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SKU: 9780134301051-SOLUTIONS

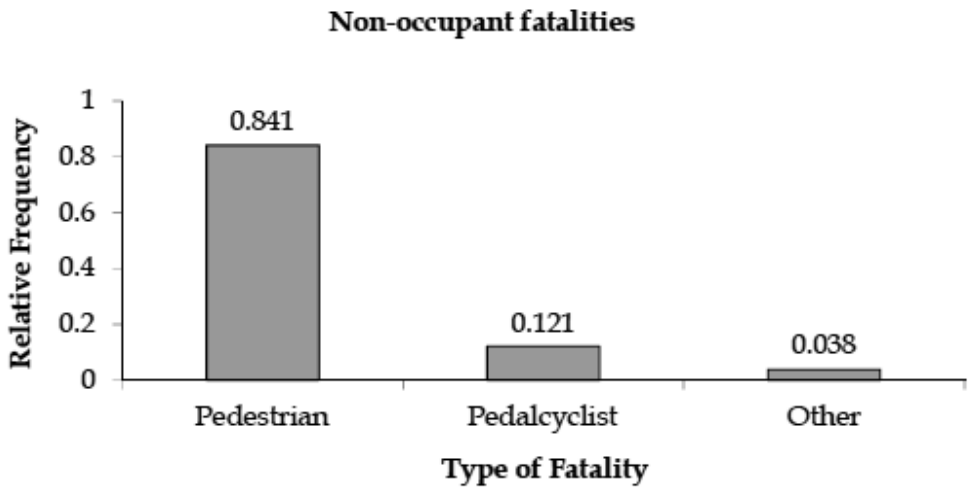
Chapter 2: Displaying and Describing Categorical Data

Section 2.1

1. Automobile fatalities.

Subcompact and Mini	0.1128
Compact	0.3163
Intermediate	0.3380
Full	0.2193
Unknown	0.0137

2. Nonoccupant fatalities.



3. Movie genres.
A) 2008 (iii) B) 1996 (i) C) 2006 (ii) D) 2012 (iv)

4. Marriage in decline.
A) People Living Together Without Being Married (ii)
B) Gay/Lesbian Couples Raising Children (iv)
C) Unmarried Couples Raising Children (iii)
D) Single Women Having Children (i)

Section 2.2

5. Movies again.
a) 170/348 x 100% ≈ 48.9% of these films were rated R.
b) 41/348 x 100% ≈ 11.8% of these films were R-rated comedies.
c) 41/170 x 100% ≈ 24.1% of the R-rated films were comedies.
d) 41/90 (100% x 100%) ≈ 45.6% of the comedies were R-rated.

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6. Labour force.

a) 1261/29572 x 100% ≈ 4.26% of the population were unemployed.
b) 675/29572 x 100% ≈ 2.28% of the population were both unemployed and aged 25 to 54 years.
c) 380/4387 x 100% ≈ 8.66% of 15 to 24 year olds were unemployed.
d) 745/18410 x 100% ≈ 4.05% of those who were employed were aged 65 years and over.

Chapter Exercises

7. Graphs in the news I. Answers will vary.

8. Graphs in the news II. Answers will vary.

9. Tables in the news I. Answers will vary.

10. Tables in the news II. Answers will vary.

11. Forest Fires 2014. The relative frequency distribution of the forest fires is shown below:

Cause of fire	Percentage
Lightning	46.10%
Human activities	51.40%
Unknown	2.50%

Causes of forest fires are about equally split between human activities and lightning. Only 2.50% of forest fires are due to unknown causes.

12. Forest fires 2014 by region.

Province	Percentage
Quebec	5.67%
Ontario	5.88%
Alberta	28.53%
BC	28.44%
Other	31.48%

Most forest fires occurred in Alberta and BC. Combined, they had nearly five times as many fires as Quebec and Ontario combined. The four provinces account for over two thirds of the forest fires in Canada.

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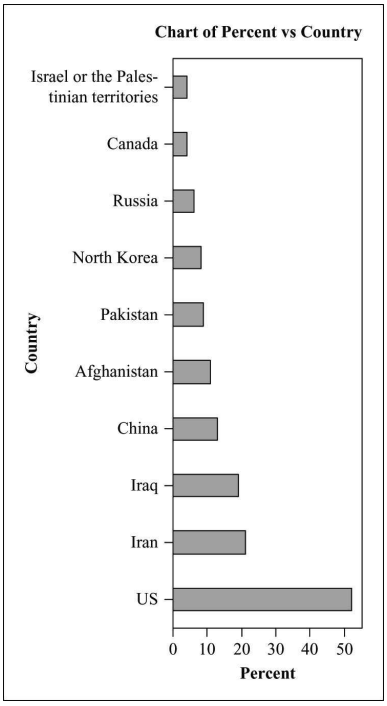
13. Teen smokers According to the Monitoring the Future study, teen smoking brand preferences differ somewhat by region. Although Marlboro is the most popular brand in each region, with about 58% of teen smokers preferring this brand in each region, teen smokers from the South prefer Newports at a higher percentage than teen smokers from the West, with 22.5% of teen smokers preferring this brand, compared to only 10.1% in the South. Teen smokers in the West are also more likely to have no particular brand than teen smokers in the South. 12.9% of teen smokers in the West have no particular brand, compared to only 6.7% in the South. Both regions have about 9% of teen smokers that prefer one of over 20 other brands.

14. Bad countries

a) A bar chart is appropriate, because the variable we want to display is a categorical variable. Some individuals can choose more than one country as bad, and for this reason a pie chart is not appropriate.



b) No, it is not possible to determine what percent of individuals could not name any country as a negative force. It is possible that only the individuals who listed the U.S. as a negative force (52%) listed other countries also, and all others (i.e., 48%) did not name any country as a negative force.

c) This not true. Some (or maybe even all) who named Iran also named Iraq and Pakistan, and in this case this proportion is less than 49% (21 + 19 + 9).

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15. Oil spills 2013.

a) Grounding, accounting for approximately 150 spills, is the most frequent cause of oil spillage for these 459 spills. A substantial number of spills, approximately 140, were caused by Collision. Less prevalent causes of oil spillage in descending order of frequency were Hull or equipment failures, Fire & Explosions, and Other/Unknown causes.

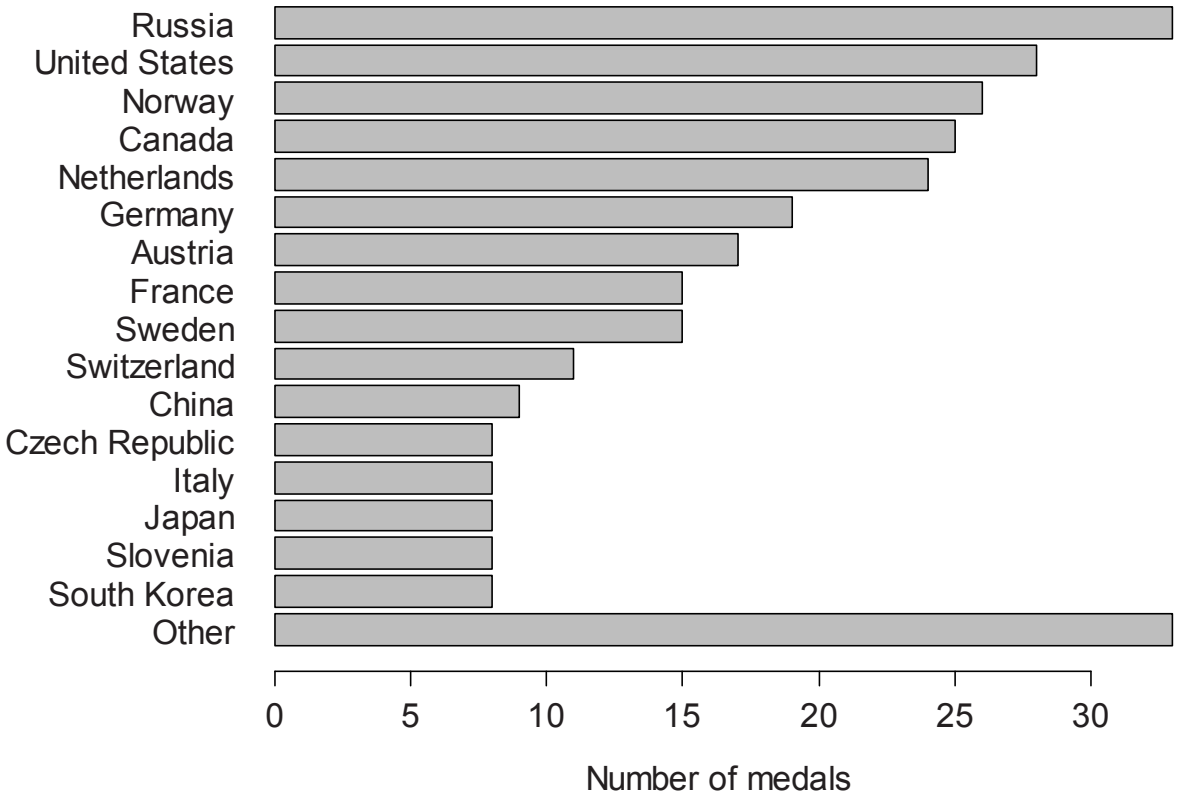
b) A pie chart is an appropriate display of the data, since there is only a single cause attributed to each spill, and all spills are represented in some category.

c) There were more spills due to Grounding than Collisions. This is much easier to see on the bar chart.

16. Winter Olympics 2014.

a) There are too many categories to construct an appropriate display. In a bar chart, there are too many bars. In a pie chart, there are too many slices. In each case, we run into difficulty trying to display those countries that didn't win many medals.

b) Perhaps we are primarily interested in countries that won many medals. We might choose to combine all countries that won fewer than 8 medals into a single category. This will make our chart easier to read. We are probably interested in number of medals won, rather than percentage of total medals won, so we'll use a bar chart. A bar chart is also better for comparisons.



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17. Global warming Perhaps the most obvious error is that the percentages in the pie chart only add up to 93%, when they should, of course, add up to 100%. Furthermore, the three-dimensional perspective view distorts the regions in the graph, violating the area principle. The regions corresponding to No Solid Evidence and Due to Human Activity should be roughly the same size, at 32% and 34% of respondents, respectively. However, the 32% region looks bigger, and the angle for the 34% region makes it look only slightly bigger than the 18% region. Always use simple, two-dimensional graphs.

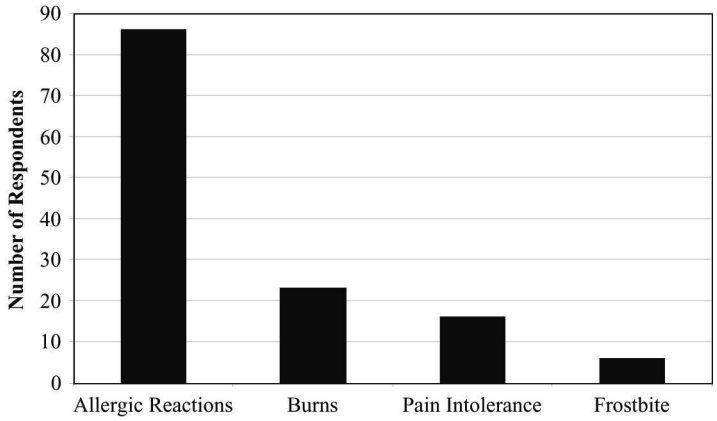
18. Modalities

a) The bars have false depth, which can be misleading. This is a bar chart, so the bars should have space between them.

b) The percentages sum to 100%. Normally, we would take this as a sign that all of the observations had been correctly accounted for. But in this case, it is extremely unlikely. Each of the respondents was asked to list *three* modalities. For example, it would be possible for 80% of respondents to say they use ice to treat an injury, and 75% to use electric stimulation. In this case, the fact that the percentages total greater than 100% would not be odd. In fact, it seems wrong that the percentages add up to 100%.

19. Complications

a) A bar chart is the proper display for these data. A pie chart is not appropriate since these are counts, not fractions of a whole.



b) The *Who* for these data is athletic trainers who used cryotherapy, which should be a cause for concern. A trainer who treated many patients with cryotherapy would be more likely to have seen complications than one who used cryotherapy rarely. We would prefer a study in which the *Who* referred to patients so we could assess the risks of each complication.

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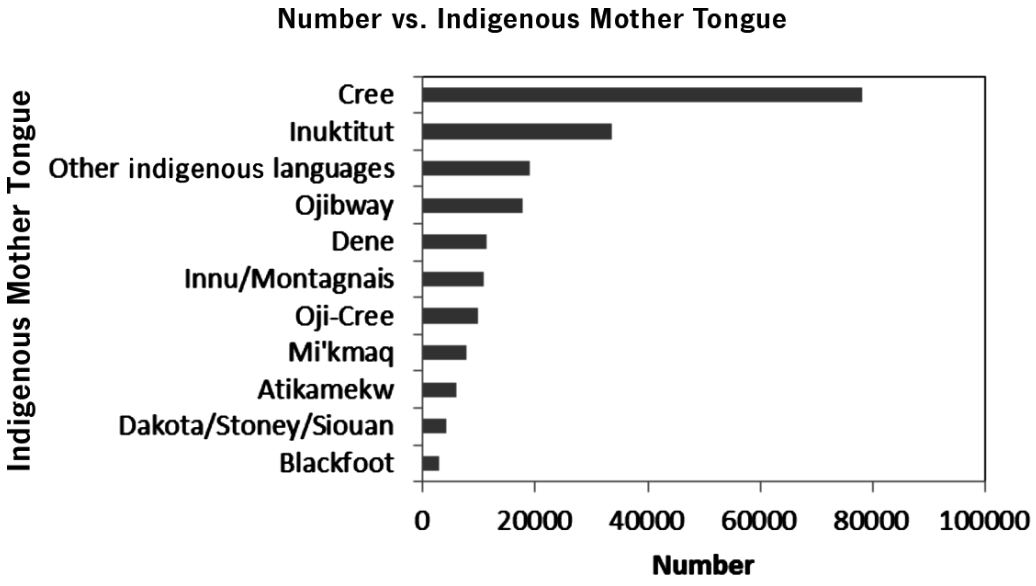
20. Indigenous languages 2011

a) The relative frequency (percentages) distribution of Indigenous mother tongue is given below.

Indigenous mother tongue	%
Cree	38.9636
Ojibway	8.7818
Oji-Cree	4.9003
Innu/Montagnais	5.3737
Mi'kmaq	3.8042
Atikamekw	2.8999
Blackfoot	1.4250
Inuktitut	16.6916
Dene	5.5879
Dakota/Stoney/Siouan	2.0927
Other	9.4793

b) Bar charts and pie charts are shown below. Cree is the mother tongue of the most and Blackfoot the least. Both bar charts and pie charts are good. It is a bit easier to compare the relative frequencies on the bar chart.



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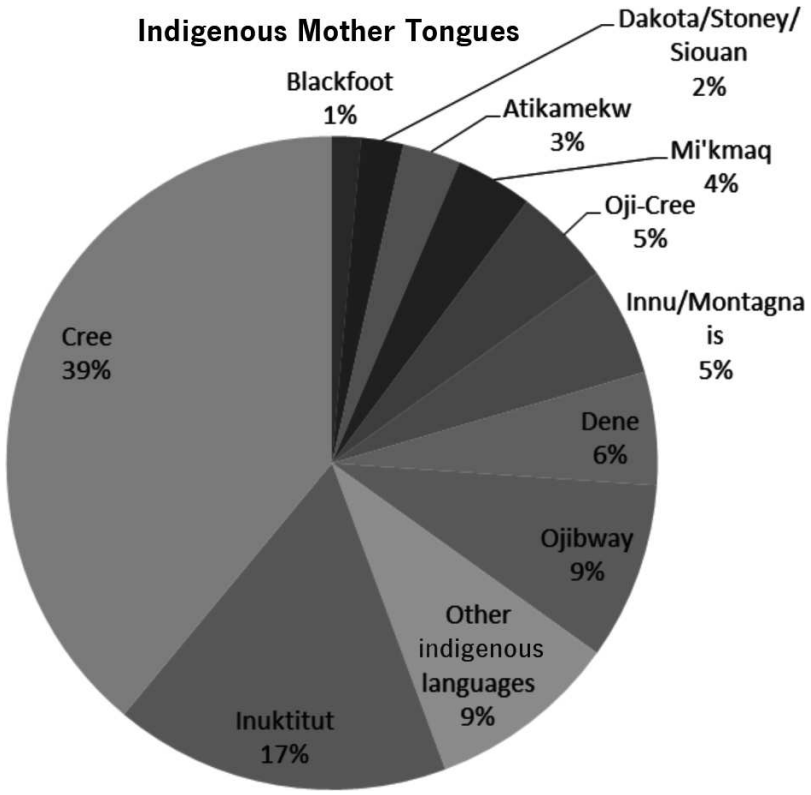
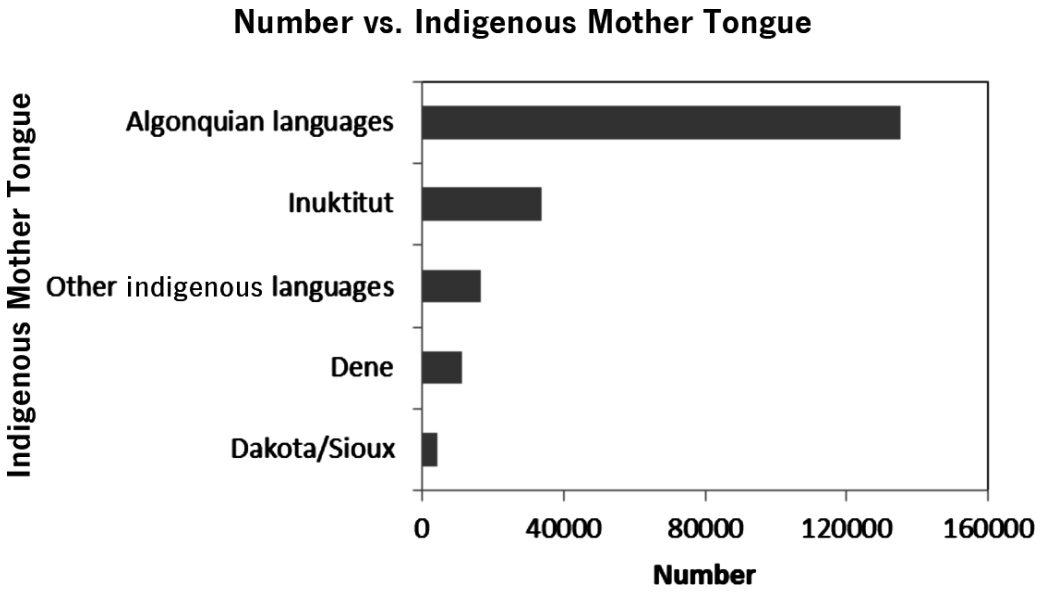


c) Bar charts and pie charts are shown below. More than 67% reported an *Algonquian* language as their mother tongue and Dakota/Sioux is the least spoken as the mother tongue (of those we have data for).



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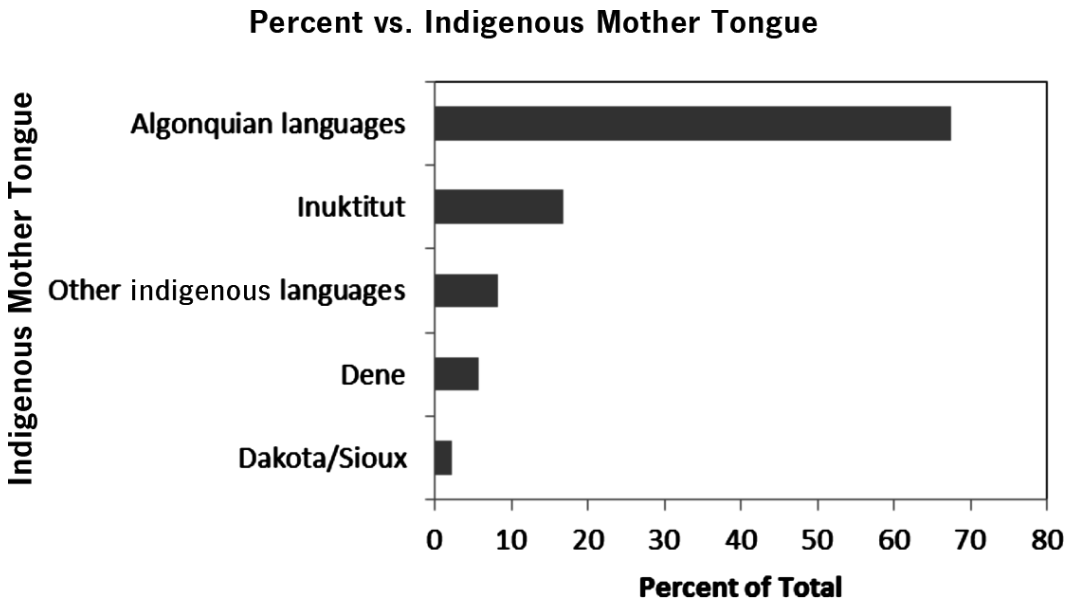

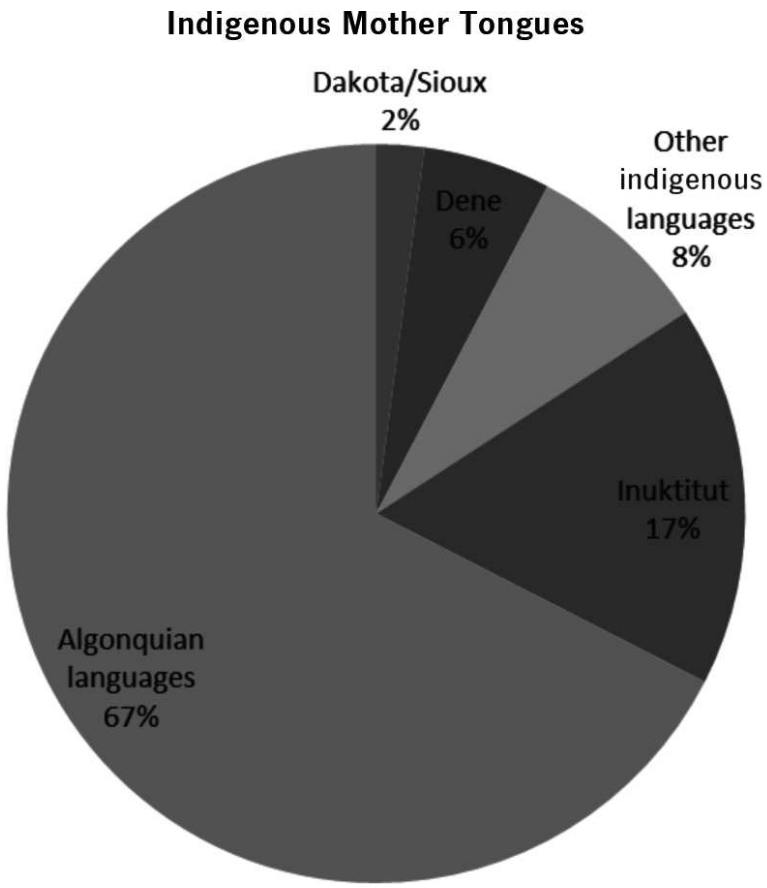

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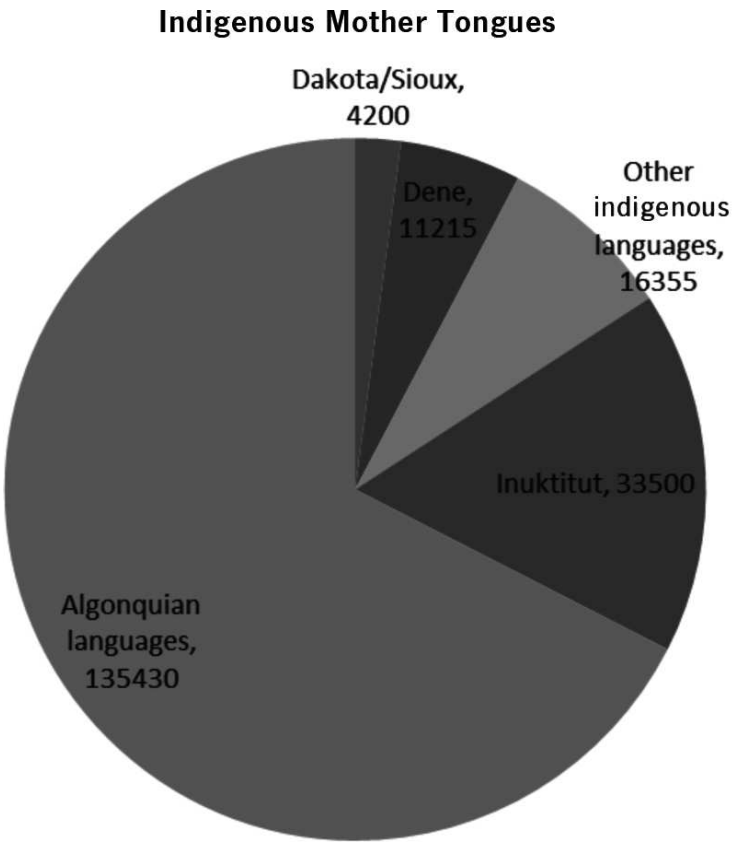

21. Spatial distribution

a) The relative frequency distribution of quadrant location is given below. Not all proportions are equal. In particular, the relative frequency for Quadrant 4 is approximately twice the other frequencies.

Quadrant	Quadrant 1	Quadrant 2	Quadrant 3	Quadrant 4
Relative Frequency	0.18	0.21	0.22	0.39

b) The relative frequency distribution of quadrant location is given below. There seems to have some similarity with that in part a. For example, Quadrant 4 has the highest relative frequency and Quadrant 1 has the lowest.

Quadrant	Quadrant 1	Quadrant 2	Quadrant 3	Quadrant 4
Relative Frequency	0.12	0.24	0.28	0.36

22. Politics

a) There are 192 students taking Intro Stats. Of those, 115, or about 59.9%, are male.

b) There are 192 students taking Intro Stats. Of those, 27, or about 14.1%, consider themselves to be "Conservative."

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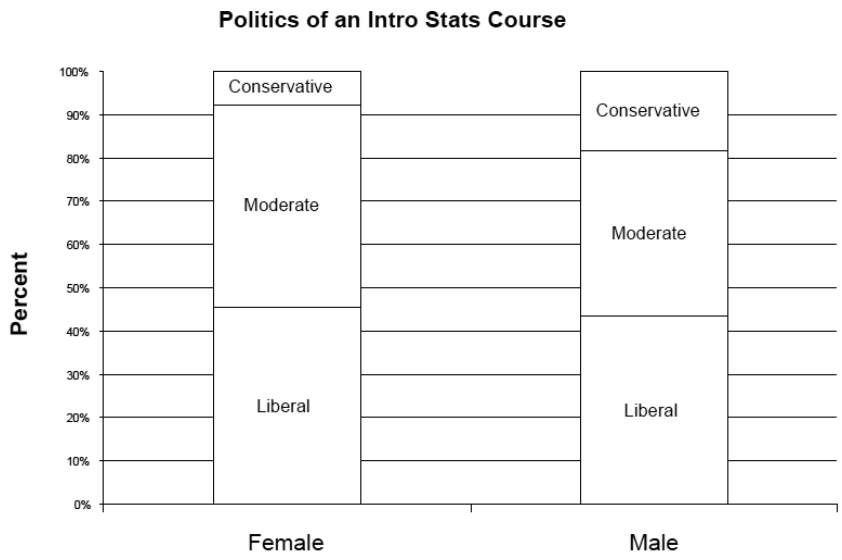
c) There are 115 males taking Intro Stats. Of those, 21, or about 18.3%, consider themselves to be "Conservative."
d) There are 192 students taking Intro Stats. Of those, 21, or about 10.9%, are males who consider themselves to be "Conservative."

23. Politics revisited

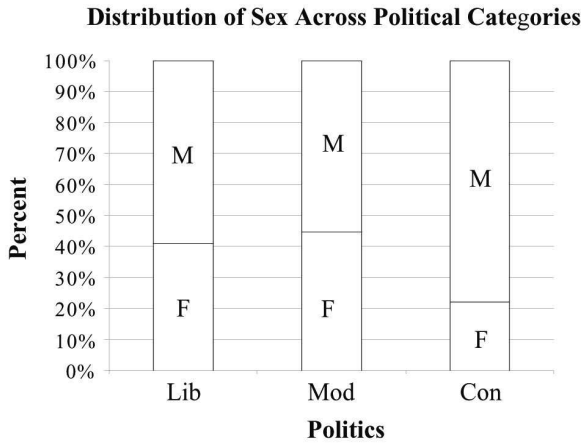
a) The females in this course were 45.5% Liberal, 46.8% Moderate, and 7.8% Conservative. (They don't add up to exactly 100% due to the roundoffs.)
b) The males in this course were 43.5% Liberal, 38.3% Moderate, and 18.3% Conservative.
c) A segmented bar chart comparing the distributions is below.



d) Politics and sex do not appear to be independent in this course. Although the percentage of liberals was roughly the same for each sex, females had a greater percentage of moderates and a lower percentage of conservatives than males.

24. More politics

a)



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b) The percentage of males and females varies across political categories. The percentage of self-identified Liberals and Moderates who are female is about twice the percentage of self-identified Conservatives who are female. This suggests that *sex* and *politics* are not independent.

25. Canadian languages 2011

a) 22,564,665 Canadians speak English only. 22,564,665/33,121,175 x 100% total Canadians ≈ 68.1%

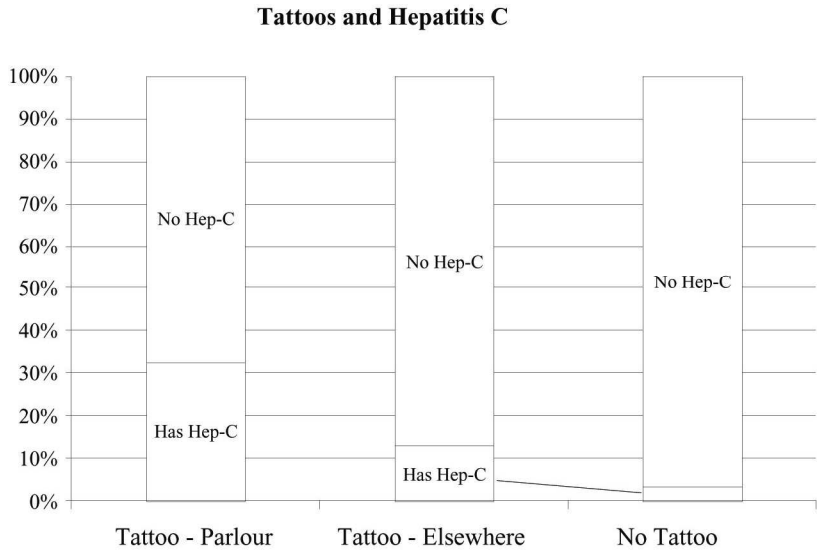
b) 4,165,015 Canadians speak French only and 5,795,575 speak both French and English, for a total of 9,960,590 French speakers. 9,960,590/33,121,175 x 100% total Canadians ≈ 30.1%

c) 4,047,175 French and 3,328,725 French and English speakers yield a total of 7,375,900 French speakers in Quebec. 7,375,900/7,815,955 x 100% Quebec residents ≈ 94.4%

d) 7,375,900 Quebec residents speak French and 9,960,590 Canadians speak French. The percentage of French-speaking Canadians who live in Quebec is 7,375,900/9,960,590 x 100% ≈ 74.1%

e) If language knowledge were independent of province, we would expect the percentage of French-speaking residents of Quebec to be the same as the overall percentage of Canadians who speak French. Since 30.1% of all Canadians speak French while 94.4% of residents of Quebec speak French, there is evidence of an association between language knowledge and province.

26. Tattoos The study by the University of Texas Southwestern Medical Center provides evidence of an association between having a tattoo and contracting hepatitis C. 32.7% of the subjects who were tattooed in a commercial parlour had hepatitis C, compared with 13.1% of those tattooed elsewhere, and only 3.5% of those with no tattoo. If having a tattoo and having hepatitis C were independent, we would have expected these percentages to be roughly the same.



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27. Weather forecasts

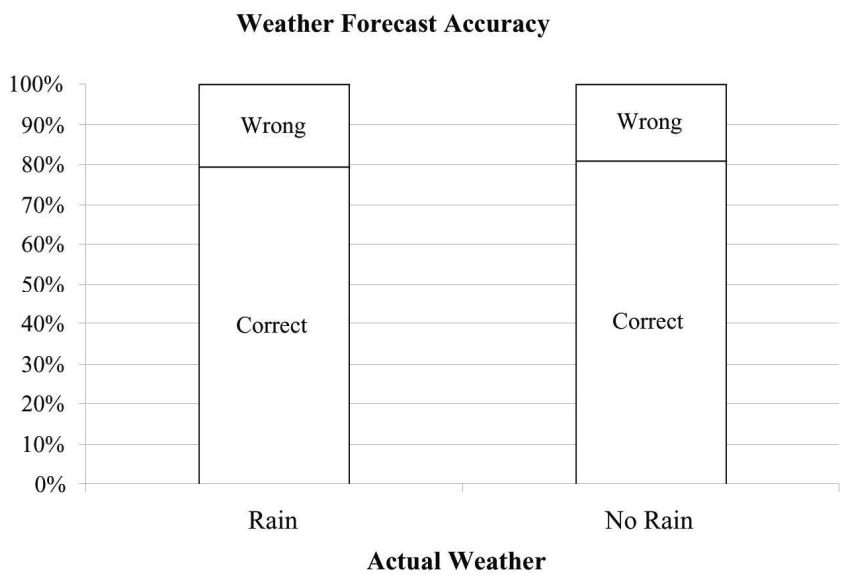
a) The table shows the marginal totals. It rained on 34 of 365 days, or 9.3% of the days.

b) Rain was predicted on 90 of 365 days. 90/365 ≈ 24.7% of the days.

		Actual Weather		
		Rain	No Rain	**Total**
Forecast	Rain	27	63	90
	No Rain	7	268	275
	Total	34	331	365

c) The forecast of rain was correct on 27 of the days it actually rained and the forecast of No Rain was correct on 268 of the days it didn't rain. So, the forecast was correct a total of 295 times. 295/365 ≈ 80.8% of the days.

d) On rainy days, rain had been predicted 27 out of 34 times (79.4%). On days when it did not rain, forecasters were correct in their predictions 268 out of 331 times (81.0%). These two percentages are very close. There is no evidence of an association between the type of weather and the ability of the forecasters to make an accurate prediction. It seems that he forecast is pretty accurate regardless of the type of weather?



28. Attraction, repulsion

a) There are 10 + 70 = 80 quadrants in which Agropyron is present. Ten of these 80 quadrants have Agrostis, i.e., (10/80) × 100% = 12.5%.
There are 40 + 80 = 120 quadrants in which Agropyron is absent. Forty of these 120 quadrants have Agrostis, i.e., (40/120) × 100% = 33.33%.

b) Conditional distribution of Agropyron presence/absence when Agrostis is present:

	Agrostis present
Agropyron present	10/50 x 100%= 20%
Agropyron absent	40/50 x 100% = 80%

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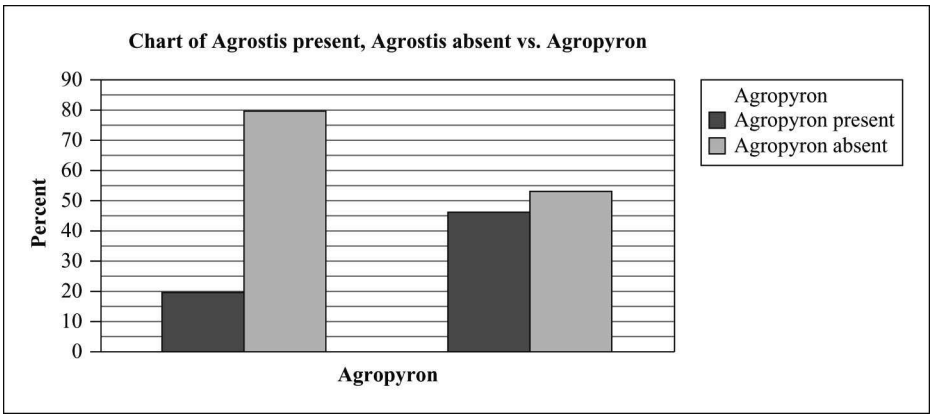
Conditional distribution of Agropyron presence/absence when Agrostis is absent:

	Agrostis absent
Agropyron present	70/150 x 100% = 46.7%
Agropyron absent	80/150 x 100% = 53.3%



Presence of Agrostis is associated with less Agropyron. Thus they repel.

29. Drivers' licences 2014.

a) (54927 + 1154574)/24914051 x 100%= 4.85%

b) 12832778/24914051 x 100%= 51.51%

c) In every age group, there are more male drivers than female drivers. The age group in which the percentage of male drivers is closest to 50% is 35-44. The age group in which the percentage of male drivers is furthest from 50% is under 16, followed by 65 and over.

d) If a driver's age and sex were independent, then the table could be approximately reconstructed using only the row and column totals by multiplying the row total and the column total, and dividing by the grand total. Doing this, we get the following table:

Age	**Male Drivers**	**Female Drivers**
Under 16	28292	26635
16-19	594700	559874
20-24	1007626	948618
25-34	2199520	2070713
35-44	2217026	2087193
45-54	2471995	2327232
55-64	2195496	2066925
65 and over	2118123	1994082

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The percentage difference between the original data and this table is:

Age	Male Drivers	Female Drivers
Under 16	5.00%	-5.93%
16-19	1.11%	-1.21%
20-24	0.76%	-0.82%
25-34	-1.20%	1.25%
35-44	-1.66%	1.70%
45-54	-0.64%	0.67%
55-64	-0.09%	0.10%
65 and over	2.94%	-3.32%

We can see that there are about 5% more male drivers under the age of 16 than would be expected if age and sex were independent, and about 3% more male drivers 65 and over than would be expected if age and sex were independent. This is what was suggested in our answer to part c) – the proportion of male drivers depends (slightly) on the age group.

30. Fat and Fatter.

a) (2776 + 441)/(90 + 3909 + 2776 + 441) x 100%= 44.58% of normal weight Canadians in 1995 became overweight or obese by 2011.

b) 521/(240 + 3909 + 521) x 100%= 11.16% of normal weight Canadians in 2011 were overweight or obese in 1995.

c) 521/(521 + 2676 + 1670 + 243 + 1491) x 100%= 7.89% of overweight or obese Canadians in 1995 got their weight down to normal by 2011.

31. Anorexia.

These data provide no evidence that Prozac might be helpful in treating anorexia. About 71% of the patients who took Prozac were diagnosed as "Healthy." Even though the percentage was higher for the placebo patients, this does not mean that Prozac is hurting patients. The difference between 71% and 73% is not likely to be statistically significant (will be discussed in later chapters).

32. Neighbourhood density.

a) They are row percentages. The rows add up to 100.

b) The segmented bar chart (showing the conditional distribution of density, by city) is given below.

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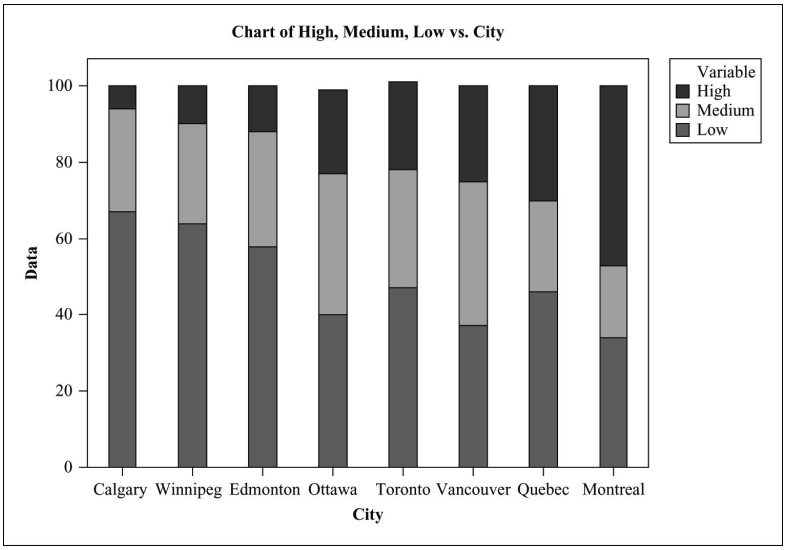

c) To construct such a table we would also need the total counts for each city (i.e., row total counts). If we knew the row total counts we could calculate the cell counts for each row by multiplying the row percents by the row totals. If we had the total sample size and the marginal distribution of each city, we could calculate the total counts for each city (just multiply the marginal proportions by the total sample size).

d) Yes, these data suggests that the Latin and French temperament causes people to live closer to each other. Cities like Quebec and Montreal have higher percentage of high density than cities like Calgary.

33. Smoking gene?

a) The marginal distribution of genotype is given below:

Genotype	Marginal percentage
GG	42.71
GT	45.08
TT	12.21

b) The conditional distributions of genotype for the four categories of smokers are given in columns 2–5 of the table below.

	Cigarettes per day				
Genotype	**1–10**	**11–20**	**21–30**	**31 and more**	**All**
GG	48.06	42.60	38.32	36.75	42.71
GT	42.96	44.75	47.39	48.28	45.08
TT	8.99	12.65	14.29	14.98	12.21
All	100.00	100.00	100.00	100.00	100.00

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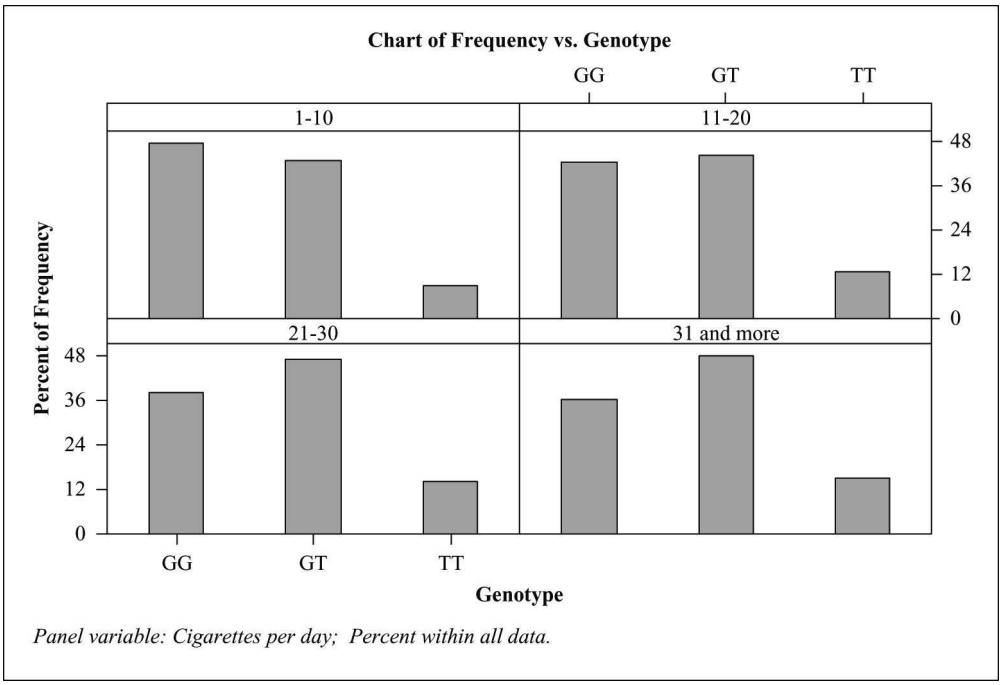

c) Though not a very noticeable difference, the percentages of smokers with genotype GT (also TT) are slightly higher among heavy smokers. However, this is only an observed association. This does not prove that presence of the T allele increases susceptibility to nicotine addiction. We cannot conclude that this increase was caused by the presence of the T allele. There can be many factors associated with the presence of the T allele, and some of these factors might be the reason for the increase in susceptibility to nicotine addiction.

34. Pet ownership

a) No, the income distributions of households by pet ownership shouldn't be the same. Caring for a horse is much more expensive, generally, than caring for a dog, cat, or bird. Households with horses as pets should be in the higher income categories.

b) These are the percentages of income levels for each type of animal owned. Each pet was classified as belonging to a family in one of the income level categories.

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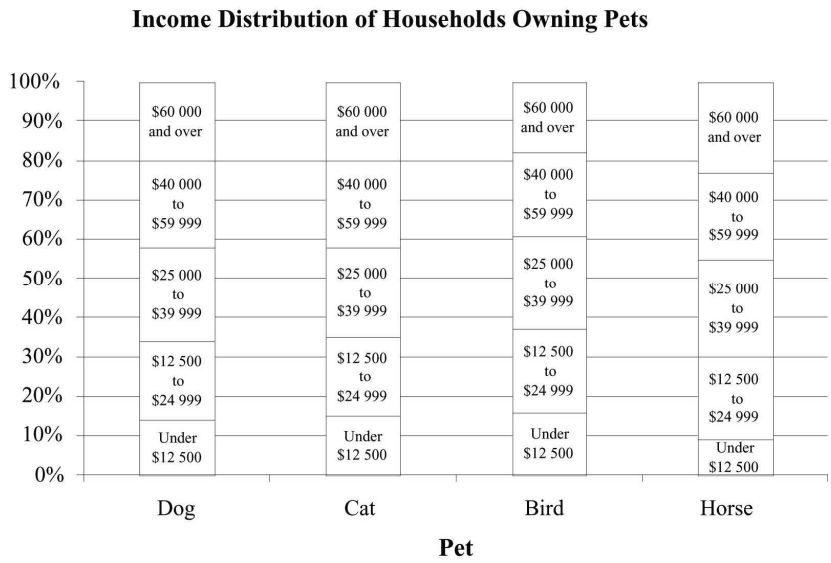
c)



The data support the initial guess to a certain extent. The percentage of horses whose owners have income less than $12 500 is only 9%, compared to percentages in the 20s for other income levels, while the income levels of owners of other pets were distributed in roughly the same percentages. However, with the exception of those earning less than $12 500, the percentages in each income level among horse owners weren't much different.

35. Antidepressants and bone fractures. These data provide evidence that taking a certain class of antidepressants (SSRI) might be associated with a greater risk of bone fractures. Approximately 10% of the patients taking this class of antidepressants experience bone fractures. This is compared to only approximately 5% in the group that were not taking the antidepressants.

36. Blood proteins. The two-way table and the conditional distribution (percentages) of protein (presence or absence) for each blood type are given below. It looks like the proportion of individuals with this protein is higher among the individuals with blood type B.

	Blood Type		
Protein	**Type A**	**Type B**	**All**
Absent	35	40	75
Present	5	20	25
All	40	60	100

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Tabulated statistics: Protein, Blood Type
Using frequencies in Count

Protein	Blood Type		
	Type A	Type B	All
Absent	87.50	66.67	75.00
Present	12.50	33.33	25.00
All	100.00	100.00	100.00

37. Cell phones

a) The two-way table and the conditional distributions (percentages) of 'car accident' (crash or non-crash) for cell phone owners and non-cell phone owners are given below. The proportion of crashes is higher for cell phone owners than for non-cell phone owners.

Car accident	Cell phone ownership		
	Cell phone owner	Non-cell phone owner	All
Crash	20	10	30
Non-crash	58	92	150
All	78	102	180

Car accident	Cell phone ownership		
	Cell phone owner	Non-cell phone owner	All
Crash	25.64	9.80	16.67
Non-crash	74.36	90.20	83.33
All	100.00	100.00	100.00

b) On the basis of this study, we cannot conclude that the use of a cell phone increases the risk of a car accident. This is only an observed association between cell phone ownership and the risk of car accidents. We cannot conclude that the higher proportion of accidents was caused by the use of a cell phone. There can be lots of other factors common to cell phone owners, and some of those factors can be the reason for the accidents.

38. Twins.

a) Of the 278 000 mothers who had twins in 1995–1997, 63 000 had inadequate health care during their pregnancies.

Twin Births 1995-97 (in thousands)				
Level of Prenatal Care	Preterm (Induced or Caesarean)	Preterm (without procedures)	Term or Postterm	Total
Intensive	18	15	28	61
Adequate	46	43	65	154
Inadequate	12	13	38	63
Total	76	71	131	278

63 000/278 000 x 100% = 22.7%

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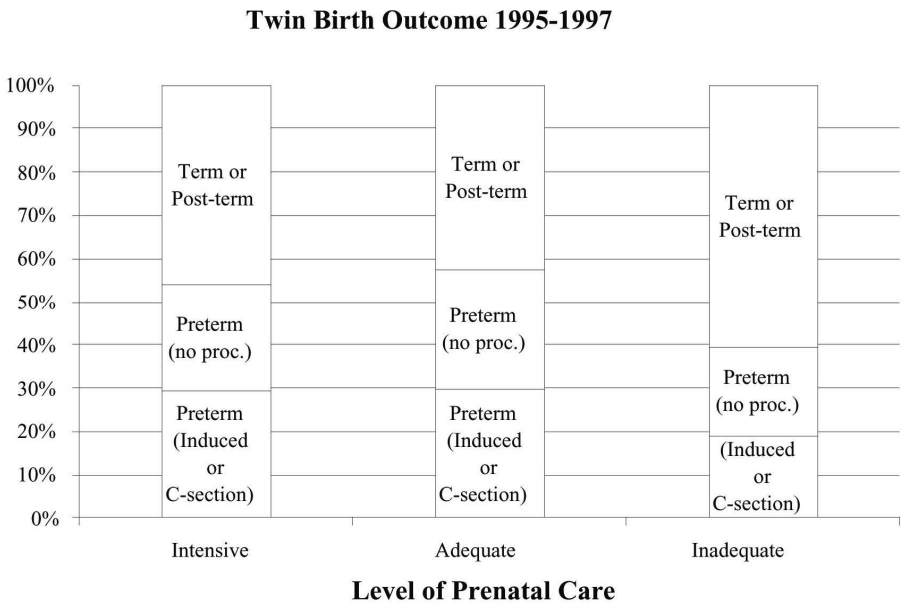
b) There were 76 000 induced or Caesarean births and 71 000 preterm births without these procedures. (76 000 + 71 000)/278 000 = 52.9%

c) Among the mothers who did not receive adequate medical care, there were 12 000 induced or Caesarean births and 13 000 preterm births without these procedures. 63 000 mothers of twins did not receive adequate medical care. (12 000 + 13 000)/63 000 = 39.7%

d)



e) 52.9% of all twin births were preterm, while only 39.7% of births in which inadequate medical care was received were preterm. This is evidence of an association between level of prenatal care and twin birth outcome. If these variables were independent, we would expect the percentages to be roughly the same. Generally, those mothers who received adequate or intensive medical care were more likely to have preterm births than mothers who received inadequate health care. This does *not* imply that mothers should receive inadequate health care to decrease their chances of having a preterm birth, since it is likely that women that have some complication *during* their pregnancy (that might lead to a preterm birth), would seek intensive or adequate prenatal care.

39. Blood pressure.

a) The marginal distribution of blood pressure for the employees of the company is the total column of the table, converted to percentages. 20% low, 49% normal, and 31% high blood pressure.

Blood pressure	under 30	30 - 49	over 50	Total
low	27	37	31	95
normal	48	91	93	232
high	23	51	73	147
Total	98	179	197	474

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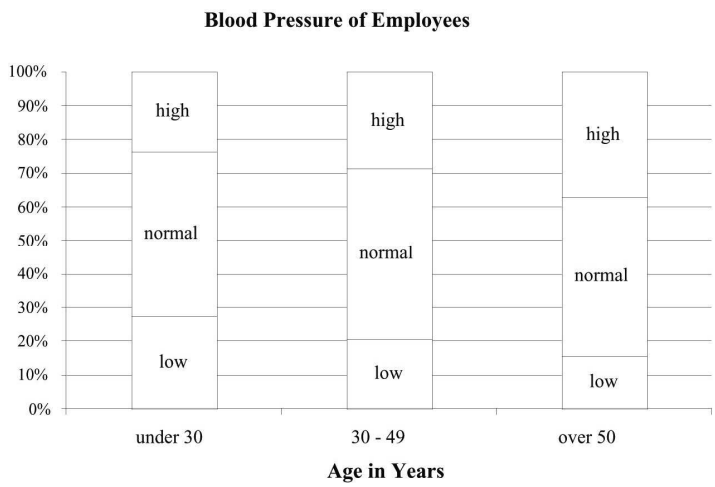
b) The conditional distribution of blood pressure within each age category is: Under 30: 28% low, 49% normal, 23% high 30–49: 21% low, 51% normal, 28% high Over 50: 16% low, 47% normal, 37% high



c) A segmented bar chart of the conditional distributions of blood pressure by age category is at the right.

d) In this company, as age increases, the percentage of employees with low blood pressure decreases, and the percentage of employees with high blood pressure increases.

e) No, this does not prove that people's blood pressure increases as they age. Generally, an association between two variables does not imply a cause-and-effect relationship. Specifically, these data come from only one company and cannot be applied to all people. Furthermore, there may be some other variable that is linked to both age and blood pressure.

40. Self-reported BMI.

a) Conditional distributions (percentages) of self-reported BMI for the three measured overweight classes are given below (the last three columns of the table).

Self-reported BMI	**Overweight (25.0 to 29.9)**	**Obese class I (30.0 to 34.9)**	**Obese class II/III (35 or more)**
Underweight (less than 18.5)	0.0114	0.1399	0.0000
Normal weight (18.5 to 24.9)	30.3075	2.7979	0.2559
Overweight (25.0 to 29.9)	66.8915	44.1595	8.5733
Obese class I (30.0 to 34.9)	2.7895	52.3898	38.5797
Obese class II/III (35.0 or more)	0.0000	0.5129	52.5912

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b) Conditional distributions (percentages) of measured BMI for the three self-reported overweight classes are given below (the last three columns of the table).

Measured BMI	**Overweight (25.0 to 29.9)**	**Obese class I (30.0 to 34.9)**	**Obese class II/III (35 or more)**
Underweight (less than 18.5)	0.0000	0.0000	0.0000
Normal weight (18.5 to 24.9)	4.6934	0.0000	0.0000
Overweight (25.0 to 29.9)	70.7754	7.8862	0.0000
Obese class I (30.0 to 34.9)	22.9104	72.6244	2.6066
Obese class II/III (35.0 or more)	1.6209	19.4893	97.3934

c) It is reasonable to expect the self-reported BMI values to be close to the measured BMI values at least to some extent, and so not to be independent. The table (for example, column 3 of the table given in part a above) shows the conditional distribution of the self-reported BMI for each measured BMI class. These conditional distributions do not look very similar. In fact, they look very different. This means that the two variables (self-reported and measured BMI) are not independent.

d) A considerable percentage of people tend to understate their weight and overstate their height (i.e., report a smaller BMI). From the conditional distributions of self-reported BMI for the three measured overweight classes in part a, we see that approximately 47% of obese class II/III people have done this. This proportion is similar (i.e., approximately 47%) for obese class I people, and is about 30% for overweight people.

e) Answers might vary. Gender and age (young, old) are some examples.

f) Risk of overweight to health will be overestimated. For example, if those with BMI of 35 or more have high diabetes rates and are misclassified as having a BMI of 30, we will think it is only those with a BMI of 30 who have a high diabetes risk.

41. Indigenous identity 2011

a) The second column includes some individuals in the 3rd, 4th, and 5th columns, so it is not a standard contingency table.

b) Use the label "Indigenous population not included in columns 3, 4, and 5" (or call them "other Indigenous"). Use the value in second column minus those in the third, fourth and fifth columns as the new value.

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c) There are 27 070 Canadians who are Inuit from Nunavut. The Canadian population is 32 852 320, so the proportion of Canadians who are Inuit from Nunavut is 27 070/32 852 320 = 0.00082 = 0.08% (approx.).
d) There are 27 070 Canadians who are Inuit from Nunavut. The total Canadian Indigenous population is 1 400 685, so the proportion of Indigenous Canadians who are Inuit from Nunavut is 27 070/1 400 685 = 0.0193 = 1.93% (approx.).
e) The total Canadian Indigenous population is 1 400 685 and of them 59 440 are Inuit. So 59 440/1 400 685 = 0.0424 = 4.24% of Indigenous Canadians are Inuit.
f) The total Canadian Aboriginal population is 1 400 685 and of them 27 360 are from Nunavut. So 27 360/1 400 685 = 0.0195 = 1.95% of Indigenous Canadians are from Nunavut.
g) The total population in Nunavut is 31 700 and 27 360 of them are Inuit. So 27 070/31 700 = 0.8539 = 85.39% of the people from Nunavut are Inuit.
h) There are 27 360 Nunavut Indigenous Canadians and 27 070 of them are Inuit. So 27 070/27 360 = 0.9894 = 98.94% of Nunavut Indigenous Canadians are Inuit.
i) The total Inuit population is 59 440 and of them 27 070 are from Nunavut. So 27 070/59 440 = 0.4554 = 45.54% of Inuit live in Nunavut.
j) The total number of Ontario Indigenous Canadians is 301 430, and 301 430 – 201 105 – 86 015 – 3360 = 10 950 of them are other Indigenous Canadians (i.e., other than Inuit, Metis, or N.A. Indian) and so 10 950/301 430 = 0.0363 = 3.63% of Ontario Indigenous Canadians could not be simply classified as Inuit, Metis, or N.A. Indian.
k) A table of percentages of total provincial population for each Indigenous identity group (Inuit, Metis, N.A. Indian) for Newfoundland, Ontario, Saskatchewan, and Alberta is given below. The second table is a bit easier if using MINITAB. The side-by-side bar charts below show that Saskatchewan has the highest proportion of N.A. Indian and Metis. Ontario, Saskatchewan, and Alberta have very small proportions of Inuit.

Region	**Percent N.A. Indian**	**Percent Metis**	**Percent Inuit**
Newfoundland and Labrador	3.80764%	1.51004%	1.23504%
Ontario	1.58954%	0.67986%	0.02656%
Saskatchewan	10.23137%	5.19945%	0.02875%
Alberta	3.26992%	2.71498%	0.05563%

Group	**Newfoundland and Labrador**	**Ontario**	**Saskatchewan**	**Alberta**
N.A. Indian	3.80764%	1.58954%	10.23137%	3.26992%
Metis	1.51004%	0.67986%	5.19945%	2.71498%
Inuit	1.23504%	0.02656%	0.02875%	0.05563%

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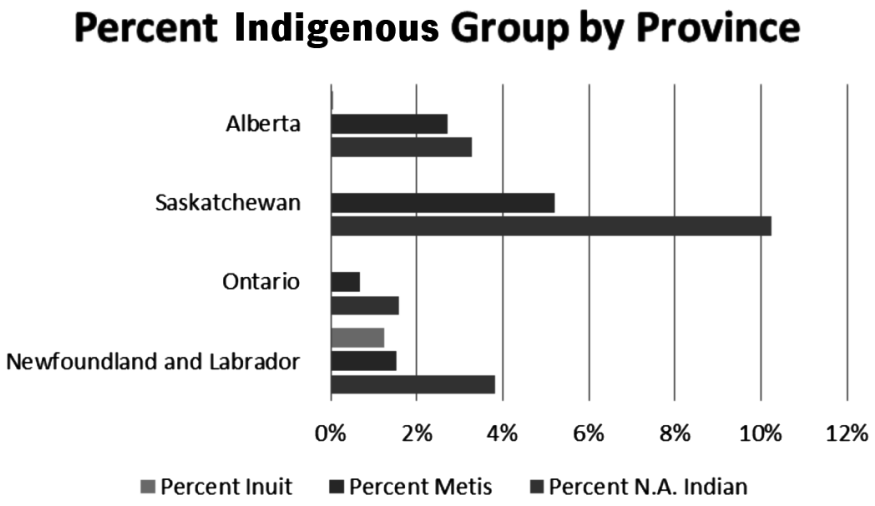

42. Dim sum 2011.

a) There are three categorical variables, namely city (Calgary, Toronto, or Oshawa), spoken Chinese dialect (Cantonese or Mandarin), and year (2011 or 2006).

b) The conditional distribution of spoken Chinese dialect for 2011, in Toronto:
Cantonese: 156 425/(156 425 + 91 670) = 0.631
Mandarin: 91 670/(156 425 + 91 670) = 0.369
The conditional distribution of spoken Chinese dialect for 2006, in Toronto:
Cantonese: 129 925/(129 925 + 44 990) = 0.743
Mandarin: 44 990/(129 925 + 44 990) = 0.257
The conditional distribution of spoken Chinese dialect for 2011, in Calgary:
Cantonese: 16 920/(16 920 + 9 900) = 0.631
Mandarin: 9 900/(16 920 + 9 900) = 0.369
The conditional distribution of spoken Chinese dialect for 2006, in Calgary:
Cantonese: 12 785/(12 785 + 5 345) = 0.705
Mandarin: 5 345/(12 785 + 5 345) = 0.295
The conditional distribution of spoken Chinese dialect for 2011, in Vancouver:
Cantonese: 113 610/(113 610 + 83 825) = 0.575
Mandarin: 83 825/(113 610 + 83 825) = 0.425
The conditional distribution of spoken Chinese dialect for 2006, in Vancouver:
Cantonese: 94 760/(94 760 + 51 465) = 0.648
Mandarin: 51 465/(94 760 + 51 465) = 0.352

c) Can't determine since we don't know how many speak other Chinese dialects.

d) Bar charts can be used as we might want to compare between 2011 and 2006 and also between different cities. A pie chart may be used if our interest is in comparing the relative proportions of those who speak only these two dialects, but it might give the reader the impression that these are the only two dialects spoken. The percentage bar charts are shown below. In each city and each year the proportion of Mandarin speakers is relatively low, but in each city this proportion is higher in 2011 than in 2006. Vancouver has a higher proportion of Mandarin speakers compared to Calgary and Toronto.

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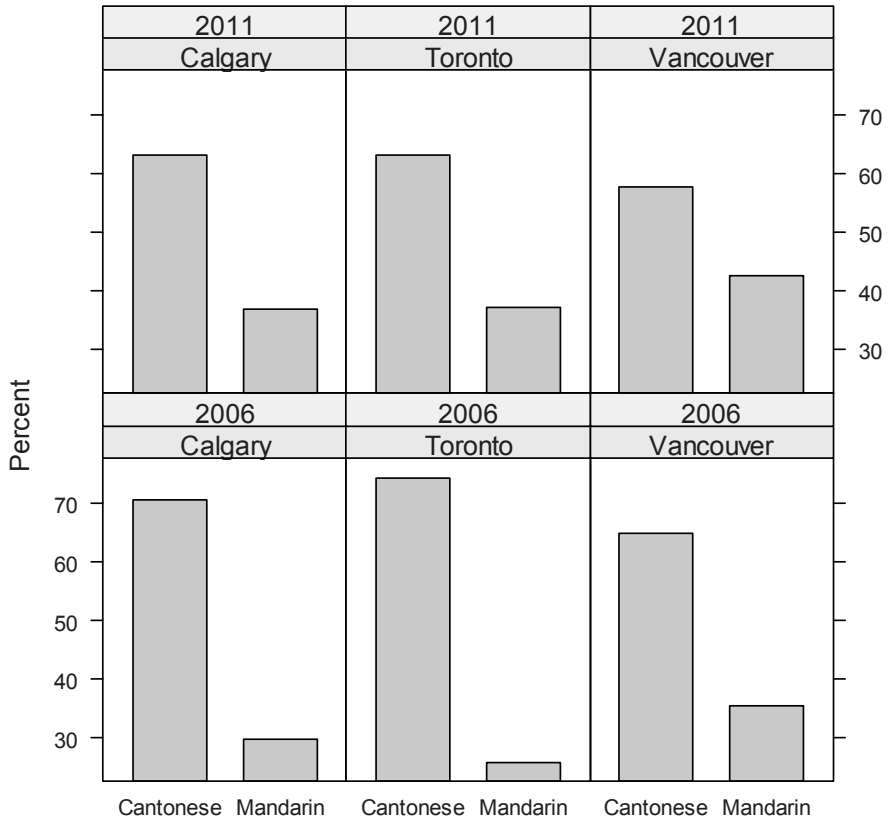

e) Two-way table by year and dialect is shown below.

Year	Dialect		
	Cantonese	**Mandarin**	**All**
2011	286 955	185 395	472 350
2006	237 470	101 800	339 270
All	524 425	287 195	811620

The conditional distribution of dialect for each year:

Year	Dialect		
	Cantonese	**Mandarin**	**All**
2011	60.75%	39.25%	100%
2006	69.99%	30.01%	100%

The proportion of Mandarin speakers has increased from 30.01% (in 2006) to 39.25% (in 2011). It looks like more immigrants have come from other parts of China.

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f) The marginal distribution of dialect (using 2011 data) is given in the fifth column of the table below. The conditional distributions of dialect for Calgary, Toronto, and Vancouver are given in the second, third, and the fourth columns, respectively. The conditional distribution for Vancouver differs the most from the marginal distribution; Calgary and Toronto have nearly identical distributions, but Vancouver has a higher percentage of Mandarin speakers.

	City			
Dialect	**Calgary**	**Toronto**	**Vancouver**	**All**
Cantonese	63.09%	63.05%	57.54%	60.75%
Mandarin	36.91%	36.95%	42.46%	39.25%
All	100%	100%	100%	100%

43. Hospitals.

a) The marginal totals have been added to the table:

		Discharge delayed		
		Large Hospital	**Small Hospital**	**Total**
Procedure	**Major surgery**	120 of 800	10 of 50	130 of 850
	Minor surgery	10 of 200	20 of 250	30 of 450
	Total	130 of 1000	30 of 300	160 of 1300

160 of 1300, or about 12.3%, of the patients had a delayed discharge.

b) Yes. Major surgery patients were delayed 130 of 850 times, or about 15.3% of the time. Minor surgery patients were delayed 30 of 450 times, or about 6.7% of the time.

c) Large Hospital had a delay rate of 130 of 1000, or 13%. Small Hospital had a delay rate of 30 of 300, or 10%. The small hospital has the lower overall rate of delayed discharge.

d) Large Hospital: Major Surgery 15% delayed and Minor Surgery 5% delayed. Small Hospital: Major Surgery 20% delayed and Minor Surgery 8% delayed. Even though small hospital had the lower overall rate of delayed discharge, the large hospital had a lower rate of delayed discharge for each type of surgery.

e) No. While the overall rate of delayed discharge is lower for the small hospital, the large hospital did better with *both* major surgery and minor surgery.

f) The small hospital performs a higher percentage of minor surgeries than major surgeries. 250 of 300 surgeries at the small hospital were minor (83%). Only 200 of the large hospital's 1000 surgeries were minor (20%). Minor surgery had a lower delay rate than major surgery (6.7% to 15.3%), so the small hospital's overall rate was artificially inflated. Simply put, it is a mistake to look at the overall percentages. The real truth is found by looking at the rates after the

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information is broken down by type of surgery, since the delay rates for each type of surgery are so different. The larger hospital is the better hospital when comparing discharge delay rates.

44. Delivery service.

a) Pack Rats has delivered a total of 28 late packages (12 regular + 16 overnight), out of a total of 500 deliveries (400 regular + 100 overnight). 28/500 = 5.6% of the packages are late. Boxes R Us has delivered a total of 30 late packages (2 regular + 28 overnight) out of a total of 500 deliveries (100 regular + 400 overnight). 30/500 = 6% of the packages are late.

b) The company should have hired Boxes R Us instead of Pack Rats. Boxes R Us only delivers 2% (2 out of 100) of its regular packages late, compared to Pack Rats, who deliver 3% (12 out of 400) of its regular packages late. Additionally, Boxes R Us only delivers 7% (28 out of 400) of its overnight packages late, compared to Pack Rats, who delivers 16% of its overnight packages late. Boxes R Us is better at delivering regular and overnight packages.

c) This is an instance of Simpson's Paradox, because the overall late delivery rates are unfair averages. Boxes R Us delivers a greater percentage of its packages overnight, where it is comparatively harder to deliver on time. Pack Rats delivers many regular packages, where it is easier to make an on-time delivery.

45. Graduate admissions.

a) 1284 applicants were admitted out of a total of 3014 applicants. 1284/3014 = 42.6%

Program	Males Accepted (of applicants)	Females Accepted (of applicants)	Total
1	511 of 825	89 of 108	600 of 933
2	352 of 560	17 of 25	369 of 585
3	137 of 407	132 of 375	269 of 782
4	22 of 373	24 of 341	46 of 714
Total	**1022 of 2165**	**262 of 849**	**1284 of 3014**

b) 1022 of 2165 (47.2%) males were admitted. 262 of 849 (30.9%) females were admitted.

c) Since there are four comparisons to make, the table at the right organizes the percentages of males and females accepted in each program. Females are accepted at a higher rate in every program.

Program	Males	Females
1	61.9%	82.4%
2	62.9%	68.0%
3	33.7%	35.2%
4	5.9%	7%

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d) The comparison of acceptance rate within each program is most valid. The overall percentage is an unfair average. It fails to take the different numbers of applicants and different acceptance rates of each program. Women tended to apply to the programs in which gaining acceptance was difficult for everyone. This is an example of Simpson's Paradox.

46. Be a Simpson! Answers will vary. The three-way table below shows one possibility. The number of local hires out of new hires is shown in each cell.

	Company A	**Company B**
Full-time New Employees	40 of 100 x 100% = 40%	90 of 200 x 100% = 45%
Part-time New Employees	170 of 200 x 100% = 85%	90 of 100 x 100% = 90%
Total	210 of 300 x 100% = 70%	180 of 300 x 100% = 60%

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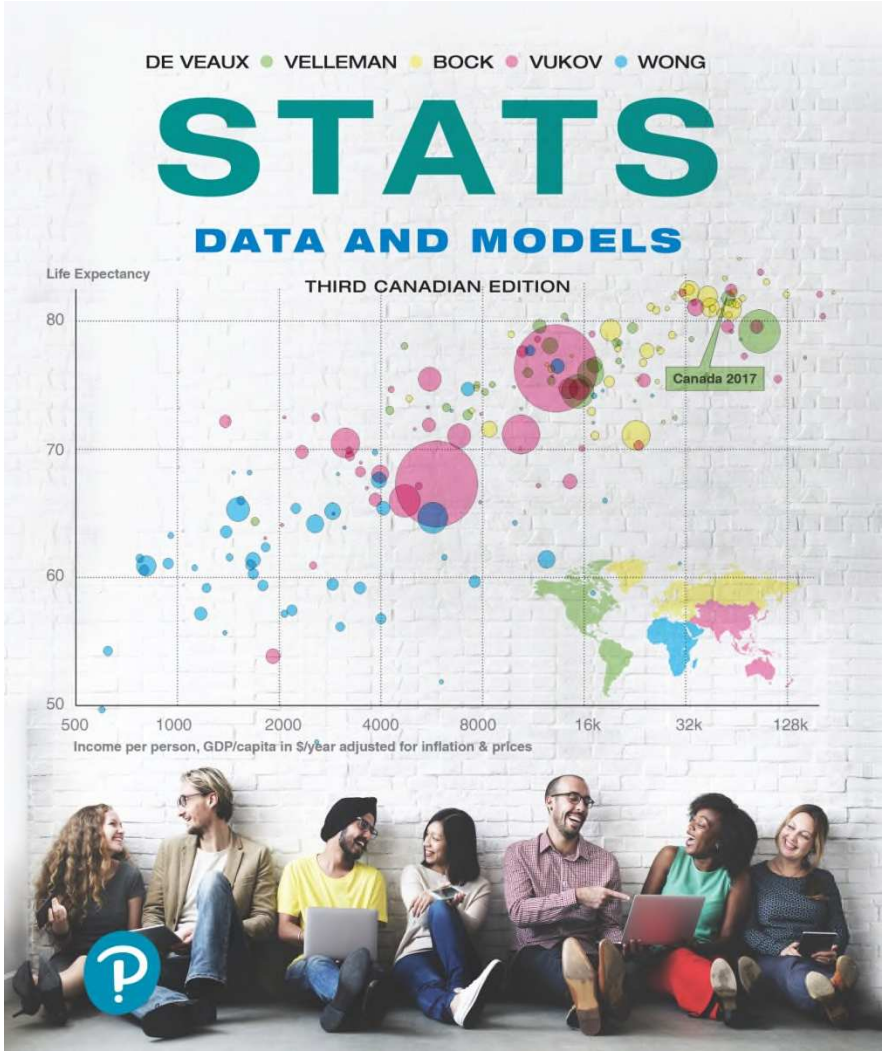
Stats: Data and Models

Third Canadian Edition



Chapter 2

Displaying and Describing Categorical Data

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Summarizing and Displaying a Single Categorical Variable

- The three rules of data analysis won't be difficult to remember:
  1. Make a picture—things may be revealed that are not obvious in the raw data. These will be things to *think* about.
  2. Make a picture—important features of and patterns in the data will *show* up. You may also see things that you did not expect.
  3. Make a picture—the best way to *Tell* others about your data is with a well-chosen picture.

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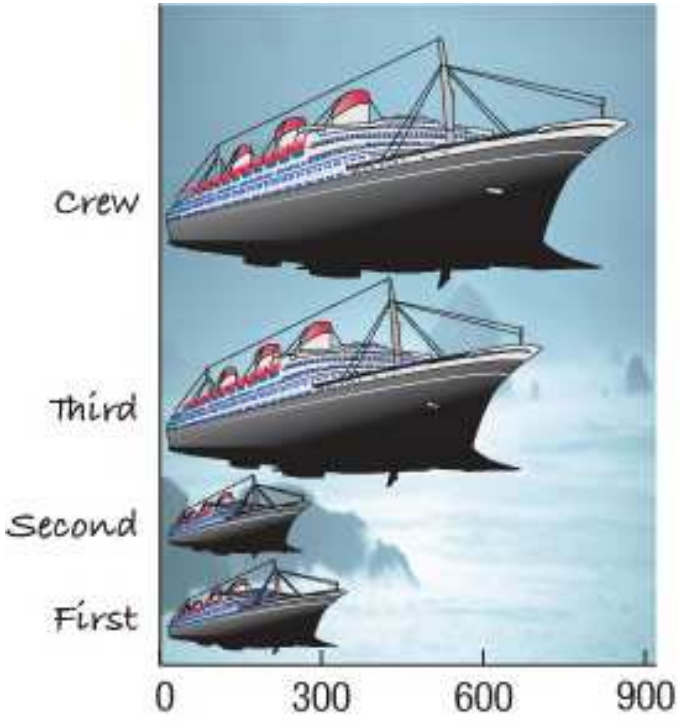
The Area Principle (1 of 2)

Figure 2.2 is a colorful graph of the *Titanic* data, showing the total number of persons in each class, as well as the number of crewmembers aboard.



What's Wrong With This Picture?

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The Area Principle (2 of 2)

- The ship display makes it look like most of the people on the *Titanic* were crew members, with a few passengers along for the ride.
- When we look at each ship, we see the *area* taken up by the ship, instead of the *length* of the ship.
- The ship display violates the area principle:
  - The area occupied by a part of the graph should correspond to the magnitude of the value it represents.

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Frequency Tables (1 of 2)

- To display a categorical variable, we need to organize the number of cases associated with each category
- A **frequency table** records the totals for each category names

Class	Count
First	325
Second	285
Third	706
Crew	885

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Frequency Tables (2 of 2)

- A relative frequency displays the *proportions* or *percentages*, rather than the counts, of the values in each category.

Class	%
First	14.77
Second	12.95
Third	32.08
Crew	40.21

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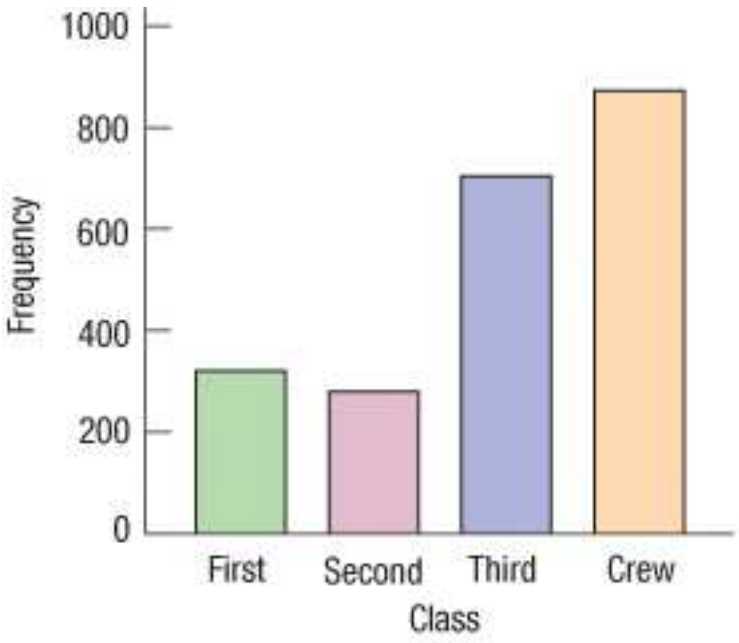
Bar Charts (1 of 2)

- A bar chart displays the distribution of a categorical variable, showing the counts for each category next to each other for easy comparison.
- A bar chart stays true to the area principle.
- A better display for the ship data is:



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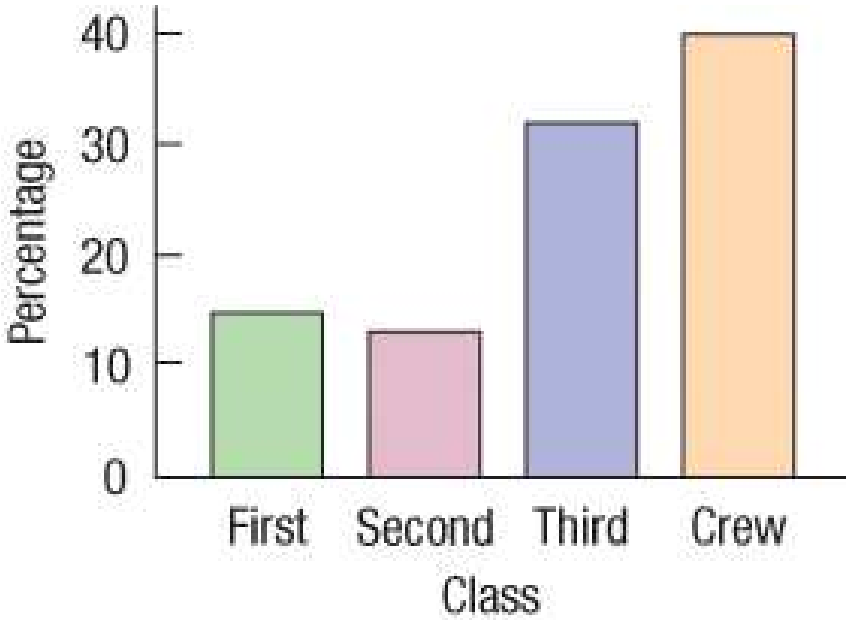
Bar Charts (2 of 2)

- A relative frequency bar chart displays the relative *proportion* of counts for each category.
- A relative frequency bar chart also stays true to the area principle.



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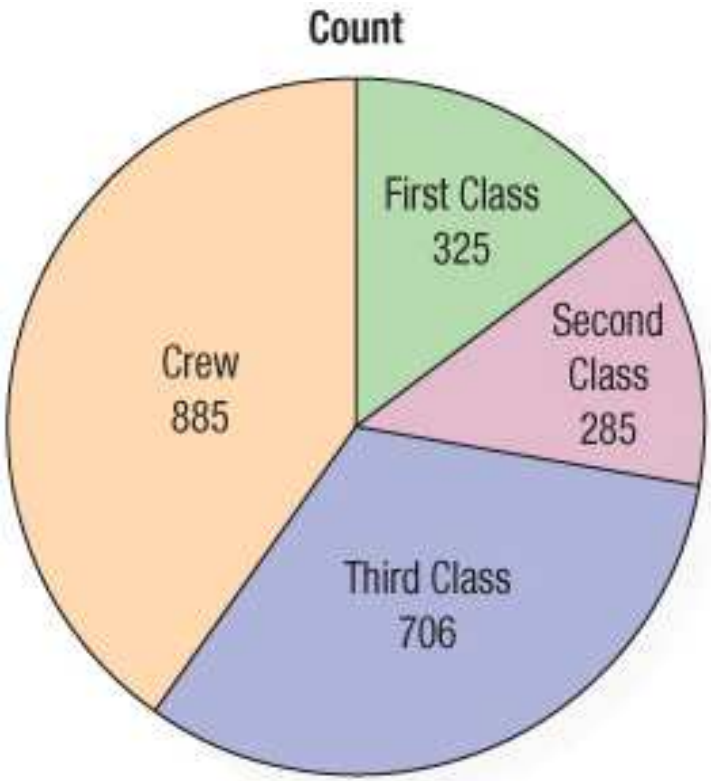
Pie Charts

- When you are interested in parts of the whole, a pie chart might be your display of choice.
- Pie chart show the whole group of cases as a circle.
- They slice the circle into pieces whose size is proportional to the fraction of the whole in each category.



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Exploring relationship between two categorical variables

- A Contingency Table allows us to look at two categorical variables together. It shows how individuals are distributed along each variable, contingent on the value of the other variable.
  - Example: we can examine the class of ticket and whether a person survived the *Titanic*:

Survival	First Class	Second Class	Third Class	Crew Class	Total
Alive	203	118	178	212	**711**
Dead	122	167	528	673	**1490**
Total	**325**	**285**	**706**	**885**	**2201**

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Contingency Tables (1 of 3)

- Each cell of the table gives the count for a combination of the two values.
  - For example, the second cell in the crew column tells us that 673 crew members died when the *Titanic* sunk.

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Contingency Tables (2 of 3)

- The margins of the table, both on the right and on the bottom, give totals and the frequency distributions for each of the variables.
- Each frequency distribution is called a marginal distribution of its respective variable.

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Contingency Tables (3 of 3)

– The marginal distribution of *Survival* is:

Survival		First Class	Second Class	Third Class	Crew Class	Total
Alive	**Count**	**203**	**118**	**178**	**212**	**711**
	% of Row	28.6	16.6	25.0	29.8	100
	% of Column	62.5	41.4	25.2	24.0	32.3
	% of Overall Total	9.2	5.4	8.1	9.6	32.3
Dead	**Count**	**122**	**167**	**528**	**673**	**1490**
	% of Row	8.2	11.2	35.4	45.2	100
	% of Column	37.5	58.6	74.8	76.0	67.7
	% of Overall Total	5.5	7.6	24.0	30.6	67.7
Total	**Count**	**325**	**285**	**706**	**885**	**2201**
	% of Row	14.8	12.9	32.1	40.2	100
	% of Column	100	100	100	100	100
	% of Overall Total	14.8	12.9	32.1	40.2	100

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Conditional Distributions (1 of 3)

- A conditional distribution shows the distribution of one variable for just the individuals who satisfy some condition on another variable.
  - The following is the conditional distribution of ticket *Class*, conditional on Alive and conditional on Dead:

Survival	Class First	Class Second	Class Third	Class Crew	Total
Alive	**203**	**118**	**178**	**212**	**711**
	28.6%	16.6%	25.0%	29.8%	**100%**
Dead	**122**	**167**	**528**	**673**	**1490**
	8.2%	11.2%	35.4%	45.2%	**100%**

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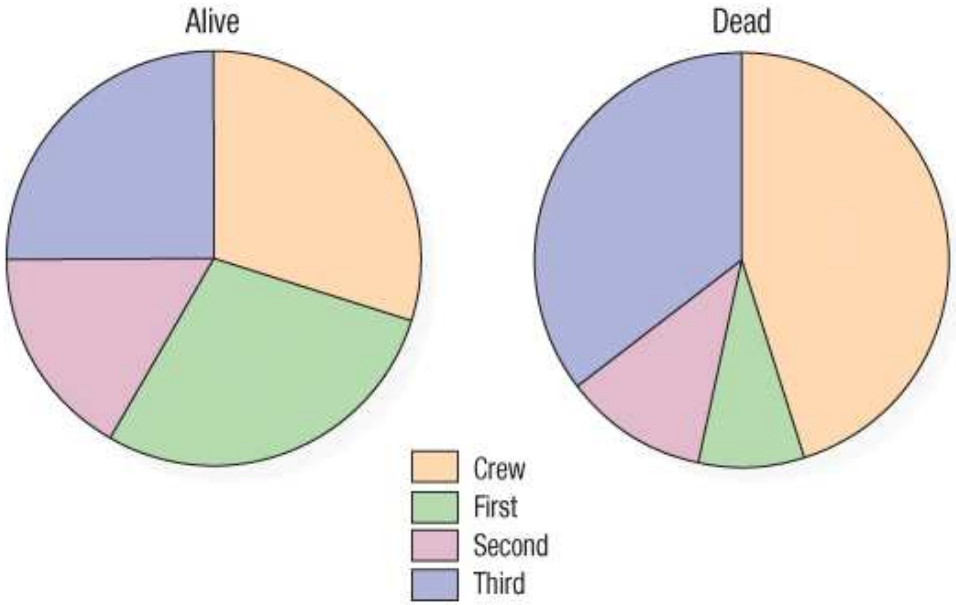
Conditional Distributions (2 of 3)

- The conditional distributions tell us that there is a difference in class for those who survived and those who perished, which can also easily shown using pie charts



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Conditional Distributions (3 of 3)

- We see that the distribution of *Class* for the survivors is different from that of the nonsurvivors.
- This leads us to believe that *Class* and *Survival* are associated, that they are not independent.
- In a contingency table, when the distribution of *one* variable is the same for all categories of another, we say that the variables are **independent**.

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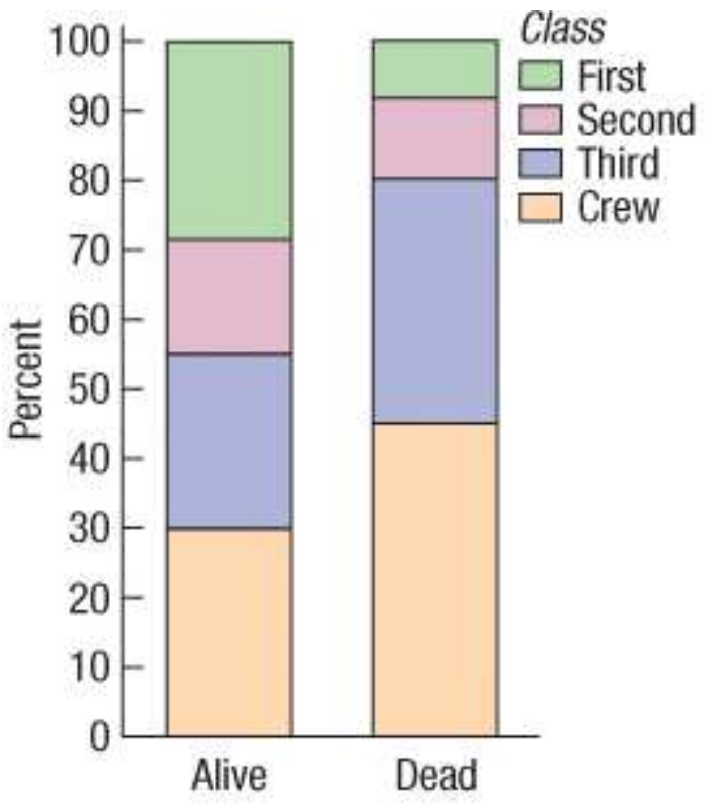
Segmented Bar Charts

- A **segmented bar chart** treats each bar as the "whole" and divides it proportionally into segments corresponding to the percentage in each group.
- A segmented bar chart displays the same information as a pie chart, but in the form of bars instead of circles.



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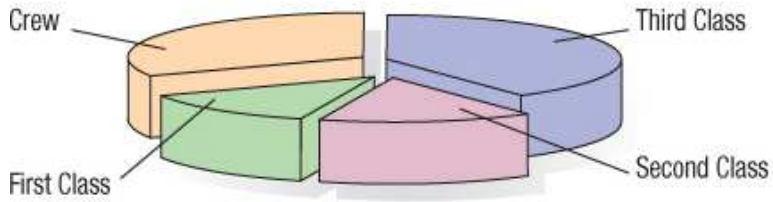
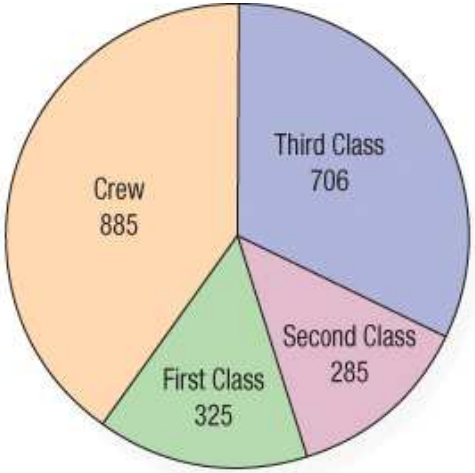
What Can Go Wrong? (1 of 5)

- Don't violate the area principle.





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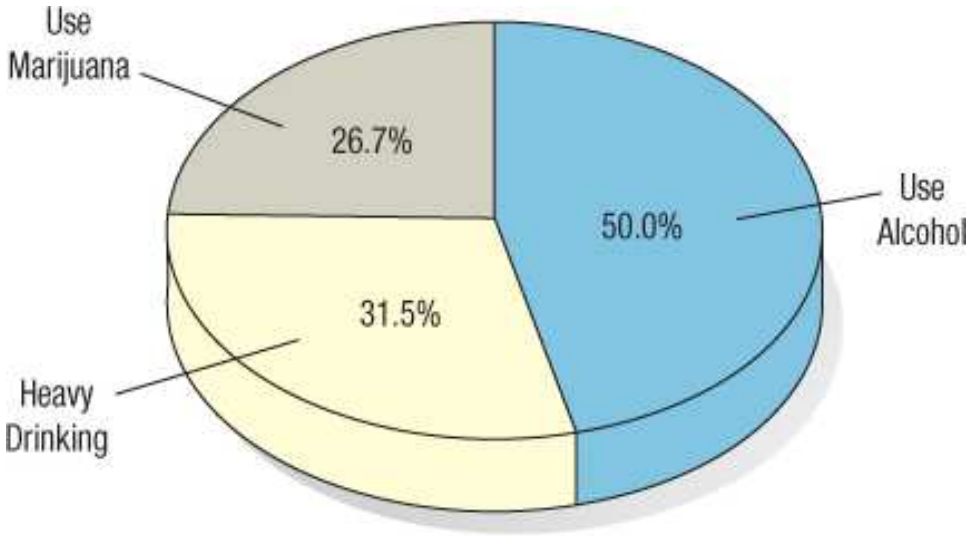
showing the pie on a slant violates the area principle and makes it much more difficult to compare fractions

What Can Go Wrong? (2 of 5)

- Keep it honest—make sure your display shows what it says it shows.

What is wrong with the pie chart?



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What Can Go Wrong? (3 of 5)

- Don't confuse similar-sounding percentages—pay particular attention to the wording of the context.
- Don't forget to look at the variables separately too—examine the marginal distributions, since it is important to know how many cases are in each category.

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What Can Go Wrong? (4 of 5)

- Be sure to use enough individuals!
  - Do not make a report like “We found that 66.67% of the rats improved their performance with training. The other rat died.”

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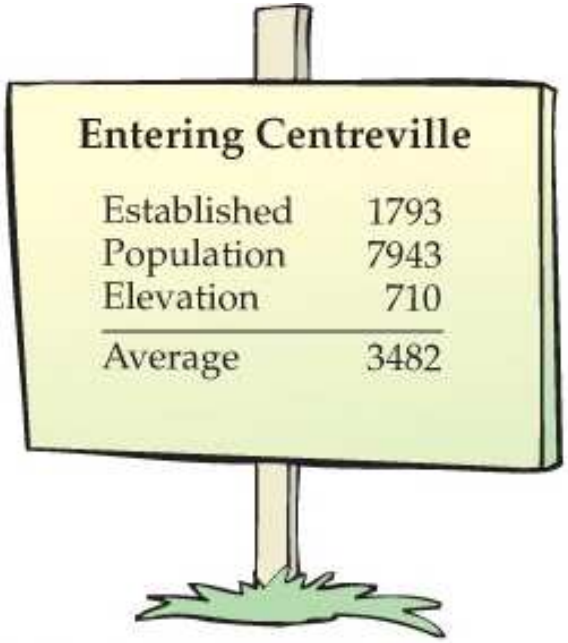
What Can Go Wrong? (5 of 5)

- Don't overstate your case—don't claim something you can't.
- Be wary of looking only at overall percentages - this could lead to Simpson's Paradox, so be careful when you average one variable across different levels of a second variable.



Don't use inappropriate averages. Sometimes they aren't as obvious as the Centreville sign.

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What Have We Learned?

- We can summarize categorical data by counting the number of cases in each category (expressing these as counts or percents).
- We can display the distribution of a cateogrical variable in a bar chart or pie chart.
- We can use two-way tables called contingency tables, for examining marginal and/or conditional distributions of two categorical variables.
- If conditional distributions of one variable are the same for every category of the other, the variables are independent.

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