How Risky is Life?
Lesson 3: The Bigger Picture

Australian Curriculum: Mathematics (Year 9 and 10)

ACMNA208: Solve problems involving direct proportion (Year 9)

ACMNA210: Express numbers in scientific notation (Year 9)

ACMSP226: Calculate relative frequencies from given or collected data to estimate probabilities of events involving 'and' or 'or'. (Year 9)

ACMSP228: Identify everyday questions and issues involving at least one numerical and at least one categorical variable, and collect data directly and from secondary sources (Year 9)

ACMSP252: Investigate and describe bivariate numerical data where the independent variable is time. (Year 10)

ACMSP253: Evaluate statistical reports in the media and other places by linking claims to displays, statistics and representative data (Year 10)

Lesson abstract

This lesson focuses on 'base' probability of dying in a year, the total risk of death broken down only by age and gender. This is dominated by illness-related deaths, which are strongly age-dependent. The overall picture is built up from further data on various causes of death in various age bands. Students read and interpret graphs and tables, and express risk in multiple ways (probability, proportion, percent). They use data to evaluate statements.

Mathematical purpose (for students)

Take care when interpreting data.

Mathematical purpose (for teachers)

Students read data for meaning from tables, line graphs, bar and pie charts, and make some complex interpretations. They experience the interpretation and evaluation phases of mathematical modelling, within a data-heavy situation with multiple variables. Students see the dominance of health risks, strong age dependence, and differences for young males and females. Calculations are generally straightforward (e.g. expressing risk as probability or proportion of population) but interpretation involves making sense of very large or small numbers.

Lesson Length 45 minutes approximately

Vocabulary Encountered

- age dependence
- base risk

Lesson Materials

- Slide show *ST7_Risk_3a_The_Bigger_Picture.pptx*
- Student Sheet 1 – Base Risk of Death by Age (one per group)
- Student Sheet 2 – How Risks Vary with Age (one per group)
- Student Sheet 3 – Column Graphs (one per group)
- Student Sheet 4 – Pie Charts (one per group)
- Student Sheet 5 – True, False or Maybe? (one per group)
- Students' data sheets and completed Swan Diagrams from last lesson.

We value your feedback after these lessons via https://www.surveymonkey.com/r/J8GPD7Z

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Lesson structure

- Estimating number of deaths per year (5 minutes)
- How “base risk” varies with age and gender (Group work - 10 minutes)
- Learning from the data (Group work - 20 minutes)
- Evaluating statements - True, False or Can't tell (Group work - 10 minutes)

All the data used in this lesson is from the Australian Bureau of Statistics. Note that two spreadsheet files of original data and an overview document are included in the package, for teachers who wish to do further exploration or construct other graphs or exercises for students.

The Bigger Picture of Deaths in Australia

This introductory section sets up the reflective tone of the lesson, asking students to reconsider their focus on deaths from unnatural causes.

Ask students to calculate the total number of deaths per year in Australia from the unnatural causes of the last lesson (5577). Point out that these are not really all the deaths and ask students to make a reasoned estimate of the total number of people that die of any cause (sudden or not) in each year. They will need time to think through how they might make this estimate.

Enabling prompts

- To what age do you think people might reasonably live to?
- What if everyone died in the year that they reached this age, how many would die in that year?

Expected response

If everyone lived for 100 years, you might expect about 1/100th of the population to die each year. This would give about 25,000,000÷100 = 250,000 deaths. This is a pretty good estimate. In fact, 159 052 people died in Australia in 2015. (That’s not because we all live longer than 100; the population is expanding with more young people.)

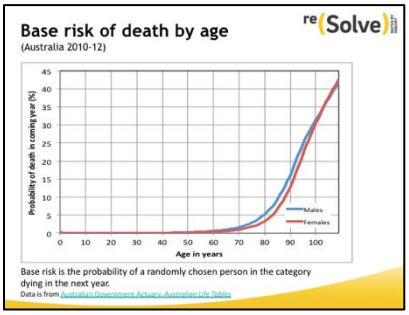
Ask a few students for their estimates and their reasoning and have others critique.

Now students to look back at their previously completed Swan Diagrams with the squares representing the Australian population, and then represent about 250,000 deaths from illness and label it. (ANS: Shade one big square).

Some students may be thinking: 'Surely most of these deaths happen to people older than me." In the next part of the lesson students will explore this.

How 'Base Risk' Varies with Age and Gender

Show the slide Base **risk of death by age** (for age range 0-100). The data is derived from Australian Government Actuary, *Australian Life Tables* http://www.aga.gov.au/publications/#life_tables



The graph shows how the chance of a randomly chosen person dying in the next year varies with age. This is called the "base risk of death".

The base risk is used, for example, when calculating life insurance payments. The base risk is calculated across all people of that age and gender – whether well or ill, prudent or reckless. It is the best estimate of risk if we only have very general information about the person.

Give students a few minutes to discuss what the graph shows. Call on one or two to describe what they see, and what they infer from it.

Key features:

- The y-axis is probability expressed as a percent.
- The risk of death increases with age, slowly at first, but especially after about age 60.
- Young Australians are very unlikely to die. Even people aged about 60 have only a 1% chance of dying next year.
- It is hard to see any change with age for young people.
- The risk of death is higher for males than for females, possibly at all ages.
- Even when you are over 100, your chance of dying in the next year is less than half.

Hand out Student Sheet 1 – Base Risk of Death by Age and show the slide: **Base risk of death by age (5-30)**

Give students some time to interpret the new graph and write down key features.

In whole-class discussion consider:

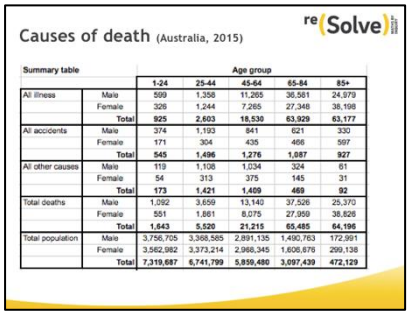
- What quantity is on the y-axis of the 5 – 30 graph? (ANS: Probability of death next year, multiplied by 10 000. So, for 15 year old boys, the probability is 0.0002)
- Reading the base risk for, say, 10 year old boys, girls and both (ANS: about 0.0001) That means "1 in how many"? (ANS: 10,000 – you may want to convert this to decimals and percent.)
- How are the two graphs on the student sheet related? (ANS: They show different age ranges. In fact, the second is an enlarged view of part of the first). Why does the second graph look so different to the first?
- What are the main messages in the second graph? (ANS: A gender gap.) What might be the explanation? (ANS: After the age of 15, males have a much greater chance of dying than females. This is probably not due to illness, as they are still young, but rather because males on average live more risky lives than females including having more risky jobs, so they have more accidents! The suicide rate for young men is also higher. Even so, the risk of death for young men is very small.)

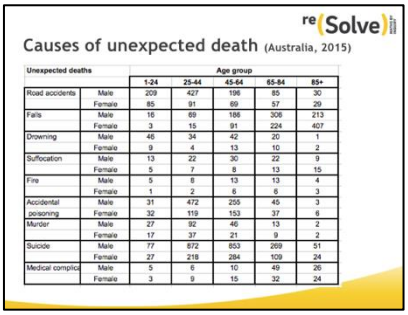
Learning from the Data

This section looks at a deeper and more complex pattern, combining age and gender with different causes of death. A primary goal is to develop skill in translation between different representations (tables and graphs).

Make sure each student has a calculator and a copy of Student Sheet 2 – How Risks Vary with Age.

Show slides **Causes of death** and **Causes of unexpected death**





Explain that the data is from the Australian Bureau of Statistics, and is reliable, but to understand it properly may require carefully reading the full reports (e.g. to see definition of poisoning). The full reports are included in the Lesson 3 folder for teacher reference, if desired.

Ask some questions that will help students to interpret the tables on Student Sheet 2 – How Risks Vary with Age. (You may need to help students to express the large numbers in words. Often it helps to round them to, say, 2 significant figures).

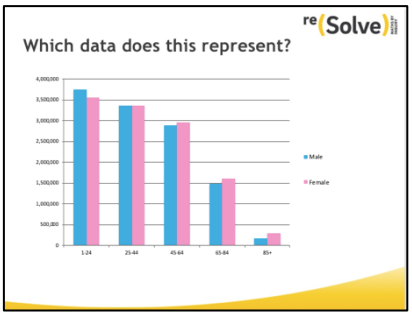
- How many men aged from 65 to 84 died in an accident in 2015? (621)
- What is this number to the nearest hundred, to the nearest thousand? (600, 1000)
- How many males were there in Australia in 2015 aged from 1 to 24? (3,756,705)
- What is this number to the nearest hundred thousand, nearest thousand? (3,800,000, 3757000)

Ask some more challenging questions that involve calculations. For example, you could refer again to "base risk":

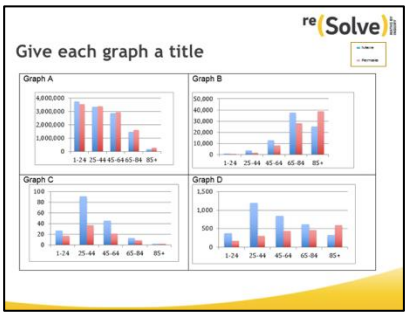
- How many people aged between 1 and 24 died in 2015 to the nearest thousand (1643, 2000)
- How many people aged between 1 and 24 lived in Australia, to the nearest million? (7 319 687, 7 million)
- What is the base risk of death for 1 to 24 year olds? (ANS: $2.2 \times 10^{-4} = 0.00022$)
- Express this as 1 person in ?? (ANS 1 person in 4455).
- Now repeat this for the over 85s. (ANS: The base rate is approximately 1 person in 7.35 per year. That is much greater than for younger people)
- If all of us in this class were over 85, how many would we expect to die in one year? (3 or 4 people).

What do the graphs represent?

In this next part of the lesson students relate graphical representations of the data to the tables. Give each group a copy of Student Sheet 3 – Column Graphs and Student Sheet 4 – Pie Charts.



If desired, show slide **Which data does this represent?** to introduce the task. Students will need to look at Student Sheet 2 – How Risks Vary with Age to work out which rows of data from the table have been used to make this graph. (Ans: Total population in 2015). This graph is the same as Graph A on Student Sheet 3 – Column Graphs.



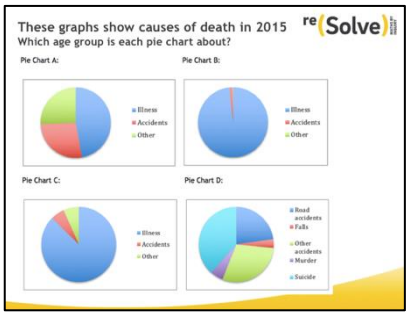
Ask students to work together to work out *from the tables* what each bar graph shows. Looking first at the overall message of the graph might indicate where to look. Students should write a title for each graph.

For a class discussion all charts are shown on the slide **Give each graph a title.**

Repeat with the pie charts and the unexpected death data for 2015, assisting the discussion with the slide **Which age group is each pie chart about?**

Expected Responses

Bar Chart	A	Total population in 2015
Bar Chart	B	Number of deaths from illness in 2015
Bar Chart	C	Number of murders in 2015
Bar Chart	D	Number of deaths from accidents in 2015
Pie Chart	A	Age 25 - 44
Pie Chart	B	Age 85+
Pie Chart	C	Age 45 - 64
Pie Chart	D	Age 25 – 44



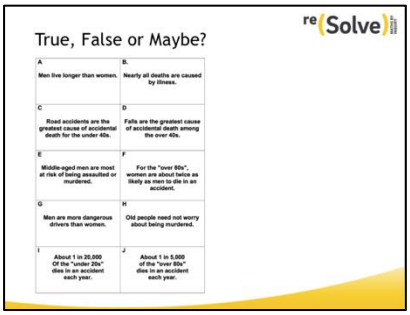
Evaluating Statements - True, False or Maybe?

This section gives students experience in using logical reasoning to evaluate inferences from data.

Give out Student Sheet 5 – True, False or Maybe? and show the slide **True, False or Maybe.**

Ask students to work together to decide whether they think each statement is true, false or whether it is impossible to tell without being given more data.

Ask them to write down convincing reasons using common knowledge, the data, and logical reasoning. Make it clear that they should use the data on Student Sheet 2 – How Risks Vary with Age and/or the graphs.

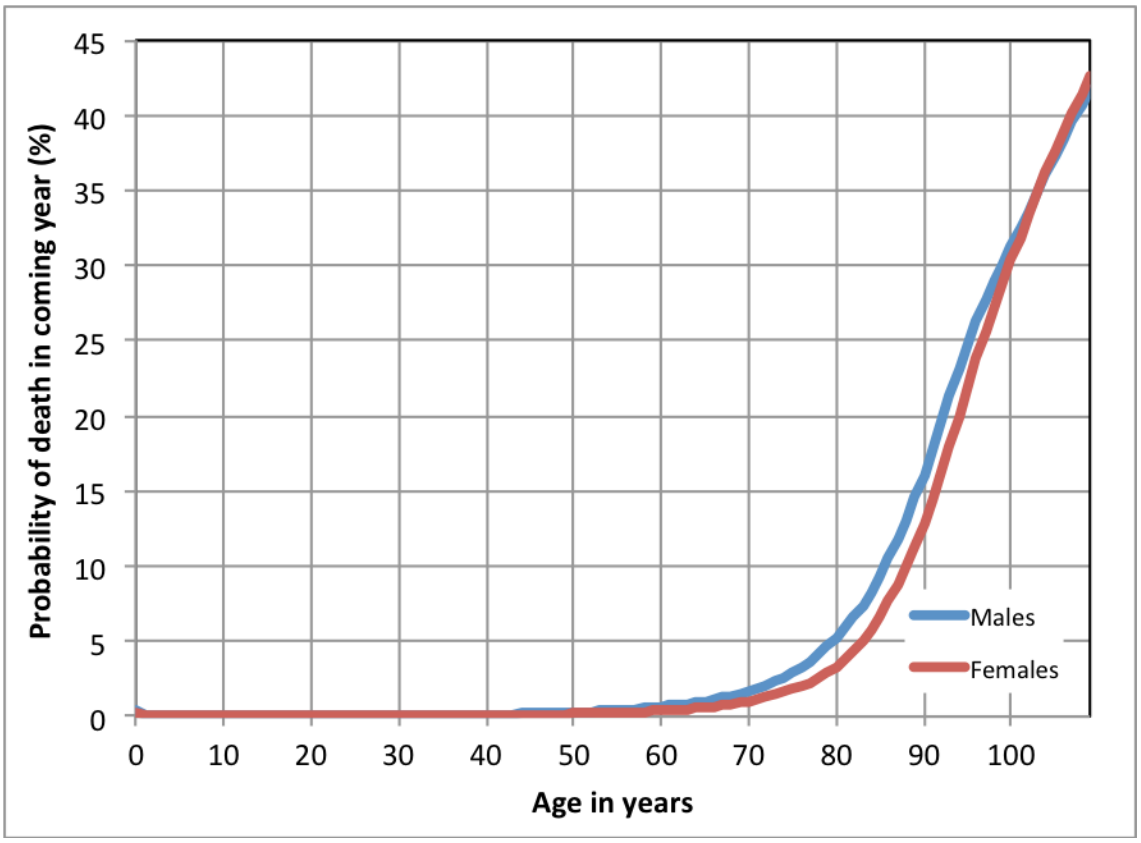


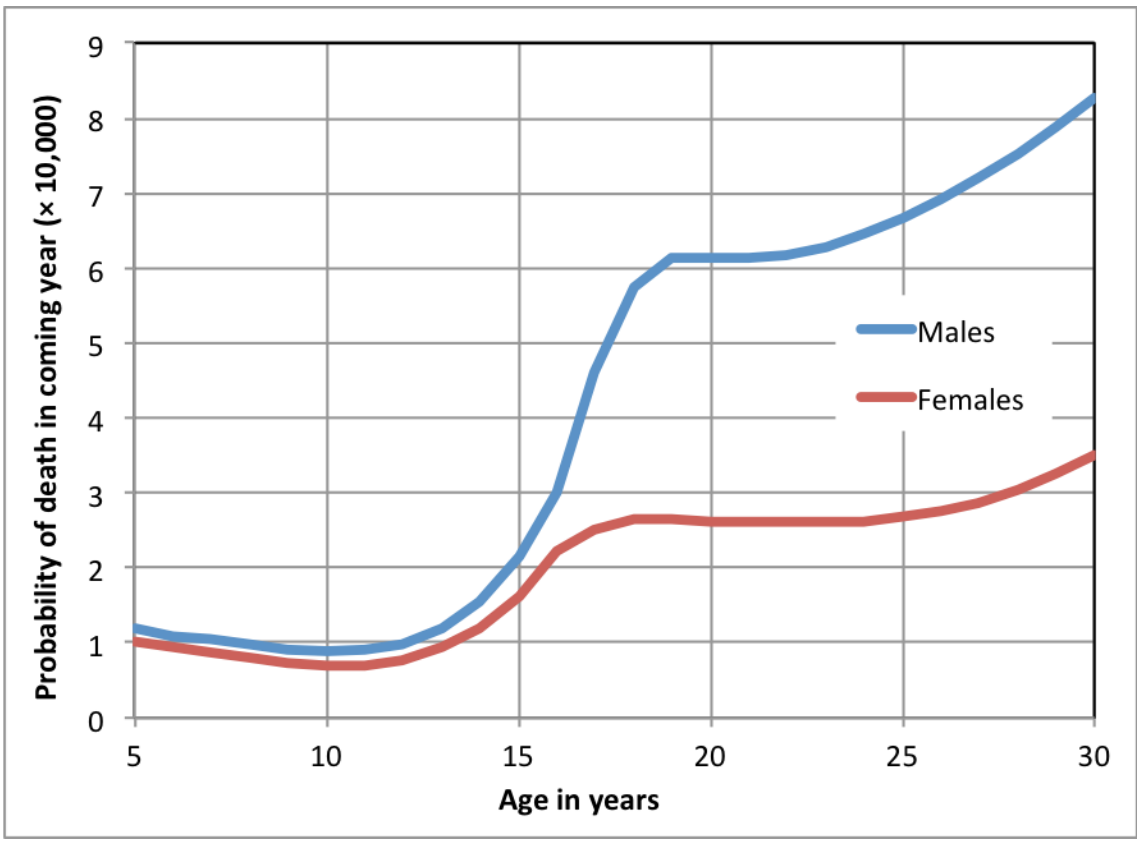
As students work on the task, identify groups of students who come up with both correct and incorrect reasoning so that you can help develop a productive discussion.

Ask each group to share their reasoning on some of the statements. Teacher Sheet – True, False or Maybe? has some expected responses.

Base Risk of Death by Age

Name: _____





Australian Government Actuary. Australian Life Tables. http://www.aga.gov.au/publications/life_table_2010-12/03-Part1.asp#P99_6539

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How Risks Vary with Age

Name: _____

Causes of death (Australia, 2015)

Summary table		Age group				
		1-24	25-44	45-64	65-84	85+
All illness	Male	599	1,358	11,265	36,581	24,979
	Female	326	1,244	7,265	27,348	38,198
	Total	**925**	**2,603**	**18,530**	**63,929**	**63,177**
All accidents	Male	374	1,193	841	621	330
	Female	171	304	435	466	597
	Total	**545**	**1,496**	**1,276**	**1,087**	**927**
All other causes	Male	119	1,108	1,034	324	61
	Female	54	313	375	145	31
	Total	**173**	**1,421**	**1,409**	**469**	**92**
Total deaths	Male	1,092	3,659	13,140	37,526	25,370
	Female	551	1,861	8,075	27,959	38,826
	Total	**1,643**	**5,520**	**21,215**	**65,485**	**64,196**
Total population	Male	3,756,705	3,368,585	2,891,135	1,490,763	172,991
	Female	3,562,982	3,373,214	2,968,345	1,606,676	299,138
	Total	**7,319,687**	**6,741,799**	**5,859,480**	**3,097,439**	**472,129**

Some causes of unexpected death (Australia, 2015)

Unexpected deaths		Age group				
		1-24	25-44	45-64	65-84	85+
Road accidents	Male	209	427	196	85	30
	Female	85	91	69	57	29
Falls	Male	16	69	186	306	213
	Female	3	15	91	224	407
Drowning	Male	46	34	42	20	1
	Female	9	4	13	10	2
Suffocation	Male	13	22	30	22	9
	Female	5	7	8	13	15
Fire	Male	5	8	13	13	4
	Female	1	2	6	6	3
Accidental poisoning	Male	31	472	255	45	3
	Female	32	119	153	37	6
Murder	Male	27	92	46	13	2
	Female	17	37	21	9	2
Suicide	Male	77	872	853	269	51
	Female	27	218	284	109	24

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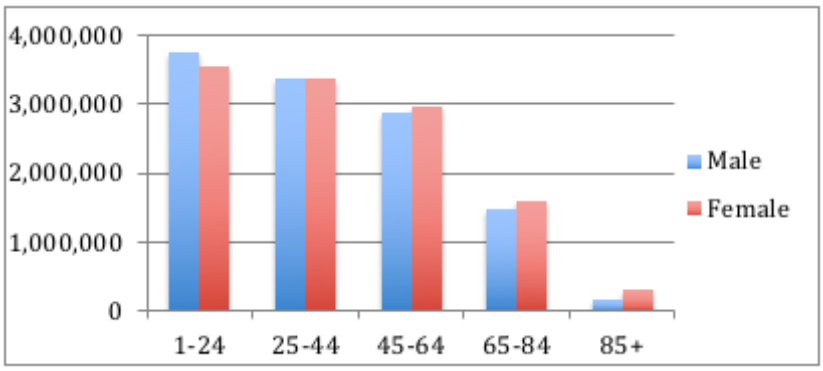
Column Graphs

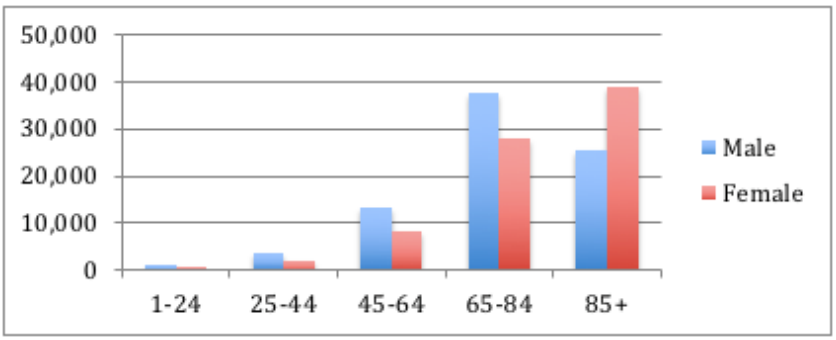
Name: _____

Decide what each graph shows and give it a title.

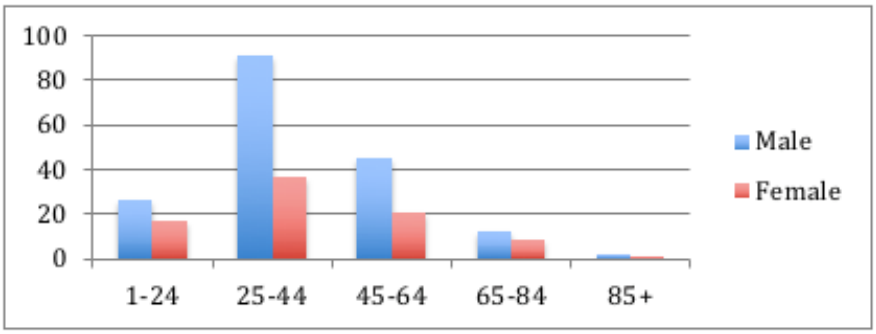
Graph A:



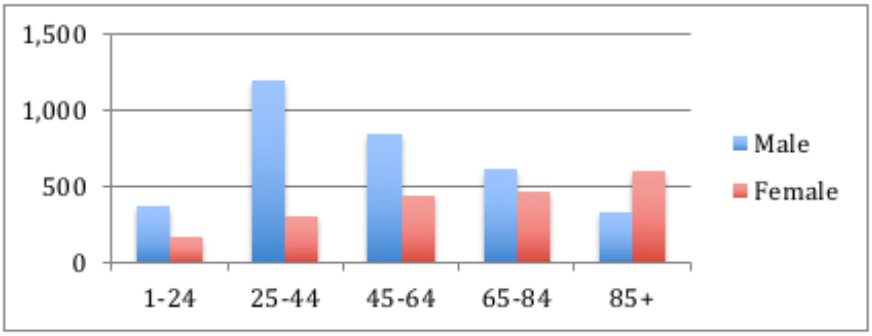
Graph B:



Graph C:



Graph D:



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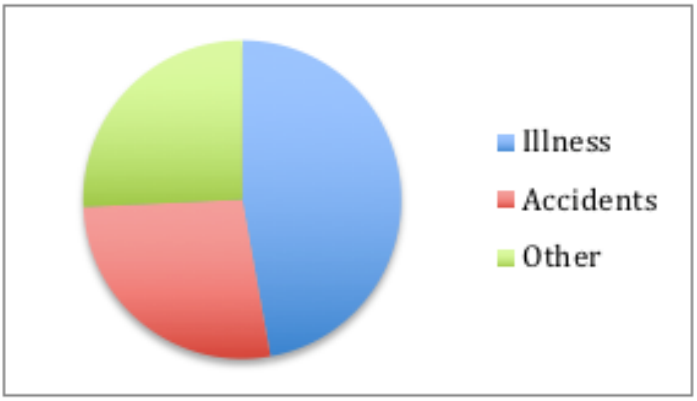
Pie Charts

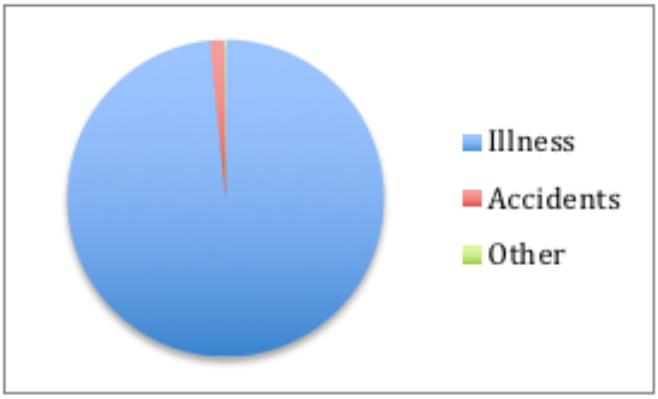
Name: _____

Decide what age group is represented in each pie chart and give it a title.

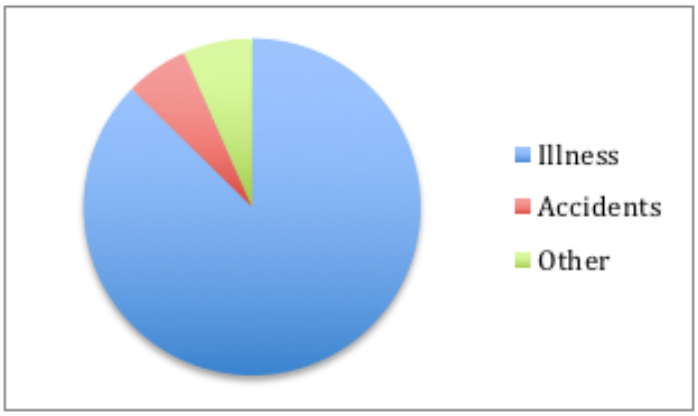
Pie Chart A:



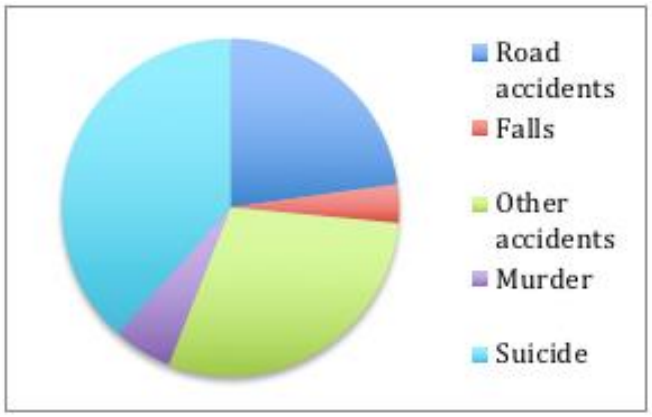
Pie Chart B:



Pie Chart C:



Pie Chart D:



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True, False or Maybe?

Name: _____

A **Men live longer than women.**	**B** **Nearly all deaths are caused by illness.**
C **Road accidents are the greatest cause of accidental death for the under 40s.**	**D** **Falls are the greatest cause of accidental death among the over 40s.**
E **Middle-aged men are most at risk of being assaulted or murdered.**	**F** **For the "over 80s", women are about twice as likely as men to die in an accident.**
G **Men are more dangerous drivers than women.**	**H** **Old people need not worry about being murdered.**
I **About 1 in 20,000 of the "under 20s" dies in an accident each year.**	**J** **About 1 in 5,000 of the "over 80s" dies in an accident each year.**

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Teacher Sheet - True, False or Maybe?

A **Men live longer than women.** **False** Bar chart A shows that there are a similar number of men and women under 65; there are more women than men over the age of 65, and almost twice as many over the age of 85. A combination of genetic and lifestyle reasons seems to result in women living longer.	**B** **Nearly all deaths are caused by illness.** **True** Adding the numbers from the 2015 table shows that149164 deaths were caused by illness, out of a total of 158059 deaths. That is 94%. However, this is an average across all age groups and there is variation: only 56% for the 1-24 year olds, but 98% for 85+ years old.
C **Road accidents are the greatest cause of accidental death for the under 40s.** **True** In 2015, there were 812 fatal road accidents among the under 45s. The next largest category of accidents is poisoning with 654 deaths. More people died by suicide, but these are not accidents.	**D** **Falls are the greatest cause of accidental death among the over 40s.** **True** The data shows that this definitely true for the over 65s, and close to true for the 45 -64 category. True for the whole group over 45.
E **Middle-aged men are most at risk of being assaulted or murdered.** **False** The greatest number of deaths in this category is among 25-44 year old men (92 deaths on 2015). This is the largest single category. When you take into account the different size populations, it is still the case that younger men have the greatest risk.	**F For the "over 80s", women are about twice as likely as men to die in an accident.** **False** Although about twice as many females die of accidents in this age group, this is mainly because there are almost twice as many females alive at this age. However, it is true that a person over 80 who dies from an accident is twice as likely to be a woman than a man. You must be careful exactly how probabilities are expressed.
G **Men are more dangerous drivers than women.** **Maybe/Impossible to tell** It is true that men have far more road accidents than females, but this may be due to many causes. For example, there may be more male drivers, or males may drive further on average etc.	**H** **Old people need not worry about being murdered.** **True** Only 4 'over 85s' were murdered out of a total population of over two million. The risk is less than 1 in 500 000.
I **About 1 in 20,000 of the "under 20s" dies in an accident each year.** **True** About 626 people die in an accident out of 12.5 million in this age group. (12500000/626 = 19968.05)	**J** **About 1 in 5,000 of the "over 80s" dies in an accident each year.** **False** 4688 'over 80s' died in accidents, out of a total population of 2,384,800 million. That is about 5000 out of 2.5 million or 1 in 500.

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