

Agenda

1. Experimental Design

Stratified sampling simulation Recall the stratified sampling exercise from last time, and suppose that hourly wages were normally distributed with means \$25, \$15, \$22, and \$15, among the 90 women working full-time, 18 women working part-time, 9 men working full-time, and 63 men working part-time, respectively. The following R code builds a data frame that represents one possible reality.

```
staff = c(rep("women-ft", 90), rep("women-pt", 18), rep("men-ft", 9), rep("men-pt", 63))
wage = c(rnorm(90, mean = 25), rnorm(18, 15), rnorm(9, 22), rnorm(63, 15))
ds = data.frame(staff, wage)
head(ds)

##      staff    wage
## 1 women-ft 24.24287
## 2 women-ft 25.49924
## 3 women-ft 25.73812
## 4 women-ft 25.80283
## 5 women-ft 26.09438
## 6 women-ft 26.54672

nrow(ds)

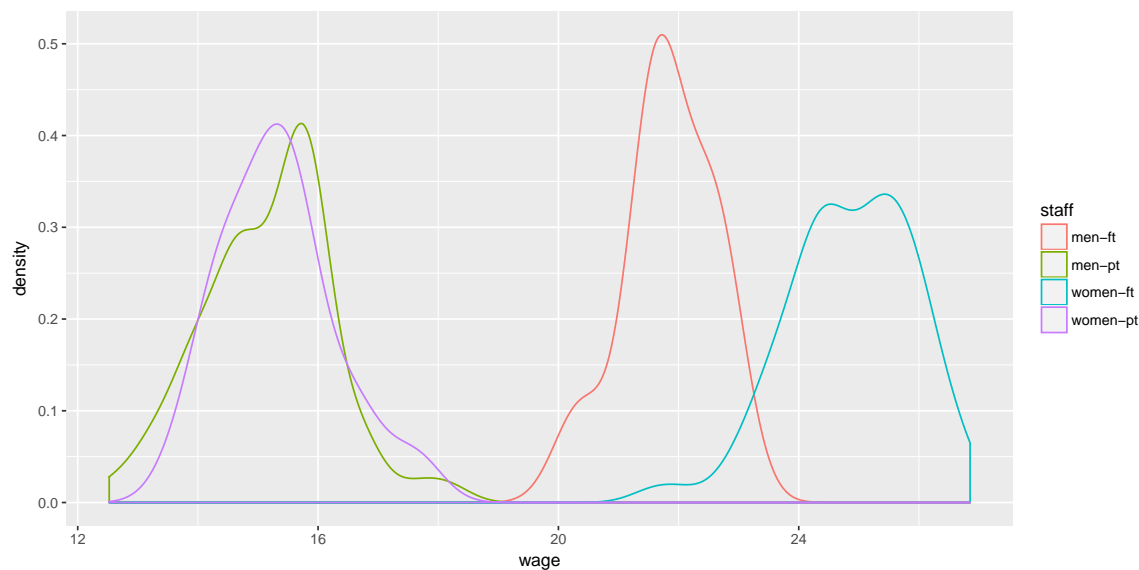
## [1] 180
```

Note that wages are similar *within* the four groups, but dissimilar *among* the groups. This command will draw separate densities for the four groups on the same plot.

```
require(mosaic)

## Warning: package 'dplyr' was built under R version 3.4.1

qplot(x = wage, color = staff, geom = "density", data = ds)
```



We want to estimate the mean wage among all 180 workers. In this case, since we know the wage of all of the workers, we can just compute it.

```
mean(~wage, data = ds)
## [1] 20.36328
```

But recall that for the purposes of this exercise, we don't actually know all 180 wages, and we are asked to sample 40 of them. We can take a *simple random sample* and compute the mean wage within that sample.

```
# simple random sampling
mean(~wage, data = sample(ds, 40))
## [1] 20.00752
```

Note that this is close to the actual mean wage, but not the same. Note also that each time we take a different random sample, we get a different mean wage in that sample.

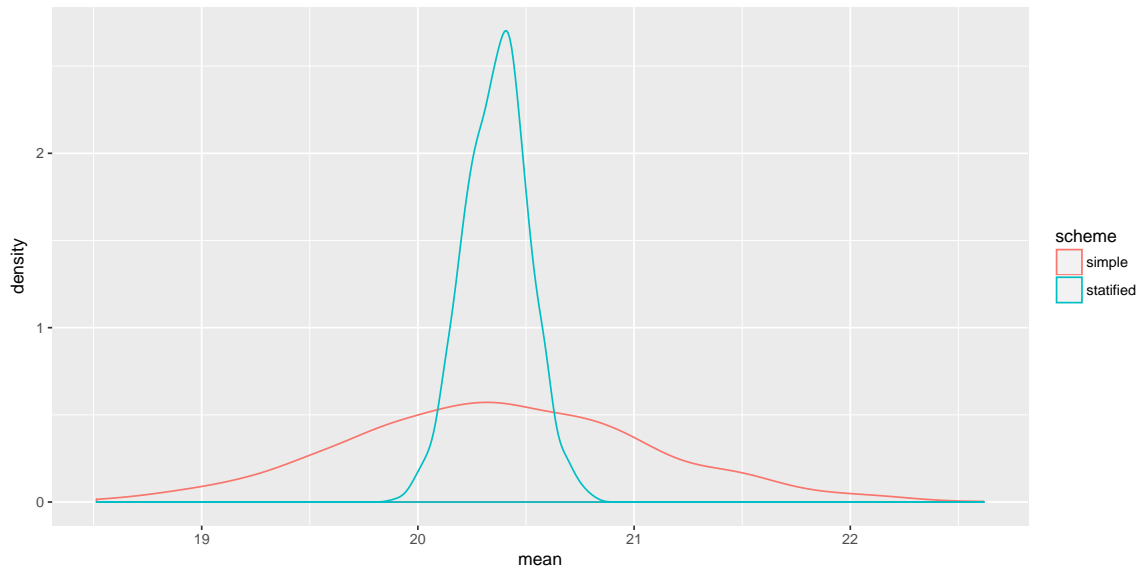
Now let's implement the *stratified sampling* scheme.

```
# Stratified sampling
strat_samp <- bind_rows(
  sample(filter(ds, staff == "women-ft"), 20),
  sample(filter(ds, staff == "women-pt"), 4),
  sample(filter(ds, staff == "men-ft"), 2),
  sample(filter(ds, staff == "men-pt"), 14)
)
mean(~wage, data = strat_samp)
## [1] 20.3993
```

Again, the stratified sample mean is close to the actual value, but not the same. It will also differ each time we take a different random sample. So why might we prefer stratified sampling over simple random sampling?

Let's compare the *distribution* of sample means if we do this many, many times!

```
# Comparison
SRS = do(1000) * mean(~wage, data = sample(ds, 40))
STR = do(1000) * mean(~wage, data = bind_rows(
  sample(filter(ds, staff == "women-ft"), 20),
  sample(filter(ds, staff == "women-pt"), 4),
  sample(filter(ds, staff == "men-ft"), 2),
  sample(filter(ds, staff == "men-pt"), 14)
))
sim = bind_rows(SRS, STR) %>%
  mutate(scheme = rep(c("simple", "stratified"), each = 1000))
qplot(data = sim, x = mean, color = scheme, geom = "density")
```



Experimental Design

1. What is the best way to answer each of the questions below: an experiment, a sample survey, or an observational study that is not a sample survey? Explain your choices.
 - (a) Are people generally satisfied with how things are going in the country right now?
 - (b) Do college students learn basic accounting better in a classroom or using an online course?
 - (c) How long do your teachers wait on average after they ask their class a question?
2. A study showed that women who work in the production of computer chips have abnormally high numbers of miscarriages. The union claimed that exposure to chemicals used in production caused the miscarriages. Another possible explanation is that these workers spend most of their work time standing up. Illustrate these relationships in a diagram.
3. A study shows that there is a positive correlation between the size of a hospital (measured by its number of beds x) and the median number of days y that patients remain in the hospital. Does this mean that you can shorten a hospital stay by choosing a small hospital? Use a diagram to explain the association.

4. Students sign up to be subjects in a psychology experiment. When they arrive, they are told that interviews are running late and are taken to a waiting room. The experimenters then stage a theft of a valuable object left in the waiting room. Some subjects are alone with the thief, and others are in pairs – these are the treatments being compared. Will the subject report the theft? The students had agreed to take part in an unspecified study, and the true nature of the experiment is explained to them afterward. Do you think this study is ethically OK?

Activity For each of the following pairs of variables, a statistically significant positive relationship has been observed. Identify a potential lurking variable that might cause the spurious correlation.

1. The amount of ice cream sold in New England and the number of deaths by drowning
2. The salary of U.S. ministers and the price of vodka
3. The number of doctors in a region and the number of crimes committed in that region
4. The number of storks sighted and the population of Oldenburg, Germany, over a six-year period
5. The amount of coffee consumed and the prevalence of lung cancer