Iechyd Cyhoeddus Cymru
Public Health Wales

Bonfire night and air quality – an assessment of the impact in Wales

Contents

Summary

- We investigated the changes in air pollution and health outcomes associated with Bonfire Night in Wales
- During the bonfire period each year, mean daily PM10 levels peaked on 5th November
- Bonfire night appears to affect hospital admissions, with more people seeking medical attention for respiratory conditions
- More 999 calls are made during the bonfire period
- These findings have implications for monitoring the acute health effects of air pollution incidents in Wales.

Introduction

Globally nine out of ten people breathe in polluted air (WHO, 2023). Seven million people die each year as a result of health harms of air pollution, mainly respiratory conditions and coronary heart disease (WHO, 2023). Poor air quality is the largest environmental risk to public health in the United Kingdom (UK) (Public Health England. 2018).

In the UK, Bonfire Night (Guy Fawkes Night, 5th November) is celebrated yearly, with mass public events and private home gatherings. Air pollution from fireworks and bonfires predominantly consists of particulate matter (PM; Tiwari et al, 2016; Godri et al, 2010); solid and liquid particles small enough to penetrate deep into the lung (less than 10 microns in diameter, PM_{10}), that harm human health (Hickey et al, 2020). The entirely preventable health effects of fireworks and bonfires, include, but are not limited to the acute exacerbation of respiratory conditions such as asthma. These acute respiratory effects are driven by increased air pollution and smoke inhalation (Kumar et al, 2016; Lin, 2016; Yao et al, 2019).

These analyses aimed to inform understanding of data signals in routinely collected NHS data following air pollution events. It is intended that it will support future monitoring of the health effects of acute, unplanned air pollution incidents.

Methods

These analyses investigated whether Bonfire Night leads to any adverse effects on air quality in Wales, as well as acute effects on respiratory conditions in Wales. All data were analysed in R version 4.1.3.

Using data on emergency, or 999, calls to the Welsh Ambulance Service, 111 calls (generally non-emergency, medical advice calls), and emergency department (ED) attendance and hospital admission data, we compared the incidence of respiratory conditions during "Bonfire period" (29th October – 12th November) (BON) and the preceding 15 day "pre-Bonfire" period (14th October – 28th October) (PRE-BON). Data for 2017 to 2022 were analysed, but 2020 was excluded from all analyses due to the COVID19 pandemic.

The rates were calculated per 100,000 of the population for hospital admissions, ED attendances, 999 call data and 111 call data using the mid-year population estimates (ONS) (Table 1). Mid-year estimates were available for all years apart from 2022, where 2021 mid-year estimate was used.

Year	Mid-year population estimate
2017	3,125,165
2018	3,138,631
2019	3,152,879
2021	3,105,410
2022	3,105,410

Table 1: Office for National Statistics Mid-year population estimates for Wales. 2017 – 2022.

Air quality data

The Automatic Urban Rural Network (AURN) is the UK's largest automatic monitoring network and is the main network used for compliance reporting against the Ambient Air Quality Directives (DEFRA, 2023). There are 11 AURN monitoring sites in Wales. In addition, there are approximately 19 locally managed automatic monitoring stations (WAQF, 2023); in most cases these are managed by local authorities (LAs), but academia, industry and airports may also operate sites. Site selection considers distribution of pollutants, practical limitations (such as site availability, planning constraints, utilities and access), historical interest and political concerns. Sites selected typically involves a level of compromise. Air quality (AQ) data were obtained from 30 monitoring stations across Wales via the Wales Air Quality Network (WAQN) (Table 2). It is important to note that not all 30 stations were operational for the entirety of the study period. The data included hourly, daily mean and maximum PM_{10} ($\mu g/m^3$) levels for the study period. To assess the impact of BON on AQ, the daily mean and maximum PM_{10} levels were compared for the PRE-BON and BON night periods. The monitored data were also referenced against the Daily Air Quality Index (DAQI) which for PM_{10} categorises air quality data into four concentration bands, low (0-50 $\mu g/m^3$), moderate (51-75 $\mu g/m^3$), high (76-100 $\mu g/m^3$) and very high (over 101 $\mu g/m^3$)[1].

[1] What is the Daily Air Quality Index? - Defra, UK

Air Quality monitoring station	Health Board
Aston Hill	Betsi Cadwaladr
Anglesey Brynteg	Betsi Cadwaladr
Anglesey Felin Cafnan	Betsi Cadwaladr
Anglesey Llynfaes	Betsi Cadwaladr
Anglesey Penhesgyn 3	Betsi Cadwaladr
Wrexham	Betsi Cadwaladr
Wrexham Chirk	Betsi Cadwaladr
Narberth	Hywel Dda
Port Talbot Docks	Swansea Bay
Port Talbot Dyffryn School	Swansea Bay
Port Talbot Little Warren	Swansea Bay
Port Talbot Margam	Swansea Bay
Port Talbot Talbot Road	Swansea Bay
Port Talbot Theodore Road	Swansea Bay
Port Talbot Twll-yn-y-Wal Park	Swansea Bay
Swansea Roadside	Swansea Bay
Caerphilly Blackwood High St	Aneurin Bevan
Caerphilly Fochriw	Aneurin Bevan
Caerphilly Islwyn Road Wattsville	Aneurin Bevan
Caerphilly White Street	Aneurin Bevan
Cardiff Castle Street	Cardiff and Vale
Cardiff Centre	Cardiff and Vale
Cardiff Newport Road	Cardiff and Vale
Chepstow A48	Aneurin Bevan
Cwmbran	Aneurin Bevan
Cwmbran Crownbridge	Aneurin Bevan
Newport St Julians Comprehensive School	Aneurin Bevan
Rhondda Glyncoch Garth Avenue	Cwm Taf
Twynyrodyn	Cwm Taf
Bridgend Park Street	Cwm Taf

Table 2:Air quality monitoring stations across Wales from which data was obtained., 2017 -2022

Boxplots of the data were produced via the use of R studio's tidyverse package (Wickham *et al.* 2019). The graphs visualise the mean (horizontal black line), the interquartile range (boxes), the minimum and maximum values (vertical black line), and the outliers from the range (dots).

DAQI data

The Daily Air Quality Index (DAQI) provides information about the levels of air pollution. This information is dependent on pollutant concentrations averaged over specified periods. These averaging periods were defined by the Committee on the Medical Effects of Air Pollutants (COMEAP) based on epidemiology studies regarding the short-term impacts of air pollution (Met Office). The overall air pollution index for each day of the study period for North Wales and South Wales were obtained from UK Air (DEFRA) and averaged to give an overall score for the whole of Wales. DAQI categorises the air quality data into four pollution bandings, low (1-3), moderate (4-6), high (7-9) and very high (10).

Hospital admission data

Hospital admission data were obtained from Patient Episode Database for Wales (PEDW), maintained by Digital Health and Care Wales (DHCW). To quantify air pollution related health effects, we counted admissions with ICD-10 codes J00 to J99 (diseases of the respiratory system) and calculated the admission rates per 100,000 of the population. Rates of admission to hospital for all ages were calculated for BON and PRE-BON for each study year per 100,000 of the population.

Emergency Department attendance data

Emergency Department (ED) attendance data were obtained from Digital Health and Care Wales (DHCW). All attendances were analysed, with no disaggregation according to diagnosis. The total number of admissions and admission rates per 100,000 of the population were calculated. Rates of ED attendance were calculated for BON and PRE-BON for each study year per 100,000 of the population.

Welsh Ambulance Service call data

999 calls to the Welsh Ambulance Service (WAST) were analysed for incidents logged as “Breathing problems”. Call rates were calculated for BON and PRE-BON for each study year per 100,000 of the population.

111 call data

Calls were analysed for incidents logged as “Cough”, “Nasal”, “Sore Throat” and “Breathing”. Call rates per 100,000 of the population were calculated for BON and PRE-BON.

Results

Air Quality Data

Across 2017 to 2022, mean daily PM_{10} concentrations were low (<50 µg/m³, DAQI classification), including during the bonfire night period (Figure 1). The variation in the means is relatively small, at a national level. In one sense, this highlights the challenges with seeing substantial changes in an environmental incident, but in another, does not show how much variation there may be between different places.

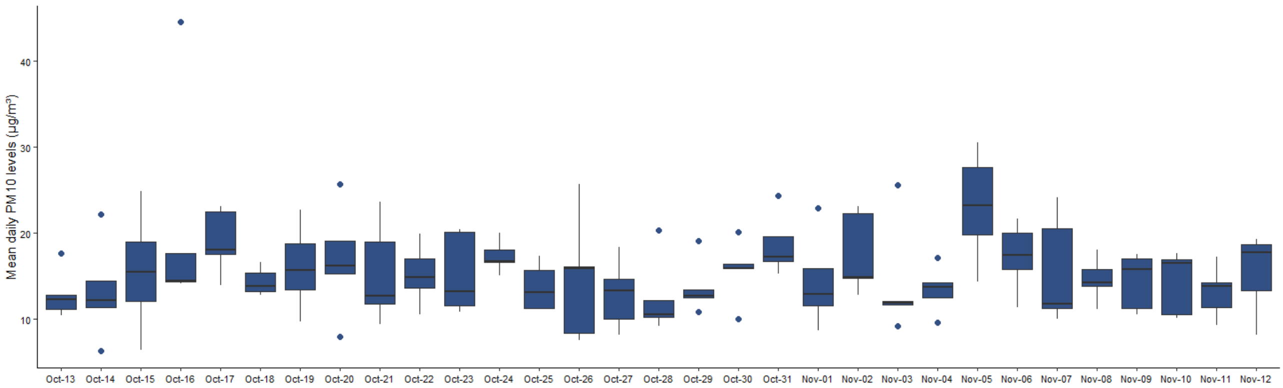


Figure 1. Mean daily PM_{10} levels (µg/m³) recorded at 19 sites in Wales between 13th October and 12th November each year between 2017 to 2022.

Across 2017 to 2022, mean DAQI values were low (1-3), which the exception of November 5th, where the average DAQI value was moderate (Figure 2).

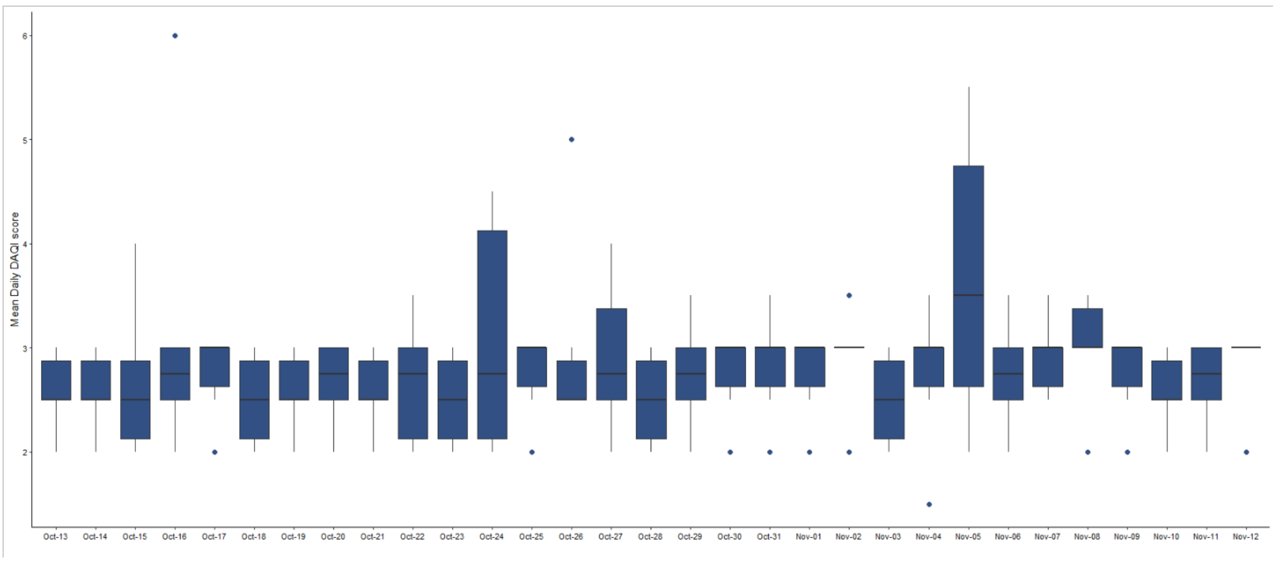


Figure 2. Mean daily DAQI scores across Wales between 13th October and 12th November each year between 2017 to 2022.

However, looking at the mean daily PM_{10} levels somewhat masks the effect of fireworks and bonfires and analysis of the maximum PM_{10} levels confirmed that the maximum levels occurred on 5th November, but with considerable variation across the 19 recording sites (Figure 3). Further analyses are needed, but incident based assessments may more usefully focus on maximum PM_{10} than means.

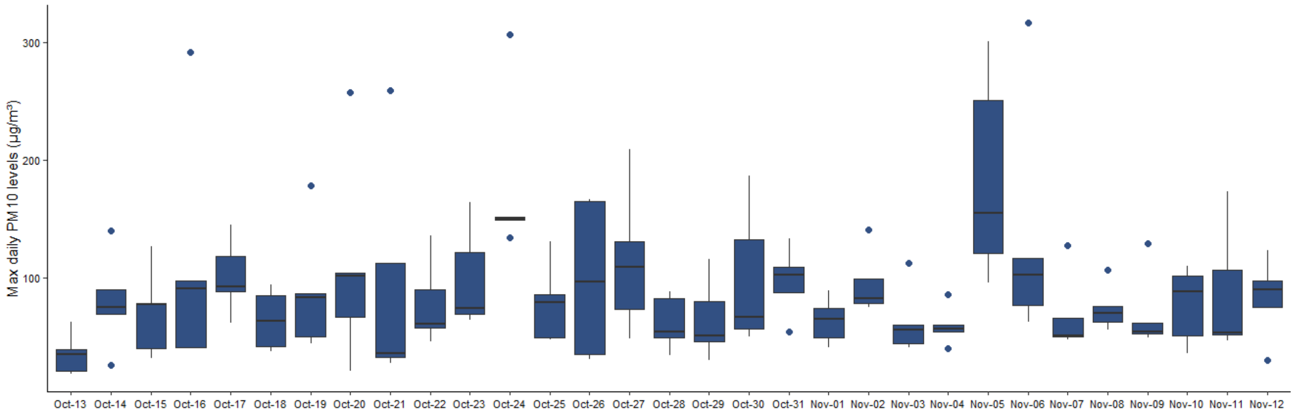


Figure 3. Maximum daily PM_{10} levels (µg/m³) recorded at 19 sites in Wales between 13th October and 12th November each year between 2017 to 2022.

When looking at November 5th in more detail, as expected PM_{10} levels peaked in the evening from 5pm onwards (Figure 4).

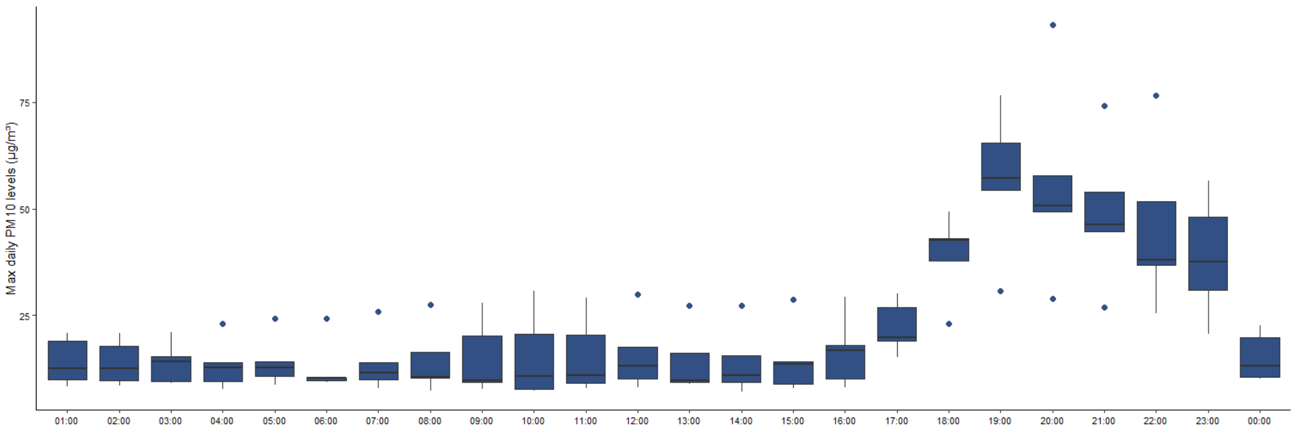


Figure 4. Hourly PM_{10} levels (µg/m³) recorded at 19 monitoring sites across Wales on 5th November 2017-2022.

Health effects

Hospital admission data

There is an increased rate of hospital admissions for respiratory conditions each year around BON, compared with PRE-BON, bar 2021 (Figure 5). Admission rates tend to be higher in men than women.

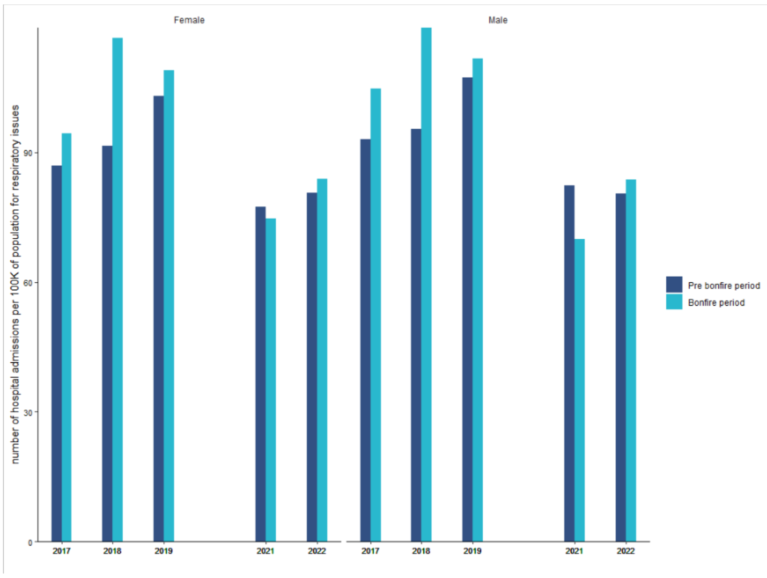


Figure 5: Rate of hospital admissions (per 100,000 population) during BON (light blue) and PRE-BON (dark blue) for the time period 2017 to 2022 for diseases of the respiratory system.

Emergency department attendance

Across all years, and all attendance types, there were fewer ED attendances during BON than PRE-BON (Figure 6). In both periods, male attendances were higher than female.

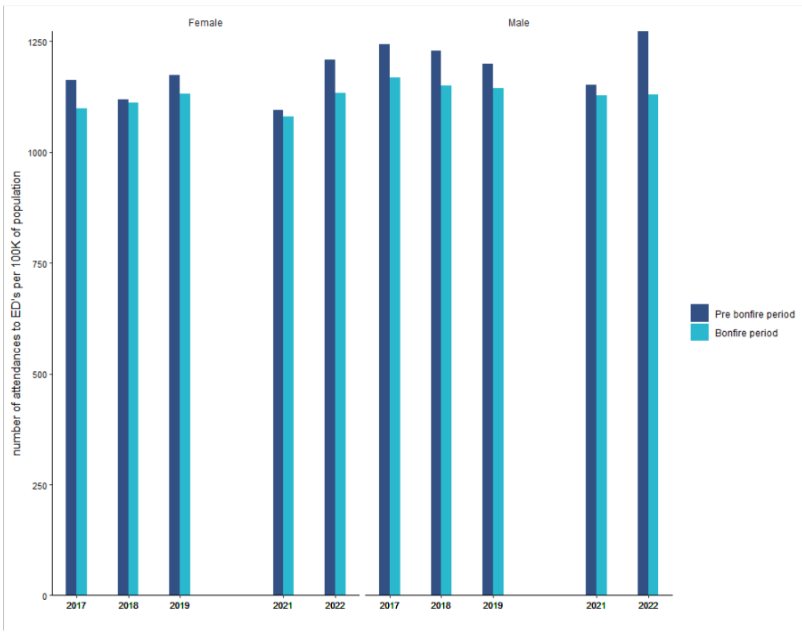


Figure 6: Rates (per 100,000 population) of attendances to emergency departments during BON (light blue) and PRE-BON (dark blue)

Welsh Ambulance 999 Call Data

More 999 calls were made to the Welsh ambulance service for breathing problems during BON in 2019 and 2022 (Figure 7).

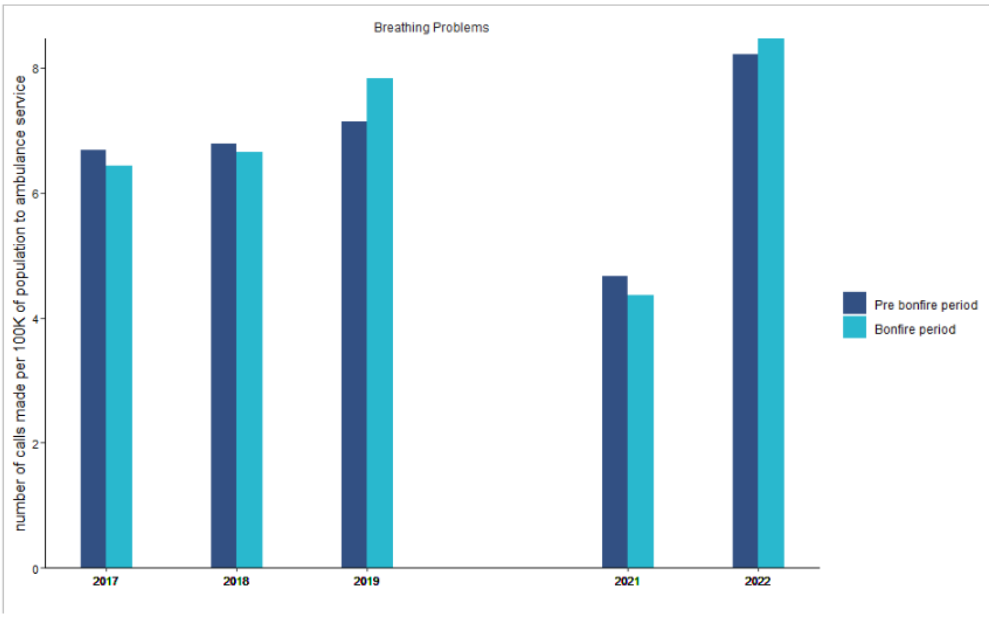


Figure 7: Number of calls and call rates (per 100,000 population) made to the Welsh Ambulance Service during BON (light blue) and PRE-BON (dark blue) for breathing problems for 2017 to 2022.

More 999 calls were for females than males for respiratory issues. Calls were not significantly different between BON and PRE-BON for both sexes (Figure 8). The full table of results is presented in the appendix (Appendix figure 1).

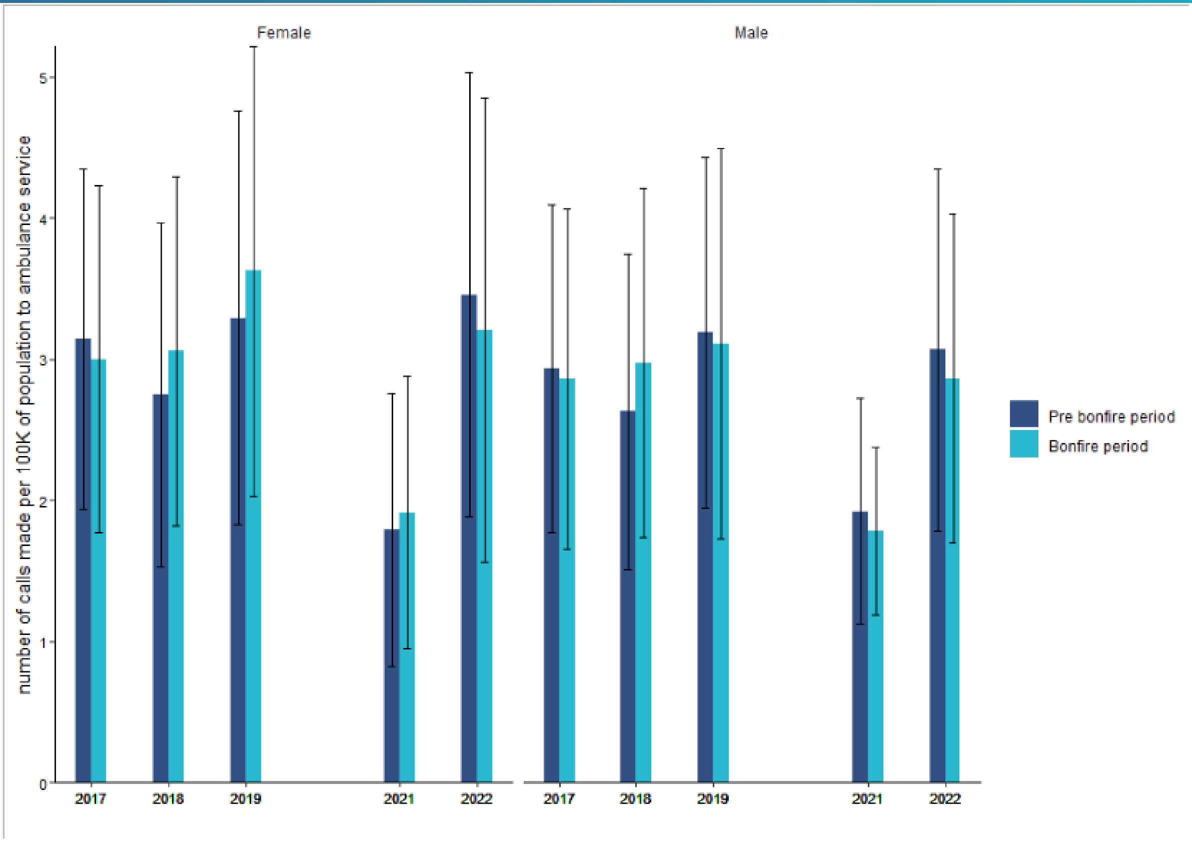
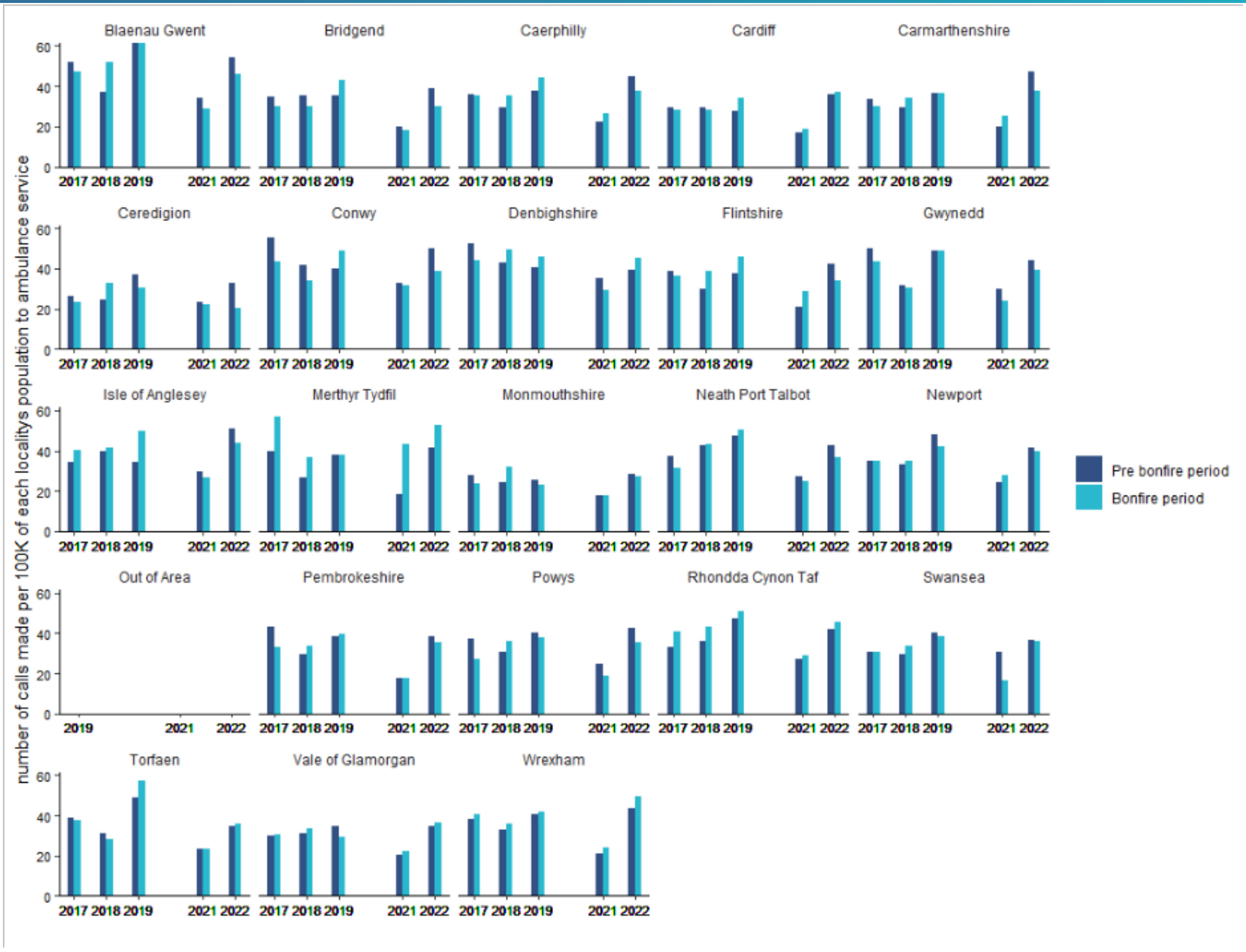


Figure 8: 999 call rates (per 100,000 population) during BON (light blue) and PRE-BON (dark blue) for breathing problems for 2017 to 2022 disaggregated by sex.

Area

Some areas consistently make more 999 calls during BON; namely Wrexham, Rhondda Cynon Taf and Merthyr Tydfil, with Cardiff also having a higher BON call rate for 2019 to 2021 (Figure 9). Whether this is indicative of poorer health in general being exacerbated by a pollution event, or for other reasons, is not clear.



<u>Figure 9: 999 call rate per 100,000 population during BON (light blue) and PRE-BON (dark blue) for breathing problems for 2017 to 2022.</u>

Deprivation fifth

999 call rates for people living in the most deprived quintile (quintile 1) for respiratory issues are higher than those in the least deprived quintile (quintile 5) each year (Figure 10), but there is no trend for BON v PRE-BON. The full table of results is presented in the appendix (Appendix figure 2). Patterns tend to reflect known variations in health with deprivation; what is not clear is whether bonfire night exacerbates health harms in the most deprived to a greater extent than the least deprived. There does appear to be a widening of call rates between the most and least deprived over time, but this is happening in the pre-bonfire as well as the bonfire period. Therefore, it suggests that other factors, possibly including COVID-19, may be influencing outcomes.

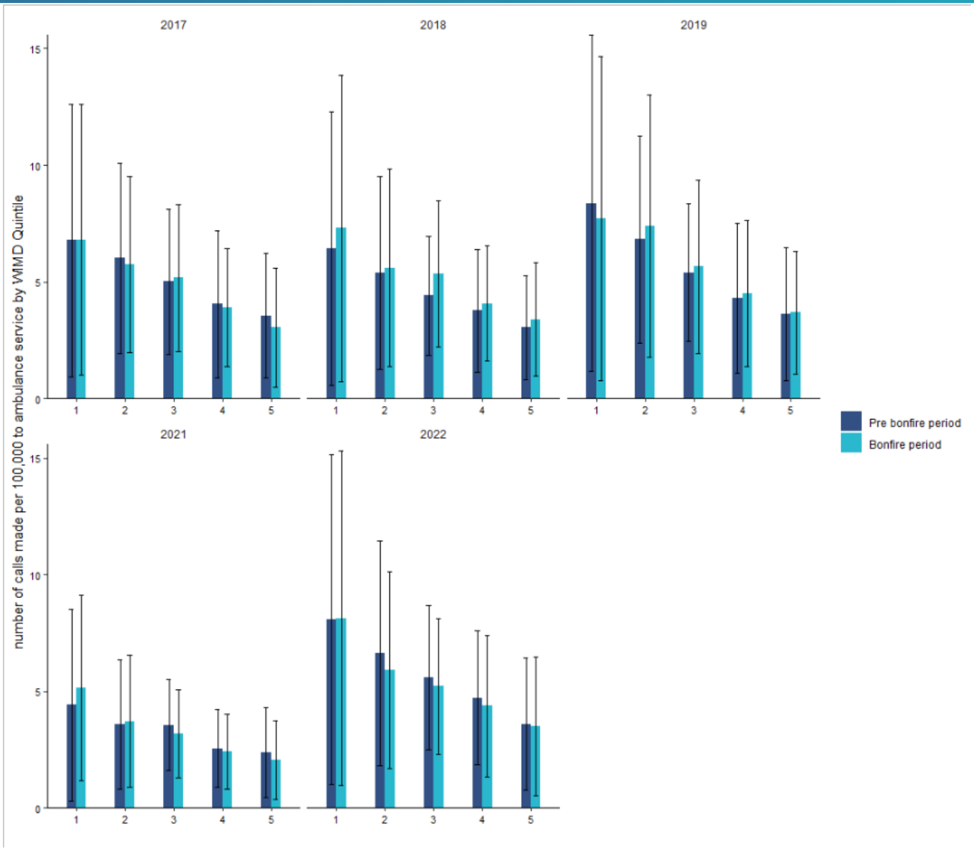


Figure 10: 999 call rates per 100,000 population by WIMD quintile during BON (light blue) and PRE-BON (dark blue) for breathing problems for 2017 to 2022.

Rurality

Generally, more 999 calls were by residents of urban areas compared with rural areas (Figure 11).

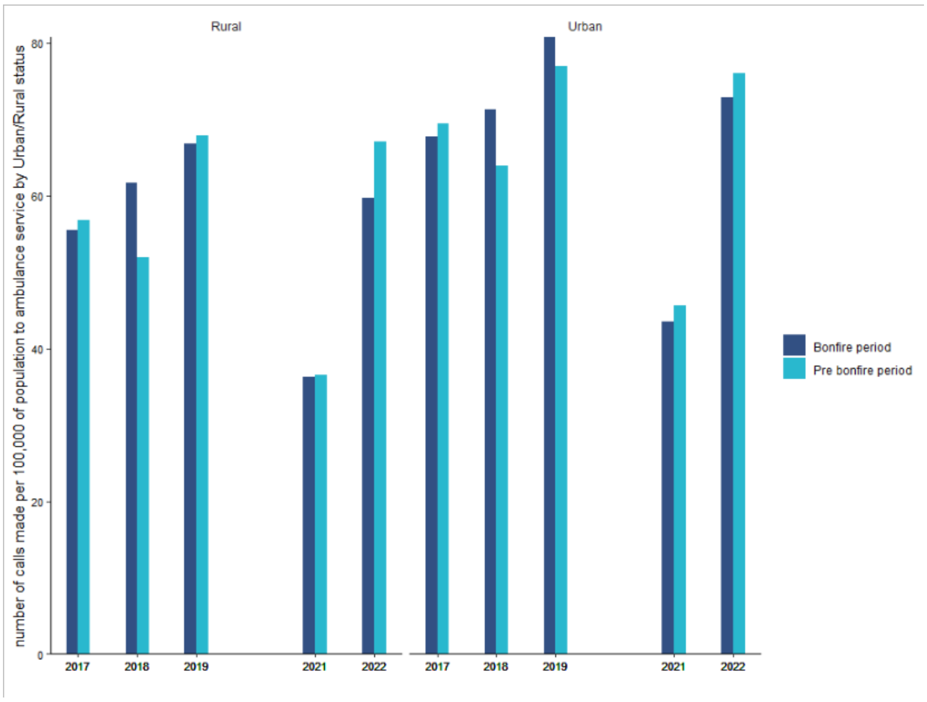


Figure 11: 999 call rates per 100,000 population by Urban/Rural status during BON (light blue) and PRE-BON (dark blue) for breathing problems for 2017 to 2022.

111 Call Data

There was no substantial difference in the call rates to 111 during BON and PRE-BON. More 111 calls were made for females than males (Figure 12).

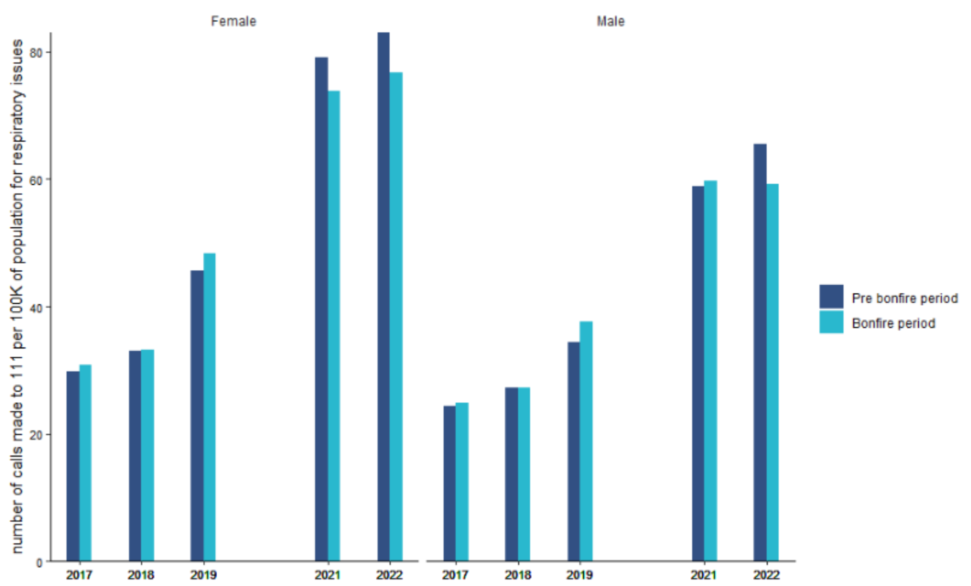


Figure 12: Call rates per 100,000 of the population to 111 during BON (light blue) and PRE-BON (dark blue) for breathing problems for 2017 to 2022.

Discussion

The current analysis sought to determine whether there is an adverse effect of Bonfire Night on air quality and health. In terms of air quality, we have seen that there is an increase in PM_{10} on and around the 5th November. However, across the health service measures, we only found a small, non-significant increase in acute health service demand for respiratory conditions when looking at hospital admissions. Given that Bonfire Night is the largest routine pollution event in the UK, this finding has implications for our ability to detect health harms associated with any other, usually much smaller, pollution event that occurs in Wales.

Although we were able to reliably quantify air pollution levels, comparisons between years should be made with caution. Bonfire Night falls on the 5th November, and therefore, each year it will fall on a different day of the week. This will have had a substantial effect on use of fireworks and lighting of bonfires and therefore subsequent air pollution. For example, on years where Bonfire Night has fallen on a weekday night, we have seen fireworks and bonfires on Bonfire Night itself, and the following weekend. This is supported by the air quality data, showing elevated concentrations on November 5th and in subsequent days. This creates difficulties with comparing air quality trends year on year. Furthermore, while fireworks and bonfires produce air pollution, the extent to which that pollution concentrates in the atmosphere is affected by weather conditions including temperature, wind and rain. Comparing these from year to year is difficult, further compounding the challenges of matching days noted above.

Geography may also affect the extent to which people experience the effects of pollution; people living in Rhondda Cynon Taf consistently made more 999 calls during the Bonfire Night period. This may be due to concentrations of pollutants tending to be greater in valleys than areas on higher ground and some weather conditions “trapping” pollutants.

Limitations

Based on the data available to us, there is no obvious effect of a significant, “planned” pollution event on health and health service demand. However, this may be due to the datasets analysed here. It is not possible to analyse the ED data in any more detail, namely by diagnosis, than all attendances. It is therefore impossible to determine if there is a change in ED attendance around Bonfire Night.

In terms of health outcomes we used a proxy measure of “health service demand”, defined as the incidence of air pollution related illness by measuring hospital admissions for respiratory issues, as well as 999 call data and 111 call data for breathing problems.

COVID-19 had significant effects on the cardio-respiratory health of the people of Wales and across the world. Data for 2020 were removed from the analyses, but it is not yet clear how the long-term effects of COVID have or have not affected cardio-respiratory health and health service use. Interpreting the more recent data from this study is therefore extremely difficult.

More detailed statistical analysis was considered, for example, calculations of rate ratios, and 95% Confidence Intervals, for female v male for each year for the pre-bonfire and bonfire periods, as well as pre-bonfire v bonfire for each year and for females and males. However, with the limited variations in the data set it was decided that this would be more useful in a subsequent analysis, ideally with more data and more detailed ED data.

How this study adds to our understanding

This study sought to determine the acute effects of a significant air pollution event on health. Cardio-respiratory disease is chronic with effects accumulating over long periods of time. A pollution event such as Bonfire Night may have chronic, rather than acute, effects that are not necessarily seen in a time frame that leads to the outcome being attributed to a specific event. Longer lasting celebrations such as Diwali have been more rigorously studied, with multiple studies establishing that the increased particulate concentrations due to firecrackers is directly associated with hospitalisation and mortality for respiratory and cardiovascular diseases and a decrease in people's lung function (Beig *et al.* 2013., Perrino *et al.* 2011., Prakash *et al.* 2019). These festivities have been found to be particularly damaging to the elder population and young children, and those with cardiovascular impairments (Singh *et al.* 2010).

It is important to consider that notifying individuals of air pollution events, or the adverse effects of events such as Bonfire Night on air quality could have an adverse effect on health and health services. Previous research has identified that in some contexts notifying people of air pollution events lead to an increase in ED attendances (Lyons et al. 2016). In the context of Bonfire Night, this could be particularly problematic given that EDs would potentially be facing winter pressures at this time. In Wales, peaks in admissions to ED departments have been apparent historically in November and March, with 3% to 5% increase in attendance, primarily driven by respiratory conditions (Azam *et al.* 2019). The data obtained here do not, however, tend to suggest an increase in health service demand; in fact, more to the contrary they almost suggest that where the pollution event is "expected", there is no change in demand for treatment. If this is the case, it has significant implications for if and how people are made aware of changes in pollution levels.

That admission rates are higher in men is difficult to interpret but may indicate further that there is a limited effect of pollution on acute health services demand. If such demand occurred, it would reasonably be expected to be across both sexes given that both men and women celebrate bonfire night. Analysing these data again alongside trends in infections will improve understanding further.

It is important in all studies with findings of this nature to re-emphasise that absence of evidence is not evidence of absence. In these datasets we have no evidence of effect on health services after an acute pollution event. That does not mean that other datasets, e.g. disaggregated ED data would also show no effect. It also does not mean that there is no effect on health. As noted above, cardio-respiratory disease is a chronic disease often characterised by acute exacerbations. Over time, sufferers become familiar with, and can manage better their "triggers" and symptoms. Those who suffer symptoms triggered by Bonfire Night may be able to manage these symptoms. It may also be the case that rather than an acute health services demand, this type of event triggers a chronic demand that varies from individual to individual.

Conclusion

The current analysis found that Bonfire Night leads to an increase in air pollution. However, for the reasons discussed above, determining whether this increase in pollution leads to any acute health service demands for respiratory conditions is challenging; these data show that there is no obvious, consistent increase in demand. However, the potential harm to human health from particles emitted by fireworks and bonfires is increasingly being recognised (Hickey et al. 2020).

Recommendations:

Specific recommendations arising from this report are:

Methods

1. Explore the use of different case definitions of air pollution related respiratory issues that is more capable of capturing incidence. This will help better determine the impact on people's health.
2. Consider whether a qualitative study / analysis might contribute to understanding of whether there is an increase in health service demand around Bonfire Night.
3. Consider whether it is possible to enhance these analyses with inclusion of weather data
4. Consider whether sub-group analyses might provide more of a "signal", for example, older people and children
5. Analyse these data in conjunction with respiratory infections data to determine whether that helps to improve understanding of the trends.

Data sources

6. Seek to obtain ED data that is good enough quality to analyse changes in cardio-respiratory attendances, possibly only from one large hospital in the first instance.
7. Seek to analyse prescribing data for seasonal trends; does "turnover" of reliever inhalers increase around Bonfire Night

Implications

8. Consider the implications of these findings for policy and practice, including field epidemiology during incident management and wildfires.

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Appendix:

Appendix table 1: 999 calls by sex

Year	Sex	Time period	Average call rate	Standard deviation	Standard error	Confidence interval
2017	Male	Pre bonfire period	2.93	1.32	0.59	1.16
2017	Female	Pre bonfire period	3.14	1.38	0.62	1.21
2018	Male	Pre bonfire period	2.63	1.38	0.57	1.11
2018	Female	Pre bonfire period	2.75	1.39	0.62	1.22
2019	Male	Pre bonfire period	3.19	1.42	0.64	1.24
2019	Female	Pre bonfire period	3.29	1.67	0.75	1.46
2021	Male	Pre bonfire period	1.92	0.91	0.41	0.80
2021	Female	Pre bonfire period	1.79	1.11	0.49	0.97
2022	Male	Pre bonfire period	3.07	1.46	0.65	1.28
2022	Female	Pre bonfire period	3.46	1.80	0.80	1.58

Year	Sex	Time period	Average call rate	Standard deviation	Standard error	Confidence interval
2017	Male	Bonfire period	2.86	1.37	0.61	1.20
2017	Female	Bonfire period	3.00	1.40	0.63	1.23
2018	Male	Bonfire period	2.97	1.41	0.63	1.24
2018	Female	Bonfire period	3.06	1.41	0.63	1.24
2019	Male	Bonfire period	3.11	1.58	0.71	1.38
2019	Female	Bonfire period	3.63	1.82	0.81	1.59
2021	Male	Bonfire period	1.78	0.68	0.30	0.59
2021	Female	Bonfire period	1.92	1.09	0.49	0.96
2022	Male	Bonfire period	2.86	1.33	0.59	1.16
2022	Female	Bonfire period	3.21	1.87	0.84	1.64

Appendix table 2: 999 calls by deprivation quintile

Year	Deprivation quintile	Time period	Average call rate	Standard deviation	Standard error	Confidence interval
2017	1	Pre bonfire period	6.77	6.67	2.98	5.84
2017	2	Pre bonfire period	6.02	4.66	2.08	4.08
2017	3	Pre bonfire period	5.00	3.64	1.58	3.10
2017	4	Pre bonfire period	4.05	3.60	1.61	3.15
2017	5	Pre bonfire period	3.55	3.04	1.36	2.66
2018	1	Pre bonfire period	6.41	6.69	2.99	5.86
2018	2	Pre bonfire period	5.39	4.71	2.11	4.13
2018	3	Pre bonfire period	4.40	2.90	1.30	2.54
2018	4	Pre bonfire period	3.77	2.30	1.34	2.63
2018	5	Pre bonfire period	3.04	2.54	1.14	2.23
2019	1	Pre bonfire period	8.37	8.24	3.68	7.22
2019	2	Pre bonfire period	6.81	5.07	2.27	4.45
2019	3	Pre bonfire period	5.40	3.36	1.50	2.95
2019	4	Pre bonfire period	4.30	3.67	1.64	3.22
2019	5	Pre bonfire period	3.63	3.25	1.45	2.85
2021	1	Pre bonfire period	4.43	4.69	2.10	4.11
2021	2	Pre bonfire period	3.59	3.15	1.41	2.76
2021	3	Pre bonfire period	3.57	2.22	0.99	1.94
2021	4	Pre bonfire period	2.56	1.90	0.85	1.67
2021	5	Pre bonfire period	2.39	2.21	0.99	1.94
2022	1	Pre bonfire period	8.09	8.07	3.61	7.07
2022	2	Pre bonfire period	6.64	5.50	2.46	4.82
2022	3	Pre bonfire period	5.59	3.54	1.58	3.10
2022	4	Pre bonfire period	4.72	3.27	1.46	2.87
2022	5	Pre bonfire period	3.60	3.23	1.44	2.83

Year	Deprivation quintile	Time period	Average call rate	Standard deviation	Standard error	Confidence interval
2017	1	Bonfire period	6.80	6.61	2.96	5.79
2017	2	Bonfire period	5.75	4.29	1.92	3.76
2017	3	Bonfire period	5.17	3.59	1.60	3.15
2017	4	Bonfire period	3.89	2.88	1.29	2.53
2017	5	Bonfire period	3.04	2.92	1.30	2.56
2018	1	Bonfire period	7.29	7.50	3.35	6.57
2018	2	Bonfire period	5.60	4.84	2.16	4.25
2018	3	Bonfire period	5.34	3.56	1.59	3.12
2018	4	Bonfire period	4.08	2.82	1.26	2.48
2018	5	Bonfire period	3.39	2.78	1.24	2.43
2019	1	Bonfire period	7.70	7.92	3.54	6.95
2019	2	Bonfire period	7.39	6.42	2.87	5.62
2019	3	Bonfire period	5.65	4.23	1.89	3.70
2019	4	Bonfire period	4.51	3.58	1.60	3.14
2019	5	Bonfire period	3.69	3.01	1.35	2.64
2021	1	Bonfire period	5.14	4.53	2.03	3.97
2021	2	Bonfire period	3.73	3.22	1.44	2.82
2021	3	Bonfire period	3.17	2.15	0.96	1.88
2021	4	Bonfire period	2.43	1.83	0.82	1.60
2021	5	Bonfire period	2.06	1.91	0.86	1.68
2022	1	Bonfire period	8.14	8.19	3.66	7.18
2022	2	Bonfire period	5.91	4.82	2.16	4.22
2022	3	Bonfire period	5.22	3.31	1.48	2.90
2022	4	Bonfire period	4.37	3.47	1.55	3.04
2022	5	Bonfire period	3.50	3.39	1.52	2.97