Hierarchichal modeling to evaluate monthly differences in the number of sold anxyolitics

Gerardo

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Introduction to the problem

The purpose is to compare if the quantities of anxyolitic drugs registered in pharmacies is higher during the entry of winter (December) than in the middle-year (June)

Data

It was originally obtained from Kaggle, Involves hourly/monthly/yearly USA data from 2014-2019 reporting sales in 8 different pharmaceutical types of products. For more information you can access the next link:

https://www.kaggle.com/datasets/ybifoundation/pharma-drug-sales

```
## Rows: 50532 Columns: 14
## -- Column specification --------------------------------------------------------
## Delimiter: ","
## chr (5): Time, Year, Month, Date, Day
## dbl (9): Hour, AceticAcidDerivatives, PropionicAcidDerivatives, SalicylicAci...
##
## i Use `spec()` to retrieve the full column specification for this data.
## i Specify the column types or set `show_col_types = FALSE` to quiet this message.
```

```
## # A tibble: 6 x 14
##   Time             Year  Month Date   Hour Day      AceticAcidDerivatives
##   <chr>            <chr> <chr> <chr> <dbl> <chr>                    <dbl>
## 1 01-02-2014 08:00 2014  2     1         8 Thursday                     0
## 2 01-02-2014 09:00 2014  2     1         9 Thursday                     0
## 3 01-02-2014 10:00 2014  2     1        10 Thursday                     0
## 4 01-02-2014 11:00 2014  2     1        11 Thursday                     0
## 5 01-02-2014 12:00 2014  2     1        12 Thursday                     0
## 6 01-02-2014 13:00 2014  2     1        13 Thursday                     0
## # i 7 more variables: PropionicAcidDerivatives <dbl>,
## #   SalicylicAcidDerivatives <dbl>, PyrazolonesAndAnilides <dbl>,
## #   AnxiolyticDrugs <dbl>, HypnoticsSndSedativesDrugs <dbl>,
## #   ObstructiveAirwayDrugs <dbl>, Antihistamines <dbl>
```

Adapt the dataset to work with it easily

```
## Warning: There were 2 warnings in `mutate()`.
```

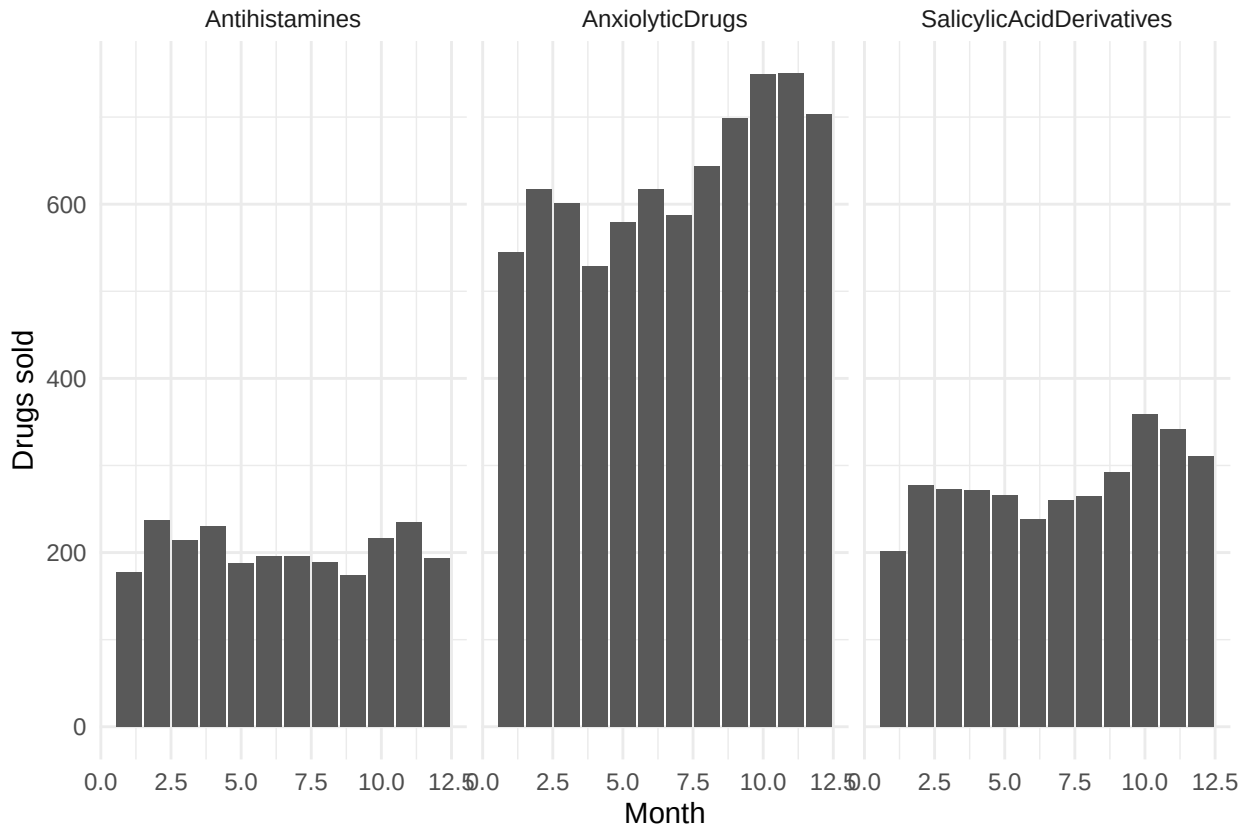
```
## The first warning was:
## i In argument: 'Month = as.integer(Month)'.
## Caused by warning:
## ! NAs introduced by coercion
## i Run 'dplyr::last_dplyr_warnings()' to see the 1 remaining warning.
```

```
## # A tibble: 6 x 8
##   Time              Year Month Date   Hour Day      drug                    value
##   <chr>            <dbl> <int> <chr> <dbl> <chr>    <chr>                   <dbl>
## 1 01-02-2014 08:00  2014     2 1         8 Thursday PropionicAcidDerivati~  0.67
## 2 01-02-2014 08:00  2014     2 1         8 Thursday SalicylicAcidDerivati~  0.4
## 3 01-02-2014 08:00  2014     2 1         8 Thursday PyrazolonesAndAnilides  2
## 4 01-02-2014 08:00  2014     2 1         8 Thursday Antihistamines          1
## 5 01-02-2014 09:00  2014     2 1         9 Thursday SalicylicAcidDerivati~  1
## 6 01-02-2014 09:00  2014     2 1         9 Thursday AnxiolyticDrugs         2
```

```
## [1] 2014 2015 2016 2017 2018 2019
```

Based on the data most pharmaceuticals present many outliers and not that clear differeces in their medians. Although October (month 10) seems clearly differentiated from the others for Anviolytic drugs. Let's see what happens when we inspect the summed absolute values:

```
## 'summarise()' has grouped output by 'Month'. You can override using the
## '.groups' argument.
```



Here the difference seems more blatant, specially for anxyolitic drugs. What if we use a Hierarchical Bayesian model to model the distributions?

Model

Let's perform now the JAGS simulation. We assume a gamma prior based on alpha and beta hyperparameters. They two are generating our expected number of drugs saled per month (lambda). Our lambda prior will be the average number sold registered.

```
## [1] 1.355496
```

```
## [1] 1.434457
```

```
## [1] 1.053888
```

```
## Compiling model graph
##    Resolving undeclared variables
##    Allocating nodes
## Graph information:
##    Observed stochastic nodes: 4235
##    Unobserved stochastic nodes: 14
##    Total graph size: 8491
##
## Initializing model
```

```
##    lam[1]    lam[2]    lam[3]    lam[4]    lam[5]    lam[6]    lam[7]    lam[8]
##  9662.234  9625.619  6363.019  4700.790  8202.517  9651.251  9346.543 10122.618
##    lam[9]   lam[10]   lam[11]   lam[12]        mu       sig
##  5403.375  6388.395  6777.443  9225.966  4177.982  1719.881
```

There does not seem to be any autoccorelation and the effective sample size is large. It seems the model has indepedent variables.

Results: Odds and histograms comparison

What is the probability that an anxyolitic drug will be sold more in December than in January?

```
## [1] "Odds ratio: 0.962654554630331"
```

Conclusion

The odds ratio that in December are more medicines sold than in June is practically 1. The distributions also seem to be very similar. Thus, we cannot strongly declare the market differences in anxyolitic drugs between the two months.