Chapter 7

Data Ethics

Besides honesty, basic ethical requirements for any study of human subjects in U.S. are approval by a review board, informed consent and confidentiality of data. Main purpose of *institutional review board (IRB)* is to be sure subjects in *human* studies are safe. *Informed consent* means asking subjects to agree to participate in a study after first informing them of nature of study and possible risks and benefits. *Confidentiality* means publishing group data where individual information cannot be determined.

Exercise 7.1 (Data Ethics)

1. *Institutional review board.* Purdue's IRB board consists of at least five individuals who first decide level of review is required for each research proposal. Subjects in research proposals face *minimal* risk if the risks are no more than "...those ordinarily encountered in daily life or during performance of routine physical or psychological examinations or tests". Which situation do *you* feel involves minimal risk?

   (a) **minimal risk / more than minimal risk / not applicable**
   Assessing association between *number* of student emails asking for online help and student academic performance for a statistics course at PNW.

   (b) **minimal risk / more than minimal risk / not applicable**
   Assessing association between *content* of student emails asking for online help and academic performance for a statistics course at PMW.

   (c) **minimal risk / more than minimal risk / not applicable**
   Analyzing an *anonymous* student survey of student asking for online help for a statistics course at PNW.

   (d) **minimal risk / more than minimal risk / not applicable**
   Assessing impact of water temperature, acidity, current strength on Bryozoan growth rate in Michigan City harbor.

   (e) **minimal risk / more than minimal risk / not applicable**
   Drawing a drop of blood by pricking a finger for a DNA study on blood.

(f) **minimal risk / more than minimal risk / not applicable**
Drawing vial of blood from an arm for full set of blood tests.

(g) **minimal risk / more than minimal risk / not applicable**
Social scientist attends public religious meetings to observe behavior.

(h) **minimal risk / more than minimal risk / not applicable**
Social scientist pretends conversion to attend private religious meetings to observe behavior patterns.

2. *Informed consent.* Which situation do *you* think requires informed consent?

   (a) **required / not required / not applicable**
   Assessing association between *number* of student emails asking for online help and student academic performance for a statistics course at PNW.

   (b) **required / not required / not applicable**
   Assessing association between *number* of student emails asking for online help and student academic performance for a statistics course given at PNW between 1995 and 2005.

   (c) **required / not required / not applicable**
   Assessing association between *content* of student emails asking for online help and academic performance for a statistics course at PNW.

   (d) **required / not required / not applicable**
   Analyzing an *anonymous* student survey of student asking for online help for a statistics course at PNW.

   (e) **required / not required / not applicable**
   Assessing impact of water temperature, acidity, current strength on Bryozoan growth rate in Michigan City harbor.

   (f) **required / not required / not applicable**
   Drawing a drop of blood by pricking a finger for DNA study on blood.

   (g) **required / not required / not applicable**
   Drawing vial of blood from arm for full set of blood tests.

   (h) **required / not required / not applicable**
   Social scientist attends public religious meetings to observe behavior.

   (i) **required / not required / not applicable**
   Social scientist pretends conversion to attend private religious meetings to observe behavior patterns.

3. *Informed consent and authority.* Situations where researcher is authority figure to subject require care in obtaining informed consent. Which of following situations is researcher possible authority figure to subjects?

(a) **authority / no authority / not applicable**
Assessing association between *number* of student emails asking for online help and student academic performance for a statistics course at PNW, based on data gathered by the instructor of the statistics course.

(b) **authority / no authority / not applicable**
Assessing association between *number* of student emails asking for online help and student academic performance for a statistics course given at PNW between 1995 and 2005, based on data gathered by the instructor of the statistics course.

(c) **authority / no authority / not applicable**
Assessing association between *content* of student emails asking for online help and academic performance for a statistics course at PNW, based on data gathered by third party.

(d) **authority / no authority / not applicable**
Analyzing an *anonymous* student survey of student asking for online help for a statistics course at PNW.

(e) **authority / no authority / not applicable**
Assessing impact of water temperature, acidity, current strength on Bryozoan growth rate in Michigan City harbor.

(f) **authority / no authority / not applicable**
Drawing a drop of blood by pricking patient's finger by personal doctor for DNA study on blood.

(g) **authority / no authority / not applicable**
Drawing vial of blood from arm for full set of blood tests by government agency representative.

(h) **authority / no authority / not applicable**
Social scientist attends public religious meetings to observe behavior.

(i) **authority / no authority / not applicable**
Social scientist pretends conversion to attend private religious meetings to observe behavior patterns.

4. *Anonymous or confidential?* Published research papers maintain confidentiality by presenting average or counts of individual information. Often, though, published results based on researcher's data where individuals can be identified. If researcher's private individual information also not identifiable, then research maintains individual's anonymity. Identify which situation achieves anonymity or confidentiality.

(a) **anonymous / confidential / not applicable**
Assessing association between *number* of student emails asking for online

help and student academic performance for a statistics course at PNW, based on data gathered by the instructor of the statistics course.

(b) **anonymous / confidential / not applicable**
Assessing association between *number* of student emails asking for online help and student academic performance for a statistics course given at PNW between 1995 and 2005, based on data gathered by the instructor of the statistics course.

(c) **anonymous / confidential / not applicable**
Assessing association between *content* of student emails asking for online help and academic performance for a statistics course at PNW, based on data gathered by third party.

(d) **anonymous / confidential / not applicable**
Analyzing an *anonymous* student survey of student asking for online help for a statistics course at PNW.

(e) **anonymous / confidential / not applicable**
Assessing impact of water temperature, acidity, current strength on Bryozoan growth rate in Michigan City harbor.

(f) **anonymous / confidential / not applicable**
Drawing a drop of blood by pricking patient's finger by personal doctor for DNA study on blood.

(g) **anonymous / confidential / not applicable**
Drawing vial of blood from arm for full set of blood tests by government agency representative.

(h) **anonymous / confidential / not applicable**
Social scientist attends public religious meetings to observe behavior.

(i) **anonymous / confidential / not applicable**
Social scientist pretends conversion to attend private religious meetings to observe behavior patterns.

5. *Benefits versus risks.* As long as subjects are not harmed, benefits should outweigh risks in any study. Which situations do *you* feel benefits outweigh risk?

(a) **beneficial / risky / not applicable**
Assessing association between *number* of student emails asking for online help and student academic performance for a statistics course at PNW, based on data gathered by the instructor of the statistics course.

(b) **beneficial / risky / not applicable**
Assessing association between *number* of student emails asking for online help and student academic performance for a statistics course given at

PNW between 1995 and 2005, based on data gathered by the instructor of the statistics course.

(c) **beneficial / risky / not applicable**
Assessing association between *content* of student emails asking for online help and academic performance for a statistics course at PNW, based on data gathered by third party.

(d) **beneficial / risky / not applicable**
Analyzing an *anonymous* student survey of student asking for online help for a statistics course at PNW.

(e) **beneficial / risky / not applicable**
Assessing impact of water temperature, acidity, current strength on Bryozoan growth rate in Michigan City harbor.

(f) **beneficial / risky / not applicable**
Drawing a drop of blood by pricking patient's finger by personal doctor for DNA study on blood.

(g) **beneficial / risky / not applicable**
Drawing vial of blood from arm for full set of blood tests by government agency representative.

(h) **beneficial / risky / not applicable**
Social scientist attends public religious meetings to observe behavior.

(i) **beneficial / risky / not applicable**
Social scientist pretends conversion to attend private religious meetings to observe behavior patterns.

Chapter 8

Measuring

The property of a person or thing is *measured* if a numerical value (previously called a numerical data point) is used to represent this property. The result of the measurement is a numerical *variable* which takes different values (also discussed previously). An *instrument* performs the measurement; *units* identifies the type of measurement. Measurement is used throughout statistics. In particular, recall, a "good" statistic is one which is both a *valid* and *reliable* estimate of a parameter and, so it is not surprising measurement can be modelled in the following way:

$$\text{measured value} = \text{true value} + \text{bias} + \text{random error},$$

where, as before, bias is systematic error which either overstates or understates true value and random error is the random variability in the measurement. Since a SRS has been used and so has corrected (reduced) some bias, this implies the bias in this model is either instrument error or validity error. Notice, a measured value is closer to the true value the smaller the bias (so increasing validity) and also the smaller the random error (so increasing reliability). *Variance* is another way (margin of error was previously used) to measure reliability:

$$\text{variance} = \frac{\text{sum of (each measured value} - \text{average of measured values)}^2}{n-1}.$$

The square root of variance, *standard deviation*, is yet another way to measure random error. If it is difficult to make a (direct) valid measurement of property A, it is often possible to first make an easier measurement of associated property B to then make an (indirect) *predictive valid* measurement of property A instead (as in, for example, randomized comparative experiments).

Exercise 8.1 (Measuring)

1. *Measurement: milk study.* Consider table below which contains various measurements on a number of cows taken during a study on effect of a hormone, given in tablet form, on daily milk yield.

Cow ID	Test Date	Farm	Height	Health	Tablets	Before Yield	After Yield
14	9/03/98	F	49	fair	3	98.8	99.6
15	9/01/98	M	45	good	3	100.9	100.0
16	9/10/98	F	42	poor	1	101.1	100.1
17	9/11/98	M	41	poor	2	100.7	100.3
18	9/11/98	F	40	bad	1	97.8	98.1
19	9/25/98	M	45	good	2	100.0	100.4
20	9/25/98	M	37	good	3	101.5	100.8

(a) (review) Individuals in study are (choose one)
hormones / **daily milk yields** / **cow ID** / **cows**

(b) (review) Variables in this study are (choose one of the two lists)

i. 14, 15, 16, 17, 18, 19, 20

ii. Cow ID, Test Date, Farm, Height, Health, Tablets, Before/After Yield

(c) *(Number of) Tablets variable*

i. is **numerical** / **qualitative**, whose values are measurements

ii. measured with instrument **cows** / **tablet dispenser** / **researcher**

iii. with units of measurement **number of tablets** / **number of cows**

(d) *Height (of cow) variable*

i. is numerical, whose values **are** / **are not** measurements

ii. measured with instrument **measuring tape** / **thermometer** / **scale**

iii. with units of measurement **inches** / **feet** / **quarts**

(e) *(Before and After) Milk yield variables*

i. are numerical, whose values **are** / **are not** measurements

ii. measured with **thermometer** / **voltmeter** / **weight scale**

iii. with units of measurement **quarts per foot** / **centimeters** / **pounds**

(f) *Test date variable*

i. is **numerical** / **qualitative**, whose values are measurements

ii. measured with instrument **thermometer** / **clock** / **quart buckets**

iii. with units of measurement **days** / **centimeters** / **minutes**

(g) Cow ID **does** / **does not** consist of a number of measurements because it is a qualitative variable. Cow ID is observed, not measured.

(h) Health **does** / **does not** consist of a number of measurements because it is a qualitative variable. Health measurable *if* numerical points, such as "1" for bad, "2" for poor, "3" for fair and "4" for "good" *valid* (cow undergoes complete physical exam to determine sensible numerical health score) assignment to this variable.

2. *More measurements.*

   (a) *Height of a man variable*

      i. is **numerical** / **qualitative**, whose values are measurements
      ii. measured with instrument **thermometer** / **clock** / **measuring tape**
      iii. with units of measurement **days** / **meters** / **minutes**

   (b) *Recorded traffic accidents variable*

      i. are numerical, whose values **are** / **are not** measurements
      ii. measured with instrument **thermometer** / **police reports** / **tape**
      iii. with units of measurement **days** / **centimeters** / **number**

   (c) *Person's length of time of exposure to sun variable*

      i. is **numerical** / **qualitative**, whose values are measurements
      ii. measured with instrument **clock** / **police reports** / **measuring tape**
      iii. with units of measurement **minutes** / **centimeters** / **number**

3. *Variance and Standard Deviation (SD): measuring reliability (variability): weight.* It is known Sally weighs 130 pounds. She weighs herself four times on a faulty scale which gives readings which are 3 pounds lower than they should be:

   125 129 126 128

   (a) If it is assumed

   $$\text{measured value} = \text{true value} + \text{bias} + \text{random error},$$

   then, rearranging,

   $$\text{random error} = \text{measured value} - \text{true value} - \text{bias},$$

   and so the random error associated with first weight measurement, 125 pounds, actual weight 130 pounds and bias -3 pounds, is

   $$\text{random error} = 125 - 130 - (\text{-}3) =$$

   −2 / **−1** / **0** / **1** / **2** pounds

   (b) Random error associated with second weight measurement, 129 pounds, actual weight 130 pounds and bias -3 pounds, is

   $$\text{random error} = 129 - 130 - (\text{-}3) =$$

   −2 / **−1** / **0** / **1** / **2** pounds

   (c) Random error associated with third weight measurement, 126 pounds, actual weight 130 pounds and bias -3 pounds, is

   $$\text{random error} = 126 - 130 - (\text{-}3) =$$

−2 / **−1** / **0** / **1** / **2** pounds

(d) Random error associated with fourth weight measurement, 128 pounds, actual weight 130 pounds and bias -3 pounds, is

$$\text{random error} = 128 - 130 - (\text{-}3) =$$

−2 / **−1** / **0** / **1** / **2** pounds

(e) *Average of random errors.*

$$\text{average} = \frac{-2 + 2 - 1 + 1}{4} =$$

−0.25 / **0** / **0.25** pounds

(f) *Measure reliability using variance.*

random error	(random error − average)^2
-2	$(-2-0)^2 = (-2)^2 = 4$
2	$(2-0)^2 = (2)^2 = 4$
-1	$(-1-0)^2 = (-1)^2 = 1$
1	$(1-0)^2 = (1)^2 = 1$
	sum = 10

so

$$\text{variance} = \frac{10}{4-1} =$$

1.8 / **3.3** / **4.3** pounds^2 and so

$$\text{SD} = \sqrt{\text{variance}} = \sqrt{\frac{10}{4-1}} =$$

1.8 / **3.3** / **4.3** pounds^2

4. *More variance and standard deviation (SD): measuring reliability (variability): weight again.* It is known Sally weighs 130 pounds. She is weighs herself four times on a faulty scale which gives readings which are 6 pounds lower (instead of 3 pounds lower) than they should be:

$$125 \quad 129 \quad 126 \quad 128$$

(a) Random error associated with first weight measurement, 125 pounds, actual weight 130 pounds and bias -6 pounds, is

$$\text{random error} = 125 - 130 - (\text{-}6) =$$

1 / **2** / **3** / **4** / **5** pounds

(b) Random error associated with second weight measurement, 129 pounds, actual weight 130 pounds and bias -6 pounds, is

$$\text{random error} = 129 - 130 - (\text{-}6) =$$

1 / **2** / **3** / **4** / **5** pounds

(c) Random error associated with third weight measurement, 126 pounds, actual weight 130 pounds and bias -6 pounds, is

$$\text{random error} = 126 - 130 - (\text{-}6) =$$

1 / **2** / **3** / **4** / **5** pounds

(d) Random error associated with fourth weight measurement, 128 pounds, actual weight 130 pounds and bias -6 pounds, is

$$\text{random error} = 128 - 130 - (\text{-}6) =$$

1 / **2** / **3** / **4** / **5** pounds

(e) *Average of random errors.*

$$\text{average} = \frac{1+5+2+4}{4} =$$

1 / **2** / **3** pounds

(f) *Measure reliability using variance.*

random error	(random error − average)^2
1	$(1-3)^2 = (-2)^2 = 4$
5	$(5-3)^2 = (2)^2 = 4$
2	$(2-3)^2 = (-1)^2 = 1$
4	$(4-3)^2 = (1)^2 = 1$
	sum = 10

so

$$\text{variance} = \frac{10}{4-1} =$$

1.8 / **3.3** / **4.3** pounds^2 and so

$$\text{SD} = \sqrt{\text{variance}} = \sqrt{\frac{10}{4-1}} =$$

1.8 / **3.3** / **4.3** pounds^2

so, notice, variance is the *same* here as before; in other words, changing bias (6 pounds lower rather than 3 pounds lower) only does *not* influence reliability

5. *Validity: cows.*

(a) *Milk yield of cow.* Identify *valid* measurement(s) of milk yield of cow.
age / **weight** / **quarts** / **quarts per day** / **pounds of milk**

(b) *Health of cow.* Identify valid measurement(s) of health of cow.
age / **weight** / **blood pressure** / **injures** / **eyesight** / **all**

Difficult to say since "health" is vague.

(c) *Cardiovascular health of cow.*
Identify valid measurement(s) of cardiovascular health of patient.
age / **body mass index** / **blood pressure** / **injures** / **eyesight**

Still difficult to say but easier identification of valid measurement since cardiovascular health, related to the heart, is more specific than just "health".

(d) *Milk yield of farm.* Identify valid measurement(s) of milk yield of farm.
age / **weight** / **pounds per farm** / **quarts** / **pounds per cow**

6. *Validity: rates versus counts.* Rate (fraction, proportion, percentage) often **is** / **is not** more valid measurement than count. Having said this, giving both rate and count is probably best of all: It might be scary to say traffic accidents increased by 50% at intersection until you discover this means there were 3 instead of 2 accidents at intersection ($\frac{3-2}{2} = 0.50$ or 50%).

7. *Reliability (variability) and validity (bias): political preference.* It is known 68% of registered voters in Berrien County, Michigan, are registered as Democrats. We call 500 Berrien County voters at random and ask their party. We do this 5 times. Results are 59.2%, 58.9%, 60.5%, 57.4% and 61.3% Democratic.

(a) Sampling method appears to be (choose one)

(i) unreliable (large variability) and not valid (large bias)
(ii) unreliable (large variability) and valid (small bias)
(iii) reliable (small variability) and not valid (large bias)
(iv) reliable (small variability) and valid (small bias)

indicating sampling instrument (method of asking voter's preference) must be improved

(b) Calling 1000 instead of 500 voters
improves / **does not change** / **worsens** reliability.

proportions (averages, really) of 1000 voters will be less variable, more reliable, than proportions based on 500 voters

(c) Calling 1000 instead of 500 voters
improves / **does not change** / **worsens** validity.

if the method of measuring whether a voter is Democrat or not is broken, using it 1000 times instead of 500 times is not going to improve matters

(d) Calling 500 voters ten times instead of five times
improves / **does not change** / **worsens** reliability.

will get a better idea of what the reliability is, but the reliability itself will not change because the number of voters remains the same whether done five or ten times

8. *Predictive validity.*

   (a) *Milk yield of cow.*
   Valid measurement of milk yield of cow is *pounds per day.* If younger cows produce more milk than older cows, *age* would be a *predictive valid* measurement of milk yield of cow. Identify other possible predictive valid measurement(s) of milk yield of cow.
   demeanor / weight / gender / living conditions
   Identifying predictive valid measurements may be used to identify *why* there is an increase or decrease in milk yield in this case.

   (b) *Voting habits.*
   Identify predictive valid measurement(s) of voting habits.
   age / weight / gender / education / TV viewing habits

Chapter 9

Do the Numbers Make Sense?

Items which may influence either validity or reliability or both of the study are

- Is context of data valid: is important information missing?
- Are numbers consistent with one another?
- Implausible number: too big or too small?
- Are numbers *too* consistent: agree too well?
- Is the arithmetic correct; in particular, related to percentage change:

$$\% \text{ change } = \frac{\text{amount of change}}{\text{starting value}} \times 100$$

Exercise 9.1 (Do the Numbers Make Sense?)

1. *Some examples.* Identify problem with numbers in following situations.

   (a) **missing information / consistency / implausible**
   too consistent / arithmetic
   Huge percentage, 42% in fact, of traffic accidents occur on Friday, Saturday and Sunday, apparently due to increased weekend drinking.
   Hint: Phrase "huge percentage 42%" overshadows that three days of week is $\frac{3}{7} \approx 0.43 = 43\%$, so although not missing information exactly, worded in such a way to miss this.

   (b) **missing information / consistency / implausible**
   too consistent / arithmetic
   In set of 10 rats in experiment, percentage of 10 rats changed by DNA experiment is 18%.
   Hint: One out of 10 rats is 10% and two out of 10 rats is 20%, so where did the 18% come from? This seems inconsistent.

(c) **missing information / consistency / implausible too consistent / arithmetic**
One in 75 drivers die in a car accident each year.
Hint: In fact, about 42,000 people of 304 million die in the U.S. every year, $\frac{300{,}000{,}000}{42000} \approx 7,143$; in other words, 1 in 7,143 die each year, so 1 in 75 is an implausibly large fraction.

(d) **missing information / consistency / implausible too consistent / arithmetic**

semester	STAT 113 final
fall 2006	75%
spring 2006	75%
fall 2007	75%

Hint: The 75% for all semesters seems too consistent.

(e) **missing information / consistency / implausible too consistent / arithmetic**
Stock values dropped 125% on Monday.
Hint: Someone got their arithmetic mixed up: stocks can *increase* 125% but can values drop more than 100% (everything) ?

2. *More examples.* Identify problem with numbers in following situations.

(a) **missing information / consistency / implausible too consistent / arithmetic / no problem**
Sea-side resort boasts largest waves, on average, for surfers.
Hint: *Average* wave large, but possibly there is the missing information of a very few large waves and many small waves which average out to a large average because the average is sensitive to outliers.

(b) **missing information / consistency / implausible too consistent / arithmetic/ no problem**
Of 25,000 hovercrafts sold in U.S. each, Float-Craft company sells 15,000.
Hint: Is Float-Craft only company in U.S. to sell hovercrafts? Seems implausible that one company would sell more than half of the hovercrafts in the U.S.

(c) **missing information / consistency / implausible too consistent / arithmetic/ no problem**
Stock values dropped from 2456 to 2134, a 13% decrease, on Monday.
Hint: $\frac{\text{change}}{\text{starting value}} = \frac{2456-2134}{2456} \approx 0.13$.

(d) **missing information / consistency / implausible too consistent / arithmetic / no problem**
Stock values increase from 200 to 600, a 200% increase, on Monday.
Hint: $\frac{\text{change}}{\text{starting value}} = \frac{600-200}{200} = 2$, an absolutely massive increase which seems implausible.