ROYAL STATISTICAL SOCIETY

DATA | EVIDENCE | DECISIONS

Radiotherapy: setting the "right" dose

Activity Summary:	
This activity introduces the idea of a simulation study to investigate the impact of different doses of radiation when targeting tumour cells. **It is highly interactive and requires minimal resources.**	

Activity Learning Outcomes:	Suggested Resources:
• Understand what a "simulation study" is and why it is necessary. • Understand "uncertainty" in the context of our outcome of interest.	• Activity sheet printed A2 or larger (example sheet attached). • 20-30 six-sided dice and several counters.

How to run the activity:

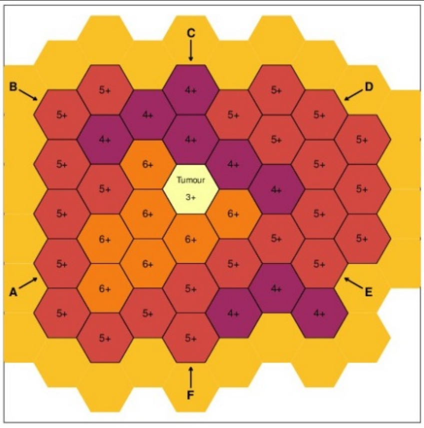
- Explain that the activity sheet represents a human body, with hexagons representing cells in the body. Some of these are tumour cells that we want to damage with ionizing radiation.
- Note, the topic of this activity is a potentially sensitive subject and care should be taken when introducing and explaining the activity. In particular, the activity is a simplified illustration and does not reflect the state of modern radiotherapy delivered by trained oncologists.
- We will represent the radiation using six-sided dice, which will be absorbed by the cells. We want to maximise the damage to the tumour cells (number of absorbed dice) while minimising the number of damaged healthy cells (a cell is damaged if it absorbs three or more dice).
- Dice will move in a straight line, passing through cells or being absorbed depending on whether they exceed the value in the cells when rolled; the dice may pass through the entire body.
- A **simulation study** is one statistical approach to explore how different doses affect damage to the tumour and damage to healthy cells. For a single starting point we can (with effort) calculate the "best" dose, but with multiple starting points it becomes very difficult; especially when we are also interested in the number of damaged healthy cells.
- Ask the participant to select one or more starting points outside the body; at each point they must also assign a number of dice. Place the player's counter at each of their starting point. (for the first attempt, consider picking a single starting point).
- For each counter in turn, collect all the starting dice and advance the counter one space into the body, then roll the dice. Any dice that equal or exceed the value of the cell are placed on that cell. Then, advance the counter again. Roll the remaining dice, and repeat placing and rolling dice. Eventually the

counter will stop when either it leaves the other side of the body, or there are no dice left to roll.

- When all counters have finished moving, we can check the outcome of the dose in this simulation. Specifically, count the total damage to the tumour cells (number of absorbed dice) and the number of damaged healthy cells (number of spaces with three or more dice).
- Record the outcomes from all simulations to explore how the outcome depends on the dose.
- Explore how variable the outcome is for a given dose. If we repeat the exact same dose there is a lot of **uncertainty** and we are quite unlikely to see the exact same outcome.

Exploring the activity:

- Calculate the best dose for a single starting point. The expected damage to the tumour is straight forward, but the number of damaged healthy cells is not trivial – try one direction for 1, 2, 3, 4 and 5 starting dice.
- There are two outcome components, amount of damage to tumour and number of damaged healthy cells, is the variability in these components the same? We might be more concerned by doses that have a higher probability of damaging more healthy cells.
- Consider alternative activity sheets, with different arrangements of cells and cell values. Further, imagine the impact if the tumour consists of two or more cells.



What's going on?

- Although it may appear simple, the activity is sufficiently complex (the outcome of interest being the "best" trade-off between the damage to the tumour and the number of healthy cells damaged and the variability of these outcomes being important) that it requires performing a **simulation study** – attempts to exactly calculate the probabilities of various outcomes will quickly become unwieldly.

Video demonstration:

A video demonstrating this activity is available on the RSS website at www.rss.org.uk/hands-on

Risk assessment:

The subject matter of this activity is a sensitive topic; care must be taken when presenting this to participants. Minimal risks for participants, similar to playing a board game (ensure age appropriate playing pieces to avoid any choking hazard, etc.).

Additional information and taking it further:

https://en.wikipedia.org/wiki/Radiation_therapy

Credits:

Dr Simon R. White (Medical Research Council Biostatistics Unit, University of Cambridge).