# foodpath

## Review of Best Practice for Interventions to Reduce Consumer Food Waste

DELIVERABLE 1B

Sarah Broderick [1], Colum Gibson [1], Keelin Tobin [1]

Eileen Mitchell [2], Alberto Longo [2]

Pauline McDonogh [3]

[1] Clean Technology Centre, Munster Technological University
[2] Queen's University, Belfast
[3] Southern Regional Waste Management Office

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**Food Path**

Food Path is collaborative research project involving Queen's University Belfast, the Regional Waste Management Offices and led by the Clean Technology Centre, Munster Technological University.

This project is funded under the EPA Research Programme 2014-2020. The EPA Research Programme is a Government of Ireland initiative funded by the Department of the Environment, Climate and Communications. It is administered by the Environmental Protection Agency, which has the statutory function of co-ordinating and promoting environmental research.

Food Path aims to identify existing best practice in consumer behaviour change and food waste prevention, and to apply this through intervention trials in Irish communities. This work will inform Ireland's response to food waste prevention and the achievement of UN Sustainable Development Goal: Target 12.3.

**Context of Report**

This report is one of two outputs for Food Path Workpackage 1. It consists of a detailed review of food waste prevention best practices and interventions. It is accompanied by the report: *Review of Relevant Consumer Behaviour Change Studies and Initiatives*, which provides a broader view of behaviour change policies and interventions that are relevant to food waste prevention.

These dual reports have been published to combine knowledge from the well-established areas of research such as such as health promotion, diet, climate action and energy conservation, with that from the developing discipline of food waste prevention.

This report, led by the Clean Technology Centre, MTU aims to compile best practice guidance and key examples of consumer food waste interventions. This finding from this work will be combined with those from the wider review of behaviour change interventions to inform future food waste prevention activities in Ireland, in particular the upcoming Food Path intervention design.

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This report is based on research carried out/data from April 2020 to January 2021. More recent data may have become available since the research was completed.

The EPA Research Programme addresses the need for research in Ireland to inform policymakers and other stakeholders on a range of questions in relation to environmental protection. These reports are intended as contributions to the necessary debate on the protection of the environment.

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# 1. Introduction

## 1.1 Background

Food waste is a global issue that countries across the world are working to address. Both food waste and its prevention are complicated topics. The issue of food waste occupies a unique space closely linked with wider sustainability. It interacts with areas such as global consumption, health, land-use and food security, in addition to questions of moral philosophy, hunger and the industrialisation of food. Food waste continues to attract considerable attention in academic (Quested et al., 2013; C. Reynolds et al., 2019; Schanes et al., 2018) and popular literature (e.g. Stuart, 2009, Bloom, 2010), as well as in policy at European, national, organisation and community levels (DCCAE, 2019; EPA, 2019; EC, 2015; EPRS, 2017). The problem of food waste is widely recognised as one that has yet to be adequately addressed. The UN Food and Agricultural Association (FAO) (2015) estimate that 1.3 billion tonnes of food is wasted globally each year. The International Panel on Climate Change (IPCC) (2019) highlight that approximately 25%-30% of all food produced worldwide is lost or wasted.

*Food waste prevention*

Reductions in the current levels of food waste worldwide will allow a relative reduction in global food production and therefore allow for significant improvements in terms of carbon emissions and broader environmental and social impacts (Hawkins, 2017; Quested, 2013). National, regional and business level food waste reduction targets have been in place in many countries since the 2010s. Since 2015, a global food waste prevention target has been in place as part of the United Nations Sustainable Development Goals (Target 12.3). This target aims to:

**"By 2030, halve per capita global food waste at the retail and consumer levels and reduce food losses along production and supply chains, including post-harvest losses."**

Champions 12.3 is a coalition of executives from across the food system who are dedicated to achieving this target. According to this group, governments should apply the three-step approach – *Target, Measure, Act*. Progress is being made, in particular with state-level food waste measurement, but at a rate that may not be fast enough to achieve this goal.  According to the 2019 global progress report, government representing just 15% of the world's population are working at scale to reduce food waste. They state that more governments and businesses need to take stronger actions against food waste (Champions 12.3, 2020).

*Household food waste prevention*

Food waste occurs throughout the food supply chain. Thus, in order to affect real change in the incidence of food waste, a multi-disciplinary approach, with meaningful system-wide action is required. However, it has been clearly identified that a significant proportion of overall waste occurs at the consumer level. Estimates of EU food waste attribute 53% of overall food waste to the household level (Stenmarck et al., 2016). When wasted at this late stage, food has typically undergone a range of transportations, processing, storage and even cooking. As such, it represents the accumulated embedded environmental impacts of all previous stages of food supply and thus is the most environmentally significant. Interventions within the manufacturing, retail and food service sectors can influence household food waste. Changes to packaging technology, pack sizes, promotion and marketing, serving practices etc can have a direct effect on food that is subsequently wasted at the consumer stage. However, there is an opportunity for direct consumer focussed interventions to be implemented concurrently.

Along with many other countries, Ireland is committed to the achievement of the SDGs. With food waste reduction targets just 10 years away, it is clear that consumer facing campaigns or interventions must be effective in order to have necessary impact. Since 2008, the Irish government, through the EPA, has been actively addressing household food waste through a number of National Waste Prevention Programmes (NWPP) initiatives, primarily the Stop Food Waste Programme[1]. Food waste has been included as a priority sector in Ireland's Waste Action Plan for a Circular Economy. As part of this plan, a Food Waste Prevention Roadmap

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[1] https://stopfoodwaste.ie/

will be developed (Government of Ireland, 2020). This is due to take place in the coming months.

## 1.2 Aims and Objectives

Through this research project, we aim to bring together insights from across behavioural science including sociology, psychology and behavioural economics. An in-depth analysis of best-practice behaviour-change-based food waste prevention interventions will inform the design of a set of effective consumer-focused food waste prevention interventions for Ireland.

The objective of this report is to gather and synthesise existing information on household food waste prevention best practice. Information has been gathered from various sources, including behaviour change theory, best practice guidelines and examples of previous interventions. The term intervention in this case is taken to mean any activity that is designed and implemented with the aim of reducing food waste. The information outlined here will be used to inform the design and implementation of food waste prevention interventions later in the project. We also aim to provide up-to-date and relevant information for project stakeholders on the best practice of reducing household food waste.

## 1.3 State of Research on Household Food Waste Prevention

The level of work on food waste prevention is rapidly increasing (Schanes et al., 2018). In the last 2 years alone, several significant bodies of work have been published, summarising previous interventions and proposing best practice for the future. Of particular relevance to this project is the EU Horizon 2020 project *Refresh*. This large scale, multi-stakeholder project aimed to reduce avoidable food waste and improve the valorisation of food resources through social, technological, and organisational insights and practices related to food waste[2]. Other relevant work includes the recent review papers by Reynolds et al., (2019), Kim et al. (2019), Schanes et el., (2018) and Hebrok & Boks (2017).

While there are numerous recent and emerging articles and reports dealing with concepts around food waste prevention (e.g., the drivers, determinants, barriers, motivations, attitudes), there are still relatively few detailing interventions with quantified results. A general shortage of food waste prevention interventions that have been sufficiently evaluated can be observed (Stöckli, Niklaus, et al., 2018). Reynolds et al., (2019) identified just 17 articles featuring applied interventions, with only six of these focussing on household or community level waste.

Of course, not all food waste prevention interventions are reported in peer-reviewed literature or indeed even through websites or published reports. Many actions are implemented at a community or local authority level or in some cases by private organisations. However, without access to information evaluating these interventions, it is difficult to draw reliable conclusions or insights into their efficacy. Where interventions are evaluated, there is currently a reliance on self-reporting as a measure of success. This is the case across intervention types and reporting media. While of course some evaluation is better than nothing, this approach has intrinsic limitations. The difficulties of effective evaluation are discussed in section 2.3

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[2] https://eu-refresh.org/

Within an Irish context, a number of relevant research projects have been carried out in the recent past. TriFOCAL, was an EU Life project that was focused on London, UK but included a replication phase in Dublin (TRiFOCAL, 2020). While the main research activities included food waste prevention, the Dublin work focused on source segregation of food waste in apartments. In 2016, as part of a research project on government policy for behaviour change O'Rafferty studied the existing food waste prevention and home composting programme run by Stop Food Waste (Open Practices, 2016). Davies et al., (2017) implemented food waste prevention interventions as part of wider sustainable household consumption research. More detail on these interventions will be provided in Section 3 Interventions.

We have attempted to gather insights on best practice from a variety of sources. However, in addition to the general scarcity of largescale direct interventions, there is typically a lack of material evaluating the effectiveness of such intervention types. Consequently, it is difficult to draw reliable conclusions about the efficacy of the reported interventions. With this in mind, the best practices that are explored in this report are those that have been explicitly stated as such, rather than those that could be inferred from their use.

However, there is much existing knowledge in the parallel areas of behaviour change, particularly relating to diet, health and environment related behaviour change. In fact, reviewing existing knowledge both in food waste prevention and other related fields is a recommended aspect in the design of such food waste interventions (Quested, 2019). Consequently, through this work package, we aim to achieve exactly that.

The broad, high-level best practices relevant to food waste prevention are discussed in section 2 while the more targeted best practices are provided in Section 3, organised according to intervention type.

## 2.    Best Practice in Food Waste Interventions

This section compiles aspects and examples of high-level best practice in food waste interventions presented by several sources. The sources of the best practices themselves are from food waste prevention literature. However, material from wider areas of behaviour change has been drawn on to supplement descriptions and explanations of these practices. A large part of best practice has been gathered from the EU project Refresh, which set out to design policy recommendations and supports for food waste prevention in the EU. Further best practice guidance has been compiled from the EU project FUSIONS and from a wide range of peer-reviewed literature.

Here we gather and present some high-level best practices for food waste prevention. These best practices will be relevant for projects and programmes at both national and local levels, aiming to reduce household food waste.

Some of the broad elements of best practice identified include:

- A clear definition of food waste
- A basis in established theory
- Use of design thinking and logic mapping
- A detailed plan for evaluation

The following table, based on work by FUSIONS and extracted from a report by the Central European Interreg project STREFOWA (2015), provides further best practices principles for food waste prevention work.

*Table 1. Best practice principles for food waste prevention activities (STREFOWA, 2015)*

| Criteria | Description |
|---|---|
| targeted | practices that have a strong waste prevention focus, clearly distinct from other waste management strategies or broad environmental goals |
| effective | practices based on guidelines, protocols, standards, reports, or preferred practice patterns that have been proven to lead to effective food waste prevention/reduction practices |
| measurable | practices that have an evaluation plan in place to measure program outcomes, even if they do not yet have evaluation data available to demonstrate the effectiveness of positive outcomes |
| innovative | practices that use original or resourceful techniques for waste prevention |
| replicable | practices that can be easily reproduced and are similarly relevant in regions across Europe |

## 2.1 Defining Food Waste

According to Quested (2019), one of the first steps researchers should take when designing an intervention evaluation is to decide what constitutes food waste. There has been much debate in the past about the definition of food waste. Inconsistencies in definition and classification have caused difficulties in the past in the comparison of food waste studies (Elimelech et al., 2018). In the last number of years much work has been done to standardise food waste definitions and classification systems. In 2012, the project FUSIONS was established to harmonise food waste monitoring in the EU. As part of this work, a definition of food waste was developed. According to FUSIONS, "Food waste is any food, and inedible parts of food, removed from the food supply chain to be recovered or disposed (including composted, crops ploughed in/not harvested, anaerobic digestion, bio-energy production, co-generation, incineration, disposal to sewer, landfill or discarded to sea)" (FUSIONS, 2014). The FAO differ in their definition, distinguishing the notion using two terms "food waste" and "food loss" (FAO, 2013).

It is widely accepted that food losses usually take place at the production, post-harvest and processing stages of the food supply chain (Parfitt et al, 2010). Food waste generally occurs at later stages of the food supply chain when an edible item is unconsumed. It could be argued that the term food loss suggests an inevitability while conversely, food waste might imply something that is avoidable. For Gustavsson et al (2011) food waste includes food produced for human consumption that is later used for a different purpose e.g., feed for animals or biofuel. Sage's concept of food waste extends to include that which is consumed though not needed in the body, i.e., through overeating (2012). The scope of food waste could be extended to all that is edible but is not generally consumed (e.g., insects, rodents, etc.). That which is considered edible and inedible are often socially and culturally determined.

The definition used should reflect the aims of the project or intervention (Quested, 2019).

**Food Waste Classification**

Inconsistencies in how food waste is measured has led to significant difficulties in comparing results from various food waste prevention or indeed quantification projects (van der Werf et al., 2020). This issue was recognised several years ago, and two major bodies of work were carried out to address it through the development of standardised food waste measurement protocols or methodologies. The first was the EU project FUSIONS, and the second was by an international team, led by the World Resources Institute called the Food Loss and Waste Protocol.

The FLW Standard provides specific requirements and guidance for countries or other entities implementing food waste quantification and reporting. It is designed to be used by entities of any size, in any sector or country and so is purposely flexible in terms of scope. However, there are mandatory requirements for defining project scope and reporting results (FLW, Protocol).

FUSIONS, which preceded FLW produced a high-level methodology for food waste quantification at a more granular level addressing the different stages within the food production/consumption cycle (Tostivint et al., 2016).

Both of these methodologies outline key principles for quantification of food waste and should be consulted when designing a food waste quantification methodology.

## 2.2 Theoretical Basis for Intervention Design

In their recent review of food waste prevention interventions, Reynolds et al. (2019) call for stronger links between interventions and existing relevant theories. They identify that, while food waste prevention interventions are relatively common, it is still the case that much of this work lacks a link to an established theoretical framework or disciplinary orientation (C. Reynolds et al., 2019). The authors recommend the use of established theory and the findings from previous research to inform future food waste interventions. In doing so, researchers or practitioners can build upon and are guided by previous work. Additionally, readers are not left to inferring connections between cause and effect (C. Reynolds et al., 2019).

There are numerous theoretical frameworks that could be applied to food waste prevention. Examples include, The Theory of Planned Behaviour, social practice theory, behavioural economics, pro-environmental behaviour change and transformative consumer research. To date, there have been two main theoretical frameworks applied to food waste prevention to date. These originate from the fields of psychology and sociology (Schanes et al., 2018). The psychological approach focuses on individual factors affecting behaviour, and most often, the theory of Planned Behaviour is applied. Social practice theory is the other commonly used framework that comes from the field of sociology. This approach shifts the focus from the individual to the behaviour itself (i.e., practice) but also the wider social setting of the behaviour. Due to their prominence in the field of food waste prevention, both of these approaches are discussed below.

### 2.2.1 Theory of Planned Behaviour

The theory of planned behaviour (TPB) (Ajzen, 1985) is the most frequently used theoretical framework for work in environmental psychology (Schmidt, 2019). This long-established theory is based on the assumption that the stronger one's intention to carry out a behaviour is, the more likely it is that this will occur. The theory, which focuses on the individual, is based

on the principle that intention is the major antecedent for behaviour change. The underlying factor here is 'intention' which in turn is influenced by a number of factors. Within the theory there are core factors that influence an individual's intention. These are attitude towards the behaviour, subjective norm and perceived behavioural control. When applied to food waste, these factors can be described as follows:

Table 2. Core factors of TPB applied to food waste

| Attitude | thinks food should not be wasted |
|---|---|
| Subjective norm | important people in one's life would not want them to waste food |
| Perceived behavioural control | confidence in one's own ability to avoid food waste |

To date numerous studies have applied the TPB to investigating or addressing consumer food waste (Graham-Rowe et al., 2014; Russell et al., 2017; Stancu et al., 2016; Stefan et al., 2013; Stöckli, Niklaus, et al., 2018; Visschers et al., 2016; Wajon & Richter, 2019). Some work has found that all three factors have a significant influence on behavioural intention (Graham-Rowe et al., 2015) while other have found no significant associations with one of the factors, for example attitude (Russell et al., 2017) subjective norms (Visschers et al., 2016), and perceived behavioural control (Visschers et al., 2016).

This theory has been regularly extended to incorporate other factors such as anticipated emotions, self-identity, personal norms, taste preferences and habit when examining people's behaviours. When extended factors are included models based on the TPB have accounted for 29-74% of variance in food waste intention and 16-46% of variance in food waste behaviour (Neubig et al., 2020). It is worth noting that the effectiveness to predict actual behaviour is lower than that of intention. While intentions have been shown to correlate with food waste levels, (Stefan et al., 2013) found that when practices such as planning and shopping routines were included in the model, the intentions did not show significant correlation. The explanation offered is that the act of wasting food is not an intentional behaviour but rather a result of more indirect habits or actions. While it may be possible to predict whether a person intends on wasting food, by assessing their attitudes,

norms and behavioural control, whether or not they intend to create food waste is not a good predictor of the waste that they go on to generate.

In response to the limitations of the TPB, an additional and complimentary method for analysing food waste behaviour has been found in the *theories of social practice* (Schanes et al., 2018).

### 2.2.2   Social Practice Theory

Social practice theory (SPT) has been regularly applied to food waste research. In contrast to the approaches based in environmental psychology, social practice decentralised the individual and instead studies societal constructs. In SPT, rather than the person themselves being the unit of study, or even the behaviour itself, the overall social and collective structures and discourse are the base unit of study (Hargreaves, 2011). This approach acknowledges that individuals are 'embedded' in their wider social, economic and cultural settings and that these factors cannot be decoupled from individuals' behaviour (Schanes et al., 2018). The use of SPT in consumer research is promoted by Warde (2005) who states that practices steer the processes of consumption. Consumption is not a practice itself, rather it exists as an aspect of many everyday practices (Warde, 2005).

Practices, including those relating to food consumption, can be carried out on a somewhat automatic basis (Davies et al., 2017). They can include learned sequences of behaviours - things that are considered to be just 'the way things are done'. In the context of food provision, consumption and in turn food waste, individuals undoubtably have the capacity to make decisions based on their attitudes and beliefs. However, the effect of convention and infrastructure must be taken into account. The ideas we hold of 'the way things are done' are particularly strong for food due to its multifaceted links with other aspects of life such as health, family and culture. Put simply, surrounding context can override cognitive factors (Stern, 2000).

Evans (2011) further argues that there is an over emphasis on the individual or the consumer in food waste prevention work. He argues that while attitudes and values are important

aspects of food management, culturally held norms (such as what constitutes a proper meal) have an impact on what ends up wasted. In addition to this, Evans gives evidence that discarding food is not a carefree activity but often in fact, a manifestation of care (Evans, 2012). He found, through ethnography-based work, that people experience negative emotions such as guilt when discarding food. This has been subsequently supported by Wunder et al. (2019).  In fact, in order to alleviate this guilt, people often stagger the disposal process, storing food in the fridge until it is no longer edible to make the act of discarding it less negative. Factors such as health, caregiving, the idea of proper meals all have a very real impact on how individuals manage food. Evans uncovers the significance of our understanding of what constitutes 'a proper meal' and the relative consistency of a household's culinary repertoire and food provision practices. He identifies the discrepancy between the relatively fixed practices of food acquisition/purchasing and the fluid nature of modern life as an important driver of food waste in modern UK households.

In the context of food waste, social practice theory provides a basis to study the practices that surround and result in food waste, at an individual and societal level. SPT has been used on numerous occasions to study food waste in the home (Evans, 2011a, b, 2012a, b; Cappellini, 2009; Cappellini and Parsons, 2012; Ganglbauer et al., 2013; Davies et al., 2016; Lazell, 2016; Leray et al., 2016; Meah, 2014).

With the exception of Davies et al. (2016), these works all use social practice theory to explore concepts around food waste. They do not describe interventions that were quantified. The work by Davies et al. (2015) was carried out in Ireland as part of a wider intervention on sustainable food consumption. The intervention was implemented intensively. The research team worked with five households, and the direct intervention period lasted five weeks. Week three focused on storage of food waste, week four on food waste management, including prevention. Davie et al. used *bundled* interventions. For food waste prevention these included fridge triage boxes, portion control tools and a visit from a chef to discuss meal planning. For food waste management food waste caddies and electronic composters were provided. On average, food waste reductions of 28% were experienced by the participating households. Davies et al. acknowledge the part the researcher plays in the intervention, in

deconstructing and rebuilding household practices. They mention the difficulty this poses to widespread intervention role out.

## 2.3 Systems Thinking and Logic Mapping

The need for careful consideration of the wider systems that surround food waste has been identified in the literature (Halloran et al., 2014; Wunder et al., 2019). To understand food waste, it cannot be studied in isolation. Food waste is a systemic problem, no one aspect of the food system is entirely responsible for the current levels of waste. The issue is sometimes considered a symptom of a broken food system (Lang, 2020). O'Brien (2013) argues that food waste is entwined within a complex network of relationships and actions which have meaning and value, connecting to broader issues in the industrialisation of food. Consequently, food waste prevention is complex, even in the context of behaviour change. Wasting food is not a behaviour in and of itself, rather a consequence of a wide series of behaviours, themselves influenced by wider social and cultural constructs. Food consumption and therefore food waste has close links with public health, policy and our environment. It is also an integral part of people's everyday habits, relationships, culture and identity. As such, it is argued that for any intervention to successfully address household food waste prevention, there must be thorough consideration to the web of relevant factors, influences and potential outcomes (Halloran et al., 2014).

In order to account for the systematic nature of the issue, the use of "systems thinking" and/or "logic mapping" in intervention design is being called for (Quested, 2019; Wunder et al., 2019). These tools have been widely applied beyond the discipline of food waste prevention. While these approaches differ in detail, they all involve a process of identifying and clearly defining the proposed activities of the intervention, and importantly the potential outcomes of the work.

### 2.3.1   Systems thinking

System thinking is the processes of thinking about a system as a whole, rather than examining it in the individual parts (Sanneh, 2018). Davidz and Nightingale (2007) define systems

thinking as the "analysis, synthesis and understanding of interconnections, interactions, and interdependencies that are technical, social, temporal and multi-level". When applied to food waste prevention, this approach considers a wide range of factors that influence whether food is wasted in the home, including external drivers, infrastructures and paradigms. It also considers the potential outcomes of an intervention and the effects they may have on aspects other than food waste prevention. Systems thinking generally involves three broad stages. Firstly, all of the relevant stakeholders are identified, secondly the relationships between those are then identified. Finally, the impact of these relationships on each other and on factors outside the system are explored. Food waste could be regarded as being an aspect of the food system. Therefore, the actors earlier in the food supply chain are relevant, both in terms of changes to infrastructure and materiality (e.g. packaging, portion size) but also as potential agents for social change (Quested et al., 2013).

### 2.3.2 Logic mapping

Logic mapping is recommended by Quested (2019) as an early stage of food waste interventions and he directs to the Magenta Book and Logic Mapping: Hints and Tips for further information on how this could be employed. It is an approach that involves setting out the intended plan for an intervention, including the theories behind it, the activities of the intervention itself, any assumptions being made, expected outcomes, etc. This approach emphasises a need to define behaviours in question clearly. However, this is complicated for food waste prevention because of the large number of relevant behaviours (Quested et al., 2013).

One of the important motivations for this form of preliminary work is that it helps to avoid unintended consequences from food waste interventions. Consideration of potential unintended, or rebound effects (aka second order effects), is deemed by Reynolds et al., (2020) as critical for measures aiming to save time or money for consumers. From an environmental perspective, if the money or time saved (in this case through reduced food waste) is used for less environmentally friendly activities, then the overall improvement may not be realised. From a health perspective, interventions aimed to reduce waste should not inadvertently encourage overconsumption of food, or the consumption of food that may have health implications.

Where possible, Reynolds et al. suggest that these are studied as part of the intervention. However, this will always likely be precluded due to limitations in scope, time and finances and so, in the likely event that this is not possible, the risk of rebound effects should be assessed, and steps should be taken to minimise it.

## 2.4 Evaluation

Food waste prevention is very difficult to measure accurately. As a result, there has been a lack of quantified information on the efficacy of different intervention types. Several studies have identified intervention evaluation as a key area that needs to be addressed in future work (Tom Quested, 2019; C. Reynolds et al., 2019; Stöckli et al., 2018). Some of the main evaluation methods used to date are explored here. Common methods for evaluation include surveys, self-reporting questionnaires, direct weighing, photographs, journals or diaries.

Evaluations can examine either the process or the outcome of an intervention (Tom Quested, 2019). Outcome evaluations can be further divided to focus on the final outcome (i.e. food waste generation) or on intermediary outcomes (e.g. changes in attitude or behaviours). The use of logic mapping to design the intervention and evaluation will help to guide the selection of evaluation metrics. The final outcome of actual food waste produced should be measured if possible (Quested, 2019).

Stöckli et al. (2018) stated that "interventions should be evaluated in a systematic manner, by using a framework that implements standardized definitions and measurement methods, addresses specific behaviours and behavioural change processes, differentiates between combined interventions (i.e., a campaign as a whole) and isolated interventions, and ensures evaluations of long-term effectiveness". In 2018, Eimelech et al., proposed a new detailed method of household food waste quantification based on direct measurement on a daily basis. This method is discussed as part of waste composition analysis.

**Evaluation Methods**

Evaluation methods can be described as reactive or non-reactive (Gallo, 1980). Reactive methods rely on direct participation by the person whose waste, or behaviour is being studied. They include surveys or questionnaires and food waste diaries. There is significant potential for the evaluation method to influence behaviour in this form. This is sometimes known as the Hawthorne Effect (Landsberger, 1958), or simply observation bias. Alternatively, non-reactive methods do not involve participation by those being studied. In some cases, they may not even be aware that the study is taking place. These forms of evaluation typically occur outside the home and include direct weighing or photographing. While non-reactive methods reduce the risk of causing influence to the waste habits of participants, there are other drawbacks. They can be more expensive to implement and can miss certain waste streams (e.g. liquids disposed to drain, food fed to animals). In addition, it can be difficult to determine the nature of food waste once it has entered the waste stream. Information on whether food waste avoidable or unavoidable, or even what is consists of, can be inferred when waste is captured at this stage but cannot be deemed with certainty.

As part of Refresh, Quested (2019) outlined key recommendations for evaluating household food waste prevention interventions quantification. He presents guidance under three categories: understand the intervention, develop the evaluation approach and implement and disseminate evaluation findings. In order to understand the intervention, Quested recommends the aforementioned Logic Mapping approach and the distinguishing of factors such as:

- What constitutes food waste?
- Who is the intervention seeking to influence?
- What is the intervention type?
- Is it singular or a bundled intervention?
- Will the intervention involve passive or active participation?

Further to this, Quested (2019) outlines the need for a literature review, and recommends the option of piloting or testing interventions if possible.

There are a range of evaluation options for household food waste prevention. A selection of these methods: diaries, surveys, in-home observation, waste compositional analysis and self-collection through kitchen caddies, were tested and compared by Ven Herpen et al., 2016.

Overall, the accuracy of most of these methods is questionable. In fact, Van Herpen et al. (2016) found that most of the methods they tested underestimated total household food waste. A description of the main evaluation methods, including the advantages and disadvantages to each is provided below. Van Herpen et al. (2019) suggest the following criteria for assessing the effectiveness of an evaluation method:

- Degree to which estimates of food waste are biased
- Effort required by participants/respondents
- Effort required by researcher/practitioner
- Cost
- Ability of the method to provide information about different states of food waste.

Evaluating interventions will often require researchers to gather information on participants. Van Herpen et al., (2016) highlight the need for ethical checks and privacy procedures to be part of measurement protocol.

In terms of timing, Van Herpen et al., (2016) carried out their research on the various methods of evaluation over a two-week period and found significant correlation between the two weeks of data across measurement methods. From this they conclude that a one-week period may be sufficient.

### 2.4.1 Surveys or Interviews

This reactive method of evaluation involves directly asking participants questions, either in person or over the phone through interviews or using postal or online questionnaires. Surveys are one of the commonly used methods to evaluate food waste interventions or to research the factors/determinants of food waste (van Herpen et al., 2016). Surveys provide an opportunity to measure intermediary outcomes such as changes to attitudes, awareness or

behaviour (Quested, 2019). However, when it comes to quantifying the final intervention outcome of food waste reduction, According to Refresh, surveys were in fact the least reliable method of evaluation (van Herpen et al., 2019).

Surveying people to ask about the amount of food they waste has been found to result in an underrepresentation of actual waste (Giordano et al., 2019). In general, people have a biased view of their own food waste behaviour. For example, in a Greek study 87% of respondents claim they waste little to no food (Abeliotis et al., 2014). In UK survey from 2007, 70% of respondents reported throwing out 'a small amount', 'hardly any' or 'none' (WRAP, 2007). A more recent Irish survey found very similar results with 70% reporting that they only waste "a small amount' or "none" (EPA, 2020). The underreporting of food waste through surveys could be due to a number of factors.

Social desirability bias has been identified as a potential source of the skew. Social desirability bias occurs when participants believe they know what type of answer reflects what they should be doing, or what is socially considered good behaviour. This bias should be considered when designing and interpreting surveys or questionnaires. Care should be taken to avoid presenting the questions with obvious "correct" answer, or answer that clearly "should" be done. If this is the case, social desirability bias may skew results. This is when respondents give answers that they think to be more favourable to others (Nijenhuis-De Vries et al., 2016).

A more straight-forward but important issue with survey is participants' memory. It may be the case that people simply do not remember the food they have wasted. Food waste is typically not a topic that members of the public consciously engage with on a day to day basis and so there is potential for occurrences of waste to be forgotten (Hebrok & Boks, 2017). Van Herpen et al. (2019) found that surveys asking about food waste for the previous week showed high correlation with other methods, although still an under-representation. Using a pre-announcement can improve the reliability of data by making respondents more aware of their waste. This may have concurrent effect on the current level of awareness so should not be carried out in advance of asking survey questions dealing with awareness (Nijenhuis-De Vries et al., 2016). There is potential that a pre-announcement may also alter the behaviour and subsequent food waste of participants. As part of their survey development, Nijenhuis-

De Vries et al. (2016) prepared a table of food quantities that can be used to increase accesssibility and accuracy for respondants. For exampe, measures such as spoonful of vegetables, portion of meat, piece of fruit are given estimate mass in grams for conversion.

Despite their draw backs, surveys offer the advantages that that they are typically a low cost form of evaluation, they can reach large numbers of participants, they typically require low level of effort of respondents, and can be expanded to investigate other relevant factors (van Herpen et al., 2019).

### 2.4.2   Interviews

Interviews can be used in a similar mode as surveys to measure household food waste. They are considered a suitable method for determining food waste practices and amounts (Moller et al., 2014). Interviews can facilitate commonality in data gathering while also allowing participants to speak more freely (Devaney & Davies, 2017)information more Alternatively, interviews have also been used in loosely ethnographic studies to research factors relating to food waste generation (Evans, 2012). For example, when conducting very detailed investigation on the social and material contexts of food waste, Evans (2012), used "on to go" observation and interview to examine the food waste practices of several households in Manchester, UK. In this case, Evans complimented his approach with further investigations – "diary records, cupboard rummages and fridge inventories".

Interviews can allow a more thorough investigation of household food waste and food waste prevention than other less intensive methods (Hebrok & Heidenstrøm, 2019). However, they necessitate a small sample size which reduces their suitability for gathering data for scaling (Moller et al., 2014).

### 2.4.3   Food Waste Diaries

Food waste diaries are a relatively common method used to investigate household food waste (Giordano et al., 2019; Katajuuri et al., 2014; Langley et al., 2010; Williams et al., 2012; WRAP 2008; WRAP, 2009). Diaries can be used to record the quantities, types and state of food waste in the home. Respondents can be either asked to provide weights of wasted food (in gram or kilogram) or in other (potentially easier to work with) quantities (e.g., spoonful,

serving). The latter removes the burden of weighing but requires the use of a conversion method by the researchers (such as the table by Nijenhuis-De Vries et al. (2016)).

Regardless of the approach to food waste quantification, the effort involved in keeping a food waste diary is high for participants. Even over a period as short as a week, Langley et al. (2010) found a reduction in enthusiasm by participants. Sharp et al (2010) review quantification methods for waste prevention more generally and concluded that while diaries have been found to be enjoyable for some participants, and an important motivator to behaviour change, the process is arduous for both the participants and research team and therefore can only be carried out in a limited number of households. The effort required to participants, self-selects only willing and able households. The fact that this method facilitates behaviour change may reduce it suitability for pure evaluation purposes

The effort required and so can result in a reduction in participation over time, reducing data quality (Sharp et al., 2010; van Herpen et al., 2019). Another inherent limitation to diaries is that they are mediated by the person who's behaviour is being studied (Giordano et al., 2019). Høj (2011) found that diaries underestimated food waste by 40% when compared to waste composition analysis. Giardano et al. (2019) recommend a combination of diaries and waste sorting (or waste composition analysis) to produce high quality qualitative and quantitative data.

### 2.4.4   Waste Composition Analysis & Direct Weighing

Waste composition analysis and direct weighing involve the direct measurement of food waste by the research team. Direct weighing typically refers to the measurement of total food waste. Waste composition analysis involves a range of techniques whereby the waste is separated and measured according to waste type. These direct approaches are considered more accurate that those involving self-reporting of food waste (Jorissen et al., 2015; Langley et al., 2010; Lebersorger and Schneider, 2011).

Direct weighing is a good option to gather data on total food waste generated and is less onerous than waste composition analysis. However, the latter can provide more information with classification of the food or waste type, and the state of the material possible. There are

significant difficulties with waste composition analysis, in terms of the inaccurate classification of food waste post-disposal. This is due to factors such as mixing, compaction, degradation and evaporation. These factors need to be considered to allow for accurate and reliable waste composition analysis. A number of studies have been carried out to identify the best methods for waste composition analysis of food waste (Elimelech et al., 2018; Langley et al., 2010; Lebersorger & Schneider, 2011). Dahlén & Lagerkvist (2008) carried out an extensive review of methods for household waste composition analysis (not just food waste) and made recommendations accordingly.

Lebersorger and Schneider (2011) discuss the various classification options for food waste measured using waste composition analysis in terms of avoidability, recyclability (possibly recyclable and non-recyclable), life-cycle stage (preparation residues. leftovers, whole unused food, partly consumed food) and (preparation state (fresh, ready to consumer, cooked or prepared at home) and food category (fruit, veg, drinks, bakery, meat and fish, other). Some of these categories are difficult to use due to the state of the food waste itself or the variances with waste management practices. These classification issues are intensified with degradation of the material. The classification system used by Lebersorger and Schneider (2011) is presented in Table 3.

*Table 3. Classification system from Lebersorger and Schneider, 2011*

| | Avoidability | Life-cycle stage | Packaging |
|---|---|---|---|
| Food Waste | Non avoidable | Preparation residues | |
| | Avoidable | leftovers | |
| | | Whole unused item | In original packaging |
| | | | other |
| | | Part consumed food | In original packaging |
| | | | other |
| | | Non-classifiable remainder | |

In addition to the classification system they propose, Lebersorger and Schneider make the recommendation to avoid the screening of waste before analysis Several steps have been suggested to address the difficulties of waste composition analyses.

In order to minimise degradation of food waste samples, best practices in waste composition analysis have been suggested by various practitioners.

*Sample Unit*

Elimelech et al, (2018) recommend that the sample unit for waste composition analysis is one household. This was also the sampling level used by Lebersorger and Schneider, 2011.

*Segregation*

Once food waste is combined in a container it can be very difficult to accurately re-segregate. Langley et al., (2010) employed a method where participants sorted and weighed food waste themselves, at the point of disposal to ensure fully accurate compositional data. In this case, participants were equipped with a detailed recording sheet (infact 5 sheets per day). Langley et al., (2010) acknowledge the significant burden this lays on the participants and the susceptibility to variation in data quality. They argue that despite these limitations, this is the most accurate method to measure food waste entering the waste stream.

In other work, specific food waste caddies are provided to participants to avoid some of the issues of contamination and compaction that may occur using households own waste infrastructure (van Herpen et al., 2019).

*Disposal – analysis gap*

Minimising the time between disposal and analysis is recommended to reduce chemical and biological degradation and evaporation. Dahlé & Lagerkvist (2008) recommend a 2-day maximum period between disposal and sorting, while Lebersorger and Schneider (2011) state that this frequency may be impractical in terms of municipal waste collection schedules. They argue that while waste should be sorted as soon as possible, exceeding the 2 day limit is "tolerable". Elimelech et al., (2018) suggest that daily collection and analysis of food waste is necessary to avoid inaccuracies.

While direct weighing and waste composition analysis are considered more accurate than other methods, they still have No one aspect of the food system is entirely responsible for the current levels of waste. the potential to underreport total food waste. For example, it does not include food waste disposed to drain, home composted (van Herpen et al., 2016)fed to animals or disposed of in the incorrect waste stream. Establishing the extent to which these alternate disposal methods take place may improve the accuracy of total food waste estimates. For example, in Irish households, organic non garden waste makes up 13.6% of total municipal solid waste and 2.3% of mixed dry recycling (EPA, 2018). There are no data on food waste disposed to drain or for home composting in Ireland. In the UK, a WRAP study in 2009 using food waste diaries, found that over 1 million tonnes of food waste were being disposed of to drain.

### 2.4.5   Photographs

Photography can be used as a reactive method of food waste measurement that involves the participants taking photographs of their food waste and sharing these with the researchers. Researchers subsequently code the photographs and estimate the quantities of waste food (van Herpen & van der Lans, 2019). Photographed coding has been successfully used to assess consumed food by comparing photographs of food served and plate waste (Martin et al., 2019). Van Herpen & van der Lans (2019) studied the efficacy of this method for food waste quantification by comparing the estimates of nine coders who were undergraduate students. The coders, who were unaware of the study design, were asked to estimate the weight of food in photographs. These estimates were compared to the actual weight of the food, and to each other. Coders were given some training on the task (but not in coding or weight estimation method) ahead of the activity and were encouraged to find reference weights online if possible. Estimates show high correlation with actual weights and with each other. Coders did not systematically over- or under-estimate weights (van Herpen & van der Lans, 2019). Limitations of this approach, which were not tested by van Herpen & van der Lans, include waste that contain mixed food components (e.g. salads), or food waste in other types of containers. Technology developments allowing for automated photographing systems may provide reliable method of quantification with low burden for participants in the future (van

Herpen et al., 2019). Interventions that incorporate automated photography are discussed in section 3.8, Information and Communication Technology Interventions.

### 2.4.6 Inference

Although not listed in recent best practice guidance (Nijenhuis-De Vries et al., 2016) an inferential mode of quantification has also been used in the past. This involves interviewing or using a diary method for participants to record the total amount of food purchased/brought into the home and the total amount of food wasted. It does not directly mention with food waste therefore it is "nonreactive" and therefore, may have less potential to influence the food wate behaviour or attitudes of participants (Gallo, 1980). Proportional reporting has also been used (Aschemann-Witzel et al., 2017; Graham-Rowe et al., 2015; Stancu et al, 2016; Stefan et al., 2013). With this approach, participants report (through the use of interviews or surveys) the proportion of total food brought into the home that ends up being wasted. Total food waste can be inferred by comparing to some measure of total food acquired.

# 3.    Interventions

In order to inform the latter stages of our research, a review of existing food waste prevention interventions was carried out. This review focused on the scientific literature and grey literature and but also included other online sources.  In addition to the underlying principles of best practice, gathered from the literature in the previous section, this section will outline the various types of food waste prevention interventions providing specific examples of each where possible. Included are details on the best practice principles underpinning the works within each of these intervention modes.

People across the world are working to solve the problem of food waste at a household level. Some of these projects or interventions are being carried out by researchers and are being reported in the scientific literature while many more are being carried out by local governments and community organisations. The latter are less commonly represented in the scientific or even grey literature. In order to gather a full picture of existing food waste prevention interventions, a broad online search was carried out in addition to the literature review.

There have been some recent systematic reviews carried out of food waste prevention interventions (Kim et al., 2019; C. Reynolds et al., 2019; Schanes et al., 2018). In 2015, the EU project FUSIONS compiled a list of policies and legislation for all 28 EU member states. These country reports outline national strategy, market-based instruments, regulations, voluntary agreements, technical reports, scientific papers, communications and campaigns, projects and other measures (FUSIONS, 2015). Additionally, STEFOWA an EU Interreg project compiled a profile of all food waste prevention activities for countries in Central Europe (Obersteiner and Schwödt, 2016).

Behaviour change interventions can be categorised into two groups, antecedent or consequence. Antecedent initiatives focus on altering the context preceding the behaviour while consequence interventions focus on the behaviour's consequences. Examples of the former include information provision, prompts, modelling, and commitment while the latter

typically consists of interventions based on feedback, rewards, and penalties (Stöckli, Niklaus, et al., 2018).

A selection of existing food waste prevention interventions is discussed below. Interventions are organised according to type, based on work by Refresh and others (Wunder et al., 2019**;** Pelt et al., 2020)
These are:

**Information**

**Social influence**

**Psychology-based**

**Economic Instruments**

**Regulations**

**Nudges and organisation of choice architecture**

**Voluntary agreements**

**Strategies and guidance**

**Information and Communication Technology (ICT)**

It is worth noting that there are various ways in which behaviour change techniques or interventions can be arranged. Mitchie et al. 2015 list 93 discrete behaviour change techniques and organise them into 16 groups. However, for the purpose of this research we will focus on nine broad intervention categories listed above.

## 3.1 Information

Information based interventions have been heavily relied upon in the past and continue to be one of the most common approaches to food waste prevention (Priefer et al., 2016; Stancu et al., 2016; Stöckli, Niklaus, et al., 2018). A recent study found that out of food waste prevention 23 interventions reviewed, 16 were based on the provision of information (Kim et al., 2019).

Of course, if individuals do not have the information, they cannot make decisions about their behaviour based on it (Umpfenbach, 2014). As such there is a critical place for the provision of information in behaviour change. Historical information-based approaches can be broken into two categories: 'attitude-behaviour' and 'economic self-interest'. The 'attitude-behaviour' approach relies on the idea that by providing information, one can first change public attitudes, which in turn leads to changes in behaviour. The economic self-interest approach assumes that individuals will assess the information they are given and make choices that benefit them economically e.g., installing energy efficient appliances at home (McKenzie-Mohr, 2011). These simplistic assumptions fail to recognise the strong influence of many of the social and psychological factors discussed above, a phenomenon sometimes referred to simply as the "intention-behaviour gap" (Wunder et al., 2019) .

It is now widely accepted that information-based interventions are not an optimal mechanism for achieving behaviour change – for food waste prevention or other issues relating to environment or consumption (Abrahamse et al., 2005). For example, recent work by Refresh found that awareness of the problem of food waste did not significantly influence waste levels (van Geffen, van Herpen, and van Trijp 2017). In a study that analysed the effect of co-occurring interventions across environmental behaviour, Osbaldiston and Schott (2012) found information-based campaigns to be less successful when compared with cognitive dissonance, goal setting, social modelling and prompts. This has been corroborated by McKenzie-Mohr (2011) who provides numerous examples of the lack of success of information-based only campaign.

There have been several examples of food waste information interventions that have recorded positive results (Reynolds et al., 2019). However, evidence suggests that providing information alone is far from the most efficient way to change behaviour.

That said, information-based campaigns are still widely implemented, especially by government and institutional actors. This is likely due to the fact that they are relatively easy and visible (McKenzie-Mohr, 2011) and that those often contracted to run and manage such campaigns are usually creative or advertising rather than behaviour change experts (McKenzie-Mohr, pers comm).

However, while evidence suggests that purely information-based campaigns are ineffective, the provision of information as part of a wider campaign is still a crucial aspect of behaviour change (McKenzie-Mohr, 2011; Priefer et al., 2016). In terms of the successful attributes of information-based campaigns, Refresh noted some key recommendations to improve information-based campaigns. These include:

- The use of positive messaging

- Focussing on abilities rather than awareness of the issue

- Careful consideration of the narratives used (Wunder et al., 2019)

### 3.1.1 Awareness

Awareness interventions focus messaging on the relevant problem with the aim of educating people about it, and its importance. According to Priefer et al. (2016) awareness campaigns should be specific to a target audience, should be implemented in close collaboration with retail and the hospitality businesses. Due to the above recommendation to avoid awareness only campaigns these intervention types are not discussed any further.

### 3.1.2 Prompts

Prompts are messages, either verbal or written that act as a reminder of the target behaviour (Osbaldiston & Schott, 2012). They have been shown to be more effective at achieving behaviour change than purely information-based interventions (Stöckli, Niklaus, et al., 2018). While some other forms of information-based interventions provide *justification* (why-to) prompts provide *instruction* (how-to). Prompts address the fact that for many target behaviours, the simple act of forgetting to do so one of the major barriers to adoption (McKenzie-Mohr, 2011). They have been shown to be an effective element of behaviour change campaigns. McKenzie-Mohr provides guidelines on the effective use of prompts. To be most effective, prompts need to be explicit, noticeable, self-explanatory, close in space and time to the target behaviour and should focus on encouraging positive behaviours rather than discouraging negative actions. In addition to this list, Stöckli et al. (2018) suggest that prompts need to be politely written and work best when the target behaviour is easy to perform.

Prompts have been shown to be effective at reducing food waste in self-serve dining facilities (Stöckli, Dorn, et al., 2018).(Whitehair et al., 2013) (Kallbekken and Sælen, 2013)

In a household settling, sticker prompts have been shown to cause a significant increase in food waste segregation (Shearer et al., 2016).

### 3.1.3 Skills

Information based intervention can be successful when they focus on skills and abilities. Similar to prompts, skill-based interventions focus on instruction rather than justification. This aligns with the idea from the Theory of Planned Behaviour that perceived behavioural control can be an important determinant of behaviour change. If individuals perceive themselves to be able to solve or have control over a certain issue or problem, they are more likely to intend to change their behaviour to try to deal with it (Graham-Rowe et al., 2015).

Van der Werf et al. (2020) applied the Theory of Planned behaviour to an information-based campaign in Ontario Canada. Using randomise control testing, and waste composition analysis, the team recorded a 30% decrease in the level of avoidable food waste using this approach.

The intervention was multi-facetted. It included the provision of information and tools through a food waste pack. Messaging was focused on saving money and information centred on individuals perceived behavioural control of food waste. Test households were given a food waste pack containing an explanatory letter, a postcard and fridge magnet with key messages, freezer stickers and shopping list notepad. All materials included directions to the intervention website with further information. Participants were also sent 5 emails during the study period, which lasted 2 weeks.

## 3.2 Social influence

Work throughout the fields of behaviour change and sociology shows that social influence has the capacity to change behaviour. While Wunder et al., (2019) include social norms as a

sub-category of information interventions, in this work we aim to explore social influence in a broader content and therefore have separated it into a category of its own. There are several forms intervention based on social influence. (Abrahamse & Steg, 2013) split these into six categories:

- **Social norms in information and feedback provision**
- **Block leaders and social networks**
- **Public commitment making**
- **Modelling**
- **Social comparison in feedback provisioning**

### 3.2.1 Social Norms

Social norms are "rules and standards that are understood by member of a group, and that guide or constrain social behaviour without the force of law" (Cialdini & Trost, 1998). They are considered a crucial aspect of behaviour change, particularly that of populations (Reynolds et al., 2015). Refresh identified descriptive social norms to be the most important determinants of consumer food waste (Van Geffen et al., 2016).

There are various categories of social norms that exist at both a collective and individual level (Lapinski & Rimal, 2005). These include injunctive[3], descriptive[4], collective[5] and perceived[6] norms.

There are three identified sources of information for social norms. These are observable behaviour, direct and indirect communication, and knowledge of oneself (Miller & Prentice, 1996). In order for social norms to change, they need to therefore be either observable or directly communicated. Observable social norms tend to be more readily adopted by a

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[3] Injunctive norms are those which deal with morality. They provide information on behaviours that are approved or disapproved of (Cialdini, 2003).
[4] Descriptive norms are those which can be observed. They provide information about what is typically done
[5] Collective norms are those which are held and maintained by a group of people are develop over time through convergence of behaviour (Bettenhausen & Murnighan, 1985)
[6] Perceived norms are an individual's interpretation of collective norms. Due to the unspoken nature of social norms, there may be significance variation between perceived and collective norms (Lapinski & Rimal, 2005). Overtime, these can become internalised or personal norms.

population (Lapinski & Rimal, 20050. In order to use social norms for food waste interventions, situations could be created where the desired food waste prevention behaviour is observable. Alternatively, norms based on direct and indirect communication or knowledge of oneself could be used. It may be possible to use descriptive norms within tighter social groups like families and close friends, where food management behaviours are observed within the home by others.

Injunctive norms are what people believe 'ought to be done' and therefore are relevant to food waste. Unlike descriptive norms, which provide information on how present a behaviour is, injunctive norms deal with the morality or appropriateness of a behaviour. In their PhD thesis, Liu (2017) examined the effect of culture on injunctive social norms and food waste. This work used mock social media posts, with varying messaging and apparent user engagement (by generating comments, thumbs ups and thumbs down reactions to the post). representing different levels of perceived injunctive norms. The work was carried out in the USA, classed as having low context (loose) culture and China, with a high context (tight) culture. Communication typically tends to be more direct in low context cultures than in high with less reliance on perceived meanings or values. Liu found that people who perceived their culture to be tighter were more influenced by the effects of injunctive norms.

The potential of a social norm to influence behaviour is dependent on the group or setting. But people have been shown to want to reduce their waste if they know that their social group is doing so (Van Geffen et al., 2017)

### 3.2.2 Block leaders and social networks

Diffusion of innovation theory (Rogers, 1995) posits that social networks are crucial to the spread of information. Block leaders can be explained as volunteers who share information amongst their peers. This approach is underpinned by the supposition that information sharing is more effective when messages are relayed by members of a shared social network to one another (rather than by someone outside of that social network). Many food waste interventions have used approaches rooted in this theoretical basis where block leaders and

their social networks have been targeted in different ways in order to change food waste behaviours in particular social groups. Some of these approaches include food sharing and skill sharing among social networks. Community fridges are a commonly applied mechanisms used for this approach.

**Food Sharing:**

Literature on collaborative consumption (e.g. (Albinsson & Perera, 2012; Belk, 2010; Botsman & Rogers, 2010) acknowledges collaborative consumption as peer-led activities involving procuring, offering, or sharing the access to goods and services through the use of information and communications technologies (ICTs), including trading, swapping, lending and rental. Food sharing has been considered a potential mechanism for food waste prevention at a community level. The SHARECITY100 Database, an output from a European funded research project, identifies 3,644 food sharing initiatives all over the world (Davies, 2016). This includes 47 initiatives in Dublin. Another output from the Share City project is a free online toolkit which can be used to generate a sustainability impact assessment regarding any food sharing initiative.

**Community Fridge**

Generally, a community fridge (sometimes also referred to as a public fridge, a solidarity fridge or honesty fridge) is a central space where local people (individuals and businesses) can give or take surplus food. In the UK, the Community Fridge Network (CFN) is coordinated by the environmental charity Hubbub. The CFN was first established in 2017 and now the network is made up of 110 active locations. Hubbub (2020) reports that between November 2019 and October 2020, over 2,000 tonnes of surplus food were redistributed to over 150,000 unique visitors at these locations. Hubbub identify that the main aim of the network is to support peer-to-peer learning and resilience. Food waste impacts of the community fridges as identified by Hubbub include: a reduction in household food waste as people are enabled to donate food via the fridge and a reduction in household food waste as people have benefited from food saving advice and recipes at the fridges. In the case of this network, 95% of the donated foodstuffs are given by businesses with the remainder emanating from domestic donations. Hubbub has a redistribution arrangement with seven major retailers.

Hubbub (2018) has published a 'How To' Guide and provides each member of the Community Fridge Network with a Resource Pack.

### 3.2.3 Public commitment making

Public commitments have been shown to be an effective engagement approach. When an individual makes a public commitment, they are more likely to carry out a behaviour than otherwise. This is due to our aversion to behaving inconsistently. By making a commitment to a cause or action, we very slightly redefine our understanding of ourselves as someone who is committed to this topic. Therefore, to some degree we will try to avoid behaviours that contradict this belief ((McKenzie-Mohr, 2011).

Public commitment around food waste prevention has been widely adopted at the government and large business level. The SDG 12.3, the Courtauld Commitment (WRAP, 2020) and the Food Waste Charter for Ireland[7]. This approach has been used in some instances with individuals. Examples of these include Stop Food Waste Day (INT)[8], Feedback (UK)[9] Earth Overshoot Day (INT), Waste Reduction Week Canada[10], Small Action Big Impact (UK)[11] and FoodWise (AUS)[12].

Self-perception theory plays a role in the efficacy of pledges. Individuals build their idea of themselves by observing their own behaviour and the circumstances of their behaviour (Bem, 1972). Research shows that is people make a commitment to something, particularly if this commitment is public, they are more likely to carry out the behaviour in question (McKenzie-Mohr, 2011).

### 3.2.4 Modelling

Modelling is a form of behaviour change intervention that that involves the demonstration of the desired behaviour or the clear indication that the person presenting the information

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[7] https://foodwastecharter.ie/
[8] https://www.stopfoodwasteday.com/en/index.html
[9] https://feedbackglobal.org/join-movement/
[10] https://wrwcanada.com/en/food-waste-pledge
[11] https://www.smallactionbigimpact.com/december-pledge
[12] http://www.foodwise.com.au/about-foodwise/sign-up-to-be-foodwise/

engages in the behaviour themselves (Osbaldiston & Schott, 2012). Modelling behaviours can include activities such as the publication of online videos (Quested, 2109), or the hosting of cooking demonstrations etc. It can also involve a more peer-to-peer diffusion of information(McKenzie-Mohr, 2011). Modelling builds on many of the concepts behind social networks and block leaders but as an approach it specifies the demonstration of the desired behaviour. The person delivering the information or modelling the behaviour can be an important factor for modelling and block leaders. People typically are more willing to engage with those they like and are more likely to comply with a request if they deem themselves similar to the person requesting (Burger et al., 2004; Cialdini & Goldstein, 2004).

Online videos and cooking demonstrations have been commonly applied to food waste prevention in Ireland and abroad. However, found no reported or evaluated intervention of this nature.

### 3.2.5   Comparative feedback & competition

The use of competition or comparative feedback involves providing individuals with information on their own performance but also that of others relative to them. This builds on people's tendency to compare themselves to others to help make sense of their own opinions and behaviours. It has been shown to encourage people to engage in sustainable behaviours, especially when the feedback is about people who are similar  (Abrahamse & Steg, 2013). This approach was used as part of a Dutch intervention in 2012, called FoodBattle. This intervention involved a collaboration with a supermarket, and combined an event, the provision of information and tools as well as the use of a food waste diary.  Participants were provided with a box with information, storage and portioning aids, they were invited to participate online through surveys (before and after) and online games. The intervention involved a competition between three districts and the use of local champions. The effect of tis intervention was measured using both surveys and direct waste sorting. In total, 62 households fully participated in the intervention. ON average, these households reduced food waste by 20% during the three-week period (Nieuwenkamp, 2013). The research intervention called BinCam also used comparison/competition as an aspect of their intervention. Households' recycling and food waste performance was tracked on a league table. .

## 3.3 Psychology

Psychology based interventions are most commonly designed using the Theory of Planned Behaviour as a framework (Pelt et al., 2020). Of course, there is overlap between psychology- and sociology-based intervention, the difference remains that the former focus on the individual. The key example of a psychology-based intervention for food waste prevention used cognitive dissonance.

### 3.3.1 Dissonance based

(Pelt et al., 2020) carried out 3 experimental interventions in France in late 2014 in order to compare the effectiveness of an information-based intervention, awareness raising intervention and a dissonance-based intervention. They applied quantitative evaluation through waste composition analysis, before, 1 week and 5 weeks post intervention.

The information-based sample were given leaflets providing advice on how to reduce food waste. In order to raise awareness, this sample was asked to keep a food waste diary for one week. The dissonance-based intervention aimed to use cognitive dissonance and induced hypocrisy to trigger behaviour change. In order to do this, subjects are facilitated or encouraged to "preach" about food waste prevention followed by a prompt to recall their own behaviour. The idea being that they will identify the gap between their normative beliefs and their past-transgressive behaviours. In this case, this was done on paper, by asking participants to fill in a form about how food waste can be reduced, and to include their name age and city of residence. This form was followed by a private survey where they were asked to recall the detail of food thrown out in the last 2 weeks. Finally, participants in this group were given an intention implementation plan and an informative leaflet.

(Pelt et al., 2020) found that the dissonance-based intervention was more effective than the information-based intervention in the medium term (5 weeks). The awareness intervention using a food waste diary did not result in significant changes to food waste, contrary to proposal by (Visschers et al., 2016).

## 3.4 Economic Instruments

Economic instruments are a tool that can shift food consumption practices towards more sustainable alternatives (Reisch et al. 2013; Schanes et al., 2018). They have been applied infrequently to deal with food waste. In Italy, tax incentives were introduced to encourage food donation. The French have been using penalties for supermarkets that do not redistribute surplus food (LOI no 2016-138). There are no well-known examples of economic instruments used at a regional or national scale to address consumer food waste. Currently, too little is known about the effectiveness of taxes and fees on food waste prevention (Schanes et al., 2018).

At an individual business level, a small number of restaurants have implemented payment models where customers pay extra for any food left on their plate. Examples on this include Asian restaurants in New York, London and Stuttgart[13][14] and a buffet in Switzerland[15] . Coverage of these policies is limited to newspaper and magazine articles and there is little evidence to their effect.

Altering pricing for waste disposal is an economic or regulatory option that may influence food waste generation. However, from a waste enforcement point of view, increased disposal costs have the potential to encourage incorrect segregation, illegal dumping and back-yard burning. In Ireland, waste disposal costs are currently designed to incentivise segregation, with food waste streams often being the same cost or cheaper than mixed waste.

The relative cost of food is believed to play a role in the levels of food waste at a consumer level (Evans, 2012). It is hypothesised that an increase in the cost of food would lead to a decrease in the level of waste. According to Wunder et la., (2019), the internalised external cost of food is not represented in the price we pay i.e., current food prices do not account for the actual environmental or human cost of food production.

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[13] https://www.good.is/articles/could-charging-people-for-uneaten-food-in-restaurants-help-us-stop-wasting-it
[14] https://www.thelocal.de/20160816/eat-up-or-pay-up-why-guests-are-charged-for-leftovers
[15] https://www.thedailymeal.com/swiss-restaurant-charges-customers-unfinished-food/51014

## 3.5 Regulations

Food waste prevention regulations have been implemented in the commercial and processing sectors. However, none have been introduced that focus on consumer food waste. to date Regulations that have the potential to impact consumer food waste include those regarding food date labelling, prohibition of certain practices (e.g., buy-one-get-one-free promotions), packaging requirements and consumer education. For the most part, these regulations are directed at the manufacturing and retail sectors, while the intended impact is at consumer level food waste (Wunder et al., 2019).

During this review, we found no evidence of any food waste prevention specific regulations being implemented. Where food waste specific regulations have been introduced, they have typically dealt with the segregation and management of food waste.

For example, in 2015 the European Union (Household Food Waste and Bio-waste) Regulations was introduced to Ireland. This built on the commercial food waste regulations introduced in 2009. These regulations were in line with the Waste Framework Directive and made it a requirement to segregation food waste for disposal at a household level. This regulation was introduced first to large population centres and then over time down to areas of population of 500 or more. This regulation focuses solely on food waste segregation. However, many actors in food waste management suggest that the process of segregating waste can lead to food waste prevention through improved awareness and visibility of the food waste within a household (Reynolds et al., 2019).

## 3.6 Nudges and the organisation of choice architecture

Nudging is a process of changing behaviour that does not involve coercion. Rather than convincing people to consciously change how they behave, nudging using automatic cognitive processes to achieve the desired behavioural outcome (Sunstein & Thaler, 2008; Wunder et al., 2019).

As of yet, there is very little published work of the effectiveness of nudges in household food waste prevention. Von Kamake and Fischer (2018) explored consumer perceptions on the topic but did not apply any nudges or measure behaviour change.

Nudges have been shown to be successful in preventing consumer level food waste in food service settings. For example, several studied have found that a reduction in the size of the plate used in self-service dining can significantly reduce food waste (Kallbekken and Sælen, 2013; Richardson et al., 2020). Research has also been conducted in school settings, exploring the effectiveness of nudges with children who are provided with school lunches. In these instances, nudges are implemented in the form of signs, verbal cues by staff and were paired with some skill sharing with the children, for example on how to peel fruit (Vidal-Mones et al., 2019). Nudges have also been successfully implemented to encourage the uptake of 'doggy-bags' or the practice of taking leftovers home after a meal in a restaurant (Nudge Unit Greece, 2017). In the household setting, nudging (through the provision of food waste caddies) has also shown to be effective for improving food waste segregation (Regional Waste Management Offices, 2020; Zhang and Wang, 2020).

Nudging is discussed in more detail in the accompanying report "Review of relevant consumer behaviour change studies and initiatives".

## 3.7 Voluntary agreements, strategies and guidance

Voluntary agreements were identified by early Refresh work as one of three core areas of food waste prevention warranting further research (the others being consumer behaviour and food surplus valorisation). The coalition, started by defining voluntary agreements within the context of food waste:

> Voluntary Agreements (VAs) are self-determined commitments or pacts with qualitative and quantitative objectives, developed by private entities and/or other stakeholders in consultation with their signatories. They are used as alternative courses of action to

traditional legislation, can be piloted by government officials, businesses or other actors, and can be used in addition to, or independently from existing legislation.

According to Refresh, the flexible and collaborative nature of voluntary agreements make them very effective tools for food waste prevention in the supply chain. However, there is no discussion of their application with consumers, other than the potential of consumer recognition for food businesses (Burgos et al., 2019).

There are numerous examples of Voluntary agreements in the food manufacturing, retail and service sectors. In Ireland, the Food Waste Charter was launched in 2017 as a voluntary agreement for the entire food supply chain. The Courtauld Commitment in the UK is a key example of the potential of voluntary agreements to achieve food waste reductions.

At a consumer level, many organisations have implemented voluntary agreements through pledges and public commitments (see section 3.2.1).

## 3.8 Information and Communication Technology (ICT)

The use of information and communication technology is increasing being incorporated into all of the intervention types previously discussed. The integration of technology into food waste prevention is broadening the scope of interventions and creating the opportunity to lessen the burden of participation. To date, ICT interventions have focused on both household food infrastructure and also on relevant food behaviours. They have worked to assist people in the activities of meal preparation, food shopping and the use of food already in the home. In some instances, these technologies act as prompts, in others they allow skill sharing or the provision of information. Some examples of ICT interventions include Fridge Cams, interactive fridges, meal planning apps and online social networking for food waste.

Nyugen et al, (2015) designed a prototype interactive fridge that performed three functions: stickers to help group food, sliders with colour coding to indicate food state and an LCD screen to provide graphic and sound feedback. They found that the prototype was successful in changing behaviours around food grouping and awareness of the availability of food.

Soma et al., (2020) trialled three food waste prevention interventions in Toronto, Canada, including one that involved ICT through online gamification. The first intervention was a passive information intervention (distribution of booklet and sticker prompt). The second was and a community engagement intervention (information combined with workshops provided by Love Food Hate Waste). The gamification intervention involved the use of an online quiz on food waste with the information. A fourth control group was also studied. Soma et al. (2020) evaluated the interventions using before and after waste audits and surveys and a focus group after the interventions. They found a marginally significant reduction in food waste with the gamification group compared with the control group. No differences were detected in the other groups. Participation in the intervention was also measured and the passive group and gamification group experiences similarly high participation while the community engagement group had very low participation.

# 4. Conclusions

In order for widespread behaviour change to occur, food waste interventions must be developed that can achieve effective and long-term behaviour change through economically viable means. To this end, interventions which draw from contemporary interdisciplinary knowledge and are carefully designed in a manner in which they can be reliably evaluated and improved will be most effective.

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