# MODULE ONE: PRESENTING AND DESCRIBING INFORMATION

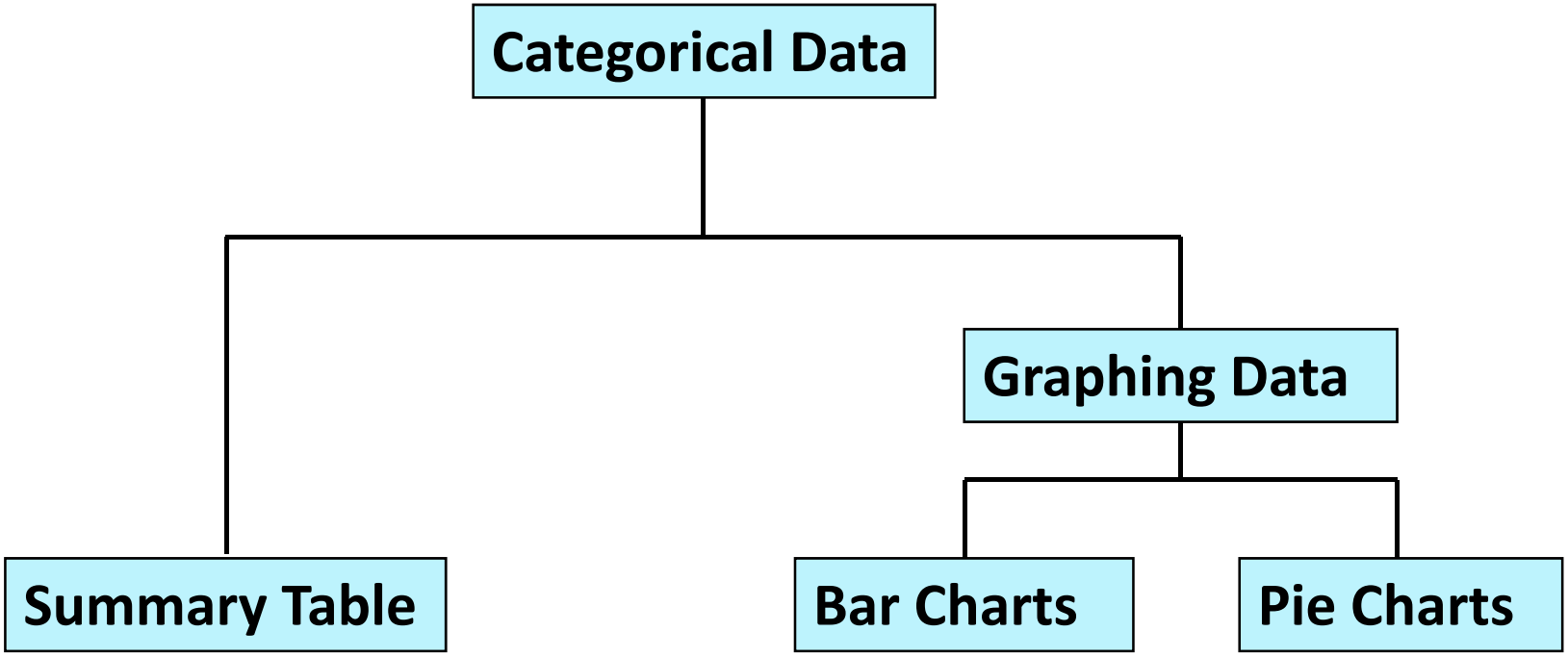
## TOPIC 2: VISUALISING DATA

# Learning Objectives

At the completion of this topic, you should be able to:

- describe the distribution of a single categorical variable using tables and charts
- describe the distribution of a single numerical variable using tables and graphs
- describe the relationship between two categorical variables using contingency tables
- correctly present data in graphs

# Tables and Charts for Categorical Data



# Summary Tables



**Table 2.2A**
A frequency and percentage summary table for the location of 100 recent property sales

| Location | Number (frequency) of properties | Percentage of properties |
|---|---|---|
| Rural | 34 | 34.0 |
| Town | 66 | 66.0 |
| Total | 100 | 100.0 |

**Table 2.2B**
A frequency and percentage summary table for type of 100 recent property sales

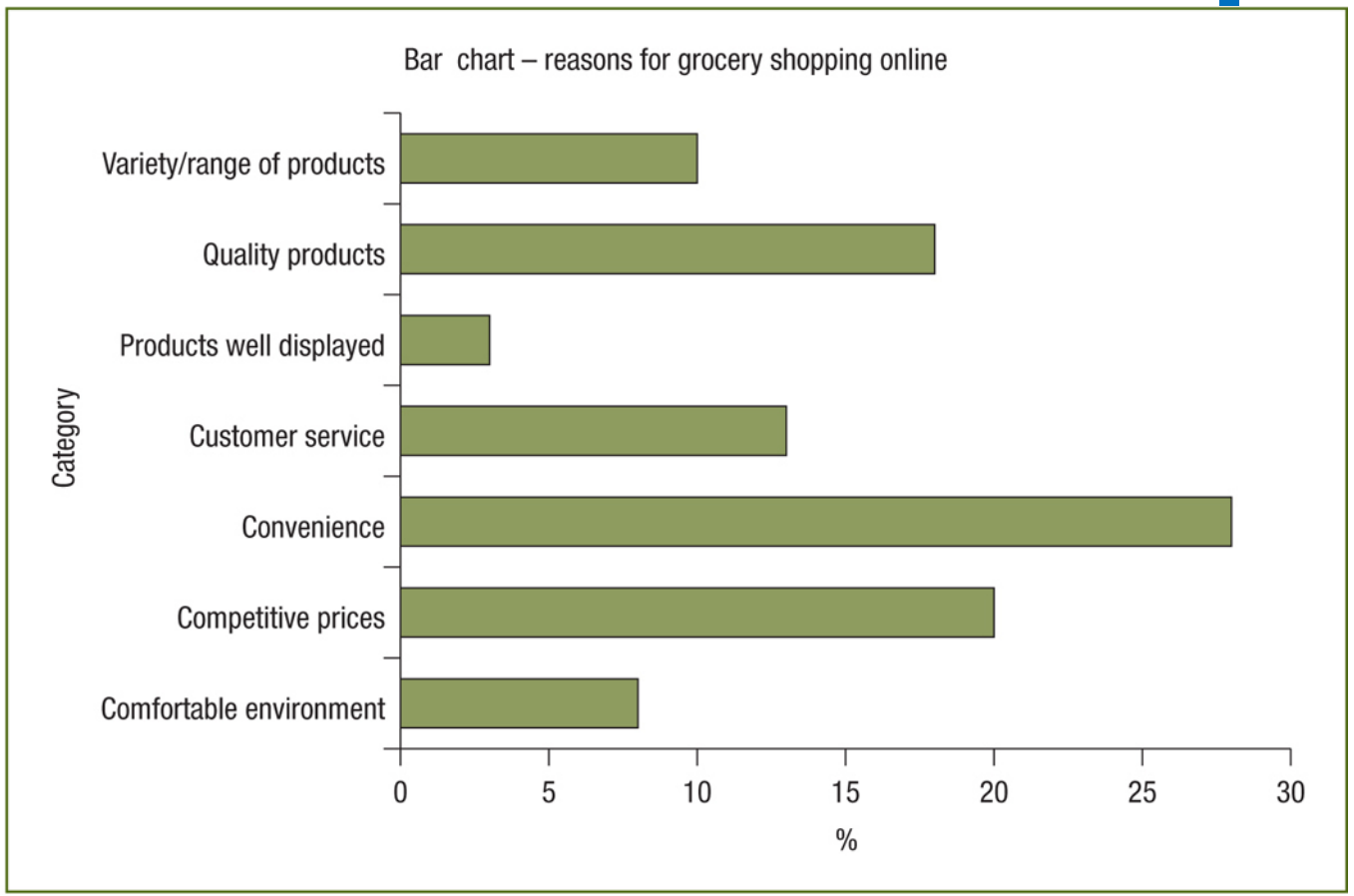
| Type | Number of properties | Percentage of properties |
|---|---|---|
| House | 82 | 82.0 |
| Unit | 18 | 18.0 |
| Total | 100 | 100.0 |

# Bar Charts and Pie Charts

- Bar charts and pie charts are often used for qualitative data (categories or nominal scale)
- The length of bar, or size of pie slice, shows the frequency or percentage for each category
- Bar charts are preferred for comparing categories
- Pie charts are preferred for observing portion of the total which lies in a particular category (e.g. market share)

# Bar Charts

**Figure 2.1**
Microsoft Excel bar chart of the reasons for grocery shopping online



# Bar Charts

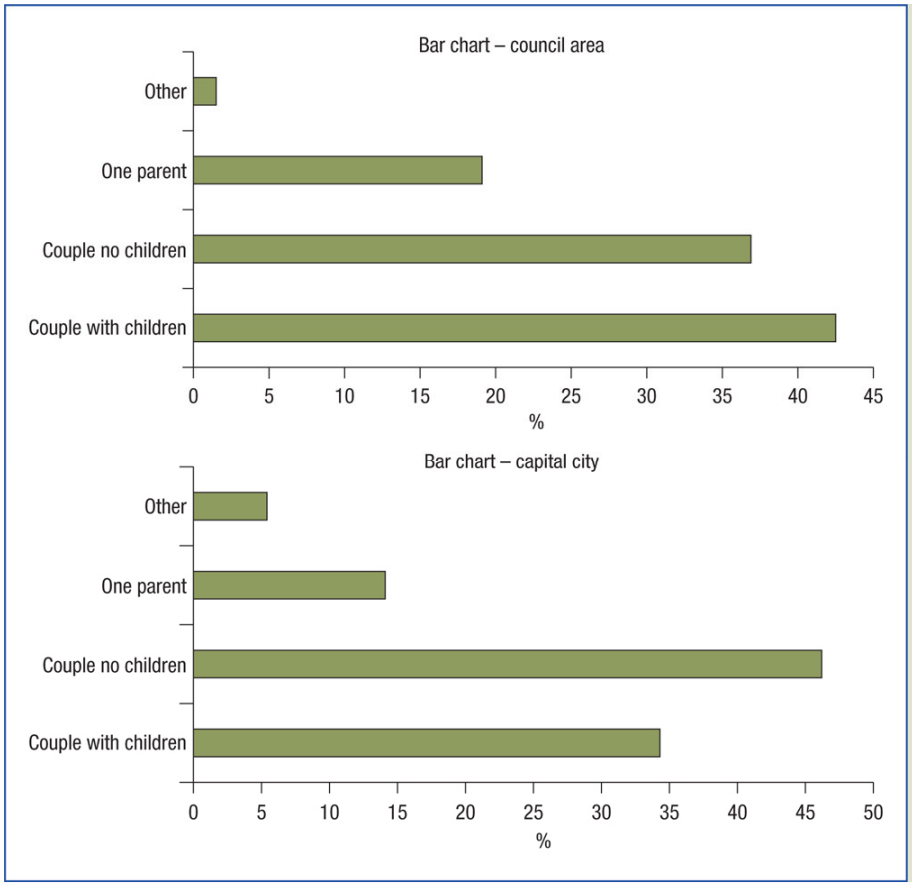
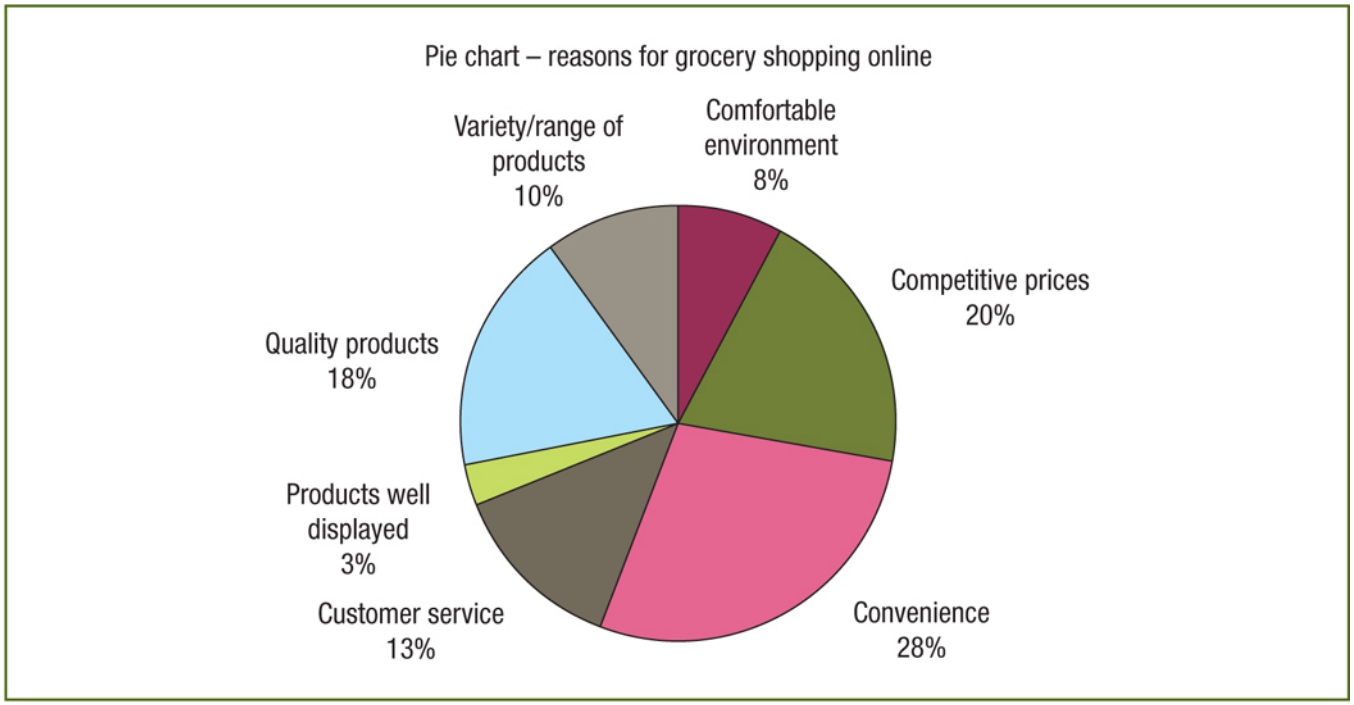



**Figure 2.2**
Microsoft Excel bar chart for family type

# +Pie Charts

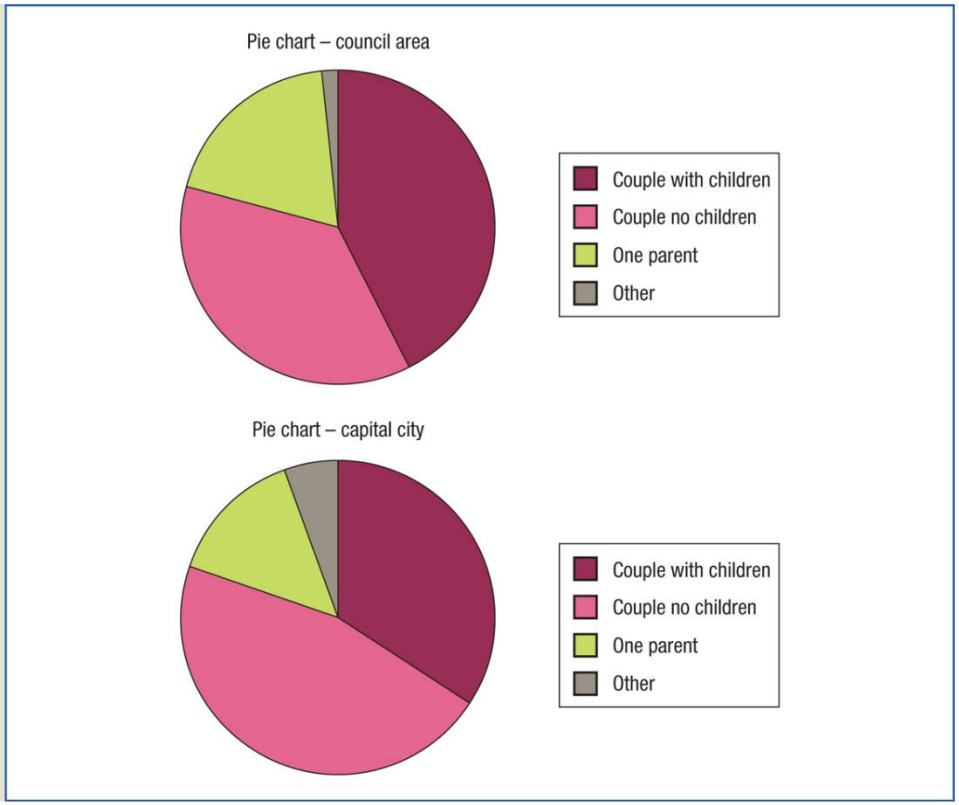


**Figure 2.3**
Microsoft Excel pie chart of the reasons for grocery shopping online

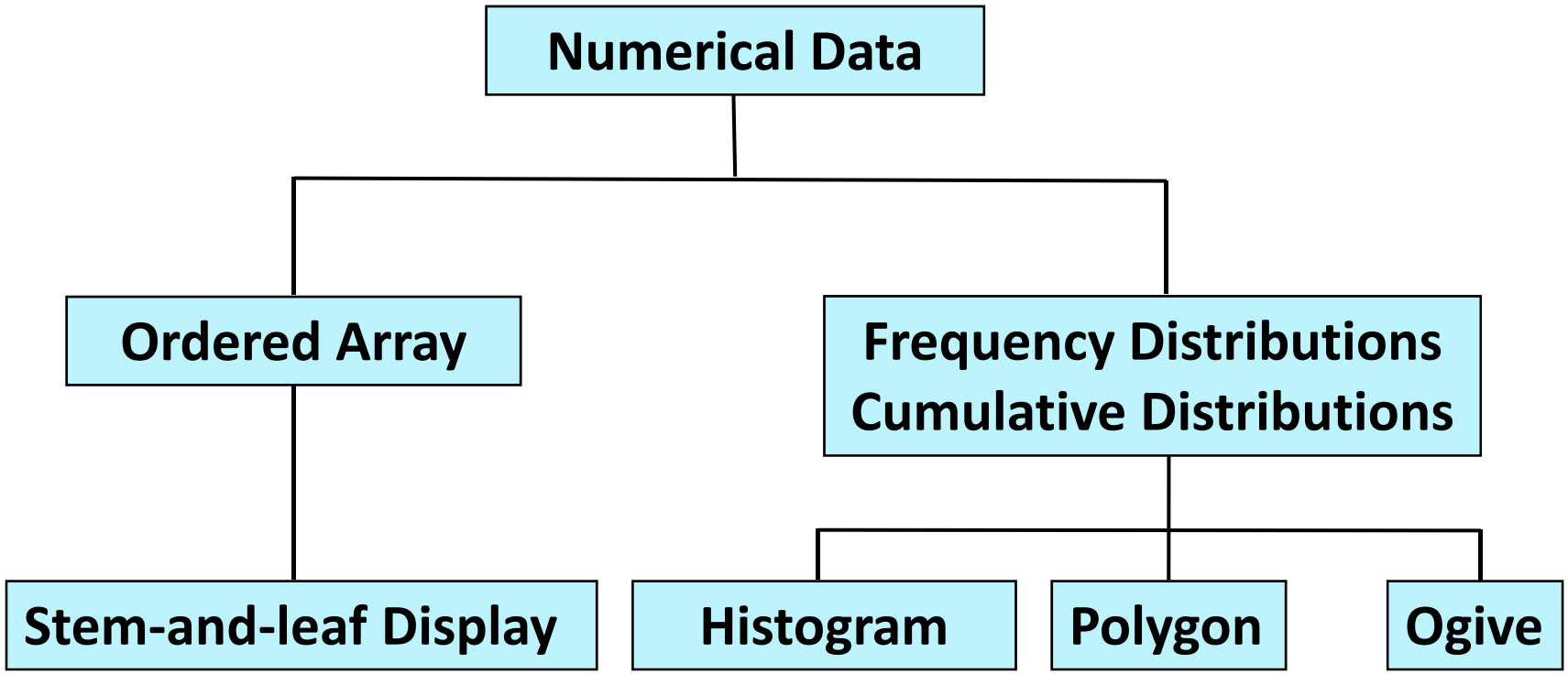


# +Pie Charts

**Figure 2.4**
Microsoft Excel pie chart for family type



# Organising Numerical data



# Ordered Arrays

A **sequence of data** in rank order:

Shows range (minimum to maximum); e.g.

24, 26, 24, 21, 27, 27, 30, 41, 32, 38 becomes:

21, 24, 24, 26, 27, 27, 30, 32, 38, 41

Provides some signals about variability within the range and may help identify outliers

If the data set is large or if the data is highly variable, the ordered array is less useful

# +Ordered Arrays

**Table 2.3** Price per main meal at 50 city restaurants and 50 suburban restaurants

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **City** | | | | | | | | | |
| 50 | 38 | 43 | 56 | 51 | 36 | 25 | 33 | 41 | 44 |
| 34 | 39 | 49 | 37 | 40 | 50 | 50 | 35 | 22 | 45 |
| 44 | 38 | 14 | 44 | 51 | 27 | 44 | 39 | 50 | 35 |
| 31 | 34 | 48 | 48 | 30 | 42 | 26 | 35 | 32 | 63 |
| 36 | 38 | 53 | 23 | 39 | 45 | 37 | 31 | 39 | 53 |
| **Suburban** | | | | | | | | | |
| 37 | 37 | 29 | 38 | 37 | 38 | 39 | 29 | 36 | 38 |
| 44 | 27 | 24 | 34 | 44 | 23 | 30 | 32 | 25 | 29 |
| 43 | 31 | 26 | 34 | 23 | 41 | 32 | 30 | 28 | 33 |
| 26 | 51 | 26 | 48 | 39 | 55 | 24 | 38 | 31 | 30 |
| 51 | 30 | 27 | 38 | 26 | 28 | 33 | 38 | 32 | 25 |

**Table 2.4** Ordered array of price per main meal at 50 city restaurants and 50 suburban restaurants

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **City** | | | | | | | | | |
| 14 | 22 | 23 | 25 | 26 | 27 | 30 | 31 | 31 | 32 |
| 33 | 34 | 34 | 35 | 35 | 35 | 36 | 36 | 37 | 37 |
| 38 | 38 | 38 | 39 | 39 | 39 | 39 | 40 | 41 | 42 |
| 43 | 44 | 44 | 44 | 44 | 45 | 45 | 48 | 48 | 49 |
| 50 | 50 | 50 | 50 | 51 | 51 | 53 | 53 | 56 | 63 |
| **Suburban** | | | | | | | | | |
| 23 | 23 | 24 | 24 | 25 | 25 | 26 | 26 | 26 | 26 |
| 27 | 27 | 28 | 28 | 29 | 29 | 29 | 30 | 30 | 30 |
| 30 | 31 | 31 | 32 | 32 | 32 | 33 | 33 | 34 | 34 |
| 36 | 37 | 37 | 37 | 38 | 38 | 38 | 38 | 38 | 38 |
| 39 | 39 | 41 | 43 | 44 | 44 | 48 | 51 | 51 | 55 |

# Stem-and-Leaf Displays



A quick and simple way to see distribution details in a data set

**Method:** Separate the sorted data series into groups (the **stem**) and the values within each group (the **leaves**)

**An example:** Data in an ordered array (21), 24, 27, 30, 32, (38), (41)

21 is shown as →

38 is shown as →

41 is shown as →

| Stem | Leaf |
|---|---|
| 2 | 1 |
| 3 | 8 |
| 4 | 1 |

# +Stem-and-Leaf Displays (cont)



**Figure 2.5**
PhStat2 stem-and-leaf display for festival expenditure by interstate visitors

Festival expenditure by interstate visitors

Stem unit: $100

Leaf unit: $10

| | |
|---|---|
| 2 | 2 7 8 |
| 3 | 1 2 3 5 9 9 9 |
| 4 | 0 2 3 3 5 5 6 7 8 8 9 |
| 5 | 1 2 5 5 6 8 9 |
| 6 | 0 0 0 3 3 3 4 6 6 8 9 |
| 7 | 3 5 6 7 7 8 9 |
| 8 | 0 6 7 |
| 9 | 1 1 4 |
| 10 | 4 |

# Frequency Distributions



## What is a frequency distribution?

- A frequency distribution is a summary table in which data are arranged into numerically ordered classes or intervals
- The number of observations in each ordered class or interval becomes the corresponding frequency of that class or interval

## Why use a frequency distribution?

- It is a way to summarise numerical data
- It condenses the raw data into a more useful form
- It allows for a quick visual interpretation of the data and first inspection of the shape of the data

# Frequency Distributions (cont)



**Table 2.5** Frequency distribution of the price per main meal for 50 city restaurants and 50 suburban restaurants

| Price of main meal ($) | City frequency | Suburban frequency |
|---|---|---|
| $10 but less than $15 | 1 | 0 |
| $15 but less than $20 | 0 | 0 |
| $20 but less than $25 | 2 | 4 |
| $25 but less than $30 | 3 | 13 |
| $30 but less than $35 | 7 | 13 |
| $35 but less than $40 | 14 | 12 |
| $40 but less than $45 | 8 | 4 |
| $45 but less than $50 | 5 | 1 |
| $50 but less than $55 | 8 | 2 |
| $55 but less than $60 | 1 | 1 |
| $60 but less than $65 | 1 | 0 |
| Total | 50 | 50 |

# Frequency Distributions (cont)

## Class Intervals and Class Boundaries

- Each data value belongs to one - and only one - class
- Each class grouping has the same width
- Determine the width of each interval by:

$$\text{Width of Interval} \cong \frac{\text{Range}}{\text{Number of desired class groupings}}$$

- Usually at least 5 - but no more than 15 - groupings
- Class boundaries must be mutually exclusive
- Classes must be collectively exhaustive
- Round up the interval width to get desirable endpoints

# Relative Frequency Distributions and Percentage Distributions

| | City | | Suburban | |
|---|---|---|---|---|
| Price of main meal ($) | Relative frequency | Percentage | Relative frequency | Percentage |
| $10 but less than $15 | 0.02 | 2.0 | 0.00 | 0.0 |
| $15 but less than $20 | 0.00 | 0.0 | 0.00 | 0.0 |
| $20 but less than $25 | 0.04 | 4.0 | 0.08 | 8.0 |
| $25 but less than $30 | 0.06 | 6.0 | 0.26 | 26.0 |
| $30 but less than $35 | 0.14 | 14.0 | 0.26 | 26.0 |
| $35 but less than $40 | 0.28 | 28.0 | 0.24 | 24.0 |
| $40 but less than $45 | 0.16 | 16.0 | 0.08 | 8.0 |
| $45 but less than $50 | 0.10 | 10.0 | 0.02 | 2.0 |
| $50 but less than $55 | 0.16 | 16.0 | 0.04 | 4.0 |
| $55 but less than $60 | 0.02 | 2.0 | 0.02 | 2.0 |
| $60 but less than $65 | 0.02 | 2.0 | 0.00 | 0.0 |
| Total | 1.00 | 100.0 | 1.00 | 100.0 |

**Table 2.7**
Relative frequency distribution and percentage distribution of the price of main meals at city and suburban restaurants

# Cumulative Distributions

**Table 2.9** Cumulative percentage distributions of the price of city and suburban restaurant main meals

| Price ($) | City percentage of restaurants less than indicated value | Suburban percentage of restaurants less than indicated value |
|---|---|---|
| $10 | 0 | 0 |
| $15 | 2 | 0 |
| $20 | 2 | 0 |
| $25 | 6 | 8 |
| $30 | 12 | 34 |
| $35 | 26 | 60 |
| $40 | 54 | 84 |
| $45 | 70 | 92 |
| $50 | 80 | 94 |
| $55 | 96 | 98 |
| $60 | 98 | 100 |
| $65 | 100 | 100 |

# Histograms

A graph of the data in a frequency distribution is called a **histogram**

The **class boundaries** (or **class midpoints**) are shown on the horizontal axis

The vertical axis is either **frequency**, **relative frequency**, or **percentage**

Bars of the appropriate heights are used to represent the frequencies (number of observations) within each class or the relative frequencies (percentage) of that class

# +Histograms (cont)



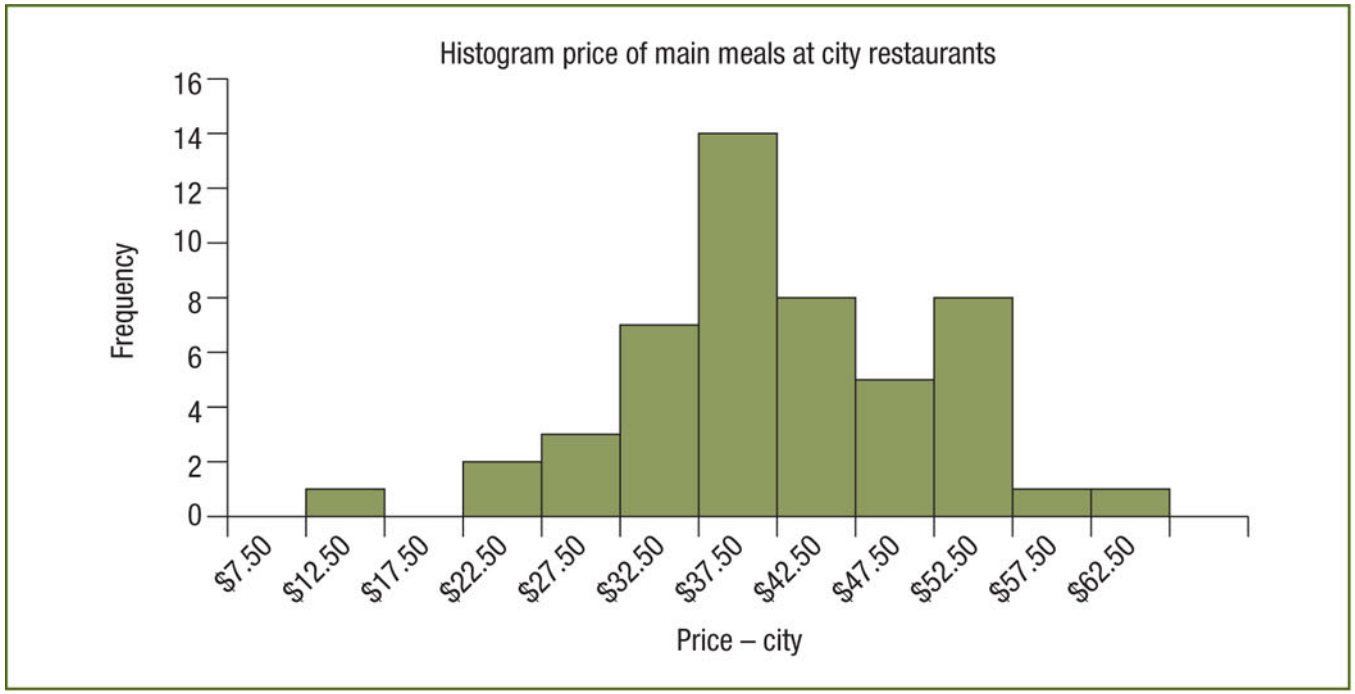



**Figure 2.6**
Excel histogram of the price of main meals at city restaurants

# +Polygons



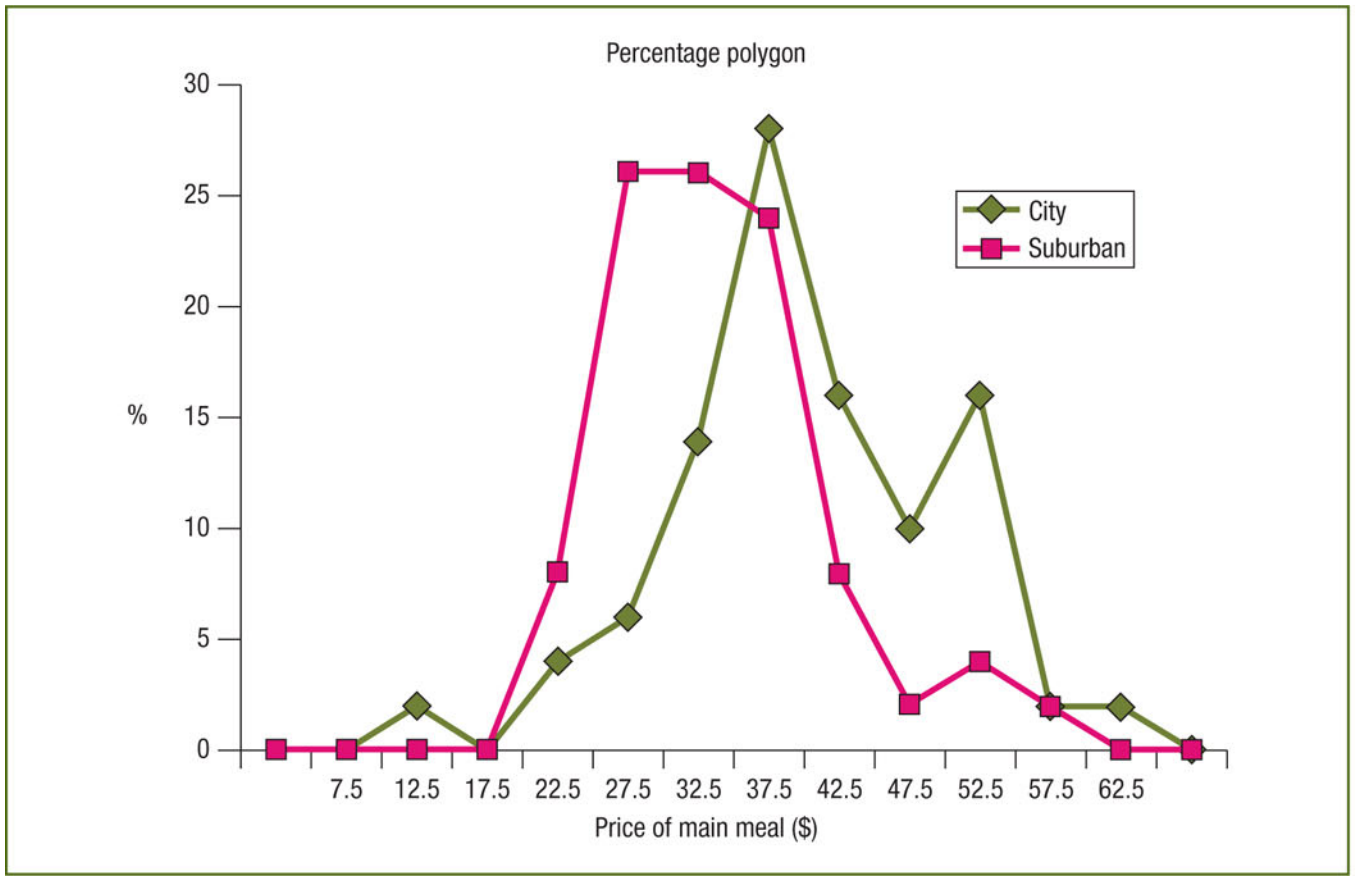
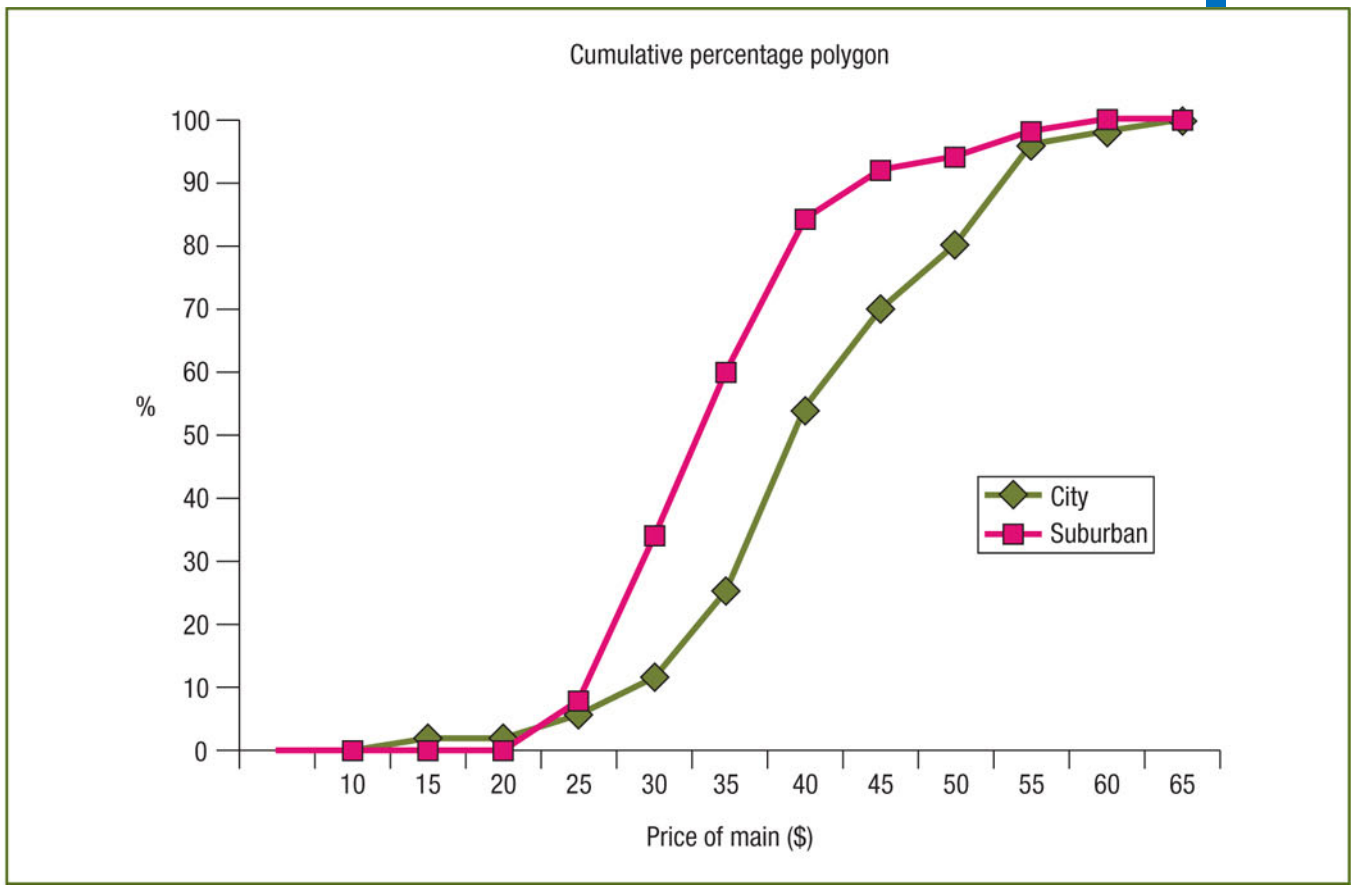



**Figure 2.8**
Percentage polygons for the price of main meals in city and suburban restaurants

# Cumulative Percentage Polygons (Ogives)

**Figure 2.10**
Cumulative percentage polygons of the cost of main meals at city and suburban restaurants



# Cross Tabulations



**Table 2.11** Frequency contingency table for number of bedrooms and location

| | Bedrooms | | | | | |
|---|---|---|---|---|---|---|
| **Location** | **1** | **2** | **3** | **4** | **>4** | **Total** |
| **Rural** | 2 | 5 | 16 | 10 | 1 | 34 |
| **Town** | 4 | 14 | 29 | 14 | 5 | 66 |
| **Total** | 6 | 19 | 45 | 24 | 6 | 100 |

**Table 2.12** Percentage contingency table for number of bedrooms and location based on overall total

| | Bedrooms % | | | | | |
|---|---|---|---|---|---|---|
| **Location** | **1** | **2** | **3** | **4** | **>4** | **Total %** |
| **Rural** | 2.0 | 5.0 | 16.0 | 10.0 | 1.0 | 34.0 |
| **Town** | 4.0 | 14.0 | 29.0 | 14.0 | 5.0 | 66.0 |
| **Total** | 6.0 | 19.0 | 45.0 | 24.0 | 6.0 | 100.0 |

# Cross Tabulations



| | Bedrooms % | | | | | |
|---|---|---|---|---|---|---|
| Location | 1 | 2 | 3 | 4 | >4 | Total % |
| Rural | 5.9 | 14.7 | 47.1 | 29.4 | 2.9 | 100.0 |
| Town | 6.1 | 21.2 | 43.9 | 21.2 | 7.6 | 100.0 |
| Total | 6.0 | 19.0 | 45.0 | 24.0 | 6.0 | 100.0 |

**Table 2.13** Contingency table for number of bedrooms and location based on row total reported as a percentage

| | Bedrooms % | | | | | |
|---|---|---|---|---|---|---|
| Location | 1 | 2 | 3 | 4 | >4 | Total % |
| Rural | 33.3 | 26.3 | 35.6 | 41.7 | 16.7 | 34.0 |
| Town | 66.7 | 73.7 | 64.4 | 58.3 | 83.3 | 66.0 |
| Total | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |

**Table 2.14** Contingency table for number of bedrooms and location based on column total reported as a percentage

# Side-by-Side Bar Charts

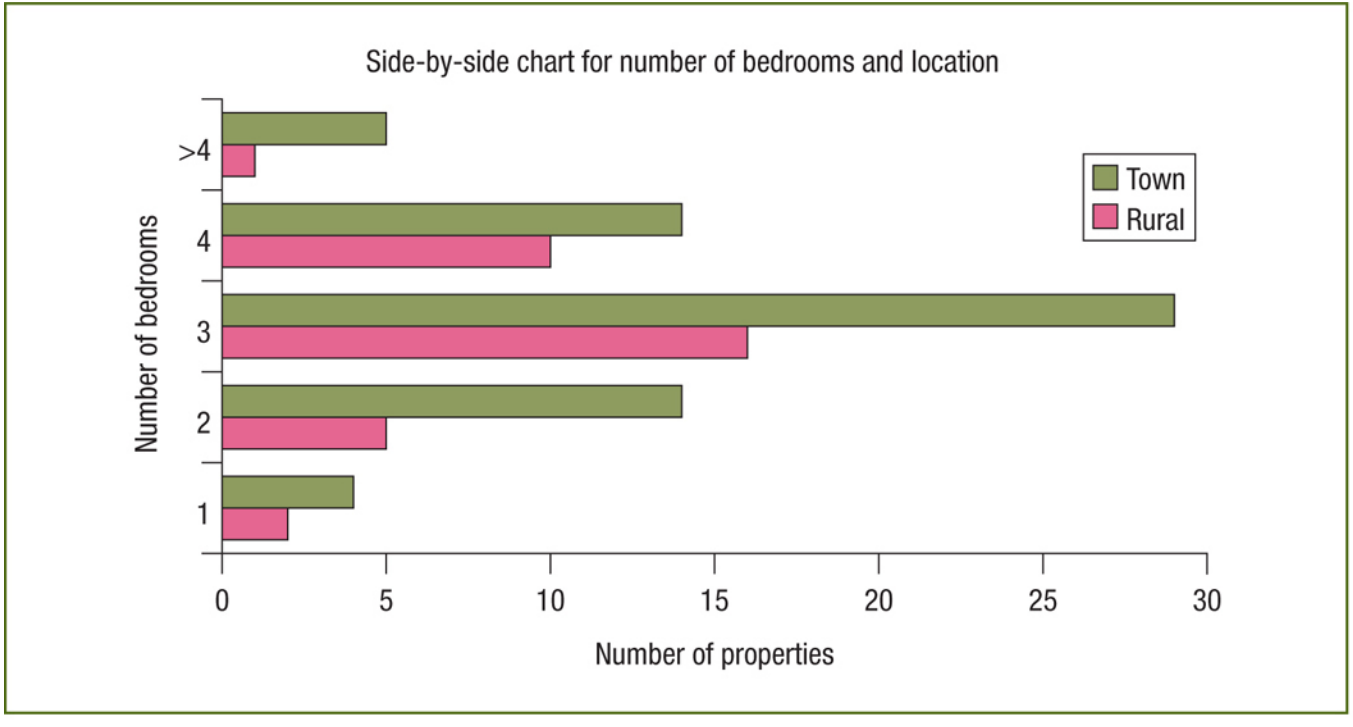



**Figure 2.12**
Microsoft Excel side-by-side bar chart for number of bedrooms and location

# Side-by-Side Bar Charts

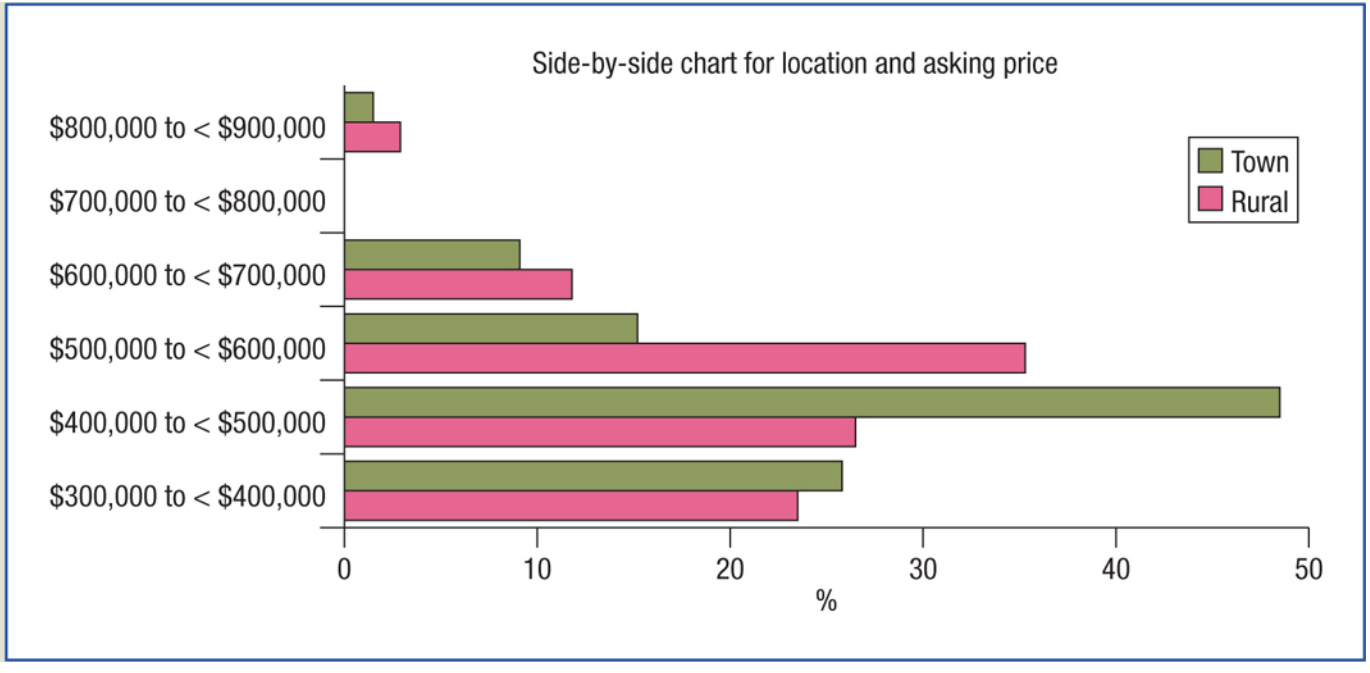


**Table 2.15**
Contingency table for price and location based on percentage of column total

| | Frequency | | Column percentage | |
|---|---|---|---|---|
| **Asking price ($)** | **Rural** | **Town** | **Rural** | **Town** |
| 300,000 to < 400,000 | 8 | 17 | 23.5 | 25.8 |
| 400,000 to < 500,000 | 9 | 32 | 26.5 | 48.5 |
| 500,000 to < 600,000 | 12 | 10 | 35.3 | 15.1 |
| 600,000 to < 700,000 | 4 | 6 | 11.8 | 9.1 |
| 700,000 to < 800,000 | 0 | 0 | 0.0 | 0.0 |
| 800,000 to < 900,000 | 1 | 1 | 2.9 | 1.5 |
| Total | 34 | 66 | 100.0 | 100.0 |

# Side-by-Side Bar Charts

**Figure 2.13**
Side-by-side chart for location and price



# Scatter Diagrams and Time-Series Plots

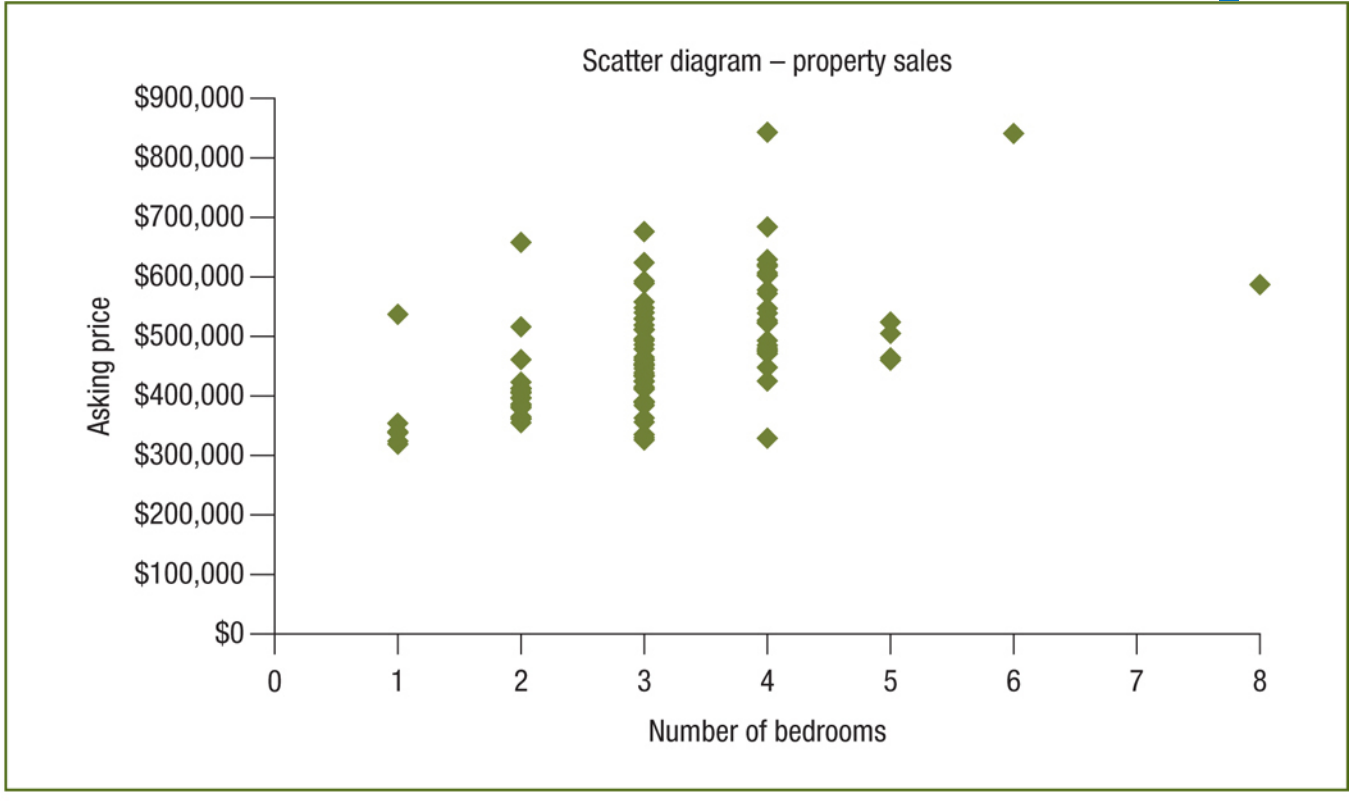
Scatter diagrams are used to examine possible relationships between two numerical variables

In a scatter diagram:

- one variable is measured on the vertical axis (Y)
- the other variable is measured on the horizontal axis (X)

# Scatter Diagrams

**Figure 2.14**
Microsoft Excel scatter diagram for number of bedrooms and asking price



# Time-Series Plots

A time-series plot is used to study patterns in the values of a variable over time

In a time-series plot:

- one variable is measured on the vertical axis
- the time period is measured on the horizontal axis

# Time-Series Plots



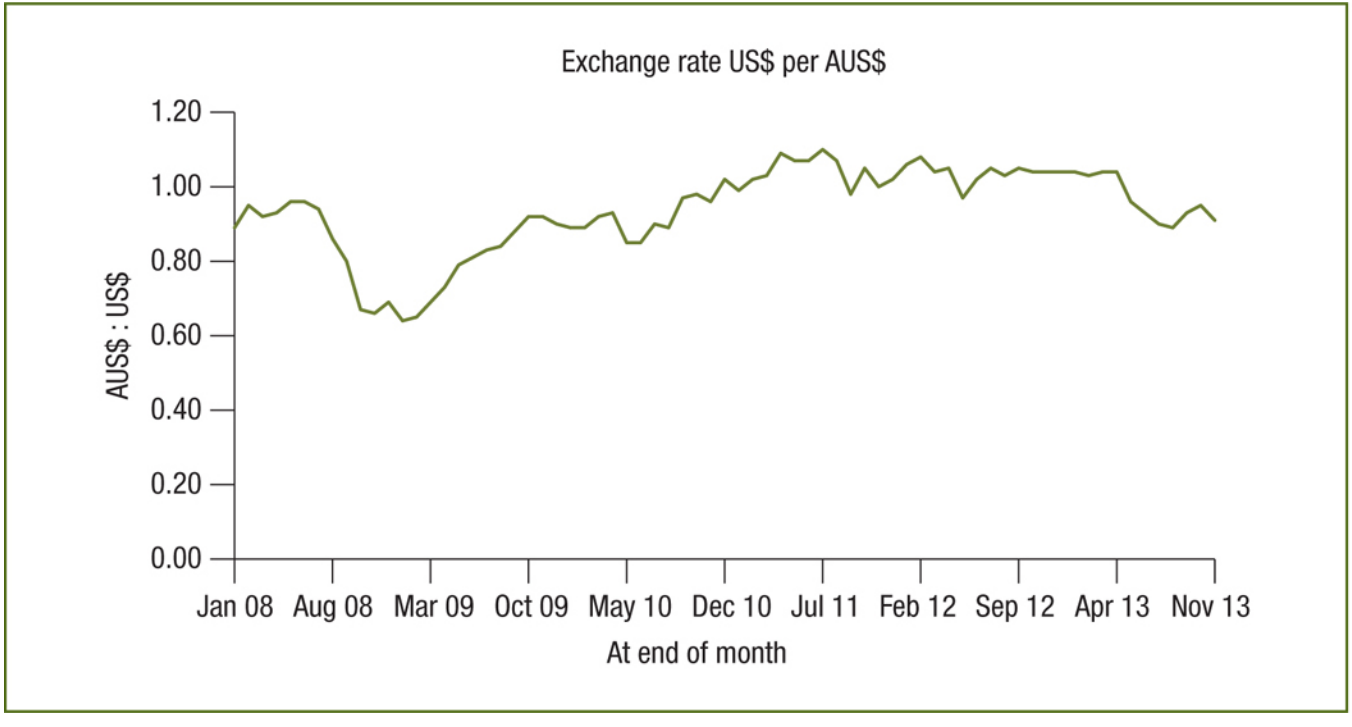



**Figure 2.15**
Microsoft Excel time-series plot of exchange rates: Australian dollar against US dollar 2008 to 2013

*Source:* Data based on *Reserve Bank of Australia, Statistics, Exchange Rates* <www.rba.gov.au> accessed December 2013.

# Roadmap for Selecting Tables and Charts

**Table 2.16**
Roadmap for selecting tables and charts

| Type of analysis | Type of data | |
|---|---|---|
| | **Numerical** | **Categorical** |
| Tabulating, organising and graphically presenting the values of a variable | Ordered array, stem-and-leaf display, frequency distribution, relative frequency distribution, percentage distribution, cumulative percentage distribution, histogram, polygon, cumulative percentage polygon **(Sections 2.2 and 2.3)** | Summary table, bar chart, pie chart **(Section 2.1)** |
| Graphically presenting the relationship between two variables | Scatter diagram, time-series plot **(Section 2.5)** | Contingency table, side-by-side bar chart **(Section 2.4)** |

# Misusing Graphs and Ethical Issues



Do not distort the data

- Frequency/quantity should be proportional to the area/volume

Avoid unnecessary adornments

- No 'chart junk'

Use a scale for each axis on a two-dimensional graph

- Should be properly scaled along each axis
- All axes should be labelled

# Misusing Graphs and Ethical Issues (cont)

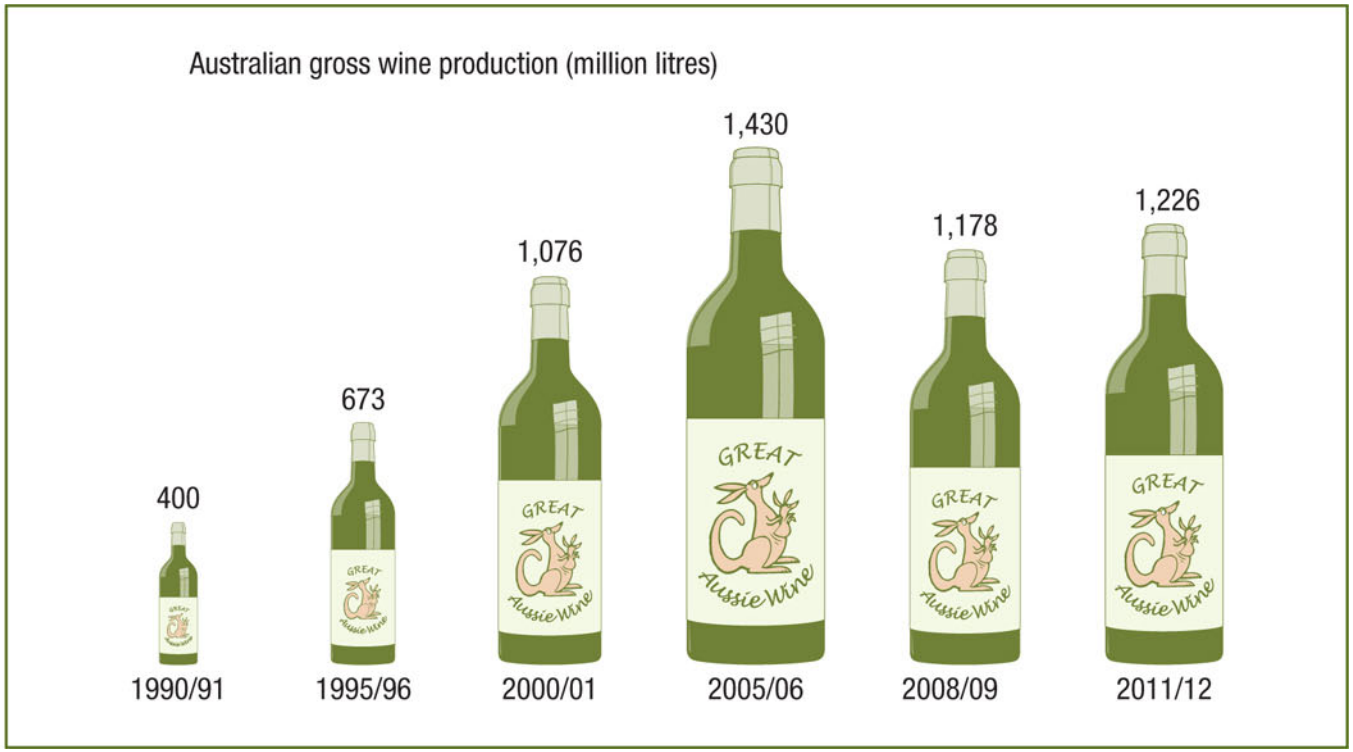
- The vertical axis scale should begin at zero unless there is justification for truncation (which must be clearly labelled and explained to the reader)
- The graph should contain a title
- Use the simplest graph for a given set of data

# Misusing Graphs and Ethical Issues (cont)



**Figure 2.16**
Misleading display of Australian wine production

*Source:* Data obtained from 'Australian Gross Wine Production – pdf format', Wine Australia Corporation <www.wineaustralia.com/australia> accessed December 2013.



# Misusing Graphs and Ethical Issues (cont)

**Figure 2.17**
Misleading display of New Zealand alcohol consumption

*Source:* Data from OECD (2011 and 2013), 'Alcohol consumption', Health: Key Tables from OECD, No. 24. doi: 10.1787/alcoholcons-table-2013-2-en and 10.1787/alcoholcons-table-2011-1-en, accessed December 2013.

# +Ethical Concerns



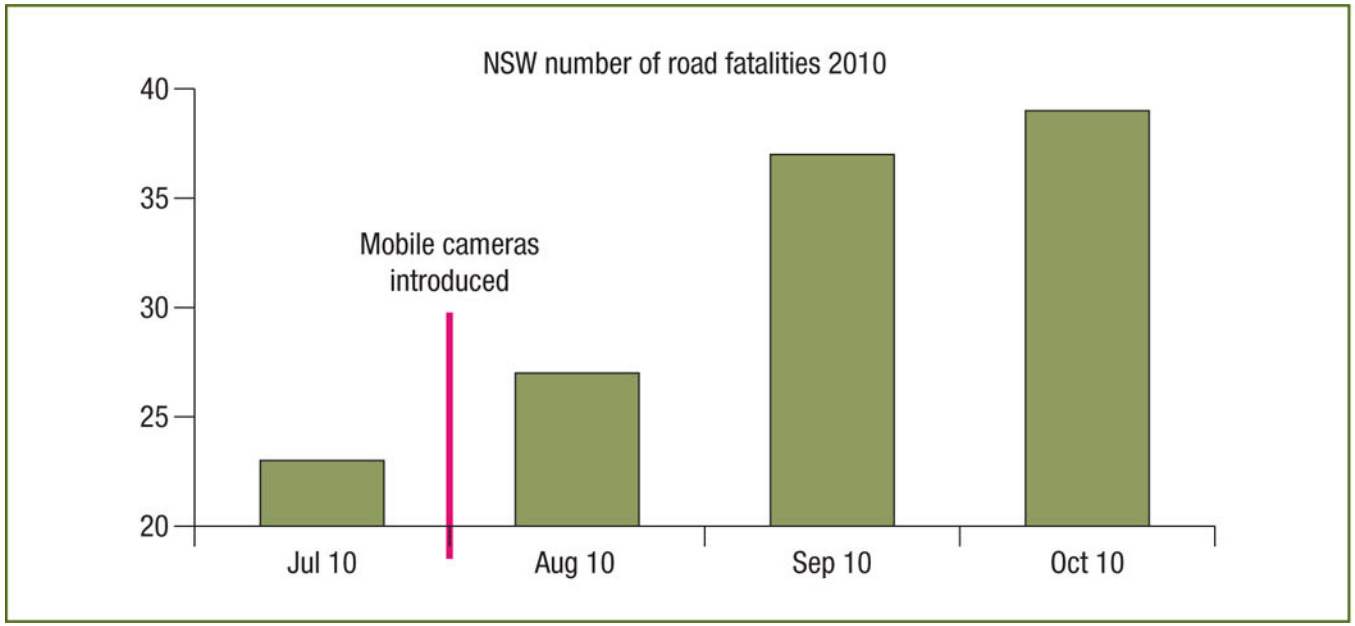
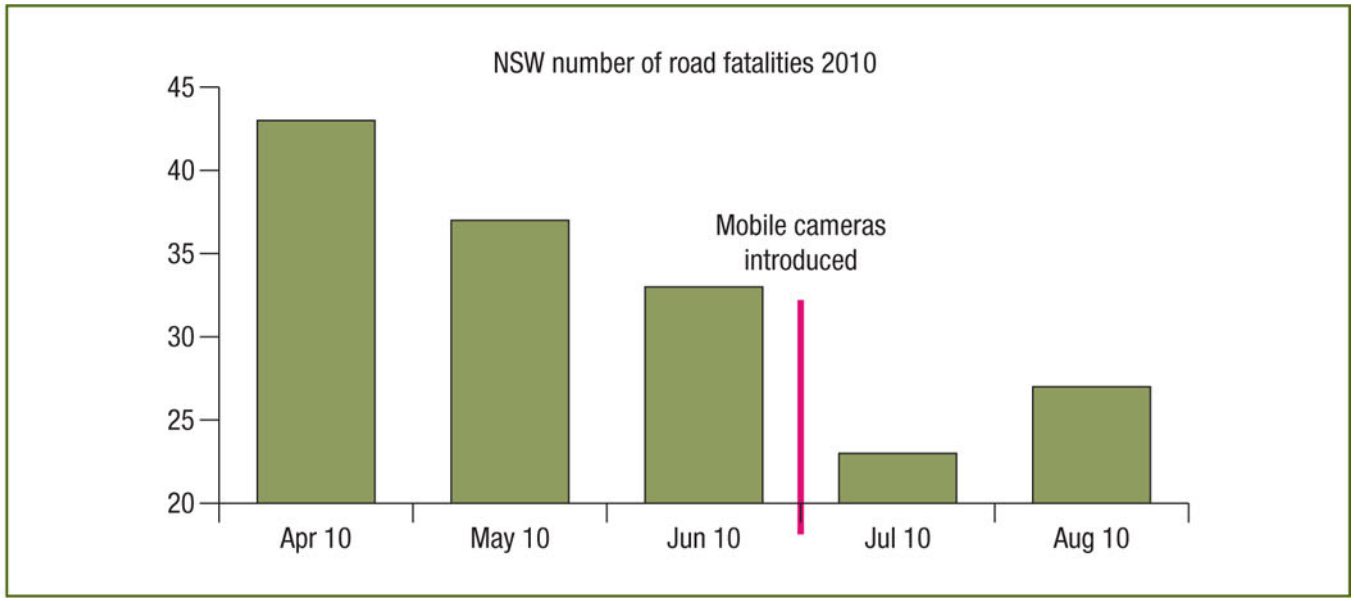



**Figure 2.18a**
NSW road fatalities 2010

# +Ethical Concerns



**Figure 2.18b**
NSW road fatalities 2010

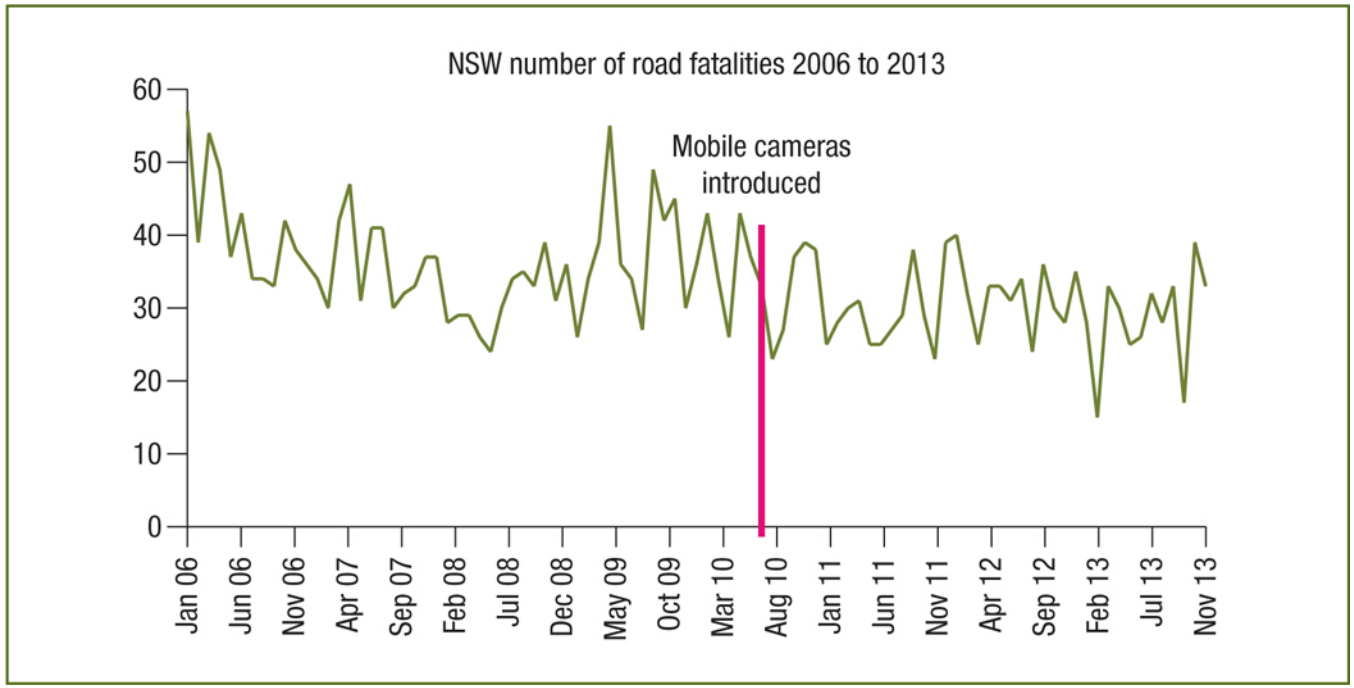


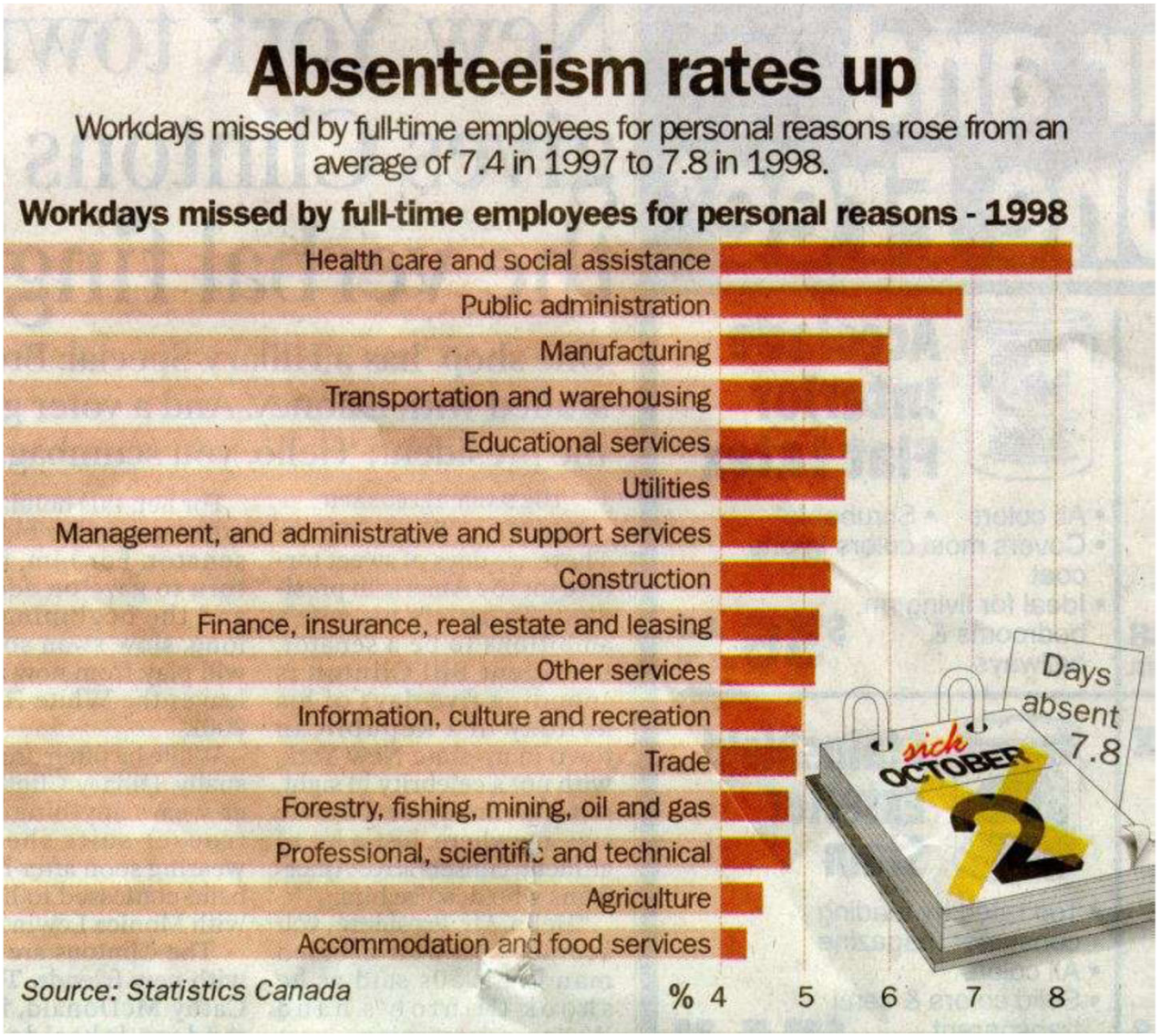
# +Ethical Concerns



**Figure 2.18c**
NSW road fatalities 2006 to 2013

*Source:* Data in Figures 2.18(a)–(c) obtained from Australian Road Deaths Database, <www.bitre.gov.au/statistics/safety/fatal_road_crash_database.aspx>, accessed 27 December 2013.




Absenteeism rates up
Workdays missed by full-time employees for personal reasons rose from an average of 7.4 in 1997 to 7.8 in 1998.
Workdays missed by full-time employees for personal reasons - 1998
Health care and social assistance
Public administration
Manufacturing
Transportation and warehousing
Educational services
Utilities
Management, and administrative and support services
Construction
Finance, insurance, real estate and leasing
Other services
Information, culture and recreation
Trade
Forestry, fishing, mining, oil and gas
Professional, scientific and technical
Agriculture
Accommodation and food services
Source: Statistics Canada
%
4
5
6
7
8
Days absent 7.8
sick
OCTOBER