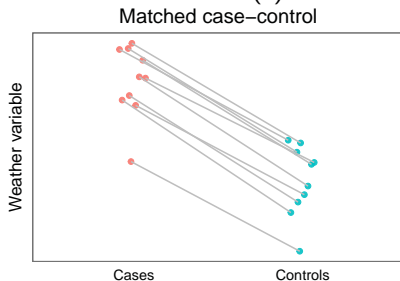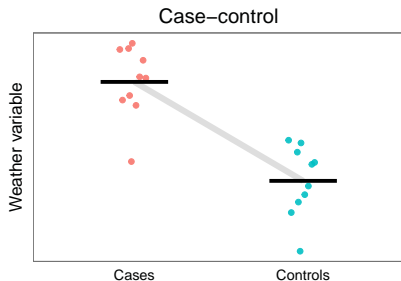# Case-crossover studies

Brooke Anderson
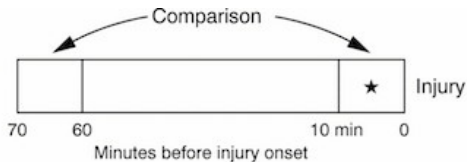
February 3, 2016

Case-crossover models

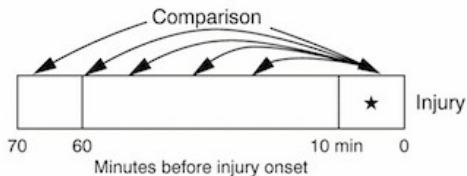Case-crossover model designs are based on the idea of matched case-control studies. For these, instead of comparing averages of exposure for cases versus controls, you compare the average difference across each matched set of case and control(s).
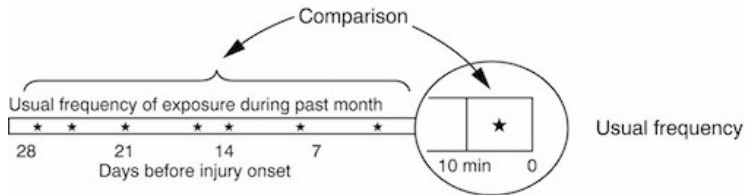
Types of case-crossover designs

Source: Sorock et al. 2001, Injury Prevention

Strata for case-crossover

Strata for a case–crossover: Year, month, day of week
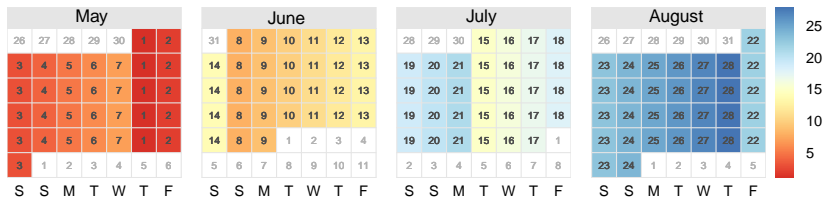
chicagoNMMAPS data

chicagoNMMAPS data

For the examples in this lecture, I'll use some data from Chicago on
mortality, temperature, and air pollution. These data are available
as part of the dlnm package. You can load them in R using the
following code:

```
library(dlnm)

## This is dlnm 2.1.3. For details: help(dlnm) and vignette
## Important changes since version 2.0.0
## See: 'file.show(system.file('Changesince200',package='dl

data("chicagoNMMAPS")
```

chicagoNMMAPS data

To make the data a little easier to use, I'll rename the data frame as
chic:

```
chic <- chicagoNMMAPS
chic[1:3, c("date", "death", "cvd", "temp", "dptp", "pm10"
```

```
##           date death cvd        temp   dptp     pm10
## 1 1987-01-01   130  65 -0.2777778 31.500 26.95607 4.376(
## 2 1987-01-02   150  73  0.5555556 29.875       NA 4.9298
## 3 1987-01-03   101  43  0.5555556 27.375 32.83869 3.7510
```

chicagoNMMAPS data

To find out more about this data, you can look at its help file:

```
?chicagoNMMAPS
```

Ways to fit case-crossover models

GLM method

One way to fit this type of model is using a GLM, but with control by strata of year-month-day of week.

Case-crossover fit using a GLM:

$$E(log(Y_t)) \sim \beta_0 + \beta_1 PM_t + \beta_2 Stratum_t$$

GLM method

To code this, first you need to create a column with the stratum. In R, you can use `format` with the date to do this easily, and then convert the formatted date for a `factor` class:

```
chic$casecross_stratum <- format(chic$date, "%Y-%m-%a")
chic$casecross_stratum <- factor(chic$casecross_stratum)
head(chic$casecross_stratum, 3)
```

```
## [1] 1987-01-Thu 1987-01-Fri 1987-01-Sat
## 1176 Levels: 1987-01-Fri 1987-01-Mon 1987-01-Sat 1987-01
```

Case-crossover

Now you can include this factor in your model (note: this takes the place of model control for time trends and day of week in a typical time series model):

```
mod_f <- glm(cvd ~ pm10 + ns(temp, 4) + casecross_stratum,
             data = chic,
             family = quasipoisson())
summary(mod_f)$coef[c(1:2, 7:10), ]
```

```
##                                  Estimate    Std. Error
## (Intercept)                   4.0482946294 0.0855215089 4
## pm10                          0.0001909843 0.0001680322
## casecross_stratum1987-01-Mon  0.1907876393 0.1137590495
## casecross_stratum1987-01-Sat  0.0855529446 0.1168756412
## casecross_stratum1987-01-Sun  0.3300835895 0.1099033832
## casecross_stratum1987-01-Thu  0.0462517003 0.1043859066
##                                     Pr(>|t|)
## (Intercept)                      0.000000000
## pm10                             0.255782198
```

Case-crossover

You can interpret the coefficients now in the same way as with the time series model:

```r
pm_coef <- summary(mod_f)$coefficients["pm10", ]
100 * (exp(10 * pm_coef[1]) - 1)
```

```
##  Estimate
## 0.1911668
```

Therefore, for this model, there is a 0.191% increase in mortality for an increase of 10 $\mu g/m^3$ PM10.

Case-crossover

There are also other methods for fitting case-crossover models:

- ▶ Armstrong et al. (Conditional Poisson models: a flexible alternative to conditional logistic case cross-over analysis) suggest using a conditional Poisson regression model (gnm()) to speed up computational time.
- ▶ The casecross function in the season package by Adrian Barnett uses 28-day strata (rather than by month) and a Cox proportional hazards regression model to fit the model.

If you are using this method for a paper, it is worthwhile testing the different methods to see if you get similar results.

Case-crossover

Using a conditional Poisson model:

```r
library(gnm)
mod_g <- gnm(cvd ~ pm10 + ns(temp, 4),
             eliminate = casecross_stratum,
             data = chic,
             family = quasipoisson())
pm_coef <- summary(mod_g)$coefficients["pm10", ]
100 * (exp(10 * pm_coef[1]) - 1)

## Estimate
## 0.1911668
```

Case-crossover

Using a Cox proportional hazards regression model:

```
library(season)
mod_h <- casecross(cvd ~ pm10 + temp,
                   matchdow = TRUE,
                   data = chic)


## Note, irregularly spaced data...
## ...check your data for missing days


pm_coef <- mod_h$c.model$coefficients[1]
100 * (exp(10 * pm_coef[1]) - 1)


##      pm10
## 0.4320228
```