care/national-clinical-audits/the-national-respiratory-audit-programme-nrap/).

Analysis methodology

Data transfer

The audit applied for linkage of audit data to outcome data sources via NHS England data access request service. See below for application references:
Adult asthma: DARS-NIC-357479-S6C7T (England HES APC and ONS)
Children and young people asthma: DARS-NIC-379653-W3G5Q (England HES APC and ONS)
COPD: DARS-NIC-349273-T3L4K (England HES APC and ONS)
Adult asthma: DARS-NIC-727343-L3N2H (Wales ONS) and Request 870 (Wales DHCW PEDW)
Children and young people asthma: DARS-NIC-727954-G5X8B (Wales ONS) and Request 798 (Wales DHCW PEDW)
COPD: DARS-NIC-727537-C3V4G (Wales ONS) and Request 849 (Wales DHCW PEDW)

The files contained a unique audit ID and necessary identifiable information (NHS number, date of birth and postcode) for patients within the following audit cohorts:

> Adult asthma: those discharged between 1 April 2021 – 31 March 2023
> Children and young people asthma: those discharged between 1 April 2021 – 31 March 2023
> COPD: those discharged between 1 April 2021 – 31 March 2023

This data was sent by Crown Informatics to the Data Access Request Service (DARS) and DHCW. NHS England DARS team and DHCW used these identifiers to provide records for people in the audit cohort from the Hospital Episode Statistics (HES) Admitted Patient Care (APC) dataset (NHS England) and the Patient Episode Database for Wales (PEDW) dataset (DHCW). NHS England DARS team also provided Office for National Statistics (ONS) mortality data for all people within the cohort in England and Wales. Please note, NHS England DARS team upheld national data opt-outs before providing the data.

NHS England DARS team and DHCW produced linked datasets containing respectively requested records from HES and ONS, plus the unique audit ID and requested PEDW records, plus the unique audit ID. The linked data was then anonymised with the removal of NHS number, transfer of date of birth to age, and postcode to Lower Super Output Area (LSOA). Anonymised files containing non-identifiable patient data were sent via secure file transfer to the statistical team at Imperial College London, where they were analysed.

Data cleaning

Data received by Imperial College London were imported into R for cleaning. The bulk of the cleaning of the clinical audit data is described in the secondary care clinical report methodology section. The clinical datasets contained 187,620 admissions, of which 144,184 were index admissions. These were linked to PEDW, HES and ONS datasets according to patient ID, admission date (+- 1 day) and discharge date (+- 1 day) to leave 135,572 linked index admissions for analysis (89,945 COPD, 26,150 adult asthma, 19,477 CYP asthma). Full cleaning and analysis scripts can be found at https://github.com/NationalAsthmaCOPDAudit.

Data analysis

> Comorbidities were defined using the Charlson comorbidity index (CCI)[1] with updated weights[2] using primary and all secondary diagnosis codes from the index admission. The 'comorbidity' package in R was used to calculate the CCI for the diagnosis codes of each index admission. When categorising CCI, the lowest category was taken as '0–1' rather than '0' as all patients are expected to have a diagnosis of pulmonary disease.
> Mixed effects logistic regression models were created using the R package 'lme4' to find odds of 30-day and 90-day readmission or death by gender, deprivation (quintiles of joint English and Welsh IMD), age (categorical: 35–44, 45–54, 55–64, 65–74, 75–84, 85+, or as a continuous variable with polynomial), CCI (0-1, 2, 3, 4, 5, 6, 7+, or as a linear effect), length of hospital stay (+10 days), receipt

of NIV (yes, no), asthma severity, and IV asthma medication used. The variables used in each model differ according to disease and outcome, the relevance of variables and limitations in the numbers of outcome events. CYP asthma had too few deaths for regression model to be built. Models were mutually adjusted for all exposure variables.

Adjusted odds ratios (see tables 1.2 and 2.2 of the summary report)

> Odds tend to be used for statistical analysis due to their helpful properties, despite proportions being conceptually easier to understand. If an event occurs in 'x' out of 'n' individuals, the proportion (or 'risk') is equal to 'x/n', while the odds are equal to 'x/(n-x)'. Odds can have a value of any positive number, whereas proportions must lie between 0–1.

> An odds ratio (OR) is a measure of association between an exposure and an outcome, calculated by dividing one set of odds by the other. The OR represents the odds that an outcome will occur given a particular exposure, compared with the odds of the outcome occurring in the absence of that exposure. For example, an odds ratio of 0.75 means that in that particular group the outcome is 25% less likely to occur. An odds ratio of 1.33 means that in that particular group the outcome is 33% more likely to occur.

> Odds ratios are always more extreme than the equivalent risk ratio (ie odds ratios are always further from 1 than the equivalent risk ratio). At low numbers of events compared to non-events, odds ratios approximate risk ratios. At higher numbers of events, such as for COPD readmissions, odds ratios will be more extreme than risk ratios.

> An adjusted odds ratio takes into account the effect due to other variables included in the analysis; ie it helps to account for confounding.

> Regression models were performed in a 'mixed effects' model framework that includes a random intercept for hospital. This means that the hierarchical nature of the data, with patients clustered within hospitals, is accounted for in the analysis.

Outlier methodology

Non-participation in the audit:

> Identification and reporting of providers who did not participate in one or more of the NRAP clinical audits over the *Catching our breath* annual cohort period:

  – 1 April 2023 – 31 March 2024 for adult asthma, COPD, children and young people asthma, and pulmonary rehabilitation

> Non-participation for NRAP means:

  – a provider not registering for an audit they are eligible for
  – a registered provider has failed to enter a single patient record into the respective audit where it had eligible cases in any annual cohort (cohort definitions are outlined below).
  – eligible providers will be determined as all those who are shown as having 60 or more eligible cases during the cohort period within Hospital Episode Statistics (HES) or Patient Episode Database for Wales (PEDW).
  – audit participation and case ascertainment for the cohort period, as indicated above, can be accessed by clicking on the following workstream datafile link via the *Catching our breath: Time for change in respiratory care report*: adult asthma, COPD, CYP asthma, and PR.

References

[1] Charlson M, Pompei P, Ales, K and MacKenzie C. A new method of classifying prognostic comorbidity in longitudinal studies: Development and validation. *J Chronic Dis* 1987;40:373–383.

[2] Quan H, Li B, Couris C *et al*. updating and validating the charlson comorbidity index and score for risk adjustment in hospital discharge abstracts using data from 6 countries. *Am J Epidemiol* 2011;173:676–682.