Hierarchical_2

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```r
library(tidyverse)
```

```
## -- Attaching core tidyverse packages ----------------------- tidyverse 2.0.0 --
## v dplyr     1.1.2     v readr     2.1.4
## v forcats   1.0.0     v stringr   1.5.0
## v ggplot2   3.4.2     v tibble    3.2.1
## v lubridate 1.9.2     v tidyr     1.3.0
## v purrr     1.0.1
## -- Conflicts ----------------------------------------- tidyverse_conflicts() --
## x dplyr::filter() masks stats::filter()
## x dplyr::lag()    masks stats::lag()
## i Use the conflicted package (<http://conflicted.r-lib.org/>) to force all conflicts to become errors
```

```r
library(fpp3)
```

```
## -- Attaching packages ---------------------------------------------- fpp3 0.5 --
## v tsibble     1.1.3     v fable       0.3.3
## v tsibbledata 0.4.1     v fabletools  0.3.3
## v feasts      0.3.1
## -- Conflicts ------------------------------------------------- fpp3_conflicts --
## x lubridate::date()    masks base::date()
## x dplyr::filter()      masks stats::filter()
## x tsibble::intersect() masks base::intersect()
## x tsibble::interval()  masks lubridate::interval()
## x dplyr::lag()         masks stats::lag()
## x tsibble::setdiff()   masks base::setdiff()
## x tsibble::union()     masks base::union()
```

```r
library(hts)
```

```
## Loading required package: forecast
## Registered S3 method overwritten by 'quantmod':
##   method             from
##   as.zoo.data.frame zoo
##
## Attaching package: 'forecast'
##
## The following object is masked from 'package:fabletools':
##
##     accuracy
```

```r
library(dplyr)
library(tidyr)

data <- read.csv("HLTH0037_ts_cleaned.csv")

data1 <- data %>%
  mutate(YearMonth = yearmonth(YearMonth)) %>%
  as_tsibble(index = YearMonth, key = c(Age_Code, Sex_ItemName_ENG, Hospital_Code, Hospital_ItemName_ENG

data1 <- data1 %>%
  mutate(Number = 1)
```
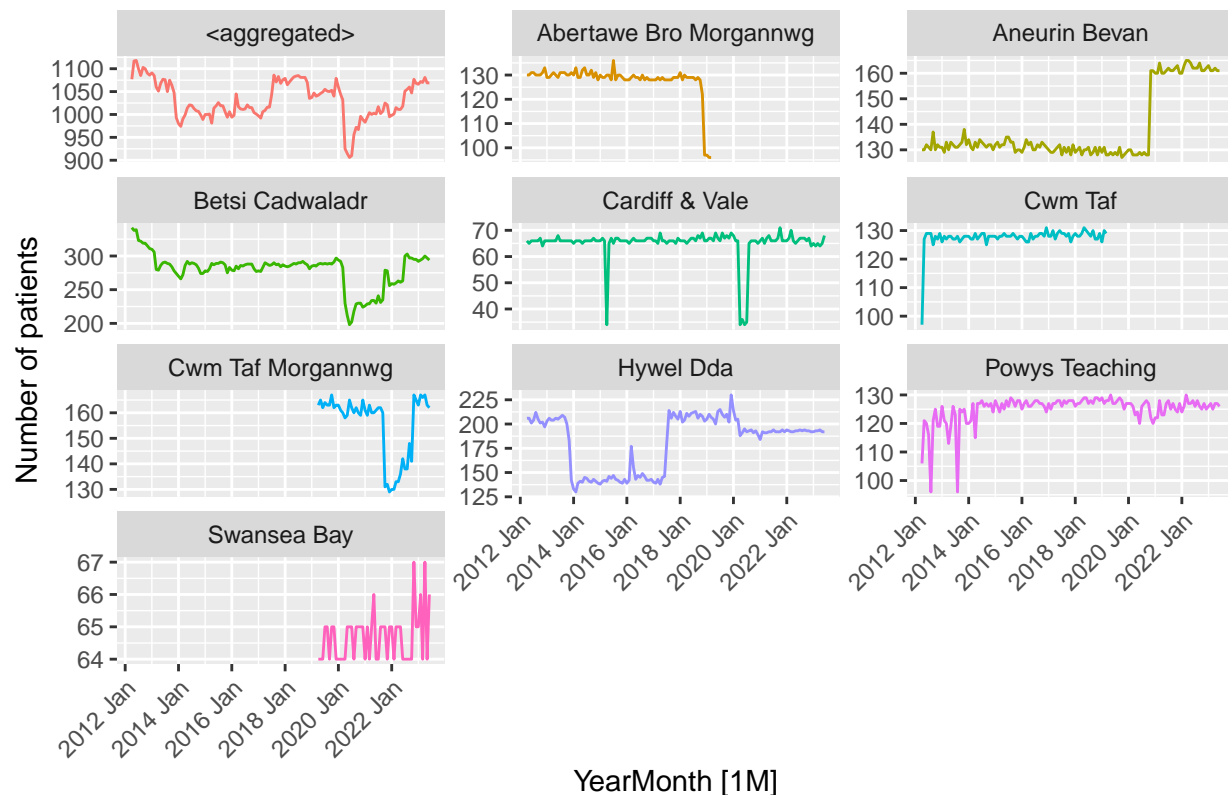
#Number of patients entering ED under different hospital hierarchy

```r
data1_hts <- data1 %>%
  aggregate_key(Organisation/Hospital_ItemName_ENG, Number = sum(Number))

data1_hts |>
  filter(is_aggregated(Hospital_ItemName_ENG)) |>
  autoplot(Number) +
  labs(y = "Number of patients",
       title = "Number of patients who enter ED") +
  facet_wrap(vars(Organisation), scales = "free_y", ncol = 3) +
  theme(legend.position = "none")+
  theme(axis.text.x = element_text(angle = 45, hjust = 1))
```

• A couple of Local Health Boards (LHBs) were redefined from the 1st of April 2019 onwards: Cwm Taf (27)–> Cwm Taf Morgannwg (30)// Abertawe Bro Morgannwg (26) –> Swansea Bay (31). Therefore, if you decide to forecast at LHB resolution, you might want to consider these 4 as a unique one. • A the Princess of Wales Hospital changed its Local Health Boards • So we analyse these 4 as one organisation

Group the changed Local Health Board together

```
data1_grouped <- data1 %>%
  mutate(Grouped_Organisation = case_when(
    Organisation %in% c("Cwm Taf", "Cwm Taf Morgannwg", "Abertawe Bro Morgannwg", "Swansea Bay") ~ "Grou
    TRUE ~ Organisation
  ))
```

There are 6 Local Health Boards

```
unique(data1_grouped$Grouped_Organisation)
```

```
## [1] "Betsi Cadwaladr"      "Hywel Dda"          "Grouped_organisation"
## [4] "Cardiff & Vale"       "Aneurin Bevan"      "Powys Teaching"
```

```
data2_hts <- data1_grouped %>%
  group_by(Grouped_Organisation) %>%
  summarise(Number = sum(Number))
```

Number of patients who enter ED under 6 different local health boards

```
data2_hts |>
  ggplot(aes(x = YearMonth, y = Number)) +
  geom_line(stat = "identity") +
  labs(y = "Number of patients",
       title = "Number of patients who enter ED") +
  facet_wrap(vars(Grouped_Organisation), scales = "free_y", ncol = 3) +
  theme(legend.position = "none") +
  theme(axis.text.x = element_text(angle = 45, hjust = 1))
```

Number of patients who enter ED
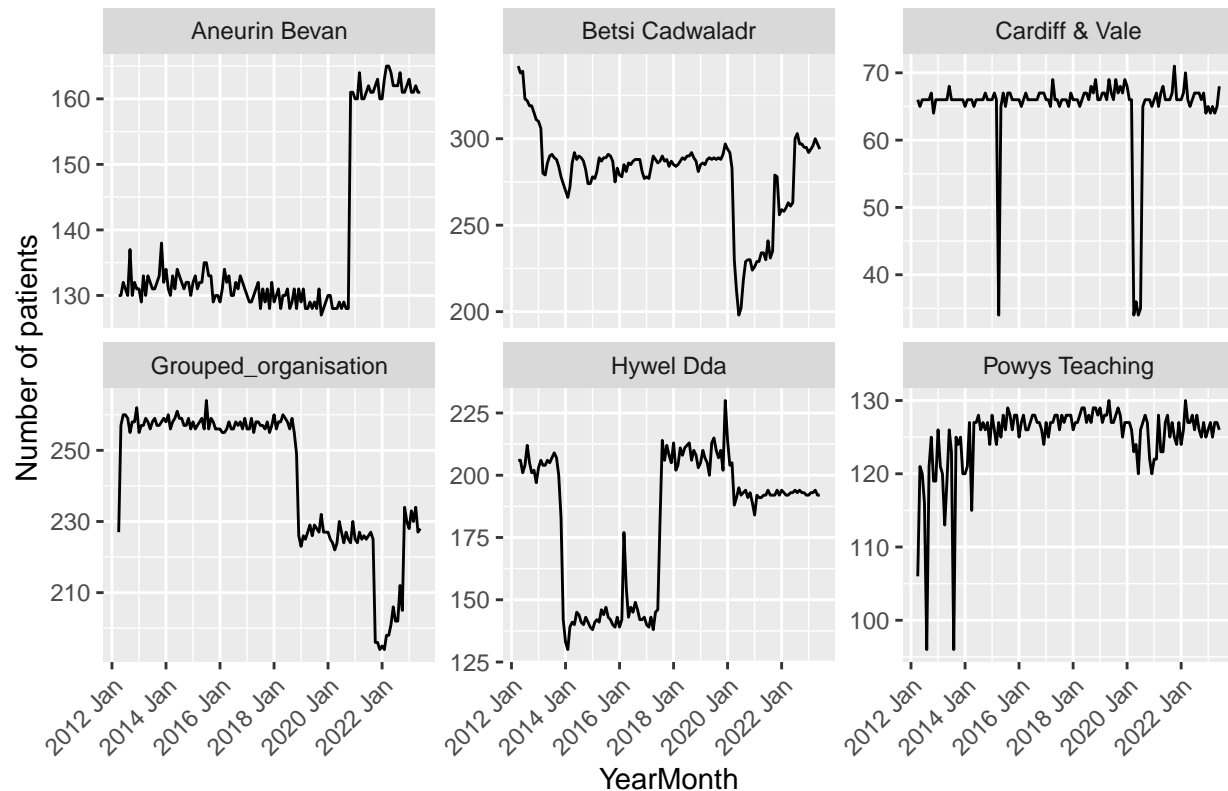
Change the Age_Code structure into different groups

```
unique(data1_grouped$Age_Code)
```

```
##  [1] "0 to 4"   "18 to 24" "25 to 29" "30 to 34" "35 to 39" "40 to 44"
##  [7] "45 to 49" "5 to 17"  "50 to 54" "55 to 59" "60 to 64" "65 to 69"
## [13] "70 to 74" "75 to 79" "80 to 84" "85"       "Unknown"
```

Age group: "0-4", "5-17", "18-69", "70^"

```
data1_grouped_age <- data1_grouped %>%
  filter(Age_Code != "Unknown") %>%
  mutate(Grouped_Age = case_when(
    Age_Code == "0 to 4" ~ "0-4",
    Age_Code == "5 to 17" ~ "5-17",
    Age_Code %in% c("18 to 24", "25 to 29", "30 to 34", "35 to 39",
                    "40 to 44", "45 to 49", "50 to 54", "55 to 59",
                    "60 to 64", "65 to 69") ~ "18-69",
    Age_Code %in% c("70 to 74", "75 to 79", "80 to 84", "85") ~ "70 and over",
    TRUE ~ "Other"
  ))
```

Plot Number of Patients in different age groups

```
data1_gts <- data1_grouped_age %>%
  filter(Sex_ItemName_ENG != "Not Specified or invalid") %>%
  group_by(Grouped_Age, Sex_ItemName_ENG) %>%
  summarize(Number = sum(Number, na.rm = TRUE))

ggplot(data1_gts, aes(x = Grouped_Age, y = Number)) +
  geom_bar(stat = "identity") +
  labs(y = "Number of patients") +
  theme(axis.text.x = element_text(angle = 45, hjust = 1)) +
  facet_wrap(~ Sex_ItemName_ENG, scales = "free")
```
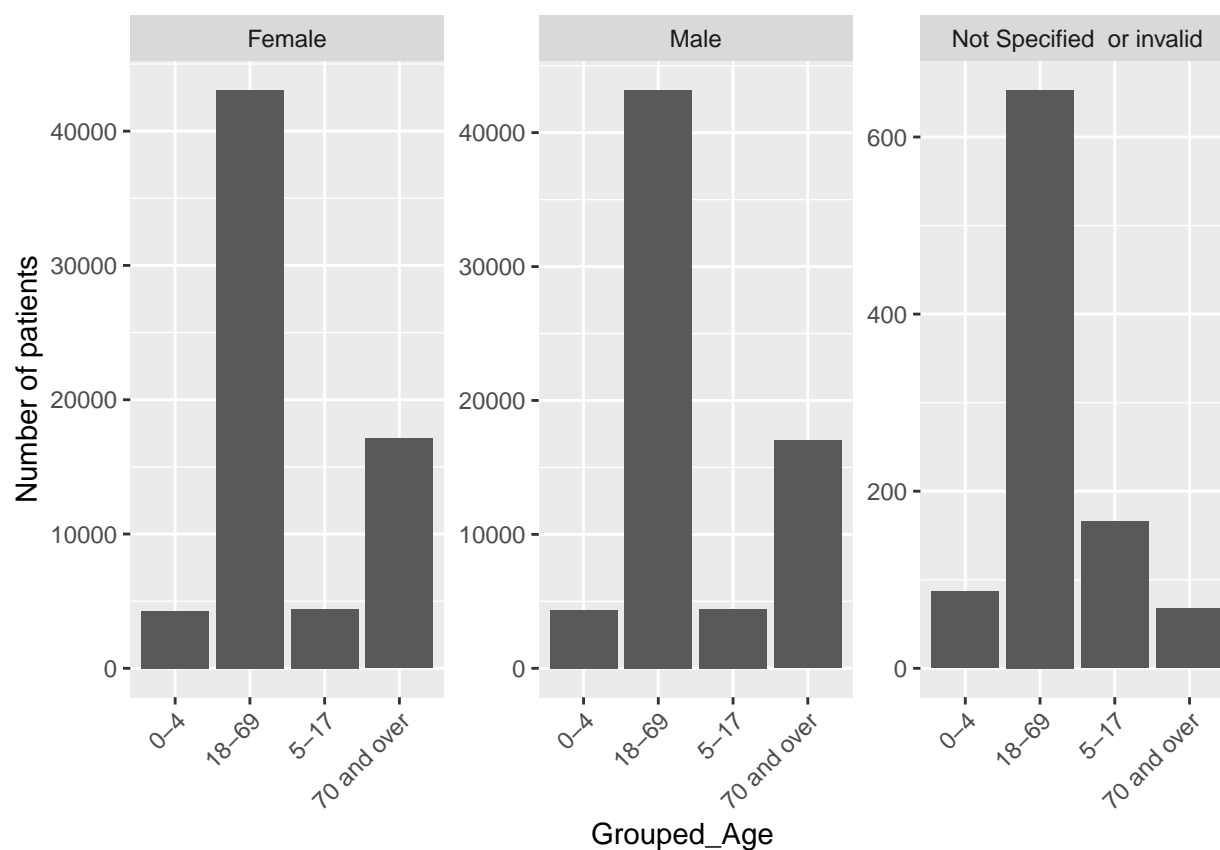

#Change the data into wide format

```
data2_wide <- data1_grouped %>%
  group_by(Grouped_Organisation) %>%
  index_by(YearMonth) %>%
  summarise(Number = sum(Number)) %>%
  pivot_wider(names_from = Grouped_Organisation, values_from = Number)
```

Forecast under Total (hierarchy 1) and Local Health Board (Hierarchy 2)

```r
# Create the hierarchical time series object
hts_data <- hts(data2_wide[,-1])  # exclude the YearMonth column
```

```
## Since argument characters are not specified, the default labelling system is used.
```

```r
# Forecast using the hierarchical model
forecasts_hts <- forecast(hts_data)

# Plot the forecasts
plot(forecasts_hts)
```

Level 0
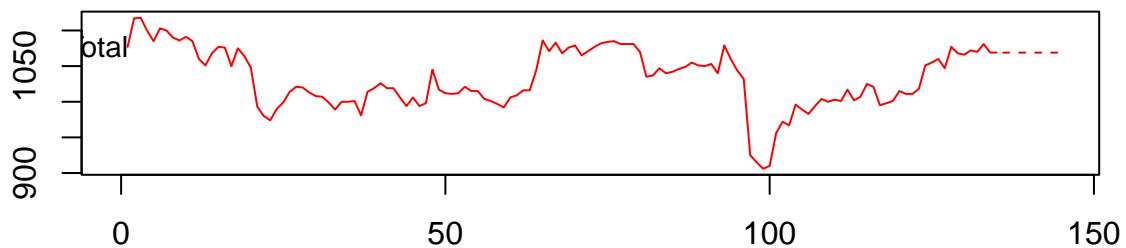
Level 1
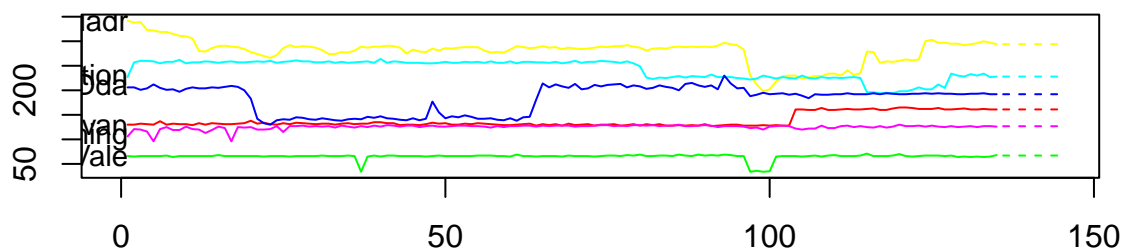

```r
# If you want to inspect the forecasts for the aggregated level:
aggregated_forecast <- forecasts_hts$allfcasts$Total

# If you want to inspect the forecasts for an individual health board, say "Aneurin Bevan":
aneurin_bevan_forecast <- forecasts_hts$allfcasts$`Aneurin Bevan`

str(forecasts_hts)
```

```
## List of 6
##  $ bts    : Time-Series [1:10, 1:6] from 136 to 145: 161 161 161 161 161 ...
##   ..- attr(*, "dimnames")=List of 2
##   .. ..$ : NULL
##   .. ..$ : chr [1:6] "Aneurin Bevan" "Betsi Cadwaladr" "Cardiff & Vale" "Grouped_organisation" ...
##  $ histy  : Time-Series [1:135, 1:6] from 1 to 135: 130 130 132 131 130 137 130 132 131 131 ...
##   ..- attr(*, "dimnames")=List of 2
##   .. ..$ : NULL
##   .. ..$ : chr [1:6] "Aneurin Bevan" "Betsi Cadwaladr" "Cardiff & Vale" "Grouped_organisation" ...
##  $ labels :List of 2
##   ..$ Level 0: chr "Total"
##   ..$ Level 1: chr [1:6] "Aneurin Bevan" "Betsi Cadwaladr" "Cardiff & Vale" "Grouped_organisation" .
##  $ method : chr "comb"
##  $ fmethod: chr "ets"
##  $ nodes  :List of 1
##   ..$ Level 1: int 6
##  - attr(*, "class")= chr [1:2] "hts" "gts"
```

- bts: This contains the forecasts for the different series.It's a time-series matrix.
- histy: This represents the historical data for the different series.
- labels: This list contains labels for the different levels in the hierarchy.
- method, fmethod: These are metadata about the forecasting process, indicating the method used for forecasting and combination.
- nodes: Information about the nodes at different levels in the hierarchy.

```r
# Required Libraries
library(zoo)
```

```
##
## Attaching package: 'zoo'
```

```
## The following object is masked from 'package:tsibble':
##
##     index
```

```
## The following objects are masked from 'package:base':
##
##     as.Date, as.Date.numeric
```

```r
library(ggplot2)
library(lubridate)
library(tsibble)

# Dates for Historical Data
start_date <- yearmonth("2012 Apr")
end_date <- yearmonth("2023 Jun")
hist_dates <- seq(as.Date(start_date), as.Date(end_date), by = "1 month") %>% yearmonth()

# Extract historical time series data from the hts object
historical_data <- zoo(forecasts_hts$histy, order.by = hist_dates)

# Adjusting the forecast start date
```

```r
forecast_start_date <- end_date + 1

# The rest of the code remains the same
forecast_dates <- seq(as.Date(forecast_start_date), by = "1 month", length.out = 10) %>% yearmonth()

# Extract forecast data from the hts object
forecast_data <- zoo(forecasts_hts$bts, order.by = forecast_dates)

# Combine historical and forecast data for plotting
combined_data <- rbind(historical_data, forecast_data)

# Convert the combined data to a long data frame for ggplot
df <- as.data.frame(fortify(combined_data, melt = TRUE))
names(df) <- c("Date", "Health_Board", "Number")

# Plot
ggplot(df, aes(x = Date, y = Number, color = Health_Board)) +
  geom_line() +
  labs(title = "Hierarchical Time Series Forecast",
       x = "YearMonth",
       y = "Number",
       color = "Health Board") +
  theme_minimal()
```
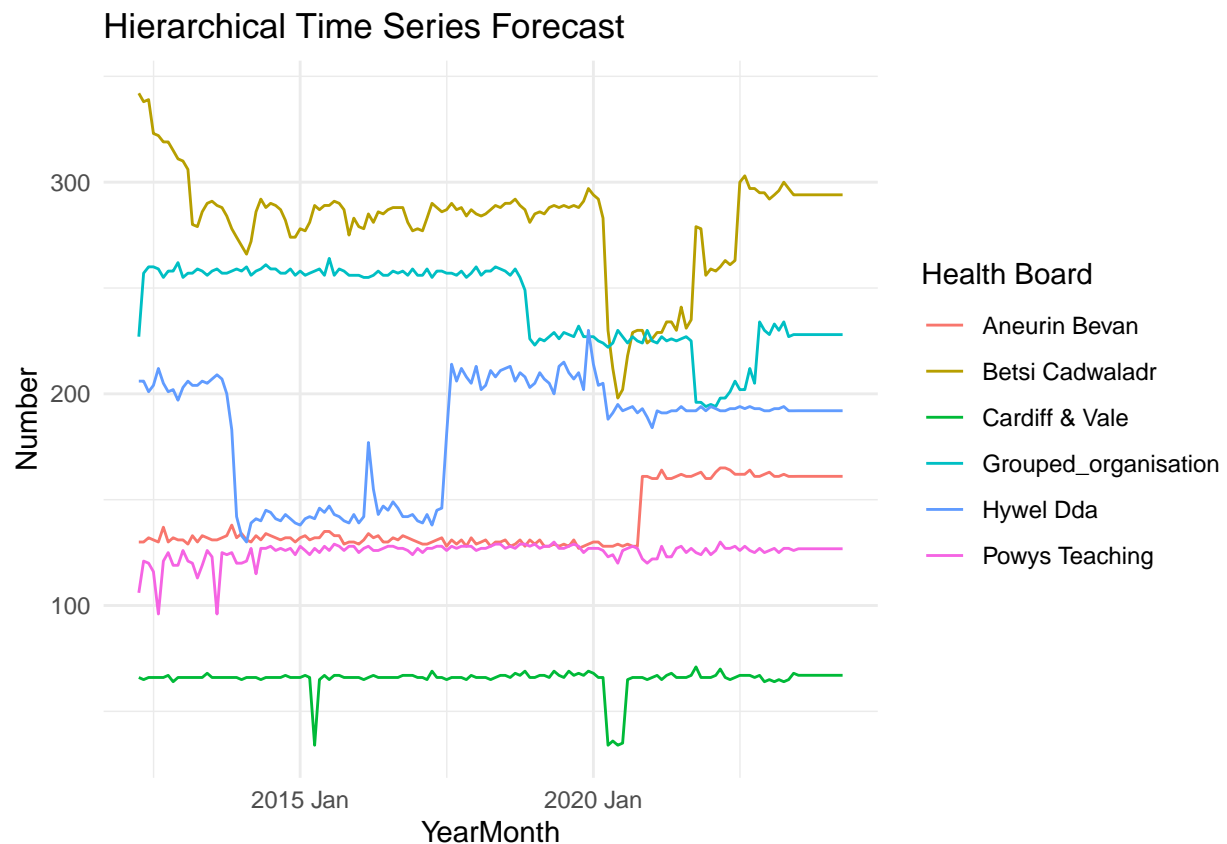
```r
print(combined_data)
```

```
##          Aneurin Bevan Betsi Cadwaladr Cardiff & Vale Grouped_organisation
## 2012 Apr      130.0000        342.0000       66.00000             227.0000
## 2012 May      130.0000        338.0000       65.00000             257.0000
## 2012 Jun      132.0000        339.0000       66.00000             260.0000
## 2012 Jul      131.0000        323.0000       66.00000             260.0000
## 2012 Aug      130.0000        322.0000       66.00000             259.0000
## 2012 Sep      137.0000        319.0000       66.00000             255.0000
## 2012 Oct      130.0000        319.0000       67.00000             258.0000
## 2012 Nov      132.0000        315.0000       64.00000             258.0000
## 2012 Dec      131.0000        311.0000       66.00000             262.0000
## 2013 Jan      131.0000        310.0000       66.00000             255.0000
## 2013 Feb      129.0000        306.0000       66.00000             257.0000
## 2013 Mar      133.0000        280.0000       66.00000             257.0000
## 2013 Apr      130.0000        279.0000       66.00000             259.0000
## 2013 May      133.0000        286.0000       66.00000             258.0000
## 2013 Jun      132.0000        290.0000       68.00000             256.0000
## 2013 Jul      131.0000        291.0000       66.00000             258.0000
## 2013 Aug      131.0000        289.0000       66.00000             259.0000
## 2013 Sep      132.0000        288.0000       66.00000             257.0000
## 2013 Oct      133.0000        284.0000       66.00000             257.0000
## 2013 Nov      138.0000        278.0000       66.00000             258.0000
## 2013 Dec      132.0000        274.0000       66.00000             259.0000
## 2014 Jan      134.0000        270.0000       65.00000             258.0000
## 2014 Feb      131.0000        266.0000       66.00000             260.0000
## 2014 Mar      130.0000        272.0000       66.00000             256.0000
## 2014 Apr      133.0000        286.0000       66.00000             258.0000
## 2014 May      131.0000        292.0000       65.00000             259.0000
## 2014 Jun      134.0000        288.0000       66.00000             261.0000
## 2014 Jul      133.0000        290.0000       66.00000             259.0000
## 2014 Aug      132.0000        289.0000       66.00000             259.0000
## 2014 Sep      131.0000        287.0000       66.00000             257.0000
## 2014 Oct      132.0000        282.0000       67.00000             257.0000
## 2014 Nov      132.0000        274.0000       66.00000             259.0000
## 2014 Dec      130.0000        274.0000       66.00000             256.0000
## 2015 Jan      132.0000        278.0000       66.00000             258.0000
## 2015 Feb      133.0000        277.0000       67.00000             256.0000
## 2015 Mar      131.0000        281.0000       66.00000             257.0000
## 2015 Apr      132.0000        289.0000       34.00000             258.0000
## 2015 May      132.0000        287.0000       65.00000             259.0000
## 2015 Jun      135.0000        289.0000       67.00000             256.0000
## 2015 Jul      135.0000        289.0000       65.00000             264.0000
## 2015 Aug      133.0000        291.0000       67.00000             256.0000
## 2015 Sep      133.0000        290.0000       67.00000             259.0000
## 2015 Oct      129.0000        287.0000       66.00000             258.0000
## 2015 Nov      130.0000        275.0000       66.00000             256.0000
## 2015 Dec      130.0000        283.0000       66.00000             256.0000
## 2016 Jan      129.0000        279.0000       66.00000             256.0000
## 2016 Feb      131.0000        278.0000       65.00000             255.0000
## 2016 Mar      134.0000        285.0000       66.00000             255.0000
## 2016 Apr      132.0000        281.0000       67.00000             256.0000
## 2016 May      133.0000        286.0000       66.00000             258.0000
```

```
## 2016 Jun      130.0000      285.0000      66.00000      256.0000
## 2016 Jul      130.0000      287.0000      66.00000      256.0000
## 2016 Aug      132.0000      288.0000      66.00000      258.0000
## 2016 Sep      131.0000      288.0000      66.00000      257.0000
## 2016 Oct      133.0000      288.0000      67.00000      258.0000
## 2016 Nov      132.0000      281.0000      67.00000      256.0000
## 2016 Dec      131.0000      277.0000      67.00000      259.0000
## 2017 Jan      130.0000      278.0000      66.00000      256.0000
## 2017 Feb      129.0000      277.0000      66.00000      256.0000
## 2017 Mar      129.0000      283.0000      65.00000      259.0000
## 2017 Apr      130.0000      290.0000      69.00000      255.0000
## 2017 May      131.0000      288.0000      66.00000      258.0000
## 2017 Jun      132.0000      286.0000      66.00000      258.0000
## 2017 Jul      128.0000      287.0000      65.00000      257.0000
## 2017 Aug      131.0000      290.0000      66.00000      257.0000
## 2017 Sep      129.0000      287.0000      66.00000      256.0000
## 2017 Oct      131.0000      288.0000      66.00000      258.0000
## 2017 Nov      128.0000      284.0000      65.00000      255.0000
## 2017 Dec      132.0000      287.0000      67.00000      257.0000
## 2018 Jan      129.0000      285.0000      66.00000      260.0000
## 2018 Feb      130.0000      284.0000      66.00000      256.0000
## 2018 Mar      131.0000      285.0000      66.00000      258.0000
## 2018 Apr      128.0000      287.0000      65.00000      258.0000
## 2018 May      130.0000      289.0000      66.00000      260.0000
## 2018 Jun      130.0000      288.0000      67.00000      259.0000
## 2018 Jul      131.0000      290.0000      67.00000      258.0000
## 2018 Aug      128.0000      290.0000      66.00000      256.0000
## 2018 Sep      129.0000      292.0000      68.00000      259.0000
## 2018 Oct      131.0000      289.0000      67.00000      255.0000
## 2018 Nov      128.0000      287.0000      69.00000      249.0000
## 2018 Dec      131.0000      281.0000      66.00000      226.0000
## 2019 Jan      129.0000      285.0000      66.00000      223.0000
## 2019 Feb      131.0000      286.0000      67.00000      226.0000
## 2019 Mar      128.0000      285.0000      67.00000      225.0000
## 2019 Apr      128.0000      288.0000      66.00000      227.0000
## 2019 May      129.0000      289.0000      69.00000      229.0000
## 2019 Jun      128.0000      288.0000      67.00000      226.0000
## 2019 Jul      129.0000      289.0000      66.00000      229.0000
## 2019 Aug      128.0000      288.0000      69.00000      228.0000
## 2019 Sep      131.0000      289.0000      67.00000      227.0000
## 2019 Oct      127.0000      288.0000      68.00000      232.0000
## 2019 Nov      128.0000      291.0000      67.00000      227.0000
## 2019 Dec      129.0000      297.0000      69.00000      227.0000
## 2020 Jan      130.0000      294.0000      68.00000      227.0000
## 2020 Feb      130.0000      292.0000      66.00000      225.0000
## 2020 Mar      128.0000      283.0000      66.00000      224.0000
## 2020 Apr      128.0000      230.0000      34.00000      222.0000
## 2020 May      128.0000      212.0000      36.00000      224.0000
## 2020 Jun      129.0000      198.0000      34.00000      230.0000
## 2020 Jul      128.0000      202.0000      35.00000      227.0000
## 2020 Aug      129.0000      218.0000      65.00000      224.0000
## 2020 Sep      128.0000      229.0000      66.00000      227.0000
## 2020 Oct      128.0000      230.0000      66.00000      225.0000
## 2020 Nov      161.0000      230.0000      66.00000      224.0000
```

```
## 2020 Dec      161.0000       224.0000    65.00000          230.0000
## 2021 Jan      160.0000       226.0000    66.00000          225.0000
## 2021 Feb      160.0000       229.0000    67.00000          224.0000
## 2021 Mar      164.0000       229.0000    65.00000          227.0000
## 2021 Apr      160.0000       234.0000    67.00000          225.0000
## 2021 May      160.0000       234.0000    68.00000          226.0000
## 2021 Jun      161.0000       230.0000    66.00000          225.0000
## 2021 Jul      162.0000       241.0000    66.00000          226.0000
## 2021 Aug      161.0000       231.0000    66.00000          227.0000
## 2021 Sep      161.0000       235.0000    67.00000          225.0000
## 2021 Oct      162.0000       279.0000    71.00000          196.0000
## 2021 Nov      163.0000       278.0000    66.00000          196.0000
## 2021 Dec      160.0000       256.0000    66.00000          194.0000
## 2022 Jan      160.0000       259.0000    66.00000          195.0000
## 2022 Feb      163.0000       258.0000    67.00000          194.0000
## 2022 Mar      165.0000       260.0000    70.00000          198.0000
## 2022 Apr      165.0000       263.0000    66.00000          198.0000
## 2022 May      164.0000       261.0000    65.00000          201.0000
## 2022 Jun      162.0000       263.0000    66.00000          206.0000
## 2022 Jul      162.0000       300.0000    67.00000          202.0000
## 2022 Aug      162.0000       303.0000    67.00000          202.0000
## 2022 Sep      164.0000       297.0000    67.00000          212.0000
## 2022 Oct      161.0000       297.0000    66.00000          205.0000
## 2022 Nov      161.0000       295.0000    67.00000          234.0000
## 2022 Dec      162.0000       295.0000    64.00000          230.0000
## 2023 Jan      163.0000       292.0000    65.00000          228.0000
## 2023 Feb      161.0000       294.0000    64.00000          233.0000
## 2023 Mar      161.0000       296.0000    65.00000          230.0000
## 2023 Apr      162.0000       300.0000    64.00000          234.0000
## 2023 May      161.0000       297.0000    65.00000          227.0000
## 2023 Jun      161.0000       294.0000    68.00000          228.0000
## 2023 Jul      161.0338       294.0219    67.03731          227.9861
## 2023 Aug      161.0338       294.0220    67.03735          227.9861
## 2023 Sep      161.0338       294.0221    67.03738          227.9861
## 2023 Oct      161.0338       294.0222    67.03742          227.9862
## 2023 Nov      161.0338       294.0223    67.03745          227.9862
## 2023 Dec      161.0338       294.0223    67.03748          227.9862
## 2024 Jan      161.0339       294.0224    67.03751          227.9863
## 2024 Feb      161.0339       294.0225    67.03754          227.9863
## 2024 Mar      161.0339       294.0226    67.03756          227.9863
## 2024 Apr      161.0339       294.0226    67.03759          227.9864
##            Hywel Dda Powys Teaching
## 2012 Apr  206.0000       106.0000
## 2012 May  206.0000       121.0000
## 2012 Jun  201.0000       120.0000
## 2012 Jul  204.0000       116.0000
## 2012 Aug  212.0000        96.0000
## 2012 Sep  205.0000       121.0000
## 2012 Oct  201.0000       125.0000
## 2012 Nov  202.0000       119.0000
## 2012 Dec  197.0000       119.0000
## 2013 Jan  203.0000       126.0000
## 2013 Feb  206.0000       121.0000
## 2013 Mar  204.0000       120.0000
```

```
## 2013 Apr  204.0000         113.0000
## 2013 May  206.0000         119.0000
## 2013 Jun  205.0000         126.0000
## 2013 Jul  207.0000         123.0000
## 2013 Aug  209.0000          96.0000
## 2013 Sep  207.0000         125.0000
## 2013 Oct  200.0000         124.0000
## 2013 Nov  183.0000         125.0000
## 2013 Dec  142.0000         120.0000
## 2014 Jan  133.0000         120.0000
## 2014 Feb  130.0000         121.0000
## 2014 Mar  139.0000         127.0000
## 2014 Apr  141.0000         115.0000
## 2014 May  140.0000         127.0000
## 2014 Jun  145.0000         127.0000
## 2014 Jul  144.0000         128.0000
## 2014 Aug  141.0000         126.0000
## 2014 Sep  140.0000         127.0000
## 2014 Oct  143.0000         126.0000
## 2014 Nov  141.0000         127.0000
## 2014 Dec  139.0000         124.0000
## 2015 Jan  138.0000         128.0000
## 2015 Feb  141.0000         126.0000
## 2015 Mar  142.0000         124.0000
## 2015 Apr  141.0000         127.0000
## 2015 May  146.0000         125.0000
## 2015 Jun  144.0000         128.0000
## 2015 Jul  147.0000         126.0000
## 2015 Aug  143.0000         129.0000
## 2015 Sep  142.0000         128.0000
## 2015 Oct  140.0000         126.0000
## 2015 Nov  139.0000         128.0000
## 2015 Dec  143.0000         128.0000
## 2016 Jan  139.0000         125.0000
## 2016 Feb  142.0000         127.0000
## 2016 Mar  177.0000         128.0000
## 2016 Apr  155.0000         126.0000
## 2016 May  143.0000         126.0000
## 2016 Jun  147.0000         127.0000
## 2016 Jul  145.0000         128.0000
## 2016 Aug  149.0000         128.0000
## 2016 Sep  146.0000         127.0000
## 2016 Oct  142.0000         127.0000
## 2016 Nov  142.0000         126.0000
## 2016 Dec  143.0000         124.0000
## 2017 Jan  140.0000         127.0000
## 2017 Feb  139.0000         125.0000
## 2017 Mar  143.0000         127.0000
## 2017 Apr  138.0000         127.0000
## 2017 May  145.0000         128.0000
## 2017 Jun  146.0000         128.0000
## 2017 Jul  181.0000         126.0000
## 2017 Aug  214.0000         128.0000
## 2017 Sep  206.0000         127.0000
```

```
## 2017 Oct  212.0000        128.0000
## 2017 Nov  208.0000        128.0000
## 2017 Dec  205.0000        128.0000
## 2018 Jan  213.0000        126.0000
## 2018 Feb  202.0000        127.0000
## 2018 Mar  204.0000        127.0000
## 2018 Apr  211.0000        128.0000
## 2018 May  208.0000        129.0000
## 2018 Jun  211.0000        129.0000
## 2018 Jul  212.0000        127.0000
## 2018 Aug  213.0000        128.0000
## 2018 Sep  206.0000        127.0000
## 2018 Oct  210.0000        129.0000
## 2018 Nov  208.0000        129.0000
## 2018 Dec  203.0000        128.0000
## 2019 Jan  205.0000        129.0000
## 2019 Feb  210.0000        127.0000
## 2019 Mar  207.0000        128.0000
## 2019 Apr  205.0000        128.0000
## 2019 May  200.0000        130.0000
## 2019 Jun  213.0000        127.0000
## 2019 Jul  215.0000        127.0000
## 2019 Aug  210.0000        128.0000
## 2019 Sep  207.0000        129.0000
## 2019 Oct  210.0000        128.0000
## 2019 Nov  202.0000        125.0000
## 2019 Dec  230.0000        127.0000
## 2020 Jan  214.0000        127.0000
## 2020 Feb  204.0000        127.0000
## 2020 Mar  205.0000        126.0000
## 2020 Apr  188.0000        123.0000
## 2020 May  191.0000        124.0000
## 2020 Jun  195.0000        120.0000
## 2020 Jul  192.0000        126.0000
## 2020 Aug  193.0000        127.0000
## 2020 Sep  194.0000        128.0000
## 2020 Oct  191.0000        127.0000
## 2020 Nov  193.0000        122.0000
## 2020 Dec  189.0000        120.0000
## 2021 Jan  184.0000        122.0000
## 2021 Feb  192.0000        122.0000
## 2021 Mar  191.0000        128.0000
## 2021 Apr  191.0000        123.0000
## 2021 May  192.0000        123.0000
## 2021 Jun  192.0000        127.0000
## 2021 Jul  194.0000        128.0000
## 2021 Aug  192.0000        125.0000
## 2021 Sep  192.0000        127.0000
## 2021 Oct  192.0000        125.0000
## 2021 Nov  194.0000        124.0000
## 2021 Dec  192.0000        127.0000
## 2022 Jan  194.0000        124.0000
## 2022 Feb  193.0000        126.0000
## 2022 Mar  192.0000        130.0000
```

```
## 2022 Apr  192.0000      127.0000
## 2022 May  193.0000      127.0000
## 2022 Jun  193.0000      128.0000
## 2022 Jul  194.0000      126.0000
## 2022 Aug  193.0000      128.0000
## 2022 Sep  194.0000      126.0000
## 2022 Oct  193.0000      125.0000
## 2022 Nov  193.0000      127.0000
## 2022 Dec  192.0000      125.0000
## 2023 Jan  192.0000      126.0000
## 2023 Feb  193.0000      127.0000
## 2023 Mar  193.0000      125.0000
## 2023 Apr  194.0000      127.0000
## 2023 May  192.0000      127.0000
## 2023 Jun  192.0000      126.0000
## 2023 Jul  192.0194      126.8134
## 2023 Aug  192.0195      126.8126
## 2023 Sep  192.0196      126.8120
## 2023 Oct  192.0197      126.8113
## 2023 Nov  192.0198      126.8107
## 2023 Dec  192.0199      126.8101
## 2024 Jan  192.0199      126.8096
## 2024 Feb  192.0200      126.8091
## 2024 Mar  192.0201      126.8086
## 2024 Apr  192.0201      126.8082
```