Science Beyond the Boundaries

**Prenatal ultrasound**

**Teacher notes**

**Intended learning outcome**

Students understand the importance of scientific evidence in making informed medical decisions, appreciate that science can only take us so far in answering some questions, and recognise how medical practice and procedures can strongly influence the quality of patients’ decision making on what is right and best for them.

***Commentary:***

Scientific understanding has developed ultrasound scanning technology that can routinely screen babies for life changing conditions during pregnancy. This unit prompts students to consider implications such as the risks of screening tests and the certainty of results, answer ethical and moral questions, and make decisions on what is the best or right thing to do.

Doctors and nurses need to communicate with prospective parents, to enable them to make an evidence-informed decision about the future of their foetus. In these decisions there are very few certainties and although the size of the risks can be quantified, people’s perception of the size of a risk may differ and may not be based on scientific evidence. Ultimately a decision on whether to proceed with a pregnancy cannot be made based on scientific evidence alone and will depend in part on judgements based on individual and societal values, and on the structures and support mechanisms that are in place to support those who may need them.

For a significant proportion of pregnancies, testing will introduce uncertainty as to whether a baby is developing as expected, even though in most cases it will be, and can increase anxiety and stress in some mothers to a degree that can have a negative impact on their pregnancy. Ultrasound screening tests during pregnancy are not compulsory, but almost all women choose to have one and many do not realise they are optional.

**Outline of teaching unit**

At the end of this unit students will take part in a role-play activity in which they will individually make decisions about whether to have a screening test during pregnancy. They will be presented with a range of different scenarios and asked to make a choice. For each question they will be asked either to justify the choice they made or to explain the reasons why they might otherwise have made a different decision. This activity will help them to identify the non-medical factors and perspectives which influence decision-making.

**Bold sections are classroom-based activities,** those not in bold can be completed either in or out of the classroom.

**Phase 1. Engage students with an introduction to ultrasound scans during pregnancy and choices that parents need to make, and those they may have to make as a consequence.**

**Introduce tasks for phase 2**

Phase 2. Students explore what ultrasound scans show in terms of screening for these diseases and the types of decisions that parents will need to consider.

Perhaps divide the class into small research groups to follow up on the research questions.

Links to some different sources of information are given in the slide presentation.

A pro-former sheet for collating research information is available to accompany this task. As well as collecting information, students need also to consider the accuracy and reliability of their source, as well as separating opinion and bias from objective fact.

Questions might include, amongst others:

* What can an ultrasound scan detect and is it safe?
* What is the normal medical ultrasound screening process during pregnancy in the NHS?
* False-negative and false-positive tests (data analysis)
* What is Down’s syndrome?
* Who ought to decide whether another person has a quality of life worth living?
* Can diagnosis at a foetal stage improve quality of life for someone with Down’s syndrome?
* Are there circumstances under which the termination of pregnancy is desirable?
* What structures and support mechanisms are in place to support those who may need them?

**Phase 3. Students share and explain their findings to build up an understanding of the different stages of the ultrasound screening process and potential outcomes.**

**A structured class discussion exploring potential future scenarios for the whole family. This could consider the abortion debate and the reasons for having screening tests**

Phase 4. Students are asked to explore philosophical questions – some of which can relate to termination of pregnancy. Possibly develop a flow diagram showing how an individual might make a decision about terminating a pregnancy that they could apply to a situation.

They could explore life stories of people with Down’s syndrome and produce summaries of some form. (Would need a range of people’s experiences – for example from the Down’s Syndrome Association’s website.

**Phase 5. Various scenarios of a mother’s/family’s situation are given to students to make a decision of what to do individually. They may ask questions for clarification on factual information. They either justify their choices or explain why they might otherwise have made a different decision.**

***Activities for each of the five phases of learning***

Phases 1, 3 and 5 are classroom based; and *phases 2 and 4* can be completed either in the classroom or independently out of the classroom.

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| **Activity** | **Phase** | **Reason for it** | **Activity summary** | **Estimated time** |
| 1 Introduction | 1 | Stimulus material, used to develop a considered set of research questions. | Video footage (provided) of a scan with a discussion. | 40 minutes  (Video is 4:21 mins) |
| 2 Research | 1  *2* | To organise students into research groups and for each research group to organise what they are each going to do.  *Complete research.* | Structured research of ideas that feed into next phase | 20 minutes in lesson time.  *1-3 hours* |
| 3 Screening tests for Down’s syndrome | 3 | To collate research findings into a structured format that can be referenced during activity 4: Difficult decisions. | Summary map of research for students to complete in small groups | 30 m – 1 hr  (Ideally a full hour) |
| 4 Difficult decisions | 3 | To explore research findings through structured discussion. | Philosophical dilemmas and a guided class discussion to identify dilemmas that may be raised during the different stages of the screening process and to explore how choices are made, the factors that affect individuals’ choices, and whether these influences are justified. | 30 m – 1 hr  (Ideally a full hour) |
| *5 Life stories* | *4* | *To raise awareness of what it is like to live with Down’s syndrome, to illustrate how emotions, awareness and understanding play a part in the decisions we make.* | *Research and write up life stories of those with Down’s syndrome* | *1-3 hours* |
| 6 ‘Screen time’ | 5 | For students to experience making and justifying difficult decisions; to explore reasons for different decisions; and to develop understanding of what influences their decisions. | Role play: scenarios of mothers in different situations deciding if they should have the screening test. Students justify their decision and consider what could influence others to make a different decision. | Role play:  40 minutes  Class discussion:  20 minutes |

**Guidance notes: pedagogical approaches**

The issues explored in this unit may directly affect some students, their friends or family. Students are likely to come from diverse backgrounds and may hold conflicting viewpoints. To facilitate constructive discussion, it is helpful to begin by setting ground rules for these sessions.

A school may have particular rules or approaches to teaching potentially controversial or upsetting topics.

The following is a short checklist of things to consider in advance of teaching this unit:

* If it is known (or if you are worried) that particular students may be affected by the content of this unit, it can sometimes be a good idea to let students know what is to be covered in advance and/or to seek advice from experts in your school.
* The classroom should be an open and non-judgemental space. It may be a good idea to allow students the opportunity to leave the room without explanation or time to speak with you confidentially if they wish.
* It should be made clear that everyone is entitled to an opinion but that hurtful or offensive comments will not be tolerated.
* Students should be encouraged to provide deeper explanations of their thinking. This can lead them to challenge what they think and understand why, or why not, they believe what they have said.
* Students should not be pressured into talking about personal experiences.

With a unit like this, it can be hard to keep your personal views to yourself. One of the most important things to do is to create a balance of views with respect and acknowledgement of different arguments.

**AS/A level specification links**

**AQA A-Level physics content:**

**Waves (AS-content):**

* Oscillation of the particles of the medium; amplitude, frequency, wavelength, speed, phase, phase difference, c = f λ, f = 1/T
* Phase difference may be measured as angles (radians and degrees) or as fractions of a cycle.
* Laboratory experiment to determine the speed of sound in free air using direct timing or standing waves with a graphical analysis.
* Students will be expected to describe and explain interference produced with sound and electromagnetic waves.
* Path difference and coherence.
* Reflection: Students are expected to understand the principles and consequences of pulse broadening and absorption.

**Medical Physics Option:**

* Reflection and transmission characteristics of sound waves at tissue boundaries, acoustic impedance, Z, and attenuation.
* Advantages and disadvantages of ultrasound imaging in comparison with alternatives including safety issues and resolution.
* Piezoelectric devices
* Principles of generation and detection of ultrasound pulses.
* A-scans and B-scans.
* Examples of applications.
* Use of the equations Z = ρ c and *I*r /*I*i = ((*Z*2 − *Z*1)/(*Z*2 + *Z*1))2

**AQA A-Level religious studies content:**

The application of natural moral law, situation ethics and virtue ethics to:

* Issues of human life and death:
* abortion

**AQA A-Level Psychology**

Attachment:

* Caregiver-infant interactions in humans: reciprocity and interactional synchrony. Stages of attachment identified by Schaffer. Multiple attachments and the role of the father.
* The influence of early attachment on childhood and adult relationships, including the role of an internal working model.

**AQA A-Level Biology**

Genetic information, variation and relationships between organisms:

* Genetic diversity within a species can be caused by gene mutation, chromosome mutation or random factors associated with meiosis and fertilisation. This genetic diversity is acted upon by natural selection, resulting in species becoming better adapted to their environment.

Genetic diversity can arise as a result of mutation or during meiosis:

* Mutations in the number of chromosomes can arise spontaneously by chromosome non-disjunction during meiosis.

**Key information**

***History of ultrasound scanning during pregnancy (Nicolson and Fleming, 2013)***

The history of ultrasound (sonography) in Obstetrics and Gynaecology dates from the classic Lancet paper of Ian Donald and his team from Glasgow (Donald et al., 1958). The paper reports the work of Donald and an engineer called Tom Brown who, together with the help of a local engineering company, developed the world’s first practical ultrasound scanning machine. It begins with the physics of ultrasound scanning techniques, then describes safety experiments, ultrasound images of pregnancy, the foetus and gynaecological tumours, and includes a really detailed description of the strengths, weaknesses and potential of this new technique.

The use of ultrasound scans in pregnancy gradually increased and became widely used in British hospitals in the 1970s. Presently they are used routinely throughout the developed world.

Ian Donald was a member of the Scottish Episcopalian Church. He held strong anti-abortion beliefs that some people believe cost him a knighthood.

***Ultrasound scans in pregnancy***

In the Global North it is routine for pregnant mothers to be invited to attend an ultrasound scan to check the development of their foetus at different stages of pregnancy. Ultrasound scans use sound waves to build a picture of the foetus in the womb. The scans are painless, have no known side effects on mothers or babies (NHS, 2018), and can be carried out at any stage of pregnancy.

For many potential parents, ultrasound scans are exciting and happy events. However, ultrasound scans are medical screening tests and there is a possibility that a scan may detect some serious health conditions.

Sometimes the position of the foetus in the uterus may make screening tests impossible, and sometimes the resolution may not be clear enough. Accuracy of screening also depends on the interpretation of scan results, which can be affected by the training and experience of the person carrying out the scan.

Ultrasound screening tests during pregnancy are not compulsory, but almost all women choose to have one and many do not realise they are optional (Ohman and Waldenstrom, 2008). Most women view the scan as a social rather than a medical event and expect the scan will confirm the wellbeing of the foetus and enable them to have a visual encounter with their foetus (Ahman, Runestam and Sarkadi, 2010).

Down’s syndrome is the most common chromosomal condition in live-born babies, and the most common cause of intellectual disability (Natoli et al., 2012)

***Down’s syndrome, Edwards’ syndrome and Patau’s syndrome.***

These conditions are caused by the foetus having an extra chromosome. The particular condition depends on which chromosome this is.

The chance of having an extra chromosome is independent of the actions of potential parents before or during pregnancy.

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| Syndrome | Chance of a baby having the syndrome. | How babies may be affected by the condition. |
| Down’s | 1 in 1000  age 20: 1 in 1500  age 30: 1 in 1000  age 40: 1 in 100  (National Screening Committee, 2008) | Some level of learning disability. Some people will be more independent and do thinks like get a job. Other people might need more regular care.  About half of babies with Down’s syndrome are born with a heart condition and some can have also have autism. Adults with Down’s syndrome can develop Alzheimer’s and dementia at a younger age. The average life expectancy for someone with Down’s syndrome in the UK is 58 years.  (NHS, 2019b) |
| Edwards’ | 1 in 5000 | Most babies die before or shortly after being born.  13/100 survive to age 1 and a few into adulthood.  All have learning disability and may also have heart, respiratory, kidney of gastrointestinal conditions.  (NHS, 2020) |
| Patau’s | 1 in 5000 | Often miscarriage, still birth or dying shortly after birth.  1/10 survive to age 1.  Babies with Patau’s syndrome can have a wide range of health problems. Their growth in the womb is often restricted. 8 out of 10 have severe heart defects. The brain often does not divide into two halves, which can affect facial features and cause defects to the face and head. Patau’s syndrome can also cause many other abnormalities.  (NHS, 2019a) |

A screening test cannot tell how severe a baby will be affected by one of these syndromes.

The Down’s Syndrome Association provides information, support and advice on their website, [www.downs-syndrome.org.uk](http://www.downs-syndrome.org.uk), which includes descriptions of what it is like to have Down’s from the perspectives of those who have the syndrome.

***Medical screening for Down’s syndrome, Edwards’ Syndrome and Patau’s syndrome (NHS, 2018)***

In Britain, all women are offered a combined test for these three conditions between 10 and 14 weeks of pregnancy. It involves a blood test and measuring the fluid at the back of the foetus’s neck (nuchal translucency) with an ultrasound scan. The test reveals the chances of having a baby with one of these conditions, but cannot give absolute certainty one way or the other. Approximately 5% of women will receive news around the potential need for further diagnostic testing and face potentially difficult decisions (ARC; National Screening Committee, 2008).

If it is not possible to measure the nuchal translucency (e.g. if the foetus is not in a suitable position) or the woman is more than 14 weeks pregnant, a different blood screening test can be used to test for Down’s syndrome, but this is not as accurate as the combined test. Edwards’ and Patau’s syndromes are not detected by this test, but they can still be screened for during a mid-pregnancy ultrasound scan.

If a foetus is found to have a high chance of having one of these syndromes, women are offered further diagnostic tests that can tell with much more certainty whether the foetus has these conditions, but these tests have a small risk of miscarriage.

***Uncertainty in test data***

A false-negative test indicates a foetus does not have a condition when it does.

When tested during pregnancy, three in ten babies with Down’s syndrome tests showed false-negative result from the combination test (National Screening Committee, 2008).

A false-positive test indicates a foetus has one of these conditions when they do not.

About one in twenty combination tests identifies a foetus at higher risk of having one of these conditions, most of these are false-positive results. About one in fifty testing positive on the combination test will actually have Down’s syndrome (National Screening Committee, 2008). To find out which babies these are requires a more invasive test: amniocentesis or chorionic villus sampling. About 0.5 to 1 in a hundred of these tests result in a miscarriage (NHS, 2018).

***Parental reaction to the detection of higher risk***

Most babies that a screening test detects as being at high risk are in fact normal. If a foetus is identified as at a high risk, the woman is usually referred to a hospital consultant to confirm the diagnosis which may entail a wait of several hours. Follow up tests that can provide more certainty may take a few weeks and involve a small risk to the foetus (NHS, 2018).

Most potential parents find these waits very stressful, with most still worrying two or three weeks after the event, even if the tests were negative (Ahman et al., 2010). By contrast, stress levels in women in a high risk group were high before a scan and reduced well if the scan showed a normal foetus (Brisch et al., 2003).

Ahman, Lindgren and Sarkadi (2012) found that fathers often respond to the initial diagnosis with feelings of frustration and thoughts about possible consequences; they often need ‘facts’ in order to gain a sense of control; and they typically have much concern for their partner’s wellbeing. Often fathers take on the role of a kind of fact manager in the parents’ decision-making process.

Some parents may have already decided they want to see a pregnancy through to full term, so choose not to have follow up tests. A majority of those who choose not to have follow up tests say that the perceived risk of causing a miscarriage is a factor. Those that do take the tests often seek certainty and also differ from those who don’t take the tests in post-screening anxiety level, religious beliefs and their attitudes towards disability (Kobelka, Mattman and Langlois, 2009; Ahman et al., 2010; Natoli et al., 2012).

Most women who choose to have a follow-on test put their pregnancy ‘on hold’ emotionally whilst they await results. Some then find it difficult to become attached to what they perceive to be a possibly ‘damaged’ baby, even after negative results (Ahman et al., 2010).

***Trends in Down’s syndrome live births in the UK (Morris and Alberman, 2009)***

In the UK in the twenty years from 1989 through to 2008: antenatal tests detected 70% of babies with Down’s syndrome that women taking the tests were carrying (and missed 30%); 92% of women have consistently elected to terminate their pregnancy on receiving a positive diagnosis; and the number of babies born with Down’s syndrome was approximately the same each year.

This suggests that nothing changed from 1989 through to 2008, but it did: the average age of women giving birth increased and this should have led to a 48% increase in babies with Down’s syndrome. Instead what happened was that through this period the test was offered to more and more women, which meant more women terminated their pregnancy overall.

The proportion of women electing to have a test in this period remained constant at about 70% of those offered the test.

***The abortion debate (BBC, 2014)***

The abortion debate is complex and often raises strong feelings. The primary questions in the moral debate about the termination of a pregnancy are: is the termination of a pregnancy morally wrong; and should the termination of a pregnancy be legal or illegal?

These questions are just the start of the debate. If we conclude that the termination of a pregnancy is not morally wrong then we still need to ask in each case whether the termination of a pregnancy is the best (or least bad) thing to do. If instead we conclude that the termination of a pregnancy is morally wrong, it may be that in some circumstances the alternatives are more morally wrong.

Those choosing the termination of a pregnancy following a positive test result do not take a casual or callous attitude to the foetus; and most often the opposite is true. They are most likely making what they consider to be the least bad choice out of a set of difficult options.

Some other questions about the termination of a pregnancy can be stated in terms of the sorts of decisions that pregnant women may have to face. Here they are quoted from a BBC webpage that introduces the abortion debate (BBC, 2014).

* Does the foetus have a right to be carried in the woman's womb until it's ready to be born?
* Under what circumstances, if ever, can we take an 'innocent' human life?
* Is any other right more important than the right to life - for example, a woman's right to decide what to do with her own body?
* If the woman's life is in danger because of the pregnancy, how do we decide whose rights should prevail?

The first two questions are particularly relevant to this unit, but wrapped up in those questions are other issues. In answering the first question, many people will automatically consider death to be a bad thing, but there are circumstances that are easily imagined in which death is a good thing. It can be argued that it is wrong to kill only when death is a bad thing. The second question additionally raises the issue of what we mean by a ‘human being’ and when, if ever, the foetus becomes a ‘human being’.

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