Indirect effects of the first two years of the COVID-19 pandemic on secondary care for cardiovascular disease in the UK: an electronic health record analysis across three countries.

Authors

F Lucy Wright¹, Kate Cheema², Raph Goldacre¹, Nick Hall¹, Naomi Herz², Nazrul Islam¹, Zainab Karim², David Moreno-Martos³, Daniel R Morales^{3,4}, Daniel O'Connell², Enti Spata¹, Ashley Akbari⁵, Mark Ashworth⁶, Mark Barber⁷, Norman Briffa⁸, Dexter Canoy⁹, Spiros Denaxas^{10,11}, Kamlesh Khunti¹², Amanj Kurdi¹³, Mamas Mamas¹⁴, Rouven Priedon¹¹, Cathie Sudlow¹¹, Eva JA Morris¹, Ben Lacey¹, Amitava Banerjee^{10,15} on behalf of the CVD-COVID-UK Consortium

Corresponding author:

Amitava Banerjee. Email: ami.banerjee@ucl.ac.uk

Affiliations

¹The Big Data Institute, Nuffield Department Nuffield Department of Population Health, University of Oxford, Oxford, UK

²British Heart Foundation, London, UK

³Division of Population Health and Genomics, University of Dundee, Dundee, UK

⁴Department of Public Health, University of Southern Denmark, Odense, Denmark

⁵Population Data Science, Swansea University Medical School, Faculty of Medicine, Health & Life

Science, Swansea University, Wales, UK

⁶Department of King's College London, London, UK

⁷Scottish Stroke Care Audit, Public Health Scotland, Glasgow, UK

⁸Sheffield Teaching Hospitals & University of Sheffield, Sheffield, UK

⁹Population Health Sciences Institute, University of Newcastle, Newcastle, UK

¹⁰Institute of Health Informatics, University College London, London, UK

¹¹British Heart Foundation Data Science Centre, Health Data Research UK, London, UK

¹²Leicester Diabetes Centre, University of Leicester, Leicester, UK

¹³Strathclyde Institute of Pharmacy and Biomedical Science, University of Strathclyde, Glasgow, UK

¹⁴Keele Cardiovascular Research Group, Keele University, Stoke on Trent, UK

¹⁵Department of Cardiology, Barts Health NHS Trust, London, UK

Abstract

Background

Although morbidity and mortality from COVID-19 have been widely reported, the indirect effects of the pandemic beyond 2020 on other major diseases and health service activity have not been well described.

Methods

Analyses used national administrative electronic hospital records in England, Scotland and Wales for 2016-2021. Admissions and procedures during the pandemic (2020-2021) related to six major cardiovascular conditions (acute coronary syndrome, heart failure, stroke/transient ischaemic attack, peripheral arterial disease, aortic aneurysm, and venous thromboembolism) were compared to the annual average in the pre-pandemic period (2016-2019). Differences were assessed by time period and urgency of care.

Results

In 2020, there were 31,064 (-6%) fewer hospital admissions (14,506 [-4%] fewer emergencies, 16,560 [-23%] fewer elective admissions) compared to 2016-2019 for the six major cardiovascular diseases combined. The proportional reduction in admissions was similar in all three countries. Overall, hospital admissions returned to pre-pandemic levels in 2021. Elective admissions remained substantially below expected levels for almost all conditions in all three countries (-10,996 [-15%] fewer admissions). However, these reductions were offset by higher than expected total emergency admissions (+25,878 [+6%] higher admissions), notably for heart failure and stroke in England, and for venous thromboembolism in all three countries. Analyses for procedures showed similar temporal variations to admissions.

Conclusion

This study highlights increasing emergency cardiovascular admissions as a result of the pandemic, in the context of a substantial and sustained reduction in elective admissions and procedures. This is likely to increase further the demands on cardiovascular services over the coming years.

Key Question: What is the impact in 2020 and 2021 of the COVID-19 pandemic on hospital admissions and procedures for six major cardiovascular diseases in England, Scotland and Wales?

Key Finding: In 2020, there were 6% fewer hospital admissions (emergency: -4%, elective: -23%) compared to 2016-2019 for six major cardiovascular diseases, across three UK countries. Overall, admissions returned to pre-pandemic levels in 2021, but elective admissions remained below expected levels.

Take-home Message: There was increasing emergency cardiovascular admissions as a result of the pandemic, with substantial and sustained reduction in elective admissions and procedures. This is likely to increase further the demands on cardiovascular services over the coming years.

Introduction

Since the early stages of the coronavirus (COVID-19) pandemic, acute workload on health systems managing those with the virus has led to direct effects (e.g. hospitalisations, intensive care admissions and mortality of infected individuals)(1–3). In addition, indirect effects have impacted non-COVID diseases by health system strain and changes in behaviours, documented across some individual specialties, clinical procedures, and countries but only in the first year of the pandemic(4–7).

The role of non-communicable diseases (NCDs) and their care as a COVID-related risk factor and outcome is consistent with a "syndemic", "characterised by biological and social interactions between conditions and states, interactions that increase a person's susceptibility to harm or worsen health outcomes" (8). However, pandemic planning and preparedness excludes modelling of indirect effects, which have not been of this scale in prior public health emergencies. Moreover, pandemic monitoring has focused on metrics of infection, excluding NCDs as a risk factor or indirect outcome(9).

Cardiovascular disease (CVD) is the greatest burden of disease in UK and globally(10). Any attempt to quantify indirect effects or NCDs must consider CVD. Even in the early first wave, there were indirect effects across 6 CVD subtypes in 9 UK hospitals with reduced admissions, emergency department attendances and procedures after lockdown (23 March 2020) by 58%, 53%, 31%-88% respectively, compared with prior years(2). Several studies confirmed indirect effects in different CVD subtypes and countries(7, 11-13). However, over two years into the pandemic with increasing non-COVID care backlogs in the UK and other countries, three questions remain. First, "Is the risk profile of individuals with CVD different before and during COVID-19?", which could inform risk prediction models and CVD prevention priorities during pandemics. Second, "How has clinical activity varied across subtypes(14), admissions and procedures during the pandemic?", to understand impact of changing pandemic waves and policy landscapes, including vaccinations and lockdowns. Third, "Are CVD admissions and procedures affected more for elective or emergency activity?", to inform service planning and resource utilisation during and post-COVID-19. In the <u>CVD-COVID-UK/COVID-IMPACT consortium</u>, national electronic health record (EHR) data are available for pandemic-related research(15,16).

Objectives

Using EHR phenotypes for CVD and associated procedures(14), the indirect impact of the COVID pandemic on CVD can be studied with access to data for 65.7 million individuals across multiple sources with >700 validated phenotyping algorithms. For six major CVD subtypes (acute coronary

syndrome, heart failure, stroke/transient ischaemic attack, peripheral arterial disease, aortic aneurysm, and venous thromboembolism) in three UK countries (England, Scotland and Wales), we investigated hospital activity before (2016 to 2019) and during the COVID-19 pandemic (2020 to 2021) by: (i) demographic characteristics; (ii) admissions and procedures; and (iii) urgency of care.

Methods

Setting and data sources

National administrative hospital records for England, Scotland and Wales were used for this study and data sources are shown in **Figure S1**. Data were accessed through each country's trusted research environment (TRE), which was made possible through agreements with Health Data Research UK for the British Heart Foundation Data Science Centre's CVD-COVID-UK/COVID-IMPACT research programme (15, 16). For England, data were obtained from the Admitted Patient Care Hospital Episode Statistics in NHS Digital's TRE service for England. For Scotland, the Scottish Morbidity Records (SMR 01) for General / Acute Inpatient and Day Case admission in the Scottish National Safe Haven was the data source (17) and for Wales, it was the Patient Episode Database Wales in the SAIL Databank (18). These datasets cover inpatient admissions to all NHS hospitals including day cases.

Data extraction and analysis of patient-level hospital data was undertaken in each nation's TRE using common data specifications and analysis codes, accounting for differences in data structure and clinical coding procedures between the three nations. In the raw form, each record represents a new admission, a change between medical specialists within the same admission or an interhospital transfer. To minimise overcounting, a record that represented a continuous hospital stay and included changes between medical specialists within the same admission and accounted for interhospital transfers was created. Only aggregated data were shared.

Study population

The study population included all individuals admitted to hospital in England, Scotland or Wales with a primary diagnosis of each CVD subtype between January 1st, 2016 and December 31st, 2021– the study period covers four years before the COVID-19 pandemic for comparison with the first two years of the pandemic. The study population also included all individuals admitted for each of the associated CVD procedures to ensure that all procedures were captured, since the associated CVD subtype diagnosis might not necessarily be recorded as the primary diagnosis for these admissions.

Admissions for CVD diagnoses and procedures

The CVD diagnoses included in this study were acute coronary syndrome (ACS), heart failure (HF), acute stroke or transient ischaemic attack (stroke/TIA), peripheral arterial disease (PAD), aortic aneurysm (AA) and venous thromboembolism (VTE). The associated CVD procedures were: percutaneous coronary intervention, coronary artery bypass graft surgery, pacemaker or cardiac resynchronisation therapy, ventricular assist device or heart transplant, stroke thrombolysis or thrombectomy, carotid endarterectomy or stenting, cerebral aneurysm coiling, aortic aneurysm repair, peripheral limb angioplasty, limb revascularisation, bypass or amputation, and pulmonary artery embolectomy or embolisation.

Phenotypes for CVD diagnoses were defined using the international classification of diseases, 10th revision (ICD-10 codes) and procedures using office of population censuses and surveys classification of interventions and procedures, version 4 (OPCS-4 codes). These were chosen to align with an earlier study (2) and a few minor modifications were made to OPCS-4 codes after clinical and academic expert consensus (e.g. additional codes for coronary artery bypass surgery or pacemaker insertion). For procedures, we counted all recorded procedures in a single admission. Details of diagnostic and procedural clinical terminology codes are in **Table S1**.

Admissions, not individuals, were counted. One patient may have been readmitted for a CVD subtype or procedure, or had an admission for other CVD subtypes or procedures during the study period, and each admission was counted. Admissions were classified as emergency or elective using the admission type variable in each dataset. Generally, emergency admissions were when the admission was unpredictable and at short notice due to clinical need, such referral from accident and emergency, a general practitioner or a clinic. Admissions were classified as elective when the decision to admit could be separated from the time of the actual admission such as being admitted from a waiting list, or having the admission booked or planned at the time when it was deemed clinically necessary.

Statistical analysis

Analyses were for men and women combined and for all ages. Demographic characteristics of individuals admitted to hospital pre-pandemic with those admitted during the first two years of the pandemic for CVD subtypes and procedures were investigated. The characteristics were for each admission and included sex, age, and ethnic group, and Charlson comorbidity index using ICD-10 codes from the admission(19). The average number of people in each category of the selected demographic characteristic was divided by the average number of admissions. Due to small numbers (<5) in some categories, characteristics for 2020 and 2021 were reported as an average of the two

years. For all other analyses, 2020 and 2021 are reported separately. The average of 2016-2019 was selected as the comparator for all analyses, using a four-year period to give stability over time.

Initially all admissions (emergency and elective combined) were assessed. To explore indirect effects of the pandemic on unplanned and planned CVD care and inform policy responses, admissions were reported separately as emergency or elective, respectively on CVD admissions to hospital separately from hospital capacity to provide planned care during the pandemic. Annual counts were calculated within the three time periods of interest: pre-pandemic 2016-2019, and pandemic 2020 and 2021. The percentage change between the time periods was calculated by subtracting the total for each pandemic year from the average of 2016-2019 and dividing it by the 2016-2019 average. Percentage changes were calculated with 95% confidence intervals, assuming the pre-pandemic annual counts followed a negative binomial distribution. Monthly counts of admissions were also calculated and plotted to show trends during the years. The analyses were performed according to a pre-specified protocol and analysis plan with phenotyping and analysis code, which is available at https://github.com/BHFDSC/CCU003_04.

Results

Study population

We identified a total of 1,973,104 and 970,374 admissions and 1,616,550 and 635,187 procedures in 2016-2019 and 2020-2021 respectively.

Demographic characteristics

There were no major differences by age, gender or ethnic group between 2016-2019 and 2020-2021 for admissions (**Table S2**) or procedures (**Table S3**) across countries or CVD subtypes. The Charlson comorbidity profile was more severe in 2020-2021, compared with 2016-2019, for all admissions and all procedures in England, except VAD/transplant and PA embolectomy. In Scotland, individuals with PAD (20.4% vs 17.9%) and VTE (18.8% vs 17.9%) had more severe comorbidities in 2020-2021, compared with pre-pandemic, but otherwise, in Scotland and Wales, there were no notable differences by comorbidities in admissions or procedures between pre- and post-pandemic periods.

Hospital admissions

Total admissions

In 2020, there were 31,064 (-6%) fewer admissions for all six CVD subtypes combined in the three countries combined compared with the expected number from 2016-2019. In 2021, there was an overall increase of 14,884 (+3%) admissions. **Figure 1** shows the annual counts and percentage

change in total admissions for CVD as the primary diagnosis for all CVD and across subtypes for each country. In 2020, admissions for all CVD in the three individual countries were lower than expected (-6% in England, -6% in Scotland, -7% in Wales). In 2021, admissions in England were 4% higher than expected, but in Scotland and Wales, the numbers were similar to 2016-2019.

For most CVD subtypes, admissions in 2020 were lower than expected across countries compared with 2016-2019 (Figure 1). Admissions for ACS, AA and PAD were lower in all three countries (annual % change range: -6% to -27%), and for HF in Wales (-13%). For stroke/TIA in England, admission numbers were somewhat lower (-3%). For the remaining CVD subtypes, the observed numbers of admissions in 2020 were similar to those in 2016-2019. In 2021 in all three countries, admissions for AA and PAD continued to remain lower than expected (range: -10% AA in Scotland to -19% AA in Wales) and there were more admissions for VTE than expected (range: +11% in Scotland to +27% in Wales). In England, there were somewhat more admissions for stroke/TIA in England (+4%). In Scotland, admissions for ACS, HF and stroke/TIA were similar in 2021 compared to 2016-2019. In Wales, admissions for ACS and stroke/TIA were lower, -5% and -7% respectively.

The observed changes were not uniform throughout the two pandemic years (Figure 2). In 2020, monthly admissions for all CVD subtypes in all three countries decreased from January, with greatest reductions in April, compared to 2016-2019. Admissions remained lower than expected during the rest of 2020, except VTE admissions which increased above 2016-2019 levels by May/June 2020 and throughout 2021. In 2021, monthly admissions for all CVD subtypes were lower than 2016-2019 levels in January and February in all 3 countries, except VTE. Timing and extent of recovery to expected levels varied by CVD subtype and country.

Urgency of Care

In 2020, there were 14,506 (-4%) fewer emergency admissions than expected for all CVD in the three countries combined, and the proportion reduction was similar in all three countries. For most CVD subtypes, emergency admissions in all three countries were similar to those in 2016-2019 (**Figure 3**). The exceptions were ACS in England (-8%), HF in Wales (-13%), stroke/TIA in England (-3%), AA in England and Scotland (-9% and -12% respectively) and PAD in England (-5%). There were also fewer elective admissions for all CVD in 2020 with a total of 16,560 (-23%) fewer in the three countries (-22% for England and Wales, -30% for Scotland). For most CVD subtypes across countries compared to 2016-2019, elective admissions were lower (e.g: -16% ACS in England and stroke/TIA in Scotland, - 35% HF in Scotland). Admissions with the greatest reductions were AA (-34%, -38% and -37%) and PAD (-30%, -36% and -40%) in England, Scotland and Wales respectively. Admission numbers were

similar to 2016-2019 for ACS in Scotland and Wales, Stroke/TIA in England and Wales and VTE in England and Scotland. No admissions for CVD subtypes were higher than expected.

In 2021, there were 25,878 (+6%) more emergency CVD admissions in the three countries combined. This was driven by the 7% higher number of admissions in England, while in Scotland and Wales numbers returned to expected levels (Figure 3). For most CVD subtypes across countries, the number of emergency admissions returned to expected levels, although there were some exceptions. Admissions were higher than expected in all three countries for VTE (England +19%, Scotland +29%, Wales +13%). In England, admissions were higher than expected for HF (+11%), stroke/TIA (+5%) and PAD (+6%) and somewhat lower for AA (-4%). Elective admissions remained lower in 2021 with 10,996 (-15%) fewer CVD admissions than in 2016-2019 in the three countries combined (England -14%, Scotland -25%, Wales -15%). For individual CVD subtypes, elective admissions remained below pre-pandemic levels across all subtypes and countries, except HF in Wales (+23%) (Figure 3). Monthly emergency and elective admissions across CVD subtypes and across countries decreased between January and April 2020 (Figures 4 and 5 respectively). Emergency activity returned to 2016-2019 levels by June/July 2020, except for VTE which remained higher throughout the rest of 2020 and 2021. Between February and April 2021, emergency CVD admissions exceeded 2016-2019 levels, then decreased, particularly in Wales, where ACS, HF and stroke admissions decreased to lower than pre-pandemic levels (Figure 4). Other than VTE, elective admissions did not return to expected levels by end of 2021, across CVD subtypes and countries (Figure 5). Reductions for elective and emergency admissions were greater in England and Wales.

Procedures

Total procedures

In 2020, there were 96,554 (-24%) fewer total procedures for all six CVD subtypes combined in the three UK countries compared with the expected number in 2016-2019. In 2021, there were 76,541 (-19%) fewer CVD procedures. In 2020, admissions for all CVD procedures in the three individual countries were lower than expected and varied by country (England -25%, Scotland -16%, Wales - 23%) (**Figure 1**). In 2021, there was a small increase (5-8%) in all CVD procedures in the three countries, but numbers remained below expected levels (England -20%, Scotland -10%, Wales -15%).

There were major reductions across most individual CVD procedures in 2020 compared with 2016-2019. These included percutaneous coronary intervention (range: -17% in Scotland to -27% in England), coronary artery bypass graft surgery (-23% in Scotland to -44% in Wales), carotid endarterectomy (England -24% to Wales -43%) and limb angioplasty (-16% in England to -30% in Wales). Only stroke thrombolysis in England was higher than expected (+8%), and cerebral artery

coiling in all three countries was similar to 2016-2019. In 2021, although there was some improvement, most CVD procedures remained well below the expected levels in all three countries, ranging from -6% for PAD revascularisation in Scotland to -49% for carotid endarterectomy in Wales. Only stroke thrombolysis in England (+17%), cerebral artery coiling in Scotland (+21%), and ventricular assist device or heart transplant in Scotland (+81%) were higher, but numbers were low and confidence intervals wide. Generally, monthly numbers of CVD procedures were lower in 2020 and 2021, compared to 2016-2019 across countries (**Figure 3**).

The observed changes were not consistent throughout 2020 and 2021 (Figure 6). In 2020, monthly admissions for all CVD procedures in all three countries decreased from January, with greatest reductions in April, compared to 2016-2019. Overall admissions for procedures all CVD subtypes remained lower than expected during the rest of 2020 and 2021 in all three countries.

Urgency of Care

In 2020 there were 11,775 (-9%) fewer emergency CVD procedures than in 2016-2019 in all three countries combined. The proportion reduction varied between countries (England -10%, Scotland +3%, Wales -4%) (**Figure 7**). The total number of individual emergency CVD procedures was either lower than or similar to 2016-2019. Examples of procedures that were lower were coronary artery bypass graft surgery (-26% in England, -57% in Wales), carotid endarterectomy (-36% in Wales), AA repair (-23% in England, -25% in Wales) and pulmonary artery embolectomy (-20% in England). Some procedures were higher in 2020 than expected: permanent pacemaker or resynchronisation therapy in Scotland (+20%) and cerebral artery coiling (+15% in England and +47% in Wales), although numbers were relatively low.

In 2021 there were only 1,990 (-2%) fewer emergency CVD procedures in all three countries combined, with some variation observed between countries (England -2%, Scotland +10%, Wales 0%). Generally, there was variability across individual CVD procedures and countries (**Figure 7**). For example, emergency coronary artery bypass graft surgery was lower in England (-9%) and Wales (-53%) and higher in Scotland (+46%). However, AA repair across all three countries remained lower in 2021 than 2016-2019 (England -19%, Scotland -18%, Wales -33%).

For elective CVD procedures in 2020, there were 84,766 (-31%) fewer procedures combined for all three countries (England and Wales -32%, Scotland -21%). Individual elective procedures were all lower in 2020 compared to 2016-2019 across countries, except stroke thrombolysis was higher in England (+230%, N+81). The reduction in CVD procedures varied by country and procedure, e.g. - 39%, -39% and -24% for CABG, and -29%, -24% and -41% for limb angioplasty in England, Wales and Scotland, respectively.

In 2021, the reduction in elective procedures persisted with 74,566 (-27%) fewer elective CVD procedures combined for all three countries (England -29%, Scotland -15%, Wales -23%) (Figure 7). The reductions continued for all individual elective procedures, except stroke thrombolysis in England. Between January and April 2020, monthly emergency procedures decreased for AA, ACS, HF and PAD, recovering to pre-pandemic levels in late 2020 and 2021. (Figure S2). Monthly elective procedures decreased in January-April 2020, across subtypes and countries, and had not recovered to 2016-19 levels by end of 2021 (Figure S3).

Discussion

In the first comprehensive study to use national routinely collected electronic hospital data in the pandemic context across CVD subtypes, admissions, procedures, urgency of care and countries, we demonstrate three major findings. First, there were profound reductions across CVD subtypes and countries during the pandemic, particularly for procedural activity which reduced by a third in 2020 and by a quarter in 2021, compared with pre-pandemic levels. Second, except for VTE, although emergency admissions and procedures had returned to pre-pandemic levels by 2021, elective activity remained significantly reduced, especially for procedures. Third, the comorbidity profile for CVD admissions and procedures was more severe during the pandemic than pre-pandemic in England for most CVD subtypes but did not generally differ between 2020-21 and 2016-19 for Scotland and Wales.

Despite multiple analyses of indirect effects in the UK and other countries using EHR(11-14, 20), these effects have been neglected in pandemic surveillance and policy responses(21). Moreover, prior analyses have tended to be disease- or procedure-specific and have not taken a system-level view across diseases and countries(22). We now confirm previous reports of reduced activity for admissions and for PCI and other CVD-related procedures, showing variation by timing, speed and extent of recovery across subtypes. Given the significant backlogs across services in the UK(23-25) and other countries(26), there is an urgent need to monitor and understand these indirect impacts of the COVID-19 pandemic, to develop coordinated, but tailored responses, based on subtype, type and urgency of care, and country. Without urgent action, indirect and long-term consequences could create far greater burden and cost to individuals, populations and health systems than acute, direct effects.

Reductions in emergency care are likely to require different approaches to workforce and resource planning, compared with elective care, and for admissions versus procedures(27, 28). Therefore, the greater effect on procedural activity and the relatively slower recovery of elective procedural activity, especially in England and Wales, requires further investigation, explanation and mitigation strategies. The widespread strain on health systems due to COVID-19 is unprecedented and staff and resource shortages over successive waves may provide part of the explanation. In 2021, some emergency admissions were greater than pre-pandemic levels, which may in part, be related to the reduction in elective admissions and procedures the year before. There may also have been changes in coding of admissions as "emergency" or "urgent" so that they were less delayed during the pandemic.

Although projections from national and international efforts such as the Global Burden of Disease Study provide important context(29), more detailed national-and local-level data are required for informed health policy. Ultimately, answers require standardised, near real-time data which has become possible in the COVID-19 context but has historically not been a priority. To-date, admissions and procedures have been tracked in a "rear view mirror", which is not fit-for-purpose for surveillance and planning during public health emergencies such as pandemics, due partly to specialty- and disease-specific silos, and partly due to a culture of retrospective data collection, monitoring and analysis. For example, the UK's National Heart Failure Audit and National Audit of PCI publish annual reports with a one year delay, which has been further delayed or de-prioritised during the pandemic(30) and national AA screening data during the pandemic has not been published(31). National EHR data can and should be used to study CVD and non-COVID diseases and services at scale, with low-hanging fruits for public health and policy planning during and postpandemic.

Late presentation, greater severity of illness and inequalities in access to healthcare have been invoked to explain increased rates of CVD during the pandemic. The finding of similar baseline characteristics before and during the pandemic among most individuals presenting with CVD and undergoing CVD-related procedures in Scotland and Wales suggests that these patient-level factors (including age, sex and ethnicity) do not fully explain the reductions in CVD care during the pandemic, and that system-level factors may be more important. However, for most CVD subtypes in England, there was greater comorbidity burden in those presenting during pandemic years than during pre-pandemic years, which could suggest decreased prevention, late presentation and/or reduced access to CVD services. We show differences by subtype, by urgency of care and by country, which may signify different reasons for reductions in activity and therefore different, nuanced solutions. For example, the higher impact on CABG, carotid endarterectomy and PAD procedures needs to be explored. There is now clear evidence of increased VTE risk associated with COVID-19, up to 1 year after infection, which at least partly explains the observed increase in VTE admissions and procedures(32). We have only considered certain CVD admissions and procedures, but indirect effects across all diseases and procedures are likely. A complex interplay of factors makes analysis

difficult with successive pandemic waves, lockdowns, vaccination programmes and changing COVID-19-related policies. However, without a whole-system perspective and better up-to-date data, the indirect effect across diseases cannot be quantified, tackled or predicted. Only then can the correct, nuanced approaches to workforce, public health priorities, health resource utilisation be planned.

Strengths/limitations

Our analyses used standardised, validated, open-source coding in national level EHR data in the most comprehensive investigation of indirect effects to-date. We used pre-pandemic data for comparison. We used the same methods for admissions and procedures across diseases, CVD subtypes and comparable datasets across countries (17). Our study does have some limitations. First, we only investigated some, not all CVD admissions and procedure. Second, there were low numbers for certain procedures, particularly in Scotland and Wales. Third, we only examined inpatient and not outpatient or emergency department activity. Fourth, we only had sociodemographic and comorbidity data at baseline and not tracked over time. Fifth, we do not look in detail at impact of lockdowns, vaccination, successive waves. Sixth, we are reliant on EHR and coding errors are possible though prior published studies suggest that this unlikely to be a major issue. Seventh, we did not investigate impact of changes in CVD admissions or procedures on CVD-related mortality, which should be considered in future studies. Finally, our analyses only concerned UK data, and may not be necessarily generalisable to other countries and settings.

Implications for clinical practice and policy

Our results suggest that procedural activity needs to be prioritised and planned to provide timely services for high-risk patients during pandemics. Data about potential indirect effects needs to be collected and monitored, and ways of collecting, storing and analysing data need to be standardised across diseases and procedures, i.e. we cannot have every specialty and disease developing its own methods and "re-inventing the wheel". During planning for pandemics, NCD surveillance needs to be part of the preparation and during pandemics, it should be part of the dashboards.

Implications for research

With the advent of national TRE data, the type of research which we have conducted needs to be scaled up. Open-source data and methods can facilitate valid comparisons within and across countries, but differences in capture and coding of data need to taken into account. Our methods and our results have application to other diseases (19,20) and other countries, with potential implications for current and future pandemic policy. The science of pandemic preparedness has been largely restricted to infection dynamics. Future prediction models have to incorporate NCDs, and should include indirect effects, which may be as profound as direct effects.

Conclusions

There have been wide and far-reaching reductions in secondary care for cardiovascular disease throughout the pandemic, with incomplete recovery, particularly for procedural and elective activity, even two years into the COVID-19 pandemic. Monitoring and protection of cardiovascular and non-COVID services should be part of pandemic planning in future.

Acknowledgements

This work is carried out with the support of the BHF Data Science Centre led by HDR UK (BHF Grant no. SP/19/3/34678). This study makes use of de-identified data held in NHS Digital's TRE for England, the SAIL Databank and the Scottish National Data Safe Haven and made available via the BHF Data Science Centre's CVD-COVID-UK/COVID-IMPACT consortium. This work uses data provided by patients and collected by the NHS as part of their care and support. We would also like to acknowledge all data providers who make health relevant data available for research.

The study makes use of anonymised data held in the Scottish National Safe Haven. The authors would like to acknowledge the support of the eDRIS Team (Public Health Scotland) for their involvement in obtaining approvals, provisioning and linking data and the use of the secure analytical platform within the National Safe Haven.

This study makes use of anonymised data held in the Secure Anonymised Information Linkage (SAIL) Databank. This work uses data provided by patients and collected by the NHS as part of their care and support. We would also like to acknowledge all data providers who make anonymised data available for research. We wish to acknowledge the collaborative partnership that enabled acquisition and access to the de-identified data, which led to this output. The collaboration was led by the Swansea University Health Data Research UK team under the direction of the Welsh Government Technical Advisory Cell (TAC) and includes the following groups and organisations: the SAIL Databank, Administrative Data Research (ADR) Wales, Digital Health and Care Wales (DHCW), Public Health Wales, NHS Shared Services Partnership (NWSSP) and the Welsh Ambulance Service Trust (WAST). All research conducted has been completed under the permission and approval of the SAIL independent Information Governance Review Panel (IGRP) project number 0911.

The Big Data Institute has received funding from the Li Ka Shing Foundation and Robertson Foundations, the Medical Research Council, British Heart Foundation, and is supported by the NIHR Oxford Biomedical Research Centre.

Authors contributions

AB, FLW, and EM conceptualised the study. FLW and AB were the project leads. FLW and AB created the data specifications. NHall, KC, DO'C, ZK and DM-M were responsible for data extraction. NI, KC, DO'C, D M-M and RG conducted data analyses. RG and ES provided statistical advice. FLW, EM, BL, RG and AB reviewed the methods and interpreted the data. KC, NHerz and NI produced the graphics. CS is the Director of the BHF Data Science Centre and coordinated approvals for and access to data within NHS Digital's TRE for England, the SAIL Databank and the Scottish National Safe Haven for CVD-COVID-UK/COVID-IMPACT. FLW and AB drafted the manuscript and all authors reviewed and edited the final version of the manuscript.

Funding

The British Heart Foundation Data Science Centre (grant No SP/19/3/34678, awarded to Health Data Research (HDR) UK) funded co-development (with NHS Digital) of the TRE, provision of linked datasets, data access, user software licences, computational usage, and data management and wrangling support, with additional contributions from the HDR UK Data and Connectivity component of the UK Government Chief Scientific Adviser's National Core Studies programme to coordinate national covid-19 priority research. Consortium partner organisations funded the time of contributing data analysts, biostatisticians, epidemiologists, and clinicians. This work was supported by the Con-COV team funded by the Medical Research Council (grant number: MR/V028367/1).

This work was supported by Health Data Research UK, which receives its funding from HDR UK Ltd (HDR-9006) funded by the UK Medical Research Council, Engineering and Physical Sciences Research Council, Economic and Social Research Council, Department of Health and Social Care (England), Chief Scientist Office of the Scottish Government Health and Social Care Directorates, Health and Social Care Research and Development Division (Welsh Government), Public Health Agency (Northern Ireland), British Heart Foundation (BHF) and the Wellcome Trust.

This work was supported by the ADR Wales programme of work, aligned to the priority themes 410 as identified in the Welsh Government's national strategy: Prosperity for All. ADR Wales brings together data science experts at Swansea University Medical School, staff from the Wales Institute of Social and Economic Research, Data and Methods (WISERD) at Cardiff University and specialist teams within the Welsh Government to develop new evidence which supports Prosperity for All by using the SAIL Databank at Swansea University, to link and analyse anonymised data. ADR Wales is part of the Economic and Social Research Council (part of UK Research and Innovation) funded ADR UK (grant ES/S007393/1). This work was supported by the Wales COVID-19 Evidence Centre, funded by Health and Care Research Wales.

Conflict of interest

AB has received research grants from National Institute for Health and Care Research (NIHR), British Medical Association, UK Research and Innovation, European Union, and Astra Zeneca. AB is trustee of the South Asian Health Foundation and Long COVID SOS. Other authors have declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Ethics statement

The North East - Newcastle and North Tyneside 2 research ethics committee provided ethical approval for the CVD-COVID-UK/COVID-IMPACT research programme (REC No 20/NE/0161) to access, within secure trusted research environments, unconsented, whole-population, de-identified data from electronic health records collected as part of patients' routine healthcare.

Data availability statement

The data used in this study are available in NHS Digital's TRE for England, but as restrictions apply they are not publicly available (https://digital.nhs.uk/coronavirus/coronavirus-data-servicesupdates/trusted-research-environment-service-for-england). The CVD-COVID-UK/COVID-IMPACT programme led by the BHF Data Science Centre (https://www.hdruk.ac.uk/helping-with-healthdata/bhf-data-science-centre/) received approval to access data in NHS Digital's TRE for England from the Independent Group Advising on the Release of Data (IGARD) (https://digital.nhs.uk/aboutnhs-digital/corporate-information-and-documents/independent-group-advising-on-the-release-ofdata) via an application made in the Data Access Request Service (DARS) Online system (ref. DARS-NIC-381078-Y9C5K) (https://digital.nhs.uk/services/data-access-request-service-dars/dars-productsand-services). The CVD-COVID-UK/COVID-IMPACT Approvals & Oversight Board (https://www.hdruk.ac.uk/projects/cvd-covid-uk-project/) subsequently granted approval to this project to access the data within NHS Digital's TRE for England, the Scottish National Safe Haven and the Secure Anonymised Information Linkage (SAIL) Databank. The de-identified data used in this study were made available to accredited researchers only. Those wishing to gain access to the data should contact bhfdsc@hdruk.ac.uk in the first instance.

Data used in this study are available in the Scottish National Safe Haven (Project Number: 2021-0102), but as restrictions apply they are not publicly available. Access to data may be granted on application to, and subject to approval by, the Public Benefit and Privacy Panel for Health and Social (PBPP (https://www.informationgovernance.scot.nhs.uk/pbpphsc/)). Care Applications are (electronic coordinated by eDRIS Data Research and Innovation Service (https://www.isdscotland.org/Products-and-services/Edris/)). The anonymised data used in this study was made available to accredited researchers only through the Public Health Scotland (PHS) eDRIS User Agreement (https://www.isdscotland.org/Products-and-services/Edris/ docs/eDRIS-User-Agreement-v16.pdf).

The data used in this study are available in the SAIL Databank at Swansea University, Swansea, UK, but as restrictions apply they are not publicly available. All proposals to use SAIL data are subject to review by an independent Information Governance Review Panel (IGRP). Before any data can be accessed, approval must be given by the IGRP. The IGRP gives careful consideration to each project

to ensure proper and appropriate use of SAIL data. When access has been granted, it is gained through a privacy protecting safe haven and remote access system referred to as the SAIL Gateway. SAIL has established an application process to be followed by anyone who would like to access data via SAIL at https://www.saildatabank.com/application-process

References

- Banerjee A, Pasea L, Harris S, Gonzalez-Izquierdo A, Torralbo A, Shallcross L, et al. Estimating excess 1-year mortality associated with the COVID-19 pandemic according to underlying conditions and age: a population-based cohort study. The Lancet. 2020 May;395(10238):1715–25.
- Ball S, Banerjee A, Berry C, Boyle JR, Bray B, Bradlow W, et al. Monitoring indirect impact of COVID-19 pandemic on services for cardiovascular diseases in the UK. Heart. 2020 Dec;106(24):1890–7.
- 3. Banerjee A, Chen S, Pasea L, Lai AG, Katsoulis M, Denaxas S, et al. Excess deaths in people with cardiovascular diseases during the COVID-19 pandemic. European Journal of Preventive Cardiology. 2021 Dec 20;28(14):1599–609.
- 4. Lai AG, Pasea L, Banerjee A, Hall G, Denaxas S, Chang WH, et al. Estimated impact of the COVID-19 pandemic on cancer services and excess 1-year mortality in people with cancer and multimorbidity: near real-time data on cancer care, cancer deaths and a population-based cohort study. BMJ Open. 2020 Nov 17;10(11):e043828.
- Ho KMA, Banerjee A, Lawler M, Rutter MD, Lovat LB. Predicting endoscopic activity recovery in England after COVID-19: a national analysis. The Lancet Gastroenterology & Hepatology. 2021 May;6(5):381–90.
- Islam N, Shkolnikov VM, Acosta RJ, Klimkin I, Kawachi I, Irizarry RA, et al. Excess deaths associated with covid-19 pandemic in 2020: age and sex disaggregated time series analysis in 29 high income countries. BMJ. 2021 May 19;n1137.
- Martin GP, Curzen N, Goodwin AT, Nolan J, Balacumaraswami L, Ludman PF, et al. Indirect Impact of the COVID-19 Pandemic on Activity and Outcomes of Transcatheter and Surgical Treatment of Aortic Stenosis in England. Circulation: Cardiovascular Interventions. 2021 May;14(5).
- 8. Horton R. Offline: COVID-19 is not a pandemic. Lancet. 2020;396(10255):874.
- Mizani MDAPLLATJTC. Using National Electronic Health Records for Pandemic Preparedness: Validation of a Parsimonious Model for Predicting Excess Deaths Among Those With COVID-19. SSRN. 2022 Mar 8;
- Vos T, Allen C, Arora M, Barber RM, Brown A, Carter A, et al. Global, regional, and national incidence, prevalence, and years lived with disability for 310 diseases and injuries, 1990–2015: a systematic analysis for the Global Burden of Disease Study 2015. The Lancet. 2016;388(10053).
- 11. Guarinello GG, D'Amico RC, Miranda ANM, Novack J, Coral FE. Impacto da COVID-19 no perfil cirúrgico dos pacientes de cirurgia vascular em serviço de referência em Curitiba. Jornal Vascular Brasileiro. 2022;21.
- 12. Lechner I, Reindl M, Tiller C, Holzknecht M, Troger F, Fink P, et al. Impact of COVID-19 pandemic restrictions on ST-elevation myocardial infarction: a cardiac magnetic resonance imaging study. European Heart Journal. 2022 Mar 14;43(11):1141–53.
- 13. Shoaib A, van Spall HGC, Wu J, Cleland JGF, McDonagh TA, Rashid M, et al. Substantial decline in hospital admissions for heart failure accompanied by increased community mortality

during COVID-19 pandemic. European Heart Journal - Quality of Care and Clinical Outcomes. 2021 Jul 21;7(4):378–87.

- Denaxas S, Gonzalez-Izquierdo A, Direk K, Fitzpatrick NK, Fatemifar G, Banerjee A, et al. UK phenomics platform for developing and validating electronic health record phenotypes: CALIBER. Journal of the American Medical Informatics Association. 2019 Dec 1;26(12):1545– 59.
- 15. Thygesen JH, Tomlinson C, Hollings S, Mizani MA, Handy A, Akbari A, et al. COVID-19 trajectories among 57 million adults in England: a cohort study using electronic health records. The Lancet Digital Health. 2022 Jul;4(7):e542–57.
- 16. Wood A, Denholm R, Hollings S, Cooper J, Ip S, Walker V, et al. Linked electronic health records for research on a nationwide cohort of more than 54 million people in England: data resource. BMJ. 2021 Apr 7;n826.
- 17. ISD Scotland. SMR Datasets. <u>https://www.ndc.scot.nhs.uk/Data-Dictionary/SMR-Datasets/SMR01-General-Acute-Inpatient-and-Day-Case/</u> (Accessed 10/10/2022)
- Jones KH, Ford DV, Jones C, Dsilva R, Thompson S, Brooks CJ, Heaven MI, Thayer DS, McNerney CL, Lyons RA. A case study of the Secure Anonymous Information Linkage (SAIL) Gateway: a privacy protecting remote access system for health related research and evaluation. Journal of Biomedical Informatics 2014. 50: 196-204.
- 19. Szakmany T, Hollinghurst J, Pugh R et al. Frailty assessed by administrative tools and mortality in patients with pneumonia admitted to the hospital and ICU in Wales. Sci Rep. 2021 Jun 28;11(1):13407.
- 20. Banerjee A, Chen S, Pasea L et al. Excess deaths in people with cardiovascular diseases during the COVID-19 pandemic. Eur J Prev Cardiol. 2021 Dec 20;28(14):1599-1609.
- 21. Banerjee A, Sudlow C, Lawler M. Indirect effects of the pandemic: highlighting the need for data-driven policy and preparedness. J R Soc Med. 2022 Jul;115(7):249-251.
- 22. Grimm F, Johansen A, Knight H et al. Indirect effect of the COVID-19 pandemic on hospital mortality in patients with hip fracture: a competing risk survival analysis using linked administrative data. BMJ Qual Saf. 2022 Aug 1:bmjqs-2022-014896.
- 23. UK Government. Department of Health and Social Care. Direct and indirect health impacts of COVID-19 in England: emerging Omicron impacts. 4 August 2022. <u>https://www.gov.uk/government/publications/direct-and-indirect-health-impacts-of-covid-19-in-england-emerging-omicron-impacts/direct-and-indirect-health-impacts-of-covid-19-in-england-emerging-omicron-impacts</u>
- 24. Friebel R, Fistein J, Maynou L, Anderson M. Emergency contracting and the delivery of elective care services across the English National Health Service and independent sector during COVID-19: a descriptive analysis. BMJ Open. 2022 Jul 18;12(7):e055875.
- 25. McLellan A, Abbasi K. The NHS is not living with covid, it's dying from it. BMJ. 2022 Jul 18;o1779.
- 26. van Ginneken E, Reed S, Siciliani L et al. European Observatory on Health Systems and Policies. Addressing backlogs and managing waiting lists during and beyond the COVID-19

pandemic. Policy Brief 47. 6 July 2022 <u>https://www.who.int/europe/news/item/20-07-2022-</u>covid-19-has-caused-major-disruptions-and-backlogs-in-health-care--new-who-study-finds

- 27. McCabe R, Schmit N, Christen P et al. Adapting hospital capacity to meet changing demands during the COVID-19 pandemic. BMC Med. 2020 Oct 16;18(1):329.
- 28. Nehme R, Puchkova A, Parlikad A. A predictive model for the post-pandemic delay in elective treatment. Oper Res Health Care. 2022 Sep;34:100357.
- Roth GA, Johnson C, Abajobir A et al. Global, Regional, and National Burden of Cardiovascular Diseases for 10 Causes, 1990 to 2015. J Am Coll Cardiol. 2017 Jul 4;70(1):1-25. doi: 10.1016/j.jacc.2017.04.052. Epub 2017 May 17.
- 30. National Institute for Cardiovascular Outcomes Research (NICOR). NICOR COVID-19 Report. Rapid cardiovascular data: we need it now (and in the future). 2021. <u>https://www.nicor.org.uk/covid-19-and-nicor/nicor-covid-19-report/</u>
- 31. UK Government. Abdominal aortic aneurysm screening: standards report 2019 to 2020. Data report for abdominal aortic aneurysm screening for 1 April 2019 to 31 March 2020. 25 Feb 2021. <u>https://www.gov.uk/government/statistics/abdominal-aortic-aneurysm-screening-standards-report-2019-to-2020</u>
- 32. Knight R, Walker V, Ip S et al. Association of COVID-19 With Major Arterial and Venous Thrombotic Diseases: A Population-Wide Cohort Study of 48 Million Adults in England and Wales. Circulation. 2022 Sep 20;146(12):892-906.

Figures

Figure 1. Annual counts and percentage change in total admissions and procedures between prepandemic (2016-2019) and pandemic (2020-2021) periods for cardiovascular disease as primary diagnosis for all cardiovascular disease and across subtypes and across three countries in the UK.

Figure 2. Monthly total admissions for cardiovascular disease as primary diagnosis across subtypes, across three countries in the UK and across pre-pandemic (2016-2019) and pandemic (2020-2021) periods.

Figure 3: Annual counts and percentage change in total emergency and elective admissions between pre-pandemic (2016-2019) and pandemic (2020-2021) periods for cardiovascular disease as primary diagnosis for all cardiovascular disease and across subtypes and across three countries in the UK.

Figure 4: Monthly emergency hospital admissions for cardiovascular disease as primary diagnosis across subtypes, across three countries in the UK and across pre-pandemic (2016-2019) and pandemic (2020 and 2021) periods.

Figure 5: Monthly elective hospital admissions for cardiovascular disease as primary diagnosis across subtypes, across three countries in the UK and across pre-pandemic (2016-2019) and pandemic (2020-2021) periods.

Figure 6. Monthly total procedures for cardiovascular disease across subtypes, across three countries in the UK and across pre-pandemic (2016-2019) and pandemic (2020-2021) periods.

Figure 7: Annual counts and percentage change in total emergency and elective procedures between pre-pandemic (2016-2019) and pandemic (2020-2021) periods for cardiovascular disease for all cardiovascular procedures and across subtypes and across three countries in the UK.

2016/19	Total No. 2020	2016/19 to 2020			% change (95% CI) 2016/19 to 2020	Total No. 2021	2016/19 to 2021		% change (95% 2016/19 to 20
								1	
428487 39296 25494	401447 37121 23645	-27040 -2175 -1849		**	-6 (-10,-2) -6 (-8,-2) -7 (-9,-5)	443860 39194 25101	15379 -102 -393		• 4 (-1,8) O (-3,3) · 2 (-4,1)
106217 10447	97039 9807	-9178 -640			-9 (-11,-6) -6 (-11,-1) 6 (-6,-7)	105182	-1035		-1 (-3,1) 0 (-5,6) -5 (-7,-2)
92300 6670	87386	-4914			-5 (-14,5) -5 (-15,5)	101242	8942 -47		• 10(-1,21) -1(-10,10)
4925	108689	-639		• • •	-13 (-17,-8) -3 (-5,-3)	4897	-28 4543		
7467	7312	-155			-2 (-5,1)	6926	-541		
912 674	680 489	-726 -185			-25 (-31,-18) -27 (-36,-18)	824 545	-129		-10(-16,-3) -19(-28,-9)
43476 3705 2245	34211 3065 1737	-9265 -640 -508			-21 (-23,-19) -17 (-24,-9) -23 (-30,-15)	37647 3144 1974	-5829 -561 -271		-13 (-15,-11) -15 (-22,-7) -12 (-20,-4)
62378 5091 3326	65004 5125 3359	2626 34 33		· <u> </u>	4 (-6,16) 1 (-4,6) 1 (-5,7)	73264 5643 4218	10686 552 892		17 (6,30) 11 (5,17) 27 (20,34)
ary Syndrome, H	F = Heart Failure, T						-80	-10 -20 -10 è	10 30 30 a0
Mean No. 2016/19	Total No. 2020	Difference 2016/19 to 2020			% change (95% Ci) 2016/19 to 2020	Total No. 2021	Ofference 2016/19 to 2021		% change (95% 2016/19 to 20
	-				75 (70 700	201026	20422	-	-20(-25,-15)
a101a 20775	26057 16083	-4956 -4692			-16 (-17,-15) -23 (-27,-18)	27079 17695	-3034 -3080		-10(-11,-9) -15(-19,-10
196930 18649	143370 15439	-53560 -3210	·•· .		-27(-33,-21) -17(-19,-16)	153202	-43728 -2068		-22 (-28,-16 -11 (-13,-10
15551	9961	-5590			-36 (-40,-31)	11181	-4370	-	-13 (-17,-9) -28 (-33,-23
1019	1012 568	-297 -451			-23 (-28,-16) -44 (-51,-37)	1062	-247 -292	2- • • •	-19 (-25,-12 -29 (-37,-20
77545 4096 4050	64106 3901 3842	-13439 -195 -808	-		-17 (-20,-15) -5 (-10,1) -17 (-21 -13)	66032 4190 4276	-11518 94 -374	·	-15 (-17,-12 2 (-3,0) -8 (-12,-3)
266 16	155 20	-111 4	· · · · · ·	-	-42 (-51,-31) 29 (-22,114)	147 28	-119 12		-45 (-54,-34) 81 (16,182)
hrombectomy			•	1					-49 (-78,19)
243	0 276	33			8 (2,14) 14 (-15,53)	0 254	11		17 (10,24) 5 (-22,41)
3468 398 226	2638 291 128	-830 -107 -98			-24 (-28,-19) -27 (-36,-17) -43 (-61,-18)	2939 822 116	-529 -76 -110		-15 (-20,-10 -19 (-28,-9) -49 (-65,-25
1578 247	1626 231	48		•	3 (-8,15) -7 (-19,8)	1608 300	30 53		2 (-9,14) 21 (7,38)
									-10 (-26,9) -33 (-41,-23
1459 700	1059 512	-400 -254			-27 (-35,-19) -33 (-44,-20)	1117 526	-342 -240		-23 (-31,-15 -31 (-42,-18
22824 1995	17402 1679	-5422			-24 (-28,-10) -16 (-20,-11)	18678 1757	-4146 -230		-18 (-22,-14) -12 (-16,-7) -28 (-47,-8)
, bypass or ampr	utation								-20(-47,-3) -15(-18,-12
17083 2720 1482	13152 2344 1280	-376 -202			-23 (-26,-20) -14 (-19,-8) -14 (-21,-6)	14583 2549 1232	-2500 -171 -250		-15 (-18, 12) -0 (-12,-1) -17 (-24,-9)
932	743	-189			-20(-31,-7)	729	-203	100 B 100	-22 (-33,-9)
	428487 320296 20095 20095 20095 20095 20095 20095 20095 20095 20095 20095 20095 113441 20075 10974 43576 5021 20075 2005 20075 2005 2005 2005 20075 2005 2	4.28.487 40.14.47 302296 37.21.5 1.662.17 9.80.7 96457 9.80.7 96457 9.80.7 96250 6.23.8 1.32.471 1.90.7 1.32.471 1.90.7 1.32.471 1.90.7 1.32.471 1.90.7 1.32.471 1.90.7 1.32.471 1.90.7 1.32.471 1.90.7 1.32.471 1.90.7 1.32.471 1.90.7 1.32.471 4.90 4.32.765 3.02.11 5.031 2.52.5 3.031 2.52.6 3.031 2.52.6 3.031 2.56.64.7 1.30.030 1.54.31.70 1.30.031 1.56.3 1.30.39 5.50 1.30.39 5.50 1.30.30 1.56.3 1.30.30 3.56.4 1.30.30 3.56.4 1.55.3 2.00 3.00.31 2.00	128.87 101.47 270.00 120216 271.21 -21.25 100217 9607 -400 0657 -640 -640 0657 -640 -640 0657 -640 -640 0657 -640 -640 0657 -640 -640 0657 -640 -640 0657 -640 -640 06925 -640 -640 06925 -640 -640 06925 -640 -640 06925 -640 -640 1377 131 -155 1377 131 -155 1397 -160 -220 3705 3005 -160 5391 3275 -2606 5392 -2205 -2016/19 1500 10053 26547 -6006 -6006 10059 134377 -53560 -6006 10051 0901 -53560 <td>128.887 2008 401.447 372.12 2008 -27040 372.12 2008 104217 2008 27.645 37.62 9692 -20.05 9692 92300 6925 87.86 9692 -40.14 9692 92300 6925 87.86 9692 -40.14 9692 92300 6925 67.86 9692 -40.14 9692 10217 101.00007 -40.14 9692 10277 73.13 -165 97.50 10373 102.000 -7.90 97.50 10374 400 -7.50 97.50 10375 -40.90 97.50 -40.14 103775 3005 -60.00 97.50 30705 3005 -60.00 97.50 30705 3005 -60.00 97.50 50915 132.50 -4.90 97.50 50915 132.50 -4.90 97.50 50915 132.50 -4.90 97.50 100131 265.50 100013 -5.55.60 10013 100131 265.50 10013 -5.55.60 10013 100131 265.50 10013 -5.55.60 10013 100131 265.50 10013 -5.55.60 1001 101019 15.61 10.69 -4.90 10.10 101019 15.61 10</td> <td>130487 20009 401447 20124 72000 20109 400 150147 9570 9007 400 </td> <td>Note of the second second</td> <td>System System System</td> <td>Norm Norm Norm</td> <td>Super birth Super birth Superbirth Super birth Super birth</td>	128.887 2008 401.447 372.12 2008 -27040 372.12 2008 104217 2008 27.645 37.62 9692 -20.05 9692 92300 6925 87.86 9692 -40.14 9692 92300 6925 87.86 9692 -40.14 9692 92300 6925 67.86 9692 -40.14 9692 10217 101.00007 -40.14 9692 10277 73.13 -165 97.50 10373 102.000 -7.90 97.50 10374 400 -7.50 97.50 10375 -40.90 97.50 -40.14 103775 3005 -60.00 97.50 30705 3005 -60.00 97.50 30705 3005 -60.00 97.50 50915 132.50 -4.90 97.50 50915 132.50 -4.90 97.50 50915 132.50 -4.90 97.50 100131 265.50 100013 -5.55.60 10013 100131 265.50 10013 -5.55.60 10013 100131 265.50 10013 -5.55.60 10013 100131 265.50 10013 -5.55.60 1001 101019 15.61 10.69 -4.90 10.10 101019 15.61 10	130487 20009 401447 20124 72000 20109 400 150147 9570 9007 400	Note of the second	System System	Norm Norm	Super birth Superbirth Super birth Super birth

Figure 1. Annual counts and percentage change in total admissions and procedures between pre-pandemic (2016-2019) and pandemic (2020-2021) periods for cardiovascular disease as primary diagnosis for all cardiovascular diseases and across subtypes and across three countries in the UK.

22



Figure 2. Monthly total admissions for cardiovascular disease as primary diagnosis across subtypes, across three countries in the UK and across pre-pandemic (2016-2019) and pandemic (2020 and2021) periods.

ondition	Mean No. 2016/19	Total No. 2020	Difference 2016/19 to 2020		% change (95% Cl) 2016/19 to 2020	Total No. 2021	Difference 2016/19 to 2021		% change (95% C 2016/19 to 2021
mergency adm	issions								
All conditions									
England	364636	351766	-12870	· · · · · · · · · · · · · · · · · · ·	-4 (-9,2)	389202	24566	······•	7 (1,13)
Scotland	34521	33901	-720	• •	-2 (-8,4)	35602	1081		3 (-3,9)
Wales	21233	20317	-916	P	-4 (-6,-3)	21464	231	1-0-1	1 (0,3)
ACS .									
England	101186	92790	-8396		-8 (-11,-6)	100449	-737		-1 (-3,2)
Scotland	9807	9324	-483	• • •	-5 (-12,3)	9888	81	• •	1 (-7,9)
Wales	5689	5454	-235		-4 (-8,0)	5589	-100	P	-2 (-6,3)
łF									
England	80997	78042	-2955	•	-4 (-14,8)	90270	9273	•	11 (0,25)
Scotland	5919	5837	-82		-1 (-14,13)	6096	177	•	3 (-10,18)
Wales	4464	3903	-561		-13 (-17,-8)	4329	-135		-3 (-8,2)
troke/TIA									
England	106461	103371	-3090		-3 (-5,-1)	111303	4842	+ • -1	5 (2,7)
Scotland	11843	11583	-260	• • • •	-2 (-7,2)	12015	172		1 (-3,6)
Wales	6574	6466	-108	· • • • •	-2 (-5,1)	6124	-450	dense de la constancia de	-7 (-10,-4)
A					- 1 - 1 - 1				
England	4800	4351	-449	····•	-9 (-12,-6)	4612	-188	→ •→	-4 (-7,-1)
Scotland	449	397	-52	• • •	-12 (-21,-1)	448	-1	• • • • • • • • • • • • • • • • • • •	0(-10,11)
Wales	273	238	-35	•	-13 (-24,0)	279	6		2 (-10,17)
AD									
England	14773	14032	-741	·····•	-5 (-9,-1)	15640	867	·•	6 (1,11)
Scotland	1750	1805	55	· · · · · · · · · · · · · · · · · · ·	3 (-3,10)	1789	39	· · · · · · · · · · · · · · · · · · ·	2 (-4,9)
Wales	1164	1091	-73	• • •	-6 (-12,0)	1184	20	· · · · · · · · · · · · · · · · · · ·	2 (-5,8)
/TE					-1				-1-1-1
England	56419	59180	2761	, · · · · ·	5 (-5,16)	66928	10509	•	19 (8,31)
Scotland	4753	4855	102		2 (-2,6)	5366	613	· · · · · · · · · · · · · · · · · · ·	13 (8,18)
Wales	3069	3165	96		3 (-4,10)	3959	890	· · · · ·	29 (21,38)

Figure 3: Annual counts and percentage change in total emergency and elective admissions between pre-pandemic (2016-2019) and pandemic (2020 and 2021) periods for cardiovascular disease as primary diagnosis for all cardiovascular disease and across subtypes and across three countries in the UK.

Condition	Mean No. 2016/19	Total No. 2020	Difference 2016/19 to 2020		% change (95% Cl) 2016/19 to 2020	Total No. 2021	Difference 2016/19 to 2021		% change (95% Cl) 2016/19 to 2021
Elective admission All conditions	ns								
England	63852	49681	-14171	H•+	-22 (-25,-20)	54664	-9188	2.00	-14 (-17,-12)
Scotland	4775	3320	-1455	· · · · · · · · · · · · · · · · · · ·	-30 (-42,-17)	3592	-1183		-25 (-37,-10)
Wales	4262	3328	-934		-22 (-30,-13)	3637	-625		-15 (-23,-5)
ACS	42.02				-22 (-30) 231	3037	-025		-23 (-23,-3)
England	5031	4249	-782	1	-16 (-18,-13)	4733	-298	1	-6 (-9,-3)
Scotland	640	483	-157	(Association)	-25 (-44,1)	570	-70		-11 (-33,19)
		1008	-157						
Wales	1168	1008	-160	-	-14 (-32,9)	952	-216		-18 (-36,3)
England	11303	9344	-1959		-17 (-26,-7)	10972	-331		-3 (-13,9)
Scotland	751	488	-263			527			
					-35 (-46,-22)	568	-224		-30 (-42,-16)
Wales	461	383	-78		-17 (-26,-7)	568	107		23 (12,35)
Stroke/TIA									
England	5680	5318	-362	· · · ·	-6 (-13,0)	5381	-299	· · · · ·	-5 (-12,2)
Scotland	628	530	-98		-16 (-28,-1)	487	-141	•	-22 (-34,-9)
Wales	893	846	-47	· · · · · · · · · · · · · · · · · · ·	-5 (-14,5)	802	-91	· · · · · · · · · · · · · · · · · · ·	-10 (-19,0)
AA									
England	7175	4767	-2408	· · · ·	-34 (-39,-28)	5235	-1940		-27 (-33,-21)
Scotland	463	289	-174	• • • • • • • • • • • • • • • • • • •	-38 (-46,-27)	376	-87	• • • • • • • • • • • • • • • • • • •	-19 (-29,-7)
Wales	401	251	-150	++ I	-37 (-52,-18)	266	-135	· · · · · · · · · · · · · · · · · · ·	-34 (-49,-13)
PAD									
England	28703	20179	-8524		-30 (-34,-26)	22007	-6696		-23 (-28,-19)
Scotland	1955	1260	-695	• • • • • • • • • • • • • • • • • • • •	-36 (-46,-23)	1355	-600	· · · · · · · · · · · · · · · · · · ·	-31 (-42,-18)
Wales	1081	646	-435	• • • • • • • • • • • • • • • • • • • •	-40 (-52,-25)	790	-291	· · · · · · · · · · · · · · · · · · ·	-27 (-41,-9)
VTE			100		10 (00, 00)				
England	5960	5824	-136	•	-2 (-17,15)	6336	376		6 (-10,25)
Scotland	338	270	-68	•	-20 (-36,0)	277	-61		-18 (-34,2)
Wales	258	194	-64	· · · · · · · · · · · · · · · · · · ·	-25 (-38,-8)	259	-01		-18 (-34,2) 0 (-17,21)
we are S	4.40	7766	-04	-50 -40 -30 -20 -10 0 10	-25 (-38,-8)	2.39		0 40 40 30 30 10 0 10 30 30	

ACS= Acute Coronary Syndrome, HF = Heart Failure, TIA= Transient Ischaemic Attack, AA= Aartic Aneurysm, PAD = Peripheral Arterial Disease, VTE= Venous Thromboembolism







Figure 5: Monthly elective hospital admissions for cardiovascular disease as primary diagnosis across subtypes, across three countries in the UK and across pre-pandemic (2016-2019) and pandemic (2020 and 2021) periods.



Figure 6. Monthly total procedures for cardiovascular disease across subtypes, across three countries in the UK and across pre-pandemic (2016-2019) and pandemic (2020 and 2021) periods

Figure 7: Annual counts and percentage change in total emergency and elective procedures between pre-pandemic (2016-2019) and pandemic (2020-2021) periods for cardiovascular disease for all cardiovascular procedures and across subtypes and across three countries in the UK

Procedure for.	Mean No. 2016/19	Total No. 2020	Difference 2016/19 to 2020		% change (95% CI) 2016/19 to 2020	Total No. 2021	Difference 2016/19 to 2021		% shange (95% C 2016/19 to 2021
Emergency Proced NI procedures	lures								
England	114799	103164	-11635	•	-10 (-11,-9)	112179	-2620		-2 (-3,-1)
Scotland Wales Cardiac	6764 7321	6952 6993	188 -328		3 (0,6) -4 (-8,0)	7421 7294	657 -27	÷	10 (7,13) 0 (-4,4)
ACI England	68542	60891	-7651		-11 (-13,-9)	65105	-3437		-5 (-7,-3)
Scotland	4280	4317	37		1 (-3,5)	4564	284	•	7 (3,11)
Wales CABG	3651	3794	143	-	4 (0,8)	4092	441	•	12 (8,16)
England Scotland	3786 75	2789 71	-997 -4	· · · · · · · · · · · · · · · · · · ·	-26 (-29,-23) -5 (-29,27)	3459 109	-327 34	•	-9 (-12,-5) 46 (15,86)
Wales sert Failure	277	118	-159		-57 (-65,-48)	129	-148	·••	-53 (-61,-44)
PM/resynchronia England	ation 21011	19387	-1624	100	-8 (-12,-3)	21777	760		4 (-2,9)
Scotland Wales	573 1581	688 1345	115		20 (8,33) -15 (-24,-5)	807 1457	234	(here and)	41 (28,55) -8 (-17,3)
AD/transplant			-4)			57	-49	100	
England Scotland	106	63 6	-10		-41 (-54,-23)	37	-49	Alford .	-46 (-59,-29)
Wales troke/TIA									
hrombolysis or th England	stambectomy 3828	4049	221		6 (0,12)	4400	572		15 (8,22)
Scotland Wales	243	261	18		8 (-20,45)	244	1		0 (0,0) 1 (-25,35)
arotid endertecto England		540	-61		-7 (-13,1)	863	-11	I	-1 (-8.6)
Scotland	40	45	5	· · · · · · · · · · · · · · · · · · ·	14 (-18,59)	40	0	· · · · · · · · · · · · · · · · · · ·	1 (-28,43)
Wales colling of carebral	84 artery	54	-30		-36 (-56,-5)	63	-21		-25 (-48,9)
England Scotland	775	894 100	119 -11		15 (1,31) -10 (-27,12)	863 145	88 34	1	11 (-2,27) 31 (6,58)
Wales ther vascular	45	66	21	• • •	47 (4,130)	46	1	••	3 (-31,53)
A repair England	2702	2077	-625		-23 (-35,-10)	2176	-526		-19 (-31,-5)
Scotland	244	209	-35		-14 (-27,1)	200	-44		-18 (-31,-3)
Wales AD	199	149	-50		-25 (-41,-5)	134	-45		-33 (-47,-14)
England	5991	5504	-487		-8 (-13,-3)	6126	135	4	2 (-3,8)
Scotland Wales	499 417	535 359	36 -58	· • · · · · · · · · · · · · · · · · · ·	7 (-7,23) -14 (-27,2)	534 339	35 -78	and a set of the set o	7 (-7,23) -19 (-31,-3)
England	bypass or ampu 7024	dation 6563	-401		-7 (-10,-3)	7185	161		2 (-1,6)
Scotland Wales	904 814	958 841	54 27		6 (-1,14) 3 (-7,15)	1005 774	101		11 (4,19) -5 (-15,6)
TE		0.1			24-104		~		24.204
A embolectomy England	133	107	-26		-19 (-35,-1)	143	10		8 (-10,30)
PA embolectomy England Scotland Wales	38 10 Meen No.	23 6	-15 -4		-39 (-83,112) -38 (-74,45) 110 % change (95% CI)	17 16	-21 6 -130 Difference	· · · · · · · · · · · · · · · · · · ·	-55 (-88,63) - 64 (-8,194) 200 230 % change (95% C
A embolectomy England Scotland Wales Youndure for, lective Procedure Il procedures	38 10 Meen No. 2016/19	23 6 Total No. 2020	15 -4 Difference 2016/19 to 2020	0 30 0 30 30	-39 (43,312) -38 (-74,45) 150 % change (95% Cl) 2016/19 to 2020	17 16 Total No. 2021	-21 6 Difference 2016/19 to 2021	· · · · · · · · · · · · · · · · · · ·	
A embolectomy England Scotland Wales Howedure for, lective Procedure England Scotland	38 10 Mean No. 2056/29 H 237354 24235	23 6 Total No. 2020 162283 13105	15 -4 Difference 2016/19 to 2020 -75271 -5130		-39 (43,112) -38 (-74,45) 200 5 change (95% Cl) 2016/19 to 2020 -32 (-38,-25) -21 (-22,-20)	17 16 Total No. 2021 160747 20530	-21 -0 -0 -0 -0 -0 -0 -0 -0 -0 -0	· · · · · · · · · · · · · · · · · · ·	55 (48,61) 64 (4,194) 200 210 % change (95% C 2016/19 to 2027 -29 (-35,-22) -15 (-17,-14)
A embolectomy England Scotland Wales Wales Inconduce for. Jective Procedure England Scotland Wales andise	38 10 Mean No. 2016/29 H 237554	23 6 Total No. 2020 162283	15 -4 Difference 2016/19 to 2020 -75271		-39 (43,112) -36 (-74,45) 200 % change (95% Ct) 2016/18 to 2020 -32 (-38, -25)	17 16 Total No. 2021 160747	21 6 339 00fference 2016/19 to 2021 -67807	107 50 8 30 30 3	55 (-88,61) 64 (-8,134) 200 200 % change (95% 0 2016/19 to 202 -29 (-35,-22)
A embolectomy England Scotland Woles Woles England Scotland Woles ardiac Cl	38 30 Meen No. 2016/29 W 237554 24235 13455	23 6 Total No. 2020 162283 153105 9090	-15 -4 Difference 2014/1910-2020 -75271 -5130 -1365		-39 (43,112) -38 (-74,45) 2014/24 -	17 16 Total No. 2021 169747 20530 30401	-21 6 Difference 2016/19 to 2021 -47807 -3705 -3254	107 50 8 30 30 3	- 45 (48,63) - 64 (4,134) 200 200 X change (95% C 2014/15 to 202 - 29 (35,-22) - 15 (-12,-14) 23 (-36,-16)
A embelectomy England Scotland Wales Wales England Scotland Wales England Scotland England Scotland Scotland	38 10 Meen No. 2016/19 H 217554 24235 13455 128388 14369	23 6 Total No. 2020 162283 19105 6090 82479 111122	-15 -4 -1 DHFerence 2016/19 to 2020 -75271 -5120 -4185 -455009 -1247		-39 (41,12) -39 (-74,45) 200 	17 16 Total No. 2021 160747 20530 10001 880977 12017	-21 6 	107 50 8 30 30 3	
A embleteromy England Scotland Wales Vocedure for Jerotedure for England Scotland Wales CI England Scotland Wales Addise CI England Scotland Wales Addise CI England Scotland	38 10 2016/18 8 237354 24235 13455 13455 128388 14869 7502	23 6 Total No. 2020 162283 19105 9090 82479 11122 4802	-15 -4 2016/19 to 2020 -75271 -5130 -4385 -45509 -3247 -2200		-39 (41,12) -39 (-74,45) 200 	17 16 Total No. 2021 160747 20530 30101 88097 12017 5569	23 6 	107 50 8 30 30 3	
A embeldetomy England Scotland Woles Vosesfure Frocedures England Scotland Wales Cl England Scotland Wales Zel6 England Scotland	38 10 Meen No. 200/19 * 237554 24725 124725 13455 14369 7500 11765 1235	23 6 Total No. 2020 162283 19305 8090 82479 11122 4802 7172 941	-15 -4 2016/19 to 2020 -75271 -5130 -4855 -455097 -3347 -2700 -4593 -394		-39 (41,12) -39 (-74,45) 200 -2014/38 to 2020 -2014/38 to	17 16 Total No. 2021 140747 20530 10401 12017 12017 1509 7722 953	23 6 2016/terence 2016/12/12/02 407807 -3005 -3005 -3005 -3005 -3005 -402901 -2552 25933 -4043 -382	107 50 8 30 30 3	
A embelescomy England Scotland Woles Vocasive for, Electhe Procedures England Scotland Wales Cl England Scotland Wales ABG England Scotland Wales ABG	38 10 Mean No. 2004/19 * 2337554 242355 123558 14309 14309 7502 1128388 14309 7502	23 6 Total No. 2020 162283 19105 9080 82479 11122 4802 7172	-15 -4 Difference 2016/19 to 2020 -75271 -5130 -4185 -45907 -3347 -2200 -4593		-99 (40,122) -39 (-74,45) 100 5016/18 to 2020 -32 (-38,-28) -32 (-38,-28) -32 (-38,-28) -32 (-38,-28) -32 (-38,-28) -33 (-24,-28) -39 (-44,-28) -39 (-44,-28) -39 (-44,-28) -39 (-44,-28) -39 (-44,-28)	17 16 Tetal No. 2021 160747 20530 10401 88097 12017 5569 7722	23. 6 2016/reence 2034/12 to 2023 42807 -3705 -3705 -3254 -40291 -2153 -2153 -4043	107 50 8 30 30 3	35 (40,41) 64 (4,194) 200 200 X change (\$95% 2005) 205 (15,194) 201 (35,22) 2554/18 to 2022 202 (35,22) 251 (35,22) 251 (35,22) 251 (35,22) 251 (35,22) 251 (35,22) 251 (35,22) 251 (35,22) 251 (35,22) 251 (35,22) 251 (35,22) 251 (35,22) 251 (35,22) 251 (35,22) 251 (35,22) 251 (35,22) 251 (35,22) 251 (35,22) 351 (35,22) 351 (35,22) 361 (35,22) 361 (45,28) 361 (42,28) 361 (42,28)
A embelaciony England Soutiand Wales Vessefure Procedure England Soutiand Soutiand Wales Contend Conte	38 10 Meen No. 2016/19 * 237554 24235 13455 124388 14369 7360 1235 742 1235 742 1235 55533	23 0 Total No. 2020 162283 19105 82479 11122 4002 7172 450 44719	-15 -4 2014/19 to 2020 -75271 -5120 -4365 -4365 -4365 -3367 -2700 -33647 -2700 -33647 -292 -292 -11814		-99 (40,12) -39 (-74,45) -39 (-74,45) -20 (-74,45) -20 (-74,45) -20 (-74,45) -20 (-74,45) -20 (-74,45) -21 (-22,20) -21 (-22,20) -21 (-22,-10) -20 (-23,-10)	17 16 Tetal No. 2021 160747 20530 10401 88097 12017 12017 5549 953 598 953 598	23. 6 Difference 2016/18 to 2022 42/807 -32/05 -32/	107 50 8 30 30 3	- 55 (40,42) 64 (4,194) 200 201 201 S change (95% S 2018/1/19 402 -32 (35,127,24) -32 (35,227) -31 (37,24) -31 (3
A embelsectory England Soutiand Wales Vesselber Procedure Byroachurs England Soutiand Wales Wales Contend Wales Contend Wales England Soutiand Wates England Soutiand Wates England Soutiand Wates	38 10 2016/13 8 23355 13455 128388 128388 128388 128388 12899 7502 11765 1235 24299 7502 21765 1235 2429 2420 2420 2420 2420 2420 2420 2420	23 0 Tetal No. 2020 162283 19105 8080 82479 11122 4402 7172 941 4502	-15 -4 2016/1910 2020 -5271 -5271 -520 -4385 -4590 -1347 -2347 -2347 -2347 -2347 -2347 -2347 -2347 -234		-99 (40,12) -39 (-7,45) 200 2016/25 to 2020 2016/25 to 2020 -32 (-30, 20) -32 (-30, 20) -32 (-30, 20) -33 (-40, 20) -36 (-40, 20	17 16 Total No. 2021 160747 20530 10401 12017 5569 7722 953 953	23 6 204ference 2046/18 to 2021 407807 -2005 -2005 -2051 -2053 -2051 -20		
A embelsectory England Soutiand Wales Vesselber Procedure Byroachurs England Soutiand Wales Wales Contend Wales Contend Wales England Soutiand Wates England Soutiand Wates England Soutiand Wates	38 10 Mean No. 2016/19 4 237554 24275 13455 1263888 14399 7502 11765 12355 1253 35523	23 0 Tetal No. 2020 162283 19105 8080 82479 11122 4402 7172 941 450 44719 3233	15 4 0 0 0 0 0 0 0 1 0 1 0 1 0 0 0 0 0 0 0		-99 (40,12) -99 (-74,45) -99 (-74,45) -99 (-74,45) -99 (-74,45) -99 (-74,45) -99 (-74,45) -99 (-74,20) -99 (-	17 16 Total No. 2021 160747 20530 10401 12017 5569 7722 953 958 44255 3383	23 6 20Hference 2016/18 to 2022 -2005 -2005 -2005 -2015 -2033 -2033 -204 -2032 -244 -245 -245		
A embelsionry England Sociand Sociand Wales Interesting Sociand Wales Co England Sociand Wales Co England Sociand Wales ABG England Sociand Wates ABG England Sociand Wates ABG England Sociand Wates ABG England Sociand Wates ABG England Sociand Wates ABG England Sociand Wates ABG England Sociand Wates ABG England Sociand Wates ABG England Sociand Wates ABG England Sociand Wates England Sociand England Engl	38 10 Mean No. 2036/28 12425 13455 124388 14390 128388 14390 113765 1235 1235 1235 1275 13455 1235 1235 1235 1235 1235 1235 1235 12	23 6 Total No. 2020 16/283 15/105 1000 82479 11122 4002 4002 401 402 402 402 402 402 402 402 402	15 4 2016/19-10 2016/19-10 2020 15100 -15000 -15000 -15000 -15000 -15000 -15000 -1500		-99 (40,12) -99 (-74,65) -98 (-74,65) -99 (-	17 16 Testal No. 2021 160747 10075 10001 10001 12017 12017 12017 1569 953 598 953 598 593 598	-33 6 Difference -20201 -20205 -20205 -2032 -2033 -2033 -2033 -2034 -2035 -2034 -2035 -2034 -2035 -2034 -2035 -2034 -2035 -2034 -20		
A embelsion England Soutand Wales Vesselater R Sociaria England Soutand Wales CCI England Soutand Wales England Soutand Wales England Soutand Wales England Soutand Wales England Soutand Wales England Soutand Wales England Soutand Wales England Soutand Wales England Soutand Wales England Soutand Wales England Soutand Wales	38 10 2014/19 30 201554 24225 13455 12459 126388 1295 7502 11765 1235 742 3503 3553 3069	23 6 Total No. 2020 16/283 19105 9080 82479 11122 941 4502 4402 941 4513 2497 97 14	15 4 2016Feneta 2018/19 to 2020 2018/19 to 2020 2019 2019 2019 2019 2019 2019 2019		-99 (40,12) -39 (-74,45) -30 (-74,45) -30 (-74,45) -30 (-74,45) -30 (-74,45) -30 (-74,27) -31 (-74,27) -32 (-74,27) -33 (-74,27) -34 (-	17 16 Testal No. 2021 160747 10075 10001 12017 12017 12017 12017 12017 12019 1509 953 598 593 598 598 2819 2819	-33 6 2014/19 to 2021 2014/19 to 2021 2014/19 to 2021 2015 2015 2015 2015 2015 2015 2015		
A embelsionmy England Sociation Winken Winken Winken Einstein Birgendurse England Sociation Co England Sociation Co England Sociation Wates Co England Sociation Socia	38 10 Mean No. 2036/28 12425 13455 124388 14390 128388 14390 113765 1235 1235 1235 1275 13455 1235 1235 1235 1235 1235 1235 1235 12	23 6 Total No. 2020 16/283 19105 9080 82479 11122 941 4502 4402 941 4513 2497 97 14	15 4 2016Feneta 2018/19 to 2020 2018/19 to 2020 2019 2019 2019 2019 2019 2019 2019		-99 (40,12) -39 (-74,45) -30 (-74,45) -30 (-74,45) -30 (-74,45) -30 (-74,45) -30 (-74,27) -31 (-74,27) -32 (-74,27) -33 (-74,27) -34 (-	17 16 Testal No. 2021 160747 160747 10017 12017 12017 12019 1	-33 6 2014/19 to 2021 2014/19 to 2021 2014/19 to 2021 2015 2015 2015 2015 2015 2015 2015		
A embelsion England Sociand Sociand Weles Housefure for, letthe Procedures England Sociand Works Class Class England Sociand Works Man Sociand Works Man Sociand Socia	38 10 Meen No. 2004/39 ** 237554 114555 124308 124309 7502 11755 742 ** 56533 3523 15255 742 ** 56533 3523 1009 100 12 trundadtemy 30 0	23 0 Tatla Na. 2020 162283 19105 8040 82479 11122 4400 941 4500 44719 912 32497 921 14 92 14 92	15 4 2014/04/04 to 2020 752/71 5130 4305 4305 2700 3207 2700 4303 -244 3307 2700 4303 -244 330 -244 330 -244 330 -244 330 -244 330 -244 330 -244 330 -244 330 -244 -244 -244 -244 -244 -244 -244 -24		-99 (40,12) -99 (74,05) -90 (7	17 16 Total No. 2021 160747 20530 20630 20530 20607 20530 20607 20530 20607 20530 2060 40235 3088 20819 500 6	-73 6 2007 -2007 -3705 -3705 -2532 -2552 -		. 65 (40,02) . 66 (4,194) 20 20 20 20 20 20 20 20 20 20 20 20 20 20 20 20
A embelsion of the second social soci	38 10 Mean No. 3056/13 4 122355 1223554 14255 122355 122355 122355 1237554 14390 13765 12755 12755 13765 12755 13765 13775 14775 13765 13775 14775 13765 13775 14775 13775 14775 13775 14775 13775 14775 13775 14775 13775 14775 137755 13775 13775 13775 13775 13775 13775 13775	23 0 Testal No. 2020 162283 15905 12022 42079 11222 42079 11222 44719 1203 2497 941 42739 1212 941 1233 2499 124 95 125 125 125 125 125 125 125 12	15 14 17 17 17 17 17 17 17 17 17 17		-99 (40,12) -99 (74,5) -90 (74,5) -91 (74,5)	17 16 160747 20530 20401 20530 20401 20537 2053 2053 2053 2053 2053 2054 2055 2055 2055 2055 2055 2055 2055	-33 6 2014/19 to 2021 -47807 -3705 -3705 -3705 -3705 -3705 -3705 -3705 -370 -4018 -362 -70 -70 6 81 10 -516		. 65 (40.30) 66 (4.394) 200 200 506 (4.394) 506 (4.394) 506 (4.394) 201 (4.394) 201 (4.394) 201 (4.394) 201 (4.394) 201 (4.394) 201 (4.394) 201 (4.394) 201 (4.494) 201 (4.49
A embelsion of the second of t	38 10 Meson Ro. 2014/28 237554 24225 13455 124398 14499 7500 120 13255 13255 13459 7500 102 102 102 102 102 102 102 1	23 0 Total No. 2020 10/2283 19105 0000 82479 11122 4402 7772 941 450 44719 1112 2497 941 95 117 117 15	15 4 2016/19.10 2016/19.10 2016/19.10 2016/19.10 2016 2016/19.10 2016/10 2016/1		-99 (40,12) -99 (40,12) 100 % dhaqqi (95 (2) 2014/95 - 2020 -21 (32, 2) -21 (42, 5) -21 (17 16 70147 No. 2021 160747 20530 10401 12017 5569 7722 953 569 7923 953 569 953 569 90 6 1117 10	33 6 200fference 2016/18 to 2022 -2005 -2005 -2005 -2015 -2015 -2014 -20291 -2019 -2		. 05 (40,3) 06 (40,3) 200 200 200 200 2010(20,3)
A embeldectomy England Sociand Wales interface interface interface interface ingland Sociand Wales College England Sociand Wales College Sociand Wales College Sociand Sociand Wales Sociand Sociand Wales Sociand Wales Sociand Wales Sociand Sociand Wales Sociand Wales Sociand Sociand Wales Sociand Wales Sociand Sociand Wales Sociand Sociand Sociand Sociand Sociand Sociand Sociand Sociand Sociand S	38 10 30 3056/13 4 31255 1233554 14255 1233554 14359 7362 7362 7362 35533 3000 12 100 12 100 12 100 12 100 12 100 12 100 12	23 0 Total No. 2020 142283 19105 82479 11112 4802 7112 4802 7112 1402 7112 4802 7112 1402 7112 1402 1112 1112 1117 11	15 2016/19.10 2018/19.10 2018/19.10 2018/19.10 2018/19.10 2019 20		-99 (40,12) -39 (-7,45) 200 -200 (-7,45) -200 (-7,45) -20	17 16 Tutal No. 2021 160747 20530 10001 12017 5569 953 598 953 598 40255 2819 90 6 117 10 2051	-73 6 2014/21 to 2021 -2705 -2705 -2705 -2705 -2705 -2705 -2707 -2007 -2		- 05 (00,20) 06 (00,20) 200 200 X change (95% of 200 200 (35,22) 35 (47,24) -20 (35,22) -35 (47,24) -31 (39,24) -31 (39,24) -
A embeddecomy Social Social Weles Weles Weles England Social Brockdars Brockdars Brockdars Brockdars Co England Social So	38 10 Mean No. 2014/13 8 323554 24275 13455 124388 124589 7502 7420 11255 742 7450 1225 742 742 1255 742 1255 742 1255 14599 7502 1235 742 10 10 12 3059 14 30 10 12 3059 14 30 12 3059 14 30 12 3059 14 30 12 3059 14 30 12 3059 14 30 30 30 30 30 30 30 30 30 30 30 30 30	23 0 Total No. 2020 195228 19505 82459 19505 82459 19505 1950 1950 1950 1950 1950 1950 1950 1957 1951 1957 19	15 4 2016/eneod 2018/39 to 2020 2018/39 to 2020 2019 2		-99 (40,12) -39 (-40,12) 200 X dange (55 (C) 201(/25 to 200) 201(/25 to 200) -21 (-22,-20) -21 (-22,-20)	17 16 Testal No. 2021 160747 20530 10001 12017 5549 7722 5549 7723 5549 7723 5549 7723 5549 7723 5549 7723 5549 7723 549 7723 549 7723 549 705 6 117 10 2051 2051 2051 2051 2051 2051 2051 2	-33 6 2004farence 2014/18 to 2021 -2005 -2005 -2005 -2005 -2007 -2		
A embeddecomy Social Social Weles Weles Social England Social Biotecher Procedures England Social Weles Clas	38 10 2006/13 2005/14 24255 124255 124255 124255 124255 124255 124255 124255 124255 124255 124255 124255 124255 12425 124255 12425 1245 124	23 0 Total No. 2020 16/288 19/05 82479 11127 4400 941 4500 44719 913 2407 941 1233 2407 941 155 156 156 157 157 157 157 157 157 157 157	15 2014 20		-99 (40,12) -99 (40,12) 100 Xi chaoge (95 Cc) 2016/19 to 2020 -12 (12, 23) -12 (12, 23) -12 (12, 23) -12 (12, 23) -12 (12, 23) -13 (14, 20) -13 (14, 20) -13 (14, 20) -14 (14, 20) -14 (14, 20) -19 (14, 20) -10 (17 16 160747 20530 20207 20207 20207 20207 20207 20207 20207 20207 2020 20207 20207 20207 2020 200 200 2020 200 200 200 200 200 200 200 200 200 200 200 200 200 200 20	-73 6 2014/21 to 2021 -2705 -2705 -2705 -2705 -2705 -2705 -2707 -2007 -2		. 65 (40.02) 66 (4.59) 200 200 200 200 201 200 200 201 201 201 201 201 201 201 201 201 201 201 201 201 201 201 201 201
A embelance any Explained Sociational Workers Workers Explained Sociational Workers Forcedures England Sociational Worker Control Sociational Worker England Sociational Worker England Sociational Worker England Sociational Worker England Sociational Worker England Sociational Worker England Sociational Worker England Sociational Worker England Sociational Worker England Sociational Worker England Sociational Worker England Sociational Worker England Sociational Worker England Sociational Worker England Sociational Sociational Worker England Sociational	38 10 MAssen No. 2006/13 24 24 25 24 25 24 25 25 25 25 25 25 25 25 25 25	23 0 Testal No. 2020 162283 15105 13222 43079 11222 4307 1222 44715 1233 2497 147 15 15 1298 246 111 15 15 1298 246 111 15 15 15 15 15 15 15 15 1	15 17 17 17 17 17 17 17 17 17 17		-99 (40,12) -99 (40,12) 100 X chaoge (95, Cc) 2014/13 to 2020 -12 (-14, 2) -12 (-14, 2) -12 (-14, 2) -12 (-14, 2) -13 (-14, 2) -14 (-14, 2) -19 (-14, 3) -19 (-14, 3) -10 (-14, 2) -10 (17 160747 20530 20530 20530 20530 20530 20530 20530 20530 20530 20530 20530 20540 20541 2025 20541 2025 20541 2025 2055 2025 2055 2025 2055 2025 2055 2	33 6 3014 3014 3015 3015 3015 3015 3015 3015 3015 3015		. 45 (40.3) 46 (4.39) 20 20 20 20 504(4394) 20 (43.94) 20 (4
A embeddecomy England Sociand Sociand Wales Instant Social	38 10 2016/20 2025/20 202554 24225 11245 112555 112555 112555 112555 112555 112555 1125555 1125555 1125555 112555555 11255555555	23 0 Total No. 2020 162283 15105 1000 82479 11122 4402 7772 943 4402 7772 943 2409 714 9 117 15 15 15 15 15 15 15 15 15 15	15 2014/13/16 12020 2014/13/16 12020 2014/13/16 12020 2014 20		-99 (40,12) -99 (40,12) 100 X 6Asopi (95 Cc) 2016/20 - 2020 -21 (-22,-20) -21 (-22,-20) -	17 16 7000 7000 7000 7000 7000 7000 7000	33 6 2007erence 2014/21 to 2022 -2005 -2005 -2005 -2005 -2005 -2005 -2005 -2007 -20		. 05 (00,02) 06 (00,02) 200 200 200 200 2010(10,000)
A embeddecomy England Sociand Sociand Wales reseture for. Sociand Sociand Sociand Wales Bigend Sociand Wales Bigend Sociand Wales Bigend Sociand Wales Control Sociand Sociand Wales Control Sociand S	38 10 Mean No. 2026/13 237554 24255 124385 124385 124399 7500 7500 7500 13755 1375 13755 1375 13	23 0 Tatla Na. 2020 16/288 19/05 82479 11127 4400 941 4203 941 4203 941 4203 941 400 1117 1017 101 1017 1018 2407 1117 1018 10	15 17 18 18 18 18 18 18 18 18 18 18		-99 (40,12) -99 (40,12) 100 301 (40,2) -12 (40,2)	17 16 160747 20530 205500 205500 205500 205500 205500 205000 205500 205500 20500 200	- 33 - 33 - 33 - 33 - 37 - 3705 - 3705		. 05 (00,01) 06 (00,01) 200 200 200 200 2016/13 to 202 2016/13 to 202 20
sorbaland Socialand Wales Wales Social Social Social Social Social Wales England Social Wales Big Body Social Social Wales Big Body Social Soc	38 10 Mean No. 2026/13 237554 24225 124385 124385 124390 7500 7500 7500 7500 1375	23 0 Tatal Na. 2020 16/283 19/05 82479 11127 4400 11127 4401 11127 4402 941 4203 941 1127 941 400 1117	15 10 10 10 10 10 10 10 10 10 10		-99 (40,12) -99 (40,12) 100 N 40,400 (99, 02) 2016/19 to 2020 -12 (12,2) -12 (12,2)	17 160747 20530 205500 205500 205500 205500 205500 205500 205500 205500 205500 20550	33 53 53 53 53 53 53 53 53 53		
A embediescomy Singland Sociand Weles Weles England Sociand So	38 10 Mean No. 2006/13 1237554 14255 123358 14355 12375 12375 123	23 0 Testal No. 2020 162283 15905 2027 11222 40279 1122 1122 40279 1122 40279 1122 1122 40279 1122 1122 40779 1122 1127 1128	15 2007/01/01 2017/01 10/02 2017/01 10/02 2017/01 10/02 2017/01 2017/		-99 (40,12) -39 (40,12) 100 301(745) 301(745) 301(745) 301(745) -31 (34,28) -31 (34,28) -31 (34,28) -31 (34,28) -31 (34,28) -31 (34,28) -31 (42,28) -31 (42,48) -31 (42,48) -31 (42,58) -31 (42,58)	17 16 7utal No. 2021 100747 20530 10001 7233 5549 7233 598 43353 2819 90 6 107 10 2051 2051 2051 2051 2051 2051 2051 2	33 6 200fference 200fference 4-57807 -2705 -2005 -2		. 65 (40.3) 66 (4.394) 20 20 20 20 20 20 20 20 20 20 20 20 20 2
A embeldectamy Social S	38 10 Mean No. 3056/13 4 237554 14255 123355 123355 123355 12335 13765 12355 13765 12355 13765 13775 147	23 0 Testa Ne. 2020 162283 15105 162283 15105 162283 15105 162283 15105 162283 15105 162283 15105 162283 162883 16288 162883 16288 162883 163888 163888 163888 163888 163888 163888 163888 163888 164	14 2014/14/14/2020 2014/14/2020 2014/14/		-99 (40,12) -99 (40,12) 100 500 (140,20) -32 (40,20) -32 (40,20) -32 (40,20) -32 (40,20) -32 (40,20) -32 (40,20) -34 (40,20)	17 160747 205300 20530 20530 20530 20530 20530 20530 20530 20530 20530 2	33 533 534 5355 5355 5355 5355 5355 5355 5355 5355 5355 5355 5357 5355 53577 5357 5357 5357 5357 5357 5357 5357 5357 535		
A embediescomy England Sociand	38 10 Mean No. 2026/23 237554 24225 128388 128388 24390 7500 7500 7500 7500 7500 1275 1275 128388 75000 70000 7000 7000 70000 7000 7000 7000 70000 70000 700000	23 0 Total No. 2020 162283 19105 802479 111122 4402 7172 941 4500 44219 941 4500 44219 941 1112 1490 1490 1112 1490 1112 1490 1	15 100000000000000000000000000000000000		-99 (40,12) -99 (40,12) 200 X Anage (99, Ce) 2014/19 to 2009 -12 (-22,-20) -21 (-22,-20)	17 16 160747 20530 100077 20530 10007 20530 205500 205500 205500 205500 205500 205500 205500 205500 205500 205500 205500 205500 205500 205500 205500 205500 205500 2055000 205500 205500 2055000	33 0 333 344 345 345 345 345 345 345		. 05 (00,20) 07 (00,20) 200 200 200 200 2010(210,20)
A emblesteamy Explaind Sociand Sociand Weles Weles Interference England Sociand Weles Birgend Sociand Weles England Sociand Weles England Sociand Weles England Sociand Weles England Sociand Sociand Weles England Sociand Weles England Soci	38 10 Mean No. 2006/13 2017554 242755 124385 14389 73502 1255 1255 1255 1269 1000 100 100 100 100 100 100 1	23 0 Testal No. 2020 162283 19105 824737 11127 4402 941 4402 941 4403 92 44739 92 44739 92 14 93 1117 125 126 126 127 14 92 15 92 14 92 14 92 14 92 14 92 14 92 14 92 14 92 15 15 15 15 15 15 15 15 15 15	15 2014/1916 2020 2014/1916 2020 2015		-99 (40,12) 100 100 100 100 100 100 100 10	17 16 160747 205300 20530 20530 205300 20530 20530 20530 20530 20530 20530 200	33 533 534 535 535 535 535 535 5		05 (40,0) (44,196) 200 2014(3) 50 (43,52) (51,17,40) 2014(3) 50 (52,17,40) 2014(3) 50 (52,17,40) 2014(3) 20 (21,24) 2014(3) 20 (21,24) 2014(3) 21 (21,24)
A embelsion of the second of social s	38 10 Mean Ro. 2026/20 237554 24225 1124388 24390 7502 122388 124390 7502 11275	23 0 Total No. 2020 162283 15105 10208 11122 4802 7772 943 4802 7773 943 4802 7773 943 4802 7773 943 4802 7773 943 2409 74 9 1117 127 120 1117 1118 1117 11	15 2047494 2020 2047494 2020 2057474 20574 2057474 2020 2057474 2020 2057474 20577474 20577474 20577474 20577474 205777474 2057774 2057774 2057774 2057774 2057774 20577774 20577777777 205777777777777777777777777777777777777		-99 (40,12) -99 (40,12) 100 100 (1/45) -90 (1/45)	17 16 160747 20530 100077 25540 75540 7555 2555 2555 2555 2555 2555 2555 255	33 0 333 0 343 344 345 345 345 345 345 345		. 05 (40,3) 06 (40,3) 200 200 200 200 2016/21 to 2022 2016/21 to 202

s Graft, PPM- Per

maker Implantation, VAD- Ventricular Assist Device, AA- Aortic Ar

mbolism, PA = Pulm

m VTE- Ve