Lecture 7: **What the data says**

Learning objectives

✓ Interpret and communicate the results of a large-scale study

✓ Explain physical factors which may explain the trends seen in data

Scientific examples

✓ Coronary heart disease

✓ Carbon dioxide in the atmosphere (the Keeling curve)

Maths skills

✓ Describe mathematical trends in data

Case Study 3: **To the heart of the matter**

- Diseases of the circulatory system (including heart disease and stroke) are the leading cause of death in many western societies.
- Individuals, doctors and public health bodies all have an obvious interest in predicting the risk of suffering cardiovascular disease.
- In medicine and population health, risks are often specified as a probability of an identified event occurring in a given time period.
- Shortly we will encounter a famous, long-running study into cardiovascular health, called the *Framingham study* [1] The study defines Coronary Heart Disease (CHD) as including:
  - *angina pectoris*, which is severe chest pain caused by a lack of blood to heart muscle;
  - *myocardial infarction*, commonly called a heart attack, arising from complete loss of blood supply to heart muscle; and
  - death due to cardiac arrest.
- CHD is most often caused by *atherosclerosis*, which is a blockage of a coronary artery supplying blood to heart muscle tissue.

[1] All information from the Framingham study has been reproduced with permission from the National Heart, Lung, and Blood Institute as a part of the National Institutes of Health and the U.S. Department of Health and Human Services.

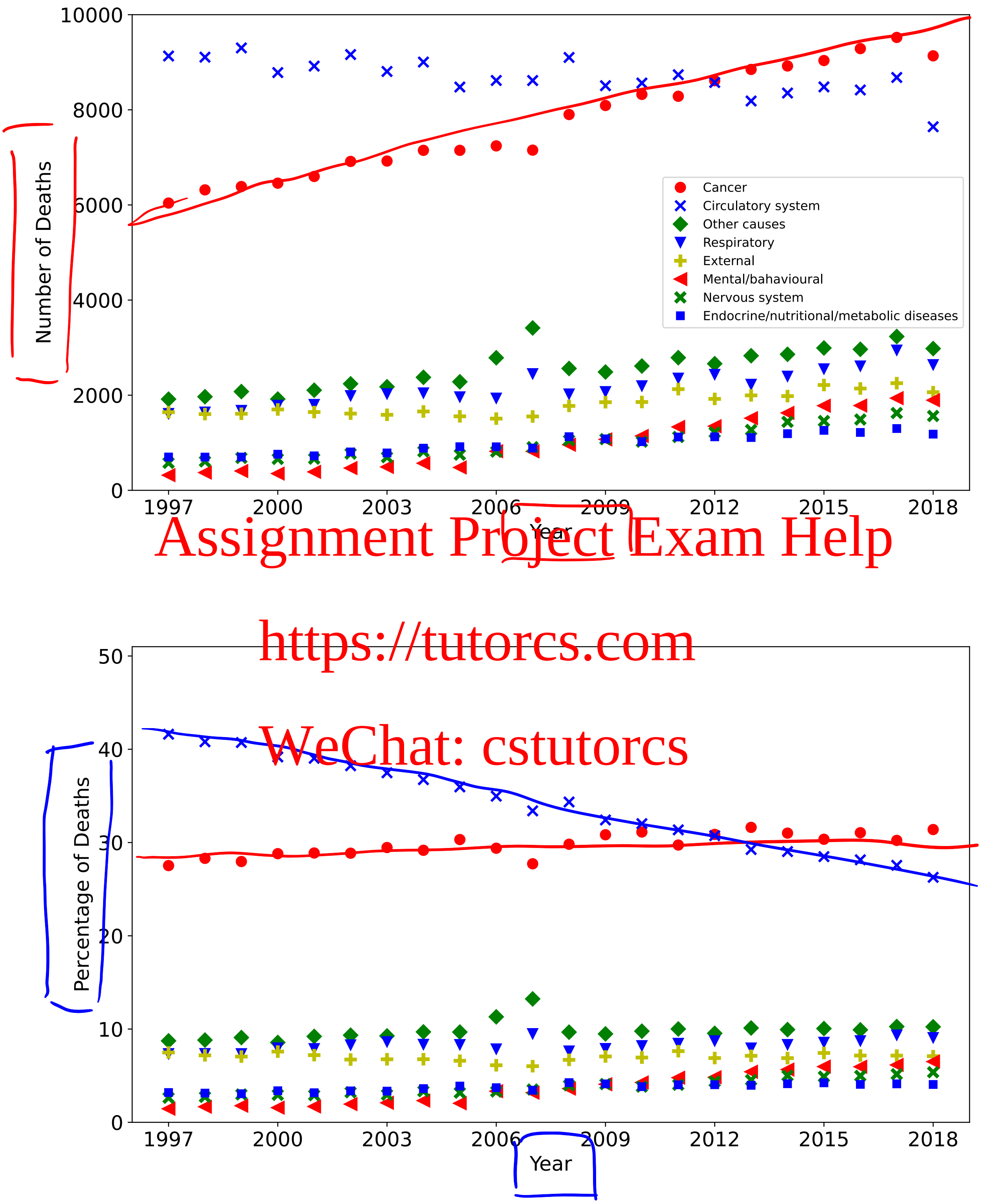


Figure 3.3: Leading causes of death in Queensland. The top graph shows total number of deaths attributed to a given cause, while the bottom graph shows the percentage of all deaths attributed to the given cause. (Data source: Australian Bureau of Statistics.)

mortality rate => number / 100,000 population

Question 3.3.3

Which factors or data are crucial when developing a model for estimating the likelihood that a person will suffer from CHD in the next 10 years? Does each factor increase or decrease the risk?

age ↑
lifestyle ↓ (better)
weight ↑
diet ↓ (good)
smoking ↑
hours worked - stress ↑
sex ↑ (depend)
body condition - general health ↑

family history ↑

What is your 'gut feeling' of the likelihood that your lecturer will suffer from CHD in the next 10 years?

Tim 10-30%
Tatsuya 5-10%

- Until comparatively recently, little was known about the general causes of heart disease and stroke, although the rates of cardiovascular disease (CVD) in many societies had been rising for some time.
- In 1948, a study into heart disease commenced in Framingham, Massachusetts, which has become one of the best-known longitudinal health studies.
- The Framingham study (which continues today) has monitored the cardiovascular health of participants, identified a range of risk factors for CHD and included these factors in a mathematical risk model.
- One of the resources produced from the Framingham Study is a CHD Risk Prediction score sheet, used to predict the likelihood that a person will suffer CHD in the next ten years.

Step 1: Age

Tim Tatsuya

Age (Years)	Points Female	Points Male
30-34	-9	-1
35-39	-4	0
40-44	0	1
45-49	3	2
50-54	6	3
55-59	7	4
60-64	8	5
65-69	8	6
70-74	8	7

1

4

Step 2: LDL cholesterol

LDL (mmol/L)	Points Female	Points Male
≤ 2.59	-2	-3
2.60-3.36	0	0
3.37-4.14	0	0
4.19-4.91	2	1
≥ 4.92	2	2

0 0

Key	
Colour	Risk
green	very low
white	low
yellow	moderate
rose	high
red	very high

Step 3: HDL cholesterol

Tatsuya 106 71

Tim - 147 96

HDL (mmol/L)	Points Female	Points Male
≤ 0.9	5	2
0.91-1.16	2	1
1.17-1.29	1	0
1.30-1.55	0	0
≥ 1.56	-2	-1

0 0

Step 4: Blood pressure (F: Female, M: Male)

Systolic (mm Hg)	Diastolic (mm Hg) < 80 Points	80-84 Points	85-89 Points	90-99 Points	≥ 100 Points
≤ 120	F: -3 M: 0				
120-129		0			
130-139			F: 0 M: 1		
140-159				2	
≥ 160					3

2

Note: When systolic and diastolic pressures provide different estimates for point scores, use the higher number.

Step 5: Diabetes

Diabetes	Points Female	Points Male
No	0	0
Yes	4	2

Step 6: Smoker

Smoker	Points Female	Points Male
No	0	0
Yes	2	2

Tim Tatsuya

Step 7: Sum points from Steps 1-6

Category	Points	
Age	4	1
LDL	0	0
HDL	0	0
Blood pressure	2	0
Diabetes	0	0
Smoker	0	0
Point total	6	1

Step 8: Determine risk from point total

Point total	10 Year CHD risk Female	Male
≤ -3	1%	1%
-2	1%	2%
-1	2%	2%
0	2%	3%
1	2%	4%
2	3%	4%
3	3%	6%
4	4%	7%
5	5%	9%
6	6%	11%
7	7%	14%
8	8%	18%
9	9%	22%
10	11%	27%
11	13%	33%
12	15%	40%
13	17%	47%
14	20%	≥ 56%
15	24%	≥ 56%
16	27%	≥ 56%
≥ 17	≥ 32%	≥ 56%

Tatsuya

Tim

Step 9: Compare to others of the same age

Age (Years)	Average 10 Yr risk	Low 10 Yr risk
30-34	F: <1% M: 3%	F: <1% M: 2%
35-39	F: 1% M: 5%	F: <1% M: 3%
40-44	F: 2% M: 7%	F: 2% M: 4%
45-49	F: 5% M: 11%	F: 3% M: 4%
50-54	F: 8% M: 14%	F: 5% M: 6%
55-59	F: 12% M: 16%	F: 7% M: 7%
60-64	F: 12% M: 21%	F: 8% M: 9%
65-69	F: 13% M: 25%	F: 8% M: 11%
70-74	F: 14% M: 30%	F: 8% M: 14%

Note: low risk was calculated for an individual of the same age, with normal blood pressure, LDL 2.60-3.36 mmol/L, HDL 1.45 mmol/L, non-smoker and no diabetes.

Figure 3.4: Framingham CHD risk assessment sheet for males and females

Question 3.3.4

Use the Framingham CHD risk assessment sheet in Figure 3.4 to estimate the probability that your lecturer will suffer CHD within 10 years. Compare this with your answers to Question 3.3.3.

Tim 11% (Framingham) c.f. class 10-30%

Tatsuya 4% (Framingham) c.f. class 5-10%

Question 3.3.5

Briefly discuss some key points highlighted by the risk prediction sheet. (You may wish to mention such things as the comparative impact of different risk factors, some 'risk factors' commonly mentioned in the media that are not included, and some differences between males and females.)

age

sex

ldl, hdl

blood press

diabetes

smoking

menopause / hormones

increases risk

End of Case Study 3: To the heart of the matter.

Chapter 4: **A place with atmosphere**

Image 4.1: *Starry Night* (1508 – 1512), Van Gogh (Source: commons.wikimedia.org)

The next three chapters introduce some tools for mathematical modelling, specifically mathematical functions. We will start with power functions including linear functions, quadratics and more general power functions. We will then move onto periodic functions, and then logarithmic and exponential functions. Later, we will also look at combinations of these functions.

You should have encountered these functions in previous study of mathematics. See Section C.1 in Appendix C for the pre-requisite mathematical tools we will use in this chapter. Use the online modules, available through the course website, for further support. Here our focus is on how these functions are applied in scientific contexts.

SOMSE

We begin the chapter with a motivating example: we consider data on atmospheric carbon dioxide. As a society, we would like to develop a mathematical model in order to get predictions or estimates of what to expect in our future. Remember that SCIE1000 is not a course on climate or climate change, so do not attempt to memorise any climate-related details. Instead, focus on the logical process of model development, and how this relates to other models in different contexts and in different areas of science.

4.1 Fully functional

Case Study 4: **Atmospheric CO_2**

- The broad scientific consensus is that:
  - Earth is undergoing a period of significant climate change;
  - global temperatures are likely to rise over coming years;
  - the warming is related to increasing concentrations of carbon dioxide (CO_2) in the atmosphere; and
  - the increase in atmospheric CO_2 concentration is a result of human activity.

- A famous, long-running study has monitored atmospheric CO_2 concentrations at the Mauna Loa observatory in Hawaii since 1958.

volcano

- When these data are plotted, the graph is called the *Keeling curve*, named after the initiator of the study, David Keeling.

- The Scripps Institution of Oceanography (which runs the study) describes the Keeling curve as *"... almost certainly the best-known icon illustrating the impact of humanity on the planet as a whole ..."*
- Gases in the lower atmosphere mix fairly well, so scientists consider the Keeling curve data to be representative of the atmospheric CO_2 concentration world-wide.
- By July 2016, the level of atmospheric CO_2 was consistently above 400 parts per million (ppm). (When SCIE1000 was first offered in 2008, the figure was about 380 ppm.)
- Other data from ice-core samples show that CO_2 levels remained relatively constant at 280 ppm for thousands of years, but the level started increasing in the 19th century.
- Figure 4.1 is a plot of the Keeling curve data, taken from [28, 49].

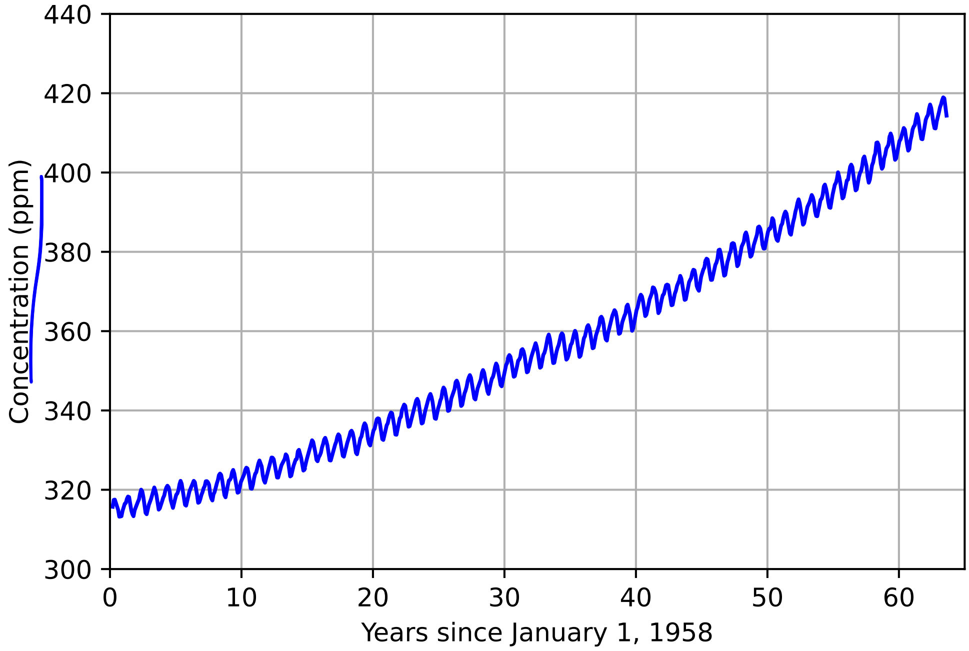


Figure 4.1: The Keeling curve.

Question 4.1.1

(a) Describe the main features of the Keeling curve graph.

oscillations

Increasing

Increasing at an increasing rate

rate

constant

increasing

spring in northern hemisphere

April

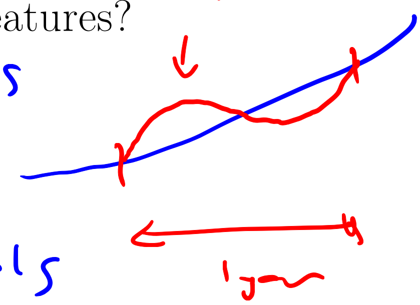
(b) What physical factor(s) could cause these features?

Seasons → oscillations

industrialisation

transport

use of fossil fuels



(c) How could you mathematically model the Keeling curve?

increasing function and an oscillation

End of Case Study 4: Atmospheric CO_2.