# Tidy data & tidy tools

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1. What is tidy data?
2. Data tidying (3/5)
3. Tidy tools
4. Case study

# What is tidy data?

# What is tidy data?

- **Data that makes data analysis easy**
- Data that is easy to model, visualise and transform.
- A step along the road to clean data.
- Relational database theory for statisticians

| | Pregnant | Not pregnant |
|---|---|---|
| Male | 0 | 5 |
| Female | 1 | 4 |

There are three variables in this data set. What are they?

| pregnant | sex | freq |
|---|---|---|
| no | female | 4 |
| no | male | 5 |
| yes | female | 1 |
| yes | male | 0 |

| Storage | Meaning |
| --- | --- |
| Table / File | Data set |
| Rows | Observations |
| Columns | Variables |

# Data tidying

# Causes of messiness

- Column headers are values, not variable names
- Multiple variables are stored in one column
- Variables are stored in both rows and columns
- Multiple types of experimental unit stored in the same table
- One type of experimental unit stored in multiple tables

```
# Tools

library(reshape2)
?melt
?dcast

library(stringr) # regular expressions
?str_replace
?str_sub
?str_match
?str_split_fixed

library(plyr) # optional, but nice
?arrange
```

Column headers values, not variable names

| | religion | <$10k | $10-20k | $20-30k | $30-40k | $40-50k | $50-75k |
|---|---|---|---|---|---|---|---|
| 1 | Agnostic | 27 | 34 | 60 | 81 | 76 | 137 |
| 2 | Atheist | 12 | 27 | 37 | 52 | 35 | 70 |
| 3 | Buddhist | 27 | 21 | 30 | 34 | 33 | 58 |
| 4 | Catholic | 418 | 617 | 732 | 670 | 638 | 1116 |
| 5 | Don’t know/refused | 15 | 14 | 15 | 11 | 10 | 35 |
| 6 | Evangelical Prot | 575 | 869 | 1064 | 982 | 881 | 1486 |
| 7 | Hindu | 1 | 9 | 7 | 9 | 11 | 34 |
| 8 | Historically Black Prot | 228 | 244 | 236 | 238 | 197 | 223 |
| 9 | Jehovah’s Witness | 20 | 27 | 24 | 24 | 21 | 30 |
| 10 | Jewish | 19 | 19 | 25 | 25 | 30 | 95 |
| 11 | Mainline Prot | 289 | 495 | 619 | 655 | 651 | 1107 |
| 12 | Mormon | 29 | 40 | 48 | 51 | 56 | 112 |
| 13 | Muslim | 6 | 7 | 9 | 10 | 9 | 23 |
| 14 | Orthodox | 13 | 17 | 23 | 32 | 32 | 47 |
| 15 | Other Christian | 9 | 7 | 11 | 13 | 13 | 14 |
| 16 | Other Faiths | 20 | 33 | 40 | 46 | 49 | 63 |
| 17 | Other World Religions | 5 | 2 | 3 | 4 | 2 | 7 |
| 18 | Unaffiliated | 217 | 299 | 374 | 365 | 341 | 528 |

| | religion | <$10k | $10-20k | $20-30k | $30-40k | $40-50k | $50-75k |
|---|---|---|---|---|---|---|---|
| 1 | Agnostic | 27 | 34 | 60 | 81 | 76 | 137 |
| 2 | Atheist | 12 | 27 | 37 | 52 | 35 | 70 |
| 3 | Buddhist | 27 | 21 | 30 | 34 | 33 | 58 |
| 4 | Catholic | 418 | 617 | 732 | 670 | 638 | 1116 |
| 5 | Don’t know/refused | 15 | 14 | 15 | 11 | 10 | 35 |
| 6 | Evangelical Prot | 575 | 869 | 1064 | 982 | 881 | 1486 |
| 7 | Hindu | 1 | 9 | 7 | 9 | 11 | 34 |
| 8 | Historically Black Prot | 228 | 244 | 236 | 238 | 197 | 223 |
| 9 | Jehovah’s Witness | 20 | 27 | 24 | 24 | 21 | 30 |
| 10 | Jewish | 19 | 19 | 25 | 25 | 30 | 95 |
| 11 | Mainline Prot | 289 | 495 | 619 | 655 | 651 | 1107 |
| 12 | Mormon | 29 | 40 | 48 | 51 | 56 | 112 |
| 13 | Muslim | 6 | 7 | 9 | 10 | 9 | 23 |
| 14 | Orthodox | 13 | 17 | 23 | 32 | 32 | 47 |
| 15 | Other Christian | 9 | 7 | 11 | 13 | 13 | 14 |
| 16 | Other Faiths | 20 | 33 | 40 | 46 | 49 | 63 |
| 17 | Other World Religions | 5 | 2 | 3 | 4 | 2 | 7 |
| 18 | Una | | | | | | |

```
# What are the variables in this dataset?
# Discuss with your neighbour for 1 minute
```

```
raw <- read.delim("pew.txt", check.names = F,
 stringsAsFactors = F)

# Fixing this problem is easy.  We use melt, from
# reshape2, with two arguments, the input data, and
# the columns which are already variables:

library(reshape2)
tidy <- melt(raw, "religion")

head(tidy)

# We can now tweak the variable names
names(tidy) <- c("religion", "income", "n")
```

| | religion | income | n |
|---|---|---|---|
| 1 | Agnostic | <$10k | 27 |
| 2 | Atheist | <$10k | 12 |
| 3 | Buddhist | <$10k | 27 |
| 4 | Catholic | <$10k | 418 |
| 5 | Don’t know/refused | <$10k | 15 |
| 6 | Evangelical Prot | <$10k | 575 |
| 7 | Hindu | <$10k | 1 |
| 8 | Historically Black Prot | <$10k | 228 |
| 9 | Jehovah's Witness | <$10k | 20 |
| 10 | Jewish | <$10k | 19 |
| 11 | Mainline Prot | <$10k | 289 |
| 12 | Mormon | <$10k | 29 |
| 13 | Muslim | <$10k | 6 |
| 14 | Orthodox | <$10k | 13 |
| 15 | Other Christian | <$10k | 9 |
| 16 | Other Faiths | <$10k | 20 |
| 17 | Other World Religions | <$10k | 5 |
| 18 | Unaffiliated | <$10k | 217 |
| 19 | Agnostic | $10-20k | 34 |
| 20 | Atheist | $10-20k | 27 |
| 21 | Buddhist | $10-20k | 21 |
| 22 | Catholic | $10-20k | 617 |
| 23 | Don’t know/refused | $10-20k | 14 |
| 24 | Evangelical Prot | $10-20k | 869 |
| 25 | Hindu | $10-20k | 9 |
| 26 | Historically Black Prot | $10-20k | 244 |
| 27 | Jehovah’s Witness | $10-20k | 27 |
| 28 | Jewish | $10-20k | 19 |
| 29 | Mainline Prot | $10-20k | 495 |
| 30 | Mormon | $10-20k | 40 |
| 31 | Muslim | $10-20k | 7 |
| 32 | Orthodox | $10-20k | 17 |
| 33 | Other Christian | $10-20k | 7 |
| 34 | Other Faiths | $10-20k | 33 |
| 35 | Other World Religions | $10-20k | 2 |
| 36 | Unaffiliated | $10-20k | 299 |
| 37 | Agnostic | $20-30k | 60 |
| 38 | Atheist | $20-30k | 37 |
| 39 | Buddhist | $20-30k | 30 |
| 40 | Catholic | $20-30k | 732 |
| 41 | Don’t know/refused | $20-30k | 15 |
| 42 | Evangelical Prot | $20-30k | 1064 |
| 43 | Hindu | $20-30k | 7 |
| 44 | Historically Black Prot | $20-30k | 236 |
| 45 | Jehovah's Witness | $20-30k | 24 |
| 46 | Jewish | $20-30k | 25 |
| 47 | Mainline Prot | $20-30k | 619 |
| 48 | Mormon | $20-30k | 48 |
| 49 | Muslim | $20-30k | 9 |
| 50 | Orthodox | $20-30k | 23 |

# Multiple variables in one column

| | iso2 | year | m04 | m514 | m014 | m1524 | m2534 | m3544 | m4554 | m5564 | m65 | mu | f04 | f514 | f014 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | AD | 1989 | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| 2 | AD | 1990 | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| 3 | AD | 1991 | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| 4 | AD | 1992 | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| 5 | AD | 1993 | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| 6 | AD | 1994 | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| 7 | AD | 1996 | NA | NA | 0 | 0 | 0 | 4 | 1 | 0 | 0 | NA | NA | NA | 0 |
| 8 | AD | 1997 | NA | NA | 0 | 0 | 1 | 2 | 2 | 1 | 6 | NA | NA | NA | 0 |
| 9 | AD | 1998 | NA | NA | 0 | 0 | 0 | 1 | 0 | 0 | 0 | NA | NA | NA | NA |
| 10 | AD | 1999 | NA | NA | 0 | 0 | 0 | 1 | 1 | 0 | 0 | NA | NA | NA | 0 |
| 11 | AD | 2000 | NA | NA | 0 | 0 | 1 | 0 | 0 | 0 | 0 | NA | NA | NA | NA |
| 12 | AD | 2001 | NA | NA | 0 | NA | NA | 2 | 1 | NA | NA | NA | NA | NA | NA |
| 13 | AD | 2002 | NA | NA | 0 | 0 | 0 | 1 | 0 | 0 | 0 | NA | NA | NA | 0 |
| 14 | AD | 2003 | NA | NA | 0 | 0 | 0 | 1 | 2 | 0 | 0 | NA | NA | NA | 0 |
| 15 | AD | 2004 | NA | NA | 0 | 0 | 0 | 1 | 1 | 0 | 0 | NA | NA | NA | 0 |
| 16 | AD | 2005 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 17 | AD | 2006 | 0 | 0 | 0 | 1 | 1 | 2 | 0 | 1 | 1 | 0 | 0 | 0 | 0 |
| 18 | AD | 2007 | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| 19 | AD | 2008 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| 20 | AE | 1980 | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |

| | iso2 | year | m04 | m514 | m014 | m1524 | m2534 | m3544 | m4554 | m5564 | m65 | mu | f04 | f514 | f014 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | AD | 1989 | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| 2 | AD | 1990 | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| 3 | AD | 1991 | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| 4 | AD | 1992 | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| 5 | AD | 1993 | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| 6 | AD | 1994 | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| 7 | AD | 1996 | NA | NA | 0 | 0 | 0 | 4 | 1 | 0 | 0 | NA | NA | NA | 0 |
| 8 | AD | 1997 | NA | NA | 0 | 0 | 1 | 2 | 2 | 1 | 6 | NA | NA | NA | 0 |
| 9 | AD | 1998 | NA | NA | 0 | 0 | 0 | 1 | 0 | 0 | 0 | NA | NA | NA | NA |
| 10 | AD | 1999 | NA | NA | 0 | 0 | 0 | 1 | 1 | 0 | 0 | NA | NA | NA | 0 |
| 11 | AD | 2000 | NA | NA | 0 | 0 | 1 | 0 | 0 | 0 | 0 | NA | NA | NA | NA |
| 12 | AD | 2001 | NA | NA | 0 | NA | NA | 2 | 1 | NA | NA | NA | NA | NA | NA |
| 13 | AD | 2002 | NA | NA | 0 | 0 | 0 | 1 | 0 | 0 | 0 | NA | NA | NA | 0 |
| 14 | AD | 2003 | NA | NA | 0 | 0 | 0 | 1 | 2 | 0 | 0 | NA | NA | NA | 0 |
| 15 | AD | 2004 | NA | NA | 0 | 0 | 0 | 1 | 1 | 0 | 0 | NA | NA | NA | 0 |
| 16 | AD | 2005 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 17 | AD | 2006 | 0 | 0 | 0 | 1 | 1 | 2 | 0 | 1 | 1 | 0 | 0 | 0 | 0 |
| 18 | AD | 2007 | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| 19 | AD | 2008 | | | | | | | | | | | | | |
| 20 | AE | 1980 | | | | | | | | | | | | | |

```
# What are the variables in this dataset?
# Discuss with your neighbour for 1 minute
# Hint: f = female, u = unknown, 1524 = 15-25
```

```
raw <- read.csv("tb.csv", stringsAsFactors = FALSE)
raw$new_sp <- NULL

names(raw) <- str_replace(names(raw), "new_sp_", "")

# na.rm = TRUE is useful if the missings don't have
# any meaning
tidy <- melt(raw, id = c("iso2", "year"),
  na.rm = TRUE)
names(tidy)[4] <- "cases"

# Often a good idea to ensure the rows are ordered
# by the variables
tidy <- arrange(tidy, iso2, variable, year)
```

| | iso2 | year | variable | cases |
|---|---|---|---|---|
| 1 | AD | 2005 | m04 | 0 |
| 2 | AD | 2006 | m04 | 0 |
| 3 | AD | 2008 | m04 | 0 |
| 4 | AD | 2005 | m514 | 0 |
| 5 | AD | 2006 | m514 | 0 |
| 6 | AD | 2008 | m514 | 0 |
| 7 | AD | 1996 | m014 | 0 |
| 8 | AD | 1997 | m014 | 0 |
| 9 | AD | 1998 | m014 | 0 |
| 10 | AD | 1999 | m014 | 0 |
| 11 | AD | 2000 | m014 | 0 |
| 12 | AD | 2001 | m014 | 0 |
| 13 | AD | 2002 | m014 | 0 |
| 14 | AD | 2003 | m014 | 0 |
| 15 | AD | 2004 | m014 | 0 |
| 16 | AD | 2005 | m014 | 0 |
| 17 | AD | 2006 | m014 | 0 |
| 18 | AD | 2008 | m014 | 0 |
| 19 | AD | 1996 | m1524 | 0 |
| 20 | AD | 1997 | m1524 | 0 |
| 21 | AD | 1998 | m1524 | 0 |
| 22 | AD | 1999 | m1524 | 0 |
| 23 | AD | 2000 | m1524 | 0 |
| 24 | AD | 2002 | m1524 | 0 |
| 25 | AD | 2003 | m1524 | 0 |
| 26 | AD | 2004 | m1524 | 0 |
| 27 | AD | 2005 | m1524 | 0 |
| 28 | AD | 2006 | m1524 | 1 |
| 29 | AD | 2008 | m1524 | 0 |
| 30 | AD | 1996 | m2534 | 0 |
| 31 | AD | 1997 | m2534 | 1 |
| 32 | AD | 1998 | m2534 | 0 |
| 33 | AD | 1999 | m2534 | 0 |
| 34 | AD | 2000 | m2534 | 1 |
| 35 | AD | 2002 | m2534 | 0 |
| 36 | AD | 2003 | m2534 | 0 |
| 37 | AD | 2004 | m2534 | 0 |
| 38 | AD | 2005 | m2534 | 1 |
| 39 | AD | 2006 | m2534 | 1 |
| 40 | AD | 2008 | m2534 | 0 |
| 41 | AD | 1996 | m3544 | 4 |
| 42 | AD | 1997 | m3544 | 2 |
| 43 | AD | 1998 | m3544 | 1 |
| 44 | AD | 1999 | m3544 | 1 |
| 45 | AD | 2000 | m3544 | 0 |
| 46 | AD | 2001 | m3544 | 2 |
| 47 | AD | 2002 | m3544 | 1 |
| 48 | AD | 2003 | m3544 | 1 |
| 49 | AD | 2004 | m3544 | 1 |
| 50 | AD | 2005 | m3544 | 1 |

```
str_sub(tidy$variable, 1, 1)
str_sub(tidy$variable, 2)

ages <- c("04" = "0-4", "514" = "5-14",
  "014" = "0-14", "1524" = "15-24", "2534" = "25-34",
  "3544" = "35-44", "4554" = "45-54", "5564" = "55-64",
  "65"= "65+", "u" = NA)
ages[str_sub(tidy$variable, 2)]

tidy$sex <- str_sub(tidy$variable, 1, 1)
tidy$age <- factor(ages[str_sub(tidy$variable, 2)],
   levels = ages)
tidy$variable <- NULL

tidy <- tidy[c("iso2", "year", "sex", "age", "cases")]
```

| | iso2 | year | sex | age | cases |
|---|---|---|---|---|---|
| 1 | AD | 2005 | m | 0-4 | 0 |
| 2 | AD | 2006 | m | 0-4 | 0 |
| 3 | AD | 2008 | m | 0-4 | 0 |
| 4 | AD | 2005 | m | 5-14 | 0 |
| 5 | AD | 2006 | m | 5-14 | 0 |
| 6 | AD | 2008 | m | 5-14 | 0 |
| 7 | AD | 1996 | m | 0-14 | 0 |
| 8 | AD | 1997 | m | 0-14 | 0 |
| 9 | AD | 1998 | m | 0-14 | 0 |
| 10 | AD | 1999 | m | 0-14 | 0 |
| 11 | AD | 2000 | m | 0-14 | 0 |
| 12 | AD | 2001 | m | 0-14 | 0 |
| 13 | AD | 2002 | m | 0-14 | 0 |
| 14 | AD | 2003 | m | 0-14 | 0 |
| 15 | AD | 2004 | m | 0-14 | 0 |
| 16 | AD | 2005 | m | 0-14 | 0 |
| 17 | AD | 2006 | m | 0-14 | 0 |
| 18 | AD | 2008 | m | 0-14 | 0 |
| 19 | AD | 1996 | m | 15-24 | 0 |
| 20 | AD | 1997 | m | 15-24 | 0 |
| 21 | AD | 1998 | m | 15-24 | 0 |
| 22 | AD | 1999 | m | 15-24 | 0 |
| 23 | AD | 2000 | m | 15-24 | 0 |
| 24 | AD | 2002 | m | 15-24 | 0 |
| 25 | AD | 2003 | m | 15-24 | 0 |
| 26 | AD | 2004 | m | 15-24 | 0 |
| 27 | AD | 2005 | m | 15-24 | 0 |
| 28 | AD | 2006 | m | 15-24 | 1 |
| 29 | AD | 2008 | m | 15-24 | 0 |
| 30 | AD | 1996 | m | 25-34 | 0 |
| 31 | AD | 1997 | m | 25-34 | 1 |
| 32 | AD | 1998 | m | 25-34 | 0 |
| 33 | AD | 1999 | m | 25-34 | 0 |
| 34 | AD | 2000 | m | 25-34 | 1 |
| 35 | AD | 2002 | m | 25-34 | 0 |
| 36 | AD | 2003 | m | 25-34 | 0 |
| 37 | AD | 2004 | m | 25-34 | 0 |
| 38 | AD | 2005 | m | 25-34 | 1 |
| 39 | AD | 2006 | m | 25-34 | 1 |
| 40 | AD | 2008 | m | 25-34 | 0 |
| 41 | AD | 1996 | m | 35-44 | 4 |
| 42 | AD | 1997 | m | 35-44 | 2 |
| 43 | AD | 1998 | m | 35-44 | 1 |
| 44 | AD | 1999 | m | 35-44 | 1 |
| 45 | AD | 2000 | m | 35-44 | 0 |
| 46 | AD | 2001 | m | 35-44 | 2 |
| 47 | AD | 2002 | m | 35-44 | 1 |
| 48 | AD | 2003 | m | 35-44 | 1 |
| 49 | AD | 2004 | m | 35-44 | 1 |
| 50 | AD | 2005 | m | 35-44 | 1 |

# Variables in rows and columns

| | id | year | month | element | d1 | d2 | d3 | d4 | d5 | d6 | d7 | d8 | d9 | d10 | d11 | d12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | MX000017004 | 2010 | 1 | TMAX | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| 2 | MX000017004 | 2010 | 1 | TMIN | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| 3 | MX000017004 | 2010 | 2 | TMAX | NA | 273 | 241 | NA | NA | NA | NA | NA | NA | NA | 297 | NA |
| 4 | MX000017004 | 2010 | 2 | TMIN | NA | 144 | 144 | NA | NA | NA | NA | NA | NA | NA | 134 | NA |
| 5 | MX000017004 | 2010 | 3 | TMAX | NA | NA | NA | NA | 321 | NA | NA | NA | NA | 345 | NA | NA |
| 6 | MX000017004 | 2010 | 3 | TMIN | NA | NA | NA | NA | 142 | NA | NA | NA | NA | 168 | NA | NA |
| 7 | MX000017004 | 2010 | 4 | TMAX | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| 8 | MX000017004 | 2010 | 4 | TMIN | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| 9 | MX000017004 | 2010 | 5 | TMAX | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| 10 | MX000017004 | 2010 | 5 | TMIN | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| 11 | MX000017004 | 2010 | 6 | TMAX | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| 12 | MX000017004 | 2010 | 6 | TMIN | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| 13 | MX000017004 | 2010 | 7 | TMAX | NA | NA | 286 | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| 14 | MX000017004 | 2010 | 7 | TMIN | NA | NA | 175 | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| 15 | MX000017004 | 2010 | 8 | TMAX | NA | NA | NA | NA | 296 | NA | NA | 290 | NA | NA | NA | NA |
| 16 | MX000017004 | 2010 | 8 | TMIN | NA | NA | NA | NA | 158 | NA | NA | 173 | NA | NA | NA | NA |
| 17 | MX000017004 | 2010 | 10 | TMAX | NA | NA | NA | NA | 270 | NA | 281 | NA | NA | NA | NA | NA |
| 18 | MX000017004 | 2010 | 10 | TMIN | NA | NA | NA | NA | 140 | NA | 129 | NA | NA | NA | NA | NA |
| 19 | MX000017004 | 2010 | 11 | TMAX | NA | 313 | NA | 272 | 263 | NA | NA | NA | NA | NA | NA | NA |
| 20 | MX000017004 | 2010 | 11 | TMIN | NA | 163 | NA | 120 | 79 | NA | NA | NA | NA | NA | NA | NA |

```
           id year month element d1  d2  d3  d4  d5 d6  d7  d8 d9 d10 d11 d12
1  MX000017004 2010     1    TMAX NA  NA  NA  NA  NA NA  NA  NA NA  NA  NA  NA
2  MX000017004 2010     1    TMIN NA  NA  NA  NA  NA NA  NA  NA NA  NA  NA  NA
3  MX000017004 2010     2    TMAX NA 273 241  NA  NA NA  NA  NA NA  NA 297  NA
4  MX000017004 2010     2    TMIN NA 144 144  NA  NA NA  NA  NA NA  NA 134  NA
5  MX000017004 2010     3    TMAX NA  NA  NA  NA 321 NA  NA  NA NA 345  NA  NA
6  MX000017004 2010     3    TMIN NA  NA  NA  NA 142 NA  NA  NA NA 168  NA  NA
7  MX000017004 2010     4    TMAX NA  NA  NA  NA  NA NA  NA  NA NA  NA  NA  NA
8  MX000017004 2010     4    TMIN NA  NA  NA  NA  NA NA  NA  NA NA  NA  NA  NA
9  MX000017004 2010     5    TMAX NA  NA  NA  NA  NA NA  NA  NA NA  NA  NA  NA
10 MX000017004 2010     5    TMIN NA  NA  NA  NA  NA NA  NA  NA NA  NA  NA  NA
11 MX000017004 2010     6    TMAX NA  NA  NA  NA  NA NA  NA  NA NA  NA  NA  NA
12 MX000017004 2010     6    TMIN NA  NA  NA  NA  NA NA  NA  NA NA  NA  NA  NA
13 MX000017004 2010     7    TMAX NA  NA 286  NA  NA NA  NA  NA NA  NA  NA  NA
14 MX000017004 2010     7    TMIN NA  NA 175  NA  NA NA  NA  NA NA  NA  NA  NA
15 MX000017004 2010     8    TMAX NA  NA  NA  NA 296 NA  NA 290 NA  NA  NA  NA
16 MX000017004 2010     8    TMIN NA  NA  NA  NA 158 NA  NA 173 NA  NA  NA  NA
17 MX000017004 201
18 MX000017004 201
19 MX000017004 201
20 MX000017004 201
```

```
# What are the variables in this dataset?
# Discuss with your neighbour for 1 minute
# Hint: TMIN = minimum temperature,
#       id = weather station identifier
```

```
raw <- read.table("weather.txt",
  stringsAsFactors = FALSE)

raw1 <- melt(raw, id = 1:4, na.rm = T)
raw1$day <- as.integer(
  str_replace(raw1$variable, "d", ""))
raw1$variable <- NULL
raw1$element <- tolower(raw1$element)

raw1 <- raw1[c("id", "year", "month", "day",
  "element", "value")]
raw1 <- arrange(raw1, year, month, day, element)
```

```
            id year month day element value
1  MX000017004 2010     1  30    tmax   278
2  MX000017004 2010     1  30    tmin   145
3  MX000017004 2010     2   2    tmax   273
4  MX000017004 2010     2   2    tmin   144
5  MX000017004 2010     2   3    tmax   241
6  MX000017004 2010     2   3    tmin   144
7  MX000017004 2010     2  11    tmax   297
8  MX000017004 2010     2  11    tmin   134
9  MX000017004 2010     2  23    tmax   299
10 MX000017004 2010     2  23    tmin   107
11 MX000017004 2010     3   5    tmax   321
12 MX000017004 2010     3   5    tmin   142
13 MX000017004 2010     3  10    tmax   345
14 MX000017004 2010     3  10    tmin   168
15 MX000017004 2010     3  16    tmax   311
16 MX000017004 2010     3  16    tmin   176
17 MX000017004 2010     4  27    tmax   363
18 MX000017004 2010     4  27    tmin   167
19 MX000017004 2010     5  27    tmax   332
20 MX000017004 2010     5  27    tmin   182
```

```
# dcast shifts variables from rows to columns
tidy <- dcast(raw1, ... ~ element)

# casting syntax:
#   row_var1 + row_var2 ~ col_var1 + col_var2
#   ... = all variables not otherwise mentioned
```

| | id | year | month | day | tmax | tmin |
|---|---|---|---|---|---|---|
| 1 | MX000017004 | 2010 | 1 | 30 | 278 | 145 |
| 2 | MX000017004 | 2010 | 2 | 2 | 273 | 144 |
| 3 | MX000017004 | 2010 | 2 | 3 | 241 | 144 |
| 4 | MX000017004 | 2010 | 2 | 11 | 297 | 134 |
| 5 | MX000017004 | 2010 | 2 | 23 | 299 | 107 |
| 6 | MX000017004 | 2010 | 3 | 5 | 321 | 142 |
| 7 | MX000017004 | 2010 | 3 | 10 | 345 | 168 |
| 8 | MX000017004 | 2010 | 3 | 16 | 311 | 176 |
| 9 | MX000017004 | 2010 | 4 | 27 | 363 | 167 |
| 10 | MX000017004 | 2010 | 5 | 27 | 332 | 182 |
| 11 | MX000017004 | 2010 | 6 | 17 | 280 | 175 |
| 12 | MX000017004 | 2010 | 6 | 29 | 301 | 180 |
| 13 | MX000017004 | 2010 | 7 | 3 | 286 | 175 |
| 14 | MX000017004 | 2010 | 7 | 14 | 299 | 165 |
| 15 | MX000017004 | 2010 | 8 | 5 | 296 | 158 |
| 16 | MX000017004 | 2010 | 8 | 8 | 290 | 173 |
| 17 | MX000017004 | 2010 | 8 | 13 | 298 | 165 |
| 18 | MX000017004 | 2010 | 8 | 23 | 264 | 150 |
| 19 | MX000017004 | 2010 | 8 | 25 | 297 | 156 |
| 20 | MX000017004 | 2010 | 8 | 29 | 280 | 153 |
| 21 | MX000017004 | 2010 | 8 | 31 | 254 | 154 |
| 22 | MX000017004 | 2010 | 10 | 5 | 270 | 140 |
| 23 | MX000017004 | 2010 | 10 | 7 | 281 | 129 |
| 24 | MX000017004 | 2010 | 10 | 14 | 295 | 130 |
| 25 | MX000017004 | 2010 | 10 | 15 | 287 | 105 |

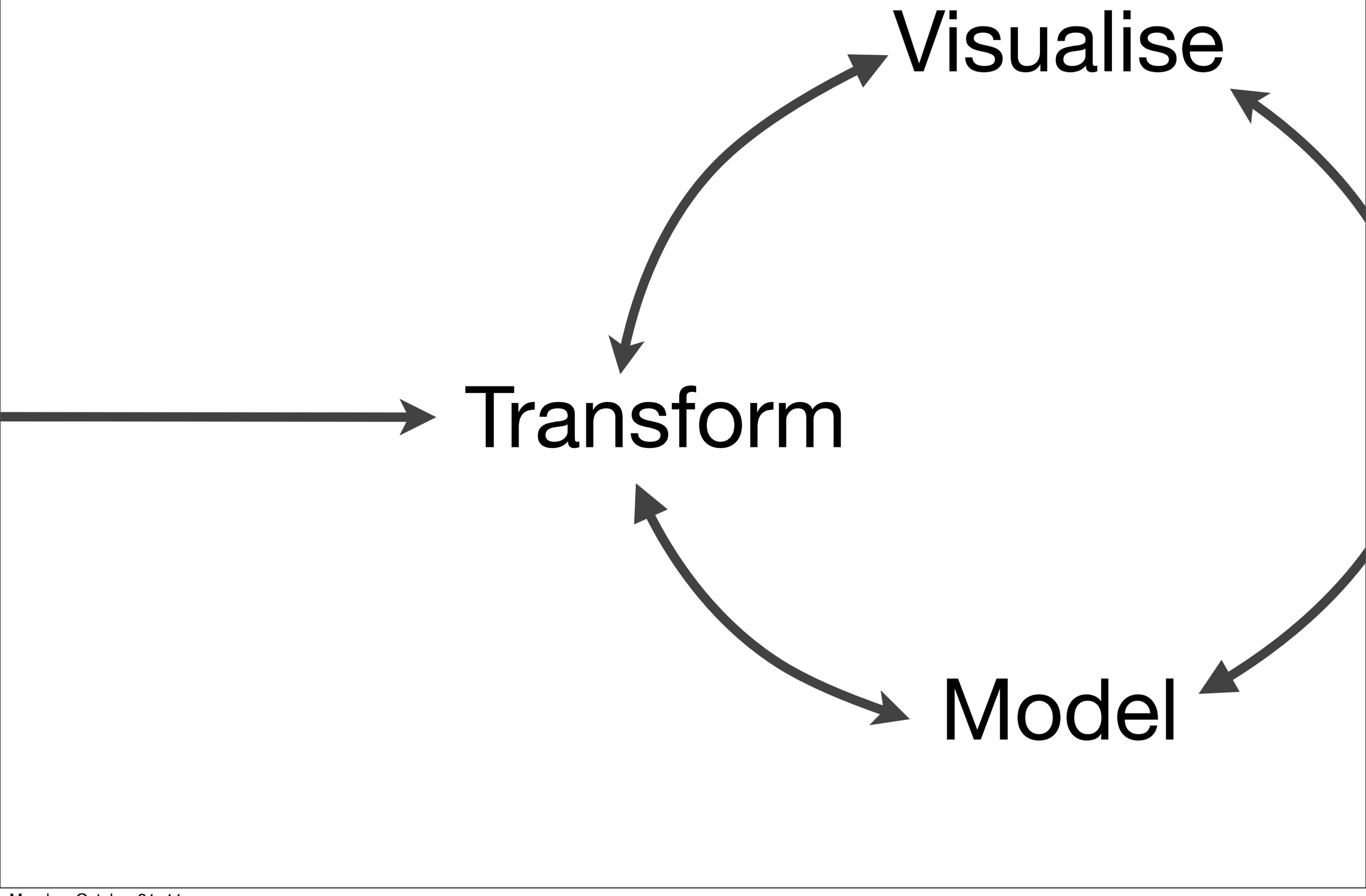
# Tidy tools

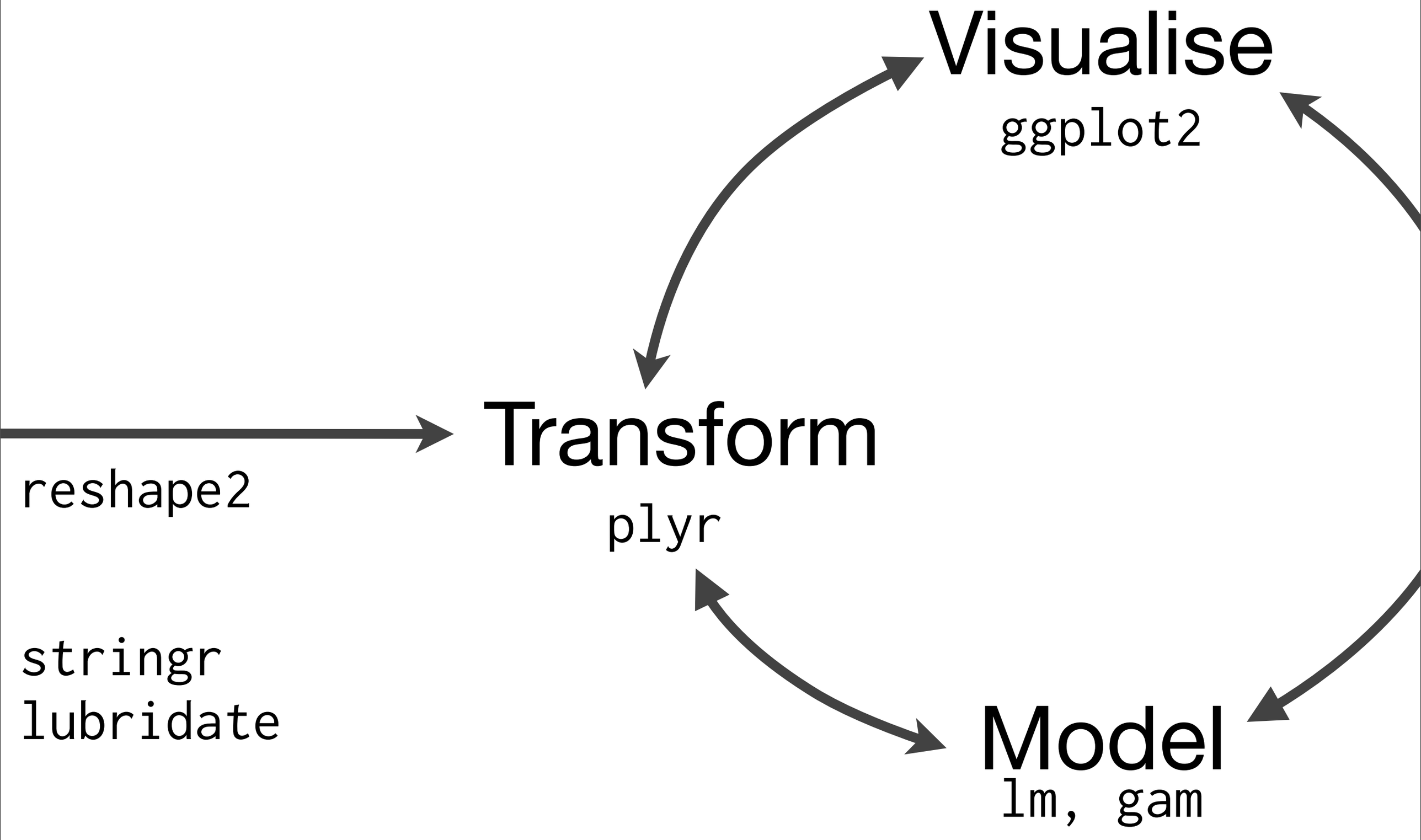
# Tidy tools

Now we have our data in a tidy format, what can we do with it?

Tidy tools work input and output tidy data, and avoid data restructuring during an analysis.

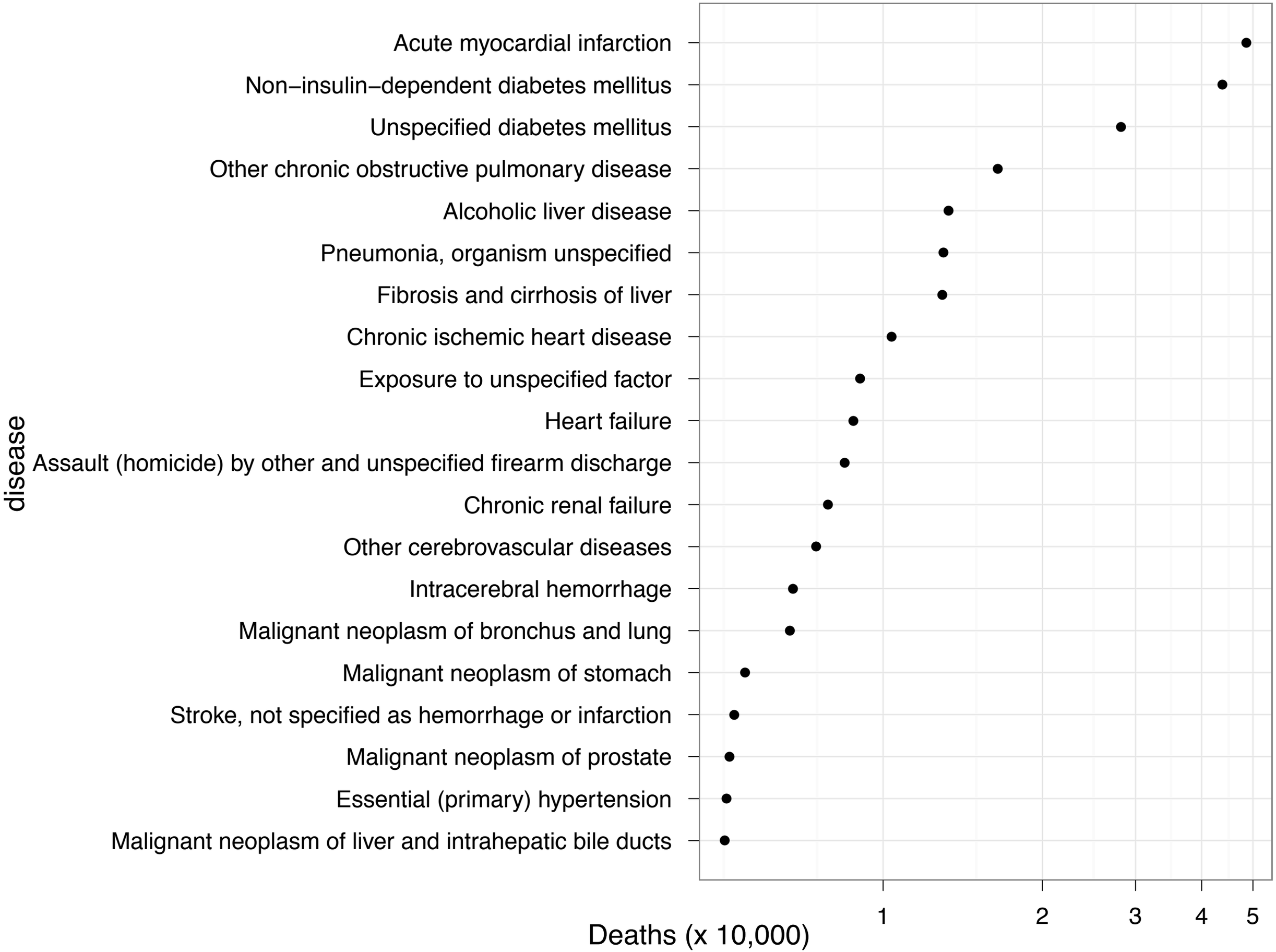

http://www.flickr.com/photos/wwworks/2473052504


Visualise
Transform
Model


Visualise
ggplot2
Transform
plyr
reshape2
stringr
lubridate
Model
lm, gam

| Function | Reason |
| --- | --- |
| `table()` | Returns an array |
| `by()` | Returns a list |
| `coef(summary())` | Returns a matrix with row names |
| `matplot()` | Inputs a matrix |

# Case study


Acute myocardial infarction
Non–insulin–dependent diabetes mellitus
Unspecified diabetes mellitus
Other chronic obstructive pulmonary disease
Alcoholic liver disease
Pneumonia, organism unspecified
Fibrosis and cirrhosis of liver
Chronic ischemic heart disease
Exposure to unspecified factor
Heart failure
Assault (homicide) by other and unspecified firearm discharge
Chronic renal failure
Other cerebrovascular diseases
Intracerebral hemorrhage
Malignant neoplasm of bronchus and lung
Malignant neoplasm of stomach
Stroke, not specified as hemorrhage or infarction
Malignant neoplasm of prostate
Essential (primary) hypertension
Malignant neoplasm of liver and intrahepatic bile ducts
disease
1
2
3
4
5
Deaths (x 10,000)

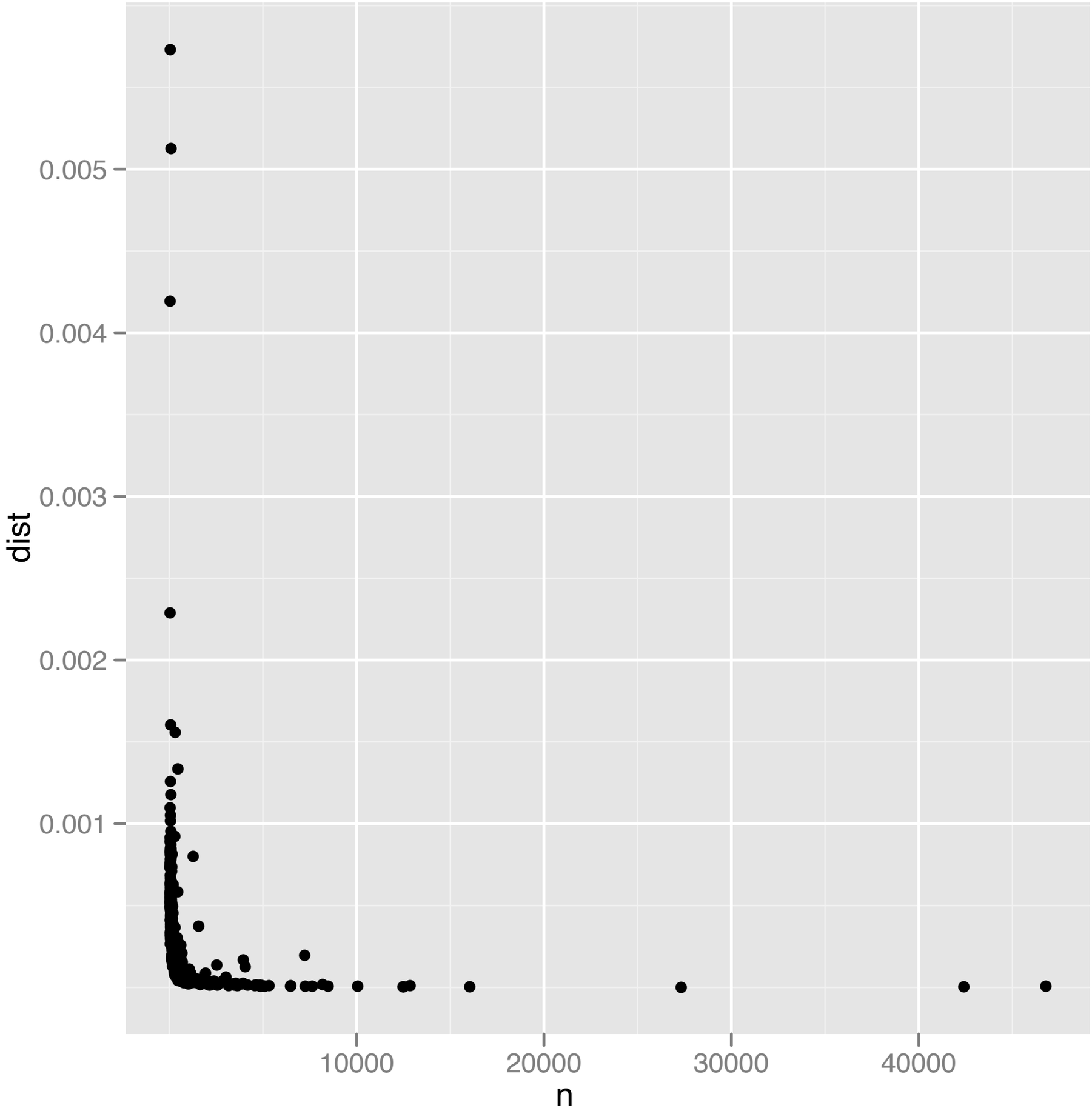

20000
15000
10000
5000
freq
0
5
10
15
20
hod
What diseases don’t fit this pattern?

```
hod2 <- count(deaths, c("cod", "hod"))
hod2 <- subset(hod2, !is.na(hod))
hod2 <- join(hod2, codes)
hod2 <- ddply(hod2, "cod", transform,
  prop = freq / sum(freq))


# Compare to overall abundance
overall <- ddply(hod2, "hod", summarise,
  freq_all = sum(freq))
overall <- mutate(overall,
  prop_all = freq_all / sum(freq_all))

hod2 <- join(overall, hod2, by = "hod")
```

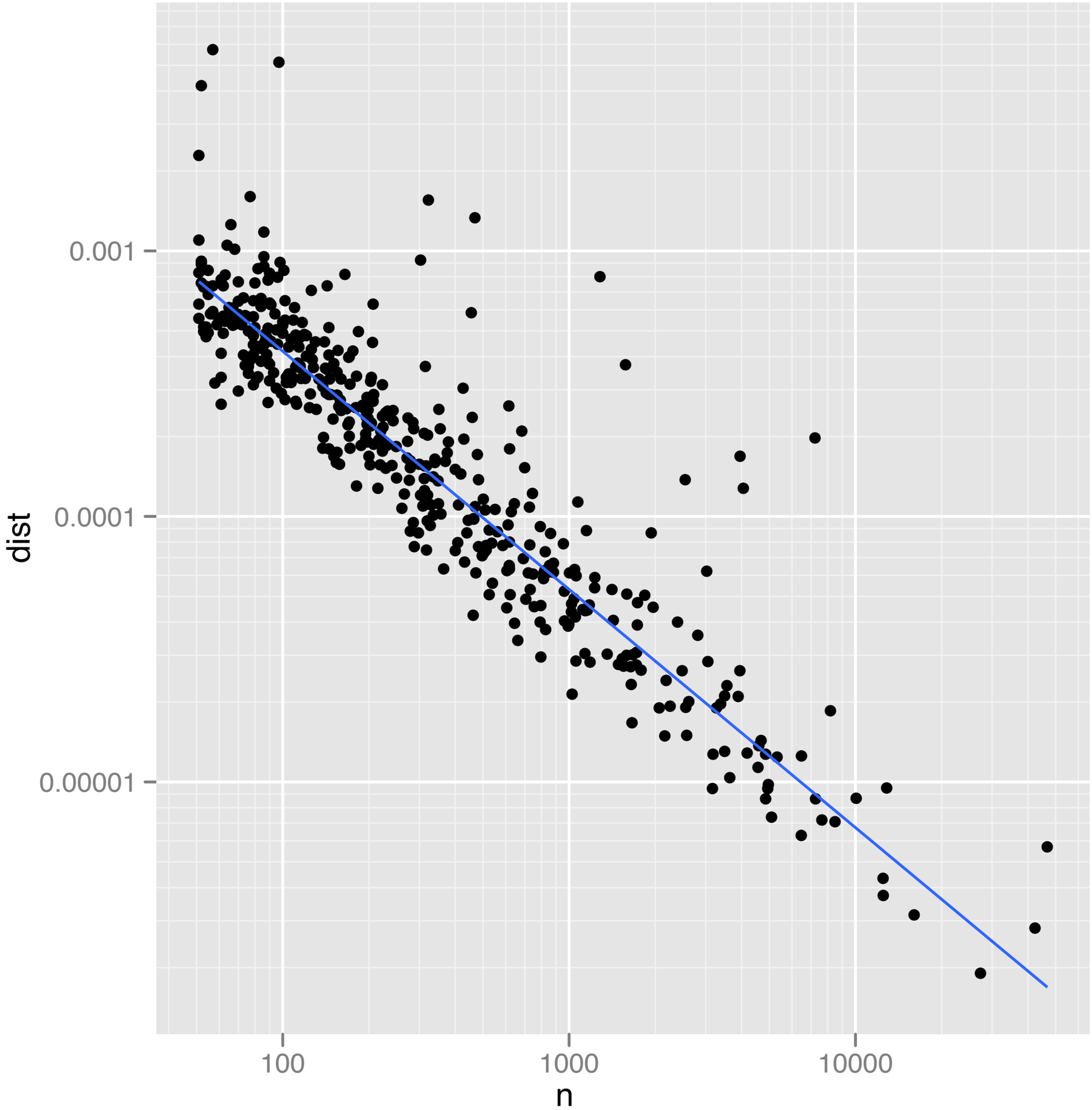
| | cod | hod | disease | freq | prop | freq_all | prop_all |
|---|---|---|---|---|---|---|---|
| 1 | A01 | 1 | Typhoid and paratyphoid\nfevers | 3 | 0.0577 | 20430 | 0.0398 |
| 2 | A01 | 2 | Typhoid and paratyphoid\nfevers | 1 | 0.0192 | 18962 | 0.0369 |
| 3 | A01 | 3 | Typhoid and paratyphoid\nfevers | 4 | 0.0769 | 19729 | 0.0384 |
| 4 | A01 | 5 | Typhoid and paratyphoid\nfevers | 5 | 0.0962 | 22126 | 0.0431 |
| 5 | A01 | 6 | Typhoid and paratyphoid\nfevers | 1 | 0.0192 | 23787 | 0.0463 |
| 6 | A01 | 8 | Typhoid and paratyphoid\nfevers | 1 | 0.0192 | 21915 | 0.0427 |
| 7 | A01 | 10 | Typhoid and paratyphoid\nfevers | 2 | 0.0385 | 24321 | 0.0474 |
| 8 | A01 | 11 | Typhoid and paratyphoid\nfevers | 2 | 0.0385 | 23843 | 0.0465 |
| 9 | A01 | 12 | Typhoid and paratyphoid\nfevers | 1 | 0.0192 | 23392 | 0.0456 |
| 10 | A01 | 13 | Typhoid and paratyphoid\nfevers | 6 | 0.1154 | 23284 | 0.0454 |
| 11 | A01 | 14 | Typhoid and paratyphoid\nfevers | 4 | 0.0769 | 23053 | 0.0449 |
| 12 | A01 | 15 | Typhoid and paratyphoid\nfevers | 5 | 0.0962 | 23278 | 0.0454 |
| 13 | A01 | 17 | Typhoid and paratyphoid\nfevers | 3 | 0.0577 | 23625 | 0.0460 |
| 14 | A01 | 18 | Typhoid and paratyphoid\nfevers | 2 | 0.0385 | 24380 | 0.0475 |
| 15 | A01 | 19 | Typhoid and paratyphoid\nfevers | 3 | 0.0577 | 22919 | 0.0447 |
| 16 | A01 | 20 | Typhoid and paratyphoid\nfevers | 3 | 0.0577 | 22926 | 0.0447 |
| 17 | A01 | 21 | Typhoid and paratyphoid\nfevers | 2 | 0.0385 | 20995 | 0.0409 |
| 18 | A01 | 22 | Typhoid and paratyphoid\nfevers | 3 | 0.0577 | 20510 | 0.0400 |
| 19 | A01 | 23 | Typhoid and paratyphoid\nfevers | 1 | 0.0192 | 21446 | 0.0418 |

```
devi <- ddply(hod2, "cod", summarise, n = sum(freq),
  dist = mean((prop - prop_all)^2))
devi <- subset(devi, n > 50)
```

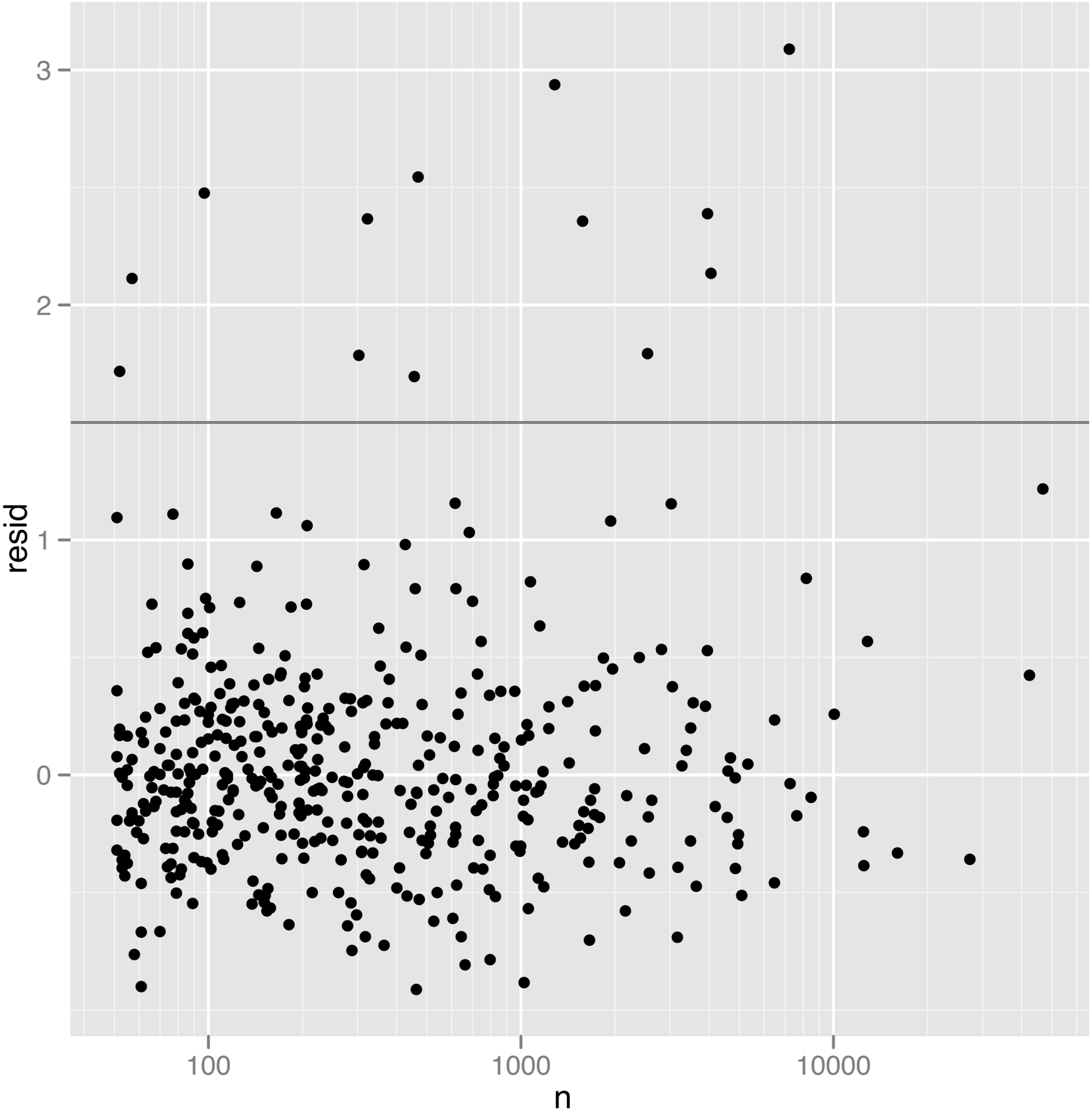
```
qplot(n, dist, data = devi)
```


dist
0.005
0.004
0.003
0.002
0.001
10000
20000
30000
40000
n

```
qplot(n, dist, data = devi) +
  geom_smooth(method = "rlm", se = F) +
  xlog10 +
  ylog10

xlog10 <- scale_x_log10(
  breaks = c(100, 1000, 10000),
  labels = c(100, 1000, 10000),
  minor_breaks = outer(1:9, 10^(1:5), "*"))
ylog10 <- scale_y_log10(
  breaks = 10 ^ -c(3, 4, 5),
  labels = c("0.001", "0.0001", "0.00001"),
  minor_breaks = outer(1:9, 10^-(3:6), "*"))
```


0.001
0.0001
0.00001
dist
100
1000
10000
n

```
devi$resid <- resid(rlm(log(dist) ~ log(n),
  data = devi))

ggplot(devi, aes(n, resid)) +
  geom_hline(yintercept = 1.5, colour = "grey50") +
  geom_point() +
  xlog10
```


3
2
1
0
resid
100
1000
10000
n

```
unusual <- subset(devi, resid > 1.5)
hod_unusual_big <- match_df(hod2, subset(unusual, n > 350))
hod_unusual_sml <- match_df(hod2, subset(unusual, n <= 350))

# Visualise unusual causes of death
ggplot(hod_unusual_big, aes(hod, prop)) +
  geom_line(aes(y = prop_all), data = overall, colour = "grey50") +
  geom_line() +
  facet_wrap(~ disease, ncol = 3)
```

Assault (homicide) by other and unspecified firearm discharge

Assault (homicide) by sharp object

Drowning and submersion while in natural water

Exposure to unspecified electric current

Motor– or nonmotor–vehicle accident, type of vehicle unspecified

Pedestrian injured in other and unspecified transport accidents

Traffic accident of specified type but victim's mode of transport unknown

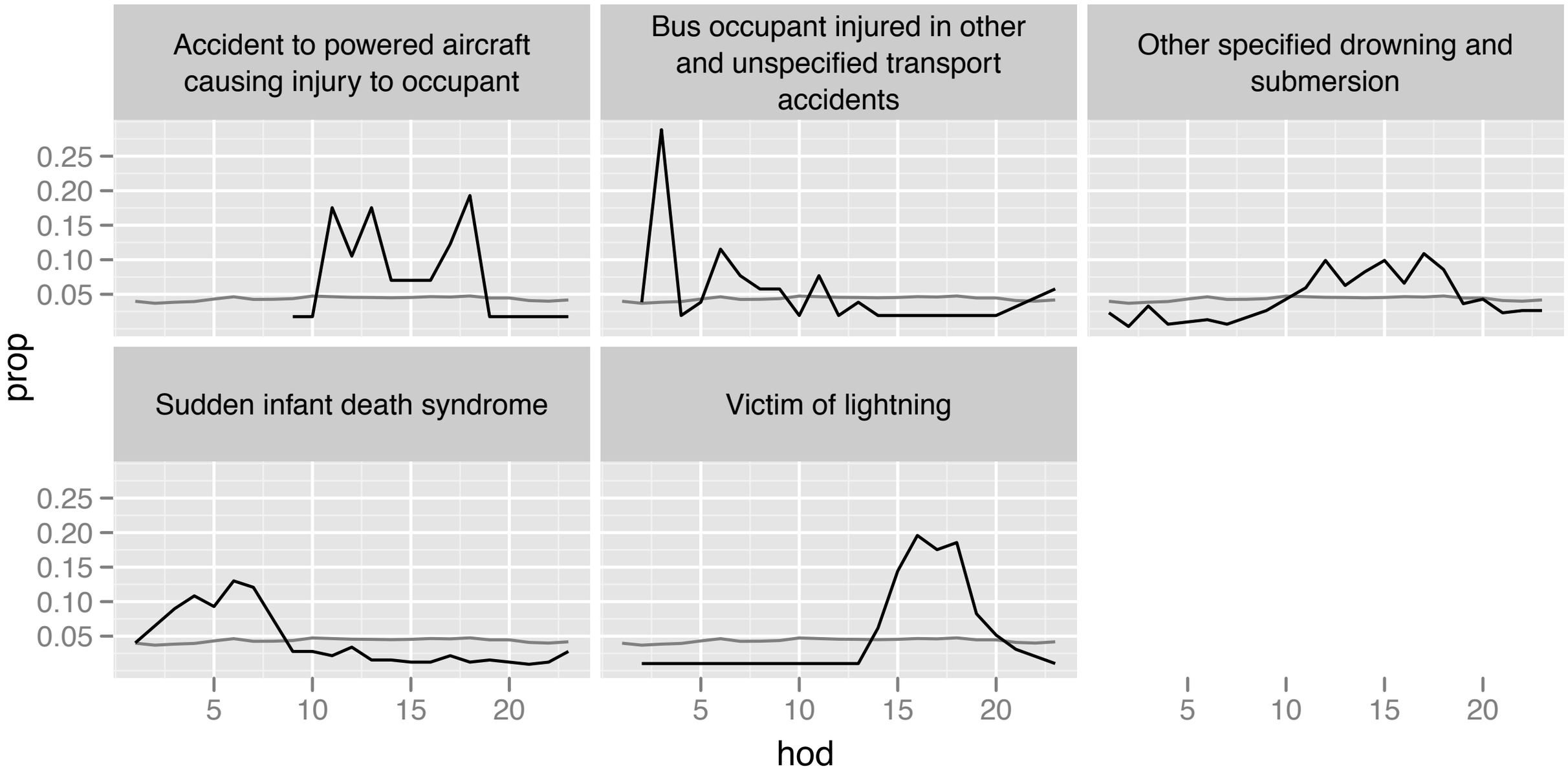
Unspecified drowning and submersion

prop

0.10
0.08
0.06
0.04
0.02

5
10
15
20

hod


Accident to powered aircraft causing injury to occupant
Bus occupant injured in other and unspecified transport accidents
Other specified drowning and submersion
Sudden infant death syndrome
Victim of lightning
0.25
0.20
0.15
0.10
0.05
prop
5
10
15
20
hod

# Conclusions

# Summary

The framework of tidy data makes it easier to get data in a useful form for analysis and provides a useful framework for critiquing existing functions.

Surprisingly few tools needed to tidy messy data.

# Future work

Data structure also affects how we think about problem statistically:

Multivariate models use matrices

Paired t-test vs. mixed effect model

```r
library(lme4); set.seed(1001)

x <- rnorm(10, 20, 1)
df <- data.frame(
  id = 1:10,
  x = x,
  y = x + rnorm(10, 2, 1))

# Paired t-test directly
t1 <- with(df, t.test(x, y, paired = TRUE))

# With mixed model (courtesy of Ben Bolker)
dfm <- melt(df, "id")
m1 <- lmer(value ~ variable + (1 | id), data = dfm, REML = T)

all.equal(
  abs(t1$statistic),
  coef(summary(m1))["variabley","t value"])
```

http://vita.had.co.nz/papers.html

http://vita.had.co.nz/presentations.html