



SOCIAL RESEARCH NUMBER:

36/2017

PUBLICATION DATE:

04/07/2017

Public Attitudes towards Genetic Modification

A Scoping Review

Mae'r ddogfen yma hefyd ar gael yn Gymraeg.

This document is also available in Welsh.

Public Attitudes towards Genetic Modification:
A Scoping Review

wavehill

social and economic research
ymchwil cymdeithasol ac economaidd

Views expressed in this report are those of the researchers and not necessarily those of the Welsh Government

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Glossary

BSA	British Social Attitudes
BSE	Bovine spongiform encephalopathy
CASP	Critical Appraisal Skills Programme
Defra	Department for farming and rural affairs
EC	European Commission
EFSA	European Food Safety Authority
EU	European Union
FSA	Food Standards Agency
GM	Genetic modification
GMMs	Genetically modified micro-organisms
GMOs	Genetically modified organisms
HM	Her Majesty
HSE	Health and Safety Executive
UK	United Kingdom
vCJD	Variant Creutzfeldt-Jakob disease

Glossary

Adventitious Presence	In modern plant biotechnology, adventitious presence refers to the unintended, trace levels of traits developed through modern plant biotechnology in seed, grain, or feed and food products.
<i>Agrobacterium tumefaciens</i>	A genus of bacteria, which researchers can use to transfer DNA to plants. <i>Agrobacterium tumefaciens</i> can infect plants and cause crown gall disease – a tumorous growth at the base of plants. The DNA transfer occurs naturally during the crown gall disease, and can be used as a method of transformation.
Agronomics	Agronomic practices are steps farmers incorporate into their farm management systems to improve soil quality, enhance water use, manage crop residue and improve the environment through better fertilizer management. These steps not only improve a farmer's bottom line by decreasing input costs, but also improve the environment by decreasing water use and over-fertilization. Agronomic practices encompass many areas of conservation from practicing reduced-tillage methods.
<i>Bacillus thuringiensis (Bt)</i>	A naturally occurring bacterium present in soil, used successfully by home gardeners and organic farmers to control certain insects for more than 40 years. When ingested by a target insect, the protein produced by <i>Bt</i> destroys the insect by disturbing the digestive system.

Biodiversity	The word – a contraction of ‘biological diversity’ – refers to the number, variety and variability of living organisms. It encompasses three basic levels of organisation in living systems: the genetic, species and ecosystem levels. Plant and animal species are the most commonly recognised units of biodiversity.
Biotechnology	A broad term used to describe any technique that uses living organisms or parts of organisms to solve problems or develop new products. Biotechnology is used in a wide range of applications including the production of foods and medicines, testing for disease, removing wastes in the environment, and improving agricultural plants. Modern biotechnology includes the tools of genetic engineering, although this is only one of many applications.
Bt crops	Crops that are genetically engineered to carry a gene from the soil bacterium <i>Bacillus thuringiensis</i> (Bt). The bacterium produces proteins, which are toxic to target pests. Crops containing the Bt gene are able to produce this toxin, thereby providing protection for the plant.
Contained Use	Any activity involving genetically modified micro-organisms (including viruses, viroids, and animal and plant cells in culture) which are carried out under containment to limit contact of these organisms with the environment. Such activities include for example the process of genetic modification, the use, storage, transport, destruction and disposal of GM microorganisms.

Conventional Crop	A non-biotech hybrid or inbred crop. Grown with inputs, such as fertiliser, herbicides, and insecticides.
Deliberate release	Living organisms, whether released into the environment in large or small amounts for experimental purposes or as commercial products, may reproduce in the environment and cross-national frontiers thereby affecting other Member States. The effects of such releases on the environment may be irreversible.
DNA (deoxyribonucleic acid)	A complex molecule, which contains, in chemically coded form, all the information needed to build, control and maintain a living organism. DNA is a ladder-like double-stranded nucleic acid, which forms the basis of genetic inheritance in all organisms except for a few viruses. In organisms other than bacteria, it is organised into chromosomes and contained in the cell nucleus.
Ecosystem	A dynamic and interdependent living community of people, parts or mechanisms, which interact with one another. The term was coined by Arthur Tansley, a British Ecologist, who said, "ecosystems have the capacity to respond to change without altering the basic characteristics of the system."
Feed	A mixture or preparation of food for feeding livestock.
Field trial	Is a test of a new technology or variety, including biotech-derived varieties, done outside the laboratory but with specific limitations and requirements on location, plot size, methodology, etc.

Gene	The basic physical unit of heredity, a linear sequence of nucleotides along a segment of DNA, which provides the coded instructions for synthesis of RNA, which, when translated into protein, leads to the expression of hereditary character.
Genetic modification	Also known as genetic engineering or recombinant-DNA technology was first applied in the 1970s. This technique allows selected individual genes to be transferred from one organism into another and also between non-related species. It is one of the methods used to introduce novel traits or characteristics into micro-organisms, plants and animals. The products obtained from this technology are commonly called genetically modified organisms (GMOs).
Genetically engineered organism (GEO)	See genetically modified organism (GMO).
Genetically Modified Organisms (GMOs)	An organism in which the genetic material has been altered in a way which does not occur naturally by mating and/or natural recombination.
Genetics	The study of hereditary and the variation of inherited characteristics.
Genome	The complete set of genetic material in an organism.
Genomics	The branch of molecular genetics concerned with the study of genomes, specifically the identification and sequencing of their constituent genes and the application of this knowledge in medicine, pharmacy, agriculture, etc.
Herbicide	A substance used to kill plants, especially weeds.
Herbicide-tolerant crops	Crops that have been developed to survive application(s) of particular herbicides by the incorporation of certain gene(s) through either genetic engineering or traditional breeding methods. The genes allow the herbicides to be applied to the crop to provide effective weed control without damaging the crop itself.

Hybrid	A plant, which is heterogeneous; the offspring of two plants of the same species but different varieties.
Insecticide	A substance used to control certain populations of insect pests. In agriculture, insecticides are used to control insect pests that feed on crops or carry plant disease.
Insect-resistant crops	Pest resistant GM crops (primarily cotton and maize), have been genetically modified so they are toxic to certain insects. They are often called Bt crops because the introduced genes were originally identified in a bacterial species called <i>Bacillus thuringiensis</i> . These bacteria produce a group of toxins called Cry toxins.
Organic (Food and Agriculture)	Organic is a term used to describe products or processes, which are developed without the use of 'man-made' or synthetic products or processes. In organic farming natural fertilizers, cultivation methods, and pesticides derived from natural sources are used as an alternative to synthetic chemicals.
Pesticide	A substance used to prevent, destroy, repel or mitigate pests, such as harmful insects, weeds or microorganisms.
Plant pests	Organisms, which may directly or indirectly cause disease, spoilage or damage to plants, plant parts or processed plant materials. Common examples include certain insects, mites, nematodes, fungi, molds, viruses and bacteria

Protein	A molecule composed of one or more chains of amino acids in a specific order. Proteins are required for the structure, function and regulation of an organism's cells and tissues, and each protein has a unique function.
Recombinant DNA (rDNA)	Procedures used to join DNA segments in a cell-free system (e.g. in a test tube outside living cells or organisms). Under appropriate conditions, a recombinant DNA molecule can be introduced into a cell and copy itself (replicate), either as an independent entity (autonomously) or as an integral part of a cellular chromosome.
Trait	An important characteristic of a crop (such as drought tolerance or insect resistance) which is determined by a specific gene or set of genes
Transgene	A gene from one organism inserted into another organism by recombinant DNA techniques.
Transgenic organism	A plant, animal, bacterium or other living organism, which has had one or more transgenes added to it by means of genetic engineering.

1. Introduction

- 1.1 This report aims to synthesise published research on the public's familiarity with, and their attitudes towards genetic modification (GM) and genetically modified organisms (GMOs). The findings from this review will contribute to the evidence base, which in turn will inform the Welsh Government's policy position on GM issues.
- 1.2 The current Welsh Government policy position on GM maintains a precautionary and restrictive approach within the parameters of European Union (EU) and UK Government legislation to the growing of GM crops (Welsh Government, 2016). GM food is not currently widely available in the UK, but recent years have seen renewed policy interest in the issue (Cabinet Office Strategy Unit 2008) and a corresponding research agenda aimed at better understanding public opinion on the subject (FSA, 2009a; FSA, 2009b; BSA, 1999, 2003).
- 1.3 This report is based on a scoping review of published research drawn from academic literature, government documents, independent reports and publically available datasets. The review maps existing research informing our understanding of public attitudes on GMOs and GM in Wales. Where possible, this review has identified and critically appraised literatures specific to Wales and the UK. Where considered relevant to Wales, this review then drew from the wider evidence-base to draw out the implications inferred within research emanating from the EU and broader international context.
- 1.4 It is clear evidence is unavailable in many areas, and an aim of this review was also to highlight such gaps in knowledge so as to inform future research objectives.
- 1.5 As a scoping review, this report is not intended to be a comprehensive review of all aspects relating to the public's familiarity with and attitudes towards GM and GMOs. It employed the same general principles of a systematic review (see HM Treasury, 2011), but in a lighter-touch manner appropriate to the research scope. As such, this review is exploratory in nature, and the conclusions outlined in this report may be subject to revision if a more systematic and comprehensive review of the evidence is undertaken.

1.6 This report acknowledges the subject of public attitudes towards GM and GMOs is complex and wide-ranging. The science underpinning GM is diverse and evolving, with a broad range of legislation controlling its use. Correspondingly, the evidence-base reviewed was broad in focus, which presented challenges in mapping the literature.

1.7 The remainder of this report is structured as follows:

- Chapter 2 outlines the methodology and explains how this study was undertaken
- Chapter 3 briefly summarises the policy context in Wales
- Chapter 4 presents an overview of the evidence base on GM technology and the shaping of public attitudes
- Chapter 5 summarises the key findings of research into public attitudes against the objectives of the review
- Chapter 6 sets out the conclusions and recommendations of the review

2. Methodology

The Purpose of the Research

2.1 The main aim of this report was to undertake an examination of the evidence on the public's knowledge of, familiarity with and their attitudes towards GM and GMOs. The method of this research was to conduct a scoping review of published evidence.

2.2 Specifically, this review aimed to:

- Map and review the current evidence on Welsh citizen's knowledge of, familiarity with and attitudes towards GM and GMOs
- Identify evidence gaps in the current knowledge and explore the ways in which these gaps could be addressed in future research via appropriate research methodologies

2.3 To this end, drawing on a range of sources, this review critically appraised and synthesized the existing research base in order to address the following objectives:

- Identify previous relevant UK and overseas research to create a corresponding reference list of public attitudes to GM crops, contained use, food and feed and GM research and trials.
- Explore how public attitudes to GM in the UK compare with attitudes in other countries.
- Establish whether/why attitudes to GM have changed with time; are there attitudinal differences between rural/urban populations and is there a clear difference of opinion between the agriculture industry, animal feed industry, the medical/research industry and the general public.
- To identify gaps in our current understanding of public attitudes, specifically from a Welsh viewpoint.

Scope of the Review

- 2.4 The scope of the research and the methodology adopted was primarily determined by two key considerations:
- Focus on key areas of interest: Public attitudes towards specific aspects of GM and GMOs; namely GM crops, contained use, food and feed, and GM research and trials.
 - Issues of practicality: In terms of what could be identified and reviewed to achieve the necessary analytical rigour within the timeframe of the research.

The search strategy and broader methodology of this review cannot be described as fully comprehensive for the topics researched. The review, in reaching for its stated objectives, drew on research synthesis techniques and approaches best described as a 'scoping' exercise. This was aimed at drawing out the main issues concerning the public's knowledge of, familiarity with and attitudes towards GM and GMOs. Due to time and resourcing constraints, a more detailed and systematic examination of the research base was not possible. A scoping exercise is understood for the purposes of this review as providing a thematic and exploratory overview of relevant and recent evidence, which can be used to inform policy.

- 2.5 The review prioritised research in order of specificity and relevance to the Welsh context. Where available, it included a more detailed examination of research emanating from Wales and the UK. Similarly, where appropriate, the review also drew on key messages from the wider EU and international evidence base that had direct relevancy for Wales.

Literature Search Strategy

- 2.6 The primary search strategy for this research was to conduct exploratory searches of online databases for academic literature and online search engines for public or third-sector published reports. In the first instance, online databases were searched (Web of Science, EBSCO Host, OvidSP, Opengrey) alongside search engines (Google Scholar) for literature. Individual searches were then conducted by directly searching through the publication lists and datasets of relevant organisations known to publish in the areas of GM and GMOs (such as the UK Data Service, the Food Safety Authority (FSA), the

Royal Society, the Soil Association, and the Farmers Union of Wales). From these initial exploratory searches, more detailed searches were then conducted relating to specific areas of concern.

Reverse Citation Tracking

- 2.7 As part of the search, the research team also completed reverse citation tracking in order to identify any additional research of relevance to the study. This involved scanning citation lists of studies identified during the database search to highlight additional relevant research.

Contacting Relevant Academics in the Field

- 2.8 Efforts were made to contact relevant academics in the field to help identify ongoing or unpublished research. However, this was unsuccessful and the responses received revealed no additional literatures.

Inclusion Criteria

- 2.9 A broad set of inclusion criteria was established in order to be sensitive to the full range of studies of potential relevance to the research objectives. Studies were deemed relevant if they:
- Explored aspects of public attitudes towards GM or GMOs; and
 - Presented empirical data from any of the groups of interest as relevant to the objectives of the research.
- 2.10 The review did not exclude studies based on study design and focus of analysis, such as particular GM applications or regulation. The review was also interested in capturing international research, and therefore did not exclude research based on the country of focus. The majority of studies reviewed were published between 2004 and 2015.
- 2.11 An objective of the review was to identify relevant research and create a corresponding reference list of public attitudes to GM crops, contained use, food and feed and GM research and trials. A summary of the included papers is provided in Annex A. The reference list of all included papers is included in the bibliography. The corresponding reference list included a number of studies, which analysed data from the same source.

- 2.12 Due to time constraints and the pragmatic nature of the scoping review, the results of the literature search are likely to underreport the full extent of the research that exists.

Critical Appraisal

- 2.13 Identified studies were critically appraised across a range of domains, including if they were reporting qualitative or quantitative data. These criteria were drawn from guidance on critical research appraisal, which emphasises issues of validity, reliability and also highlights questions around the relevance of the appraised evidence to the objectives of the research undertaken (see CASP, 2016).

Limitations

- 2.14 The review is subject to a number of limitations. One of the key issues was the lack of data specific to Wales. This sometimes reflected the views of particular studies, which took the 'UK' as their geographical basis and did not disaggregate data by individual country. In addition, due to the small population of Wales, finding large-scale (or robust) evidence for the specific areas outlined in the objectives was problematic. This meant the methodological approach adopted by this review was, where possible, to use data at the UK level to draw out the implications for Wales contained within the evidence. For many of the areas outlined in the objectives, evidence at the UK level was also found to be lacking. As a result, where feasible given the timeframe of the research, international literature has been referenced when of relevance to Wales, within the parameters set by the research objectives.
- 2.15 This scoping review pulls together studies that use a variety of research methods. Due to the difficulty of collecting robust data against some of the objectives, and the range of research methods employed in the literatures reviewed, the quality of evidence is not consistent across sources. Concerns about the reliability of evidence, such as sample size or research method, are highlighted where relevant. Qualitative studies have been included alongside statistical evidence as they provide more a detailed insight into the understanding of and attitudes towards GM and GMOs. The findings of these studies, however, cannot be generalised.

- 2.16 The completeness of the literature search was determined by time and scope constraints and, as a result, was exploratory rather than comprehensive in nature. Due to the timeframe of the research, an assessment of the evidence was limited to drawing on the narrative discussion within those sources reviewed rather than the analysis of raw data. Critical appraisals of the evidence were, therefore, dependent upon the quality of the original reporting.
- 2.17 Due to these limitations, the conclusions, which can be drawn from this review, including the gaps identified across the research base, provide an indicative, rather than a definitive statement of the evidence.

3. Policy Context

- 3.1 Since GM was first commercialised in the 1980s, it has remained a controversial topic. There continues to be public debate and disagreement surrounding the GM crops and its role in GM food.
- 3.2 In Wales, the Welsh Government has a GM policy that maintains a precautionary and restrictive approach to GM crop cultivation within the confines of the law. GM and GMOs are regulated through a range of legislation and regulatory frameworks developed and administered by a number of institutions. Welsh legislation must also be compatible with UK and EU law.
- 3.3 This policy allows the Welsh Government to protect the significant investment they have made in the organic sector and safeguard the agricultural land in Wales, which is managed under voluntary agri-environment schemes. Farming and food processing industries remain the cornerstones of the rural economy. The emphasis is on competing on quality, strong branding and adding value through local processing. The policy aims to preserve consumer confidence and maintain a focus on a clean, green, natural environment.
- 3.4 This policy position will remain under review with an open mind on future GM developments and more advanced genetic techniques. Future research into advanced plant breeding techniques carried out will be based on independence, openness and integrity that could help deliver GM or conventional crops, which benefit the Welsh farmer, consumer and environment, and lead to more sustainable forms of agriculture.
- 3.5 The Welsh Government holds competencies specifically around deliberate release, food and feed, placing on the market and transboundary movements.

Contained Use

- 3.6 The UK government's Genetically Modified Organisms (Contained Use) Regulations 2014 cover all aspects of contained use involving genetically modified micro-organisms (GMMs) and the human health aspects of the contained use of larger GMOs (for example, GM animals and plants). Acting jointly, the Health and Safety Executive (HSE) and the Secretary of State for the Department for Environment, Food and Rural Affairs (Defra) are the competent authority in England and Wales responsible for the 2014 Regulations. These

functions are delegated to officials of the HSE and Defra. Although not part of the competent authority, officials of the Welsh Government are also involved in all matters related to GMO contained use in Wales.

- 3.7 The environmental aspects of the contained use of GMOs are covered by the UK government's Environmental Protection Act 1990 and the Genetically Modified Organisms (Risk Assessment) (Records and Exemptions) Regulations 1996 (as amended). Defra is responsible for administering the legislation in England. The Welsh Government has responsibility in Wales and the Scottish Government in Scotland. Northern Ireland has its own statutory rules.

Food and Feed

- 3.8 The current procedures for evaluation and authorisation of GM food and feed are laid down in Regulation (EC) No. 1829/2003 of the European Union. The safety assessments are carried out by the European Food Safety Authority (EFSA), according to its published guidelines for the assessment of GM plants. Each application is reviewed on a case-by-case basis, including a detailed consideration of the potential toxic, nutritional and allergenic effects. GM foods may only be authorised for sale if they are judged not to present a risk to health, not to mislead customers, and not to be of less nutritional value than the foods they intend to replace. In carrying out its evaluation, the EFSA may consult the authority responsible for food safety assessment in one of the European Union (EU) Member States. In the UK, this is the Food Standards Agency (FSA), which seeks expert advice on GM foods from the independent Advisory Committee on Novel Foods and Processes (ACNFP) as appropriate.
- 3.9 The FSA is a UK-wide, non-Ministerial Government Department. In Wales, they are accountable to the National Assembly for Wales¹ through the Minister for Social Services and Public Health. The FSA is an independent regulator and in terms of EU law relating to food and animal feed, is the central competent authority for the UK. The main objectives of the FSA are to protect public health from risks, which may arise in connection with the consumption of food, and to protect the interests of consumers in relation to food. EFSA's final opinion on each application is published for public comment before any decision on

¹ The FSA are accountable to the Westminster Parliament for England, and the Northern Ireland Assembly for Northern Ireland.

authorisation is taken. The final decision on authorisation rests with Member States, who vote on each GM food at the Standing Committee on the Food Chain and Animal Health.

Labelling

- 3.10 In the EU, if a food contains or consists of GMOs, or contains ingredients produced from GMOs, this must be indicated on the label. For GM products sold 'loose', information must be displayed immediately next to the food to indicate it is GM. The GM Food and Feed Regulation (EC) No. 1829/2003 lays down rules to cover all GM food and animal feed, regardless of the presence of any GM material in the final product.
- 3.11 This means products such as flour, oils and glucose syrups have to be labelled as GM if they originate from a GM source. Products produced with GM technology (cheese produced with GM enzymes, for example) do not have to be labelled. Products such as meat, milk and eggs from animals fed on GM animal feed also do not need to be labelled.
- 3.12 Any intentional use of GM ingredients at any level must be labelled. However, the Food and Feed Regulation provides for a threshold for the adventitious or accidental presence of GM material in non-GM food or feed sources. This threshold is set at 0.9% and only applies to GMOs that have an EU authorisation. Any unauthorised GM material cannot be present at any level.

Deliberate Release

- 3.13 The Genetically Modified Organisms (Deliberate Release) (Wales) Regulations 2002 were made, in part, under the powers of the UK government's Environmental Protection Act 1990 (EPA), which gives Welsh Ministers certain powers and responsibilities regarding the deliberate release of GMOs. The Regulations supplement the EPA and implements other changes made by the EU Directive 2001/18/EC.
- 3.14 Directive 2001/18/EC is EU legislation designed to protect human health and the environment across the EU from any adverse effects, which may be caused by the deliberate release into the environment of GMOs. It does this by setting out a system by which GMOs have to be approved on safety grounds before

they are allowed to be released into the environment anywhere in the EU. The Directive is wide ranging and covers GMOs of all types, including plants, animals and micro-organisms.

- 3.15 Directive 2001/18/EC deals with two distinct types of GMO release. Part B of the Directive sets out the process which a GMO must go through before it can be released for “any other purpose than for placing on the market” (including for purposes of scientific research). Part C of the Directive sets out the process of scrutiny for the “placing on the market of GMOs as or in products.” In short, Part B refers to non-commercial, including research, releases and Part C refers to commercial releases.
- 3.16 The decision-making process for Part B and Part C GMOs are different. Responsibility for decision making on Part B applications lies at the Member State level and as such is fully implemented in national legislation. Responsibility for decision making on Part C applications lies primarily at EU-level, although it also involves action at the Member State level (in essence, a Part C application is made initially by one of the Member States, then a collective decision is made by all Member States and the Commission acting jointly). Accordingly, our UK national legislation only covers aspects of the Part C process, which takes place at the Member State level (e.g. action the Welsh Ministers must take if an application for Part C consent is made in Wales). Other Member States have implemented similar legislation for dealing with Part C applications made to them. Aspects of the Part C procedure, which take place at the EU level, are covered by the Directive itself.
- 3.17 As was previously noted, the Welsh Government has historically taken a precautionary and restrictive approach to the deliberate release and cultivation of GM crops in Wales. To date, it has not supported any field test applications. In 2000, the National Assembly for Wales voted to resist the planting of GM crops in Wales and sought grounds for a legal ban; however, this did not stop two trials from going ahead at the time (BBC, 2001)². Nonetheless, no further commercial GM field trials have since been planted in Wales. However, in 2012 the Welsh Government did grant permission for the deliberate release of a GM vaccine as part of a three-year trial treatment for prostate cancer.

² <http://news.bbc.co.uk/1/hi/wales/2902727.stm>

GM crops

- 3.18 Under EU rules, GM crops must be formally authorised before they can be cultivated within the EU geographical area. Within the EU, the application of GM and GMOs to farming production has been restrained and no GM crops are currently grown commercially in the UK, although this is likely to change as the UK Government, which determines agricultural policy in England, has a more relaxed policy towards GM crop cultivation. This could enable GM crops to be commercially grown in England (Nelson, 2015).
- 3.19 An amendment to the EU's Directive 2001/18/EC on the Deliberative Release of GMOs came into force in January 2016. This directive allowed Member States and Regions, including the UK devolved administrations, to restrict or ban the cultivation of GMOs within their territory. The Welsh Government took advantage of this change in the legislation and officially requested the geographic scope of eight GM crops applications were amended to exclude the territory of Wales.
- 3.20 However, although the extent to which GM crops have been cultivated within the EU has been limited, the EU including the UK imports more than 70 per cent of its animal protein feed requirements from GM crops (EASAC, 2013). As UK animal feed imports are transported nationally, the majority of Welsh farmers are using GM feed in production processes. However, this review found no data estimating the extent to which this is the case.

4. Measuring the public's attitudes towards GM

The main determinants in shaping public attitudes

- 4.1 There is a complex social research agenda building-up around people's knowledge of, familiarity with and attitudes towards GM. Several determinants are highlighted in the literature as contributing to the shaping of public attitudes.
- 4.2 According to the studies reviewed, the main determining factor in shaping public attitudes is a personal judgement of the perceived risks and benefits, which is based on a multifaceted mix of variables.
- 4.3 Knowledge of GM technology is one variable upon which these perceptions of risks and benefits are formed, and it is a minor one. This is because people's familiarity with and knowledge of GM is limited. Therefore, affective or emotional responses play a greater part in shaping perceptions of risks and benefits (see Brook Lyndhurst, 2009, p. 7).³
- 4.4 Affective responses also mediate the effects of how new information is interpreted. In situations of uncertainty and low understanding, deep-seated general attitudes become proportionately more important. In the case of GM, these general attitudes can include deep-seated attitudes towards issues such as science and technology, attitudes to nature, cultural values and world outlook. General attitudes act as a guide in the shaping of attitudes towards more specific issues or topics (Grunert et al., 2004, p. 4).
- 4.5 Underlying the perceptions of risk and benefits, affective responses and general attitudes is the issue of trust. Trust is understood to influence the formation of general attitudes, mediate the take-up of ideas, and has a direct effect on attitudes to GM technologies (Brook Lyndhurst, 2009).
- 4.6 The determinants that shape public attitudes are discussed in more detail in this chapter. The discussion on people's decision-making process and attitude formation around GM is loosely structured around the categorisation outlined in a systematic review by Costa-Font et al. (2006). This systematic review brought together published evidence on public attitudes towards genetically modified food. The evidence was presented under the themes risk and benefit perceptions, personal attributes and values, and people's knowledge of GM and

³ <https://www.food.gov.uk/sites/default/files/multimedia/pdfs/emergingfoodtech.pdf>

GMOs. Evidence is presented along these lines later in the chapter. First, a brief overview of the methodological approaches used by the evidence base reviewed is provided.

Methodological approaches of the studies

- 4.7 The public's attitudes are formed in a dynamic environment. Attitudes are socially and culturally embedded, and shaped and reshaped by broader public debates, values and identities (Ganiere et al., 2006). From the outset, therefore, it should be noted that because attitudes are influenced by a range of contextual factors and trends, the discussion cannot fully capture the processes at play.⁴
- 4.8 There is no consensus in the literature around how best to measure attitudes. Various quantitative and qualitative methods for measuring attitudes have been developed aimed at capturing these processes. These measures often focus on different components of the cognitive, affective and behavioural aspects of people's attitude formation.
- 4.9 It is important to interpret the findings of this review in the context of the methodological limitations of the evidence base. Issues surrounding research effect can never be completely excluded in social research. Brook Lyndhurst (2009, p. 5) emphasise how, with an issue as complex as GM technology, research design becomes a particularly important variable.
- 4.10 The quality of the studies reviewed is mixed, and some studies did not score highly on issues of validity and reliability during the critical appraisal process (see Chapter 2: 2.13). For example, surveys which used non-representative samples. However, these studies have been included because of their relevance to the objectives of the research. These instances are marked clearly in the reference list of reviewed studies included in Annex A and in the discussion of these studies in this chapter and the next, where the body of evidence is discussed against the main methodological limitations.

⁴ An attitude has been broadly defined by Pratkanis et al. (1986) as an individual's combined affect (their feelings and emotions), beliefs and cognitive processes interacting with the outside world through stimulus and response. From this perspective, attitudes are not fixed, and also do not necessarily determine an individual's behaviour. As Myers (1999) points out, attitudes can be both explicit, defined as those which we are consciously aware of, and implicit, understood as unconscious but influencing beliefs and behaviours.

- 4.11 The review identified an array of literature on the public's knowledge, familiarity, and attitudes towards GM and GMOs. The reviewed literature included studies which adopted qualitative (e.g. Allum, 2005), quantitative (e.g. Gaskell, 2003) and mixed-methods (e.g. FSA, 2003) approaches.
- 4.12 The majority of studies used an exclusively quantitative methodology, and the majority of these adopted survey methodologies. Within the body of survey research, a variety of data collection methods was used. This included postal (e.g. Tucker et al, 2006), telephone (e.g. Miles et al., 2006), and face-to-face surveys (e.g. Soregaroli et al., 2003). Quantitative studies were identified which included questions on GM as part of a broader omnibus survey (e.g. Consumer Focus Wales, 2009).
- 4.13 As a body of evidence, much of the analysis reviewed came from one-off surveys, which describe a particular instance in time. Therefore, drawing comparisons across the studies reviewed was challenging. The Eurobarometer studies,⁵ carried out by the European Commission to monitor public opinion in Member States and candidate countries, provides the most comprehensive indication of changes over time. Like the Brook Lyndhurst (2009) report, this review makes several references to the results of the Eurobarometer studies.
- 4.14 Read as a whole, many of the one-off surveys can begin to give rise to top level conclusions. Nevertheless, there are issues surrounding the sampling methodologies and differences in the wording of research questions. Many of the studies utilise a range of participants based on factors such as age, gender, and socio-economic class, but did not claim to be nationally representative. Therefore, the surveys are not directly comparable and generalising conclusions is problematic.
- 4.15 In quantitative research, the phrasing of research questions is viewed as particularly challenging for analysis surrounding public attitudes on divisive risk issues such as GM (IFC, 2005).⁶ An issue presented is many respondents may answer in a way, which is not truly reflective of their behaviour. Therefore, the attitudes measured may not be truly representative of real-life consumer

⁵ http://ec.europa.eu/public_opinion/archives/eb/eb66/eb66_highlights_en.pdf

⁶ A study in 2005, for example, found that describing cloning as 'a form of animal biotechnology which retains desirable traits by producing animals which are biologically identical to the parent' led people to have more negative impressions of animal cloning than when it was simply described as '...producing animals which are identical to the parent' (International Food Information Council, 2005, p. 29).

patterns (Lucht, 2015). Attitudinal positions to GM are often taken in situations of “high uncertainty and limited understanding” (Brook Lyndhurst 2009, p. 5). The Brook Lyndhurst (ibid) review commissioned by the FSA points to evidence which shows how slight variations to the wording of questions can result in disproportionate changes in outcomes. In addition, the review by Lucht (2015) highlights how direct comparisons of surveys from different geographical locations is problematic. According to Lucht, surveys in the EU have tended to focus on risks and the ethical implications of GM technology to a greater extent than those in the US. This may have contributed to the seemingly more doubtful attitudes in Europe (p. 4259).

- 4.16 Because this review was interested in public perceptions and understandings of GM and GMOs, it also included qualitative research that explored the factors, which drive and shape attitudes. This included research by the FSA (2003) and research conducted in the UK as part of the large-scale and multi-faceted ‘GM Nation?’ public debate (DTI, 2003).
- 4.17 Research based on qualitative methods represented a much less common approach than research based on quantitative methods within the literature reviewed. Qualitative methods adopted by the research mainly included focus groups (e.g. DTI, 2005) and, to a lesser extent, in-depth interviews (e.g. Zwick, 2005).
- 4.18 A small number of mixed-methods studies were also identified (e.g. Zwick, 2005). This included approaches that adopted quantitative methods such as surveys to compliment more in-depth qualitative methods, such as focus groups (FSA 2003). This report also drew on a number of literature reviews, for example the systematic review and meta-analysis by Frewer et al. (2013) on public perceptions of agri-food applications of GM. The thematic analysis of quantitative, qualitative and mixed methods study by Frewer et al. (2014) on attitudes towards GM animals in food production adopted a systematic review methodology, as was the case in a ‘compact evidence review’ by Brook Lyndhurst (2009) for the FSA, which aimed at consolidating information on public opinion towards emerging food technologies. The Brook Lyndhurst review also included evidence from quantitative, qualitative and mixed-methods studies. A focus of their review was GM foods. Also drawn on was the aforementioned systematic review by Costa-Font et al. (2008) (see 4.6), which

aimed at providing an overview of the current evidence on public acceptance of GM food and its underlying behavioural processes.

- 4.19 For both qualitative and quantitative studies, often the precise sampling frames and procedures was not adequately reported. This lack of consistent and comprehensive reporting made it difficult to accurately determine the rigour with which sampling was conducted, and to make assessments as to the potential influence of bias on the findings of a particular study.
- 4.20 This review found no examples of relevant research using data from longitudinal panel studies, in which the unit of analysis (e.g. an individual) is followed at specific intervals over a long-time period, often many years, to measure change over time. However, the review did draw from cross-sectional and deliberative analysis. This included evidence from UK and European cross-sectional surveys (e.g. the Eurobarometer surveys), based on a representative sample of the population of interest drawn at a specific point in time, and the reconvened deliberative workshops (FSA, 2008), which included a sample drawn from Aberystwyth, in west Wales.

Focus of analysis

- 4.21 There was considerable diversity in the focus of analysis across the studies reviewed. For example, the systematic review and meta-analysis conducted by Frewer et al. (2013), which looked at quantitative studies on public perceptions of agri-food applications of GM, highlighted “many theoretical positions and dependent measures have been applied across different studies, in different geographical locations, and at different times” (p. 143). A similar conclusion was reached in the Brook Lyndhurst (2009) report, which found some studies examined public perceptions on specific applications of GM in food production (e.g. Costa Font et al. 2008), whilst other research considered the broader perceptions of GM food such as the use of GM in plants, animals or in biotechnology more generally (see also Frewer et al. 2013, p. 143). A number of studies also took GM food and consumer attitudes as the focus of analysis and examined people’s attitudes around willingness to buy and consume GMOs (e.g. Sheldon et al. 2009; Saba and Vassallo, 2002).

4.22 The studies outlined for the mapping exercise conducted as part of this review suggest, whilst there is overlap between the issues of interest, research has tended to focus on particular topics relating to public attitudes towards GM.

These have been summarised under the following categories:

- Scientific Inquiry: attitudes towards particular areas of GM research;
- Governance and Regulation: attitudes towards specific regulatory frameworks surrounding GM and GMOs;
- Applications: attitudes towards the practical applications of GM, either a particular product or process, or more general applications such as GM crops;
- Risk Perception: attitudes towards different types of risk, including GM relative to other potential risks;
- Consumption: attitudes towards purchasing and consuming GMO products

4.23 A systematic review of international evidence conducted by Frewer et al (2013) found data collection in the area of public perceptions and attitudes to GM applied to food production was at its peak in 2003. According to them, this may reflect the increased level of public debate about GM during the late 1990s and early 2000's and a subsequent retrospective research interest within policy and research communities (p. 149).

Findings on what shapes public attitudes towards GM and GMOs

4.24 As noted previously, the relationship between those determinants, which shape public attitudes, is complex and interdependent. Attitudes can be shaped by the interaction of different variables simultaneously. Therefore, it is important to highlight that a linear explanation of the connections between the different variables does not fully capture the processes at play (see Brook Lyndhurst 2009, p. 7). For the purposes of this review, the following sections synthesise published research on what shapes public attitudes towards GM and GMOs. The determinants outlined below are viewed as particularly important in the shaping of public attitudes.

Balancing perceptions of risk and benefits

- 4.25 According to the evidence, the most influential factor that helps to shape attitudes towards GM technology is a personal judgement of perceived risks and benefits. This judgement is based on a combination of variables, and these variables can be understood as beliefs (Brook Lyndhurst 2009). Because an attitude consists of more than one specific belief, each attitude depends upon an overall perception of the risks and benefits associated with GM technology.
- 4.26 The evidence suggests most people can be categorised as moderately risk tolerant (Gaskell et al., 2006; Traill et al., 2004). However, a key issue identified by scholars is the degree of control people feel over their exposure to risk. One strong theme, which emerged from the literature, is that for the majority of people the perceived risks of GM technology outweighed the benefits, but the relative value of perceived risks and benefits were different depending on an individual's pre-existing cognitive disposition (Rimal et al., 2005).
- 4.27 The studies reviewed, which were centred on risk and benefit perceptions, tended to explore processes of cognitive reasoning. The perceived risks surrounding GM technology were also mostly centred on health (Ganiere, 2006) and environmental risks (Traill et al., 2004). For example, research conducted for the FSA by Sheldon et al. (2009) explored attitudes to GM food through in-depth interviews and deliberative workshops. They found a key driver of negative attitudes was "concern about perceived health and environmental risks and unintended consequences relating to GM food" coupled with a "scepticism about the motivations of producers and regulators of GM food" (p. 5).
- 4.28 Several studies also stated that most people found it more difficult to identify perceived benefits than risks to GM (Rimal et al., 2005; Gaskell et al., 2006). However, the evidence is mixed. For example, Traill et al. (2006) found benefits are more important than risks when people are making decisions around willingness to consume GM; and evidence suggests perceived health risks carry more weight than environmental risks, resulting in people being more accepting of GM crops than GM foods (Gaskell et al. 2000).
- 4.29 The evidence suggests the benefits need to be clear and direct in order to figure in people's risk-benefit evaluations. In this context, a study by Connor and Stiegrist (2010) found medical applications of GM were generally better

accepted than GM food applications, and viewed more positively because the benefits were more tangible.

- 4.30 The Brook Lyndhurst (2006, p. 16) review highlighted how people's attitudes towards the different applications of GM technology can help illustrate clearly the complex interactions between perceptions of risk and benefit. As an example, they cited the Eurobarometer (2006), which demonstrated people could have an overall positive view of medical applications of GM technology. The potential benefits were found to outweigh the risks, which resulted in an overall perception by respondents that the medical application of GM technology was morally acceptable and should be supported.
- 4.31 According to the review conducted by Brook Lyndhurst (2009, p. 8), risks and benefits are often negatively correlated with each other in which higher perceived risk is associated with lower perceived benefit, "but are subject to different weightings". This was confirmed by Traill et al. (2006), who found risk and benefit perceptions to be negatively but not perfectly correlated.
- 4.32 The quantitative studies reviewed tended to use unidimensional scaling methods, such as the Likert scale, where respondents can only state their degree of support or rejection (see for example Dreezens 2005). In this context, research by Poortinga and Pidgeon (2006) stated how a tendency of quantitative research to capture risks and benefits as independent dimensions neglects "some of the complexities and contingencies of people's judgements and deliberations about the issue" (p. 1708). They point to qualitative research, which suggests people have "more nuanced and sophisticated views" than simply being 'for' or 'against' GM (p. 1707). Building from an analysis, which suggests the public is generally ambivalent on the issue (Marris et al. 2001), Poortinga and Pidgeon (2006) investigated whether quantitative measurements can better capture the tensions within attitudinal positions on GM. They concluded, in the context of risk perception research, that attitude dimensions should not be studied in isolation. Traill et al. (2006) also suggested it is best to measure risks and benefits separately.

The effects of knowledge and information on attitudes to GM

- 4.33 There is mixed evidence about the effects of knowledge and information on attitudes to GM technology. Costa-Font et al., (2008) describe perceptions of risks and benefits as “dynamic processes”. This is because attitudes towards GM technology can change. One way by which the processes of attitude change can be stimulated is by increasing knowledge, of both GM products themselves and an individual’s knowledge of GM technologies (p. 103).
- 4.34 In many studies, an individual’s knowledge is linked to attitudes and perceptions towards GM technologies. In some studies, prior knowledge about GM technology has been linked to positive attitudes. For example, drawing on evidence from the Eurobarometer surveys, Vilella-Vila et al. (2005) concluded decision-making on GM technology is an information-dependent factor. They found a direct and positive relationship between an increase in knowledge of GM technology and increasing support for GM applications. Additionally, also using data from the Eurobarometer, Gaskell et al. (2006) found people with a better understanding of GM technology were slightly more likely to view GM as morally acceptable.
- 4.35 A survey commissioned by Consumer Focus Wales (2009) confirmed this outcome, concluding those who feel more informed on GM appeared more willing to buy GM produce.
- 4.36 However, the evidence base suggests the effects of new information on GM technology can be both positive and negative. For example, deliberative research (including a sample from Wales) by the FSA/COI (2008)⁷ on public attitudes towards animal cloning found views became increasingly polarised as participants were provided with more information during reconvened workshops. Some participants became increasingly concerned. Others, fewer in number, became less concerned.
- 4.37 The FSA/COI (2008) research highlighted how the relationship between knowledge, new information and attitudes is complicated. This relationship is mediated by prior knowledge, values and associations. Generally, more negative than positive qualities were found by studies to be associated with GM technology. A number of studies explicitly drew on ‘bottom-up’ and ‘top-down’

⁷ <https://www.food.gov.uk/sites/default/files/multimedia/pdfs/clonereport.pdf>

approaches to describe people's shaping of attitudes around GM. These approaches are used to describe two basic mechanisms by which people are said to form attitudes. The 'bottom-up' approach implies an individual's attitude towards a GM technology is formed based on their level of specific knowledge about the topic. The overall 'bottom-up' attitude therefore is "some kind of average of the evaluation of these perceived characteristics of the technology" (Grunert et al., 2004, p. 3). In contrast, the 'top-down' approach implies an attitude is embedded in pre-existing general attitudes and values. Both processes are usually viewed to occur simultaneously. However, where knowledge of the topic is limited, general attitudes (top-down) exert a greater influence because they act as a guide in the shaping of attitudes towards more specific issues or topics (p. 4).

- 4.38 As noted, some studies found 'top-down' general attitudes towards GM, as opposed to knowledge, to be the basis of attitudes towards GM technology (see Costa-Font et al. (2008, p. 101) for a discussion of analysis on consumer attitudes specifically regarding GM food). For example, according to Frewer et al. (1998), individual behaviours are based on perceptions or beliefs about risks, rather than information from experts (see also DTI 2003). Correspondingly, Poortinga and Pigeon (2004) stated that limited knowledge and reliance on pre-existing values combine to cause an affective or emotional response for the majority of people. According to Brook Lyndhurst (2009, p. 17), this indicates perceived risks are framed by an individual in line with the 'top-down' approach, as opposed to knowledge of the topic. In turn, it is suggested this means information in line or in synch with general attitudes is more likely to be kept in mind, whereas information which conflicts with these general attitudes is more likely to be disregarded (ibid). Brossard and Nisbit (2007) concluded that information on GM might be interpreted through pre-existing values. This, they suggest, results in the biased assimilation of knowledge, because information that does not fit with existing beliefs is rejected.
- 4.39 Other studies have found that novel food technologies are not on the top of people's agendas. Therefore, survey responses tend to be a reaction based on the first impression of a technology (Nisbet, 2005; Priest, 2001; Priest et al., 2003; Siegrist, 2000; Siegrist et al., 2000).

- 4.40 Many of the studies reviewed differentiated between what has been described by Costa-Font et al. (2008) as 'objective knowledge' and 'subjective knowledge'. The former describes the real knowledge people have about GM, and the latter describes what people think they know about GM. Analysis by House et al. (2004) found both subjective and objective knowledge to be important in the process of attitude-building around GM food, although the different types of knowledge exercised different influences.
- 4.41 Studies suggest many people feel or consider they are uninformed about the topic of GM (Costa-Font et al., 2008; Lusk et al., 2004). When GM technologies first became available, and were met with uncertainty, deficit models were developed which assumed it was a lack of information that caused uncertainty about the risks and benefits (Lucht, 2015, p. 4261). However, other evidence suggests people's prior attitudes and subjective knowledge influences the take-up of additional information (e.g. Ganiere, 2006).
- 4.42 Subjective knowledge is linked to general attitudes and values. In situations of uncertainty or low understanding, emotional responses, which are rooted in general attitudes, become proportionately more significant (Ganiere, 2006). These kinds of affective responses shape both perceived risks and benefits, and mediate or moderate the effect an increase in knowledge has on people's complex decision-making processes and overall attitudes towards GM technology (Lee et al., 2005). Evidence also suggests because many people's decisions are strongly influenced by affect, basic scientific knowledge plays less of a role in the acceptance of GM technology (Lucht, 2015). Lusk et al's (2004) research outcomes inferred those with higher levels of subjective knowledge were less likely to be influenced by new information. Similarly, research by Onyango et al. (2004) suggested people who choose to either accept or reject GM food appear to be strongly influenced by individual values and therefore by subjective knowledge. In this context, Onyango et al. (2004) found the participants in the study labelled as having an 'undecided' view on GM technology were the group most interested in learning more about GM technology, to enable them to assess their attitudes towards the topic more clearly. This suggests attitudes, which are not strongly related to values, due to lack of knowledge or ambivalence for example, could be open to change (see also Costa-Font, 2008, p. 103).

Trust and information sources

- 4.43 The evidence reviewed suggests the impact of increased information depends on the level of social trust a person has, as well as a person's trust in the source of information. This includes people's trust in information about GM, those developing and providing the information and those institutions and organisations (including science, government and industry) with an interest in GM technology.
- 4.44 Trust plays an important role in the public's assessment of GM technology. It can influence the formation of general attitudes, mediate the take-up of ideas, and have a direct effect on attitudes to GM technologies (Allum, 2007).
- 4.45 Because many people have a limited knowledge of GM technology, studies suggest they often depend on the views of those they consider trustworthy experts to make informed decisions. These views then act as a guide to establish their own positions (Lucht, 2015).
- 4.46 Higher levels of social trust are generally associated with more positive attitudes towards GM technology (Brook Lyndhurst, 2009), but the evidence is mixed. Many studies conclude consumer organisations, environmental groups and scientists are considered more trustworthy by respondents than government and industry (Costa-Font, 2008; Lucht, 2015). Using data from the Eurobarometer, Gaskell et al. (2003) cited the government and industry as the least trusted sources of information about GM technology. However, evidence suggests the level of trust varies according to location. A cross-country comparison by Traill et al. (2004) found the public in the US demonstrated a higher level of trust in GM technology and their regulators than did their European counterparts. Vilella-Vila et al. (2005) in a comparison of public acceptance to GM food in Spain and the UK concluded acceptance of GM food in both countries was linked to trust in public authorities and consumer organisations. Miles (2005) found that within a European context, trust in regulatory organisations such as the European Commission was highest in Italy and lowest in England in a comparison between the two countries. However, contrary to the above conclusion, that generally create greater trust results and more positive attitudes towards GM, the Italians perceived more risks and bodily harms from consuming GM ingredients than did the English respondents.

- 4.47 Drawing from the Eurobarometer surveys, data suggests there are still high levels of opposition towards GM, which have remained fairly constant over time (Gaskell et al. 2010). Attitudes among EU countries with a ban in place on GM crops, such as Italy and Germany for example, consistently show low levels of support. In contrast, EU member states where GM crops are grown, such as Spain, show amongst the highest levels of support (Gaskell et al. 2010).
- 4.48 Traill et al. (2004) found risks reported by environmentalists are more strongly accepted than benefits reported by industry and government. In this study, greater trust in environmental authorities was associated with a more positive attitude towards GM (see also Allum, 2007). According to Robbins et al. (2004), people who trust scientists and regulatory authorities have a lesser tendency to perceive greater risks from GM food and crops.
- 4.49 The evidence on the relationship between trust and a person's values is mixed. For example, the analysis by Huffman et al. (2004) found trust to be directly related to an individual's values and affected by characteristics such as age, educational attainment and religious affiliation. However, according to Frewer et al. (2013), trust and values are potentially associated to each other, but this depends on the extent to which people use alternative information sources.
- 4.50 There is also evidence to suggest people are more likely to trust an information source with a similar outlook to their own. According to Costa Font et al. (2008), "people who favour the use of genetic modification are more likely to trust a source promoting its benefits whereas those who oppose its development are more likely to distrust the same source providing the same information". Similarly, the mixed method research by Bruhn (2008) suggested people are more likely to trust an information source, which shares similar values to their own. According to the study, this was considered more important than the perceived accuracy of the information itself (ibid).
- 4.51 Equally, studies suggest people are more likely to trust family and friends as information sources (DTI 2003).
- 4.52 Citing Kahan et al. (2007) and Priest (2005), Brook Lyndhurst (2009) argued that pre-existing knowledge of GM technology can often be an indicator of support because those inclined to support it are more likely to find out about it. However, this "means correlations between greater (pre-existing) knowledge

and a more positive attitude may be misleading, since they may be applicable only to a non-representative subset of the population” (ibid, p. 9).

- 4.53 Studies also suggest public attitudes on topics, which are outside of people’s everyday experiences, can have little to do with the expression of individual opinions. Instead, they can have more to do with prevailing values and narratives around GM. According to Brossard and Nisbit (2007), scientific knowledge can play a modest role in attitude formation, but the media is an important source of informal learning for people. The Wellcome Trust (2013) reported how the mass media is often people’s first information source for GM related issues. This suggests how information around GM technology is communicated is also important. Frewer et al. (2013) concludes that the evidence on communicating GM technology highlights how simply providing information on the risks and benefits is in itself insufficient in shaping attitudinal change.
- 4.54 Concurrently, other studies reviewed suggest public attitudes in part inform the development of regulatory frameworks (Lucht, 2015), and the commercial acceptability of practical applications of GM technology (Sheldon et al., 2009), and calls for more proactive public involvement and deliberation in debates about the social and ethical dimensions of GM technology (Chilvers and Macnaghten, 2011).
- 4.55 Product labelling as a mechanism for communicating information has also been the focus of analysis (for example, Costa Font 2008; FSA 2003; DTI 2003). Labelling is viewed as an important communication mechanism for building trust by increasing feelings of control and enabling people to make an informed choice (Costa Font 2008). The principle of transparency and consumer choice is a priority for people holding a range of attitudes towards GM foods. Using deliberative workshops, Sheldon et al (2009) found general support for clear labelling systems, and support for labelling all GM food products, including where GM is used as a processing aid or in animal feed. There was a view that the current labelling system is confusing and uncertainty about whether there was a requirement for GM food to be labelled. Labelling is discussed in more detail in the following chapter.

The effects of socio-demographic factors on attitudes to GM

- 4.56 A number of studies have examined whether there is a relationship between a person's demographic characteristics and their attitudes towards GM technology. Studies have used different ways to examine the significance of people's personal attributes. However, the evidence is mixed and sometimes contradictory.
- 4.57 The most consistent finding was that women are less positive, more concerned about and perceive more risks around GM technology than were men (FSA 2003; DTI 2003; Gaskell et al 2006; Cost-Font 2008). The relationship between socio-demographic factors and attitudes to GM is complicated. For instance, Frewer et al. (1998) concluded the association between gender difference and benefits perceptions is insignificant among respondents with strong pro-environmental attitudes.
- 4.58 However, on the effects of other socio-demographic factors, the evidence is more varied. For example, higher levels of education and knowledge have been correlated in some studies with more positive attitudes towards GM technology. According to Triall et al. (2004), "a high level of education is associated with the acceptance of GM benefits, and conversely the opposite holds true for high levels of perceived risks". Using a UK representative sample of the 1999 Eurobarometer Survey, Costa-Font and Mossialos (2005) associated scientific knowledge and an understanding of information sources with a larger demand for information and less negative perceptions of GM food. However, an analysis by the FSA (2003) of their consumer attitudes surveys found respondents from higher socio-economic groups (AB) were more likely to be concerned about the safety of GM foods. They found the socio-economic group DE⁸ to be the main drivers of decreasing concern between 2000 and 2002.
- 4.59 There were also mixed findings on attitudes and age demographics. The FSA (2003) found the middle-aged group (ages 36-49) to be the most concerned, but also a main driver behind the decrease in concern between 2000 and 2002. In contrast, the analysis by Gaskell et al. (2006), using the Eurobarometer survey, found people over 65 to be the either more critical of GM technology or not prepared to express an opinion.

⁸ Semi-skilled and unskilled manual occupations, unemployed and lowest grade occupations (UK Office for National Statistics)

- 4.60 However, in their overview of the evidence base Costa-Font et al. (2008, p. 102) highlighted studies which found economic and demographic attributes not to be important in defining people's attitudes towards GM technology.
- 4.61 On the complexity of the evidence, Brook Lyndhurst (2009) emphasised that it is too simplistic to assume there is a single 'public'. Instead, individuals can be thought of as 'bundles of attributes'. The evidence suggests values, attitudes, belief and experience are generally better predictors of attitudes than socio demographics. Brook Lyndhurst (2009) made reference to alternative population segmentations, which have been developed in an attempt to capture this outcome

The role of values on attitudes

- 4.62 Studies have used a variety of ways to evaluate the significance of values on an individual's final attitude. Some analysis, based on the 'bottom-up' and 'top-down' approaches to measuring attitudes, has been introduced earlier in the chapter. However, in a critique of this approach, Costa-Font et al. (2008) argued empirical analysis based on 'top-down' approaches towards attitude formation by definition complement the 'bottom-up' approach, so "both give rise to some recursive system" (p. 102).
- 4.63 An alternative theoretical framework used to underpin empirical analysis on public attitudes towards GM technology is the 'means-end' approach. This approach basically links perceptions towards a product or technology with an individual's values. For instance, a study by Grunert et al. (2001) used 'laddering interviews' to draw out an individual's behaviours and goals based on their underlying values. They found consumers associated conventional means of production with safe and healthy products. GM products however were associated with the negative general values of uncertainty and poor health.
- 4.64 This finding is supported by analysis using data from a non-representative survey by Dreezens et al. (2005), which found attitudes about organic food and GM to be negatively related. According to Poulsen (1999), an important association is the perceived 'naturalness' of the GM technology or process and the resulting product. They also concluded the language surrounding GM technology could deepen negative associations.

- 4.65 Another theoretical framework underlying one of the studies reviewed used an approach, which differentiated between ‘attitude valance’ and ‘attitude centrality’ to determine opinions and acceptance towards GM. The study by Honkanen and Verplanken (2004) aimed at gaining a better understanding of the nature of negative attitudes towards GM food. A structural model was estimated to examine the value-attitude relationship. In this model, ‘attitude valance’ was defined as an individual’s view towards a product, which was described as either favourable or unfavourable. ‘Attitude centrality’ considered the importance of the relationship of an individual’s unfavourable or favourable views to their core values. According to their analysis, based upon a questionnaire administered to a non-representative sample of 250 students, attitudes strongly associated to values are more difficult to change than those based only on knowledge of a product’s characteristics (Honkanen and Verplanken, 2004). Some individuals hold negative but weak ‘central’ attitudes. They may therefore be more likely to change their attitude than those whose negative attitude is embedded in their core values (ibid, p. 401).
- 4.66 Research suggests because the general public know relatively little about GM, it can be expected as more information becomes available people may either shift towards a positive attitude or towards a more entrenched negative attitude (Honkanen and Verplanken, 2004 p. 416). The analysis in Frewer et al (2013) indicated both the risk and benefit perceptions associated with plant and animal GM technology had increased in time, independent of the country analysed.
- 4.67 Studies have also explored the relationship between morals and ethics, and the public’s attitudes towards GM and GMOs. However, the evidence is mixed on the significance of moral issues. For example, drawing on evidence from the Eurobarometer surveys, Vilella-Vila et al (2005) examined people’s moral acceptability perceptions of GM food. They concluded moral issues do not appear as a critical dimension in the acceptability of GM food. However, this is somewhat in contrast to Frewer et al (2014; see also Frewer et al. 2013). In a systematic review of public attitudes towards GM animals in food production, they concluded moral and ethical concerns are relevant.
- 4.68 There is limited evidence on the role of religion as a personal attribute for shaping attitude. One example is Hossain et al. (2002, p. 15), who found “religion has no effect on people’s self-protecting attitude, willingness to learn about biotechnology and confidence on government regulations”.

4.69 A consequence of low knowledge and high uncertainty reported in the evidence base is social norms, which are shaped by the attitudes and behaviours of those around us, and become significant. Social norms can be categorised under general attitudes towards GM, and include outlooks based on cultural values (Brook Lyndhurst 2009). According to Cormick (2007), social attitudes and beliefs are a more reliable predictor of individual opinion in comparison to opinion based on socio-demographics (2007). Studies indicate social norms are a key factor in shaping attitudes to GM. For example, according to Saba and Vassalla (2002) the relationship between others' attitudes and participants' intention to eat GM food is stronger than between participants' own attitudes and their intention to eat GM.

5. Key areas of interest

The aim of this chapter is to provide a critical appraisal of the evidence of the public's knowledge of, familiarity with and their attitudes towards GM crops, contained use, food and feed, and GM research and trials. As with the policy context Chapter (3), the narrative is structured under the headings of contained use, food and feed, labelling, deliberative release and GM crops. In line with the objectives of the review, reference is made to analyses which has compared public attitudes in the UK with attitudes in other countries, as well as studies which explored changes in attitudes over time, attitudinal differences between rural and urban populations, and differences in attitude between the general public and the agriculture, animal feed and medical research industry. The review identified a number of evidence gaps, which are highlighted in the discussion.

Contained Use

- 5.1 The literature review did not uncover any studies assessing public attitudes towards contained use. However, a 2005 Eurobarometer survey (Gaskell et al. 2006) found widespread support for medical and industrial technologies, but considerable opposition to agricultural biotechnologies in all but a few countries.

Food and Feed

- 5.2 The review found GM food was the area with the widest evidence base. As a result, the likelihood of finding data based on robust methodologies was higher for this area than it was for the others.
- 5.3 The FSA have commissioned several strands of work aimed at understanding public opinion on GM food. This has included an evidence review of public attitudes to emerging food technologies (Brook Lyndhurst 2009) a qualitative study exploring attitudes to GM food (National Centre for Social Research 2009) and a module of questions focusing on attitudes to food technology in the British Social Attitudes Survey (BSA).⁹

⁹ <http://www.natcen.ac.uk/our-research/research/british-social-attitudes/>

- 5.4 Studies suggest that for those who have a firm opinion on GM food, attitudes tend to be negative. For example, the Eurobarometer survey found in 2005 a majority of survey respondents who had a 'decided' view on GM food (approximately 50 per cent) thought it "should not be encouraged". It was seen as morally unacceptable, not being useful, and as a risk for society, (58 per cent opposed and 25 per cent supported the use of the technology). Supporters outnumbered opponents only in Spain, Portugal, Ireland, Italy, Malta, Czech Republic and Lithuania (Gaskell et al 2006).¹⁰
- 5.5 A questionnaire designed to examine public perceptions of GM food and crops in the UK by Poortinga and Pidgeon (2004) also found over three quarters of respondents claimed to be opposed (29 per cent), ambivalent (53 per cent) or indifferent (8 per cent) to GM food.¹¹ The evaluation of the 'GM Nation?' debate (DTI 2003), a UK government-sponsored public debate on the future of GM crops and food, was multi-method. It combined qualitative and quantitative approaches, and drew in particular on surveys, observational fieldwork and in-depth interviews. The result of the debate was intended form the foundation for the decision-making by the UK government for any future GM policy. As part of the evaluation, Poortinga and Pidgeon (2004) conducted a survey to assess public opinion about GM food and crops as well as possible shifts in public sensibilities, awareness and knowledge of the GM food issue across the period the public debate took place. They found when GM food was compared to other contemporary risk cases and various personal and social issues, GM food were relatively unimportant. However, despite reporting the relative unimportance of GM food, the study highlighted the fact that more than half of respondents were at least 'fairly interested' in the issue.
- 5.6 The Foods Standards Agency (2008) commissioned a module of questions on the BSA survey (cross-sectional), which included a specific focus on GM food. According to the FSA, the results of the 2008 survey suggested a substantial proportion of people are not positive or negative towards GM food. The FSA highlight how on a set of four attitude statements towards GM food, up to 4 in 10 people neither agreed nor disagreed (2008, p. 10).

10 http://ec.europa.eu/public_opinion/archives/ebs/ebs_244b_en.pdf

11 http://psych.cf.ac.uk/understandingrisk/docs/survey_2003.pdf

- 5.7 For the FSA (ibid), the BSA findings between 1999 and 2008 indicate a change in public attitudes towards GM food over time. Between 1999 and 2008, disagreement that the advantages of GM food outweigh the dangers had decreased by 26 percentage points. This decrease however was not because agreement had increased by the same extent. Instead, the most notable change was an increase in the proportion of people not holding a definite view, with evidence of a slight increase in public support for GM foods.
- 5.8 In 2009, Consumer Focus Wales commissioned a Wales wide survey on consumer attitudes to GM food as part of the Quarterly Welsh Omnibus Survey.¹² The results from this survey were compared to the results from a 2003 survey.¹³ The results of the surveys suggested a shift in the proportion of people who believe foods containing GM ingredients should be banned from sale in the UK. In 2003, nearly two fifths (38%) agreed whereas in 2009 the proportion had decreased to around a quarter of respondents (24%) (Consumer Focus Wales 2009).
- 5.9 The 2009 Consumer Focus Wales survey (2009, p. 7) also found people living in the more rural areas of Mid/West Wales (Powys, Ceredigion, Carmarthenshire and Pembrokeshire) held the strongest views that GM should be banned from sale in the UK (40%). This compared to 19% of those living in the Valleys (Rhondda Cynon Taff, Merthyr Tydfil, Caerphilly, Blaenau, Gwent) or West South Wales (Swansea, Neath Port Talbot and Bridgend), 21% of those living in North Wales and 24% of those living in Cardiff and South East Wales. According to the authors of the Consumer Focus Wales report (ibid), “This is particularly interesting as the main arable areas of Wales for crop production include Pembrokeshire and Powys”.

¹² A total of 1,002 interviews were conducted between 6 and 18 March 2009. The sample was designed to be representative of the adult population in Wales aged 16 and older.

¹³ In 2003 the Welsh Consumer Council commissioned a similar survey on consumer attitudes to GM food. For this survey, a total of 1,014 interviews were conducted between 11 and 14 June 2003.

- 5.10 In their study conducted as part of an evaluation of the ‘GM Nation?’ debate, Poortinga and Pidgeon (2004, p. 46)¹⁴ state the results suggest rather than the public being simply for or against GM food, attitudes are “more nuanced and complex”. They concluded many individuals hold essentially ambivalent beliefs about GM.
- 5.11 The survey by Poortinga and Pidgeon (2004) also contained a number of items on governance and trust in relation to GM food. In a comparison of the 2003 survey with a survey they conducted on GM food in 2002 (see Poortinga and Pidgeon 2002)¹⁵ changes in attitudes, awareness and knowledge of GM food were examined. Between 2002 and 2003, a shift in public views on the governance of GM food seemed to have taken place. In 2003, the results suggested people felt a growing need for organisations separate from government and industry to regulate developments in GM food (2004, p. 40). However, the trust ratings of government and industry remained practically unchanged over the two surveys (relatively low, at around 30% respectively (2004, p. 37). A pattern across the two surveys was consistent with other research, was that doctors, consumer rights organisations, environmental organisations, scientists working for universities, scientists working for environmental groups, as well as the FSA were the most trusted sources to tell the truth about GM food.
- 5.12 Studies suggest familiarity with GM technology is linked to increased levels of acceptability. Drawing from the wider international evidence base, studies suggest where GM food is widely available attitudes are generally more favourable (Chen and Li 2007). According to the Brook Lyndhurst (2009, p. 12) review, concerns over safety decrease where GM food is widely available, and this is a key argument used by proponents of GM. In the Brook Lyndhurst (2009) review, it was suggested the benefits (for example, lower prices) are more salient than the risks (which are viewed as minimal if GM is permitted) where GM food is available. In contrast, for places such as the UK, where GM is not so widely available and the public debate is ongoing, it is suggested the

¹⁴ The research included a survey, which drew on a national quota sample of 1,363 people, including 195 respondents from Wales. The survey was run in 116 sampling points were randomly selected with a probability proportional to the size of their population. Interviewers approached addresses within the sampling points until they reached the quotas for gender, age, and work status.

¹⁵ Poortinga, W., and Pidgeon, N.F. (2002) Results of a British survey on five risk cases. Paper presented at *Society for Risk Analysis Conference*, New Orleans, 8-11 December 2002.

benefits are not so obvious and the risks feature more prominently (ibid). Lucht (2015) also makes a comparison between Europe and the US to suggest the NGO movement has been stronger in Europe and better able to frame GMOs as a threat to biodiversity, farmer autonomy and food safety through a stronger focus on the risks and possible negative effects of GM food and feed.

- 5.13 According to Lucht (2015), surveys in the EU have tended to focus more often on risks and the ethical implications of GM food and feed than those from the US.

Labelling

- 5.14 Labelling is cited by several studies as an important way to build public trust by increasing feelings of control and choice (Costa Font 2008; FSA 2003; DTI 2003). In a mixed methods approach aimed at exploring attitudes towards food labelling in the UK, the FSA (2013, p. 9) found for the most part, participants were not seeking information or labelling concerning GM, and unless prompted, GM information was not identified as a strong need. When prompted however, there was a consensus that the labelling of GM products was important so consumers could have the right of choice (see also Sheldon et al. 2009). The study found low or no awareness of current GM labelling requirements and a strong assumption by participants that products containing GM would be regulated and labelled. When participants were made aware of its use in UK food products, they typically stated foods produced by GM technology or animal products derived from GM feed should be labelled. However, labelling the use of GMOs in production was viewed as being of lower importance overall. The study also found consumers in the UK stated they were also generally willing to pay a price premium for non-GM food if it were labelled, although other studies have found the premiums associated with labelling GM-free foods is not sufficient to cover the expected costs of labelling (Loureiro and Hine 2004).

5.15 Knight et al (2007) examined the behaviour of shoppers in a range of countries (New Zealand, Sweden, Germany, UK, France, Belgium) with highly negative perceptions of GM technology in genuine shopping situations designed to minimise the possibility of social desirability bias.¹⁶ The research found a significant percentage of consumers in European countries appeared willing to choose GM food, provided there was a price advantage coupled with clearly stated consumer benefits.

Deliberate Release

5.16 As with contained use, evidence on the public's familiarity and attitudes towards the deliberate release of GMOs is limited. The wider evidence base suggests public opinion is highly dependent on context and the technology under consideration. For example, Tait (2016) points to evidence, which suggests the deliberate release, but not the contained use, of GMOs has been contentious in the EU. Public opinion has been found to be more favourable towards GMOs in contained use for the medical and biotechnologies industries when compared with deliberate release. The 2005 Eurobarometer survey found public opposition to agricultural biotechnologies outweighed support in the majority of EU countries surveyed (Gaskell et al 2006).

GM crops

5.17 Evidence suggests people are more accepting of GM crops than GM foods (Gaskell et al. 2000). The results of the Eurobarometer survey 2010 indicated when GM technology is detached from hazards direct to humans, such as animal feed the concept is viewed more positively. Tait (2016) suggest there are hints in recent surveys that public attitudes towards GM technologies are more positive than they have been in the past (see Royal Society of Edinburgh 2015). For example, an Ipsos Mori poll (2014) on Public Attitudes to Science reported more people in the UK said the benefits of GM crops are greater than the risks, by 36% to 28%. A greater number of respondents agreed (57%) than disagreed (15%) with the statement "Genetically modified crops are needed to increase

¹⁶ Social desirability bias refers to the fact in self-reports, people will often report inaccurately on sensitive topics in order to present themselves in the best possible light (Fisher, R. J. (1993). "Social desirability bias and the validity of indirect questioning". *Journal of Consumer Research*, 20, 303-315).

world food production”. Against the more general statement “We should not rule out any agricultural techniques or technologies, which might help to increase world food production,” 80% agreed and 9% disagreed. However, it could be argued these questions are phrased as leading statements, and are therefore likely to elicit a positive response.

- 5.18 In a systematic review and meta-analysis to assess research relevant to understanding public perceptions of agri-food applications of GM, Frewer et al. (2013) compared attitudes in different global regions, at different times and between different applications of GM agri-food technology. Seventy articles were included in the final meta-analysis. From the results, it was concluded plant-related applications were more acceptable to the public than animal-related applications, and pharmaceutical production was more acceptable than food applications. In addition, the risk perceptions associated with both plants and animals were greater in Europe than in North America or Asia, and benefit perceptions were also found to be greater in North America and in Asia than in Europe. However, moral concerns were higher in North America and Asia compared to Europe. Drawing from the meta-analysis, the study also found both risk and benefit perceptions increased over time.
- 5.19 In many countries where farmers can grow GM crops, GM plants have superseded conventional varieties (see Lucht 2015, p. 4255). A meta-analysis by Klumper and Quaim (2014) investigated the reasons why farmers choose GM crops. The figures proposed by Klumper and Quaim suggested an increase in profit by 68% on average for farmers, with a rise of 22% in crop yields and a decline of 39% in relation to pesticide expense. According to their analysis, farmers based in developing countries experienced the largest increase in profit from switching to biotech crops. In addition to economic advantages, non-monetary benefits such as time-savings and ease of use were also cited by some farmers as a reason for selecting GM crops over conventional varieties.
- 5.20 As noted in the previous chapter, the perceived ‘naturalness’ of the technology or process and the resulting product is an important association which drives people’s attitudes. According to Poulsen (1999), ‘natural’ combinations in functional foods (such as milk fortified with calcium) are more likely to be accepted than apparent ‘artificial’ combinations.

5.21 Evidence also suggests the application of GM technology to plant based rather than animal based products is more acceptable to the public (see Brook Lyndhurst 2009, p. 9), and research from the USA (Cormick 2007) concluded people are more likely to accept GM technologies in food considered unhealthy, such as snack foods.

6. Conclusions

The nature of the evidence base

- 6.1 The implications of GM technology are wide-ranging and often difficult to establish. The evidence cited in this report highlights, consistent with the complexity of the GM technologies under discussion, a multifaceted social research agenda around people's knowledge of, that familiarity with and attitudes towards GM has developed. Read as a whole, the evidence base on public attitudes is inconsistent, despite the robustness of individual studies.
- 6.2 The contested nature of GM technology places additional pressures on the research process of establishing what the views are. However, many studies have highlighted either actual or perceived bias as a feature of much analysis.
- 6.3 Although there is a large body of evidence available on GM foods, evidence on the other aspects of interest is a lot more limited. In particular, the review found insufficient evidence on public attitudes towards contained use and deliberate release.
- 6.4 Overall, there is a lack of large, UK-wide representative studies, of cross-national research, of longitudinal data and of high-quality qualitative data.
- 6.5 The lack of high quality time-series data has been attributed to the novelty of GM technology, coupled with the inconsistent question design and sampling frameworks over time, which has made a comparability of data problematic.
- 6.6 The review found little evidence of robust Wales-specific data, therefore was unable to explore in detail whether there is a 'Welsh public attitude' as distinct to a UK one.
- 6.7 However, the review did find research of direct relevancy for Wales. It therefore drew on key messages from the wider UK, EU and international evidence base to draw out the implications for public attitudes towards GM in Wales in the research.

Findings on what shapes public attitudes towards GM and GMOs

- 6.8 Studies suggest the most influential factor that helps to shape attitudes towards GM technology is a personal judgement of perceived risks and benefits. Although most people can be categorised as moderately risks tolerant, a strong theme from the literature is that for the majority the perceived risks of GM technology outweigh the benefits. Perceptions of risk tended to focus around uncertainty, and concern about health and environmental risks. The public find it more difficult to identify perceived benefits, which need to be clear and direct in order to shape people's assessments.
- 6.9 There is mixed evidence about the effects of knowledge and information on attitudes to GM technology. The relationship between knowledge, new information and attitudes is complicated and mediated by prior knowledge, values and associations. The public tend to associate more negative than positives qualities to GM technology. General attitudes exert a greater influence where knowledge of the GM topic is limited by shaping attitudes towards more specific issues or topics. Research suggests for most people, limited knowledge and reliance on pre-existing values combine to cause an affective or emotional response.
- 6.10 Many people feel uninformed about GM technology. Those who have an undecided view about GM technology tend to be the most interested in learning more. There is evidence to suggest attitudes, which are not strongly related to values, are the most open to change.
- 6.11 The impact of increased information depends on the level of social trust a person has, as well as their trust in the source of information. Higher levels of social trust are generally associated with a more positive attitude towards GM technology. Studies suggest because knowledge of GM technology is often limited, people tend to depend on the views of those they consider trustworthy experts to make informed decisions, and are more likely to trust an information source with a similar outlook to their own. Government and industry are the least trusted sources of information whereas people are more likely to trust the views of family and friends. However, the public generally consider 'experts' (such as scientists and regulators) the most appropriate group for making decisions around GM technology.

- 6.12 The relationship between socio-demographic factors and attitudes towards GM technology is complicated. The evidence suggests values, general attitudes, belief and experience are better predictors of attitudes than socio-demographics. A consistent finding is women are less positive and perceive more risks to GM technology than are men. However, the association between gender difference and benefit perception is insignificant among respondents with strong pro-environmental attitudes. The evidence on the effects of other socio-demographic factors is mixed.
- 6.13 Some studies highlight the links between attitudes, claimed behaviours and actual behaviours. Drawing from evidence that consumer attitudes and stated preference may not correspond with actual purchase behaviour, there is research which suggests a strong link between people's attitudes and the choices they say they will make, but a much weaker link between this and actual behaviour.
- 6.14 Drawing from these conclusions therefore, it is not just the methodological limitations responsible for the inconsistencies across the evidence base on public attitudes to GM. Read as a whole the evidence base suggests the public's views are ambivalent and complex. This reflects a number of issues highlighted by the review. For example, studies show there are different sorts of 'publics', and there are different issues at play in the process of attitude formation such as, for example, trust, beliefs, values and so forth. In addition, studies emphasise the importance of perceived risks and benefits on people's decision-making process and attitude formation. Findings of ambivalence therefore can reflect complex attitudes, but the methods used within the evidence base do not necessarily adequately capture the complexities of these 'real life' decision making processes and the shaping of public attitudes.

Public attitudes and the key areas of interest

- 6.15 The review did not uncover any studies assessing public attitudes towards contained use.
- 6.16 GM food is the area with the widest evidence base. Studies suggest that for those who have a firm opinion on GM food, attitudes tend to be negative. However, cross-sectional analysis suggested a change in public attitudes towards GM food in the UK over time, with an increase in the proportion of

people not holding a definite view and a slight increase in public support for GM foods. Other studies have concluded many individuals hold essentially ambivalent views about GM. Drawing from the wider international evidence base, studies also suggest where GM food is widely available attitudes are generally more favourable.

- 6.17 Evidence on the labelling of GM products is more limited, however labelling is viewed as an important way to build public trust by increasing feelings of control and choice. Awareness of current GM labelling requirements is low and UK studies suggest consumers do not identify information on GM technology as a strong need without prompting. Some studies suggest people would choose GM food provided there is a price advantage coupled with clearly stated consumer benefits.
- 6.18 Evidence on the public's familiarity and attitudes towards the deliberate release of GMOs is limited. However, the wider evidence base suggests public opinion is highly dependent on context and the technology under consideration. Public opinion has been found to be more favourable towards GMOs in contained use for the medical and biotechnologies industries when compared with deliberate release.
- 6.19 Evidence suggests people are more accepting of GM crops than GM foods. Overall, studies suggest plant-related applications of GM technology are more acceptable to the public than animal-related applications, and pharmaceutical production is more acceptable than food applications.

Recommendations

- 6.20 There is evidence from deliberative studies aimed at understanding public attitudes towards GM food, which has highlighted changes in opinion as people become more informed about the topic. With this in mind, deliberative research could be used to explore in more detail attitudes towards aspects of GM technology where public knowledge is particularly limited. For example, this could include exploring public attitudes towards the deliberate release and contained use of GM technology.

- 6.21 Several studies critiqued the use of simplistic unidimensional scales in quantitative research to measure attitudes towards GM technology, particularly given insights from qualitative research studies have found people have more nuanced and sophisticated views on the issue than being simply 'for' or 'against'. The evidence base therefore would benefit from more quantitative research utilising a design with measurements aimed at capturing in greater detail some of the complexities around people's attitudes towards GM technology.
- 6.22 An objective of the review was to identify evidence that looked at attitudes towards GM and changes over time. The review came across some deliberative and cross-sectional research, but did not identify any analysis based on longitudinal panel survey data. In terms of changes over time and Wales-specific data, the National Survey for Wales is an annual cross-sectional survey based on a representative sample of around 12,000 people, which could be used to explore public attitudes towards GM technology in more detail. The research objectives outlined a particular interest in attitudinal differences between different populations and, because the National Survey Wales is based on a sample drawn from across Wales, the survey could also be used to explore whether there are attitudinal differences across different population groups and socio-demographic characteristics. Longitudinal data generated from panel studies could be used to explore changes from the same group of people or population of interest over an extended time period in more detail.
- 6.23 Because it is based on a scoping review, the report is exploratory in nature, and the findings may be subject to revision if a more systematic and comprehensive review of the evidence is undertaken. A more comprehensive review could explore whether, in responding to some of the highlighted limitations, better use could be made of existing data and drawing more from the wider evidence base to explore cross-cutting issues such as, for example, trust in regulatory institutions.
- 6.24 Although some robust qualitative studies were identified, the review found across the evidence base there was a lack of high-quality qualitative research. Further qualitative research could be undertaken to explore in greater detail some of the issues identified in the review. The studies identified tended not to combine quantitative and qualitative work, therefore any future research could benefit from a mixed methods approach.

6.25 As a result of political developments, there may be particular topics that emerge, which are of particular relevance to policy makers. The labelling of GM products, because it has been identified as way of building public trust by increasing feelings of control and choice, could be a useful way by which to frame a public debate more generally. Since reaching a peak in the mid 2000's, when opposition to GM was at its highest, the scope and amount of research on public attitudes towards GM has decreased. However, since then there have been methodological developments, for example, around measuring nuanced and complex public attitudes. In light of these developments, further research on public attitudes towards GM could be relevant, and timely, given the uncertainty surrounding the EU exit and the potential implications of this on Wales' regulatory frameworks and for policy making.

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Annex A

Table of included papers

Ref ID	Title	Publisher	Type of Data	Method	Location (Country/ region)	Focus of analysis	Headline findings
Allum (2007)	An empirical test of competing theories of hazard-related trust: The case of GM food	Risk Analysis	Quantitative	Quota-controlled sample online survey with 1,142 respondents	UK	Exploring relationships of dimensions of trust and perceptions of GM food risks	Trust judgments based on the perception of shared values e.g. Between public and institutions are most important in relation to GM food risk. Judgments about scientists' technical competence are also important.
Brossard 2007	Deference of Scientific Authority among a low information public: Understanding U.S opinion on agricultural biotechnology	International Journal of Public Opinion Research	Quantitative Study	Mail survey sent to a random sample of 1500 New York State residents. 150 follow up phone interviews, 40.4% response rate.	New York State, USA	Examining the deference of science authority and science knowledge among residents	Deference to science authority is the largest factor in acceptance and understanding of agricultural biotechnology. Age as a determining factor of deference to science authority was positively correlated to trust. Men were seen to pay greater attention too and hold a larger frame of knowledge on science and scientific authority.
Braman et al 2007	Affect, Values, and Nanotechnology Risk Perceptions: An Experimental Investigation	GW Law Faculty Publications	Quantitative	Online survey of 50 questions to 1,850 respondents	USA	Survey conducted to investigate on what basis are judgements about nanotechnology made & how do views evolve after exposure to information	Public perceptions of nanotechnology risks, like public perceptions of societal risks generally, are largely affect driven: individuals' visceral reactions to nanotechnology (ones likely based on attitudes toward environmental risks generally) explain more of the variance in individuals' perceptions of nanotechnology's risks and benefits than does any other influence.
Connor & Siegrist 2010	Factor's Influencing people's acceptance of gene technology: the role of knowledge, health expectations, naturalness and social trust	Science Communication	Quantitative study	Questionnaire mailed to Swiss respondents measuring perceived benefits and risk perceptions on a 6 point scale, Knowledge measured by true/false statements and answers.	Switzerland	Evaluate perceptions of different applications of gene technology to assess risk/benefit perceptions. Used the impact of knowledge to analyse an individual's perception of GM applications through expectations, importance of naturalness, risk/benefit perceptions and socio-demographic variables	Individuals tend to distinguish applications between medical and non-medical. Medical applications are generally better accepted and viewed more positively than food applications. Knowledge was assessed through basic biological knowledge, gene technology knowledge and knowledge of legalities in Switzerland. Level of biological knowledge concluded to be very high therefore sample unrepresentative of all Swiss residents due to level of educational attainment.

Ref ID	Title	Publisher	Type of Data	Method	Location (Country/region)	Focus of analysis	Headline findings
Dreezens 2005	Food and values: an examination of values underlying attitudes towards genetically modified and organic grown food products	Appetite	Quantitative	Survey to a non-representative sample of 100 students	Netherlands	Survey aimed at examining which specific values play a role in predicting participant's attitudes towards GM food and organic food.	Demonstrated that opposing attitude positions are reflected in a different structure of values. Found that: - Attitudes towards organic food and GM food were negatively related. - Organic food was related to the value 'power' (negatively) and 'universalism' (positively). Implies that two opposing attitude positions have a connection with distinctly different values
Frewer 2013	Public perceptions of agri-food applications of genetic modification: A systemic review & meta-analysis, in trends in food science & technology	Trends in food science & technology	Quantitative	A systematic review and meta-analysis. 70 articles used in the final meta-analysis.	International	Assessment of research relevant to understanding consumer and societal attitudes to GM applied to agri-food production. Objective was to compare attitudes in different global regions, at different times and between applications.	Plant-related or 'general' applications are more acceptable than animal-related applications. Risk perceptions greater in Europe than in North America and Asia; reverse true of benefit perceptions Moral concerns are higher in North America and Asia. Both risk and benefit perceptions increased with time.
Food Standards Agency 2012	GM Labelling: Exploring public responses to the labelling of GM food and the use of GM-free labelling	FSA	Qualitative interviews and group discussions	Pilot research (4 in depth interviews & 2 discussions) Main research (16 in depth interviews and 8 group discussions) Follow up interviews with ¼ of the sample.	UK (Wales boost sample)	This research intends to understand UK public views towards the labelling of GM on foods and the options for labelling food as GM-Free. The research also looked at understanding the interest in labelling information for products where animals had been fed GM feed.	The findings indicate that the provision of information can affect response to labelling. For those with less established opinions, or those lacking understanding, providing information about potential benefits and drawbacks of GM often lessened initial negativity and assumptions regarding GM foods.
Define Research & Insight 2013	GM labelling: exploring public responses to the labelling of GM food and the use of GM-free labelling	Food Standards Agency	Mixed Methods	Qualitative. In depth interviews, group discussions & telephone. Devised interviews using purposive sampling. Quantitative statistical analysis of the interviews	UK	To explore the UK public's views on the labelling of GM foods and the options of GM-free labelling.	A large proportion (79%) of the population were aware of GM use but did not have much knowledge on the applications of GM. Respondents showed a positive view towards the labelling of gm-free foods and indicated strong views of having a right to know about their consumer products.
Ganiere 2006	A Continuum of consumer attitudes toward genetically modified foods in the United States	Journal of Agricultural and Resource Economics	Quantitative Study	Survey to randomly selected US households via random digit dialling procedure. Respondents required to be the designated 'shopper' for that household.	U.S.A (excluding Hawaii & Alaska)	Willingness to pay for GM foods & knowledge around the topic	The biggest risks of GM foods as identified by consumers, is that of human health. Benefits of GM foods need to be highlighted by the food industry to make consumers decisions more informative. Acceptance of GM foods correlates with the level of trust and confidence in the government. Support for GM is determined by subjective and objective knowledge se out through information.

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Gaskell et al 2006	Eurobarometer Survey	European Commission	Quantitative	Survey conducted in 1991,1993, 1996, 1999, 2002 & 2005 to a representative sample of 25,000 respondents with 1000 from each EU member state	EU	Currently, issues such as stem cell research, the co-existence of GM, conventional and organic farming, the use of genetic information, and other Innovations such as nanotechnology and pharmacogenetics are under discussion. Furthermore debates about broader issues such as the governance of science and citizen engagement continue. This survey stands as a contribution to the informed public and policy debate.	2005 survey respondents are more optimistic than the previous. Found widespread support for medical & industrial biotechnologies but general opposition to agricultural biotechnologies unless there are consumer benefits.
Grunert 2001	Consumer perceptions of food products involving genetic modification – results from a qualitative study in four Nordic countries	Swedish Institute for Food & Biotechnology	Qualitative	Interviews with 285 female respondents with main responsibility for household grocery shopping	Denmark, Finland, Norway & Sweden	The present study addresses consumer acceptance of food products involving the use of different applications of genetic modification in four Nordic countries. Three food products were used as examples: hard cheese, hard candy, and salmon. Three types of applications of genetic modification were investigated: modification of the raw material, use of genetic modification in enzyme production, and direct use of genetically modified microorganisms. In addition, Three levels of presence of the genetically modified material in the final product were investigated: not present, present, and present and living/able to function.	Pattern of mean rankings of GM foods shown to the respondents are almost exactly the same across the four countries. Conventional products were most well received even when explicit benefits were not mentioned.
Honkanen & Verplanken 2004	Understanding Attitudes Towards Genetically Modified Food: The role of values and attitude strength	Journal of Consumer Policy	Quantitative	Questionnaire to a non-representative sample of 250 students	Norway	Investigated the nature of negative attitudes towards GM food	Values and attitude strength are important constructs when explaining the attitudes. Attitude centrality found to moderate the value-attitude relationship. People holding weak attitudes may be more likely to change their attitude than those whose attitude is embedded in values.
Kearon 2009	Seeds of Confusion: Consumer attitudes to GM food	Consumer Focus Wales	Quantitative	Survey Wales-wide	Wales	Survey used to update the results from the 2003 Gm Nation debate	Greatest opposition of GM applications found in mid/west Wales. 34% of wales-wide consumers are completely opposed to purchasing GM foods, 24% believe they should be completely banned from the UK. 23% of respondents are opposed to the idea on ethical grounds.

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Knight et al 2007	Acceptance of GM food – an experiment in six countries	Nature	Quantitative	Choice Modelling Experiment	NZ, Sweden, Belgium, France, Germany & UK	The experiments reported here were undertaken to determine how consumers in a range of countries with highly negative public perceptions of GM technology might react toward GM food products that offer clearly stated consumer benefits if introduced into their markets.	In conclusion, this research revealed that a significant (and in some markets, surprisingly high) percentage of consumers in European countries appear willing to choose GM food provided there is a price advantage coupled with a consumer benefit (in this case, 'spray-free' status).
Lee 2005	Public attitudes towards emerging technologies: Examining the interactive effects of cognitions and effect on public attitudes toward nanotechnology	Science Communication	Quantitative	Telephone survey	USA	Testing both the cognitive and affective decision-making pathways, which may shape public attitudes toward nanotechnology. More importantly, it included an examination of the interplay between cognitive and affective factors and their combined influences on public attitudes toward nanotechnology. Before outlining an integrated model in which affective factors moderate the effects of knowledge about nanotechnology on public attitudes toward nanotechnology. This study examined the interactive effects of knowledge and effect on people's attitudes toward nanotechnology. Focusing particularly, on how the influences of cognitive variables differ, depending on various affective reactions to new technologies.	This research found that people use their knowledge about science in general in order to evaluate the possible risks and benefits of nanotechnology and to decide whether they support nanotechnology or not. Also, affective variables, such as negative emotion toward science in general and negative emotion toward nanotechnology, serve as important cues for risks-versus-benefits judgments and for general attitudes towards nanotechnology.
Loueiro & Hine 2004	Preferences and willingness to pay for GM labelling policies	Food Policy	Quantitative	Face-to-face survey administered in various supermarkets and on various days	USA	This research analyses whether consumers prefer mandatory or voluntary labelling schemes through contingent valuation. Additionally, the study calculates the premium that consumers are willing to pay in order to subsidize their favourite labelling alternative.	The results of the surveys indicate that consumers were only ready to pay premiums that were, in fact, lower than those required to internalize the total costs of mandatory labelling estimated by previous studies.
Miles 2005	Public attitudes towards genetically modified food	British Food Journal	Quantitative Study	Questionnaire investigating public attitudes towards genetically modified foods	Italy, Norway & England	To investigate the public's attitudes towards labelling of GMOs and the awareness and impact of traceability across Italy, Norway and England	Consumer attitudes were not affected by new detection methods or traceability of GM foods. Consumers responding to the questionnaire desired all foods containing GMOs to be labelled.

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Onyango et al 2004	Consumer acceptance of nutritionally enhanced genetically modified food: Relevance of gene transfer technology	Journal of Agricultural and Resource Economics	Quantitative Study	Computer Assisted Telephone Interview to 1,203 respondents	USA	This study examines consumer's willingness to consume different types of a nutritionally enhanced food product (i.e., breakfast cereal with calcium, omega fatty acids, or anti-oxidants) derived from grains genetically modified using two types of technologies: plant-to-plant gene transfer technology and animal-to-plant gene transfer technology.	Findings indicate a majority of the respondents are willing or somewhat willing to consume the three types of nutritionally enhanced genetically modified breakfast cereal, but are less willing if the genetically modified product is derived from animal-to-plant gene transfer technology than from plant-to-plant gene transfer technology. However, the results of the ordered probit models suggest there are groups of consumers who will not approve of the use of either type of gene transfer technology even with the presence of an enhanced nutritional benefit in the product.
Poortinga & Pidgeon 2003	Public perceptions of risk science and governance. Main findings of a British survey on five risk cases	Centre for Environmental Risk	Quantitative	Questionnaires used for face to face interviews with quota sample of 1547 people	UK	The study is designed to provide theoretical progress and integration in the field of risk perception and representation, facilitating advances in our theoretical understanding of public framings and attitudes towards science and risk issues. It is also intended to provide scientists and policy makers with an understanding of how the public views and characterises science and scientific procedures in settings where risk and policy interact	Most people appeared neutral about GM food by indicating that GM food is neither a good nor a bad thing. Moreover, people appeared to be less concerned about GM food than about the other risk cases, with perceived risks and benefits compared to the other risk cases judged as intermediate. However, across the whole sample mores people thought the risks outweigh the benefits, and the acceptability of GM Food was moderately low
Poortinga & Pidgeon 2006	Exploring the Structure of Attitudes Toward Genetically Modified Food	Risk Analysis	Quantitative	Self-completion questionnaire with 396 respondents	Norwich, UK	This study explores the structure of attitudes toward GM food. An important assumption underlying the proposed four-way typology of attitudes is that the positive and negative evaluations are independent from one another. This study additionally explores people's affective response to GM food.	Different degrees of perceived risks can co-exist with different degrees of perceived benefits. The results of the current study suggest that, in the context of risk perception research, the three attitude dimensions should not be studied in isolation. Studying them separately obscures the fact that they collectively define people's attitudinal positions on a particular issue, and consequently may lead to only partial or even spurious findings.

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Poulsen 1999	'Danish Consumers' Attitudes Towards Functional Foods'	MAPP Centre	Mixed Methods	Quantitative survey & focus group interviews	Denmark	The aim of this study is to examine Danish consumers' attitudes to functional foods, including: whether enrichment with health-promoting substances results in a higher value perception among consumers; the relative importance consumers attach to enrichment compared with other product attributes; which beliefs consumers associate with enrichment; and, which beliefs influence and determine consumers' purchasing intentions and the relative importance of these beliefs.	The study found that consumers are most positive about functional foods, which have been enriched with a substance already present in the conventional product. With regard to price, the analyses show that some segments are willing to pay more for functional foods if they think there is a health effect. The marketing of functional foods should emphasise the convenience of getting enrichment substances through the daily diet and naturalness, since these factors are the most important in determining consumers' intention to buy functional foods
Trail 2004	Categories of GM risk-benefit perceptions and their antecedents	AgBioForum	Data collection & analysis	Females ages 25-65 completing questionnaire on grocery shopping	US/UK/France	Analysis of risk-benefit perceptions in consumers and in relation to trust	The majority of respondents viewed GM applications as medium level risk. USA respondents generally had a more favourable attitude towards technology and therefore also GM applications. European respondents held a high level of trust in consumer and environmental groups resulting in fewer perceived benefits and larger perceived risks in GM.
Tucker 2006	Consumer perceptions of food-related risks	International Journal of Food and Science Technology	Quantitative	Mail survey data are reported for 4,014 respondents with a total response rate of 56%	USA (Ohio)	The purpose of this study was to assess Ohioans perceptions of various food safety risks and to identify factors influencing risk judgments.	Findings reveal moderate perceived levels of risk for the food safety items assessed. Pesticide residues in food and contamination of drinking water generated the highest levels of perceived risk, while mad cow disease and genetically modified foods generated the lowest levels of perceived risk. Regression results indicate that attitude toward biotechnology was the strongest predictor of perceived risk, followed by perceptions of media system dependency. Findings from this research can assist food safety specialists in developing more effective education and risk communication programmes for target audiences.
Vilella-Vila et al 2005	Consumer involvement and acceptance of biotechnology in the European Union: a specific focus on Spain and the UK	International Journal of Consumer Studies	Paper including findings of 2 Eurobarometer surveys	Two Eurobarometer surveys	Spain & UK	How public opinion has conditioned acceptance of GM food.	Information dependency on attitude formation towards GM: Widespread diversity in views across the countries