Risk of winter hospitalisation and death from acute respiratory infections in Scotland: national retrospective cohort study

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Abstract

Objectives

We undertook a national analysis to characterise and identify risk factors for acute respiratory infections (ARIs) resulting in hospitalisation during the winter period in Scotland.

Design

A population-based retrospective cohort analysis

Setting

Scotland

Participants

5.4 million residents in Scotland

Main outcome measures

Cox proportional hazard models were used to estimate adjusted hazard ratios (aHR) and 95% confidence intervals (CIs) for the association between risk factors and ARI hospitalisation.

Results

Between September 1, 2022 and January 31, 2023, there were 22,284 (10.9% of 203,549 with any emergency hospitalisation) ARI hospitalisations (1,759 in children and 20,525 in adults) in Scotland. Compared to the reference group of children aged 6-17 years, the risk of ARI hospitalisation was higher in children aged 3-5 years (aHR=4.55 95%CI (4.11-5.04)). Compared to 25-29 years old, the risk of ARI hospitalisation was highest amongst the oldest adults aged ≥80 years (7.86 (7.06-8.76)). Adults from more deprived areas (most deprived vs least deprived, 1.64 (1.57-1.72)), with existing health conditions (≥5 vs 0 health conditions, 4.84 (4.53-5.18)) or with history of all-cause emergency admissions (≥6 vs 0 previous emergency admissions 7.53 (5.48-10.35)) were at higher risk of ARI hospitalisations. The risk increased by the number of existing health conditions and previous emergency admission. Similar associations were seen in children.

Conclusions

Younger children, older adults, those from more deprived backgrounds and individuals with greater numbers of pre-existing conditions and previous emergency admission were at increased risk for winter hospitalisations for ARI.

Introduction

Acute respiratory infections (ARI) constitute a substantial disease burden, particularly in young children and older adults.[1, 2] The Global Burden of Disease (GBD) Study 2019 estimated that, in 2019, lower respiratory tract infections (LRIs) caused 628,338 deaths (95% uncertainty interval [UI] 513,848-775,433) in children younger than 5 years, 613,468 deaths (526,059-698,564) in adults older than 70 years, and over 1.6 million deaths in people of all ages, worldwide.[3]

Many health systems internationally, including the National Health Services (NHS) in the UK, face considerable pressures each year over the winter period, particularly being driven by the seasonal increases in ARI. These increases in ARI typically begin with the start of the new school year and extend throughout the winter period. In addition to the usual surge in demand for care associated with ARI, the NHS was under unprecedented pressure last winter (2022-23) as a result of the ongoing COVID-19 pandemic, NHS staff absences and vacancies, and the cost-of-living crisis.[4] Last year, there were in addition major concerns about increases in the incidence and severity of respiratory syncytial virus (RSV) as seen in parts of the United States and Europe.[5] In summary, the ongoing health system pressures are substantial during winter and therefore there is policy interest in trying to understand who might be most likely to be admitted to hospital. This would help to inform targeted preventive actions (such as vaccination, optimising care for individuals with pre-existing conditions).

During the pandemic, we created the Early Pandemic Evaluation and Enhanced Surveillance of COVID-19 (EAVE II) national COVID-19 surveillance platform, which has been used to identify and predict children and adults at increased risk of serious COVID-19 outcomes leading to hospitalisation and death. Following an urgent commission from the Department of Health and Social Care, we repurposed the EAVE II platform to characterise and identify risk factors predicting those at risk of hospitalisation associated with ARI during the winter period across Scotland.

Methods

Study design

EAVE II is a Scotland-wide COVID-19 surveillance platform that has been used to track and forecast the epidemiology of COVID-19, inform risk stratification assessment, and investigate vaccine effectiveness and safety.[6-10] It comprises national health-care datasets on 5·4 million people (~99% of the Scottish population) deterministically linked through the Community Health Index (CHI) number, which is a unique identifier for each population member and used in all healthcare contacts across NHS Scotland.

We used the EAVE II platform to describe the demographic profile of people of different age groups who had hospital admissions associated with ARI (henceforth 'ARI hospitalisation'). We also undertook a national population-based observational cohort analysis to investigate risk factors of ARI as well as the risk factors for common respiratory pathogens associated ARI (influenza, RSV and SARS-CoV-2), stratified by age groups. The cohort baseline was March 1, 2020 (when the COVID-19 pandemic started in Scotland) thus our cohort included individuals who were at least three years old. This analysis was based on all 5,021,056 people in the EAVE II linked dataset on September 1, 2022. The study period was September 1, 2022 to January 31, 2023.

Data sources

The national datasets linked using CHI numbers were primary care (demographics and clinical history), the Scottish Morbidity Record (which records hospitalisation data), the Scottish Intensive Care Society Audit Group (which records intensive care unit (ICU) admissions), and National Records of Scotland (which records mortality data). A data linkage diagram is available at Figure S1. All individuals were

128 followed from September 1, 2022 until the date of ARI hospitalisation, date of death or end of follow-
129 up (January 31, 2023), whichever came first.
130

Outcomes

Our primary outcome was ARI hospitalisation. We defined ARI hospitalisation as the first hospital emergency admission during the study period with an International Classification of Diseases, Tenth Revision (ICD-10) code for respiratory infections in any position of the first episode (admitted due to or with respiratory infections). We also looked at common respiratory pathogens (I.e. influenza, RSV and SARS-CoV-2) related ARI hospitalisation, defined by ICD-10 code. The full list of ICD-10 codes for ARI is available in Table S1.

Our secondary outcomes were ARI related length of hospital stay, ICU admission and death. ICU admission was defined as admission to ICU after ARI hospitalisation. Death was defined as any cause of death within 28 days of ARI hospitalisation. Follow-up time for individuals who were hospitalised within 28 days prior to the cohort end date was extended to allow 28 days of follow-up after hospitalisation. For the primary outcome (ARI hospitalisation), we also applied a strict definition in a sensitivity analysis, which was a hospital emergency admission with an ICD-10 code for respiratory infections in the first position of the first episode.

Covariates

We included age, sex, ethnicity, urban/rural areas, Scottish Index of Multiple Deprivation (SIMD), number of previous all-cause emergency hospitalisation (for any reason) in the six months prior to September 1, 2022, number of risk groups (co-morbidities), Health Board, body mass index (BMI), vaccination for COVID-19 (at any time; number of doses) and influenza vaccination (during study period) as the covariates. Socioeconomic status was determined using the SIMD.[11] The SIMD is a measure of deprivation in areas typically comprising 700-800 people, that captures multiple dimensions of socioeconomic disadvantage. We used quintiles of SIMD, where quintile 1 refers to the most deprived and quintile 5 refers to the least deprived. SIMD was assigned according to residential postcode. Risk groups (co-morbidities) were defined by those used in the QCOVID risk prediction algorithm, which consists of 30 clinical characteristics identified from primary care records that are known to be associated with increased risk of serious COVID-19 outcomes in adults (Box 1).[12] For the analysis of children, we excluded risk groups that were not relevant to the paediatric population (i.e. care home/homeless (no children in the cohort were classified as homeless over the study period), chronic obstructive pulmonary disease, coronary heart disease, dementia, Parkinson's disease) and BMI (due to different measurement for children with substantial percentage of missing data, 95%).

Statistical analysis

We developed the statistical analysis plan for this work in advance which is available at https://www.ed.ac.uk/usher/eave-ii/connected-projects/winter-respiratory-pressures-in-scotland/project-outputs/statistical-analysis-plan.

A Cox proportional hazard was used to model the time to ARI hospitalisation and to derive the adjusted hazard ratios (aHR) and 95% confidence intervals (CIs) for the association between risk factors and ARI hospitalisation. This model eliminated the need to model the underlying temporal trends, which was incorporated into the baseline hazard. To improve the efficiency of the analysis, the cox model was fitted to a subset of the data – all the cases who had experienced an emergency ARI hospitalisation and, for each case, 10 randomly selected controls who did not have an emergency ARI hospitalisation during the study period. Sample weights were then used to weight the analysis sample back to the full population. The 10:1 ratio was predetermined and the sampling of the original cohort was a simple random sample without replacement.

178
179 Age, sex, socioeconomic status, number of risk groups (defined above), and number of previous
180 emergency hospitalisations within six months prior to September 1, 2022 were included as
181 adjustments. Ethnicity (due to 14.6% missing data in cases, and 29.0% in controls), Health Board,
182 COVID-19 and influenza vaccination were not included in the modelling in our main analysis. A small
183 number of individuals had missing data for urban/rural areas (0.6%) and SIMD (0.6%), and they were
184 excluded from the analysis. Some individuals were also missing BMI data (7.8%), which we imputed
185 using multiple imputations. Similarly, Cox proportional hazard models were fitted to estimate the
186 association between risk factors and specific common respiratory pathogens (RSV, influenza and SARS-
187 CoV-2) related hospital admission. ARI hospitalisations which were not RSV, influenza and SARS-CoV-
188 2 related were censored at the first admission for the pathogen specific models. All controls were
189 censored at the end of the study.
190
191 A multivariable logistic regression model was conducted to estimate the association between risk
192 factors and ARI related prolonged hospital stay (a hospital stay longer than five days – the median
193 length of stay for ARI hospitalisations). Patients who died in the interim were included in the
194 multivariable logistic regression analysis for prolonged hospital stay. Odds ratio (OR) and 95% CI was
195 generated. All analyses were carried out in two age groups (i.e. 3-17 years vs. ≥18 years, respectively)
196 as the risk profiles between these groups may have been different.
197
198 For other secondary outcomes (i.e. ICU admission or death), we calculated the percentage of ICU
199 admission among individuals hospitalised with ARI and the percentage of all cause deaths among
200 individuals hospitalised with ARIs (in-hospital case fatality ratio), respectively.
201
202 A pre-specified sensitivity analysis was carried out using a strict definition for ARI hospitalisation
203 where ARI was the primary cause of hospitalisation. We also looked at Electronic Communication of
204 Surveillance in Scotland (ECOSS), which is a national database for all virology testing, to estimate the
205 number of laboratory-confirmed influenza and SARS-CoV-2 cases in comparison to those identified
206 using ICD-10 codes. Another two sensitivity analyses were conducted including ethnicity or smoking
207 status in the Cox modelling. Smoking status data were based on March 2020 and for individuals with
208 no data on smoking, we classified them as unknown, and we assumed that there has been no change
209 since then. Sensitivity analyses adjusting for either influenza vaccination status or SARS-CoV-2
210 vaccination status were also conducted when looking at outcomes of influenza hospitalisation or
211 SARS-CoV-2 hospitalisation.
212
213 The Cox proportional hazards models used sampling weights to correct for the size of the registered
214 general practice population being greater than the population in Scotland (some due to individuals
215 who had recently moved). These weights were derived by matching the age and sex numbers in the
216 general practice data to the Scottish population data (from 2011 Scotland census). This adjustment
217 ensured that the denominators in the tables matched the Scottish population.
218

Use of reporting guideline

220 We followed the Reporting of Studies Conducted using Observational Routinely-collected Data
221 (RECORD) and Strengthening the Reporting of Observational studies in Epidemiology (STROBE)
222 checklists[13, 14] to guide transparent reporting of this cohort study (Table S2).
223

Data availability

225 Analyses were carried out in R (version 3.6.1). A data dictionary covering the datasets used in this
226 study can be found at https://github.com/EAVE-II/EAVE-II-data-dictionary. All code developed for this
227 analysis is available in our GitHub repository: https://github.com/EAVE-II/winter_pressures_code. The
228 data used in this study are sensitive due to individual patient-level data and will not be made publicly

229 available. We will deposit the meta-data information in the Health Data Research Innovation Gateway
230 on publication.
231

Ethics and permissions
233 Ethical approval was obtained from the National Research Ethics Service Committee, Southeast
234 Scotland 02 (reference number, 12/SS/0201). The Public Benefit and Privacy Panel Committee of
235 Public Health Scotland approved the linkage and analysis of the de-identified datasets for this project
236 (1920-0279).
237

Patient and Public Involvement
239 We have patient and public involvement engagement throughout the project. The details are
240 available in Supplementary Materials Tables S3 and S4.
241

Role of the funding source
243 The funder of the study had no role in study design, data collection, data analysis, data interpretation,
244 or the writing of the report.
245

Results
247 5,021,056 individuals aged at least three years old across Scotland were included in this analysis.
248 Overall, there were 22,284 (10.9% of 203,549 with any first emergency hospitalisation) ARI emergency
249 first admissions during September 1, 2022 and January 31, 2023 (1,759 in children and 20,525 in
250 adults). 1,804 (7.5%) were upper respiratory infections, 5,609 (23.3%) were unspecified lower
251 respiratory infections, 11,986 (49.9%) were influenza/pneumonia, 4,280 (17.8%) were COVID-19, 227
252 (0.9%) were bronchiolitis and 138 (0.6%) were RSV. 7,997 (35.9%) had multiple respiratory infection
253 categories listed above. Among 22,284 ARI hospitalisation, the median age was 72.5 (interquartile
254 range 56.0, 82.4) years. 53.2% of them were female and 46.8% male. 13.1% of them were older adults
255 aged 75-79 years old and 33.8% were at least 80 years old. About 25.6% of them (22,284) did not have
256 any existing conditions as defined by the QCOVID prediction algorithm.[12] Most people (74.1%) did not
257 have any all-cause emergency admissions in the past six months prior to September 1, 2022. Among
258 the 22,284 people admitted to hospitals with ARI across Scotland during the study period, 1,126 (5.1%)
259 were admitted to ICU (86 children and 1040 adults) and 1,660 (7.4%) died (all adults); 1,605 (7.2%)
260 were readmitted to hospitals following discharge from their first ARI hospitalisation. A data flow
261 diagram showing the number of individuals included at different stages is available in Figure 1. More
262 baseline demographic characteristics on the study population are available in Table 1. Details on
263 individuals with ARI hospitalisation including first admissions and readmissions are available in Table
264 S5. We also compared the ARI hospitalisation to other causes emergency hospitalisation during the
265 study period (Table S6). The cumulative incidence of ARI hospitalisation in children and adults was
266 plotted in Figure S2. Number of ARI hospitalisation over time is shown in Figure S3. When we
267 compared number of ARI hospitalisation over time to emergency admissions due to other health
268 conditions, we have observed a peak in ARI hospitalisation while there was no peak for other health
269 conditions associated emergency admission during the same study period (Figure S4).
270

Adults
272 In the Cox modelling results for adults with ARI (Table 2), older adults aged ≥45 years old were found
273 to be at an increased risk of ARI hospitalisation compared to adults aged 25-29 years old. The HRs
274 increased with age with overlapping confidence intervals. The highest HR was found in adults aged
275 at least 80 years old (aHR=7.86, 95% CI 7.06-8.76). Adults from increasingly deprived areas had
276 increased risk of ARI hospitalisation (with overlapping confidence intervals): most deprived vs least

277 deprived, 1.64 (1.57-1.72). Adults with existing conditions showed a much higher risk than those
278 without existing conditions, and the more existing conditions they had the higher the risk was (with
279 overlapping confidence intervals): ≥5 vs 0 health conditions, 4.84 (4.53-5.18). Similarly, adults with a
280 history of all-cause emergency admissions had a much higher risk of ARI hospitalisation than those
281 without, and the more previous emergency admissions they had the higher the risk of ARI
282 hospitalisation was: ≥6 vs 0 previous emergency admissions 7.53 (5.48-10.35). Adults underweight
283 (BMI <18.5) or severely obese (≥40) showed slightly higher risks of ARI hospitalisation. Adults with
284 BMI 25.0-34.9 had slightly reduced risks of ARI hospitalisation. Adults from urban areas had slightly
285 increased risk of ARI hospitalisation. Similar results and trends were found when looking specifically
286 at influenza and SARS-CoV-2 respiratory pathogens (Table 2). Due to the small number of events for
287 RSV when stratified by different variables, Cox modelling was not conducted.
288
289 Length of hospital stay was five days or less for 52.7% of patients. The multivariable logistic regression
290 results showed that in adults, those aged at least 35 years old were associated with prolonged ARI
291 related longer hospital stay (>5 days) and the association increased by age (Table S7). The OR (95% CI)
292 was highest in those aged at least 80 years old (9.30 (6.98-12.64)). Those underweight (BMI <18.5),
293 from most deprived areas, with 1-4 previous emergency admissions or from urban areas were at
294 slightly higher risk of prolonged hospital stay. However, we did not find associations between adults
295 with existing conditions or who had at least five previous emergency admissions and ARI related
296 prolonged hospital stay.
297

Children
299 In the Cox modelling results for children with ARI (Table 3), children aged 3-5 years old were at
300 increased risk of ARI hospitalisation: aHR 4.55 (4.11-5.04) compared to children aged 6-17 years old.
301 Similarly, children from more deprived areas, with existing conditions or with history of all-cause
302 emergency admissions were at increased risk of ARI hospitalisation. The more existing conditions or
303 previous emergency admissions they had, the higher the risk. Children from urban areas had slightly
304 increased risk of ARI hospitalisation. Due to the limited number of events for specific respiratory
305 pathogen associated ARI when stratified by different variables, Cox modelling was not carried out.
306

Sensitivity analysis
308 In the sensitivity analysis using the strict definition of ARI hospitalisation (ARI as the primary cause of
309 hospital admission), 14,612 people were admitted to hospitals with ARI across Scotland during the
310 study period (1,534 children and 13,941 adults). The median age was 71.5 (interquartile range 53.5,
311 81.6) years old. All baseline demographic characteristics were similar to those when using the broad
312 definition (Table S8). Among the 14,612 ARI hospitalisations across Scotland, 719 (4.9%) were
313 admitted to ICU (71 children and 648 adults) and 1,008 (6.9%) died (all adults).
314

Sensitivity analysis – adults
316 The Cox modelling showed similar results on risk of ARI hospitalisation in adults (Tables S9 and S10),
317 being increased by age, higher in those from more deprived areas, with existing conditions or a
318 history of all-cause emergency admissions. Adults underweight (BMI <18.5) or severely obese (≥40)
319 or from urban areas similarly showed slightly higher risk of ARI hospitalisation. Similar findings were
320 observed for influenza or SARS-CoV-2 associated ARI hospitalisation in adults (Table S9). Another
321 sensitivity analysis comparing laboratory-confirmed influenza and SARS-CoV-2 cases to those
322 identified using ICD-10 codes has shown that 2,984 -2,749 cases of SARS-CoV-2 associated ARI
323 hospitalisation in adults during our study period. The results of the Cox model for influenza and
324 COVID-19 associated ARI hospitals showed similar findings when using laboratory-confirmed data in
325 comparison to ICD-10 codes (Table S11). Another sensitivity analysis including ethnicity in the Cox
326 modelling has shown similar results for all variables and within ethnicity "unknown" group seemed

327 to have a lower risk (compared to "White" group) (Table S12). Sensitivity analysis including smoking
328 status in the Cox modelling has shown similar results for all variables and within the smoking status,
329 adults who were current smokers or ex-smokers had a higher risk of ARI hospitalisation (1.59 (1.51-
330 1.66) and 1.26 (1.22-1.31) respectively, in comparison to non-smokers (Table S13). Similar findings
331 were found for influenza or SARS-CoV-2 associated ARI hospitalisation. Cox modelling for influenza
332 or SARS-CoV-2 related ARI hospitalisation after adjusting for influenza or SARS-CoV-2 vaccination is
333 available in Tables S14-S15. The risk of influenza hospitalisation was lower in those with influenza
334 vaccines (0.76 (0.73-0.80)). The risk of SARS-CoV-2 hospitalisation was -and fourth or fifth dose
335 vaccines (0.64 (0.58-0.71)) and 0.83 (0.73-0.93) respectively), in comparison to those unvaccinated
336 or had first or two dose vaccines.
337

338 ## Sensitivity analysis – children
339 The results for children using the strict definition of ARI hospitalisation were similar to the main
340 analyses of using broad definition (Table S10).

341 # Discussion
342 We provide national evidence of important predictors for hospitalisations due to ARI during the winter
343 2022-23. Children and adults from more deprived areas, those with existing health conditions and
344 with a history of all-cause emergency admissions experienced an increased risk of ARI hospitalisations
345 in Scotland. Younger children and older adults were at particularly at higher risk. Urban areas were
346 also associated with a slight increased risk of ARI hospitalisation. The results were similar whether a
347 broad definition for ARI (a hospital admission due to or associated with ARI) or strict definition for ARI
348 (a hospital admission due to ARI) was used. Influenza or SARS-CoV-2 associated ARI in adults had
349 similar risk factors. However, the length of hospital stay among adults was less affected by these risk
350 factors except for age and underweight. In addition, we have also shown the impact of smoking on
351 the risk of ARI hospitalisation and the impact of influenza or SARS-CoV-2 vaccines on the risk of
352 influenza or SARS-CoV-2 hospitalisation.
353

354 Our study has several strengths. We undertook a national population-level study assessing the risk of
355 ARI hospitalisations among people of different age groups in Scotland. We developed a national linked
356 dataset and created a platform that allowed rapid access to and analysis of data from routinely
357 collected electronic health records and national databases. Therefore, our study potentially has lower
358 risk of recall or misclassification bias. The use of a large population aided study power, facilitating
359 precise estimates of HRs for ARI associated hospital admission or ORs for prolonged hospital stay
360 stratified by different variables. We are likely to have excellent generalisability across the UK and
361 potentially other countries with similar demographics and health systems.
362

363 Our study has several limitations. It is noteworthy that since we only included a five-month study
364 period, there were low absolute numbers of events for RSV related ARI hospitalisations in adults and
365 RSV/influenza/SARS-CoV-2 related ARI hospitalisations in children. These low numbers precluded the
366 opportunity for further investigations into the severe outcomes of these specific respiratory
367 pathogens and highlighted the need for laboratory diagnosis of these respiratory pathogens. RSV is
368 one of the important viral pathogens identified in older adults with ARI and is increasingly recognised
369 as a cause of illness in high-risk adults, including those with chronic lung and heart disease.[15, 16] RSV is
370 also one of the most common pathogens responsible for ARI in young children and contributed to over
371 3 million hospital admissions in children under five years old annually across the world.[17] With RSV
372 vaccines in children and older adults being developed and planned internationally,[18] more research
373 assessing the risk profiles of RSV related ARI including in-hospital and post-discharge complications
374 would be needed to inform and support decisions on vaccination priorities among high-risk
375 populations. There was a lack of more granular data on the reason for admission, so we used both
376 broad and strict definitions for our main outcome – ARI hospitalisation (hospital admission due to or

377 associated with ARI vs. hospital admission due to ARI) and the results were comparable. Regarding the
378 adjustment of risk groups among children, we only included risk groups that were defined by the
379 QCOVID prediction algorithm[12] (which was based on adult population), so we may have missed some
380 important paediatric risk groups. There may also have been different healthcare seeking behaviours
381 and lower threshold for hospital admission (influenced by physician and hospital factors) in children
382 and adults with existing health conditions, which may have resulted in higher risk of hospital
383 admissions with ARI. Our main analysis did not include some potentially important predictors (such as
384 smoking status) due to these data being somewhat out of date (being updated to March 2020 only).
385 However, our sensitivity analysis including smoking status has shown that current smokers and ex-
386 smokers (compared to non-smokers) both had higher risk of ARI hospitalisation and influenza or SARS-
387 CoV-2 associated ARI hospitalisation. Our main analysis did not include influenza or SARS-CoV-2
388 vaccination in the Cox modelling either due to the fact that there were no mechanisms for these
389 vaccines to have effect on for non-specific outcomes (non-influenza/SARS-CoV-2 hospitalisation).
390 However, our sensitivity analysis including vaccination status has shown that adults with influenza
391 vaccines or SARS-CoV-2 vaccines had lower risk of influenza hospitalisation or SARS-CoV-2
392 hospitalisation.
393
394 Similar findings have been reported in the literature. The risk factors for influenza associated ARI
395 hospitalisation included age <5 and ≥65 years old, diabetes, heart diseases and chronic respiratory
396 diseases during the 2018/2019 winter season in Yemen.[19] Prematurity, presence of a chronic illness,
397 oxygen saturation < 90%, and atelectasis and consolidation on chest X-rays were associated with an
398 increased ARI related length of hospital stay based on the viral surveillance of children with ARI in two
399 main hospitals in Northern Jordan, Irbid, during the winter of 2016.[20] Also, the presence of chronic
400 obstructive pulmonary disease (COPD), other chronic disease and being housebound were found to
401 be independent risk factors associated with winter hospital admissions among older people
402 presenting with ARI.[21] Our study has added robust and generalisable evidence using population level
403 data and quantified associations between demographic and clinical risk factors and ARI hospitalisation
404 in both children and adults. Building on this work, it is important for more detailed characterisation of
405 potential modifiable risk factors for specific respiratory pathogen associated ARI hospitalisation and
406 to investigate underlying mechanisms that predispose such populations to these increased risks.
407
408 Our findings lay the foundations for the development and validation of winter respiratory risk
409 prediction models in children and adults. Scotland currently uses the Scottish Patients at Risk of
410 Readmission and Admission (SPARRA V3) risk prediction tool,[22] but it was developed for use prior to
411 the pandemic (last iteration in 2011), does not use data from GP primary care data (except for
412 prescription records), provides an assessment of risk over a 12-month horizon for highest risk of
413 admission/readmission, is only for use in adults aged ≥16 years and predicts any type of admission
414 without distinguishing specific types. The model has different performance depending on the
415 condition.[23] Thus, developing a more targeted SPARRA-like risk prediction model would be needed.
416 We will be able to use this to identify practices/areas of the country that contain the largest numbers
417 of high-risk individuals which could then inform the allocation of resources with the aim of improving
418 the delivery of care.
419
420 In conclusion, this national analysis has provided the first detailed characterisation of individuals with
421 ARI contributing NHS compound winter pressure in Scotland. We identified individuals who were at
422 greatest risk of being admitted to hospitals with ARI and lay the foundations for new risk prediction
423 tools in children and adults, which can be used to target interventions and resources to those most at
424 risk. Moreover, the unique data resources available to us through EAVE II provided insights into
425 predicting and forecasting emergency NHS use for the UK as a whole.
426
427 **Contributors**

428 AS, CR, and TS conceived this study. AS, CR, TS and TM commented on the paper, oversaw the analysis, and
429 edited the final manuscript. TS and AS led the writing of the paper. TM led the data analysis with support from
430 CR, BS and AF. All authors contributed to the study design. All authors contributed to drafting the paper and
431 revised the manuscript for important intellectual content. All authors had final responsibility for the decision to
432 submit for publication.

433 **Declaration of interests**

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457

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521   emergency admission in Scotland. *medRxiv* 2021: 2021.2008.2006.21261593. DOI: 10.1101/2021.08.06.21261593.

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Table 1: Baseline characteristics of the cases with ARI hospitalisation, selected controls and eligible controls without ARI hospitalisation from the Scottish population

Variable	Level	Cases	Controls	Full Population
All		22284	222840	4998772
Age	Mean (standard deviation)	65.6 (24)	44.6 (22.8)	44.6 (22.8)
	Median (interquartile range)	72.5 (56,82.4)	44.5 (25.7,62)	44.5 (25.7,61.9)
Number of Risk Groups	0	5699 (25.6%)	133906 (63.9%)	3195309 (63.9%)
	1	5352 (24.0%)	50267 (24.0%)	1197439 (24.0%)
	2	4439 (19.9%)	16311 (7.8%)	389051 (7.8%)
	3	3172 (14.2%)	5624 (2.7%)	135680 (2.7%)
	4	1927 (8.6%)	2156 (1.0%)	51768 (1.0%)
	≥5	1695 (7.6%)	1271 (0.6%)	29525 (0.6%)
Sex	Female	11865 (53.2%)	107306 (51.2%)	2561551 (51.2%)
	Male	10419 (46.8%)	102228 (48.8%)	2437221 (48.8%)
Age Groups (years)	3-5	896 (4.0%)	5648 (2.7%)	135310 (2.7%)
	6-17	863 (3.9%)	26894 (12.8%)	637394 (12.8%)
	18-24	427 (1.9%)	15518 (7.4%)	373455 (7.5%)
	25-29	364 (1.6%)	12940 (6.2%)	311123 (6.2%)
	30-34	397 (1.8%)	14222 (6.8%)	337104 (6.7%)
	35-39	449 (2.0%)	13998 (6.7%)	339234 (6.8%)
	40-44	458 (2.1%)	13655 (6.5%)	333720 (6.7%)
	45-49	482 (2.2%)	13014 (6.2%)	309699 (6.2%)
	50-54	811 (3.6%)	15356 (7.3%)	366700 (7.3%)
	55-59	1151 (5.2%)	16590 (7.9%)	389812 (7.8%)
	60-64	1534 (6.9%)	15238 (7.3%)	364695 (7.3%)
	65-69	1741 (7.8%)	13174 (6.3%)	309985 (6.2%)
	70-74	2276 (10.2%)	11460 (5.5%)	268762 (5.4%)
	75-79	2914 (13.1%)	9528 (4.5%)	226550 (4.5%)
	≥80	7521 (33.8%)	12300 (5.9%)	295228 (5.9%)
COVID-19 Vaccination Status	Unvaccinated	2414 (10.8%)	37712 (18.0%)	894038 (17.9%)
	1st Dose >14 days	448 (2.0%)	7362 (3.5%)	177871 (3.6%)
	2nd Dose >14 days	1542 (6.9%)	27206 (13.0%)	653529 (13.1%)
	3rd Dose >14 days	7994 (35.9%)	115904 (55.3%)	2761678 (55.2%)
	4th Dose >14 days	9215 (41.4%)	20143 (9.6%)	483534 (9.7%)
	5th Dose >14 days	671 (3.0%)	1207 (0.6%)	28122 (0.6%)
Influenza Vaccination Status	Unvaccinated	11753 (52.7%)	118391 (56.5%)	2830373 (56.6%)
	0 - 14 days	1187 (5.3%)	364 (0.2%)	8503 (0.2%)
	>14 days	9344 (41.9%)	90780 (43.3%)	2159896 (43.2%)
Urban/Rural Classification	Rural	3752 (16.8%)	40431 (19.3%)	958830 (19.2%)

	Urban	18532 (83.2%)	169103 (80.7%)	4039942 (80.8%)
SIMD quintiles	1 – Most deprived	3138 (14.1%)	41561 (19.8%)	991130 (19.8%)
	2	6035 (27.1%)	42619 (20.3%)	1021100 (20.4%)
	3	5122 (23.0%)	41758 (19.9%)	996473 (19.9%)
	4	4288 (19.2%)	41283 (19.7%)	977798 (19.6%)
	5 – Least Deprived	3701 (16.6%)	42313 (20.2%)	1012271 (20.3%)
ICU Admission	Adult ICU Admission	1012 (4.5%)	400 (0.2%)	9274 (0.2%)
	Children ICU Admission	88 (0.4%)	< 5 (0.0%)	66 (0.0%)
	No ICU Admission	21184 (95.1%)	209132 (99.8%)	4989432 (99.8%)
Deaths	Yes	1660 (7.4%)	777 (0.4%)	17910 (0.4%)
	No	20624 (92.6%)	208757 (99.6%)	4980862 (99.6%)
Length of Hospital Stay (days)	0	0	205673 (98.2%)	4906647 (98.2%)
	1	4055 (18.2%)	1027 (0.5%)	25306 (0.5%)
	2	2575 (11.6%)	583 (0.3%)	13922 (0.3%)
	3-4	5122 (23.0%)	914 (0.4%)	21812 (0.4%)
	5-9	4319 (19.4%)	635 (0.3%)	14312 (0.3%)
	10-19	3284 (14.7%)	366 (0.2%)	9064 (0.2%)
	≥20	2929 (13.1%)	336 (0.2%)	7709 (0.2%)
Number of previous admissions*	0	16523 (74.1%)	202858 (96.8%)	4841196 (96.8%)
	1	3728 (16.7%)	5489 (2.6%)	129925 (2.6%)
	2	1267 (5.7%)	860 (0.4%)	20197 (0.4%)
	3	431 (1.9%)	224 (0.1%)	4911 (0.1%)
	4	172 (0.8%)	61 (0.0%)	1547 (0.0%)
	5	79 (0.4%)	25 (0.0%)	538 (0.0%)
	≥6	84 (0.4%)	17 (0.0%)	458 (0.0%)
Ethnicity	Asian	337 (1.5%)	5261 (2.5%)	126062 (2.5%)
	Black	66 (0.3%)	1297 (0.6%)	31739 (0.6%)
	Mixed	60 (0.3%)	1472 (0.7%)	33524 (0.7%)
	White	18492 (83.0%)	139574 (66.6%)	3333646 (66.7%)
	Other	74 (0.3%)	1100 (0.5%)	26544 (0.5%)
	Unknown	3255 (14.6%)	60831 (29.0%)	1447257 (29.0%)
Health Board	NHS Ayrshire and Arran	1754 (7.9%)	12709 (6.1%)	307607 (6.2%)
	NHS Borders	400 (1.8%)	4031 (1.9%)	96177 (1.9%)
	NHS Dumfries and Galloway	812 (3.6%)	5886 (2.8%)	141258 (2.8%)
	NHS Fife	1050 (4.7%)	13735 (6.6%)	328683 (6.6%)
	NHS Forth Valley	1028 (4.6%)	11397 (5.4%)	268695 (5.4%)
	NHS Grampian	1930 (8.7%)	22300 (10.6%)	531963 (10.6%)
	NHS Greater Glasgow and Clyde	5656 (25.4%)	46480 (22.2%)	1115443 (22.3%)

	NHS Highland	828 (3.7%)	12626 (6.0%)	300571 (6.0%)
	NHS Lanarkshire	3115 (14.0%)	26170 (12.5%)	618786 (12.4%)
	NHS Lothian	3784 (17.0%)	35126 (16.8%)	838759 (16.8%)
	NHS Orkney	83 (0.4%)	805 (0.4%)	18637 (0.4%)
	NHS Shetland	63 (0.3%)	856 (0.4%)	20861 (0.4%)
	NHS Tayside	1691 (7.6%)	16548 (7.9%)	392020 (7.8%)
	NHS Western Isles	90 (0.4%)	866 (0.4%)	19312 (0.4%)

527   Data are n (%). * Number of previous admissions was within six-month period prior to September 1, 2022. ARI:
528   Acute Respiratory Infection. SIMD: Scottish Index of Multiple Deprivation. ICU: Intensive Care Unit.

Table 2: Adjusted hazard ratios of hospitalisation with acute respiratory infections in adults aged ≥18 years old

Variable	Level	ARI hospitalisation		Influenza hospitalisation		SARS-CoV-2 hospitalisation	
		No. of events	HR (LCI, UCI)	No. of events	HR (LCI, UCI)	No. of events	HR (LCI, UCI)
Sex	Female	11041	1.00	6173	1.00	2179	1.00
	Male	9484	1.06 (1.03, 1.09)	5393	1.08 (1.04, 1.12)	2017	1.18 (1.11, 1.26)
Age (years)	18-24	427	1.01 (0.88, 1.16)	123	0.68 (0.54, 0.86)	49	1.05 (0.69, 1.59)
	25-29	364	1.00 (1.00, 1.00)	154	1.00	40	1.00
	30-34	397	0.97 (0.84, 1.11)	189	1.09 (0.88, 1.34)	62	1.38 (0.93, 2.05)
	35-39	449	1.07 (0.94, 1.23)	218	1.24 (1.01, 1.52)	71	1.55 (1.05, 2.29)
	40-44	458	1.10 (0.96, 1.26)	247	1.40 (1.15, 1.72)	81	1.78 (1.22, 2.59)
	45-49	482	1.21 (1.06, 1.38)	285	1.68 (1.39, 2.05)	76	1.74 (1.19, 2.55)
	50-54	811	1.59 (1.41, 1.80)	482	2.25 (1.88, 2.70)	140	2.53 (1.78, 3.60)
	55-59	1151	1.98 (1.76, 2.22)	684	2.77 (2.33, 3.30)	223	3.56 (2.55, 4.99)
	60-64	1534	2.58 (2.30, 2.89)	920	3.64 (3.07, 4.31)	287	4.49 (3.23, 6.26)
	65-69	1741	3.10 (2.77, 3.47)	1084	4.52 (3.81, 5.35)	352	5.86 (4.22, 8.14)
	70-74	2276	4.09 (3.66, 4.57)	1376	5.87 (4.97, 6.95)	476	8.25 (5.96, 11.41)
	75-79	2914	5.34 (4.78, 5.97)	1709	7.46 (6.31, 8.82)	650	11.58 (8.39, 15.99)
	≥80	7521	7.86 (7.06, 8.76)	4095	10.47 (8.88, 12.35)	1689	18.62 (13.53, 25.62)
SIMD quintiles	1 - Most deprived	5582	1.64 (1.57, 1.72)	3241	1.75 (1.64, 1.86)	1008	1.51 (1.37, 1.68)
	2	4757	1.38 (1.32, 1.45)	2687	1.41 (1.33, 1.51)	1010	1.44 (1.30, 1.59)
	3	3937	1.24 (1.18, 1.30)	2177	1.25 (1.17, 1.34)	841	1.27 (1.14, 1.42)
	4	3376	1.13 (1.07, 1.19)	1886	1.15 (1.08, 1.24)	729	1.17 (1.05, 1.30)
	5 - Least deprived	2873	1.00	1575	1.00	608	1.00
Number of risk groups	0	4293	1.00	2197	1.00	814	1.00
	1	5090	1.93 (1.85, 2.01)	2877	2.11 (1.99, 2.23)	1026	2.00 (1.82, 2.20)
	2	4365	2.90 (2.77, 3.03)	2473	3.22 (3.03, 3.43)	929	3.05 (2.76, 3.38)
	3	3155	3.74 (3.55, 3.94)	1814	4.38 (4.08, 4.70)	687	4.21 (3.75, 4.72)

			HR (LCI, UCI)		HR (LCI, UCI)		HR (LCI, UCI)
	4	1927	4.19 (3.94, 4.46)	1149	5.16 (4.75, 5.60)	407	4.74 (4.14, 5.43)
	≥5	1695	4.84 (4.53, 5.18)	1056	6.57 (6.01, 7.18)	333	5.24 (4.51, 6.08)
BMI	<18.5	861	1.52 (1.40, 1.65)	569	1.76 (1.59, 1.95)	187	1.71 (1.45, 2.01)
	18.5 – 24.9	6372	1.00	3649	1.00	1319	1.00
	25 – 29.9	6698	0.87 (0.84, 0.90)	3736	0.83 (0.80, 0.87)	1367	0.84 (0.78, 0.91)
	30 – 34.9	3899	0.92 (0.88, 0.95)	2113	0.84 (0.80, 0.89)	782	0.89 (0.81, 0.97)
	35 – 39.9	1324	1.04 (0.97, 1.11)	755	0.98 (0.90, 1.07)	270	1.02 (0.89, 1.17)
	≥40	1371	1.11 (1.05, 1.18)	744	1.01 (0.93, 1.10)	271	1.13 (0.98, 1.29)
Number of Previous Admissions	0	15104	1.00	8542	1.00	3003	1.00
	1	3544	2.80 (2.69, 2.92)	1970	2.91 (2.75, 3.07)	785	3.43 (3.15, 3.74)
	2	1193	3.81 (3.56, 4.08)	692	4.28 (3.90, 4.69)	250	5.02 (4.34, 5.80)
	3	391	4.97 (4.38, 5.63)	203	5.28 (4.44, 6.29)	87	7.68 (5.96, 9.89)
	4	154	5.39 (4.38, 6.63)	80	5.60 (4.21, 7.46)	32	8.69 (5.68, 13.29)
	5	72	7.67 (5.71, 10.30)	42	8.93 (6.03, 13.23)	25	22.08 (13.34, 36.54)
	≥6	67	7.53 (5.48, 10.35)	37	8.34 (5.36, 12.99)	14	11.98 (7.23, 19.86)
Urban/Rural Classification	Rural	3496	1.00	1930	1.00	729	1.00
	Urban	17029	1.17 (1.12, 1.21)	9636	1.20 (1.14, 1.26)	3467	1.24 (1.14, 1.34)

530 HR: Hazard Ratio. LCI: Lower Confidence Interval. UCI: Upper Confidence Interval. Hazard ratios were derived using cox proportional hazard model adjusting for age, sex,
531 socioeconomic status, number of risk groups, and number of previous emergency hospitalisations within six months prior to September 1, 2022. BMI: Body Mass Index.
532 SIMD: Scottish Index of Multiple Deprivation.
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535 **Table 3: Adjusted hazard ratios of hospitalisation with acute respiratory infections in children aged 3-17 years old**

Variable	Level	ARI Hospitalisation	
		Number of events	**HR (LCI, UCI)**
Sex	Female	824	1.00
	Male	935	1.03 (0.94, 1.14)
Age Group (years)	3 - 5	896	4.55 (4.11, 5.04)
	6 - 17	863	1.00
SIMD quintiles	1 - Most deprived	453	1.24 (1.06, 1.44)
	2	365	1.19 (1.01, 1.39)
	3	351	1.35 (1.15, 1.58)
	4	325	1.16 (0.99, 1.36)
	5 - Least deprived	265	1.00
Number of risk groups	0	1406	1.00
	1	262	2.24 (1.95, 2.57)
	2	74	3.76 (2.86, 4.94)
	3	17	7.61 (4.54, 12.75)
	4	0	NA
	≥5	0	NA
Number of previous admissions	0	7	1.00
	1	17	4.60 (3.91, 5.41)
	2	453	8.64 (6.54, 11.43)
	3	365	17.88 (13.38, 23.91)
	4	351	16.75 (9.95, 28.18)
	5	325	7.57 (3.78, 15.15)
	≥6	265	49.23 (32.33, 74.96)
Urban/Rural Classification	Rural	256	1.00
	Urban	1503	1.33 (1.17, 1.52)

536 HR: Hazard Ratio. LCI: Lower Confidence Interval. UCI: Upper Confidence Interval. Hazard ratios were derived
537 using cox proportional hazard model adjusting for age, sex, socioeconomic status, number of risk groups, and
538 number of previous emergency hospitalisations within six months prior to September 1, 2022. SIMD: Scottish
539 Index of Multiple Deprivation. NA: Not Available.
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544 **Figure 1: Data flow diagram for the ARI hospitalisation Cox modelling***
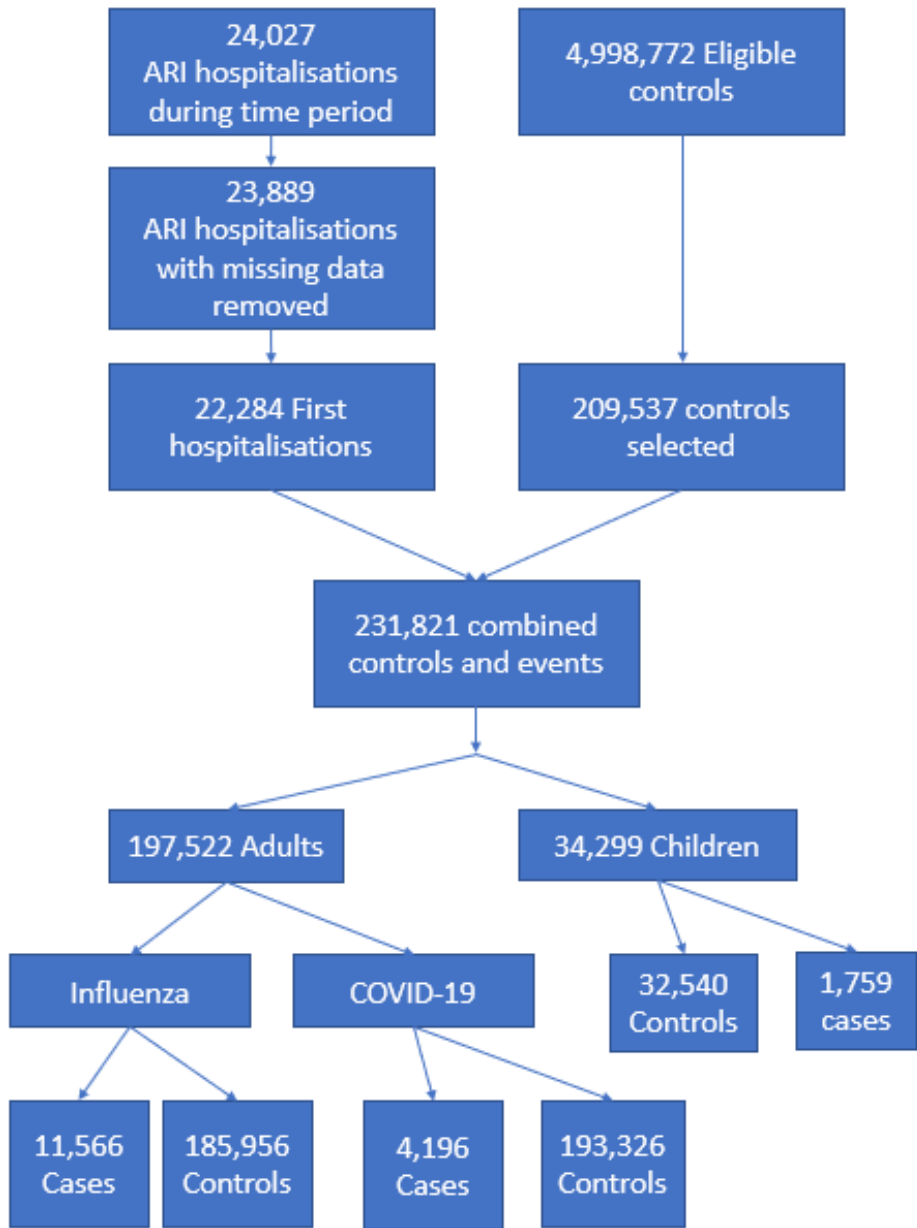
545

546 *24,027 includes 1,605 individuals with readmissions and 138 individuals with missing information on
547 Urban/Rural Classification, SIMD quintiles and Health Board.

Table of Contents

Supplementary materials

Box 1: Risk groups in the QCOVID algorithm

- accommodation (homeless, care home, neither)
- asthma
- atrial fibrillation
- blood cancer
- body mass index (BMI)
- cerebral palsy
- chronic kidney disease
- cirrhosis of liver
- congenital heart disease
- congestive cardiac failure
- chronic obstructive pulmonary disease (COPD)
- coronary heart disease
- dementia
- diabetes 1
- diabetes 2
- epilepsy
- ethnicity
- learning disability
- osteoporotic fracture
- Parkinson's disease
- peripheral vascular disease
- pulmonary hypertension or pulmonary fibrosis
- rare neurological conditions
- rare pulmonary diseases
- respiratory cancer
- rheumatoid arthritis or systemic lupus erythematosus
- severe mental illness
- sickle cell disease
- stroke
- venous thromboembolism

74 Table S1: ICD-10 codes for acute respiratory infections

Condition	ICD10
Acute upper respiratory tract infection (URTI)	J00, J02-06
Lower respiratory tract infection (LRTI)	
Pneumonia & influenza	J09-18
Bronchiolitis and bronchitis	J20-21, J40
Unspecified LRTI	J22
COVID-19	U07.1, U07.2, U08-10
RSV	J12.1, J20.5, J21.0, B97.4
Source: https://www.who.int/classifications/icd/COVID-19-coding-icd10.pdf	

75 ICD-10: International Classification of Diseases 10.
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Table S2: Reporting STROBE and RECORD checklists

	Item No.	STROBE items	RECORD items	Location in manuscript where items are reported
Title and abstract				
	1	(a) Indicate the study's design with a commonly used term in the title or the abstract (b) Provide in the abstract an informative and balanced summary of what was done and what was found	RECORD 1.1: The type of data used should be specified in the title or abstract. When possible, the name of the databases used should be included. RECORD 1.2: If applicable, the geographic region and timeframe within which the study took place should be reported in the title or abstract. RECORD 1.3: If linkage between databases was conducted for the study, this should be clearly stated in the title or abstract.	p. 1-2
Introduction				
Background rationale	2	Explain the scientific background and rationale for the investigation being reported		p. 4
Objectives	3	State specific objectives, including any prespecified hypotheses		p. 5
Methods				
Study Design	4	Present key elements of study design early in the paper		p. 5
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection		p. 5
Participants	6	*(a) Cohort study* - Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up *Case-control study* - Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the	RECORD 6.1: The methods of study population selection (such as codes or algorithms used to identify subjects) should be listed in detail. If this is not possible, an explanation should be provided. RECORD 6.2: Any validation studies of the codes or algorithms used to select the population should be referenced. If validation was conducted for this study	p. 5-6

		rationale for the choice of cases and controls *Cross-sectional study* - Give the eligibility criteria, and the sources and methods of selection of participants *(b) Cohort study* - For matched studies, give matching criteria and number of exposed and unexposed *Case-control study* - For matched studies, give matching criteria and the number of controls per case	and not published elsewhere, detailed methods and results should be provided. RECORD 6.3: If the study involved linkage of databases, consider use of a flow diagram or other graphical display to demonstrate the data linkage process, including the number of individuals with linked data at each stage.	
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable.	RECORD 7.1: A complete list of codes and algorithms used to classify exposures, outcomes, confounders, and effect modifiers should be provided. If these cannot be reported, an explanation should be provided.	p.6
Data sources/ measurement	8	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group		p. 5-6
Bias	9	Describe any efforts to address potential sources of bias		p. 6
Study size	10	Explain how the study size was arrived at		NA
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen, and why		p. 6
Statistical methods	12	(a) Describe all statistical methods, including those used to control for confounding		p. 6-7

		(b) Describe any methods used to examine subgroups and interactions (c) Explain how missing data were addressed (d) *Cohort study* - If applicable, explain how loss to follow-up was addressed *Case-control study* - If applicable, explain how matching of cases and controls was addressed *Cross-sectional study* - If applicable, describe analytical methods taking account of sampling strategy (e) Describe any sensitivity analyses		
Data access and cleaning methods		..	RECORD 12.1: Authors should describe the extent to which the investigators had access to the database population used to create the study population. RECORD 12.2: Authors should provide information on the data cleaning methods used in the study.	p.
Linkage		..	RECORD 12.3: State whether the study included person-level, institutional-level, or other data linkage across two or more databases. The methods of linkage and methods of linkage quality evaluation should be provided.	p. 5-6
Results				
Participants	13	(a) Report the numbers of individuals at each stage of the study (*e.g.*, numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed) (b) Give reasons for non-participation at each stage. (c) Consider use of a flow diagram	RECORD 13.1: Describe in detail the selection of the persons included in the study (*i.e.,* study population selection) including filtering based on data quality, data availability and linkage. The selection of included persons can be described in the text and/or by means of the study flow diagram.	p. 7-8

Descriptive data	14	(a) Give characteristics of study participants (*e.g.*, demographic, clinical, social) and information on exposures and potential confounders (b) Indicate the number of participants with missing data for each variable of interest (c) *Cohort study* - summarise follow-up time (*e.g.*, average and total amount)		p. 8
Outcome data	15	*Cohort study* - Report numbers of outcome events or summary measures over time *Case-control study* - Report numbers in each exposure category, or summary measures of exposure *Cross-sectional study* - Report numbers of outcome events or summary measures		p. 8
Main results	16	(a) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (e.g., 95% confidence interval). Make clear which confounders were adjusted for and why they were included (b) Report category boundaries when continuous variables were categorized (c) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period		p. 8-9
Other analyses	17	Report other analyses done—e.g., analyses of subgroups and interactions, and sensitivity analyses		p. 9
Discussion				

Key results	18	Summarise key results with reference to study objectives		p. 9
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	RECORD 19.1: Discuss the implications of using data that were not created or collected to answer the specific research question(s). Include discussion of misclassification bias, unmeasured confounding, missing data, and changing eligibility over time, as they pertain to the study being reported.	p. 10
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence		p. 10-11
Generalisability	21	Discuss the generalisability (external validity) of the study results		p. 11
Other Information				
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based		p. 2,12
Accessibility of protocol, raw data, and programming code		..	RECORD 22.1: Authors should provide information on how to access any supplemental information such as the study protocol, raw data, or programming code.	p.

78 STROBE: Strengthening the Reporting of Observational studies in Epidemiology. RECORD: Reporting of Studies Conducted using Observational Routinely-collected Data. NA:
79 not applicable.
80

81 Patient and public involvement with this study

82 Table S3: GRIPP2 reporting checklist (short form)

Section and topic	Item	Reported on page No
1: Aim	Report the aim of PPI in the study	S8
2: Methods	Provide a clear description of the methods used for PPI in the study	S8
3: Study results	Outcomes—Report the results of PPI in the study, including both positive and negative outcomes	S8-9
4: Discussion and conclusions	Outcomes—Comment on the extent to which PPI influenced the study overall. Describe positive and negative effects	S9-10
5: Reflections/critical perspective	Comment critically on the study, reflecting on the things that went well and those that did not, so others can learn from this experience	S10

83 PPI=patient and public involvement

84

85 **GRIPP2 Reporting Guidelines: Short Form**

86 <u>Aim</u>

87 The aims of patient and public involvement (PPI) in this study were threefold: (1) Staff and PPI Team
88 to work as peers, ensuring that public voices contribute to the detail and direction of the project,
89 from analysis design through to dissemination, evaluation and implementation; (2) named PPI Leads
90 to represent the Group in project-level decision making; and (3) to share best-practice PPI with other
91 research teams and PPI contributors where the opportunity arises.

92

93 <u>Methods</u>

94 This study uses routinely collected health data from the "Early Pandemic Evaluation and Enhanced
95 Surveillance of COVID-19" (EAVE II) platform: https://www.ed.ac.uk/usher/eave-ii/about-eave-
96 ii/introduction-to-eave-ii. The initial research bid was designed in November 2022 with significant
97 input from the EAVE II Public Advisory Group (PAG) via: 1) a short survey to assess key public
98 concerns, care priorities and research priorities (n=9); and 2) the opportunity to shape this
99 application and review its lay summary (n=5).

100

101 Due to the accelerated nature of the Compound Winter Pressures project, and their experience with
102 both PPI and navigating different parts of the NHS, Sandra [SJ] and David [DW] were invited to act as
103 PPI Leads for this project in addition to their role as Leads for the EAVE II PAG. Alongside PPI
104 Coordinator Dr Lana Woolford [LW] and Research & Operations Assistant Laura Gonzalez-Rienda
105 [LGR], they formed the PPI Team for the study.

106

107 The resulting PPI Team have been involved in agreeing PPI Objectives and Deliverables; designing
108 the Statistical Analysis Plan (SAP); steering the project; offering a public perspective on results
109 interpretation and suggestions for policy implementation; evaluating the PPI elements of the
110 project; contributing to dissemination; and authoring this GRIPP2 Appendix.

111

112 This work was carried out remotely, either using videoconferencing (Zoom, with minutes produced
113 from each recording) or asynchronously via email. Public members of the PPI Team were rewarded

114 for time and expertise shared, in line with National Institute for Health and Care Research (NIHR)
115 guidelines. Role Descriptions and Terms of Reference (ToR) were co-produced and agreed by the
116 EAVE II Patient Advisory Group (PAG) shortly after recruitment to the EAVE II study. These ToR's
117 were adopted again as a framework for this project.

118 <u>Results</u>
119 Based on the aims outlined above, the PPI Team carried out PPI deliverables in line with the research
120 cycle as summarised in Table S4.
121

122 Table S4: Results of PPI

Area of research cycle	Summary of deliverables
Identifying patient and public priorities	Identify public research priorities through a PAG survey, including a ranking exercise of research questions proposed by the funding call.
Grant development	Review the project summary for clarity and simplicity of language, and critically appraise the research content from a public perspective. Use the survey results to make comments and suggestions on the outline.
Undertaking project	PPI Leads to attend fortnightly project meetings, reviewing the content and helping to steer the project throughout.
Design	Access, review and comment on the live SAP, and meet with the Lead Analyst to ask for clarification and make suggestions for improving the public benefit of the study.
Analysis and interpretation	Discuss the preliminary findings with the Lead Analyst and design a workshop to present these findings to the wider EAVE II PAG.
Dissemination	Lead on presenting the PPI elements of the project at the Health and Data Research UK (HDR) Insight Sharing Day.
Implementation	Discuss the implementation of results in policy from a public perspective at the preliminary findings workshop.
Evaluation	Reflect on the PPI activity in the project from different perspectives under the themes of Personal, Project and Structural impacts.

123
124 This work has resulted in the production of two detailed PPI reports pre-and post-grant; a
125 presentation by DW at the HDR Insight Sharing Day for research teams funded through the Complex
126 Winter Pressures call; an infographic and publication summary in plain English; and a reflective
127 summary of the work in this Appendix.

128
129 Despite the short timescales for the project, PPI has had a significant impact. The EAVE II PAG
130 actively shaped the grant, highlighting that information about NHS pressures by health board that is
131 important to individual patients in Scotland. This public priority was built into the analysis. Involving
132 our PPI Leads in regular project meetings provided greater accountability over time, and resulted in
133 the following changes to the project: preliminary resources were sent prior to relevant activities,
134 regularly informed researchers about the "public perspective" and took part in key decision making,
135 contributed to fortnightly meetings and reviewed documentation. The opportunity to meet with the
136 Lead Analyst and ask more detailed questions led to clarifications in definitions in the SAP,
137 particularly related to death records. It also improved the content presented to the wider PAG,
138 allowing for more meaningful involvement at the workshop exploring preliminary results and policy
139 implications.

140
141 Previously, the EAVE II PAG have commented that health data research-related PPI suffers from a
142 lack of visibility, published literature and PPI training, despite its importance in the healthcare policy
143 landscape. Presenting at the HDR UK Sharing Day and publishing a GRIPP2 Appendix will allow us to
144 share best practice with a relevant wider audience.

145   The evaluation, compiling perspectives from the Lead Analyst, Professional Services staff and PPI
146   Leads, reveals useful information about activity on the project as well as its wider context amongst
147   EAVE II studies.
148
149   Public contributors remarked the value of their "lived experiences" by offering insights to regular
150   project meetings. However, time constraints were "challenging" resulting in issues with reciprocal
151   team communication and limitation to explore alternative research interests or extend scope of
152   project outcomes. Similarly, the recommendation for HDR UK to offer training to contributors on
153   research basics was considered for new members for more effective input.
154
155   Researchers emphasised the "meaningful" and "constructive" contribution of PPI involvement on
156   the project. Yet, recommended future team communication to involve regular updates to PPI
157   records post-session. Professional services staff remarked the advanced project development of PAG
158   leads on their impactful contributions at team meetings and external events. The "relaxed"
159   deliverable strategy was successfully employed throughout the project despite time constraints. The
160   creation of resources and HDR UK's role are future objectives to offer more data-related PPI support.
161
162   <u>Discussion and conclusions</u>
163   The Compound Winter Pressures call aimed to provide funding for a series of rapid projects aimed at
164   exploring the nature of chronic and seasonal pressures on NHS hospitals and factors which could be
165   modified through changes in policy. Despite the short timelines, PPI has had a significant impact on
166   the project. This is due, in part, to a long-term strategy of building meaningful working relationships
167   with the EAVE II PAG and wider PPI networks, who are able to contribute perspectives from a cross-
168   section of UK society and come from a variety of demographic backgrounds, medical histories, skills
169   and interests.
170
171   Led by the PPI Team for this project, they have been able to contribute at the level of analytical
172   detail, project steering, and suggestions for broader analytical and structural changes to PPI and
173   health data research in future projects considering the compound pressures of respiratory infections
174   on the NHS.
175
176   A flexible and pragmatic approach to PPI timelines and activities, combined with a focus on more
177   comprehensive evaluation at the end of a three-month project, represents strengths of the PPI work
178   in this study. Limitations include a lack of opportunity to discuss the finer statistical detail and
179   methodology of the project with the PPI Leads, due to analyst availability on short timescales.
180
181   <u>Reflections</u>
182   The regularity of PAG input has provided valuable insight to this project. Whilst PAG contribution has
183   been present at all ages of the research cycle, time constraints were a notable limitation. This
184   challenged direct collaboration between PAG members and researchers that led to minor
185   "pushbacks" on PPI recommendations and scope of the study. Therefore, a key learning would be to
186   maintain regular communication between professional services staff, researchers and contributors
187   to avoid any misrepresentation of findings or outcomes. In support of this, the benefit of a "relaxed"
188   approach to project deliverables contributed to the ability of resolving outstanding developments as
189   they arose.
190
191   However, the broad range PPI research experience across the PAG group may have contributed to
192   an additional limitation on relevance of queries. Therefore, the recommendation of HDR UK's role in
193   supporting data-related training to new members is of educational benefit. Furthermore, public
194   contributors emphasised the usefulness of preliminary resources. Conversely, researchers indicated

195   the importance of team communication and regularly updating records particularly in the analysis
196   stage.

197

Table S5: Baseline characteristics of the included population with ARI hospitalisation
(with readmissions included)

Variable	Level	Value
All		23,889^
Age	Mean (standard deviation)	65.7 (24)
	Median (interquartile range)	72.5 (56.4,82.4)
Number of Risk Groups	0	6005 (25.1%)
	1	5661 (23.7%)
	2	4767 (20.0%)
	3	3437 (14.4%)
	4	2134 (8.9%)
	≥5	1885 (7.9%)
Sex	Female	12727 (53.3%)
	Male	11162 (46.7%)
Age Groups (years)	3-5	965 (4.0%)
	6-17	926 (3.9%)
	18-24	445 (1.9%)
	25-29	375 (1.6%)
	30-34	412 (1.7%)
	35-39	473 (2.0%)
	40-44	470 (2.0%)
	45-49	511 (2.1%)
	50-54	862 (3.6%)
	55-59	1236 (5.2%)
	60-64	1648 (6.9%)
	65-69	1886 (7.9%)
	70-74	2472 (10.3%)
	75-79	3140 (13.1%)
	≥80	8068 (33.8%)
COVID-19 Vaccination Status	Unvaccinated	2576 (10.8%)
	1st Dose >14 days	482 (2.0%)
	2nd Dose >14 days	1654 (6.9%)
	3rd Dose >14 days	8519 (35.7%)
	4th Dose >14 days	9913 (41.5%)
	5th Dose >14 days	745 (3.1%)
Influenza Vaccination Status	Unvaccinated	12518 (52.4%)
	0 - 14 days	1252 (5.2%)
	>14 days	10119 (42.4%)
Urban/Rural Classification	Rural	4020 (16.8%)
	Urban	19869 (83.2%)
SIMD quintiles	1 – Most deprived	6486 (27.2%)
	2	5514 (23.1%)
	3	4609 (19.3%)

	4	3960 (16.6%)
	5 – Least Deprived	3320 (13.9%)
ICU Admission	Adult ICU Admission	1091 (4.6%)
	Children ICU Admission	94 (0.4%)
	No ICU Admission	22704 (95.0%)
Deaths	Yes	1776 (7.4%)
	No	22113 (92.6%)
Length of Hospital Stay (days)	1	4279 (17.9%)
	2	2734 (11.4%)
	3-5	5499 (23.0%)
	6-9	4717 (19.7%)
	10-19	3550 (14.9%)
	≥20	3110 (13.0%)
Number of previous admissions*	0	17417 (72.9%)
	1	4088 (17.1%)
	2	1441 (6.0%)
	3	503 (2.1%)
	4	215 (0.9%)
	5	104 (0.4%)
	≥6	121 (0.5%)
Ethnicity	Asian	354 (1.5%)
	Black	70 (0.3%)
	Mixed	66 (0.3%)
	White	19891 (83.3%)
	Other	84 (0.4%)
	Unknown	3424 (14.3%)
Health Board	NHS Ayrshire and Arran	1899 (7.9%)
	NHS Borders	423 (1.8%)
	NHS Dumfries and Galloway	868 (3.6%)
	NHS Fife	1122 (4.7%)
	NHS Forth Valley	1088 (4.6%)
	NHS Grampian	2077 (8.7%)
	NHS Greater Glasgow and Clyde	6039 (25.3%)
	NHS Highland	884 (3.7%)
	NHS Lanarkshire	3344 (14.0%)
	NHS Lothian	4076 (17.1%)
	NHS Orkney	93 (0.4%)
	NHS Shetland	63 (0.3%)
	NHS Tayside	1817 (7.6%)
	NHS Western Isles	96 (0.4%)

200 Data are n (%). ^ 23,889 includes 1,605 individuals with readmissions.. * Number of previous admissions was
201 within six-month period prior to September 1, 2022. ARI: Acute Respiratory Infection. SIMD: Scottish Index of
202 Multiple Deprivation. ICU: Intensive Care Unit.

203   Table S6: Baseline characteristics of the first admission to hospital for all emergency hospital admissions, and for cardiac, trauma,
204   cancer and ARI hospital admissions respectively during study period

Variable	Level	All Emergency Hospitalisations	ARI	Trauma	Cardiac	Cancer
All		114412	23889	18147	41624	10035
Age	Mean (standard deviation)	61.7 (23.1)	65.7 (24)	61.8 (23.9)	73.5 (14.2)	70.2 (14.8)
	Median (interquartile range)	66.5 (48,79.1)	72.5 (56.4,82.4)	66.5 (45.1,80.8)	75.5 (64.8,83.4)	72.5 (62.2,79.9)
Number of Risk Groups	0	37955 (33.2%)	6005 (25.1%)	6397 (35.3%)	9060 (21.8%)	3326 (33.1%)
	1	30207 (26.4%)	5661 (23.7%)	4964 (27.4%)	9823 (23.6%)	2753 (27.4%)
	2	20676 (18.1%)	4767 (20.0%)	3182 (17.5%)	8836 (21.2%)	1906 (19.0%)
	3	12864 (11.2%)	3437 (14.4%)	1843 (10.2%)	6452 (15.5%)	1067 (10.6%)
	4	7025 (6.1%)	2134 (8.9%)	1018 (5.6%)	3922 (9.4%)	561 (5.6%)
	≥5	5685 (5.0%)	1885 (7.9%)	743 (4.1%)	3531 (8.5%)	422 (4.2%)
Sex	Female	60451 (52.8%)	12727 (53.3%)	9787 (53.9%)	20433 (49.1%)	4718 (47.0%)
	Male	53961 (47.2%)	11162 (46.7%)	8360 (46.1%)	21191 (50.9%)	5317 (53.0%)
Age Groups (years)	3-5	2469 (2.2%)	965 (4.0%)	165 (0.9%)	39 (0.1%)	38 (0.4%)
	6-17	4852 (4.2%)	926 (3.9%)	966 (5.3%)	138 (0.3%)	93 (0.9%)
	18-24	3444 (3.0%)	445 (1.9%)	777 (4.3%)	109 (0.3%)	25 (0.2%)
	25-29	3068 (2.7%)	375 (1.6%)	552 (3.0%)	129 (0.3%)	32 (0.3%)
	30-34	3559 (3.1%)	412 (1.7%)	560 (3.1%)	228 (0.5%)	79 (0.8%)
	35-39	3873 (3.4%)	473 (2.0%)	679 (3.7%)	299 (0.7%)	94 (0.9%)
	40-44	4058 (3.5%)	470 (2.0%)	687 (3.8%)	583 (1.4%)	161 (1.6%)
	45-49	4273 (3.7%)	511 (2.1%)	706 (3.9%)	877 (2.1%)	220 (2.2%)
	50-54	6136 (5.4%)	862 (3.6%)	951 (5.2%)	1583 (3.8%)	454 (4.5%)
	55-59	7712 (6.7%)	1236 (5.2%)	1131 (6.2%)	2428 (5.8%)	701 (7.0%)
	60-64	8837 (7.7%)	1648 (6.9%)	1181 (6.5%)	3367 (8.1%)	1025 (10.2%)

	65-69	9511 (8.3%)	1886 (7.9%)	1257 (6.9%)	4040 (9.7%)	1218 (12.1%)
	70-74	11002 (9.6%)	2472 (10.3%)	1503 (8.3%)	5149 (12.4%)	1498 (14.9%)
	75-79	12883 (11.3%)	3140 (13.1%)	1845 (10.2%)	6654 (16.0%)	1617 (16.1%)
	≥80	28735 (25.1%)	8068 (33.8%)	5187 (28.6%)	16001 (38.4%)	2780 (27.7%)
COVID-19 Vaccination Status	Unvaccinated	11599 (10.1%)	2576 (10.8%)	1849 (10.2%)	1406 (3.4%)	356 (3.5%)
	1st Dose >14 days	2865 (2.5%)	482 (2.0%)	556 (3.1%)	422 (1.0%)	98 (1.0%)
	2nd Dose >14 days	9652 (8.4%)	1654 (6.9%)	1716 (9.5%)	1871 (4.5%)	491 (4.9%)
	3rd Dose >14 days	50097 (43.8%)	8519 (35.7%)	7455 (41.1%)	17291 (41.5%)	3805 (37.9%)
	4th Dose >14 days	37742 (33.0%)	9913 (41.5%)	6293 (34.7%)	19696 (47.3%)	4327 (43.1%)
	5th Dose >14 days	2457 (2.1%)	745 (3.1%)	278 (1.5%)	938 (2.3%)	958 (9.5%)
Influenza Vaccination Status	Unvaccinated	69478 (60.7%)	12518 (52.4%)	11184 (61.6%)	21222 (51.0%)	5786 (57.7%)
	0 - 14 days	6519 (5.7%)	1252 (5.2%)	1063 (5.9%)	2989 (7.2%)	600 (6.0%)
	>14 days	38415 (33.6%)	10119 (42.4%)	5900 (32.5%)	17413 (41.8%)	3649 (36.4%)
Urban/Rural Classification	Rural	20688 (18.1%)	4020 (16.8%)	3474 (19.1%)	8351 (20.1%)	2055 (20.5%)
	Urban	93724 (81.9%)	19869 (83.2%)	14673 (80.9%)	33273 (79.9%)	7980 (79.5%)
SIMD quintiles	1 – Most deprived	29575 (25.8%)	6486 (27.2%)	4519 (24.9%)	9826 (23.6%)	2093 (20.9%)
	2	26050 (22.8%)	5514 (23.1%)	4032 (22.2%)	9577 (23.0%)	2209 (22.0%)
	3	22053 (19.3%)	4609 (19.3%)	3528 (19.4%)	8481 (20.4%)	2016 (20.1%)
	4	19629 (17.2%)	3960 (16.6%)	3209 (17.7%)	7459 (17.9%)	1949 (19.4%)
	5 – Least Deprived	17105 (15.0%)	3320 (13.9%)	2859 (15.8%)	6281 (15.1%)	1768 (17.6%)
ICU Admission	Adult ICU Admission	4502 (3.9%)	1091 (4.6%)	732 (4.0%)	1786 (4.3%)	406 (4.0%)
	Children ICU Admission	312 (0.3%)	94 (0.4%)	53 (0.3%)	9 (0.0%)	< 5 (0.0%)
	No ICU Admission	109598 (95.8%)	22704 (95.0%)	17362 (95.7%)	39829 (95.7%)	9625 (95.9%)
Deaths	Yes	5394 (4.7%)	1776 (7.4%)	465 (2.6%)	3055 (7.3%)	1494 (14.9%)
	No	109018 (95.3%)	22113 (92.6%)	17682 (97.4%)	38569 (92.7%)	8541 (85.1%)

Length of Hospital Stay (days)	1	29559 (25.8%)	4279 (17.9%)	4602 (25.4%)	8038 (19.3%)	1603 (16.0%)
	2	16603 (14.5%)	2734 (11.4%)	2348 (12.9%)	5312 (12.8%)	1084 (10.8%)
	3-4	26974 (23.6%)	5499 (23.0%)	3378 (18.6%)	9866 (23.7%)	2304 (23.0%)
	5-9	18533 (16.2%)	4717 (19.7%)	2827 (15.6%)	7854 (18.9%)	2042 (20.3%)
	10-19	12258 (10.7%)	3550 (14.9%)	2409 (13.3%)	5495 (13.2%)	1602 (16.0%)
	≥20	10485 (9.2%)	3110 (13.0%)	2583 (14.2%)	5059 (12.2%)	1400 (14.0%)
Number of previous admissions*	0	88515 (77.4%)	17417 (72.9%)	14576 (80.3%)	31194 (74.9%)	6709 (66.9%)
	1	17064 (14.9%)	4088 (17.1%)	2401 (13.2%)	7023 (16.9%)	2054 (20.5%)
	2	5438 (4.8%)	1441 (6.0%)	727 (4.0%)	2185 (5.2%)	778 (7.8%)
	3	1895 (1.7%)	503 (2.1%)	224 (1.2%)	732 (1.8%)	280 (2.8%)
	4	804 (0.7%)	215 (0.9%)	114 (0.6%)	289 (0.7%)	130 (1.3%)
	5	333 (0.3%)	104 (0.4%)	48 (0.3%)	97 (0.2%)	47 (0.5%)
	≥6	363 (0.3%)	121 (0.5%)	57 (0.3%)	104 (0.2%)	37 (0.4%)
Ethnicity	Asian	1711 (1.5%)	354 (1.5%)	180 (1.0%)	390 (0.9%)	86 (0.9%)
	Black	421 (0.4%)	70 (0.3%)	46 (0.3%)	85 (0.2%)	17 (0.2%)
	Mixed	385 (0.3%)	66 (0.3%)	64 (0.4%)	58 (0.1%)	17 (0.2%)
	White	94449 (82.6%)	19891 (83.3%)	15031 (82.8%)	35745 (85.9%)	8421 (83.9%)
	Other	368 (0.3%)	84 (0.4%)	36 (0.2%)	67 (0.2%)	22 (0.2%)
	Unknown	17078 (14.9%)	3424 (14.3%)	2790 (15.4%)	5279 (12.7%)	1472 (14.7%)
Health Board	NHS Ayrshire and Arran	9141 (8.0%)	1899 (7.9%)	1229 (6.8%)	4485 (10.8%)	756 (7.5%)
	NHS Borders	2133 (1.9%)	423 (1.8%)	323 (1.8%)	803 (1.9%)	192 (1.9%)
	NHS Dumfries and Galloway	3904 (3.4%)	868 (3.6%)	632 (3.5%)	1918 (4.6%)	428 (4.3%)
	NHS Fife	6063 (5.3%)	1122 (4.7%)	1068 (5.9%)	2278 (5.5%)	535 (5.3%)
	NHS Forth Valley	5934 (5.2%)	1088 (4.6%)	910 (5.0%)	2089 (5.0%)	545 (5.4%)
	NHS Grampian	10833 (9.5%)	2077 (8.7%)	1914 (10.5%)	4374 (10.5%)	1132 (11.3%)

	NHS Greater Glasgow and Clyde	27689 (24.2%)	6039 (25.3%)	4408 (24.3%)	8786 (21.1%)	2130 (21.2%)
	NHS Highland	5392 (4.7%)	884 (3.7%)	841 (4.6%)	2213 (5.3%)	519 (5.2%)
	NHS Lanarkshire	15314 (13.4%)	3344 (14.0%)	2054 (11.3%)	5634 (13.5%)	1199 (11.9%)
	NHS Lothian	16862 (14.7%)	4076 (17.1%)	2657 (14.6%)	4848 (11.6%)	1608 (16.0%)
	NHS Orkney	431 (0.4%)	93 (0.4%)	87 (0.5%)	183 (0.4%)	40 (0.4%)
	NHS Shetland	361 (0.3%)	63 (0.3%)	77 (0.4%)	121 (0.3%)	31 (0.3%)
	NHS Tayside	9711 (8.5%)	1817 (7.6%)	1826 (10.1%)	3596 (8.6%)	862 (8.6%)
	NHS Western Isles	644 (0.6%)	96 (0.4%)	121 (0.7%)	296 (0.7%)	58 (0.6%)

Data are n (%). * Number of previous admissions was within six-month period prior to September 1, 2022. ^ The number of deaths in children is <5 so we did not present a separate group. ARI: Acute Respiratory Infection. SIMD: Scottish Index of Multiple Deprivation. ICU: Intensive Care Unit. ICD-10 codes for cardiac, trauma and cancer are I, S/T, C respectively.

208 Table S7: Adjusted odds ratio for acute respiratory infections associated with a prolonged hospital stay in adults aged ≥18 years old

Variable	Level	ARI hospitalisation		Influenza hospitalisation		SARS-CoV-2 hospitalisation	
		No. of events	OR (LCI, UCI)	No. of events	OR (LCI, UCI)	No. of events	OR (LCI, UCI)
Sex	Female	5994	1.00	3572	1.00	1313	1.00
	Male	5247	1.03 (0.98, 1.09)	3154	1.02 (0.94, 1.09)	1291	1.21 (1.07, 1.38)
Age (years)	18-24	52	0.78 (0.52, 1.19)	31	1.15 (0.66, 2.01)	10	1.61 (0.50, 5.69)
	25-29	53	1.00	34	1.00	5	1.00
	30-34	73	1.21 (0.82, 1.79)	47	1.11 (0.67, 1.85)	10	1.22 (0.40, 4.23)
	35-39	91	1.36 (0.94, 1.98)	66	1.40 (0.87, 2.27)	17	1.99 (0.70, 6.54)
	40-44	154	2.73 (1.94, 3.91)	96	2.17 (1.38, 3.46)	27	3.00 (1.12, 9.54)
	45-49	182	3.09 (2.20, 4.39)	120	2.26 (1.46, 3.56)	28	3.43 (1.28, 10.93)
	50-54	305	3.01 (2.19, 4.20)	198	2.15 (1.43, 3.32)	62	4.87 (1.94, 14.90)
	55-59	545	4.31 (3.18, 5.96)	342	2.94 (1.98, 4.49)	118	6.85 (2.80, 20.61)
	60-64	747	4.50 (3.34, 6.18)	497	3.42 (2.32, 5.18)	151	5.77 (2.38, 17.24)
	65-69	932	5.36 (3.98, 7.35)	611	3.68 (2.50, 5.56)	220	8.99 (3.73, 26.79)
	70-74	1259	5.73 (4.27, 7.84)	780	3.82 (2.60, 5.75)	275	7.70 (3.21, 22.85)
	75-79	1804	7.43 (5.55, 10.15)	1091	4.96 (3.38, 7.45)	441	12.06 (5.05, 35.71)
	≥80	5044	9.30 (6.98, 12.64)	2813	6.03 (4.14, 9.02)	1240	16.17 (6.82, 47.64)
SIMD quintiles	1 - Most deprived	3094	1.22 (1.11, 1.34)	1892	1.19 (1.05, 1.35)	626	1.31 (1.06, 1.61)
	2	2603	1.12 (1.02, 1.24)	1556	1.09 (0.96, 1.24)	632	1.23 (1.00, 1.51)
	3	2151	1.12 (1.02, 1.24)	1261	1.11 (0.97, 1.26)	526	1.25 (1.01, 1.56)
	4	1795	1.06 (0.96, 1.17)	1075	1.09 (0.96, 1.25)	439	1.10 (0.88, 1.38)
	5 - Least deprived	1539	1.00	905	1.00	364	1.00
Number of risk groups	0	1879	1.00	1091	1.00	430	1.00
	1	2596	1.14 (1.05, 1.24)	1585	1.14 (1.02, 1.28)	609	1.12 (0.92, 1.36)
	2	2458	1.16 (1.06, 1.27)	1429	1.08 (0.96, 1.21)	580	1.05 (0.86, 1.28)
	3	1957	1.27 (1.15, 1.39)	1166	1.22 (1.08, 1.39)	462	1.16 (0.93, 1.43)

	4	1228	1.19 (1.06, 1.33)	751	1.14 (0.98, 1.31)	276	1.00 (0.78, 1.29)
	≥5	1123	1.23 (1.10, 1.38)	704	1.14 (0.98, 1.32)	247	1.22 (0.93, 1.61)
BMI	<18.5	515	1.12 (0.97, 1.30)	350	1.07 (0.89, 1.28)	123	1.05 (0.77, 1.46)
	18.5 – 24.9	3622	1.00	2233	1.00	859	1.00
	25 – 29.9	3651	0.92 (0.86, 0.99)	2136	0.90 (0.82, 0.98)	831	0.88 (0.75, 1.04)
	30 – 34.9	2078	0.88 (0.81, 0.95)	1202	0.88 (0.80, 0.98)	464	0.85 (0.71, 1.02)
	35 – 39.9	698	0.87 (0.77, 0.98)	414	0.85 (0.72, 0.99)	165	0.95 (0.72, 1.24)
	≥40	677	0.98 (0.86, 1.10)	391	0.91 (0.77, 1.07)	162	1.20 (0.91, 1.59)
Number of Previous Admissions	0	7747	1.00	4683	1.00	1772	1.00
	1	2210	1.26 (1.17, 1.35)	1289	1.27 (1.15, 1.40)	529	1.21 (1.03, 1.43)
	2	822	1.50 (1.33, 1.68)	495	1.45 (1.24, 1.69)	192	1.66 (1.27, 2.17)
	3	268	1.42 (1.17, 1.73)	148	1.53 (1.17, 2.01)	63	1.49 (0.97, 2.34)
	4	103	1.33 (0.98, 1.80)	61	1.33 (0.89, 2.01)	20	1.45 (0.72, 2.99)
	5	49	1.30 (0.85, 2.00)	29	1.22 (0.69, 2.15)	19	1.46 (0.70, 3.13)
	≥6	42	1.49 (0.94, 2.38)	21	1.01 (0.55, 1.85)	9	1.06 (0.37, 3.23)
Urban/Rural Classification	Rural	1744	1.00	1052	1.00 (1.00, 1.00)	389	1.00
	Urban	9438	1.28 (1.19, 1.38)	5637	1.18 (1.07, 1.30)	2198	1.51 (1.27, 1.79)

Prolonged hospital stay means a hospital stay longer than five days. OR: Odds Ratio. LCI: Lower Confidence Interval. UCI: Upper Confidence Interval. Odds ratios were derived using cox proportional hazard model adjusting for age, sex, socioeconomic status, number of risk groups, and number of previous emergency hospitalisations within six months prior to September 1, 2022. BMI: Body Mass Index. SIMD: Scottish Index of Multiple Deprivation.

Table S8: Baseline characteristics of the included population using the strict definition
of acute respiratory infections (with readmissions included)

Variable	Level	Value
All		
Age	Mean (standard deviation)	63.6 (25.3)
	Median (interquartile range)	71.5 (53.2,81.6)
Number of Risk Groups	0	3926 (27.0%)
	1	3420 (23.5%)
	2	2825 (19.4%)
	3	2009 (13.8%)
	4	1242 (8.5%)
	≥5	1108 (7.6%)
Sex	Female	7814 (53.8%)
	Male	6716 (46.2%)
Age Groups (years)	3-5	745 (5.1%)
	6-17	677 (4.7%)
	18-24	321 (2.2%)
	25-29	269 (1.9%)
	30-34	294 (2.0%)
	35-39	306 (2.1%)
	40-44	311 (2.1%)
	45-49	304 (2.1%)
	50-54	503 (3.5%)
	55-59	758 (5.2%)
	60-64	993 (6.8%)
	65-69	1127 (7.8%)
	70-74	1484 (10.2%)
	75-79	1875 (12.9%)
	≥80	4563 (31.4%)
COVID-19 Vaccination Status	Unvaccinated	1836 (12.6%)
	1st Dose >14 days	298 (2.1%)
	2nd Dose >14 days	1035 (7.1%)
	3rd Dose >14 days	5151 (35.5%)
	4th Dose >14 days	5754 (39.6%)
	5th Dose >14 days	456 (3.1%)
Influenza Vaccination Status	Unvaccinated	7591 (52.2%)
	0 - 14 days	740 (5.1%)
	>14 days	6199 (42.7%)
Urban/Rural Classification	Rural	2455 (16.9%)
	Urban	12075 (83.1%)
SIMD quintiles	1 – Most deprived	4016 (27.6%)
	2	3368 (23.2%)
	3	2791 (19.2%)

	4	2379 (16.4%)
	5 – Least Deprived	1976 (13.6%)
ICU Admission	Adult ICU Admission	615 (4.2%)
	Children ICU Admission	72 (0.5%)
	No ICU Admission	13843 (95.3%)
Deaths	Yes	1003 (6.9%)
	No	13527 (93.1%)
Length of Hospital Stay (days)	1	3186 (21.9%)
	2	1933 (13.3%)
	3-5	3667 (25.2%)
	6-9	2782 (19.1%)
	10-19	1785 (12.3%)
	≥20	1177 (8.1%)
Number of previous admissions*	0	10920 (75.2%)
	1	2319 (16.0%)
	2	811 (5.6%)
	3	263 (1.8%)
	4	112 (0.8%)
	5	51 (0.4%)
	≥6	54 (0.4%)
Ethnicity	Asian	261 (1.8%)
	Black	48 (0.3%)
	Mixed	47 (0.3%)
	White	11925 (82.1%)
	Other	54 (0.4%)
	Unknown	2195 (15.1%)
Health Board	NHS Ayrshire and Arran	1154 (7.9%)
	NHS Borders	224 (1.5%)
	NHS Dumfries and Galloway	526 (3.6%)
	NHS Fife	689 (4.7%)
	NHS Forth Valley	686 (4.7%)
	NHS Grampian	1245 (8.6%)
	NHS Greater Glasgow and Clyde	3726 (25.6%)
	NHS Highland	542 (3.7%)
	NHS Lanarkshire	2133 (14.7%)
	NHS Lothian	2295 (15.8%)
	NHS Orkney	50 (0.3%)
	NHS Shetland	35 (0.2%)
	NHS Tayside	1169 (8.0%)
	NHS Western Isles	56 (0.4%)

215 Data are n (%). Strict definition of acute respiratory infections (ARIs) means a hospital emergency admission
216 with an ICD-10 code for respiratory infections in the first position of the first episode (ARIs were the primary
217 reason for hospital admission). * Number of previous admissions was within six-month period prior to
218 September 1, 2022. SIMD: Scottish Index of Multiple Deprivation.

219   Table S9: Adjusted hazard ratio for acute respiratory infections hospitalisation in adults aged ≥18 years old using the strict definition
220   of acute respiratory infections

Variable	Level	ARI hospitalisation		Influenza hospitalisation		SARS-CoV-2 hospitalisation	
		No. of events	HR (LCI, UCI)	No. of events	HR (LCI, UCI)	No. of events	HR (LCI, UCI)
Sex	Female	7144	1.00	4136	1.00	1066	1.00
	Male	5964	1.03 (0.99, 1.07)	3449	1.04 (0.99, 1.09)	976	1.16 (1.06, 1.27)
Age (years)	18-24	321	1.01 (0.86, 1.18)	85	0.64 (0.48, 0.85)	20	0.85 (0.46, 1.58)
	25-29	269	1.00	111	1.00	20	1.00
	30-34	294	0.93 (0.79, 1.10)	142	1.09 (0.85, 1.39)	38	1.59 (0.93, 2.74)
	35-39	306	0.97 (0.82, 1.14)	153	1.18 (0.92, 1.50)	29	1.22 (0.69, 2.16)
	40-44	311	0.99 (0.84, 1.16)	176	1.35 (1.07, 1.71)	37	1.53 (0.89, 2.63)
	45-49	304	1.01 (0.86, 1.19)	188	1.51 (1.19, 1.91)	34	1.47 (0.85, 2.56)
	50-54	503	1.32 (1.14, 1.53)	320	2.04 (1.65, 2.53)	59	2.00 (1.20, 3.31)
	55-59	758	1.72 (1.49, 1.97)	473	2.58 (2.10, 3.17)	115	3.40 (2.11, 5.46)
	60-64	993	2.20 (1.92, 2.52)	628	3.36 (2.74, 4.11)	149	4.21 (2.64, 6.72)
	65-69	1127	2.65 (2.32, 3.02)	719	4.05 (3.32, 4.95)	177	5.27 (3.32, 8.38)
	70-74	1484	3.48 (3.06, 3.97)	923	5.21 (4.27, 6.35)	254	7.71 (4.88, 12.17)
	75-79	1875	4.39 (3.85, 5.00)	1106	6.28 (5.15, 7.67)	321	9.68 (6.13, 15.27)
	≥80	4563	6.36 (5.60, 7.23)	2561	8.90 (7.32, 10.82)	789	15.01 (9.56, 23.56)
SIMD quintiles	1 - Most deprived	3650	1.65 (1.55, 1.75)	2182	1.79 (1.65, 1.93)	535	1.63 (1.40, 1.89)
	2	3073	1.42 (1.34, 1.51)	1774	1.49 (1.38, 1.62)	494	1.47 (1.26, 1.71)
	3	2499	1.27 (1.20, 1.35)	1435	1.33 (1.23, 1.45)	401	1.34 (1.14, 1.56)
	4	2111	1.13 (1.06, 1.20)	1215	1.18 (1.09, 1.29)	332	1.13 (0.97, 1.33)
	5 - Least deprived	1775	1.00	979	1.00	280	1.00
Number of risk groups	0	2780	1.00	1458	1.00	325	1.00
	1	3218	1.92 (1.82, 2.02)	1848	2.07 (1.93, 2.22)	486	2.39 (2.07, 2.75)
	2	2767	2.94 (2.78, 3.12)	1636	3.29 (3.05, 3.56)	460	3.87 (3.32, 4.50)

	3	1993	3.83 (3.59, 4.09)	1190	4.46 (4.09, 4.87)	356	5.63 (4.76, 6.66)
	4	1242	4.60 (4.26, 4.96)	760	5.61 (5.07, 6.19)	224	7.36 (6.07, 8.91)
	≥5	1108	5.13 (4.72, 5.57)	693	6.78 (6.07, 7.56)	191	7.72 (6.26, 9.53)
BMI	<18.5	569	1.61 (1.46, 1.78)	380	1.85 (1.64, 2.10)	93	1.83 (1.46, 2.30)
	18.5 – 24.9	4003	1.00	2358	1.00	619	1.00
	25 – 29.9	4265	0.87 (0.83, 0.91)	2436	0.83 (0.79, 0.88)	656	0.84 (0.75, 0.94)
	30 – 34.9	2537	0.90 (0.86, 0.95)	1427	0.83 (0.78, 0.89)	391	0.87 (0.76, 0.99)
	35 – 39.9	844	1.02 (0.94, 1.10)	485	0.95 (0.86, 1.05)	141	1.03 (0.85, 1.25)
	≥40	890	1.15 (1.06, 1.24)	499	1.05 (0.95, 1.16)	142	1.28 (1.06, 1.55)
Number of Previous Admissions	0	9774	1.00	5663	1.00	1448	1.00
	1	2170	2.74 (2.60, 2.88)	1242	2.88 (2.69, 3.08)	389	3.53 (3.13, 3.99)
	2	754	3.94 (3.61, 4.30)	448	4.47 (3.99, 5.01)	131	5.53 (4.54, 6.74)
	3	231	4.36 (3.73, 5.11)	130	4.62 (3.75, 5.68)	39	6.09 (4.19, 8.84)
	4	95	5.52 (4.18, 7.28)	53	5.69 (3.95, 8.21)	16	9.96 (5.30, 18.73)
	5	45	5.97 (4.25, 8.39)	27	7.44 (4.77, 11.60)	12	14.88 (8.13, 27.23)
	≥6	39	5.26 (3.65, 7.60)	22	7.44 (4.39, 12.60)	7	8.15 (4.41, 15.04)
Urban/Rural Classification	Rural	2239	1.00	1255	1.00	352	1.00
	Urban	10869	1.15 (1.10, 1.20)	6330	1.19 (1.11, 1.26)	1690	1.18 (1.05, 1.33)

221 HR: Hazard Ratio. LCI: Lower Confidence Interval. UCI: Upper Confidence Interval. Strict definition of acute respiratory infections (ARIs) means a hospital emergency
222 admission with an ICD-10 code for respiratory infections in the first position of the first episode (ARIs were the primary reason for hospital admission). Hazard ratios were
223 derived using cox proportional hazard model adjusting for age, sex, socioeconomic status, number of risk groups, and number of previous emergency hospitalisations
224 within six months prior to September 1, 2022. BMI: Body Mass Index. SIMD: Scottish Index of Multiple Deprivation.

Table S10: Adjusted hazard ratio for acute respiratory infections hospitalisation in
226 children using the strict definition of acute respiratory infections

Variable	Level	ARI Hospitalisation	
		Number of events	HR (LCI, UCI)
Sex	Female	670	1.00
	Male	752	1.04 (0.93, 1.15)
Age Group (years)	3 - 5	745	4.95 (4.42, 5.55)
	6 - 17	677	1.00
SIMD quintiles	1 - Most deprived	366	1.27 (1.07, 1.51)
	2	295	1.22 (1.02, 1.46)
	3	292	1.52 (1.27, 1.81)
	4	268	1.26 (1.05, 1.51)
	5 - Least deprived	201	1.00
Number of risk groups	0	1145	1.00
	1	203	2.16 (1.85, 2.53)
	2	58	3.69 (2.69, 5.08)
	3	16	6.22 (3.63, 10.65)
	4	0	NA
	≥5	0	NA
Number of previous admissions	0	1146	1.00
	1	149	4.26 (3.54, 5.11)
	2	57	8.11 (5.82, 11.29)
	3	32	13.81 (10.29, 18.52)
	4	17	20.84 (12.89, 33.67)
	5	6	8.18 (3.49, 19.19)
	≥6	15	32.18 (21.40, 48.40)
Urban/Rural Classification	Rural	216	1.00
	Urban	1206	1.24 (1.07, 1.44)

227 HR: Hazard Ratio. LCI: Lower Confidence Interval. UCI: Upper Confidence Interval. Strict definition of acute
228 respiratory infections (ARIs) means a hospital emergency admission with an ICD-10 code for respiratory
229 infections in the first position of the first episode (ARIs were the primary reason for hospital admission).
230 Hazard ratios were derived using cox proportional hazard model adjusting for age, sex, socioeconomic status,
231 number of risk groups, and number of previous emergency hospitalisations within six months prior to
232 September 1, 2022. SIMD: Scottish Index of Multiple Deprivation. NA: not available.

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Variable	Level	Influenza hospitalisation		SARS-CoV-2 hospitalisation	
		No. of events	HR (LCI, UCI)	No. of events	HR (LCI, UCI)
Sex	Female	1726	1.00	1410	1.00
	Male	1258	0.89 (0.82, 0.96)	1339	1.22 (1.13, 1.32)
Age (years)	18-24	71	0.67 (0.49, 0.91)	35	0.91 (0.56, 1.46)
	25-29	94	1.00	33	1.00
	30-34	95	0.87 (0.65, 1.15)	49	1.30 (0.84, 2.02)
	35-39	101	0.92 (0.70, 1.22)	48	1.28 (0.82, 2.00)
	40-44	92	0.85 (0.64, 1.14)	61	1.65 (1.08, 2.52)
	45-49	93	0.89 (0.67, 1.19)	50	1.39 (0.89, 2.15)
	50-54	164	1.22 (0.95, 1.57)	101	2.20 (1.48, 3.25)
	55-59	225	1.41 (1.11, 1.79)	149	2.76 (1.89, 4.02)
	60-64	256	1.59 (1.25, 2.02)	198	3.60 (2.49, 5.21)
	65-69	312	2.06 (1.63, 2.61)	230	4.44 (3.08, 6.40)
	70-74	323	2.12 (1.67, 2.68)	313	5.99 (4.17, 8.60)
	75-79	384	2.58 (2.04, 3.26)	444	8.66 (6.05, 12.38)
	≥80	774	3.14 (2.50, 3.95)	1038	11.74 (8.24, 16.72)
SIMD quintiles	1 - Most deprived	970	2.07 (1.83, 2.34)	722	1.57 (1.39, 1.78)
	2	718	1.60 (1.41, 1.82)	673	1.48 (1.31, 1.68)
	3	488	1.21 (1.06, 1.39)	515	1.23 (1.08, 1.41)
	4	440	1.17 (1.01, 1.34)	458	1.17 (1.02, 1.34)
	5 - Least deprived	368	1.00	381	1.00
Number of risk groups	0	573	1.00	529	1.00
	1	839	2.62 (2.35, 2.92)	666	1.96 (1.75, 2.21)
	2	653	4.26 (3.77, 4.81)	598	3.02 (2.66, 3.43)
	3	434	5.83 (5.06, 6.72)	456	4.06 (3.52, 4.67)
	4	259	7.20 (6.10, 8.50)	274	4.57 (3.88, 5.40)
	≥5	226	8.46 (7.05, 10.15)	226	4.67 (3.91, 5.57)
BMI	<18.5	140	1.74 (1.45, 2.09)	137	1.90 (1.58, 2.29)
	18.5 – 24.9	914	1.00	862	1.00
	25 – 29.9	929	0.83 (0.75, 0.91)	863	0.79 (0.72, 0.87)
	30 – 34.9	547	0.82 (0.74, 0.91)	516	0.88 (0.78, 0.98)
	35 – 39.9	199	0.98 (0.84, 1.15)	174	1.00 (0.85, 1.18)
	≥40	255	1.20 (1.04, 1.38)	197	1.26 (1.07, 1.47)
Number of Previous Admissions	0	2405	1.00	1988	1.00
	1	391	2.22 (1.98, 2.50)	510	2.87 (2.58, 3.19)
	2	126	3.21 (2.66, 3.87)	159	3.64 (3.06, 4.32)
	3	28	2.47 (1.69, 3.60)	49	3.86 (2.86, 5.21)
	4	11	3.07 (1.63, 5.77)	21	5.32 (3.31, 8.53)
	5	10	5.60 (3.01, 10.42)	15	8.65 (5.02, 14.91)
	≥6	13	9.61 (5.01, 18.43)	7	4.90 (2.33, 10.32)
Urban/Rural Classification	Rural	413	1.00	447	1.00
	Urban	2571	1.37 (1.23, 1.52)	2302	1.23 (1.11, 1.37)

238   ARI: Acute Respiratory Infection. HR: Hazard Ratio. LCI: Lower Confidence Interval. UCI: Upper Confidence
239   Interval. Hazard ratios were derived using cox proportional hazard model adjusting for age, sex, socioeconomic
240   status, number of risk groups, and number of previous emergency hospitalisations within six months prior to
241   September 1, 2022. SIMD: Scottish Index of Multiple Deprivation.

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Table S12: Adjusted hazard ratio for acute respiratory infections hospitalisation in adults aged ≥18 years old with ethnicity included

Variable	Level	ARI hospitalisation		Influenza hospitalisation		SARS-CoV-2 hospitalisation	
		No. of events	HR (LCI, UCI)	No. of events	HR (LCI, UCI)	No. of events	HR (LCI, UCI)
Sex	Female	11041	1.00	6173	1.00	2179	1.00
	Male	9484	1.09 (1.06, 1.12)	5393	1.11 (1.07, 1.16)	2017	1.22 (1.14, 1.30)
Age (years)	18-24	427	1.01 (0.88, 1.16)	123	0.68 (0.54, 0.86)	49	1.03 (0.68, 1.57)
	25-29	364	1.00	154	1.00	40	1.00
	30-34	397	0.94 (0.81, 1.08)	189	1.05 (0.85, 1.30)	62	1.34 (0.90, 1.99)
	35-39	449	1.05 (0.92, 1.20)	218	1.21 (0.98, 1.48)	71	1.52 (1.03, 2.23)
	40-44	458	1.07 (0.94, 1.23)	247	1.37 (1.12, 1.67)	81	1.73 (1.18, 2.53)
	45-49	482	1.22 (1.06, 1.39)	285	1.69 (1.39, 2.06)	76	1.76 (1.20, 2.58)
	50-54	811	1.62 (1.44, 1.84)	482	2.30 (1.92, 2.75)	140	2.60 (1.83, 3.69)
	55-59	1151	1.96 (1.74, 2.20)	684	2.73 (2.29, 3.25)	223	3.53 (2.52, 4.95)
	60-64	1534	2.55 (2.27, 2.85)	920	3.58 (3.02, 4.24)	287	4.47 (3.21, 6.22)
	65-69	1741	3.13 (2.79, 3.50)	1084	4.54 (3.83, 5.37)	352	5.95 (4.29, 8.26)
	70-74	2276	4.13 (3.69, 4.61)	1376	5.89 (4.98, 6.97)	476	8.35 (6.04, 11.56)
	75-79	2914	5.39 (4.82, 6.02)	1709	7.49 (6.34, 8.86)	650	11.86 (8.59, 16.37)
	≥80	7521	7.90 (7.09, 8.80)	4095	10.53 (8.93, 12.41)	1689	18.87 (13.71, 25.96)
SIMD quintiles	1 - Most deprived	5582	1.62 (1.54, 1.69)	3241	1.72 (1.62, 1.83)	1008	1.50 (1.35, 1.66)
	2	4757	1.41 (1.34, 1.48)	2687	1.45 (1.36, 1.54)	1010	1.47 (1.33, 1.63)
	3	3937	1.27 (1.21, 1.33)	2177	1.28 (1.20, 1.37)	841	1.31 (1.18, 1.46)
	4	3376	1.11 (1.06, 1.17)	1886	1.14 (1.06, 1.22)	729	1.14 (1.02, 1.27)
	5 - Least deprived	2873	1.00	1575	1.00	608	1.00
Number of risk groups	0	4293	1.00	2197	1.00	814	1.00
	1	5090	1.83 (1.76, 1.91)	2877	2.01 (1.89, 2.12)	1026	1.90 (1.73, 2.09)
	2	4365	2.68 (2.56, 2.80)	2473	2.98 (2.80, 3.18)	929	2.83 (2.55, 3.14)
	3	3155	3.44 (3.26, 3.63)	1814	4.03 (3.75, 4.33)	687	3.90 (3.47, 4.38)

			HR (LCI, UCI)		HR (LCI, UCI)		HR (LCI, UCI)
	4	1927	3.76 (3.53, 4.01)	1149	4.62 (4.25, 5.02)	407	4.26 (3.71, 4.89)
	≥5	1695	4.24 (3.96, 4.53)	1056	5.70 (5.21, 6.23)	333	4.61 (3.98, 5.35)
BMI	<18.5	861	1.58 (1.46, 1.71)	569	1.86 (1.68, 2.05)	187	1.85 (1.57, 2.17)
	18.5 − 24.9	6372	1.00	3649	1.00	1319	1.00
	25 − 29.9	6698	0.85 (0.82, 0.88)	3736	0.81 (0.78, 0.85)	1367	0.81 (0.75, 0.88)
	30 − 34.9	3899	0.89 (0.85, 0.93)	2113	0.81 (0.77, 0.86)	782	0.84 (0.77, 0.92)
	35 − 39.9	1324	1.01 (0.94, 1.07)	755	0.95 (0.88, 1.04)	270	0.99 (0.87, 1.13)
	≥40	1371	1.13 (1.06, 1.20)	744	1.04 (0.96, 1.12)	271	1.16 (1.01, 1.32)
Number of Previous Admissions	0	15104	1.00	8542	1.00	3003	1.00
	1	3544	2.66 (2.55, 2.78)	1970	2.76 (2.61, 2.92)	785	3.25 (2.98, 3.54)
	2	1193	3.80 (3.54, 4.07)	692	4.32 (3.94, 4.74)	250	5.14 (4.44, 5.95)
	3	391	4.56 (4.05, 5.13)	203	4.85 (4.12, 5.70)	87	6.92 (5.46, 8.78)
	4	154	5.92 (4.82, 7.28)	80	6.37 (4.79, 8.48)	32	10.94 (7.14, 16.78)
	5	72	6.65 (5.02, 8.82)	42	7.63 (5.29, 11.00)	25	17.99 (11.13, 29.09)
	≥6	67	7.99 (5.81, 10.98)	37	9.59 (6.07, 15.13)	14	13.81 (8.22, 23.20)
Urban/Rural Classification	Rural	3496	1.00	1930	1.00	729	1.00
	Urban	17029	1.12 (1.07, 1.16)	9636	1.14 (1.08, 1.20)	3467	1.16 (1.07, 1.26)
Ethnicity	Asian	272	0.93 (0.83, 1.04)	140	0.91 (0.77, 1.08)	47	0.91 (0.68, 1.21)
	Black	49	0.98 (0.73, 1.32)	19	0.70 (0.44, 1.12)	13	1.44 (0.80, 2.60)
	Mixed	37	0.84 (0.62, 1.14)	12	0.58 (0.33, 1.03)	7	0.92 (0.47, 1.83)
	Other	57	1.06 (0.81, 1.37)	32	1.09 (0.77, 1.55)	11	1.10 (0.61, 1.98)
	White	17668	1.00	9964	1.00	3590	1.00
	Unknown	2442	0.61 (0.58, 0.63)	1399	0.63 (0.59, 0.66)	528	0.64 (0.58, 0.70)

245   HR: Hazard Ratio. LCI: Lower Confidence Interval. UCI: Upper Confidence Interval. Hazard ratios were derived using cox proportional hazard model adjusting for age, sex,
246   socioeconomic status, number of risk groups, and number of previous emergency hospitalisations within six months prior to September 1, 2022. BMI: Body Mass Index.
247   SIMD: Scottish Index of Multiple Deprivation.

248   Table S13: Adjusted hazard ratio for acute respiratory infections hospitalisation in adults aged ≥18 years old with smoking status
249   included

Variable	Level	ARI hospitalisation		Influenza hospitalisation		SARS-CoV-2 hospitalisation	
		No. of events	HR (LCI, UCI)	No. of events	HR (LCI, UCI)	No. of events	HR (LCI, UCI)
Sex	Female	11041	1.00	6173	1.00	2179	1.00
	Male	9484	1.04 (1.01, 1.08)	5393	1.05 (1.01, 1.09)	2017	1.15 (1.08, 1.23)
Age (years)	18-24	427	1.00 (0.87, 1.15)	123	0.66 (0.52, 0.84)	49	1.06 (0.69, 1.61)
	25-29	364	1.00	154	1.00	40	1.00
	30-34	397	0.91 (0.79, 1.05)	189	1.01 (0.82, 1.25)	62	1.30 (0.87, 1.93)
	35-39	449	0.98 (0.85, 1.12)	218	1.10 (0.89, 1.35)	71	1.42 (0.96, 2.09)
	40-44	458	0.97 (0.85, 1.11)	247	1.20 (0.98, 1.47)	81	1.59 (1.09, 2.33)
	45-49	482	1.11 (0.97, 1.27)	285	1.50 (1.23, 1.82)	76	1.61 (1.10, 2.37)
	50-54	811	1.44 (1.27, 1.63)	482	1.95 (1.63, 2.34)	140	2.30 (1.62, 3.27)
	55-59	1151	1.79 (1.59, 2.01)	684	2.41 (2.03, 2.87)	223	3.21 (2.29, 4.50)
	60-64	1534	2.31 (2.06, 2.59)	920	3.13 (2.64, 3.72)	287	3.99 (2.86, 5.56)
	65-69	1741	2.87 (2.57, 3.22)	1084	4.05 (3.42, 4.80)	352	5.34 (3.85, 7.42)
	70-74	2276	3.74 (3.35, 4.19)	1376	5.10 (4.31, 6.04)	476	7.16 (5.17, 9.91)
	75-79	2914	4.96 (4.44, 5.54)	1709	6.55 (5.54, 7.74)	650	10.11 (7.32, 13.96)
	≥80	7521	7.61 (6.83, 8.48)	4095	9.40 (7.97, 11.09)	1689	15.38 (11.18, 21.17)
SIMD quintiles	1 - Most deprived	5582	1.52 (1.45, 1.59)	3241	1.53 (1.44, 1.63)	1008	1.33 (1.20, 1.48)
	2	4757	1.35 (1.28, 1.41)	2687	1.35 (1.27, 1.44)	1010	1.38 (1.24, 1.53)
	3	3937	1.21 (1.15, 1.27)	2177	1.20 (1.12, 1.28)	841	1.24 (1.12, 1.38)
	4	3376	1.11 (1.06, 1.17)	1886	1.12 (1.05, 1.20)	729	1.15 (1.03, 1.28)
	5 - Least deprived	2873	1.00	1575	1.00	608	1.00
Number of risk groups	0	4293	1.00	2197	1.00	814	1.00
	1	5090	1.90 (1.82, 1.98)	2877	2.05 (1.94, 2.17)	1026	1.90 (1.73, 2.09)
	2	4365	2.90 (2.77, 3.04)	2473	3.12 (2.93, 3.33)	929	2.90 (2.61, 3.21)
	3	3155	3.66 (3.47, 3.86)	1814	4.03 (3.75, 4.32)	687	3.60 (3.20, 4.05)
	4	1927	4.26 (4.00, 4.54)	1149	4.94 (4.55, 5.37)	407	4.00 (3.49, 4.58)
	≥5	1695	4.81 (4.49, 5.14)	1056	5.92 (5.43, 6.47)	333	4.15 (3.59, 4.79)
BMI	<18.5	861	1.54 (1.43, 1.67)	569	1.75 (1.59, 1.93)	187	1.67 (1.43, 1.96)
	18.5 – 24.9	6372	1.00	3649	1.00	1319	1.00
	25 – 29.9	6698	0.87 (0.84, 0.90)	3736	0.84 (0.80, 0.88)	1367	0.85 (0.79, 0.92)

	30 – 34.9	3899	0.91 (0.87, 0.95)	2113	0.84 (0.80, 0.89)	782	0.89 (0.81, 0.97)
	35 – 39.9	1324	1.05 (0.99, 1.12)	755	1.00 (0.92, 1.09)	270	1.04 (0.91, 1.18)
	≥40	1371	1.17 (1.10, 1.24)	744	1.08 (1.00, 1.18)	271	1.19 (1.04, 1.37)
Number of Previous Admissions	0	15104	1.00	8542	1.00	3003	1.00
	1	3544	2.74 (2.63, 2.85)	1970	2.62 (2.48, 2.77)	785	2.87 (2.63, 3.12)
	2	1193	3.65 (3.40, 3.92)	692	3.63 (3.32, 3.97)	250	3.57 (3.10, 4.11)
	3	391	4.68 (4.15, 5.28)	203	4.18 (3.58, 4.87)	87	4.83 (3.84, 6.07)
	4	154	5.33 (4.32, 6.59)	80	4.56 (3.49, 5.97)	32	5.28 (3.59, 7.76)
	5	72	5.59 (4.08, 7.67)	42	5.19 (3.62, 7.45)	25	9.61 (6.07, 15.22)
	≥6	67	6.05 (4.43, 8.26)	37	5.54 (3.84, 7.99)	14	6.11 (3.65, 10.22)
Urban/Rural Classification	Rural	3496	1.00	1930	1.00	729	1.00
	Urban	17029	1.17 (1.12, 1.21)	9636	1.19 (1.13, 1.26)	3467	1.18 (1.09, 1.28)
Smoking Status	Ex Smoker	4822	1.26 (1.22, 1.31)	3017	1.45 (1.38, 1.51)	935	1.12 (1.03, 1.21)
	Non Smoker	11559	1.00	6124	1.00	2490	1.00
	Smoker	2393	1.59 (1.51, 1.66)	1514	1.83 (1.72, 1.94)	462	1.48 (1.33, 1.64)
	Unknown	1751	1.09 (1.04, 1.15)	911	1.17 (1.09, 1.26)	309	0.98 (0.87, 1.11)

250 HR: Hazard Ratio. LCI: Lower Confidence Interval. UCI: Upper Confidence Interval. Hazard ratios were derived using cox proportional hazard model adjusting for age, sex,

251 socioeconomic status, number of risk groups, and number of previous emergency hospitalisations within six months prior to September 1, 2022. BMI: Body Mass Index.

252 SIMD: Scottish Index of Multiple Deprivation.

Table S14: Adjusted hazard ratio for influenza associated ARI hospitalisation in adults
254 aged ≥18 years old after adjusting for influenza vaccination

Variable	Level	Influenza hospitalisation	
		No. of events	HR (LCI, UCI)
Sex	Female	6173	1.00
	Male	5393	1.08 (1.04, 1.12)
Age (years)	18-24	123	0.68 (0.54, 0.87)
	25-29	154	1.00
	30-34	189	1.08 (0.87, 1.34)
	35-39	218	1.25 (1.02, 1.54)
	40-44	247	1.44 (1.18, 1.76)
	45-49	285	1.76 (1.45, 2.14)
	50-54	482	2.34 (1.96, 2.81)
	55-59	684	2.94 (2.47, 3.51)
	60-64	920	3.97 (3.35, 4.72)
	65-69	1084	5.15 (4.34, 6.12)
	70-74	1376	6.69 (5.64, 7.93)
	75-79	1709	8.34 (7.03, 9.89)
	≥80	4095	11.28 (9.54, 13.35)
SIMD quintiles	1 - Most deprived	3241	1.66 (1.56, 1.77)
	2	2687	1.44 (1.35, 1.53)
	3	2177	1.26 (1.18, 1.35)
	4	1886	1.15 (1.07, 1.23)
	5 - Least deprived	1575	1.00
Number of risk groups	0	2197	1.00
	1	2877	2.14 (2.02, 2.27)
	2	2473	3.24 (3.05, 3.45)
	3	1814	4.26 (3.96, 4.57)
	4	1149	5.26 (4.85, 5.71)
	≥5	1056	6.19 (5.67, 6.76)
BMI	<18.5	569	1.82 (1.66, 2.01)
	18.5 – 24.9	3649	1.00
	25 – 29.9	3736	0.82 (0.79, 0.86)
	30 – 34.9	2113	0.82 (0.78, 0.87)
	35 – 39.9	755	0.99 (0.91, 1.07)
	≥40	744	1.03 (0.95, 1.12)
Number of Previous Admissions	0	8542	1.00
	1	1970	2.62 (2.48, 2.77)
	2	692	3.73 (3.42, 4.08)
	3	203	3.91 (3.34, 4.58)
	4	80	4.30 (3.29, 5.63)
	5	42	5.64 (4.01, 7.95)
	≥6	37	6.44 (4.46, 9.29)
Urban/Rural Classification	Rural	1930	1.00
	Urban	9636	1.20 (1.14, 1.26)
Flu Vaccination Status	Unvaccinated	5666	1.00
	Vaccinated	5900	0.76 (0.73, 0.80)

255 ARI: Acute Respiratory Infection. HR: Hazard Ratio. LCI: Lower Confidence Interval. UCI: Upper Confidence
256 Interval. Hazard ratios were derived using cox proportional hazard model adjusting for age, sex, socioeconomic
257 status, number of risk groups, and number of previous emergency hospitalisations within six months prior to
258 September 1, 2022. SIMD: Scottish Index of Multiple Deprivation.

Table S15: Adjusted hazard ratio for SARS-CoV-2 associated ARI hospitalisation in
adults aged ≥18 years old after adjusting for SARS-CoV-2 vaccination

Variable	Level	SARS-CoV-2 hospitalisation	
		No. of events	HR (LCI, UCI)
Sex	Female	2179	1.00
	Male	2017	1.17 (1.10, 1.24)
Age (years)	18-24	49	0.99 (0.65, 1.50)
	25-29	40	1.00
	30-34	62	1.31 (0.88, 1.95)
	35-39	71	1.53 (1.04, 2.25)
	40-44	81	1.79 (1.23, 2.62)
	45-49	76	1.79 (1.22, 2.63)
	50-54	140	2.73 (1.92, 3.89)
	55-59	223	3.84 (2.74, 5.39)
	60-64	287	4.87 (3.49, 6.80)
	65-69	352	6.44 (4.63, 8.97)
	70-74	476	8.61 (6.20, 11.94)
	75-79	650	10.52 (7.55, 14.65)
	≥80	1689	14.87 (10.70, 20.66)
SIMD quintiles	1 - Most deprived	1008	1.34 (1.21, 1.48)
	2	1010	1.39 (1.26, 1.54)
	3	841	1.25 (1.12, 1.39)
	4	729	1.13 (1.02, 1.26)
	5 - Least deprived	608	1.00
Number of risk groups	0	814	1.00
	1	1026	1.93 (1.75, 2.12)
	2	929	2.94 (2.65, 3.26)
	3	687	3.61 (3.22, 4.06)
	4	407	4.13 (3.61, 4.73)
	≥5	333	4.34 (3.75, 5.01)
BMI	<18.5	187	1.62 (1.38, 1.90)
	18.5 – 24.9	1319	1.00
	25 – 29.9	1367	0.83 (0.77, 0.90)
	30 – 34.9	782	0.88 (0.81, 0.96)
	35 – 39.9	270	1.00 (0.87, 1.14)
	≥40	271	1.17 (1.03, 1.34)
Number of Previous Admissions	0	3003	1.00
	1	785	2.93 (2.69, 3.19)
	2	250	3.74 (3.26, 4.30)
	3	87	5.28 (4.20, 6.65)
	4	32	5.46 (3.73, 8.00)
	5	25	13.34 (8.53, 20.88)
	≥6	14	6.54 (3.95, 10.83)
Urban/Rural Classification	Rural	729	1.00
	Urban	3467	1.15 (1.06, 1.25)
Covid Vaccination Status	Unvaccinated, 1st Dose/2nd Dose	573	1.00
	3rd Dose	1533	0.64 (0.58, 0.71)
	4th / 5th Dose	2090	0.83 (0.73, 0.93)

261 ARI: Acute Respiratory Infection. HR: Hazard Ratio. LCI: Lower Confidence Interval. UCI: Upper Confidence
262 Interval. Hazard ratios were derived using cox proportional hazard model adjusting for age, sex, socioeconomic
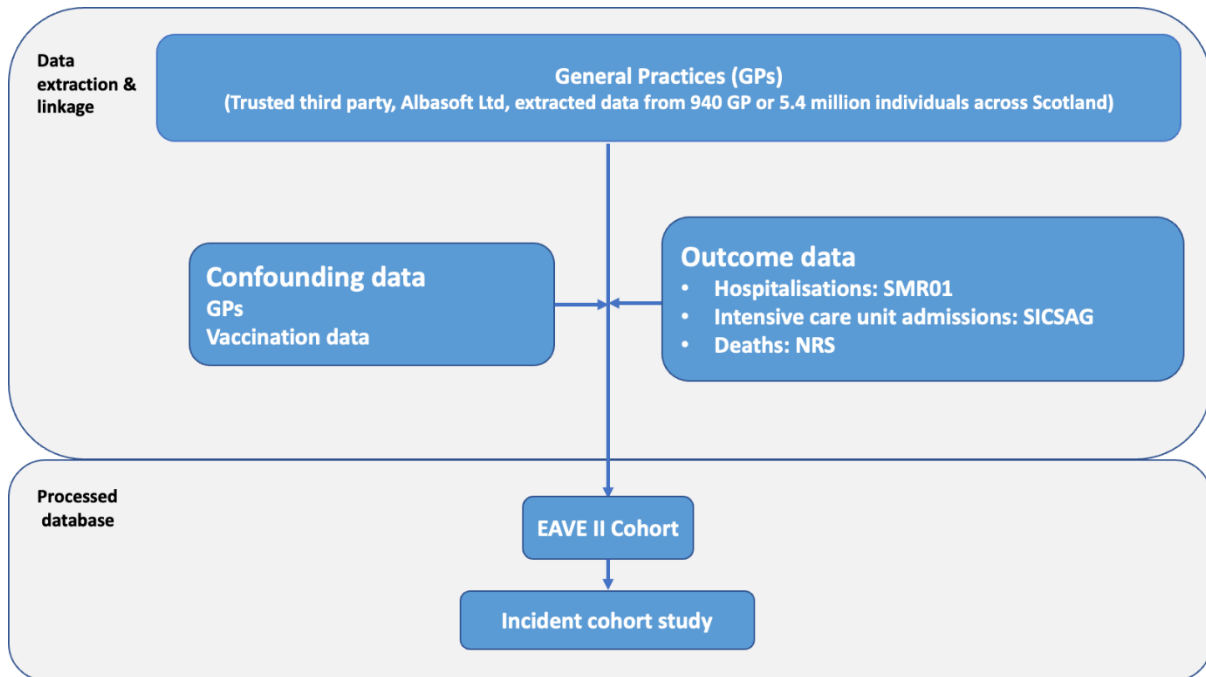
263   status, number of risk groups, and number of previous emergency hospitalisations within six months prior to

264   September 1, 2022. SIMD: Scottish Index of Multiple Deprivation.

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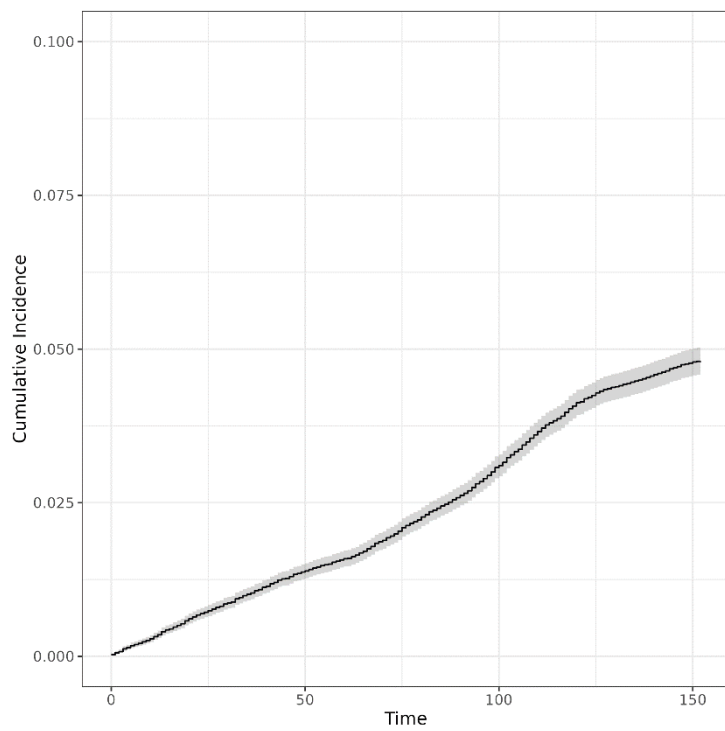Figure S1: Data linkage diagram

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271 SMR01: Scottish Morbidity Record. SICSAG: Scottish Intensive Care Society Audit Group. NRS: National Records
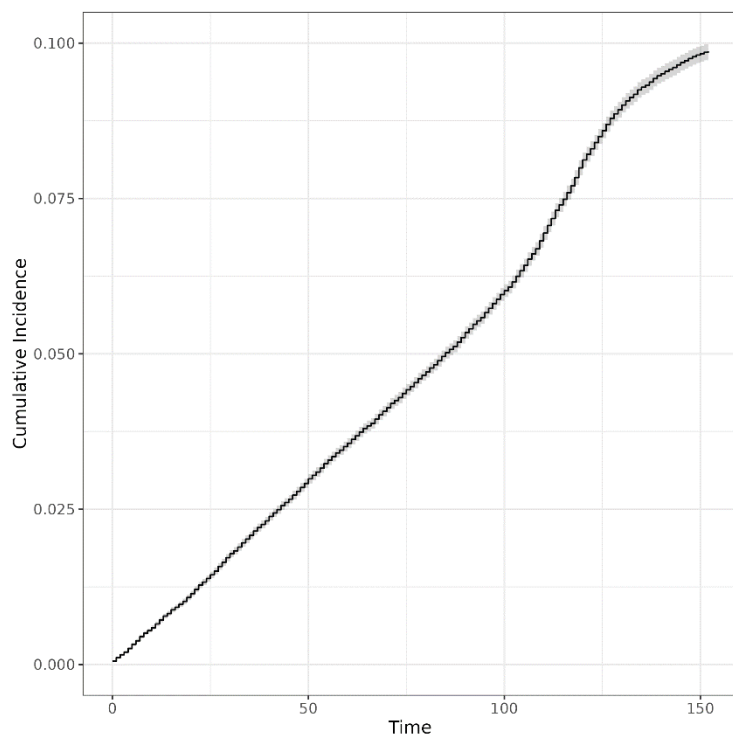272 of Scotland. EAVE II: Early Pandemic Evaluation and Enhanced Surveillance of COVID-19.

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275 Figure S2: Cumulative incidence of ARI hospitalisation over time in children (A) and
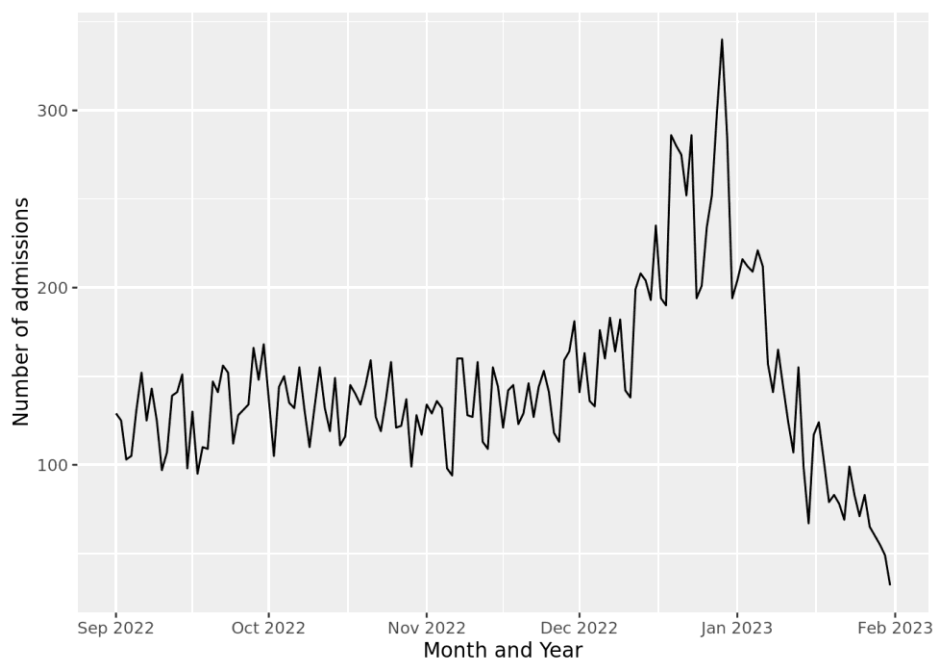276 adults (B)

277

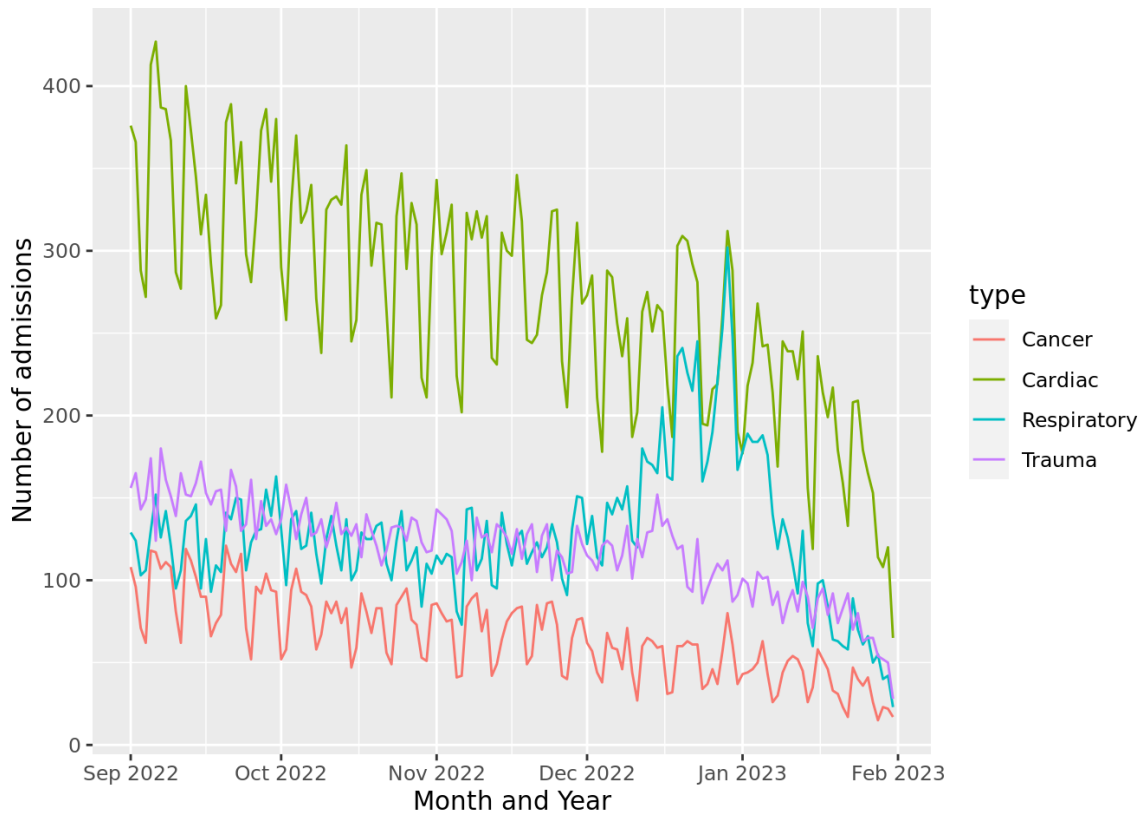278   A)   In children

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280   B)   In adults

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282   Figure S3: Number of ARI hospitalisation over time in study population

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Figure S4: Plot of emergency admissions for different conditions over time during our
study period

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