Can water remember?

Commentary

This lesson compares how homeopathic preparations are developed and how this compares with the process for mainstream medicines. If a new treatment is developed we want to be sure it works. This isn't quite as straightforward as we might think. People get better or worse for all sorts of reasons. It would be great to follow everyone with a certain condition to see what happened to them but that would be expensive as well as time consuming, and still wouldn't necessarily reveal why they'd got better (if they did).

There are three key ideas here. The first is that students should consider how evidence about the effectiveness of treatments might be gathered. The second is that they learn about pitfalls for the unwary including regression to the mean, seeing non-existent trends (such as a 'run of luck' when tossing a coin) and bias towards positive evidence and wanting the experiment to 'work'. The third is that they apply sound principles of clinical trials.

The important outcome is that students develop a better understanding of how we know modern medicines work – and how we can spot when the system has been abused.

Resources

bs_water_ worksheet 'What is homeopathy?' • play your cards right and bead sampling materials: see bs_water_technician

Learning objectives

- To understand how and why clinical trials are performed including the use of blinding, randomisation and large scale groups

Learning outcomes

By the end of the lessons students will:

- be able to explain why it may initially appear that a treatment works when in fact some other factor is having an effect
- understand how evidence from clinical trials can be made more reliable and valid
- have made an informed response to the theoretical basis of homeopathy

Key vocabulary

blinding • randomisation • regression to the mean • placebo

Obstacles to learning

Students may hold misconceptions relating to the basis of evidence needed in clinical trials.

Starter

Explain to students that sometimes there is random variation about a mean in events and that you are going to illustrate this with a set of playing cards (this is based on Bruce Forsyth's 'Play your cards right'). Ask for a volunteer to come out and tell them that you are going to test their powers of prediction. Shuffle the deck and deal out five cards in a row.

Turn over the first card and display it. Then ask the volunteer whether they think the next card will be higher or lower (Ace = 1, Jack = 11, Queen = 12 and King = 13). If you like, invite some audience participation ('Higher!', 'Lower!'). Turn over the next card and see. Repeat with the third, fourth and fifth cards. If you like, repeat with another volunteer. What happens of course is that if the previous card is low, it's more likely that the next card is higher, and vice versa. Over a number of guesses people (if they are following this rule) will be right more often than wrong, but won't always be right. Say that this is a good example of 'regression to the mean'.

- You don't know what the next card will be, but it's likely to be lower than a high card and higher than a low card.
- The variation doesn't become less over time.
- The mean is seven, but seven is no more likely an outcome than any other value.

Explain to the students that one of the problems with testing treatments is that you can often see patterns but can't be sure what would have happened if a treatment hadn't been administered.

Main activity

Explain that modern clinical trials use a set of procedures to produce objective outcomes; these are responsible for much of the medical progress made in recent years. In essence, the purpose of a clinical trial is to establish whether one treatment is better than another.

Two of the most important practices used for establishing beyond reasonable doubt whether or not a treatment works are the use double blinding and randomisation. Double blinding means that neither the person administering the treatment or the patient knows which treatment the patient has received, the new treatment or the existing treatment. This prevents the expectations of either party – the researcher wanting their treatment to work and the patient wanting to get better – affecting the outcome. Randomisation means that the selection of the patients for the two groups is random. The purpose of randomisation is to ensure that there are no differences between the two groups getting each kind of treatment.

Another very important aspect to consider when designing a medical trial is the size of the group. The more people tested, the more robust the data.

This activity models

- the dangers in interpreting data from small samples,
- the way that data can be misrepresented if you only look at the data that supports your conclusions
- how these problems can be addressed by conducting larger studies, or pooling all the studies together in one place (meta-analysis).

For set up see bs_water_technician. In this activity the groups being sampled are represented by two tubs of beads. One tub of beads represents people who have received a new treatment. Those who have responded positively are represented by blue beads, others by yellow beads. The other tub represents people who have received an established treatment. Those who have responded positively are represented by red beads, others by yellow beads. Each tub needs to have a large number of beads, say a thousand. In both tubs the ratio of non-yellow beads to yellow beads is 1:1, though this is not revealed.

Students need to work in 'research teams' of three or four. Each team is to decide, on the basis of their data, whether the new treatment is better than the conventional one. They draw a random sample of 20 beads from each pot and count them, indicating whether the new treatment is better or worse. Data and conclusions must be kept secret from other people in the room. It is likely that different groups of students will have different conclusions; some will find that the new treatment is better; some will find that the existing treatment is better. Ask them how they modified the report as more data was received and draw out the point that more data makes the result more reliable.

Now explore the way that small samples can give misleading and inconsistent results. Each group compares their results with their neighbours. Do they agree or disagree? Some will, some won't, simply by chance. Now explore how pooling data can fix these problems. Everyone's bead count is pooled on the board. Eventually, with all the data in the room pooled, the overall conclusion should be that the new treatment is no better.

Ask students to discuss these questions:

- How did your conclusions change as more data came in, and you had a larger sample to work from?
- What would you have recommended if you had been asked to advise on whether the new treatment was better than the old one, after your first small set of results?
- Look at the results that other teams came up with. If you had wanted to selectively only quote data from research groups that showed that the new treatment worked, could you have done so? This is called 'cherry picking'.
- Why is it important to work with all available data?

Introduce homeopathy with bs_water_ worksheet 'What is homeopathy?'. This describes the three main concepts of like cures like, dilution and proving. Homeopathy was founded by a German doctor called Samuel Hahnemann in the late 18th century.

Ask the students to explore the questions:

- Why do you think that some people started to become interested in Hahnemann's ideas?
- Are the ideas scientifically sound?

Draw out the points that increasing potency by successive dilutions is illogical and ineffective. Proving may seem initially to have some value, but it's important to draw out that it's highly subjective and doesn't make any attempt to isolate individual factors. Furthermore the small number of people involved and the unsystematic way of gathering data mean that it has no scientific validity.

It's good if people feel better after taking any treatment, but there are many different reasons why people may feel better, including having recovered without any medical (or homeopathic) assistance. In fact homeopathy has been

clinically trialled. Most trials have been to see if homeopathy is better than nothing, or rather, better than a dummy solution that looks just like a real homeopathy solution. A dummy treatment is called a placebo. Unsurprisingly, these clinical trials have shown homeopathic solutions to be no more effective than water at curing conditions.

Plenary

Randomisation and double blinding are two very important features in a clinical trial which help it to be a 'fair test' of a treatment. Once trials have been done, it is important to look at the results of all of them, rather than 'cherry picking' only a subset. Discuss these questions

- Why are these considered so important in clinical trials?
- To what extent are these practices used in homeopathy?

Can water remember technician sheet

Technician notes for Lesson 2

Play your cards right

You will need:

- Set of playing cards

Bead sampling activity

You will need:

- Two large tubs, each capable of containing a large number of beads (say, 1000), and made of an opaque material
- Large number of red beads (say, 1000), or colour of your choice
- Large number of yellow beads (say, 1000), or colour of your choice
- Supply of small containers such as plastic beakers, four per group.

Put half of the red beads and half of the yellow beads in each tub so they both contain a mixture of the two colours in a 1:1 ratio.

Can water remember worksheet 01

What is Homeopathy?

Homeopathy was founded by a German doctor called Samuel Hahnemann in the late 18th century. There are three main concepts.

Like cures like

Hahnemann's first treatment was to use Cinchona bark at a high dose on himself; he experienced a range of symptoms and decided that these were like the symptoms of malaria and therefore that Cinchona bark could cure malaria.

Dilution

Hahnemann decided that the treatments should be at much lower doses and that this would increase their potency so the chemicals should be diluted. In fact, the medicines are diluted by a huge amount. A typical homeopathic solution is one part in 10^{60}, which is one in a million, million, million, million, million, million, million, million, million, million. This is so dilute that there's unlikely to be a single molecule of the active ingredient left.

Proving

'Proving' is the name given by homeopaths to the way they develop new treatments. A small number of homeopath volunteers come together, take some new homeopathic preparations, and write down their dreams, physical sensations, moods, and so on, over the course of a few days. The group leader writes these down and uses these to decide which symptoms or illnesses should be treated with these new homeopathic treatments in the future.