Chapter 2: Thinking and communicating

Lecture 3: Making sense in science

Learning objectives

✓ Understand the need for clear communication of scientific information

✓ Evaluate quantitative information presented by the media

Scientific examples

✓ Contraception and thrombosis

✓ Prostate cancer

✓ Tests for breast cancer

Maths skills

✓ Interpret quantitative information

✓ Evaluate percentages and ratios

Image 2.1: *The Persistence of Memory* (1931), Salvador Dalí (Source: en.wikimedia.org)

In SCIE1000 you will develop your skills in scientific communication. Some key guiding principles of scientific communication are: be clear, know your purpose, know your audience, and identify your key messages. Refer to Appendix B "Communication in Science" for detailed advice and examples.

In this chapter, we explore the communication of scientific knowledge, particularly in the context of effectively communicating and interpreting quantitative data in a medical context. The goal is to motivate why clear scientific communication is so important.

2.1 Quantitative communication

- In SCIE1000, we will explore the fundamental skills and concepts that will help you with effective scientific analysis and communication.

- We are all producers and consumers of quantitative scientific information, in the form of scientific papers, assignments, media reports, the internet, and professional communications such as doctor/patient discussions.

- As a *producer* of such information, we should aspire to be accurate, honest, logical, unambiguous, concise, precise, not excessively technical, and always mindful of the intended audience. See Appendix B for detailed advice on how to communicate in science.

- As a *consumer*, we should aspire to be thoughtful, reflective, sceptical, logical and analytical, while at the same time open-minded and accepting of evidence that may differ from our preconceptions or opinions.

- The media and internet provide a continual bombardment of facts, reports, summaries, interpretations and opinions, often covering sophisticated concepts but written and read by non-experts. In many cases there are errors (or deliberate falsities) in such communications.

- You should form the habit of critically evaluating information, data and (claimed) conclusions.

- A useful approach (when checking your own work, or the work of others), is *rough estimation*, which is the process of calculating approximate values. It involves building rough, conceptual models, and then evaluating them 'for sense'.

- Estimating 'gives an idea' whether a particular value is plausible. Often, we aim to find an approximate value within an *order of magnitude* of the correct value (that is, within a factor of 10 of the correct value).

2.2 Losing patients with mathematics?

- Sometimes, particularly in a medical context, critically evaluating quantitative information is a matter of life and death. A paper from 2007 [20] presents the following key findings:
  - Many people (doctors, patients, journalists and politicians) do not understand health statistics.
  - Lack of understanding is due both to lack of knowledge, and intentional misrepresentation of information.
- The following paragraph is a quote from [20]:

> "Statistical literacy is a necessary precondition for an educated citizenship in a technological democracy. Understanding risks and asking critical questions can also shape the emotional climate in a society so that hopes and anxieties are no longer as easily manipulated from outside ..."

Question 2.2.1

In [20], researchers asked 450 American adults (aged 35–70; 320 had attended college; 62 had a postgraduate degree) for answers to the following questions:

> *"1. A person taking Drug A has a 1% chance of having an allergic reaction. If 1,000 people take Drug A, how many would you expect to have an allergic reaction?*
>
> *2. A person taking Drug B has a 1 in 1,000 chance of an allergic reaction. What percent of people taking Drug B will have an allergic reaction?*
>
> *3. Imagine that I flip a coin 1,000 times. What is your best guess about how many times the coin would come up heads in 1,000 flips?"*

Question 2.2.1 (continued)

(a) What are the answers to the above three questions?

1. 1% of 1000 $\frac{1}{100} \times 1000 = 10$

2. 1 in 1,000 $\Rightarrow$ 0.1 in 100 $\Rightarrow$ 0.1%

3. $\frac{1}{2}(1000) = 500$

(b) What are the ramifications of getting these answers incorrect for doctors, journalists and politicians?

Doctors: too much or wrong dose
poor advice $\Rightarrow$ misdiagnosis

Journalists: misinformation
cross panic

Politicians: poor decisions
economic loss
lose their job!

Question 2.2.2

In 1995, an emergency announcement in the UK warned that third-generation oral contraceptive pills doubled the risk of potentially life-threatening blood clots (thrombosis). The announcement led to widespread concern and fear, and many women ceased using the contraceptives. Reports estimate that in the following year there were an additional 13,000 abortions and 13,000 births, with 800 additional pregnancies in girls under 16 years of age. The announcement omitted the following relevant information:

165,000

- young women have an absolute risk of spontaneous thrombosis of 1 in 10,000.
- the absolute risk of thrombosis when taking second-generation oral

***Question** 2.2.2 (continued)*

contraceptive pills is about 1 in 7000.

- the relative risk of thrombosis increases by a factor of 4 to 8 during a Caesarean birth.
- the relative risk of thrombosis during and after pregnancy increases by a factor of around 4.
- the absolute risk of dying from thrombosis during or after an abortion is around 1.1 in 10,000.

(a) Define the terms "absolute risk" and "relative risk".

Absolute : probability of an event happening "1 in 7,000"

Relative risk : $\frac{\text{new risk}}{\text{old risk}}$ "doubled"

(b) The Australian Medical Association (AMA) website [2] states that:

"...in order to support and enhance the collaborative nature of the doctor-patient relationship, patients must be able to make informed choices regarding their health care. An informed choice is dependent on receiving reliable, balanced health information, free from the influence of commercial considerations, that is communicated in a manner easily understood by patients."

Write a public health announcement that would better advise the public on the risks of the third-generation contraceptive pill.

- include absolute risk
- risks of not taking the pill
- old & new absolute risk

The third-generation contraceptive pill has a slightly elevated risk of thrombosis. For every 7000 people who take the pill, roughly two will experience blood clots (1 in 7000 for the second generation pill).

The general risk of thrombosis is around one in 1000 for the general population and risks are slightly elevated during pregnancy, in caesarean births and abortions.

Case Study 1: **Cancer**

- Cancer is the name for a large group of diseases affecting many different parts of the body. It arises from the uncontrolled, rapid growth of abnormal cells that interfere with the usual bodily functions.
- Cancerous cells can *metastasise*, spreading to other parts of the body.
- Common cancers include cancers of the lung, prostate (males), breast (mostly females), colon, skin, bladder, kidney and blood (leukaemia).
- Smoking and excessive alcohol consumption are major risk factors.
- Cancer is a leading cause of human mortality. Table 2.1 lists all leading causes of death for Australians.

Cause of death	2009	2018
Ischaemic heart disease	22587	17533
Dementia/Alzheimer disease	8280	13963
Cerebrovascular diseases	11216	9972
Lung/bronchus/trachea cancer	7786	8586
Chronic lower respiratory disease	5984	7889
Prostate cancer	3111	3264
Breast cancer	2799	3034
Blood/lymph cancer	3811	4612
Colon/rectal cancer	5244	5420
Diabetes	4176	4656
Diseases of the urinary system	3315	3384
Heart failure / ill-defined heart disease	3219	3192
Intentional self-harm	2337	3046
Pancreatic cancer	2204	3077
Accidental falls	1450	2952
Skin cancer	1837	2094

Table 2.1: Leading causes of death in Australians. Population of 21.7 million in 2009; population of 24.9 million in 2018. (Source: Australian Bureau of Statistics.)

- Common cancer treatments include:
  - *Chemotherapy*, which involves the infusion of highly toxic chemicals into the body, killing rapidly dividing cells. (Recall that rapid division is a common characteristic of cancerous cells.)
  - *Radiation therapy*, which involves exposing cells to radiation and hence damaging their DNA, leading to cell death.
  - *Surgery*, which involves removing cancerous tissue from the individual.
  - *Stem cell transplants* (or *bone marrow transplants*), which involves infusing healthy stem cells into an individual with cancer.

- All of these treatments can have minor to major side effects, including fatigue, nausea, mouth ulcers, hair loss, cognitive problems, infection, anaemia, infertility, graft-versus-host disease, [illegible] cancer (!) or death.

- Determining the precise treatment regime and dosages involves a trade-off between the beneficial impact of reducing tumour size and the (often severe or life-threatening) side-effects resulting from the treatment.

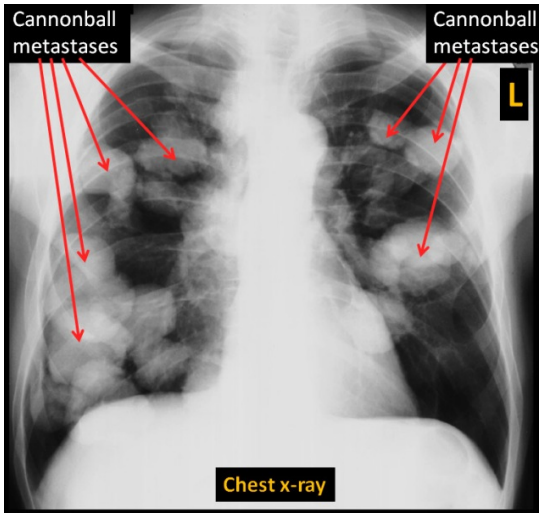

Photo 2.1: Chest X-ray displaying many classic "cannonball" metastases. (Source: Qld Health and DM.)

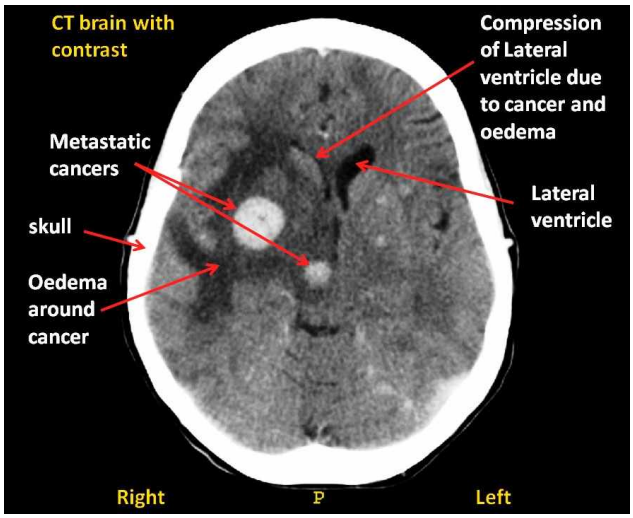

Photo 2.2: Axial CT image with contrast shows enhancing metastatic cancers with associated vasogenic oedema (swelling) in the brain. The metastases are due to breast cancer. (Source: Qld Health and DM.)

Question 2.2.3

Two commonly reported medical statistics are:

- the *5-year survival rate*, which is the percentage of people who are still alive five years after being diagnosed with a condition; and
- the *annual mortality rate*, which is the number of people dying from a given condition each year, often expressed as a rate per 100,000 people.

(a) The 5-year survival rate for prostate cancer in American men is 98%; for British men it is 71%.

(i) Assume that 1,000 British men and 1,000 American men receive a diagnosis of prostate cancer (at the same time). After 5 years how many men in each country are expected to have died?

(ii) Considering only the given data, which country has the 'better' health system, and why?

America : 98% of 1000 = 980 survive
20 die
UK : 71% of 1000 => 710 survive
290 die
Based on this - the US syst is better

(b) The annual mortality rate for prostate cancer in American men is 26 deaths per 100,000; for British men it is 27 per 100,000. Considering only these data, which country has the 'better' health system, and why?

About equal

Question 2.2.3 (continued)

(c) The medical information given in Parts (a) and (b) is all correct. Explain how the (apparent) discrepancies could occur.

- Earlier diagnosis in US
- Detection of non-life threatening tumours
- mis-diagnosis

Testing - PSA tests (US)
Symptoms (UK)

(d) Treatment for prostate cancer is invasive with many substantial side effects, including incontinence and impotence. Considering only prostate cancer, which country has the 'better' health system, and why?

UK - mortality rate is about the same

Possible in US over-diagnosis & over treatment leads to poor outcomes (side effects)

- *Breast cancer* develops due to the uncontrolled growth of cells in breast tissue, which enlarge into one or more lumps within the breast. It is a comparatively common cancer, and is a leading cause of death in women; it also affects men, but at a much lower rate.

- Some risk factors for breast cancer identified in the paper [35] include:
  - sex traits: the risk for females is around 100 times that for males;
  - age: the risk of developing breast cancer rises rapidly with age;
  - affluence: breast cancer is more common in affluent societies;
  - pre-existing breast conditions (for example, increased breast density);
  - hormonal factors (such as age at menopause or oral contraceptive use);
  - high levels of alcohol consumption.
- Some factors that reduce the risk of breast cancer include having children (more offspring at an earlier age reduces risk), breastfeeding, and increased physical activity.
- Treatment options for breast cancer include chemotherapy, radiation therapy, hormonal methods and surgery, including total removal of the breast (mastectomy) and breast-conserving surgery (lumpectomy).

Question 2.2.4

In 2009, US authorities suggested that mammogram screening for breast cancer should start at 50 years of age rather than 40 years, and be conducted every second year rather than every year. Discuss reasons for and against this decision.

40 ⌣ 41 ⌣ 42 - -
50 ⌣ 52 ⌣ 54 - -

For:
- lower exposure to radiation
- saves money
- lower risk in 40s
- reduces misdiagnosis

Against:
- late diagnosis
- lowers chance of early diagnosis
- risk of missing a serious tumour