UK – Deaths from Cardiovascular Diseases – Individual Causes, Ages 15-44

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Summary

In this study we investigate the UK trends in death rates from cardiovascular causes for individuals aged 15 to 44 by computing excess death rates, which are the difference between observed deaths rates and a given baseline for expected death rates. We measure and compare changes in the behaviour of mortality patterns before the Covid-19 pandemic with the post-pandemic period, for deaths with attributed to cardiovascular diseases.

We show a large increase in mortality from cardiovascular causes that started in 2021 and accelerated substantially in 2022. The increase in excess deaths in 2022, is highly statistically significant (black swan event). The results indicate that from late 2021 a novel phenomenon leading to increased cardiovascular deaths appears to be present in individuals aged 15 to 44 in the UK.

We also investigate the equivalent trends in deaths from individual ICD10 codes within the cardiovascular system (I00 to I99 codes). We analyse individually the 10 most common causes for cardiovascular deaths, and some causes of particular interest that are gender specific.

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1. Introduction

Beginning in early 2020, the world changed due to the emergence of a global pandemic caused by the SARS-Cov2 virus which, in some individuals, manifested in the form of Covid-19 viral disease. The Covid-19 crisis led to alterations in individuals' lifestyles and perceptions of relative and absolute risk, which impacted their day-to-day decision-making. To add to the social changes, governments added to the hysteria with the introduction of unprecedented measures of social engineering such as control of media communications, the introduction of pandemic lockdowns for healthy individuals, and from 2021, mass inoculations based upon experimental mRNA-based vaccine technology. All these factors led to a break in individuals' behaviours from 2020 onwards.

In this context, at Phinance Technologies we performed several analyses showing excess mortality (all cause) since 2020, which is a common feature for different countries, from Europe to the US. We published a methodology report to explain our estimates for excess mortality, which is based on measuring excess death rates instead of excess deaths[1]. By accurately measuring, and then tracking excess mortality trends, we can have a clearer picture of the implications of the different stages of Covid-19 pandemic, that were mentioned above.

In a separate report[2], we investigated the trends in all cardiovascular deaths and disabilities for 15 to 44 year-olds in the UK. In this study, we go into more detail and measure the changes in death rates due to individual cardiovascular diseases, by focusing our efforts on the most common types of cardiovascular deaths.

We focus our research on younger individuals, aged 15-44, as presently it is a topic of particular interest due to the rise in anecdotal evidence of many unexplained sudden deaths occurring in athletes, media personalities and in many other sectors. The focus of this study is not to examine individual claims and anecdotes, but instead to provide a statistical analysis at a population level and clarify if the anecdotal evidence is abnormal or not.

The relationships that we uncover in our analysis should be a basis for a reality check for health professionals to understand underlying trends in individuals' health.

In sections 2 and 3 we describe the data sources and the methodology, respectively. In section 4 we investigate the trends in death rates due to deaths from all cardiovascular diseases combined while in section 5 we investigate deaths from individual cardiovascular causes, focusing on the most common types.

[1] https://phinancetechnologies.com/HumanityProjects/Resources/Report%20on%20measuring%20death%20rates%20-%20V4%20-%20UK.pdf
[2] https://phinancetechnologies.com/HumanityProjects/UK%20Cause%20of%20death%20Project%20-%20Cardiovascular%20Deaths%2015-44.htm

2. Data

2.1. Cause of Death Data

The data used in this analysis is the number of deaths that occurred in England and Wales between 2010 and 2022, by underlying cause code (ICD-10), sex, and age group (up to 90+). The source is the UK Office for National Statistics (ONS). The direct links to the mortality data by cause for 2010 to 2021 and 2022 are listed below:

Link to the 2022 data source: Death occurrences by sex, five year age group and underlying cause (ICD-10 code) England and Wales: 2022 - Office for National Statistics (ons.gov.uk)

Direct link to the source file:
https://www.ons.gov.uk/file?uri=/peoplepopulationandcommunity/birthsdeathsandmarriages/deaths/adhocs/1050deathoccurrencesbysexfiveyearagegroupandunderlyingcauseicd10codeenglandandwales2022/deathoccsengwal2022final.xlsx

Link to the 2010-2021 data source: Death occurrences by sex, five year age group and underlying cause (ICD-10 code) England and Wales: 2010 to 2021 - Office for National Statistics (ons.gov.uk)

Direct link to the source file:
https://www.ons.gov.uk/file?uri=/peoplepopulationandcommunity/birthsdeathsandmarriages/deaths/adhocs/1017deathoccurrencesbysexfiveyearagegroupandunderlyingcauseicd10codeenglandandwales2010to2021/deathsoccsengwal20102021finalnew.xlsx

2.2. Registered Deaths (All Deaths)

Registered deaths are all the deaths registered in England and Wales, independently of if a cause of death has been attributed. The investigation of deaths and attribution of ICD10 codes with a cause of death can take up to 2 years to be performed.

UK Monthly Registered Deaths (All cause): Deaths registered monthly in England and Wales - Office for National Statistics (ons.gov.uk)

3. Methodology

In this study, we investigate the trends in **death rates** for the selected cause: "diseases of the circulatory system or cardiovascular diseases". We investigate these trends using yearly data and therefore we do not have to perform a seasonal adjustment to the data.

In general terms, to measure trends in these variables we use a methodology of computing **excess rates**, which are the difference between the actual **observed rates** and a given **baseline** (expected rates). Because we want to measure the impact of the Covid-19 pandemic and post-pandemic periods relative to the prior state of the world, our baselines are based upon the estimation of the trend for a period prior to the pandemic.

In this study we will use method 2C, as described in our report on methodologies for measuring excess deaths[3] in the population. Method 2C is based on computing the trends in death rates (deaths adjusted by the population) instead of deaths, as the baseline for estimating excess mortality. This method significantly reduces the noise of the estimation (as it adjusts for population growth or decline) and also takes into account the prior trend in death rates, which tend to decline over time (over the last 100 years) as population grow healthier and different risk factors are better managed.

3.1. Method 2C for Estimating Excess Death Rates

$$ExcessDeaths_{ti}^{AG} = Deaths_{ti}^{AG} - Baseline_{ti}^{AG} \qquad Eq.\ 1$$

Equation (1) is a general expression for estimating the excess absence rates relative to a given baseline. We use the subscript "AG" to indicate a given population age cohort which could refer to an age range, region, sex, or underlying cause of death.

For estimating the baseline for "normal or expected" death rates we use a simple linear fit:

$$Baseline(t_i) = \hat{b} + \hat{a}(t_i - t_0) \qquad Eq.\ 2$$

Where $\hat{b}$ and $\hat{a}$ are the estimated coefficients of the death rate trendline from 2010 to 2019.

3.2. ICD10 code list of selected causes of death for: Cardiovascular Diseases

For this analysis we selected all the ICD10 codes from category I, namely I00 to I99 which refer to deaths attributed to diseases of the circulatory system. Note that throughout this report we use cardiovascular system and circulatory system interchangeably.

The detailed list that was extracted from the ONS cause of death database shows the codes and description that were aggregated for the purpose of our analysis. The list is shown in Appendix 7.1.

Some ICD10 codes, such as I03 with the generic description of "DISEASES OF THE CIRCULATORY SYSTEM" refer to ICD10 codes that were not used in the UK from 2010 to 2022.

[3] Https://phinancetechnologies.com/HumanityProjects/Resources/Report%20on%20measuring%20death%20rates%20-%20V4%20-%20UK.pdf

4. Yearly Analysis of Excess Death Rates

In this section we perform a yearly analysis of the death rates for England and Wales, using the ONS cause of death data. In this analysis we use the 2010-2019 trend in death per 100,000 (death rates) as the baseline estimate for excess death rates. Excess death rates for the 2010-2019 period are in-sample while the rates for 2020, 2021, and 2022 are out of sample computations.

The analysis is performed for all the deaths from a particular range of underlying causes of death, as described by the list of ICD10 codes in section 3.2, which refer to all the diseases of the circulatory system.

4.1. Deaths for All Causes versus Registered Deaths

When analysing the ONS data for cause of death we noticed that there are discrepancies between the number of deaths which have a cause of death and the number of registered deaths for a year. This is particularly the case for deaths in 2022 (the most recent year) and younger individuals where there are significant discrepancies between both these datasets.

The reason for the discrepancy is that death certificates for younger individuals take longer as each death is thoroughly examined and, on many occasions, post-mortems need to be performed. For older individuals, the discrepancies are small. In this report we only investigate deaths for individuals aged from 15 to 44. For this age group, we show the differences between registered deaths and all the causes of deaths in Figure 1.

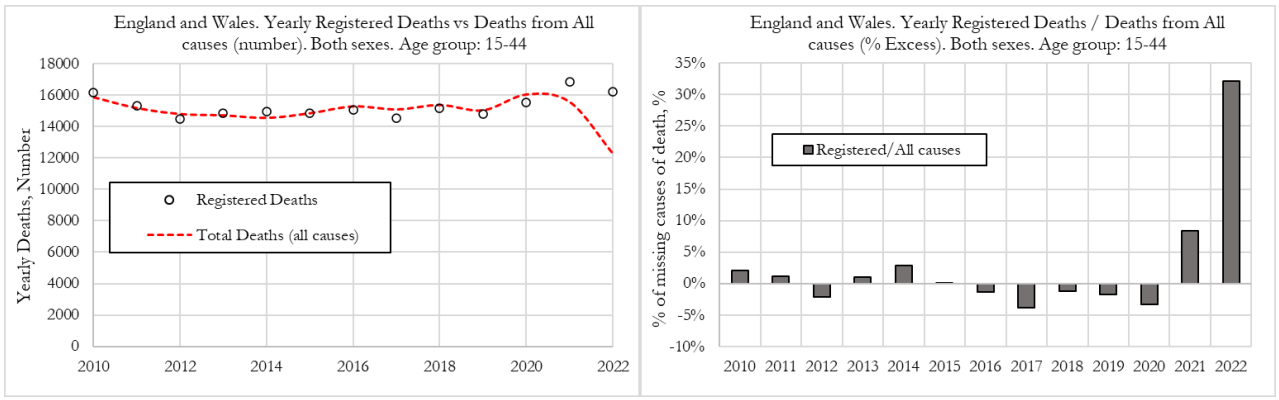

Figure 1- England and Wales, registered deaths versus deaths from all causes in the ONS deaths by cause data table for age group 15 to 44. Left: Yearly numbers. Right: % missing cause of death relative to registered deaths.

We can observe that the discrepancy between registered deaths and the sum of all deaths by cause ranges between -3% to +3% from 2010 to 2020. We consider these normal discrepancies between these databases as there are many factors that could lead to these discrepancies, including if the deaths occurred within England and Wales or abroad, or if they occurred with individuals that were temporary stays in England and Wales.

For 2021 however, we observe about 8% more registered deaths than the sum of the deaths from all causes. In 2022, there are still about 32% of registered deaths without a final cause of death. This is a large discrepancy that needs to be corrected.

To correct for the discrepancies in registered deaths compared to deaths from all causes, we scale the deaths for each ICD10 code by the ratio R=(registered/all cause deaths). This adjustment is significant for 2022 and assumes

that the proportion of deaths from the different ICD10 codes will remain the same after the final figures are published (in 1 or 2 years). This may not be the case and, therefore, the results need to be taken with a degree of caution.

In summary, to estimate the trends in death rates for different causes, we use Adjusted Deaths (Adj-deaths) which refers to the deaths from a particular cause or range of causes adjusted by the ratio defined above. Adjusted death rates are computed based on adjusted deaths.

4.2. Death Rates for Age Group 15-44

In this section we investigate the trends in death rates in England and Wales, for the 15-44 age group. We compare all-cause mortality (registered deaths) with deaths from diseases of the circulatory system (cardiovascular diseases), with ICD10 codes ranging from I00 to I99. When computing death rates, we chose to show the numbers as deaths per 100,000 as death rates for younger age groups are very low.

4.2.1. Unadjusted (Raw) Death Rates for Age Group 15-44 from Cardiovascular Causes (I00-I99)

The first analysis that we perform is the analysis of the unadjusted (raw) deaths from cardiovascular diseases. Before starting the analysis, it needs to be reiterated that as mentioned in section 4.1, there are a significant number of missing records for recorded causes of death relative to registered deaths in 2021 and 2022. This is because younger individuals are not expected to die from natural causes and, consequently, those deaths need to be investigated to understand the underlying causes.

In section 4.1 we observed that for the 15-44 age group, for 2021 there are about 8.3% of missing records in the ONS cause of death dataset, and 32% for 2022. The missing records for 2022 are about a third, which means that when analysing the raw numbers of deaths (without adjustment) for cardiovascular diseases, they will likely underreport actual deaths by that amount.

With these caveats in mind, Figure 2 shows the deaths (right) and death rate per 100,000 individuals (left) for cardiovascular deaths in England and Wales from 2010 to 2022. We can observe that even with a large number of missing records, we can already observe a clear signal in above-trend cardiovascular deaths in both 2021 and 2022.

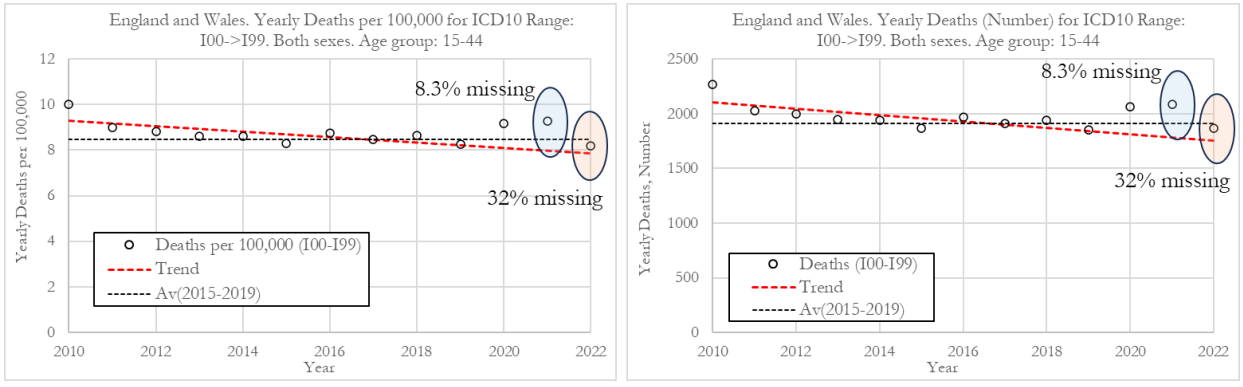

Figure 2 - Yearly unadjusted (raw) deaths for diseases of the circulatory system in England and Wales. The red dashed line shows the average from 2010 to 2019. The dotted line shows the 2015-2019 average death rate. Left: Deaths per 100,000. Right: Deaths (number).

4.2.2. Registered Deaths

The analysis of the registered deaths allows us to have a context by which we can then compare the death rates for cardiovascular diseases. Figure 3 shows the death rate per 100,000 individuals for all registered deaths in England and Wales from 2010 to 2022. We can observe that registered deaths per year had been trending slightly lower from 2010 to 2019.

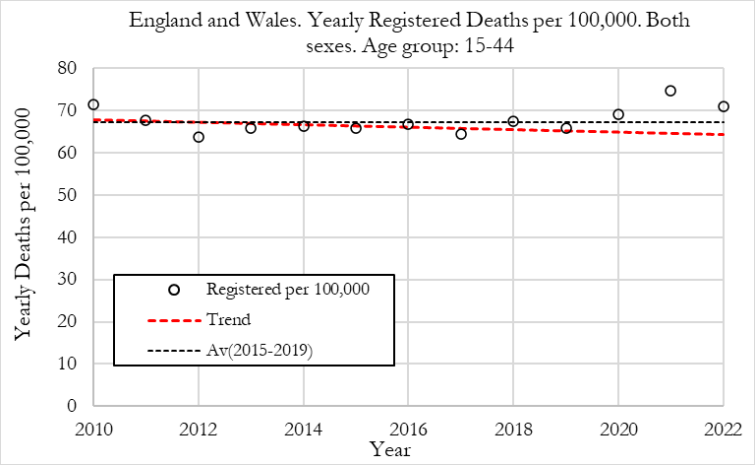

Figure 3 - Yearly registered deaths per 100,000 for England and Wales. The red dashed line shows the average from 2010 to 2019. The dotted line shows the 2015-2019 average death rate.

In 2019, the death rate was about 67 per 100,000 individuals aged 15 to 44. The death rate increased in 2020 to about 69 per 100,000 and then again in 2021 to 75 per 100,000. In 2022 the death rate dropped slightly to about 71 per 100,000, the same level as observed in 2010 and still above the 2020 level.

4.2.3. Adjusted Deaths from ICD10 codes I00 to I99 (Cardiovascular).

We now investigate adjusted[4] deaths for all cardiovascular diseases (ICD10 codes I00 to I99). Figure 4 (left) shows the death rate per 100,000 individuals for cardiovascular deaths (adjusted for under-reporting) in England and Wales from 2010 to 2022. We can observe that deaths per year from cardiovascular diseases have been trending lower from 2010 to 2019, with a significant downward slope. In 2010 the deaths rate was 10 per 100,000, in 2019 it was around 8 per 100,000, a 20% drop.

[4] Deaths adjusted for the missing causes of death relative to registered deaths.

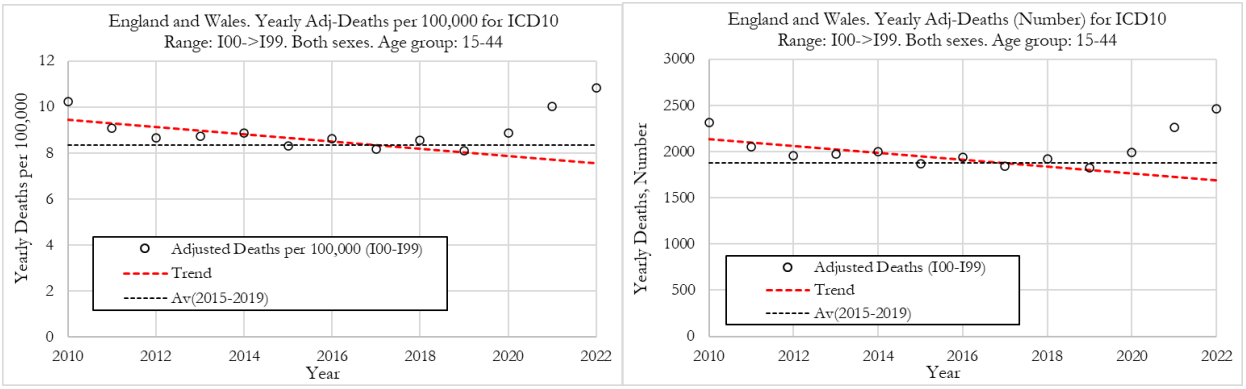

Figure 4 - Yearly adjusted deaths for diseases of the circulatory system in England and Wales. The red dashed line shows the average from 2010 to 2019. The dotted line shows the 2015-2019 average death rate. Left: Adj-Deaths per 100,000. Right: Adj-Deaths (Number).

The death rate increased in 2020 to about 9 per 100,000 and then again in 2021 to 10 per 100,000. In 2022 the death rate increased again to about 11 per 100,000, a level that is 10% higher than observed in 2010. The death rate in 2022 was about 3 deaths per 100,000 above the 2015-2019 average.

When translating these numbers into the absolute number of deaths for diseases of the circulatory system, shown in Figure 4 (right), we can observe that the 5-year average deaths from 2015 to 2019 was about 1800 deaths. In 2020, cardiovascular deaths were about 2,000, 200 more than the prior 5-year average. In 2021 there were about 2300 deaths (500 more than the 2015-2019 average) and in 2022, 2500 (700 more than the 2015-2019 average).

4.2.4. Relative Deaths from ICD10 codes I00 to I99 (Cardiovascular) vs All Causes.

In our study we also analyse the trends in the relative incidence of cardiovascular deaths relative to all other causes, which provides a different type of information related to breaks in the normal pattern of deaths in this age group.

For this purpose, in Figure 5 we plot the fraction of deaths from all causes that are attributed to the circulatory system. We observe that there was a declining trend in deaths due to the circulatory system from 2010 to 2019. In 2010, deaths attributed to the circulatory system account for 14% of total deaths, while in 2019, the fraction was only 12%.

In 2020 the fraction of deaths due to the circulatory system increased to about 13% of total deaths. The fraction increased to 13.5% in 2021 and then again to above 15% in 2022, which is above the 2010 level.

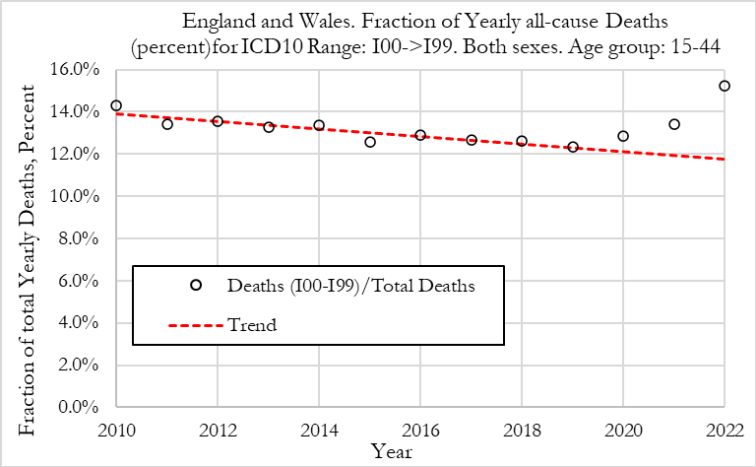

Figure 5 – Fraction of all causes for yearly deaths attributed to the circulatory system, for England and Wales. The red dashed line shows the average from 2010 to 2019.

4.3. Excess Death Rates for Age Group 15-44

In this section we investigate the trends in excess death rates in England and Wales, for the 15-44 age group. We compare excess all-cause mortality (registered deaths) with excess deaths from diseases of the circulatory system (cardiovascular diseases), with ICD10 codes ranging from I00 to I99. We also compare excess deaths for males and females.

4.3.1. Excess Adjusted Deaths from ICD10 codes I00 to I99 (Cardiovascular).

Figure 6 compares the excess death rate for cardiovascular deaths (adjusted for under-reporting) and excess registered deaths, in England and Wales from 2010 to 2022. The figure on the Figure 6 (left) refers to relative deviations from the 2010-2019 trend, while Figure 6 (right) shows the Z-Score (signal strength) for the deviations from trend.

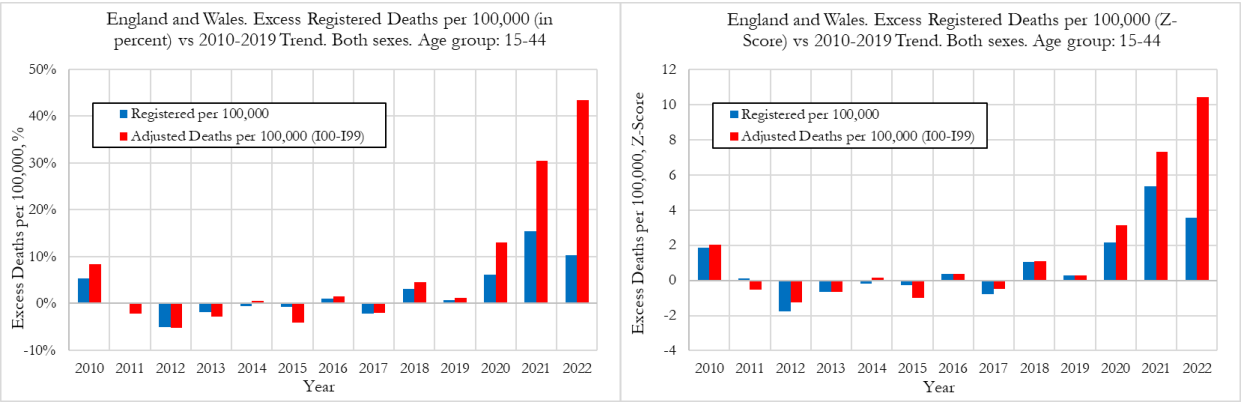

Figure 6 - Excess adjusted deaths rates for diseases of the circulatory system versus excess death rates for all registered deaths in England and Wales. Left: Relative deviation from trend, percent. Right: Deviation from trend Z-Score.

In Figure 6 (left) we can observe that the excess deaths rates from cardiovascular diseases rose by about 13% in 2020, 30% in 2021 and about 44% in 2022. On the other hand, the excess mortality for all registered deaths was

about 5% in 2020, 15% in 2021 and 10% in 2022. The drop in excess mortality for all registered deaths from 2021 to 2022 was not mirrored in a drop in cardiovascular deaths. The opposite occurred, with a sharp acceleration in excess deaths due to cardiovascular diseases.

In terms of statistical significance of the excess deaths, we observe from Figure 6 (right) that for all registered deaths, the Z-score in 2020 was only about 2, which is not a strong signal. However, in 2021, the Z-score was slightly above 5.0 which is a very strong signal. In 2022 the Z-score dropped to about 3.5, which still indicates that the excess deaths are statistically significant deviations from the 2010-2019 trend.

When looking at excess deaths for cardiovascular diseases, the Z-score in 2020 was around 3, indicating that prior to the start of the vaccinations there was already a signal pointing to an increase in cardiovascular deaths. That trend however accelerated substantially in 2021 and 2022 where we observe Z-scores of around 7.5 and 10.5, respectively. These are extreme events that we believe need a thorough investigation. Our previous work on measuring excess mortality and disabilities in the UK[5] points to the Covid-19 vaccines likely playing a significant role in the rise of mortality and morbidity. However, the pandemic rules, lockdowns and Covid-19 could have played a role in the rise of cardiovascular deaths.

4.3.2. Excess Relative Deaths from ICD10 codes I00 to I99 (Cardiovascular) vs All Causes.

A different perspective is to analyse the fraction of deaths from all causes that are attributed to the circulatory system and compare them with the absolute changes in death rates due to diseases of the circulatory system, as shown in Figure 7.

We observe that in similarity with excess death rates, the fraction of circulatory system deaths relative to all other causes increased consecutively in 2020, 2021 and 2022. However, in percentage terms, the changes were lower than those observed for deaths rates with a 5% rise in 2020, 12% in 2021 and 29% in 2022. Interestingly, when looking at the statistical significance of the signals, we observe that in 2020 and 2021 the strength of the excess deaths rates and fraction of all deaths due to the circulatory system were of similar magnitudes at 3 and 7 for 2020 and 2021, respectively. However, in 2022, the fraction of excess deaths due to the circulatory system had a Z-score of 16, higher than for excess deaths alone. This reinforces the fact that deaths related to the circulatory system are of particular concern for this age group and needs further investigation.

[5] See our work on excess deaths in the UK: (https://phinancetechnologies.com/HumanityProjects/yearly%20Excess%20Death%20Rate%20Analysis%20-%20UK.htm). and the analysis of PIP clearances: (https://phinancetechnologies.com/HumanityProjects/PIP%20Analysis-Systems.htm)

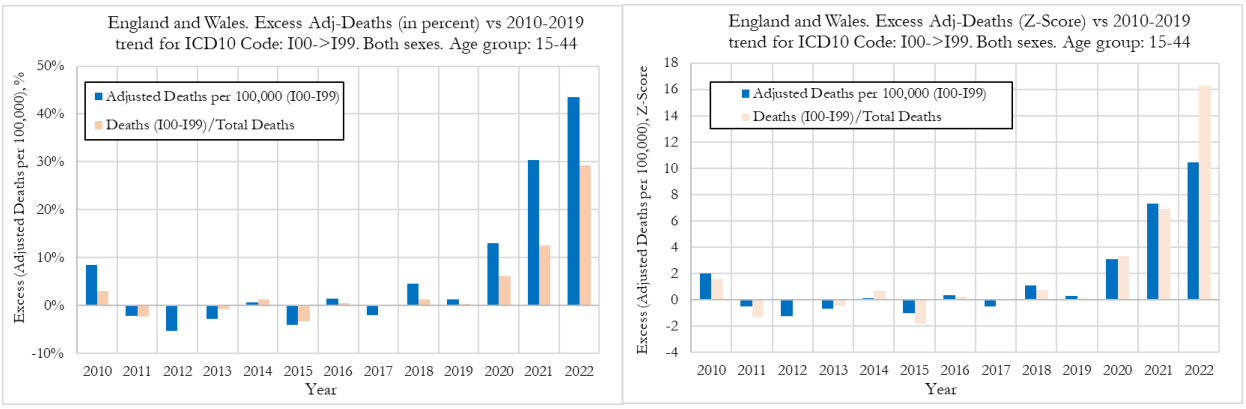

Figure 7 – Excess adjusted deaths rates for diseases of the circulatory system versus excess fraction of all deaths in circulatory system, in England and Wales. Left: Relative deviation from trend, percent. Right: Deviation from trend Z-Score.

4.3.3. Excess Adjusted Deaths for Cardiovascular System for Males and Females.

When looking at deaths attributed to the circulatory system for males and females, shown in Figure 8, we observe that in 2020 and 2021 both had similar outcomes in excess mortality (deviation from trend) as well as the respective Z-scores (statistical significance). However, we also observe that in 2022 men suffered much worse outcomes than women, with men experiencing a 56% deviation from trend, compared to about 28% for women.

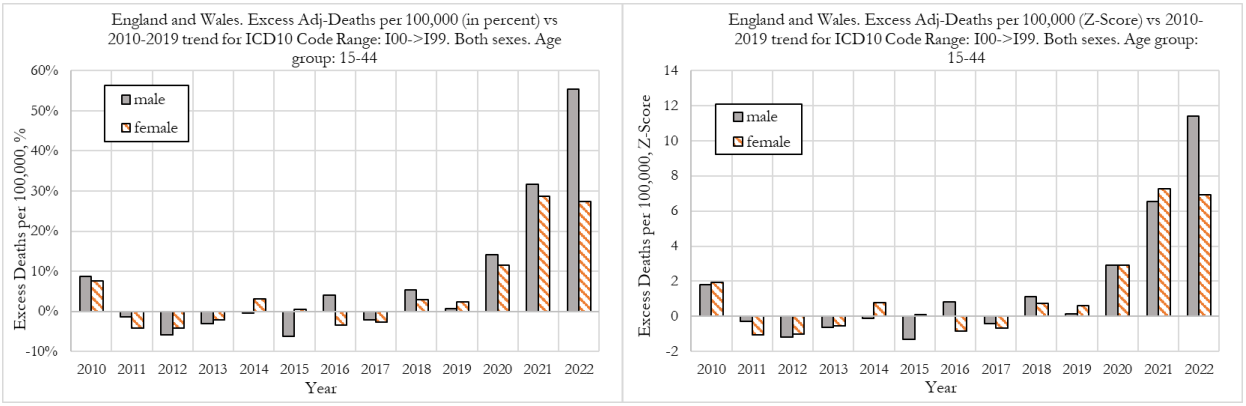

Figure 8 - Excess adjusted deaths rates for diseases of the circulatory system for males and females, in England and Wales. Left: Relative deviation from trend, percent. Right: Deviation from trend Z-Score.

4.4. Summary of the Analysis of Death Rates

We started our analysis of excess death rates due to diseases of the cardiovascular system by showing that the analysis needs to be performed with caution as not all deaths had a classified cause up to the time of publication of the ONS dataset. This issue is particularly relevant in younger age groups, which is the case of the present analysis, where we observe that in 2022, about 32% of registered deaths were still not classified with a cause (Figure 1).

We perform a correction to this problem by extrapolating the deaths in each year as if the proportion of each cause of death remained the same, when the missing deaths are finally classified. This is an assumption that must be taken with care. To make sure that we are identifying an actual trend in the data, we also analyse the deaths from cardiovascular diseases relative to all classified causes of death (Figure 7). The results show that the rise in deaths

from cardiovascular causes in 2021 and 2022 was similar to the relative rise in cardiovascular diseases in relation to all other causes. We also analyse raw unadjusted deaths (Figure 2) which show that even without accounting for the missing records, 2021 and 2022 already show significant above-trend deaths.

Our analysis shows that the excess death rates from cardiovascular diseases rose by about 13% in 2020, 30% in 2021, and about 44% in 2022. On the other hand, the excess mortality for all registered deaths was about 5% in 2020, 15% in 2021, and 10% in 2022 (Figure 6 - left). The drop in excess mortality for all registered deaths from 2021 to 2022 was not matched with a drop in cardiovascular deaths as the opposite occurred, with a sharp acceleration in excess deaths due to cardiovascular diseases in 2022.

The excess mortality from cardiovascular deaths in 2021 and 2022 are highly statistically significant with Z-scores of 7.5 and 10.5, respectively. These are very strong signals. As mentioned above, these signals are corroborated by similar findings when measuring rises in the fraction of deaths from cardiovascular diseases relative to all other deaths with classified causes.

The excess mortality rate for cardiovascular diseases could be associated to the Covid-19 vaccinations as there was already a clear signal during the Pfizer clinical trials[6]. In their paper, the authors find that "of the 15 subjects who were Sudden Adult Deaths (SAD) or Found Dead (FD), 12 died of a cardiac event, 9 of whom were vaccinated". The same numbers were published by Thomas et al.[7] in the official evaluation of the Pfizer clinical trials through 6 months.

When comparing outcomes for men and women, we observe that they had similar rises in deaths from cardiovascular diseases in 2020 and 2021. However, in 2022, men suffered much worse outcomes than women, with men experiencing a 56% deviation from trend, compared to about 28% for women.

When translating these numbers into the absolute number of deaths for diseases of the circulatory system, shown in Figure 4 (right) we can observe that in 2020, cardiovascular deaths were about 2,000, 200 more than the prior 5-year average. In 2021 there were about 2300 deaths, 500 more than the 2015-2019 average, and in 2022, 2500 (700 more than the 2015-2019 average).

In the future, we plan to expand our analysis to identify the individual causes of death (ICD10 codes) within the cardiovascular system (ICD10 codes I00-I99) that were responsible for the acceleration in these deaths.

[6] C. A. Michels et al. (Oct-2023) "Forensic Analysis of the 38 Subject Deaths in the 6-Month Interim Report of the Pfizer/BioNTech BNT162b2 mRNA Vaccine Clinical Trial", International Journal of Vaccine Theory, Practice, and Research, 3 (1), pp. 973-1009.
Link: https://doi.org/10.56098/ijvtpr.v3i1.85

[7] Thomas et al. (2021) "Safety and Efficacy of the BNT162b2 mRNA Covid-19 Vaccine through 6 Months", New England Journal of Medicine, 385(19), pp. 1761-1773.
Link: https://doi.org/10.1056/NEJMoa2110345

5. Analysis of the 10 largest individual ICD10 cause deaths within the Circulatory System.

5.1. The 10 most common causes of death within the Circulatory System (I00 to I99).

In this section we investigate the relative changes deaths for ICD10 code within the cardiovascular system. In order to better understand the underlying trends in mortality within the cardiovascular system, we decided to investigate the 10 largest individual causes of death (ICD10 codes). To such effect ranked the number of deaths for the individual ICD10 codes within the cardiovascular system by the number of deaths in 2019, prior to the Covid-19 pandemic (Table 1).

We can observe that the 2 main causes of cardiovascular deaths for 15 to 44 year-olds in the UK were I25->Chronic ischemic heart diseases and I21->Acute Myocardial infarction, which accounted respectively for 16.5% and 14.9% of cardiovascular deaths in 2019. Altogether these two causes represent about 31.4% of cardiovascular deaths, which we analyse in detail in sections 5.2 and 5.3, respectively. Furthermore, we can observe from Table 1 that the top 10 causes of cardiovascular deaths accounted for about 80% of all cardiovascular deaths.

Analysis of top 10 causes of cardiovascular deaths		Fraction of Cardiovascular deaths				Change from 2019 baseline		
ICD10 code	**Description**	**2019**	**2020**	**2021***	**2022****	**2020**	**2021***	**2022****
I25	**Chronic ischemic heart disease**	16.50%	18.62%	17.47%	18.77%	12.83%	5.86%	13.70%
I21	**Acute myocardial infarction**	14.89%	14.35%	17.38%	17.10%	-3.57%	16.73%	14.90%
I42	**Cardiomyopathy**	9.17%	8.00%	8.90%	7.88%	-12.73%	-2.90%	-14.04%
I60	**Nontraumatic subarachnoid hemorrhage**	6.74%	6.74%	5.60%	7.29%	-0.02%	-16.93%	8.16%
I80	**Phlebitis and thrombophlebitis**	6.47%	8.58%	6.75%	7.88%	32.62%	4.28%	21.78%
I51	**Complications and ill-defined descriptions of heart disease**	6.31%	5.67%	6.61%	5.25%	-10.09%	4.68%	-16.73%
I61	**Nontraumatic intracerebral hemorrhage**	5.39%	5.33%	5.79%	5.52%	-1.10%	7.39%	2.39%
I26	**Pulmonary embolism**	4.75%	6.01%	5.98%	6.54%	26.70%	26.07%	37.82%
I49	**Other cardiac arrhythmias**	4.26%	2.72%	3.49%	2.73%	-36.26%	-17.99%	-35.82%
I71	**Aortic aneurysm and dissection**	3.24%	3.83%	3.02%	3.86%	18.39%	-6.81%	19.29%
	Top 10 causes	77.72%	79.87%	81.00%	82.84%	2.77%	4.21%	6.58%
	All the rest	22.28%	20.13%	19.00%	17.16%	-9.65%	-14.69%	-22.98%
*The fraction of missing cause of death data for 2021 for the 15-44 age group is about 8.3%								
**The fraction of missing cause of death data for 2022 for the 15-44 age group is about 32%								

Table 1 - Analysis of changes in the fraction of deaths attributed to the largest 10 causes within the cardiovascular system (I00 to I99).

The results shown in Table 1 must be interpreted with some caution as they refer to the fraction of deaths for a given individual ICD10 code, relative to all cardiovascular deaths in a given year. This means that only the relative rates of death by individual causes can be compared in each year and they cannot be compared in absolute terms, as they do not capture the rise in overall cardiovascular deaths that we described previously in section 4.3. As an example, we can observe that the relative fraction of deaths attributed to cardiomyopathy decreased successively from in 2020, 2021 and 2022, but this does not mean that no signal was present in cardiomyopathy deaths. In fact, as will be shown in section 5.4, cardiomyopathies have statistically significant signals which show excess death rates in 2021 and 2022.

The results in Table 1 show that some cardiovascular diseases saw explosive changes from 2020 onwards relative to the 2019 baseline. Of particular notice are pulmonary embolisms (I26) and phlebitis and thrombophlebitis (I80) which will be investigated in further detail. Additionally, nontraumatic intracerebral haemorrhage deaths are another cardiovascular condition of particular interest, where we observe explosive rises in death rates in 2021 and 2022, but only for men.

In next sections we are going to investigate the trends in death rates for different single ICD10 codes of particular interest within the cardiovascular system, which allow us to better understand the underlying phenomenon at action.

5.2. Analysis of ICD10 Code I25 -> Chronic Ischemic Heart Disease (Rank 1 – 16.5%)

In this section we investigate the trends in death rates for ICD10 code I25 (Chronic ischemic heart disease), which represents 16.5% of all cardiovascular deaths in 2019 for 15 to 44 year-olds in the UK. This analysis investigates the absolute trends in adjusted deaths for a single ICD10 code. We also investigate the fraction of deaths attributable to ICD10 code I25 versus deaths from all other causes.

Note that this analysis is distinct from the one performed in the previous section (5.1) as the prior analysis referred to relative changes within the circulatory system for the 10 most frequent individual ICD10 code causes. As we've shown in our overall analysis for trends in deaths for the circulatory system, we observe an overall rise in those deaths in 2020, 2021 and 2022.

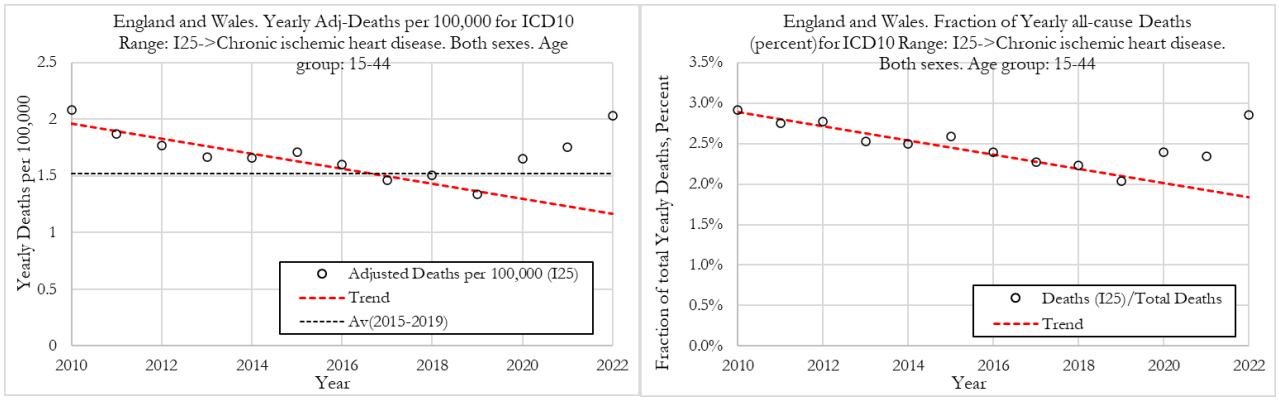

Figure 9 - Yearly adjusted deaths for ICD10 code I25 (Chronic ischemic heart disease) in England and Wales. The red dashed line shows the average from 2010 to 2019. The dotted line shows the 2015-2019 average death rate. Left: Adj-Deaths per 100,000. Right: Fraction of all deaths.

We can observe that death rates per year from chronic ischemic heart disease have been trending lower from 2010 to 2019, with a significant downward slope. In 2010 the deaths rate was about 2 per 100,000, in 2019 it was around 1.35 per 100,000, a 32.5% drop.

The death rate rose in 2020 to about 1.6 per 100,000 and then rose again to 1.7 per 100,000 in 2021. In 2022 the death rate increased again to about 2 per 100,000, a similar level as that observed in 2010.

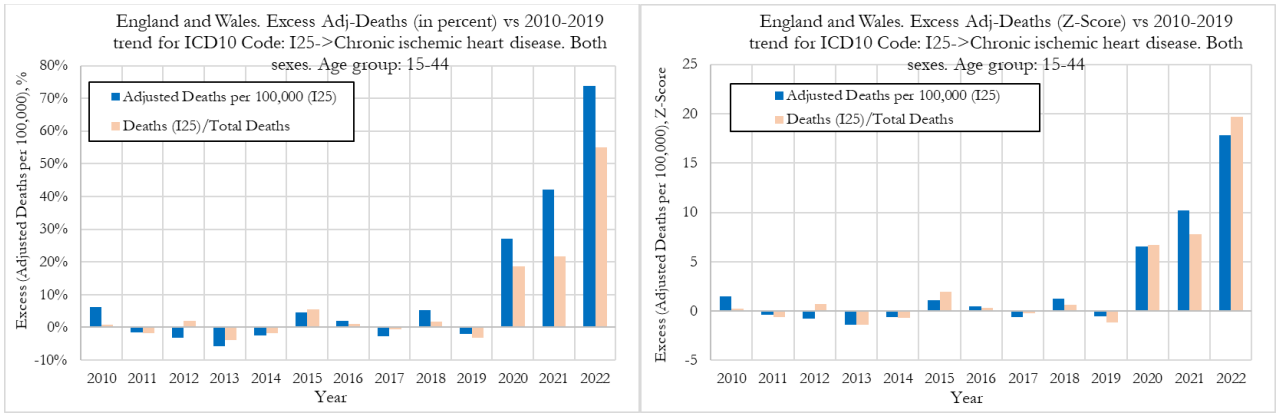

Figure 10 - Excess adjusted deaths rates for ICD10 code I25 (Chronic ischemic heart disease) versus excess fraction of all deaths for I25 deaths, in England and Wales. Left: Relative deviation from trend, percent. Right: Deviation from trend Z-Score.

In Figure 10 (left) we can observe that the excess deaths rates from chronic ischemic heart disease were +28% in 2020, then rose to about 42% in 2021 and about 74% in 2022. In terms of statistical significance of the excess deaths, we observe from Figure 10 (right) that for these cardiovascular conditions, in 2021, the Z-score for excess adjusted death rates was about 10 which points to a very strong signal (extreme event) that needs further investigating. In 2022 the Z-score rose to about 17, which is an extraordinarily strong signal and indicates that the excess deaths from chronic ischemic heart disease are statistically significant deviations from the 2010-2019 trend. We also note that in 2020, the Z-score for the excess death rates was already pointing towards a strong signal.

When looking at changes in the fraction of all deaths attributed to chronic ischemic heart disease, we observe that the fraction of deaths for these conditions were +18% and +22% above trend in 2020 and 2021, respectively (with a Z-score around 6, indicating high statistical significance). In 2022 however, the fraction of deaths for these conditions jumped about +55%, with a Z-score above 19 which points to a strong effect (extreme event).

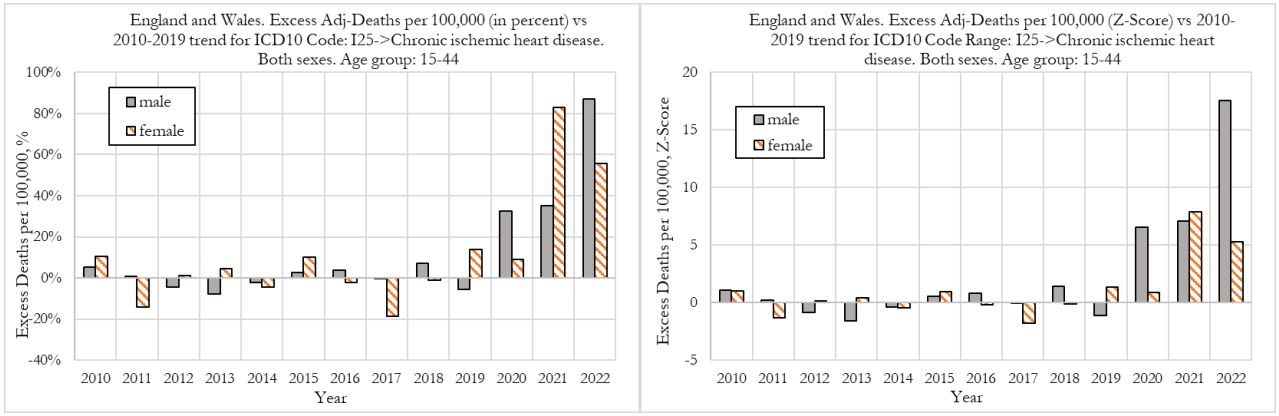

Figure 11 - Excess adjusted deaths rates for ICD10 code I25 (Chronic ischemic heart disease) for males and females, in England and Wales. Left: Relative deviation from trend, percent. Right: Deviation from trend Z-Score.

When comparing deaths attributed to chronic ischemic heart disease for males and females, shown in Figure 11, we observe that in 2020 while female had no noticeable excess mortality (with a Z-scores below 1.0), men already experience about 33% excess mortality (with a Z-score above 6 which denotes very high statistical significance).

We also observe that in 2021 women suffered worse outcomes than men, with women experiencing a 82% deviation from trend, compared to about 36% for men. These values, however, constitute strong signals, with Z-scores above 6.

In 2022 men suffered worse outcomes than women, with men experiencing about 86% deviation from trend, compared to about 56% for women. The signal strength for men was very strong (with a Z-score of close to 18) and for women the signal was also very strong signals (albeit with a lower Z-score of about 5), as shown in Figure 11-right.

5.3. Analysis of ICD10 Code I21 -> Acute Myocardial Infarction (Rank 2 – 14.9%)

In this section we investigate the trends in death rates for ICD10 code I21 (Acute Myocardial infarction), which represents 14.9% of all cardiovascular deaths in 2019 for 15 to 44 year-olds in the UK. This analysis investigates the absolute trends in adjusted deaths for a single ICD10 code. We also investigate the fraction of deaths attributable to ICD10 code I21 versus deaths from all other causes.

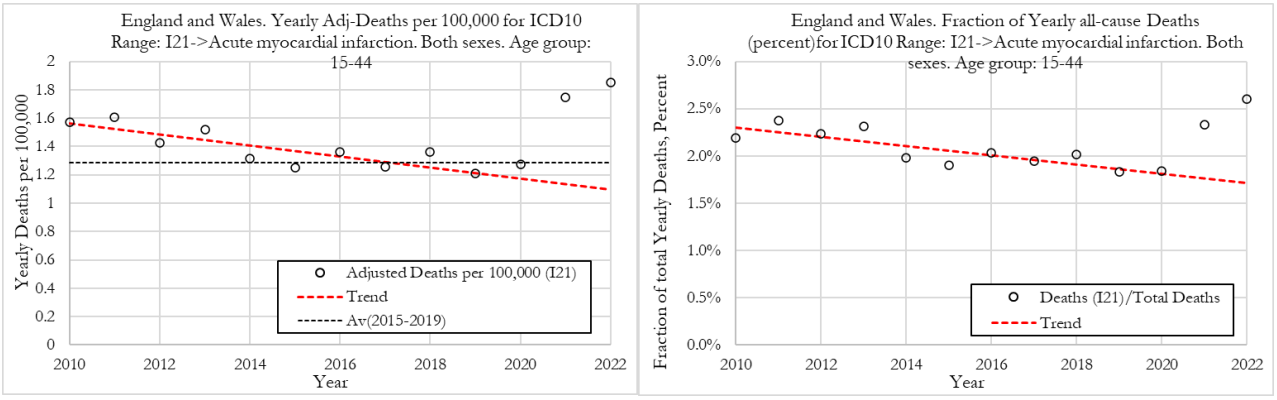

Figure 12 - Yearly adjusted deaths for ICD10 code I21 (Acute Myocardial infarction) in England and Wales. The red dashed line shows the average from 2010 to 2019. The dotted line shows the 2015-2019 average death rate. Left: Adj-Deaths per 100,000. Right: Fraction of all deaths.

We can observe that death rates per year from acute myocardial infarction have been trending lower from 2010 to 2019, with a significant downward slope. In 2010 the deaths rate was about 1.6 per 100,000, in 2019 it was around 1.2 per 100,000, a 25% drop.

The death rate rose slightly in 2020 to about 1.3 per 100,000 and then jumped to 1.78 per 100,000 in 2021. In 2022 the death rate increased again to about 1.85 per 100,000, a level that is above the observed in 2010.

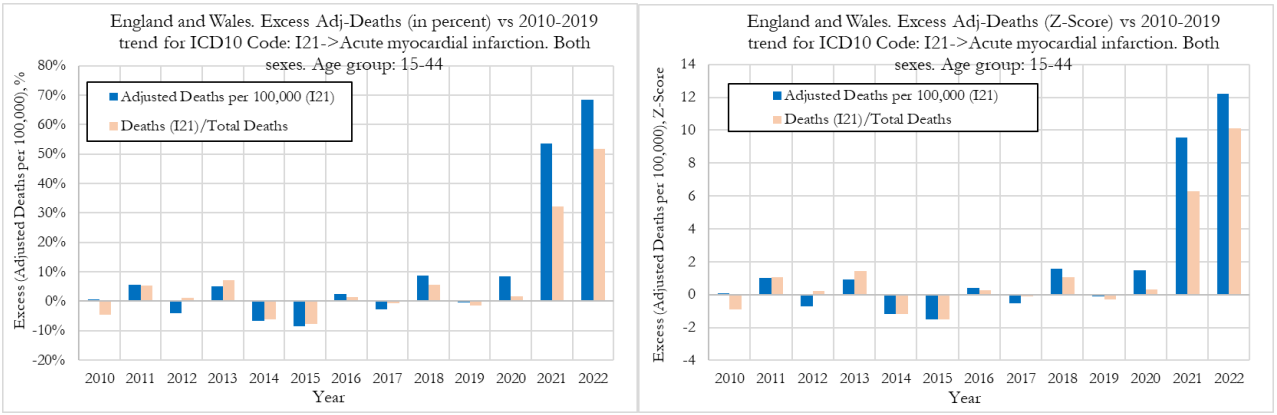

Figure 13 - Excess adjusted deaths rates for ICD10 code I21 (Acute Myocardial infarction) versus excess fraction of all deaths for I21 deaths, in England and Wales. Left: Relative deviation from trend, percent. Right: Deviation from trend Z-Score.

In Figure 13 (left) we can observe that the excess deaths rates from acute myocardial infarction were +9% in 2020, then jumped to about 53% in 2021 and about 69% in 2022. In terms of statistical significance of the excess deaths, we observe from Figure 13 (right) that for these cardiovascular conditions, in 2020, the Z-score for excess adjusted death rates was below 2 which points to a low statistical significance (within normal bounds). In 2021 however, the Z-score for excess adjusted death rates was about to 9.5 which points to a very strong signal (extreme event). In

2022 the Z-score rose to about 12, which is an extraordinarily strong signal and indicates that the excess deaths from acute myocardial infarction are statistically significant deviations from the 2010-2019 trend.

When looking at changes in the fraction of all deaths attributed to acute myocardial infarction, we observe that the fraction of deaths for these conditions were only +1% above trend in 2020, with a Z-score close to 0 showing no statistical significance. In 2021 and 2022 however, the fraction of deaths for these conditions jumped about +31% and +51% with Z-scores around 6 and 10, respectively pointing to a strong effect (extreme event).

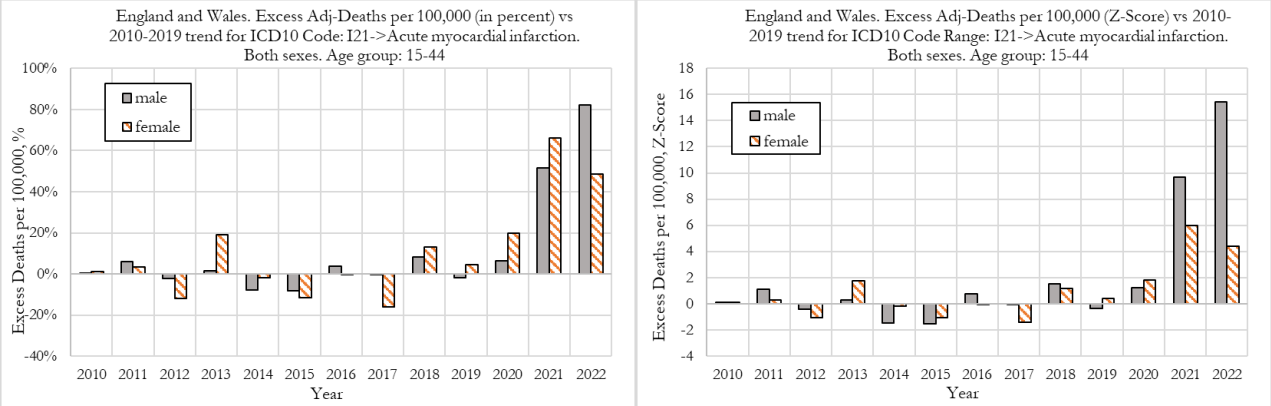

Figure 14 - Excess adjusted deaths rates for ICD10 code I21 (Acute Myocardial infarction) for males and females, in England and Wales. Left: Relative deviation from trend, percent. Right: Deviation from trend Z-Score.

When looking at deaths attributed to acute myocardial infarction for males and females, shown in Figure 14, we observe that in 2020 there was a +6% excess mortality for men and +20% for women. For men the excess mortality was not a signal, with respective Z-scores of about 1.5 (low statistical significance). However, for women, the rise in excess mortality could be seen as a weak signal (with Z-score around 2) which would warrant further investigation.

In 2021 men and women suffered similar outcomes, with men experiencing a 52% deviation from trend, compared to about 66% for women. These values, constitute very strong signals, as the Z-score was around 6.0 for women and close to 10 for men.

In 2022 men suffered much worse outcomes than women, with men experiencing about 82% deviation from trend, compared to about 50% for women. The signal strength for men was very strong (with a Z-score above 15) but for women the signal was still strong albeit weaker than in 2021 (with a Z-score above 4), as shown in Figure 14-right.

5.4. Analysis of ICD10 Code I42 -> Cardiomyopathy (Rank 3 – 9.2%)

In this section we investigate the trends in death rates for ICD10 code I42 (Cardiomyopathy), which represents 9.2% of all cardiovascular deaths in 2019 for 15 to 44 year-olds in the UK. This analysis investigates the absolute trends in adjusted deaths for a single ICD10 code. We also investigate the fraction of deaths attributable to ICD10 code I42 versus deaths from all other causes.

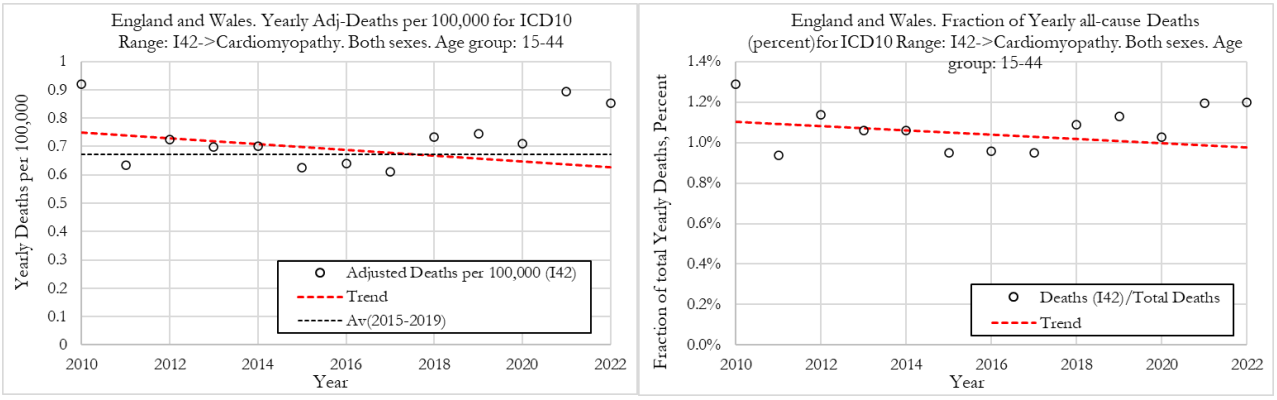

Figure 15 - Yearly adjusted deaths for ICD10 code I42 (Cardiomyopathy) in England and Wales. The red dashed line shows the average from 2010 to 2019. The dotted line shows the 2015-2019 average death rate. Left: Adj-Deaths per 100,000. Right: Fraction of all deaths.

We can observe that death rates per year from cardiomyopathies have been trending lower from 2010 to 2019. In 2010 the deaths rate was about 0.91 per 100,000, in 2019 it was around 0.75 per 100,000, a 17.6% drop.

The death rate dropped slightly in 2020 to about 0.71 per 100,000 and then jumped to 0.9 per 100,000 in 2021. In 2022 the death rate then dropped slightly to about 0.85 per 100,000. In 2021 the death rate was at a level that is close to that observed in 2010.

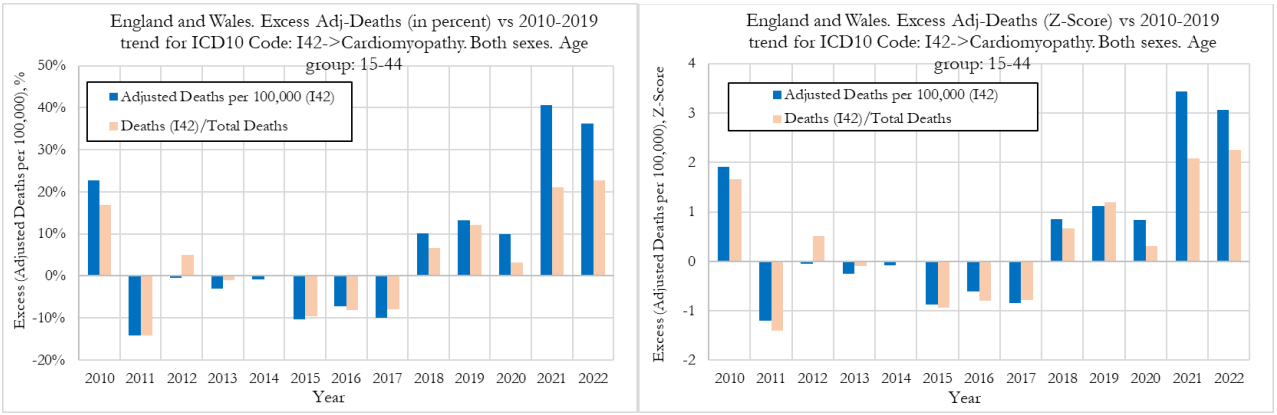

Figure 16 - Excess adjusted deaths rates for ICD10 code I42 (Cardiomyopathy) versus excess fraction of all deaths for I42 deaths, in England and Wales. Left: Relative deviation from trend, percent. Right: Deviation from trend Z-Score.

In Figure 19 (left) we can observe that the excess deaths rates from cardiomyopathy were +10% in 2020, then jumped to about +40% in 2021 and about +36% in 2022. In terms of statistical significance of the excess deaths, we observe from Figure 19 (right) that for these cardiovascular conditions, in 2020, the Z-score for excess adjusted death rates was below 1 which points to a no statistical significance. In 2021 however, the Z-score for excess adjusted death rates was about to 3.5 which points to a strong signal. In 2022 the Z-score dropped slightly to about 3, which

is still a strong signal that indicates that the excess deaths from cardiomyopathies are statistically significant deviations from the 2010-2019 trend.

When looking at changes in the fraction of all deaths attributed to cardiomyopathies, we observe that the fraction of deaths for these conditions were only +2% above trend in 2020, with a Z-score close to 0 showing no statistical significance. In 2021 and 2022 however, the fraction of deaths for these conditions jumped about +21% and +23% with Z-scores around 2 and 2.2, respectively, pointing to a weak signal (with low statistical significance).

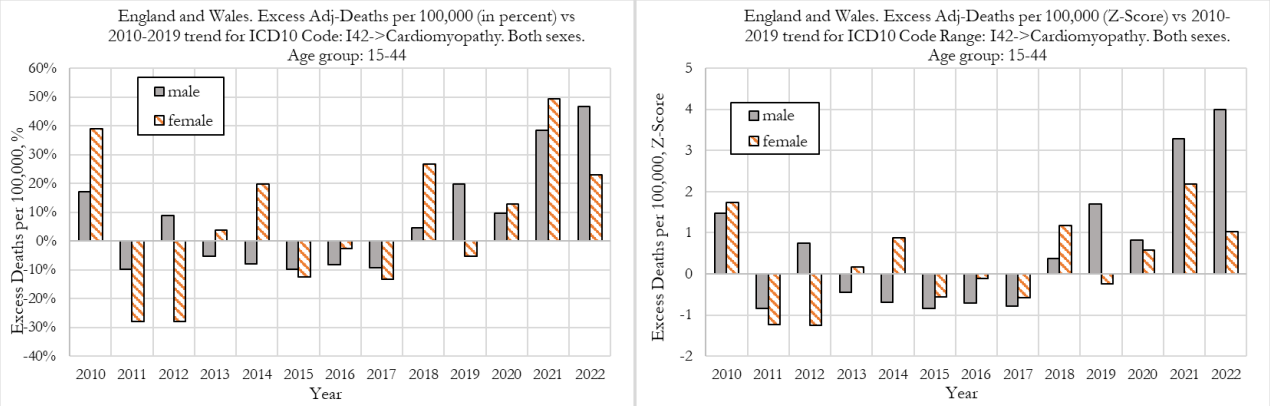

Figure 17 - Excess adjusted deaths rates for ICD10 code I42 (Cardiomyopathy) for males and females, in England and Wales. Left: Relative deviation from trend, percent. Right: Deviation from trend Z-Score.

When looking at deaths attributed to cardiomyopathies for males and females, shown in Figure 17, we observe that in 2020 there was a +10% excess mortality for men and +12% for women, with low Z-scores below 1 (no statistical significance).

In 2021 men and women suffered comparable outcomes, with men experiencing a 39% deviation from trend, compared to about 50% for women. These values, constitute strong signals for men with a Z-score above 3 but for women the statistical significance was lower (with a Z-score of close to 2).

In 2022 men suffered worse outcomes than women, with men experiencing about +48% deviation from trend, compared to about +22% for women. The signal strength for men was strong (with a Z-score about 4) and for women the signal had no statistical significance (with a Z-score close to 1), as shown in Figure 17-right.

5.5. Analysis of ICD10 Code I80 -> Phlebitis and Thrombophlebitis (Rank 5 – 6.5%)

In this section we investigate the trends in death rates for ICD10 code I80 (Phlebitis and Thrombophlebitis), which represents 6.5% of all cardiovascular deaths in 2019 for 15 to 44 year-olds in the UK. This analysis investigates the absolute trends in adjusted deaths for a single ICD10 code. We also investigate the fraction of deaths attributable to ICD10 code I80 versus deaths from all other causes.

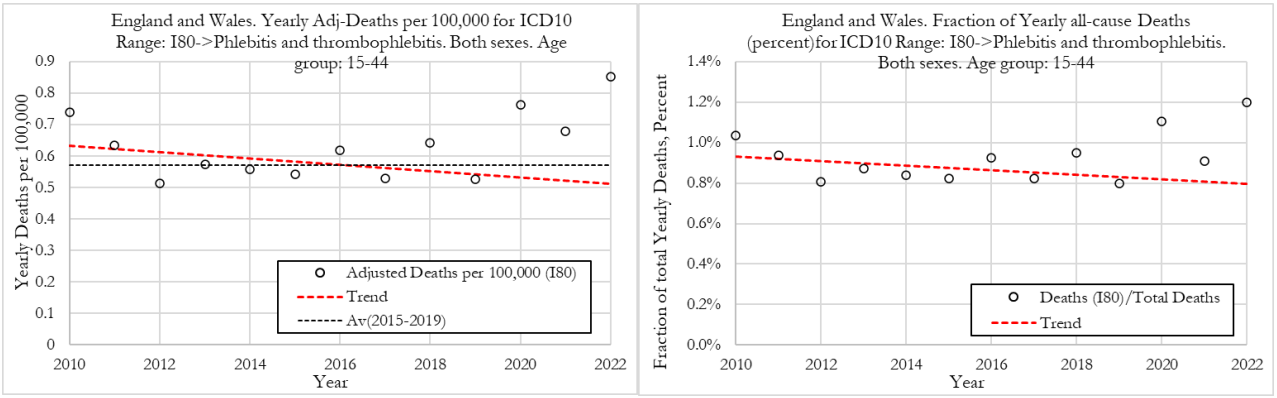

Figure 18 - Yearly adjusted deaths for ICD10 code I80 (Phlebitis and Thrombophlebitis) in England and Wales. The red dashed line shows the average from 2010 to 2019. The dotted line shows the 2015-2019 average death rate. Left: Adj-Deaths per 100,000. Right: Fraction of all deaths.

We can observe that death rates per year from Phlebitis and Thrombophlebitis have been trending lower from 2010 to 2019, with a downward slope. In 2010 the deaths rate was about 0.73 per 100,000, in 2019 it was around 0.52 per 100,000, a 28.8% drop.

The death rate rose slightly in 2020 to about 0.77 per 100,000 and then dropped slightly to 0.69 per 100,000 in 2021. In 2022 the death rate increased again to about 0.85 per 100,000, a level that is higher than observed in 2010.

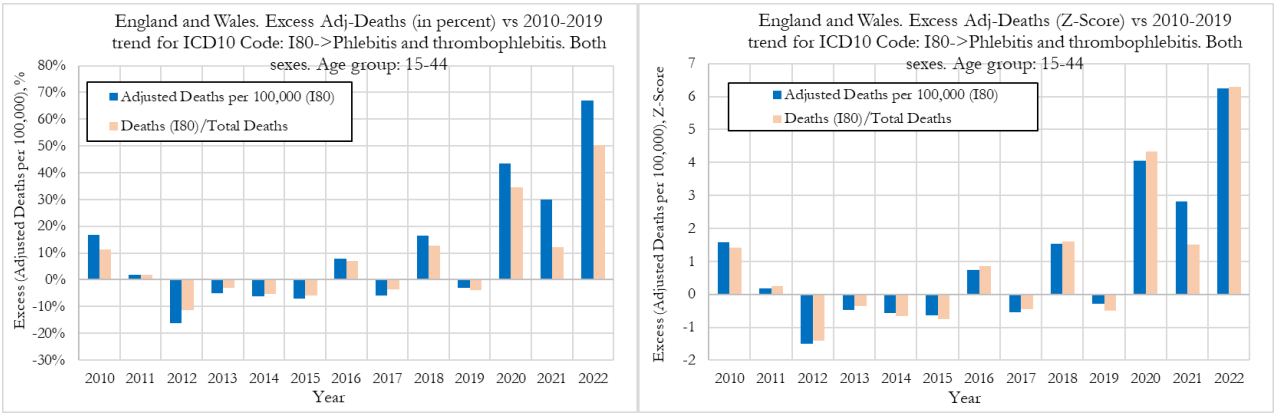

Figure 19 - Excess adjusted deaths rates for ICD10 code I80 (Phlebitis and Thrombophlebitis) versus excess fraction of all deaths for I80 deaths, in England and Wales. Left: Relative deviation from trend, percent. Right: Deviation from trend Z-Score.

In Figure 19 (left) we can observe that the excess deaths rates from Phlebitis and Thrombophlebitis were +43% in 2020, then were about +30% in 2021 and about 67% in 2022. In terms of statistical significance of the excess deaths, we observe from Figure 19 (right) that for these cardiovascular conditions, in 2020, the Z-score for excess adjusted death rates was 4 which points to a signal with high statistical significance. In 2021 however, the Z-score for excess

adjusted death rates was about 2.8 which was weaker than in 2020 and points to a signal with statistical significance worth investigating. In 2022 the Z-score rose to about 6.2, which is a strong signal and indicates that the excess deaths from Phlebitis and Thrombophlebitis are statistically significant deviations from the 2010-2019 trend.

When looking at changes in the fraction of all deaths attributed to Phlebitis and Thrombophlebitis, we observe that the fraction of deaths for these conditions were +35% above trend in 2020, with a Z-score of 4.3 showing high statistical significance. In 2021 and 2022 however, the fraction of deaths for these conditions were about +12% and +50% above trend with Z-scores around 1.2 and 6.3, respectively. While the changes were highly statistically significance in 2022, they did not show statistical significance in 2021.

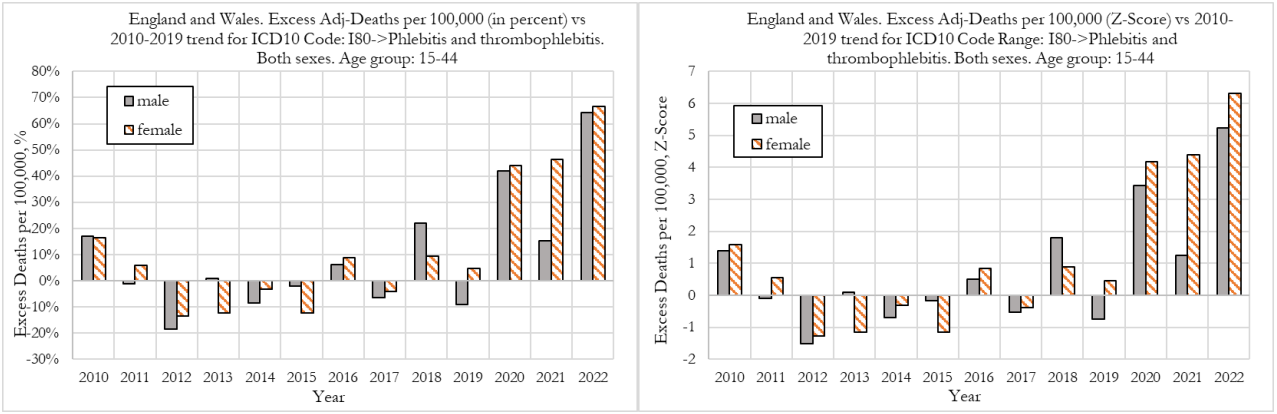

Figure 20 - Excess adjusted deaths rates for ICD10 code I80 (Phlebitis and Thrombophlebitis) for males and females, in England and Wales. Left: Relative deviation from trend, percent. Right: Deviation from trend Z-Score.

When looking at deaths attributed to Phlebitis and Thrombophlebitis for males and females, shown in Figure 20, we observe that in 2020 both had excess mortality (about 41% for men and 43% for women). Both for men and women the excess mortality was a statistically significant signal, with respective Z-scores of about 3.5 and 4.1.

In 2021 women suffered much worse outcomes than men, with women experiencing a 47% deviation from trend, compared to about 16% for men. These values, constitute a strong signal for women, as the Z-score was around 4.4, but for men there was no signal in excess deaths with a Z-score close to 1, indicating low statistical significance.

In 2022 men and women suffered similar outcomes, with men experiencing about +65% deviation from trend, compared to about +67% for women. The signal strengths for men and women were very strong, with a Z-score above 5.2 and 6.3, respectively, as shown in Figure 20-right.

5.6. Analysis of ICD10 Code I61 -> Nontraumatic Intracerebral Haemorrhage (Rank 7 – 5.4%)

In this section we investigate the trends in death rates for ICD10 code I61 (Nontraumatic intracerebral haemorrhage), which represents 5.4% of all cardiovascular deaths in 2019 for 15 to 44 year-olds in the UK. This analysis investigates the absolute trends in adjusted deaths for a single ICD10 code. We also investigate the fraction of deaths attributable to ICD10 code I61 versus deaths from all other causes.

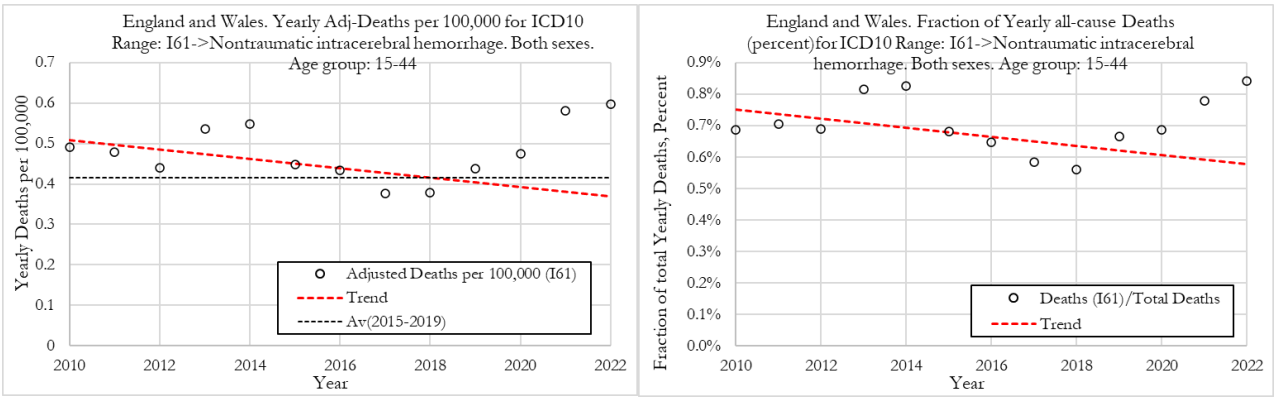

Figure 21 - Yearly adjusted deaths for ICD10 code I61 (Nontraumatic intracerebral haemorrhage) in England and Wales. The red dashed line shows the average from 2010 to 2019. The dotted line shows the 2015-2019 average death rate. Left: Adj-Deaths per 100,000. Right: Fraction of all deaths.

We can observe that death rates per year from nontraumatic intracerebral haemorrhage have been trending lower from 2010 to 2019, with a slight downward slope. In 2010 the deaths rate was about 0.5 per 100,000, in 2019 it was around 0.45 per 100,000, a 10% drop.

The death rate rose in 2020 to about 0.48 per 100,000 and then jumped to 0.59 per 100,000 in 2021. In 2022 the death rate increased again to about 0.6 per 100,000, a higher level than that observed in 2010.

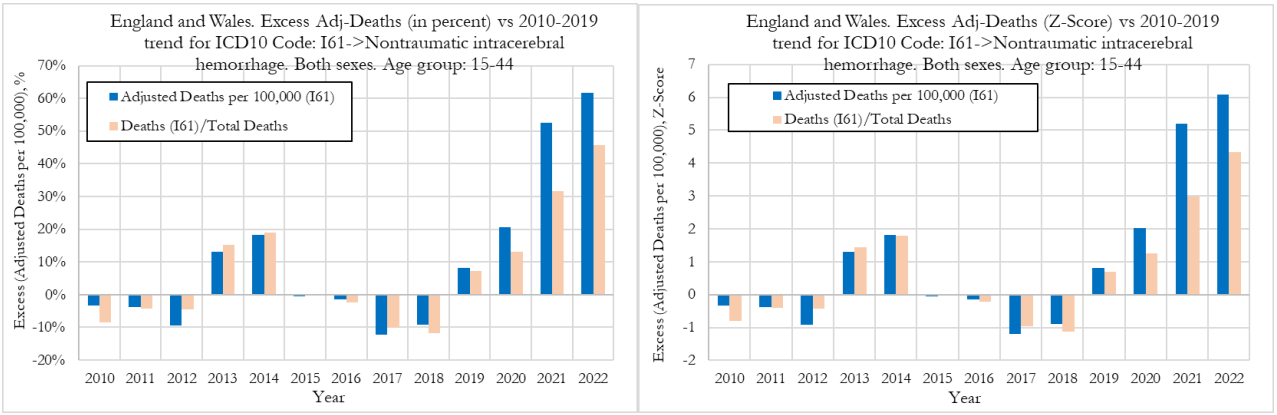

Figure 22 - Excess adjusted deaths rates for ICD10 code I61 (Nontraumatic intracerebral haemorrhage) versus excess fraction of all deaths for I61 deaths, in England and Wales. Left: Relative deviation from trend, percent. Right: Deviation from trend Z-Score.

In Figure 22 (left) we can observe that the excess deaths rates from nontraumatic intracerebral haemorrhage were +20% in 2020, then rose to about 52% in 2021 and about 61% in 2022. In terms of statistical significance of the excess deaths, we observe from Figure 22 (right) that for these cardiovascular conditions, in 2021 and 2022, the Z-

score for excess adjusted death rates were about to 5.2 and 6, respectively, which point to very strong signals (extreme events) that need further investigating. These results indicate that the excess deaths from nontraumatic intracerebral haemorrhage are statistically significant deviations from the 2010-2019 trend. We also note that in 2020, the Z-score for the excess death rates was already pointing towards a weak signal, with a Z-score close to 2, which indicates some statistical significance.

When looking at changes in the fraction of all deaths attributed to nontraumatic intracerebral haemorrhage, we observe that the fraction of deaths for these conditions were +13% and +31% above trend in 2020 and 2021, respectively. There was no noticeable signal in 2020 a Z-score close to 1, but in 2021 the Z-score was around 3 indicating high statistical significance and a signal worth investigating.

In 2022, the fraction of deaths for these conditions jumped about +46%, with a Z-score above 4.3 which points to a strong effect.

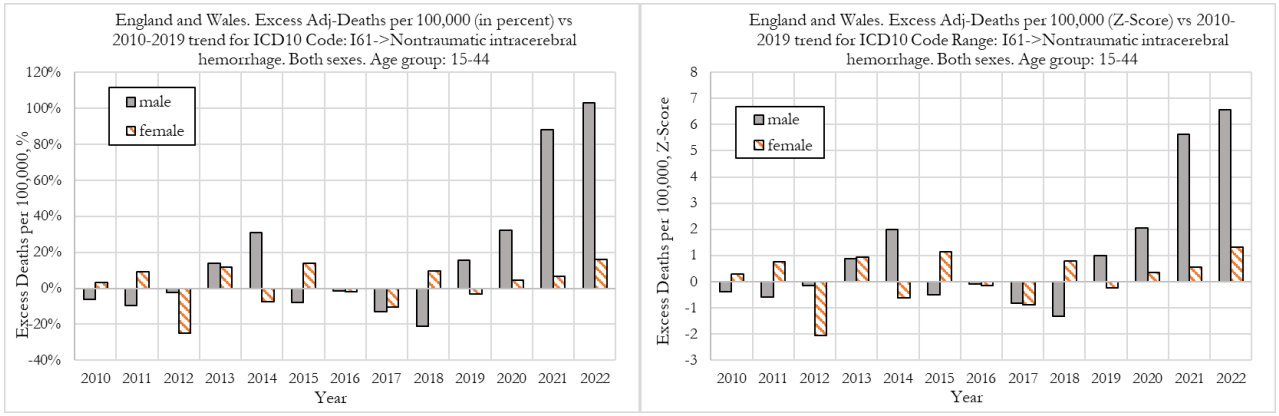

Figure 23 - Excess adjusted deaths rates for ICD10 code I61 (Nontraumatic intracerebral haemorrhage) for males and females, in England and Wales. Left: Relative deviation from trend, percent. Right: Deviation from trend Z-Score.

When comparing deaths attributed to nontraumatic intracerebral haemorrhage for males and females, shown in Figure 23, we observe and extraordinary picture. It appears all the excess mortality due to these cardiovascular conditions was in men, while female had no noticeable excess mortality (with a Z-scores close to or below 1.0 in 2020, 2021 and 2022).

Men, however, experienced about +36% excess mortality in 2020, +90% in 2021 and +110% in 2022. The Z-scores in 2021 and 2022 were 5.7 and 6.7, respectively denoting very high statistical significance while the excess mortality in 2020 had a Z-score of about 2, a weak signal.

5.7. Analysis of ICD10 Code I26 -> Pulmonary Embolism (Rank 8 – 4.75%)

In this section we investigate the trends in death rates for ICD10 code I26 (Pulmonary embolism), which represents 4.75% of all cardiovascular deaths in 2019 for 15 to 44 year-olds in the UK. This analysis investigates the absolute trends in adjusted deaths for a single ICD10 code. We also investigate the fraction of deaths attributable to ICD10 code I26 versus deaths from all other causes.

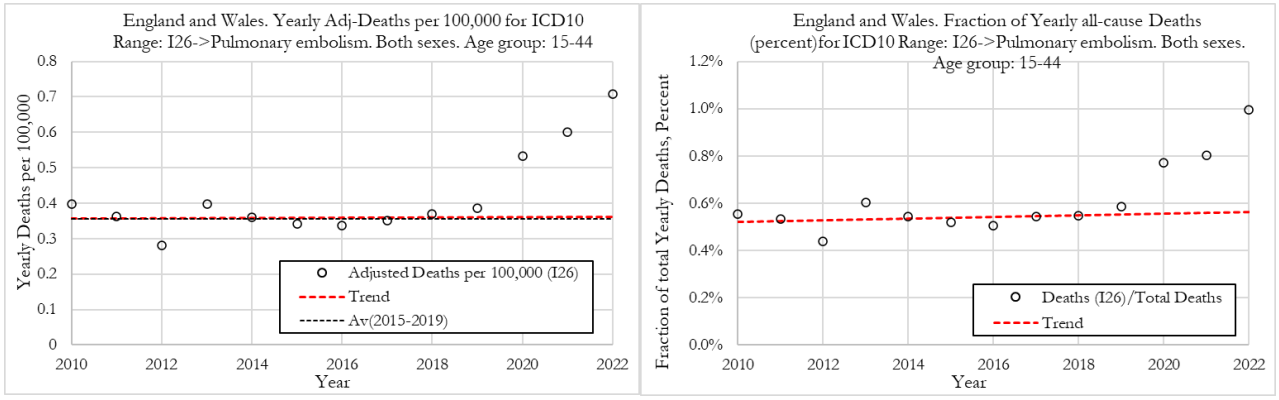

Figure 24 - Yearly adjusted deaths for ICD10 code I26 (Pulmonary embolism) in England and Wales. The red dashed line shows the average from 2010 to 2019. The dotted line shows the 2015-2019 average death rate. Left: Adj-Deaths per 100,000. Right: Fraction of all deaths.

We can observe that death rates per year from pulmonary embolisms have been stable from 2010 to 2019, with no noticeable downward slope. From 2010 to 2019 the death rate was about 0.36 per 100,000.

The death rate rose in 2020 to about 0.53 per 100,000 and then rose again to 0.6 per 100,000 in 2021. In 2022 the death rate increased again to about 0.7 per 100,000, a level that was more than double that observed in 2010.

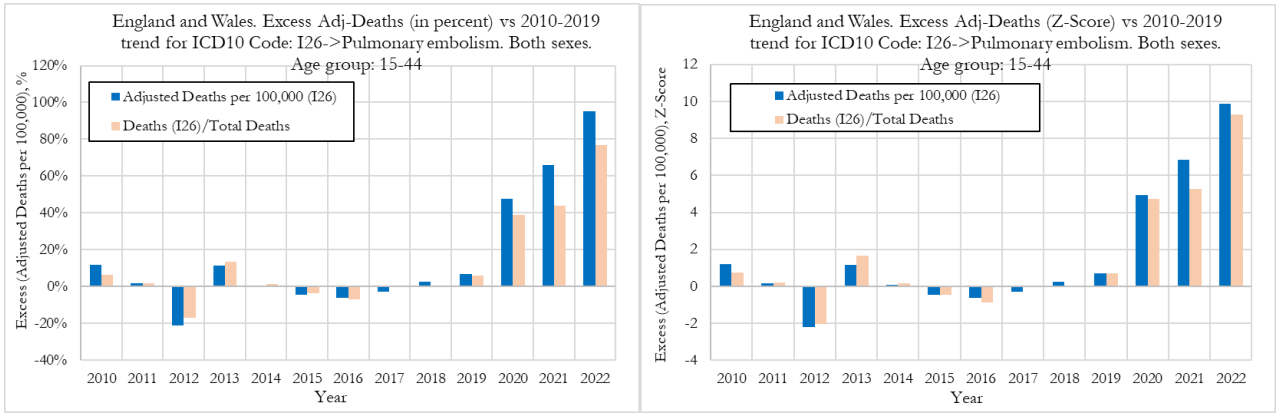

Figure 25 - Excess adjusted deaths rates for ICD10 code I26 (Pulmonary embolism) versus excess fraction of all deaths for I26 deaths, in England and Wales. Left: Relative deviation from trend, percent. Right: Deviation from trend Z-Score.

In Figure 25 (left) we can observe that the excess deaths rates from pulmonary embolisms were +48% in 2020, then rose to about +65% in 2021 and about 95% in 2022. In terms of statistical significance of the excess deaths, we observe from Figure 25 (right) that for these cardiovascular conditions, in 2021, the Z-score for excess adjusted death rates was close to 7 which points to a very strong signal (extreme event) that needs further investigating. In 2022 the Z-score rose to about 10, which is an extraordinarily strong signal and indicates that the excess deaths

from pulmonary embolism are statistically significant deviations from the 2010-2019 trend. We also note that in 2020, excess death rates were already pointing towards a strong signal, with a Z-score of about 5.

When looking at changes in the fraction of all deaths attributed to pulmonary embolisms, we observe that the fraction of deaths for these conditions were +39% and +44% above trend in 2020 and 2021, respectively (with a Z-score around 5, indicating high statistical significance). In 2022 however, the fraction of deaths for these conditions jumped about +78%, with a Z-score above 9 which points to a very strong effect (extreme event).

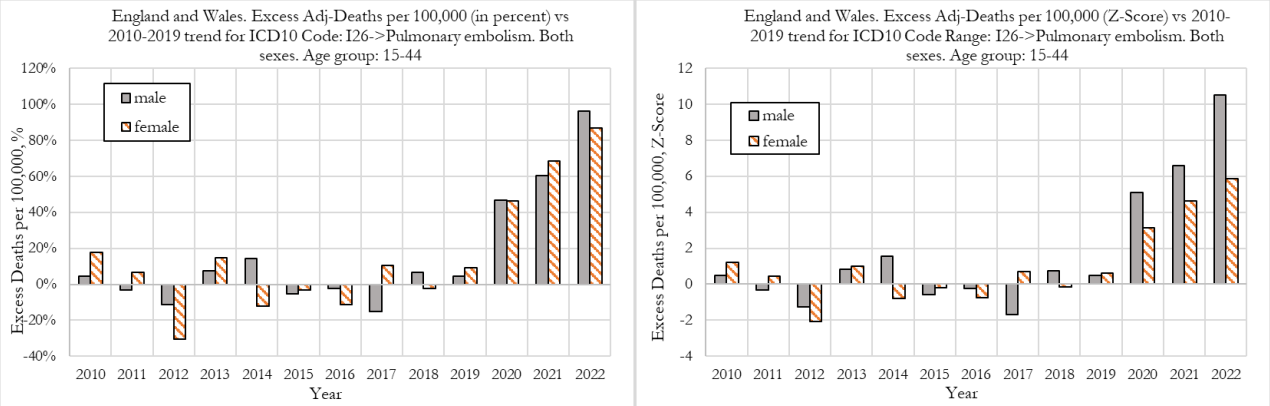

Figure 26 - Excess adjusted deaths rates for ICD10 code I26 (Pulmonary embolism) for males and females, in England and Wales. Left: Relative deviation from trend, percent. Right: Deviation from trend Z-Score.

When comparing deaths attributed to pulmonary embolisms for males and females, shown in Figure 26, we observe that males and females experienced similar outcomes in 2020, 2021 and 2022, with excess mortality rising by about 48% for males and females in 2020, 60% for males and 68% for females in 2021 and 98% for males and 88% for females in 2022.

We also observe that the statistical significance of the signals was high for both males and females, albeit higher for males than females. We also observe that the signal strength increased from 2020 to 2022, with the Z-scores in 2022 (6 in women and 10.5 in men) pointing towards extreme events.

5.8. Analysis of ICD10 Code I40 -> Acute Myocarditis (Rank 23 – 0.59%)

In this section we investigate the trends in death rates for ICD10 code I40 (Acute Myocarditis), which represents only 0.59% of all cardiovascular deaths in 2019 for 15 to 44 year-olds in the UK. This analysis investigates the absolute trends in adjusted deaths for a single ICD10 code. We also investigate the fraction of deaths attributable to ICD10 code I40 versus deaths from all other causes.

We should note that deaths from myocarditis represent only a very small proportion of deaths within the cardiovascular system (only about 0.59%). We show the analysis of trends in myocarditis here to illustrate that the cardiovascular damage occurring in 2021 and 2022 might originate from myocardial inflammation but is not being recorded as such, as our analysis will show.

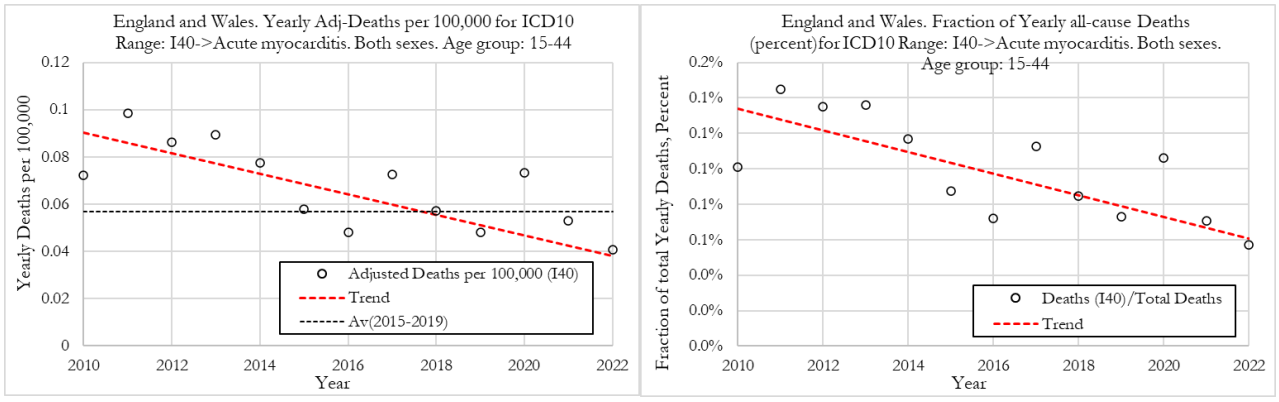

Figure 27 - Yearly adjusted deaths for ICD10 code I40 (Acute Myocarditis) in England and Wales. The red dashed line shows the average from 2010 to 2019. The dotted line shows the 2015-2019 average death rate. Left: Adj-Deaths per 100,000. Right: Fraction of all deaths.

We can observe that death rates per year from acute myocarditis have been declining from 2010 to 2019, with a sharp downward slope. In 2010 the deaths rate was about 0.9 per 100,000, in 2019 it was around 0.05 per 100,000, a 44.4% drop.

The death rate rose in 2020 to about 0.075 per 100,000 and then dropped to 0.055 per 100,000 in 2021. In 2022 the death rate dropped again to about 0.04 per 100,000, a level that falls on top of the prior trend from 2010 to 2019.

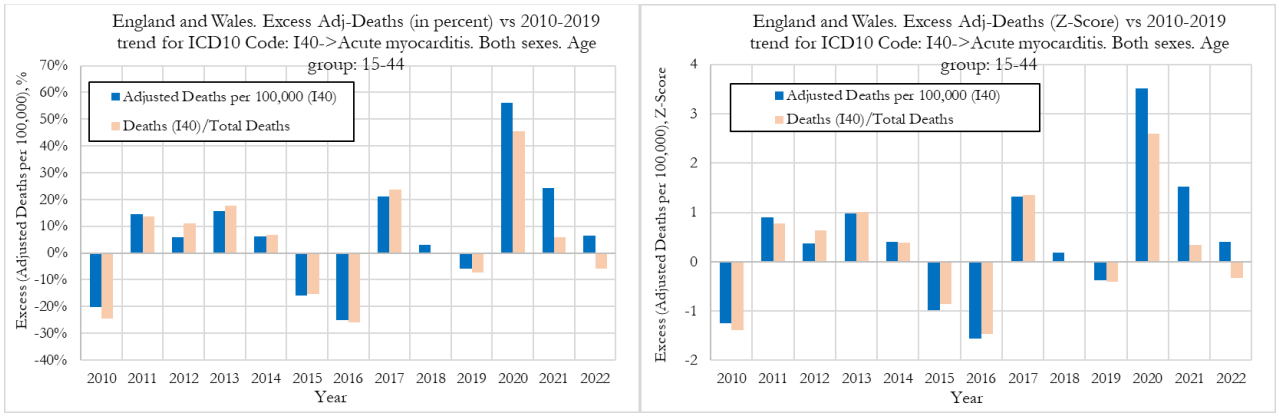

Figure 28 - Excess adjusted deaths rates for ICD10 code I40 (Acute Myocarditis) versus excess fraction of all deaths for I40 deaths, in England and Wales. Left: Relative deviation from trend, percent. Right: Deviation from trend Z-Score.

In Figure 28 (left) we can observe that the excess deaths rates from acute myocarditis were +56% in 2020, then dropped to about +25% in 2021 and to about +6% in 2022. In terms of statistical significance of the excess deaths, we observe from Figure 28 (right) that for these cardiovascular conditions, in 2021 and 2022, the Z-scores for excess adjusted death rates was close to 1.5 or lower which points to a weak signal with low statistical significance. It appears that acute myocarditis death rates were not above trend in 2021 and 2022.

However, we also note that in 2020, excess death rates were pointing towards a strong signal, with a Z-score of about 3.5.

When looking at changes in the fraction of all deaths attributed to acute myocarditis, we observe that the fraction of deaths for these conditions were +5% and -5% from trend in 2021 and 2022, respectively (with a Z-score close to 0, indicating no statistical significance). In 2020 however, the fraction of deaths for these conditions jumped about +45%, with a Z-score around 2.5 which points to a statistically significant effect.

Even though deaths from acute myocarditis are negligible in the context of cardiovascular deaths, it is interesting to notice that even though we observe an extraordinary rise in both acute myocardial infarction and chronic ischaemic heart disease deaths, we did not observe similar rises in acute myocarditis deaths. This is particularly worrying as the a recent paper[8] from Buergin et al. shows that myocarditis rates after the vaccine booster was about 2.8%, which provides medical evidence for a plausible mechanism leading to a cardiovascular event[9].

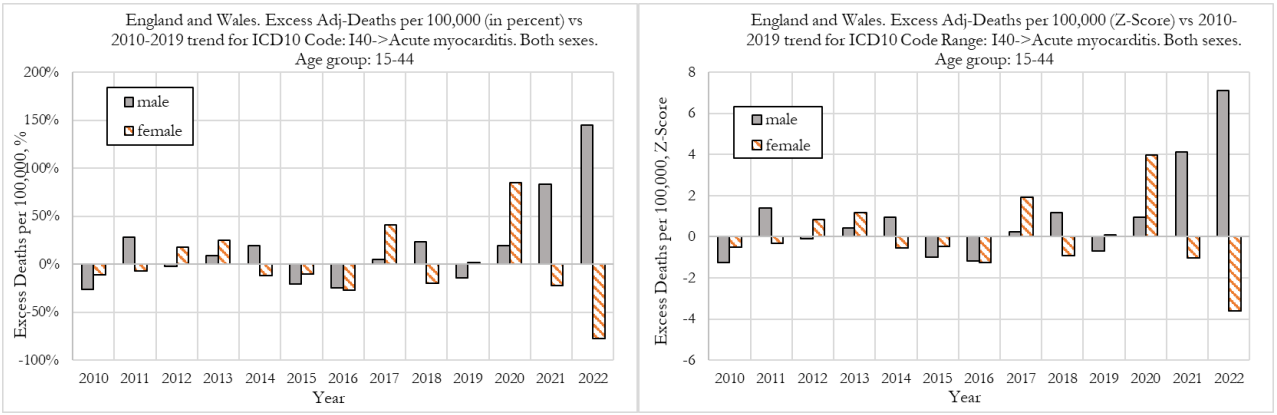

Figure 29 - Excess adjusted deaths rates for ICD10 code I40 (Acute Myocarditis) for males and females, in England and Wales. Left: Relative deviation from trend, percent. Right: Deviation from trend Z-Score.

When comparing deaths attributed to acute myocarditis for males and females, shown in Figure 29, we observe that in 2020, the excess mortality signal was due to females that experienced about +85% increase (with a Z-score of 4 indicating high statistical significance), with males experiencing only about 20% rise (with a Z-score close to 1 indicating no statistical significance).

Interestingly, in 2021, almost the exact opposite occurred with the excess mortality of about +84% (with a Z-score of 4 indicating high statistical significance) appearing in males, and with females experiencing about -22% excess mortality (with a low Z-score indicating no statistical significance).

[8] N. Buergin et al, "Myocardial injury after COVID-19mRNA-1273 booster vaccination", European Journal of Heart Failure, 2023. Link: https://onlinelibrary.wiley.com/doi/epdf/10.1002/ejhf.2978

[9] For a more detailed analysis see our full report on deaths and disabilities in the cardiovascular system. https://phinancetechnologies.com/HumanityProjects/UK%20Cause%20of%20death%20Project%20-%20Cardiovascular%20Deaths%2015-44.htm

Finally, in 2022, excess mortality in men continued rising to about +145% (with a Z-score of 7 indicating high statistical significance), while in females it continued dropping to -77% excess mortality (with a Z-score close to -4 indicating a strong statistically significant negative signal).

It should be noted that the analysis of acute myocarditis for this age group has the caveats typical of small samples where we observe large changes with low statistical significance, and where, even when statistically significant signals are observed, these might be due to misclassification issues or other factors.

6. Concluding Remarks

The results shown in Table 2 summarise the death rates and excess death rates for some of the most common causes within the cardiovascular system. It compares the death rates for males and females, and additionally, shows the overall death rates from all cardiovascular causes of death. **Note that estimates for total excess deaths or excess death rates are not equal to the sum of those rates for men and women because the linear estimates were performed independently.**

	Adj Death rate, per 100,000				Abs deviation, per 100,000			Rel deviation from trend, %			Excess Deaths, Number		
	2019	2020	2021	2022	2020	2021	2022	2020	2021	2022	2020	2021	2022
All Cardiovascular causes													
Total	8.12	8.88	10.04	10.82	1.02	2.34	3.28	13.0%	30.4%	43.5%	229.4	528.0	746.5
Men	10.85	12.00	13.49	15.51	1.49	3.25	5.53	14.1%	31.7%	55.4%	168.4	370.0	621.3
Women	5.32	5.72	6.53	6.39	0.59	1.46	1.37	11.4%	28.7%	27.3%	65.4	162.2	158.1
Acute myocardial infarction													
Total	1.21	1.27	1.75	1.85	0.10	0.61	0.75	8.4%	53.4%	68.4%	22.2	137.0	171.3
Men	1.87	1.96	2.70	3.12	0.12	0.92	1.40	6.5%	51.7%	82.1%	13.5	104.7	157.9
Women	0.52	0.58	0.78	0.68	0.10	0.31	0.22	19.9%	66.3%	48.7%	10.7	34.9	25.7
Chronic ischemic heart disease													
Total	1.34	1.65	1.75	2.03	0.35	0.52	0.86	27.1%	42.0%	73.7%	79.1	117.1	196.2
Men	2.11	2.81	2.72	3.56	0.69	0.70	1.65	32.4%	35.0%	87.0%	77.8	80.3	185.8
Women	0.55	0.50	0.78	0.63	0.04	0.36	0.22	9.2%	83.1%	55.9%	4.7	39.7	25.9
Pulmonary embolism													
Total	0.39	0.53	0.60	0.71	0.17	0.24	0.35	47.8%	66.1%	95.3%	38.8	53.9	78.7
Men	0.36	0.51	0.56	0.68	0.16	0.21	0.33	46.7%	60.4%	96.1%	18.3	23.9	37.5
Women	0.41	0.56	0.64	0.71	0.18	0.26	0.33	46.5%	68.4%	86.9%	19.7	29.0	38.3
Phlebitis and thrombophlebitis													
Total	0.53	0.76	0.68	0.85	0.23	0.16	0.34	43.5%	30.1%	66.9%	51.9	35.3	77.9
Men	0.53	0.82	0.65	0.91	0.24	0.09	0.36	41.9%	15.2%	64.2%	27.4	9.8	40.1
Women	0.52	0.70	0.70	0.78	0.21	0.22	0.31	44.0%	46.3%	66.5%	23.8	24.6	35.9
Nontraumatic intracerebral hemorrhage													
Total	0.44	0.47	0.58	0.60	0.08	0.20	0.23	20.6%	52.6%	61.7%	18.2	45.2	51.9
Men	0.56	0.60	0.81	0.82	0.15	0.38	0.41	32.3%	88.0%	103.1%	16.7	43.0	46.5
Women	0.31	0.34	0.35	0.39	0.01	0.02	0.05	4.4%	6.8%	16.1%	1.6	2.5	6.2
Acute myocarditis													
Total	0.05	0.07	0.05	0.04	0.03	0.01	0.00	56.2%	24.4%	6.4%	5.9	2.3	0.6
Men	0.04	0.05	0.07	0.07	0.01	0.03	0.04	19.4%	83.8%	145.0%	1.0	3.5	4.9
Women	0.05	0.09	0.04	0.01	0.04	-0.01	-0.04	84.7%	-22.1%	-77.1%	4.8	-1.2	-4.2

Table 2 - Summary for excess deaths from cardiovascular diseases in England and Wales for ages 15 to 44. The table compares death rates and excess deaths for all cardiovascular diseases and the most common individual causes, by ICD10 code classification.

6.1. Summary for all cardiovascular diseases

From Table 2 we can observe that the death rates for all cardiovascular diseases was 8.12 per 100,000 in 2019, of which 10.85 per 100,000 for men and 5.32 for women. Consequently, in 2019, before the Covid-19 pandemic, men had 103.9% higher death rates than women.

Death rates for all cardiovascular diseases increased to 8.88, 10.04 and 10.82 in 2020, 2021 and 2022, respectively. For males the death rates increased to 12.0, 13.49 and 15.51 in 2020, 2021 and 2022, respectively while for females, death rates were 5.72, 6.53 and 6.39 in 2020, 2021 and 2022, respectively. Death rates increased successively in 2020, 2021 and 2022 for men, but for women death rates increased in 2020 and 2021, but then dropped slightly in 2022.

When comparing the death rates for women and men in 2022, we observe that death rates for men were 142.7% higher than for women. Not only did men suffer worse cardiovascular outcomes prior the pandemic, the outcomes for men relative to women worsened in 2020, 2021 and 2022.

The deviation from trend was 1.49 per 100,000 in 2020 for men and 0.59 per 100,000 for women, corresponding to +14.1% and +11.4% in relative terms, respectively.

When analysing combined (men and women) cardiovascular death rates, we observe that in 2021, the deviation from trend was 2.34 per 100,000, a +13% excess rate. The deviation from trend was 3.25 per 100,000 in 2021 for men and 1.45 per 100,000 for women, corresponding to +31.7% and +28.7% in relative terms, respectively. In terms of the number of 15 to 44 year-olds in the UK that died in excess from cardiovascular diseases in 2021 these rates equated to 528 total excess deaths of which 370 were in men and 162.2 in women.[10]

The deviation from trend was 3.28 per 100,000 in 2022 for men and women combined (corresponding to +55.4% in relative terms). For men the deviation from trend was 5.53 per 100,000 (corresponding to +51.7% in relative terms) while for women it was 1.37 per 100,000 (corresponding to 27.3% in relative terms). In terms of the number of 15 to 44 year-olds in the UK that died in excess from cardiovascular diseases in 2022 these rates translate to 746.5 total excess deaths of which 621.3 were in men and 158.1 in women. As shown in Figure 6 and Figure 8, the excess deaths from cardiovascular diseases have very high Z-scores (above 11 for males and above 7 for females) that point to strong signals with very high statistical significance.

As mentioned previously, the excess mortality rate for cardiovascular diseases were already associated to the Covid-19 vaccinations as there was already a clear signal during the Pfizer clinical trials[11]. In their paper, the authors find that in the clinical trials after 6-months 12 died of a cardiac event, 9 of whom were vaccinated and 3 unvaccinated.

The detailed analysis of the summary results shown in Table 2 are not the scope of this report and should be investigated with detailed care by medical doctors that work in the field. However, some noticeable patterns are obvious at first glance, which we'll describe next.

6.2. Men more affected than women.

The results in Table 2 show that overall cardiovascular diseases saw explosive changes in 2021 and 2022 relative to the 2010-2019 trend that appear to be affecting men in a disproportionate manner. For example, with the two main cardiovascular diseases namely chronic ischaemic heart disease and acute myocardial infarction that account for about 31.4% of cardiovascular deaths, we see men having worse outcomes than women (see section 6.3). Additionally, as shown in section 5.6, nontraumatic intracerebral haemorrhage saw enormous rise in death rates in 2021 and 2022 for men, while women experienced almost no change. The mechanisms behind this pattern are unclear and require further investigation.

6.3. Chronic Ischemic Heart Disease Versus Acute Myocardial Infarction

The 2 main causes of cardiovascular deaths for 15 to 44 year-olds in the UK were chronic ischemic heart disease (I25) and acute myocardial infarction (I21), which accounted respectively for 16.5% and 14.9% of cardiovascular deaths in 2019. Altogether these two causes represent about 31.4% of cardiovascular deaths.

One of the noticeable patterns from Table 2 is that the deaths rates for both acute myocardial infarction and chronic ischaemic heart disease increased substantially in 2020, 2021 and 2022. In 2022, death rates from acute myocardial

[10] Please note that estimates for total excess deaths or excess death rates are not equal to the sum of those rates for men and women because the linear estimates were performed independently.

[11] C. A. Michels et al. (Oct-2023) "Forensic Analysis of the 38 Subject Deaths in the 6-Month Interim Report of the Pfizer/BioNTech BNT162b2 mRNA Vaccine Clinical Trial", International Journal of Vaccine Theory, Practice, and Research, 3 (1), pp. 973-1009.
Link: https://doi.org/10.56098/ijvtpr.v3i1.85

infarction were 68.4% above trend, while death rates for chronic ischaemic heart disease were 73.7% above trend. By 2022, both conditions had similar increases relative to pre-2020 trends.

However, we also observe that while chronic ischaemic heart disease rose by 27.1% in 2020, with a high statistical significance (Z-score of about 6), as shown in section 5.2; acute myocardial infarction death rates were only about 8.4% above trend, with low statistical significance (Z-Score of about 1.5). This means that individuals with prior heart conditions (chronic heart disease) already experienced a rise in death rate in 2020, before the introduction of the mRNA inoculations, but no significant rise in acute myocardial infarction. Acute myocardial infarction only rose significantly from 2021, with a 53.4% deviation from trend, after the Covid-19 shots were introduced.

Men and Women

When comparing men and women we observe that both chronic ischaemic heart disease and acute myocardial infarction death rate rose substantially in women in 2021, by +83.1% and +66.3%, respectively. However, in 2022, the excess death rates for these conditions were only +55.9% and +48.7%, respectively, which were lower than the deviations from trend observed in 2021. It appears that women experienced the worst of these cardiovascular conditions in 2021. For men, we observe that in 2021, death rates from chronic ischaemic heart disease and acute myocardial infarction rose by +35.0% and +51.7%, respectively.

We also observe that in 2020 men had already experienced above normal level of chronic ischaemic heart disease (of +32.4%), which likely brought forwards some of the deaths from these causes that would likely have occurred in 2021. For women, of note is that in 2020 they experienced a 19.9% deviation from trend for acute myocardial infarctions, albeit with low statistical significance (Z-score of about 2.0).

The worse outcomes in men relative to women from 2020 to 2022 in these cardiovascular diseases is evidenced by calculating the ratio of death rates in 2019 (prior the pandemic) and 2022 (after the full effect of the pandemic). In 2019, the ratio of chronic ischaemic heart disease death rates for men versus women was 2.11/0.55 = 3.84, that is, men had a 3.84 times higher death rate than women. For acute myocardial infarction the ratio was 1.87/0.52 = 2.60.

In 2022, after the pandemic (Covid-19, lockdowns and inoculation rollout), the ratio of chronic ischaemic heart disease death rates for men versus women was 3.56/0.63 = 4.65, that is, men had a 4.65 times higher death rate than women. For acute myocardial infarction the ratio was 3.12/0.68 = 3.59. Consequently, death rates for men, for both cardiovascular conditions grew more than for women, showing that men had much worse outcomes than women.

6.4. Pulmonary Embolism and Phlebitis and Thrombophlebitis

The pattern of behaviour for deaths from pulmonary embolisms and phlebitis and thrombophlebitis was similar in 2020, 2021 and 2022. Pulmonary embolisms saw +47.8% excess deaths rates in 2020 while phlebitis and thrombophlebitis the excess death rate was +43.5%, with Z-scores of about 5 and 4, respectively, indicating strong signals.

However, while excess death rates from pulmonary embolism continued accelerating in 2021 and 2022 (+66.1% and +95.3% respectively), excess death rates from phlebitis and thrombophlebitis were more subdued in 2021, then accelerated again in 2022 (+30.1% and +66.9% respectively).

When comparing women and men, we observe that for these conditions, both experienced comparable rises in death rates.

In summary, it is interesting to notice that both these conditions saw significant increases (strong signals) of death rates already in 2020, before the Covid-19 vaccination rollout, indicating that they were likely related to the Covid-19 disease. The re-acceleration of excess deaths in 2022 points to other effects at play as the virus is known to have become less virulent and more contagious over time, with the successive variants.

6.5. Nontraumatic Intracerebral Haemorrhage

Another pattern of note from Table 2 is the rise in the deaths rates from nontraumatic intracerebral haemorrhage which was dramatic in men but almost negligible in women.

For men, excess deaths rates from nontraumatic intracerebral haemorrhage were +32.3%, +88.0% and 103.1% in 2020, 2021 and 2022, respectively. The Z-score for excess adjusted death rates were about to 5.2 and 6, in 2021 and 2022 respectively, which point to very strong signals (extreme events). In 2020, the Z-score for the excess death rates was already pointing towards a weak signal, with a Z-score close to 2, which indicates some statistical significance.

For women, excess deaths rates from nontraumatic intracerebral haemorrhage were +4.4%, +6.8% and +16.1% in 2020, 2021 and 2022, respectively. These values did not have statistical significance which indicate that no signal was present in changes in death rates for these conditions.

Even though nontraumatic intracerebral haemorrhage deaths accounted for only about 5.4% of total cardiovascular deaths for 15 to 44 year-olds in the UK, these rises in death rates in men, but not in women needs further investigation.

6.6. Acute Myocarditis

As we showed in section 5.8 myocarditis deaths represent only about 0.59% of deaths within the cardiovascular system, a very small proportion. Furthermore, from the summary results shown in Table 2 we observe that even for men, that were more affected by rises in acute myocarditis deaths, the death rate increased by about 0.04 per 100,000 in 2022 corresponding to an excess mortality of about +145% (with a Z-score of 7 indicating high statistical significance). These represent large increases in relative terms, but with a small impact in absolute terms.

Several papers academic literature have shown increased myocarditis (and pericarditis) rates after the mRNA vaccinations. A study from Denmark[12] showed that absolute rates of myocarditis or pericarditis rates after vaccination were 1.6 per 100,000 after the Pfizer vaccine and 5.7 per 100,000 after the Moderna vaccine for individuals aged 12-39. A study from Korea[13] shows vaccine related myocarditis rates of 2.17 for 18 to 29 year-olds and 1.36 to 30 to 39 year olds. A population study published in December 2022 from Japan also shows increased mortality risk from myocarditis after vaccination, for all age groups[14].

An early 2023 paper[15] from Buergin et al. shows that myocarditis rates after the vaccine booster was about 2800 per 100,000, which provides medical evidence for a plausible mechanism leading to a cardiovascular event. The study was performed on 777 participants with a median age of 37. These are much lower rates of incidence than reported

[12] BMJ 2021;375:e068665. http://dx.doi.org/10.1136/bmj-2021-068665
[13] *European Heart Journal*, Volume 44, Issue 24, 21 June 2023, Pages 2234–2243. https://doi.org/10.1093/eurheartj/ehad339
[14] https://www.medrxiv.org/content/10.1101/2022.10.13.22281036v2
[15] N. Buergin et al, "Myocardial injury after COVID-19mRNA-1273 booster vaccination", European Journal of Heart Failure, 2023. Link: https://onlinelibrary.wiley.com/doi/epdf/10.1002/ejhf.2978

in the Buergin investigation. The difference is attributed that the Buergin study was an active surveillance for myocardial damage after vaccinations while previous studies in Denmark, Korea and Japan refer to passive surveys.

The mechanisms that lead to increased rates of cardiomyopathies after mRNA-1273 and BNT162b2 inoculations was recently shown by Schreckenberg et. al.[16] concluding that the inoculations induce specific dysfunctions that correlate pathophysiologically to cardiomyopathy, that may significantly increase the risk of acute cardiac events.

When comparing the increased rates of cardiovascular deaths from acute myocarditis in 2022 (0.04 per 100,000) with the rates of myocarditis found in the academic literature (passive studies) showing rates of slightly of about 2 per 100,000, we conclude that the likely explanation is the under-reporting of these deaths under "acute myocarditis". The rise in excess deaths from chronic ischemic heart disease (0.75 per 100,000 in 2022) and acute myocardial infarction (0.75 per 100,000 in 2022) are more in-line with post-vaccination rates of myocardial damage described in the academic literature.

[16] Schreckenberg R, Woitasky N, Itani N, Czech L, Ferdinandy P, Schulz R., "Cardiac side effects of RNA-based SARS-CoV-2 vaccines: Hidden cardiotoxic effects of mRNA-1273 and BNT162b2 on ventricular myocyte function and structure." British Journal Pharmacology. 2023 Oct 12. doi: 10.1111/bph.16262. Epub ahead of print. PMID: 37828636. Link: https://bpspubs.onlinelibrary.wiley.com/doi/epdf/10.1111/bph.16262

7. Appendixes

7.1. Appendix 1 – ICD10 code list for the circulatory system (I00-I99)

ICD10 Code	Cause
I00	Rheumatic fever without heart involvement
I01	Rheumatic fever with heart involvement
I02	Rheumatic chorea
I03	DISEASES OF THE CIRCULATORY SYSTEM
I04	DISEASES OF THE CIRCULATORY SYSTEM
I05	Rheumatic mitral valve diseases
I06	Rheumatic aortic valve diseases
I07	Rheumatic tricuspid valve diseases
I08	Multiple valve diseases
I09	Other rheumatic heart diseases
I10	Essential (primary) hypertension
I11	Hypertensive heart disease
I12	Hypertensive chronic kidney disease
I13	Hypertensive heart and chronic kidney disease
I14	DISEASES OF THE CIRCULATORY SYSTEM
I15	Secondary hypertension
I16	Hypertensive crisis
I17	DISEASES OF THE CIRCULATORY SYSTEM
I18	DISEASES OF THE CIRCULATORY SYSTEM
I19	DISEASES OF THE CIRCULATORY SYSTEM
I20	Angina pectoris
I21	Acute myocardial infarction
I22	Subsequent ST elevation (STEMI) and non-ST elevation (NSTEMI) myocardial infarction
I23	Certain current complications following ST elevation (STEMI) and non-ST elevation (NSTEMI) myocardial infarction (within the 28 day period)
I24	Other acute ischemic heart diseases
I25	Chronic ischemic heart disease

I26	Pulmonary embolism
I27	Other pulmonary heart diseases
I28	Other diseases of pulmonary vessels
I29	DISEASES OF THE CIRCULATORY SYSTEM
I30	Acute pericarditis
I31	Other diseases of pericardium
I32	Pericarditis in diseases classified elsewhere
I33	Acute and subacute endocarditis
I34	Nonrheumatic mitral valve disorders
I35	Nonrheumatic aortic valve disorders
I36	Nonrheumatic tricuspid valve disorders
I37	Nonrheumatic pulmonary valve disorders
I38	Endocarditis, valve unspecified
I39	Endocarditis and heart valve disorders in diseases classified elsewhere
I40	Acute myocarditis
I41	Myocarditis in diseases classified elsewhere
I42	Cardiomyopathy
I43	Cardiomyopathy in diseases classified elsewhere
I44	Atrioventricular and left bundle-branch block
I45	Other conduction disorders
I46	Cardiac arrest
I47	Paroxysmal tachycardia
I48	Atrial fibrillation and flutter
I49	Other cardiac arrhythmias
I50	Heart failure
I51	Complications and ill-defined descriptions of heart disease
I52	Other heart disorders in diseases classified elsewhere
I53	DISEASES OF THE CIRCULATORY SYSTEM
I54	DISEASES OF THE CIRCULATORY SYSTEM
I55	DISEASES OF THE CIRCULATORY SYSTEM
I56	DISEASES OF THE CIRCULATORY SYSTEM

I57	DISEASES OF THE CIRCULATORY SYSTEM
I58	DISEASES OF THE CIRCULATORY SYSTEM
I59	DISEASES OF THE CIRCULATORY SYSTEM
I5A	Non-ischemic myocardial injury (non-traumatic)
I60	Nontraumatic subarachnoid hemorrhage
I61	Nontraumatic intracerebral hemorrhage
I62	Other and unspecified nontraumatic intracranial hemorrhage
I63	Cerebral infarction
I64	Cerebrovascular diseases
I65	Occlusion and stenosis of precerebral arteries, not resulting in cerebral infarction
I66	Occlusion and stenosis of cerebral arteries, not resulting in cerebral infarction
I67	Other cerebrovascular diseases
I68	Cerebrovascular disorders in diseases classified elsewhere
I69	Sequelae of cerebrovascular disease
I70	Atherosclerosis
I71	Aortic aneurysm and dissection
I72	Other aneurysm
I73	Other peripheral vascular diseases
I74	Arterial embolism and thrombosis
I75	Atheroembolism
I76	Septic arterial embolism
I77	Other disorders of arteries and arterioles
I78	Diseases of capillaries
I79	Disorders of arteries, arterioles and capillaries in diseases classified elsewhere
I80	Phlebitis and thrombophlebitis
I81	Portal vein thrombosis
I82	Other venous embolism and thrombosis
I83	Varicose veins of lower extremities
I84	DISEASES OF THE CIRCULATORY SYSTEM
I85	Esophageal varices
I86	Varicose veins of other sites

I87	Other disorders of veins
I88	Nonspecific lymphadenitis
I89	Other noninfective disorders of lymphatic vessels and lymph nodes
I90	DISEASES OF THE CIRCULATORY SYSTEM
I91	DISEASES OF THE CIRCULATORY SYSTEM
I92	DISEASES OF THE CIRCULATORY SYSTEM
I93	DISEASES OF THE CIRCULATORY SYSTEM
I94	DISEASES OF THE CIRCULATORY SYSTEM
I95	Hypotension
I96	Gangrene, not elsewhere classified
I97	Intraoperative and postprocedural complications and disorders of circulatory system, not elsewhere classified
I98	DISEASES OF THE CIRCULATORY SYSTEM
I99	Other and unspecified disorders of circulatory system