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Review

What Nudge Techniques Work for Food Waste Behaviour Change at the Consumer Level? A Systematic Review

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Abstract: In European countries over 40% of food loss and waste occurs at the retail and consumer stages; this situation cannot be sustained and remediation is urgently needed; opportunities for change must be created. "Nudge" techniques have been shown to be effective in changing behaviour in areas related to food consumption (e.g., healthy diet), but the effectiveness of interventions using nudge techniques to change food waste behaviours remains unclear, despite a growing body of research. The aim of this review is to elucidate means to change household food waste behaviour using nudge approaches and identify priority needs for further research. Four databases, grey literature and reference lists were searched systematically to identify relevant research on nudges to change food waste behaviours. This search identified sixteen peer-reviewed research articles and two grey literature reports that were critically appraised using a critical appraisal checklist framework for descriptive/case series. Four studies deemed reliable show interventions using nudges of social norms, reminders or social norms with disclosure were effective in changing food waste behaviours at the household level, while disclosure alone, i.e., revealing environmental costs of food waste, was not. This review, unique in the application of a critical appraisal, suggests there is reliable information on the effectiveness of nudge for food waste recycling interventions when incorporating nudges of social norms, reminders or disclosure alongside use of social norms. If food waste recycling behaviour is considered an upstream measure to raise consumers' consciousness on the amount of food waste they produce, this may have a positive impact on food waste reduction and therefore has important policy implications for food waste behaviour change at the household level.

Keywords: food waste; behaviour change; consumer; household; nudge

Citation: Barker, H.; Shaw, P.J.; Richards, B.; Clegg, Z.; Smith, D. What Nudge Techniques Work for Food Waste Behaviour Change at the Consumer Level? A Systematic Review. *Sustainability* **2021**, *13*, 11099. https://doi.org/10.3390/su131911099

Academic Editors: Jun Yang, Ayyoob Sharifi, Baojie He and Chi Feng

Received: 4 September 2021
Accepted: 30 September 2021
Published: 8 October 2021

1. Introduction

Sustainability aims to protect the natural environment specifically human and environmental health, while compelling innovation so as not to compromise lifestyle for future generations [1]. Approaches to sustainability intend to maintain the delicate ecosystems of earth in balance, usually through encouraging renewable fuel sources, protecting physical environments and decreasing carbon emissions. At present, poor sustainability is a key concern affecting the global food system [2]. This situation is a significant problem globally for societies and governments. Food processing and production create environmental problems along the entire food supply chain [3,4] with direct effects on environmental resources through use of fertile soils, fresh water, energy, fertilisers and release of carbon emissions in the production and transport of food [5–9]. Globally, approximately a third of total food produced is wasted or lost [7] along the food supply chain [10]. In European countries 21–33% of food is lost during agricultural production, 21–25% during manufacturing, storage, processing and distribution, and over 40% at retail and consumer stage [11–13]. In the UK, more than £19 billion worth of food is lost or wasted annually [14]. A focus on tackling this complex problem at consumer level is an essential part of the multifarious

puzzle. The targets set under the United Nations' Sustainable Development Goals call for halving per capita food waste at the consumer level by 2030 [15].

In order to shift from the current situation of high household food waste to a more sustainable future for food waste, behaviour change will be necessary. General information can affect the motivation for and ability to change behaviour [16,17], for example information awareness campaigns [18,19] as frequently individuals lack awareness of environmental sustainability issues relating to food [20]. However, to create change at appropriate scale and speed, additional approaches to awareness campaigns would be required [21]. Research shows that although information is valuable, when offered alone this is not where the key to motivating change lies [19]. Opportunities for change must be created. Constructing opportunities to change household food waste behaviour can be simple, e.g., making preferred choices more accessible. Examples include positioning food waste caddies in households in easy reach to support recycling of food waste, offering household food deliveries containing optimal food amounts to avoid surplus, or encouraging food portioning tools that help to avoid over-portioning and thus reduce plate waste.

Psychologists and neuroscientists have developed a description of brain function based on two systems, system 1—processes that are automatic, unconscious and fast and system 2—reflective, controlled, slow and effortful [22–24]. This dual process is a theoretical basis for nudge theory, with nudge proposing that system 1, automatic decisions, can be systematically triggered to change behaviours and improve outcomes going with the flow of human nature [22,25].

Nudging [26] behaviours in this way, has considerable merit in this context. Nudging was developed from ideas advanced by Daniel Kahneman [27]. It is challenging to offer a universal definition of the term nudge as understandings of nudge can vary broadly [22]. Economist Thaler and legal scholar Sunstein convey the concept of "nudging," defined as "any aspect of the choice architecture that alters people's behaviour in a predictable way without forbidding any options or significantly changing their economic incentives" [28]. There is a growing interest in nudging as despite usually incurring low cost, they can deliver results and be highly effective all the while negating unpopular rule setting [29]. Subsequently, Bornemann and Smeddinck [30] identify five criticisms of nudge: conceptual, normative, functional, empiric and practical [31]. Conceptual criticisms question the reach of nudge and boundary between nudges and other behavioural influences, normative criticisms express concern over potential manipulation of moral concepts relevant to freedom, independence and objective information [31]. Functionality concerns the effectiveness of the nudge approach, while empiric broaches the efficiency of the method and long-term success [31]. Moreover, practical issues concerning knowledge on the decision context reflect resource demand and cost of implementation of nudge approaches [32]. These five concerns mainly centre around hard-to-avoid hidden automatic defaults, which is inconsistent with the definition offered by Thaler and Sunstein [28], thus most normative, functional and empiric criticisms may be overcome with judicious planning and implementation [31]. If resources are available then practical issues may be overcome; this is the same as with countless other interventions. Conceptual concerns are reflective of the wide-reaching applications and understandings possible to the nudge approach and will always provoke discussion due to individual perspectives of nudge [31].

In the food domain, nudging has been applied largely in response to the obesity epidemic [33] and, to a lesser extent to encourage environmental initiatives affected by food consumption, e.g., reducing red meat consumption [34]. For information on nudge interventions more broadly related to the food supply chain a systematic review shows that there is evidence to support "green nudging" as effective in leveraging more sustainable practices for farmers and consumers [35]. There remains minimal application of nudges in the context of household food waste behaviours, and those published tend to focus on eating-out options [36–38]. However, research on food waste behaviours has expanded in recent years, leading to a requirement for a systematic review to appraise critically the

body of research evidence and to understand what works to change household food waste behaviours and what are the priority needs for further research. A recent review developed a systematic map of existing research on behaviourally informed interventions targeting changes in consumer food waste and consumption behaviour [39]. However, a feature missing was 'a critical appraisal of each individual study . . . (as) . . . this is not a common standard for systematic maps' [39]. Previous reviews on food waste in households have not included a quality assessment of the studies included and have focused on policy actions, interventions for food waste reduction, food waste drivers, causal mechanisms for food waste behaviour, comparison of food waste amounts or avenues for future research. This review addresses the gap in critical assessment.

Frequently applied theoretical bases for behaviour change interventions include the transtheoretical model, social cognitive theory and the theory of planned behaviour [40]. This present review acknowledges that often these theoretical frameworks can work in parallel with nudges [41] and these theories explain why various nudges may be effective. Self-monitoring and other self-regulatory techniques (goal-setting, prompting, self-monitoring, providing feedback on performance, goal review) are consistently reported as effective behaviour change tools [42,43]. Some of these elements also constitute nudges per se. From a policy perspective, nudge interventions have advantages. Firstly, relative affordability, and secondly, ease of implementation and scope for adaptation in different contexts [28,29,44]. As shown [35,44–46] nudges can be considered not as a replacement to firmer environmental and food policies, but rather as a complement.

Ten optimal nudges have been identified with examples to define the scope of nudge in this review as shown in Table 1. They are in line with definitions described by originators of the nudge concept [29], these definitions are also used specifically in the context of food waste in a peer-reviewed primary data study [31].

Table 1. Identification of Nudges.

A. Default rules, e.g., automatic enrolment in programs such as external meal planning and fee-based strategically portioned food ingredient delivery
B. Simplification, e.g., reducing barriers of target behaviour
C. Use of social norms, e.g., Regular exchange about personal experiences on the reduction in food waste with friends and neighbours
D. Increase in ease and convenience, e.g., making low-waste food options visible
E. Disclosure, e.g., revealing environmental costs associated with food waste
F. Warnings, graphic, or otherwise, e.g., Pictures that demonstrate how food waste damages the environment
G. Pre-commitment strategies, e.g., A challenge on household food waste reduction with a friend
H. Reminders, e.g., Tips on shopping planning via email
I. Eliciting implementation intentions, e.g., asking "do you plan to reduce food waste?"
J. Informing people of the nature and consequences of their own past choices, e.g., Feedback on financial costs of an individual's food waste

The aim of this review is to determine what nudge techniques work for food waste behaviour change through comprehensive literature search, review, critical appraisal and discussion of relevant papers.

2. Materials and Methods

To identify the peer-reviewed literature on this topic, four databases were searched: Scopus, IBSS, Web of Science and Psych Info in March 2021. The search terms used were (Nudg* OR "Architect* OR Choice Architect* OR "Behavioural insights") AND ("Food Waste" OR "Food Loss") AND (Consumer* OR domest* OR Household*). Studies were identified on the basis of inclusion (Table 2) and exclusion criteria and then assessed as

full text articles. Figure 1 shows the search process as conducted. For the initial screening of titles and abstracts the free website Rayyan, developed by Mourad Ouzzani, Hossam Hammady and Ahmed Elmagarmid, was used to sort and organise the literature; articles were included or excluded on the basis of the title and abstract fitting the inclusion criteria (Table 2) and exclusion criteria, i.e., not inclusion criteria and no review study designs. Next a file was created on Elsevier Mendeley reference manager for full text PDFs identified. The inclusion and exclusion criteria (Table 2) were applied again to these texts on full reading.

Table 2. Inclusion criteria to select relevant papers.

Subject Inclusion Criteria	
Dates	2011 to March 2021. Rationale for 2011 cut off is that 2010 was the year the Nudge Unit was established in the UK government cabinet office [26].
Subject intervention	Any intervention or exploratory study that investigates interventions using nudges to change household food waste behaviours. (Food waste: the definition of food waste is taken as authors own definition and use of term 'food waste'. Rationale for this approach is due to heterogeneity of definitions of food waste in the literature [6])
Setting/sample	Household
Published and peer reviewed	Europe
Language	English
Study design	Qualitative and quantitative studies

Reference lists were searched in all papers identified for full text articles. The grey literature search was carried out in UK-only institutions due to limitations of resource and English language inclusion. In this review eight major UK supermarket websites (Tesco, Sainsbury's, ASDA, ALDI, LIDL, Morrisons, Waitrose and Coop) and the UK's Waste and Resources Action Programme (WRAP) webpages were searched.

When all papers were collated and those meeting the criteria selected, a critical appraisal of the studies was completed. Previous systematic reviews on food waste have not included a critical appraisal [39,41,47–49].

The quality appraisal is therefore a novel contribution and focused on aspects likely to affect the validity of the results including design, the methods of observation, adequate reporting, statistical analysis, sample sizes and allocation. A framework based on the Joanna Briggs Institute Critical Appraisal checklist for descriptive/case series [50] was applied. No meta-analysis was carried out as the identified studies were heterogeneous in type of design and results. A process of assessment was carried out to determine quality studies, following formalised rules detailed in Table 3:

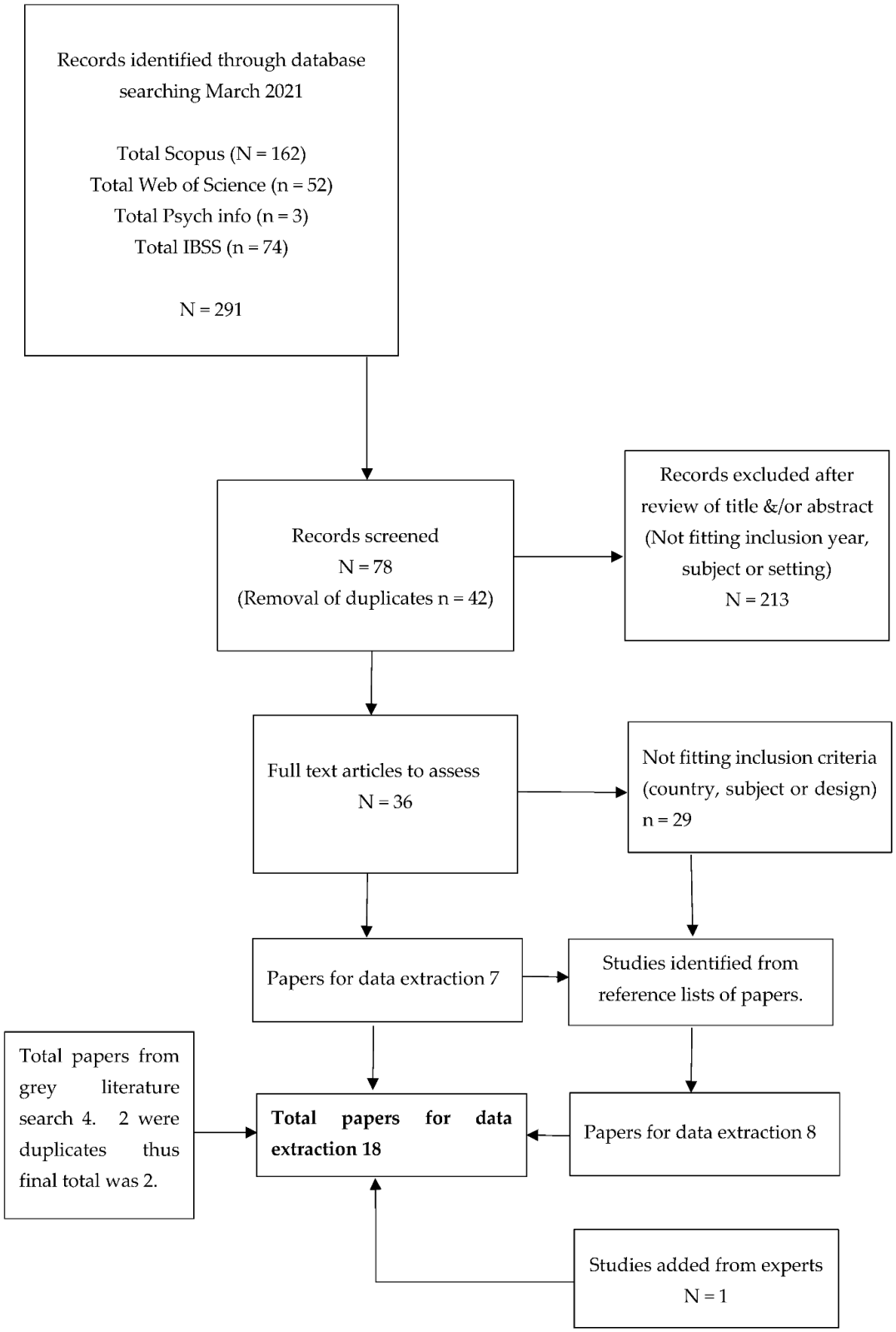

Figure 1. Search strategy and results to select relevant papers.

Table 3. Inclusion and exclusion criteria for critical appraisal of relevant papers.

Subject	Inclusion and Exclusion Criteria
Population	Include studies recruiting from a specific geographical area, social media or supermarket customer base. Exclude studies recruiting using personal contacts.
Population	Include studies that are representative demographically of the population.Include studies that represent demographics of a residential area (i.e., local authority) of a town/city even if not representative of the whole population.
Intervention	Include studies with a detailed description of methods
Comparison	Include studies with a control group
Outcome	Exclude all self-reported measures, i.e., self-reported surveys or qualitative interviews/focus groups
Outcome	Include studies with a clear description of statistical analysis and measure of precision, i.e., confidence interval, standard deviation or p value.

3. Results

Following the search strategy described above, a total of 291 potential articles were identified (Figure 1). The initial screening identified 78 research papers, of which 42 were duplicates (duplicated two, three or four times over the four databases), leaving 36 for full paper search. On reading the 36 papers fully the database search produced 7 papers for consideration. Reference list searching of the 36 papers for full paper search identified another 8 papers for data extraction. One extra paper was identified by an expert. Grey literature studies on food waste were discovered for three UK supermarkets: Tesco, Sainsburys and ASDA. The ASDA study was already captured in two journal publications. Thus, the grey literature search brought 2 extra studies for data extraction. The total number of papers identified for data extraction, from the database search, reference list search, expert advice and grey literature search was 18. Supplementary material Table S1 shows the critical appraisal applied to the eighteen selected studies. Table 4 shows the key results of papers deemed higher quality from the review and illustrates good practice to be replicated. Supplementary material Tables S2–S4 show the summarised results of lower quality papers in the review. Table S1 shows changes to food waste behaviours or perceptions of food waste behaviours in relation to food waste behaviour interventions using nudge techniques. Six studies were published between 2011 and 2016, and twelve studies were published from 2017 to 2020, illustrating the increase in research on food waste in recent years [49]. Ten of the studies were UK based, three were from Sweden, two from Germany, two from The Netherlands and one from Denmark.

3.1. Nudge Interventions

Nudge interventions and associated research were wide–ranging. Three studies did not run an intervention and instead discussed consumer perception(s) of food waste behaviour interventions [31,51,52]. Eight studies used more than one key intervention [53–60]. Most frequently interventions used written information. Five studies used written information interventions incorporating a variety of nudges ranging from disclosure, e.g., environmental impact of food waste from an average household, to individualized consequences to the environment or financial impacts, to reminders, to descriptions of food waste behaviours of other people in the same community, i.e., social norms [53,54,57,60,61]. Four studies with supermarket awareness campaigns all incorporated social norm and reminder nudges [55,56,58,59]. One campaign also included pre-commitment strategies, e.g., making pledges on food waste behaviour [59] and another included a number of tools to increase the convenience of behaviour change e.g. food bag clips [56]. Another intervention included, in addition to nudge, economic marketing techniques, i.e., incentives

and positive communication [55]. Three studies used a food waste sorting bin, arguably a visual prompt or reminder nudge for food waste behaviour [53,62,63]. Other interventions included: sticker prompts for a food waste bin, i.e., a visual reminder nudge [60]; social recipes whereby participants shared ingredients to make recipes together to reduce waste incorporating social norm nudges [57]; verbal information with environmental disclosure [54]; written social comparison feedback on food waste behaviours of nearby streets, i.e., social norms nudging [64]; written reminders and recommendations to change food waste behaviours, i.e., including nudges of pre-commitment strategies, reminders and setting implementation intentions [65]; a measuring tool for portioning of rice and pasta, i.e., increase in ease of convenience [66]; and environmental impact feedback on food waste habits, i.e., a nudge informing people of their individual consequences [57].

Table 4. Results following application of inclusion and exclusion criteria for critical appraisal of relevant papers.

Study Population	Intervention and Nudge Approach	Comparison	Outcome Measure and Methods	Results	Results Overall
Shaw et al. 2018 [60] UK N = 60 Purposive Sample; attempt at representative sample; allocation: geographical area	Intervention included households receiving a leaflet using nudge E: disclosure, either emphasizing financial impacts or environmental impacts of avoidable food waste in order to encourage avoidable food waste reduction.	Control and 2 Treatment Groups	Grams/household/week Pre- and Post-Intervention Only study in this table that differentiates between avoidable and unavoidable food waste and that breaks down food waste by food type.	No statistically significant difference in the weekly total weight of avoidable food waste before and after the intervention. Statistically significant? No	No change
Linder et al. 2018 [61] Sweden N = 474 Convenience sample; clear detail on representative sample compared to population; allocation: geographical area	Intervention: Information leaflet and recycling station. Control group received no information leaflet and recycling station. Information leaflet used C: social norms, encouraging participants to 'Join your neighbours'; attitudes of residents described as considering FW recycling as very important. E: disclosure: vivid and tangible info on benefits of recycling FW to biofuel. Recycling station includes nudge D: increase in ease and convenience	Control and Treatment Group	Kilograms of food waste/per sorting station/2 weeks Pre- and Post-Intervention Reported how missing data was managed.	Food waste Pre-intervention Control: 37.67 (29.76) Treatment: 57.31 (55.67) Difference 18.64 Food waste Post-intervention Control: 27.81 (13.67) Treatment: 59.77 (25.04) Difference 31.96 Statistically significant? Yes	Positive
Nomura et al. 2011 [64] UK N = 9082 RCT; Representative and random; allocation: geographical area	Households in the treatment group were sent two postcards that provided feedback on how their street performed on food waste recycling compared with the average for their neighbourhood (nudge was C: use of social norms)	Control and Treatment Group	Effect size (Regression) Pre- and Post-Intervention	Positive effect 2.8% Statistically significant? Yes	Positive

Table 4. *Cont.*

Shearer et al. 2017 [67] UK N = 64,284 RCT; Representative and random; allocation geographical area	Intervention included stickers, affixed to the lids of refuse bins, to encourage the separate collection of household food waste for recycling. Nudge was E: reminder, i.e., a visual-prompt as a reminder to engage in a behaviour.	Control and Treatment Group	Mean tonnage of food waste/collection round/week Pre- and Post-Intervention Reported how missing data was managed.	Control: No change. Baseline: 1.24 (SD 0.36) and Experimental: 1.24 (SD 0.36). The difference was −0.0091%. Treatment: mean weight of food waste collected increased by 20% from 1.23 (SD = 0.35) to 1.49 (SD = 0.37) tonnes. Statistically significant? Yes	Positive

3.2. Study Design and Samples

Of the eighteen studies selected (Table S1), fifteen were quantitative and three were qualitative. The most common sampling strategy used was convenience sampling (thirteen studies); however, purposive sampling [63], ad hoc sampling [31], random sampling [64,67] and unclear or unstated methods were also used [53,56]. Sixteen studies included participants who were self-selected. Total sample sizes of all eighteen studies ranged from 15 to 64,284, 9 studies used individuals [31,51,52,57–59,62,65,66] and 8 studies used households as the sampling unit [53–55,60,61,63,64,67] and 1 study was unclear [56]. In one study the sample sizes were unclear [56]. Five studies had sample sizes of under 100 [55,57,60,62,63]. Five studies had sample sizes between 100 and 500 [31,52,53,61,65]. Seven studies had total sample sizes of over 500 [51,54,58,59,64,66,67].

Regarding the allocation of the interventions, nine studies used geographical area [53,54,56,60,61,63–66]. Once the geographical area was selected, two studies used random sampling methods [64,67]. Four studies used convenience sampling [54,61,62,65]. Two studies used purposive sampling [60,63] and two studies were unclear on sampling methods [53,56]. Five studies recruited from a supermarket customer base [51,55,58,59,66]. One study [66] included random selection of customer base—all others used convenience sampling. Two studies allocated their sampling strategy from specific locations, i.e., fair or shop [31,66] both studies used convenience sampling and ad hoc sampling, respectively. Two studies recruited from social media [52,57], both used convenience sampling. Two studies recruited from personal contacts [57,62], both used convenience sampling.

The studies largely did not have samples representative of the country's population in which they took place. Eight studies included no statement on how representative the sample was [52,55–59,62,63]. Six studies included a detailed description on demographics indicating how representative the sample was in relation to the local town or area [31,53,54,60,61,65]. Three were representative [51,64,67]. Three studies had randomised samples [64,66,67]. Two studies were random and representative [64,67].

3.3. Methods of Assessment

The majority of studies were clear and transparent concerning their methods of assessment and inherent limitations. In Bernstad [53], which measured food waste weight at multiple time points with comparisons taken over 10 weeks before and 33 weeks after campaigns A and B, the method description of how many households per intervention were included in the food waste weight measurement (written information or bin equipment) was ambiguous. Three studies had two methods of measurement clearly indicated [54,55,57]. Eleven studies used questionnaire methods [31,51,52,54–59,65,66]. Eight studies used weights of food waste as measurement to varying degrees of accuracy [53–57,60,61,67]. Of these studies only one or two of five recommended methods for optimal physical measurement of food waste were used [68]. One study used observations of food caddy placement [64] and three studies used qualitative responses [52,62,63]. Nine

studies relied solely on self-reported data [31,51,52,58,59,62,63,65,66] and nine used an objective measure [53–57,60,61,64,67].

The majority of studies did not specify whether the food waste measured was inedible, or edible-avoidable-food waste; a crucial oversight given the importance of these definitions in practically informing solutions to the issue of food waste. Seven studies did specify the food waste measured was either edible food waste or avoidable food waste [55,57–60,65,66]. Five studies referred to the type of food that was wasted [57–60,66]. Hubbard and Tesco [55] used a photo diary to measure food waste however these findings were not reported in the study summary accessed through grey literature searches.

In all fifteen quantitative studies drop-out rates from interventions were not indicated. It is unclear how easy interventions were for participants to complete. Four studies did report on missing data, i.e., missed bin collections [61,67] and missed responses on online surveys [58,59].

3.4. Reliability and Precision

For the majority of studies, whether or not the assessment was reliable was unclear. It is established from van Herpen and van der Lans [69] and van Herpen et al. [70] that self-reported measures of food waste behaviour change via questionnaire are not reliably accurate as a measure of food waste unless used purely for comparative methods to assess differences between households and ideally within a specified recent timeframe, i.e., the last week. Hence, all studies that used this method of measurement via questionnaire or interview or focus group were classified as "unclear" regarding reliability. The results of the self-reported studies that used quantitative methods are summarised (Table S2–S4). These studies all had relatively small sample sizes of approximately 0–500 and did tend to report positively with regard to the effect of intervention on food waste reduction, however it may be that the positive results from these smaller studies were subject to publication bias.

There were nine studies that used objective measures [53–57,60,61,64,67]. Sainsburys et al. was not considered reliable as sample sizes, methods of recruitment and analysis were consistently unclear [56]. In Bernstad [53] the methods description of how many households per intervention were included in the food waste weight measurement (written information or bin equipment) was ambiguous, hence reliability was classified as unclear, although this study had merit in weighing food waste objectively at multiple time points before and after the intervention. The Hubbard and Tesco study [55] was classified unreliable and imprecise as the report did not clearly describe the statistical analysis for the results and there were no confidence intervals, standard deviations or p values indicated. There was a summary comparison of the average waste from the first week compared to the final week and no other data available. The Lim et al. study [57] was marked as unreliable because the sample size was only fifteen and unrepresentative (all university students between the ages of 20–28). Furthermore, the study did not take travel into account for logistics involved with the social recipe intervention.

Bernstad et al. [54] in Sweden split their sample into two intervention groups. One group consisted of 420 households and included an intervention using nudges of disclosure in written and oral information and nudges of increased ease and convenience, i.e., being given food waste recycling bags. The second group consisted of 210 households and the intervention included written information using disclosure nudges. Food waste weights were recorded at multiple time points over 24 months. P values were included along with clear details of statistical analysis. The results showed overall that there was no change in either group for food waste recycling. This study also included a clear description of the population and discussed how representative the sample was in comparison with the population average of the City of Malmo. However, the study did not include a control group in the design hence it was excluded on the application of quality rules (Table 3). Despite this exclusion, it was noted that there was no change in either group as both received nudge interventions, however without a control group it is difficult to know

whether this would have been replicated or different with other households in the same community without any intervention.

Four studies were considered reliable assessments on application of the quality rules applied (Table 3). Their results were summarised in Table 4 [60,61,64,67]. All four studies addressed food waste recycling or food waste reduction, their interventions were simple and well-articulated, sample sizes adequate or large and precision of results calculated. Three of these studies were based in the UK [60,64,67] and one in Sweden [61].

Nomura et al. [64] in a UK study incorporated a randomised control trial design with two groups, treatment and control, of 5009 and 4073, respectively. The intervention used social norms nudges by applying social feedback on local recycling rates. Regression analysis, standard errors and level of significance (p values) were calculated and showed a statistically significant positive effect of the intervention on household food waste recycling. Mode of measurement was one of observation of recycling food bin to indicate participation with food waste recycling. There were, however, no weight measures or compositional measures of the food waste. Whether the food waste was properly separated or what amount of food waste was to be recycled was not therefore specified.

Shearer et al. [67] in their UK study included a randomised control trial design with treatment and control group of 33,716 and 30,568 participants, respectively. The treatment group received a visual prompt nudge reminder as a sticker on their food waste caddy. Weights of food waste were measured for both groups at multiple time points pre and post intervention and standard deviation and p values calculated, with statistically significant changes in food waste recycling observed.

Linder et al. [61] in Sweden sent an information leaflet with nudges of social norms and disclosure for food waste recycling to the treatment group. Both treatment and control groups were subject to food waste recycling stations near their homes, i.e., arguably a nudge of increase in ease and convenience. Treatment and control groups (264 and 210, respectively) had food waste weighed pre- and post-intervention. Standard deviation was indicated and level of statistical significance (p values) calculated. A positive and statistically significant change in food waste recycling was noted in the treatment group.

The study by Shaw et al. [60] in the UK comprised a sample size of 60, including 3 groups (n = 20 for leaflet using the nudge disclosure for environmental impact, n = 20 for leaflet using the nudge disclosure for economic impact and n = 20 for control). Food waste was measured via compositional analysis and weight. It was the only study, of the four studies (Table 4), that differentiated between avoidable and unavoidable food waste and that separated food waste by food type. A standard error was included in the results. The results showed a lack of differences between the three groups which negated the need to fully conduct statistical analyses usually involved with a before-after-control-impact experimental design.

4. Discussion

This systematic review aimed to gather and appraise the evidence around interventions using nudge for food waste behaviour change. The results contribute to this field of research by identifying the most effective nudge interventions for altering food waste behaviour in households in Europe, providing insights for future policy formation and nudge applications.

There were four studies that were determined to be of higher quality that showed reliable results with three nudges used: use of social norms, reminders and disclosure. The use of social norms and reminders were both shown to have positive influence on change in food waste behaviours [61,64,67]. Disclosure was shown to have a positive influence when incorporated in an intervention for food waste recycling [61]. However, disclosure showed no change for an intervention to reduce food waste [60]. Despite these interventions all using objective measures, optimal methods for physical measurement of food waste as outlined by Elimelech et al. (2018) [68] were not used in any of the studies indicating that

although the results have rigorous elements there is room to increase rigor in the methods used to obtain a more robust result.

The outcomes of the present study provide some insight into the application of nudges in changing food waste behaviour, particularly in relation to food waste recycling. If food waste recycling is considered an upstream nudge (visual reminder) that increases awareness of food waste for the consumer the outcome could arguably be a reduction in food waste in households. There exist implications to local government and individuals, and for the practical application of the findings.

4.1. Explanation

Other reviews support the use of social norms as being one of the most influential elements affecting sustainable consumer behaviour [41,47]. It is well documented that consumer behaviour in relation to food is affected by a wide range of personal, social and environmental factors, i.e., personal beliefs, attitudes, knowledge and genetics; social interaction with friends, family and community and the environment—shops, schools, work place, facilities, the economy and technology [31]. The theory of planned behaviour explains this phenomenon as it indicates that attitudes, social norms and perceived behavioural control influence intentions which predict behaviour [40]. Despite good intentions the value-action gap is well documented and it is broadly understood that behavioural nudges may help to bridge this gap. Social cognitive theory also explains why the use of social norms in nudging for food waste behaviour change is effective as it suggests that a focus on observing and learning from others has influence on positive and negative reinforcement of behaviour [40]. This also suggests that social norms should be used with care as social norms have the potential to reinforce negative behaviour [71].

Shearer et al. [67] (Table 4) showed food waste behaviour was changed by the use of nudge reminders. This outcome was supported by other studies [53,55–59,62,65,66] that were not considered for the purpose of this review as there were no objective measures of change in food waste. However, the methods were clear and the sample sizes adequate, thus it was useful to understand the perspectives of consumers towards nudges for food waste reduction to explain the findings (Tables S1 and S4). Aschemann-Witzel [51] used a Likert scale of 1–7 (with 1 being least agreeable and 7 most agreeable) for four demographically different sample groups, the combined total N = 826. The fourth most accepted nudge interventions by all four groups out of thirteen nudges was: "I would like to avoid that food goes bad while stored at my home with the help of very easy tricks and tips" [51]. Von Kameke and Fischer [31] used a 1–5 Likert scale (1 = great support; 5 = no support at all) N = 101. Participants were recruited by ad hoc sampling outside one organic and one discount food store in the City of Lüneburg in Germany. In contrast to Aschemann-Witzel [51] one of the nudges that received the least support was: tips on shopping planning via mail/post (median = 4.49, standard deviation = 1.09); though it was better received online (median = 3.49, standard deviation = 1.69) but support was still lacking [31]. It appears perceptions on nudge reminders are divided but certainly for some groups of people it is perceived as effective in changing behaviour.

This pattern can be explained by the transtheoretical model of behaviour change which splits receptivity to behaviour change into stages: precontemplation, contemplation, preparation, action, maintenance and termination [72,73]. This model outlines that an intervention may be successful—or not—depending on the stage in which an individual is at the time. If an individual is at the action stage a reminder may be well received and effective, but, if an individual is at the precontemplation stage, they may not be interested. Equally some individuals may have more pressures from their environment and social background that may influence their response [47,48]. There would also be a difference between individuals which may be explained by the self-determination theory which references motivations and aspects required for lasting change. The theory suggests motivation 'exists in the individual and is driven by interest or enjoyment of the task itself'. The individual must believe the behaviour is enjoyable or compatible with their 'sense of self',

values and life goals [74]. This is also compatible with the SHIFT (Social influence, Habit formation, Individual self, Feelings and cognition, and Tangibility) framework of sustainable behaviour change whereby there is focus on the individual self, having powerful influences on consumer behaviour, i.e., positivity of self, self-interest, self-efficacy [71].

Two of the studies in Table 4 used disclosure. Linder et al. [61] used disclosure and social norms and did show change in food waste behaviours while Shaw et al. [60] only used disclosure as a nudge and showed no change. This difference may be due to the type of food behaviour change the intervention aimed to disrupt, the former pertained to food waste recycling, while the latter pertained to food waste reduction behaviours. Alternatively, the dual use of social norms and disclosure may be more compelling than disclosure alone. One reason for this outcome may be that the use of social norms lends a positivity to the intervention that offsets the negativity often associated with disclosure. Disclosure may reveal environmental costs associated with food waste. This may not be effective due to the problem of abstractness, information on climate change can be fear-provoking and vague with overwhelmingly large-scale consequences making individual acts feel inconsequential which may lead to green fatigue or demotivate as a result of information overload [71].

In one study individuals' perceptions of nudges of warnings, i.e., pictures that demonstrate the extent of the food waste amounts were collected. Overall the rating offered was 2.91 by 101 participants, the scale ranged from 1 ("great support") to 5 ("no support at all"). This was the only mention of the nudge warning within the review. It is unclear why this has not been used more frequently and whether it is a nudge that could be effective. The WRAP "love food hate waste" campaign commenced this line of engagement in social media campaigns [75]. In other areas, i.e., cigarette smoking, the impact of pictures of tobacco health warnings is shown to have an effect [76]. As food waste connects to a lesser degree immediately with the individual it may be that this approach is less effective due to its relative abstractness. Highlighting minimisation of food waste as a way of boosting nutrition and saving money may be more immediately beneficial to the individual and therefore a useful angle to exploit for mutual benefit of changing food waste behaviours and improving health and food security. Other nudge techniques only used once in the studies reviewed include: pre-commitment strategies, eliciting implementation intentions and simplification. It may be that pre-commitment strategies and eliciting implementation intentions are less used as these nudges require that participants already wish to change their food waste behaviours which may not be the case at all. Simplification by removing barriers is little used as it may be that barriers to food waste behaviour are frequently aspects outside of the consumer's control.

Further explanation for why social norms and reminders can be effective relate to tangibility, that is bringing sustainable behaviour to the personal human level. Often green actions can seem vague, distant from the self or abstract [71,77], only for realisation in the future or not feasible in the face of daily challenges [71]. Changes slowly emerge and uncertainty surrounds problems, solutions and outcomes. Social norms and simple reminders prompting actions at the individual and social level are tangible and key to individuals paying attention and taking part [71]. There is much long-term thinking associated with sustainable behaviours regarding cost to current pleasure to promote a sustainable result in the future. This poses problems as people are often hesitant to sacrifice their own benefit [71]. Yet, carrying out actions with others that help others can offer a positive feeling occasionally described the 'warm glow' effect [78], focusing on these kinds of benefits to the self in the present may increase sustainable behaviours [71]. Framing social norms or reminders as nudges for food waste reduction in this way, e.g., 'reducing food waste will benefit your children's future' may improve their effectiveness.

4.2. Implications for Policy

Nudges of social norms and reminders could be useful policy actions for changing food waste behaviours, particularly because they are inexpensive and adaptable approaches.

Such approaches should not replace stricter policy measures for food waste reduction at the household level, but as a complement [35,44]. This discussion will consider usage of these identified nudges for food waste behaviour change in local government contexts.

Overwhelmingly the sub context of policy around food waste is one of inefficient legislation. Filippini et al. [79] state that generally policies underlining production, social equity and governance closely connected with social and economic dimensions of food production and consumption are prioritised and food waste actions are poorly represented. The cost of food is clearly prohibitive as in 2018 the UN FAO data showed approximately 2.2 million people in the UK were severely food insecure [80]. If nudges facilitate better use of purchased food, that could also help to reduce food waste, we may positively impact on food security and diet quality (as often fresh produce is most wasted) in households [81]. Policy is often made without full understanding of the benefits and costs to society [82]. Policy measures of fields connected to food waste such as food (in)security, food safety and low cost of waste disposal may take priority [83]. It is worth acknowledging this and considering how best to frame a policy on food waste so it has more backing and traction. Framing actions for food waste within a food security policy may serve both goals as the two, although distinct, are deeply connected along the food supply chain [11–13].

Governments and stakeholders are keen to find ways to effectively improve healthier food behaviours to encourage improvement in public health [45]. The WHO recently asked for retail environments to encourage consumers in this way [84]. Interventions using nudges have gained increased attention in the international policy debate, particularly in the food context they have been applied to promote healthier food patterns of consumption such as increased fruits and vegetables [44,85–88]. Food waste is a point of intersection between these key issues. As nudges have been shown useful to both these issues, an intervention using nudge to encourage consumers towards plant-based diets could also incorporate nudges towards food waste behaviour change. This is especially key as it has been commonly shown that an increase in fresh fruit and vegetable consumption can lead to an increase in food waste [89]. A suggestion on how this could work would be to nudge consumers to buy fruit and vegetables in forms such as canned or frozen—items that are less often wasted compared with fresh produce but offer nutritional gains [90]. Alternatively, nudging storage of apples in the fridge rather than a fruit bowl would increase their shelf life. Discussion about the approach of linking healthy nutrition and food waste awareness is often neglected in the discussion around food waste. It is an approach that may benefit health and environmental outcomes for local government.

4.3. Limitations and Priorities for Future Research

Overall there is no assessment of study quality and robustness in previous reviews of food waste behaviour interventions. This review adds to the literature by indicating the paucity of quality primary studies using interventions with nudge for food waste behaviour change. This review indicates there is some information on the benefit of nudges (namely use of social norms, reminders or disclosure alongside use of social norms) for food waste recycling interventions, which as an upstream measure may have a positive impact on food waste reduction. However, there is currently limited information on the benefit of nudge for food waste reduction interventions.

There was lack of distinction, in the included studies, between whether or not food waste was edible or inedible, which is key information when considering the effectiveness of edible food waste reduction interventions. It is also key information for food waste recycling interventions as it is helpful to understand whether the increase in food waste recycling is due to edible or inedible food waste as this gives an indication of how to target food waste reduction interventions. Another key limitation included understanding the duration of effectiveness of nudge interventions as studies rarely evaluate long term outcomes [91]; some research articles state nudge may only have short term effects [92]. Thus, methods to attempt to measure the longer-term effect of interventions using nudge should

be incorporated in future studies, studies in other areas, health not food consumption, have achieved this [93] and could thus help to inform this methodology.

Regarding limitations to the current review, qualitative studies hold strength to uncover subject matter and anomalies to add to the body of research, however, they are not a reliable method to uncover whether or not nudge interventions are effective for food waste behaviour change in a generalisable sample. Thus, despite robust qualitative methods from studies reviewed in this paper, we have not deemed them reliable for the purpose of this review and research question to hand [52,62,63]. Some studies included in the present study carried out mixed methods and not all parts of the study were relevant to this review [31,46,51,56,62,66]. In these instances, the parts of the studies that did adhere to the inclusion criteria were included.

In the future we need more food waste behaviour studies that use nudge interventions and measure changes in food waste before and after the intervention using either physical weight measurements using robust methods [68], or photo diary studies using appropriate methods [94] to identify edible and inedible food waste, and capture more data on food groups wasted. There is also a need for studies to use representative samples and control groups when testing the effectiveness of a nudge intervention to change food waste behaviours as well as precision in statistical analysis. There are different outcome measures and effect sizes in almost every paper included in the review; future research could work to overcome these challenges which a more standardised approach so that a synthesis of results could be undertaken with meta-analysis. Future research could also assess effectiveness of nudges to change food waste behaviours in different demographics to find out whether there are differences in the kinds of approaches that work depending on demographics. Another area for future research would be to explore the effectiveness of interventions incorporating social norms and reminder nudges to change food waste recycling behaviours and public health nutrition given that both are shown to be effective in each area and population.

5. Conclusions

In conclusion there is no assessment of study quality in previous reviews of food waste behaviour interventions, thus this review indicates a lack of quality primary studies using interventions with nudge for food waste behaviour change. This review suggests there is reliable information on the effectiveness of nudge for food waste recycling interventions when incorporating nudges of social norms, reminders or disclosure alongside use of social norms. If food waste recycling behaviour is considered an upstream measure to raise consumer consciousness on the topic of food waste this may have a positive impact on food waste reduction. This review illustrates the limited information on the effectiveness of nudge for food waste reduction interventions. Behaviour change models and frameworks indicate nudges work when they are tangible, relevant and beneficial to the individual and their lifestyle. Nudges are inherently flexible and adaptable which lends them to policy implementation in different contexts. Incorporating policy on food waste within policy for food security and public health nutrition may maximise impact.

Supplementary Materials: The following are available online at https://www.mdpi.com/article/10.3390/su131911099/s1, Table S1: Critical Appraisal; Table S2: Food waste weight/household or individual/timeframe reported for food waste reduction; Table S3: Percentages reported for food waste reduction; Table S4: Likert scales measuring nudge intervention on food waste behaviour change.

Author Contributions: Conceptualization, H.B.; methodology, H.B., D.S. and P.J.S.; writing—original draft preparation, H.B.; writing—review and editing, H.B., D.S., P.J.S., B.R. and Z.C.; supervision, D.S., P.J.S., B.R. and Z.C.; project administration, H.B.; funding acquisition, H.B. and D.S. All authors have read and agreed to the published version of the manuscript.

Funding: The research for this article was funded by the Economic and Social Research Council South Coast Doctoral Training Partnership (Grant Number ES/P000673/1).

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: Supporting data are available in the Supplementary Materials.

Conflicts of Interest: The authors declare no conflict of interest.

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