

# Food waste concerns, eating behaviour and body weight

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**Running head:** Food waste concerns and eating behaviour

## Abstract

1  
2 Consumer food waste is now a significant social issue. However, given that the modern day  
3 food environment has become characterised by larger portion sizes of more energy-dense  
4 foods, personal concerns about wasting food may result in eating behaviours that promote  
5 excess energy intake and weight gain. Across 3 studies, we developed a brief (5-item)  
6 measure to quantify concerns about food waste and examined the relationships between food  
7 waste concerns, eating behaviour and body weight. In Study 1, we showed that our 5-item  
8 measure of food waste concerns has acceptable convergent and divergent validity, and test-  
9 retest reliability. We also found that concerns about wasting food were predictive of greater  
10 behavioural intentions to avoid food waste (e.g. eating leftovers). In Study 2, greater food  
11 waste concerns were associated with an increased tendency to plate-clear when eating (self-  
12 reported), but not with objectively measured body weight or likelihood of having overweight  
13 or obesity. In Study 3, we examined how much food participants consumed when served a  
14 large portion size of a lunchtime meal and found that food waste concerns did not directly or  
15 indirectly predict how much participants ate. Overall, we found evidence that concerns about  
16 food waste are related to self-reported intentions to minimize food waste and plate-clearing  
17 tendencies, but no evidence that food waste concerns are related to objectively measured  
18 energy intake in the laboratory or body weight.

19 **Abstract:** 226 words

20 **Keywords:** food waste; attitudes; eating behaviour; body weight.

### 21 **List of abbreviations:**

22 Three Factor Eating Questionnaire (TFEQ)

23 Intra-class correlation (ICC)

24 Theory of planned behaviour (TPB)

## 25 1. Introduction

26 In the last thirty years, there have been striking increases in population-level body weight  
27 across most developed countries (Ng et al., 2014; OECD/EU, 2017), including the U.K.  
28 (House of Commons, 2019). Changes to the food environment have been identified as a  
29 likely cause of the ‘obesity crisis’ (Swinburn et al., 2011). For example, larger portion sizes  
30 of energy dense food products are now more common (Matthiessen, Fagt, Biloft-Jensen,  
31 Beck, & Ovesen, 2003; Piernas & Popkin, 2011; Steenhuis, Leeuwis, & Vermeer, 2010;  
32 Young & Nestle, 2003, 2007, 2012). Likewise, food prepared outside of the home often has a  
33 high energy content (Robinson, Jones, Whitelock, Mead, & Haynes, 2018). Alongside  
34 increases in obesity, in recent times there has also been a growing awareness of the problem  
35 of food waste (FAO, 2014; Food and Agriculture Organization of the United Nations., 2013;  
36 Quested, Ingle, & Parry, 2013).

37 In higher income countries, a large proportion of food is wasted per capita at the retail  
38 and household level (Gustavsson, Cederberg, Sonesson, Van Otterdijk, & Meybeck, 2011).  
39 Because of this, there are attempts to raise public awareness about food waste, such as the  
40 ‘Love Food Hate Waste’ campaign that was initiated by The Waste and Resources Action  
41 Programme in 2007 (Quested et al., 2013). However, despite a 15% reduction of household  
42 food and drink waste in the U.K. in the 5 years following the campaign’s launch, there are  
43 approximately 7 million tonnes of food and drink still wasted per annum, 60% of which is  
44 considered avoidable (Quested et al., 2013). People report being concerned about (Abdelradi,  
45 2018; Abeliotis, Lasaridi, & Chroni, 2014; Gaiani, Caldeira, Adorno, Segrè, & Vittuari, 2018;  
46 Parizeau, von Massow, & Martin, 2015) and averse to (Bolton & Alba, 2012; Gjerris &  
47 Gaiani, 2013) food waste.

48 Given that consumers are generally averse to food waste, it is reasonable to predict  
49 that intentions (e.g. intentions to not waste food) drive food waste behaviours. The Theory of

50 Planned Behaviour (TPB) (Ajzen, 1985, 1991) proposes that intentions to perform a  
51 behaviour can be accurately predicted from attitudes towards that behaviour, alongside  
52 subjective norms and perceived behavioural control. However, studies that use TPB to  
53 attempt to explain food waste behaviours have yielded mixed findings. Some studies report  
54 that attitudes towards food waste were significant predictors of intentions to reduce food  
55 waste (Aktas et al., 2018; Graham-Rowe, Jessop, & Sparks, 2015; Stancu, Haugaard, &  
56 Lähteenmäki, 2016; Stefan, van Herpen, Tudoran, & Lähteenmäki, 2013), which was in turn  
57 related to less food waste (Visschers, Wickli, & Siegrist, 2016). In contrast, others have  
58 found that attitudes did not predict intentions, with perceived behavioural control being  
59 instead the key determinant of both intentions and behaviour (Mondéjar-Jiménez, Ferrari,  
60 Secondi, & Principato, 2016; Russell, Young, Unsworth, & Robinson, 2017). It has also been  
61 found that intentions are associated with food waste behaviour (Aktas et al., 2018; Russell et  
62 al., 2017), or do not have a significant effect on reported food waste (Stefan et al., 2013).  
63 Furthermore, in a canteen setting, Lorenz, Hartmann, Hirsch, Kanz, and Langen (2017) found  
64 that attitudes predicted intentions to reduce plate leftovers, whereas subjective norms and  
65 perceived behavioural control were less important. However, a subsequent study by Lorenz,  
66 Hartmann, and Langen (2017) did not directly replicate these findings.

67         Although research has demonstrated that consumers now identify food waste as a  
68 significant issue and report being concerned about wasting food, the extent to which food  
69 waste concerns may influence eating behaviour has received far less attention. Fay et al.  
70 (2011) investigated the prevalence of plate-clearing, pre-meal planning, and their influence  
71 on meal size. In an online questionnaire study, participants were asked about the last meal  
72 they had consumed. One question asked participants if they had “eaten all of the food on  
73 [their] plate, even though [they] could have stopped before that point”. Of the individuals  
74 who answered yes, 77% reported that this was because they did not want to waste food. In

75 other words, these individuals had cleared the plate past the point of fullness because they  
76 wanted to avoid food waste. Also, Robinson and Hardman (2016) found that a single item  
77 measure of disliking wasting food was predictive of self-reported plate-clearing tendencies in  
78 a sample of University students, and plate-clearing tendencies were associated with having a  
79 higher BMI.

80         Given that many people now live in an ‘obesogenic environment’, concerns about  
81 wasting food may therefore be a contributor to excess energy intake. Indeed, Hall, Guo, Dore,  
82 and Chow (2009) propose a link between surplus food, food waste and overeating. Hall et al.  
83 (2009) argue that the obesity epidemic has been the result of the “push effect” of increased  
84 food availability and marketing, with individuals being unable to match their food intake with  
85 the increased supply of cheap, easily available food.

86         Thus, the aim of the present research was to examine the relationships between food  
87 waste concerns, eating behaviour and body weight. Because concerns about food waste may  
88 promote excess energy consumption through encouraging the behaviour of plate-clearing, we  
89 made a number of predictions. We predicted that greater concerns about wasting food would  
90 be associated with greater intentions to behave in ways that minimize food waste, such as  
91 eating leftovers (Study 1, Section 2.), greater plate-clearing tendencies and heavier body  
92 weight (Study 2, Section 3.) and objectively measured energy intake when served a large  
93 portion of food (Study 3, Section 4.).

94

## 95 **2. Study 1**

96 As we were aware of no scale directly measuring concerns about wasting food when eating,  
97 we designed a 5-item measure. In Study 1, we collected data online and tested internal  
98 consistency, test-retest reliability, convergent and divergent validity of the measure.  
99 Participants completed the same battery of questionnaires 2 weeks apart. To examine

100 convergent validity, we hypothesised that the measure should predict intentions to reduce  
101 food waste and emotions experienced in response to the thought of wasting food. Given that  
102 our interest was in the potential influence of food waste concerns on eating behaviour and  
103 body weight, we tested the divergent validity of our measure by examining whether it was  
104 distinct to existing trait measures of appetite and over-eating.

105

## 106 **2.1 Method**

### 107 *2.1.1 Participant recruitment and eligibility*

108 We aimed to recruit 300 participants, which is considered appropriate for scale development  
109 by Comrey and Lee (2013) . In total, 300 U.K. participants (207 females, 93 males) were  
110 recruited through the online recruitment platform Prolific Researcher. Eligibility criteria were  
111 as follows: aged 18 or over, no history of or current food allergies, no history of or current  
112 eating disorder(s) and fluent in English. Of these 300, 276 (191 females, 85 males) completed  
113 the questionnaire a second time 2 weeks later. Participants were provided with monetary  
114 reimbursement for their time.

115

### 116 *2.1.2 Measures*

117 *Food waste concerns:* Through group discussions focussed on relevant literature, the research  
118 team identified questions for the food waste concerns measure. The measure consisted of 5  
119 items (7-point Likert-scales, ‘Strongly disagree’ to ‘Strongly agree’) designed to address  
120 concerns about wasting food (“It is morally wrong to waste food”, “I cannot stand throwing  
121 food away”, “Even if I felt full, I would rather finish what is on my plate than see it go to  
122 waste”, “It is fine for food to go to waste sometimes”, “It can be acceptable to waste food”).

123 Scores on the latter 2 items were reverse-scored. Scores were summed, with a higher score  
124 indicating stronger concerns regarding food waste.

125 *Intentions to reduce food waste:* A 4-item self-report measure was taken from Aktas et al.  
126 (2018) (e.g. “I intend to eat leftover food”) with a 7-point Likert scale response format  
127 (‘Strongly disagree’ to ‘Strongly agree’). Scores were summed, with a higher score indicating  
128 stronger intentions to reduce food waste ( $\alpha = .80$ ) (Aktas et al., 2018).

129 *Emotions towards wasting food:* A single-item measure was taken from Russell, Young,  
130 Unsworth, and Robinson (2017). Participants were asked “Which of the following words best  
131 describe how you feel about wasting food in your home?” and provided with a list of  
132 emotions. Participant selected all the emotions that applied to them. These were then dummy  
133 coded as 1 = emotion present (i.e. selected) and 0 = emotion absent (i.e. not selected). From  
134 these, a negative emotion score (total score of responses to the 3 negative emotions:  
135 frustrated, anxious, guilty) and a positive emotion score (total score of responses to the 4  
136 positive emotions: optimistic, proud, content, relaxed) were computed, with higher scores  
137 indicating higher negative or positive emotions (Russell et al., 2017).

138 *Overeating:* The disinhibition subscale of the original Three Factor Eating Questionnaire  
139 (TFEQ) was used to measure trait overeating (Stunkard & Messick, 1985). Scores were  
140 summed, with a higher score indicating higher tendency towards overeating ( $\alpha = .91$ )  
141 (Stunkard & Messick, 1985).

142 *Hunger:* The hunger subscale of the original TFEQ was used to measure trait appetite  
143 (Stunkard & Messick, 1985). Scores were summed, with a higher score indicating higher  
144 tendency towards hunger ( $\alpha = .85$ ) (Stunkard & Messick, 1985).

145 *Attention check:* We included an attention check question, “This is an attention check. Please  
146 leave blank”, at 2 points in the study to ensure that participants were attending to the  
147 questions.

148

### 149 *2.1.3 Procedure*

150 Ethical approval was gained from the University of Liverpool’s Institute of Population Health  
151 Sciences Research Ethics Committee (reference number: 5332). After accessing the online  
152 study site, participants reported their gender, age, weight, height and answered questions  
153 relating to the inclusion criteria. In a randomized order, participants then completed the food  
154 waste concerns items, food waste intentions, food waste emotions, the trait disinhibition scale  
155 and trait appetite scale. Participants were invited to complete the same questionnaires 14 days  
156 later. Participants were reimbursed for their participation and the study took approximately  
157 20 minutes to complete. A full copy of the questionnaire participants received can be found at  
158 <https://osf.io/aef75/>.

159

### 160 *2.1.4 Analysis Strategy*

161 The hypotheses and analytic strategy were specified before the data were collected, and any  
162 data-driven analyses are clearly identified and discussed appropriately. To assess the internal  
163 consistency of the food waste concerns measure, we conducted a factor analysis on the first  
164 wave of data collected (time 1) using an oblique rotation and calculated Cronbach’s alpha (a  
165 Cronbach’s alpha of  $>.70$  is considered acceptable for a sample size of  $n < 300$  (Cicchetti,  
166 1994; Kline, 2013; Nunnally & Bernstein, 1994; Ponterotto & Ruckdeschel, 2007)).



167 To assess test-retest reliability, we examined the intra-class correlation (ICC) between  
168 the total food waste concerns score obtained at the initial time of testing (time 1) and  
169 following the 2-week interval (time 2). ICC and 95% confident intervals were calculated  
170 based on the correlation between total scores at time 1 and time 2, with absolute-agreement  
171 and a 2-way mixed-effects model. Scores of 0.60 or more indicate good test–retest reliability  
172 (Cicchetti, 1994).

173 To assess convergent validity, we used linear regression to examine whether the food  
174 waste concerns measure predicted food waste intentions and food waste emotions, controlling  
175 for age, gender, BMI, trait hunger and trait overeating. Finally, to examine divergent validity,  
176 we used Pearson’s correlation analysis to examine the correlation between the food waste  
177 concerns measure and the measures of overeating and hunger. We expected that the food  
178 waste concerns measure would not be strongly correlated with overeating or hunger (i.e.  $r$   
179  $<.5$ ). Results were considered significant at a  $p <.05$ . All analyses were conducted in IBM  
180 SPSS Statistics 24.

181

## 182 **2.2 Results**

183 Two hundred and seventy-six participants (191 females and 85 males) completed both online  
184 questionnaires and had a mean age of 37.4 ( $\pm 12.7$ ) years and a mean BMI (self-reported with  
185 data missing from 2 participants) of 26.4 ( $\pm 6.0$ ) kg/m<sup>2</sup>. The sample had a mean food waste  
186 concerns score of 4.74 ( $\pm 1.23$ ) at time 1 and 4.79 ( $\pm 1.16$ ) at time 2, equating to responses of  
187 ‘Neither agree nor disagree’ to ‘Somewhat agree’ with being concerned about food waste (7-  
188 point scale).

189

### 190 *2.2.1 Exploratory factor analysis, internal consistency and test-rest reliability*

191 An exploratory factor analysis was conducted on the 5 items with oblique rotation (direct  
192 oblimin). The Kaiser-Meyer-Olkin measure verified the sampling adequacy for the analysis,  
193 (KMO = 0.78), and Bartlett's Test of Sphericity demonstrated that correlations between items  
194 were large enough for factor analysis,  $\chi^2(10) = 517.17, p < .001$ . A single factor was identified  
195 with an eigenvalue over Kaiser's criterion of 1 (Eigenvalue = 2.94) and explained 58.8% of  
196 the total variance of the observed variables. The measure had good internal consistency, with  
197 all 5 items loading onto a single factor ( $\alpha = .82$ ). See online supplementary materials for factor  
198 loadings and correlations between individual measure items. The food waste concerns  
199 measure had excellent test-retest reliability. The ICC was .90 (95% CIs = .87-.92,  $F(275,275)$   
200 = 10.00,  $p < .001$ ).

201

### 202 2.2.2 Convergent and divergent validity

203 Two participants presented unclear responses for either weight or height, and so they were  
204 removed from analyses involving BMI. No implausible height and weight values were  
205 reported; thus 274 participants were included in analyses involving BMI. As expected, food  
206 waste concerns scores were significantly positively correlated with intentions to reduce food  
207 waste ( $r(274) = .58, p < .001$ ) and negative emotions towards wasting food ( $r(274) = .34, p$   
208  $< .001$ ). Food waste concerns scores were significantly negatively correlated with positive  
209 emotions towards wasting food ( $r(274) = -.29, p < .001$ ). These associations remained  
210 significant ( $ps < .001$ ) in regression analyses controlling for age, gender, BMI, trait appetite  
211 and overeating (see online supplementary materials). As predicted, food waste concerns were  
212 not strongly correlated with trait overeating ( $r(274) = .09, p = .128$ ) or trait appetite ( $r(274)$   
213  $= .16, p = .009$ ), indicating that this measure is psychometrically distinct from measures of  
214 motivation to eat.

215

### 216 **3. Study 2**

217 In Study 1 (Section 2.), we found that the 5 items from the food waste concerns measure all  
218 loaded onto a single factor, which we operationalise as a measure of individual differences in  
219 concerns about wasting food. The measure demonstrated good internal consistency and  
220 excellent test-retest reliability. We also found evidence in support of the measure's  
221 convergent validity (predictive of emotional response to food waste and intentions to avoid  
222 wasting food) and divergent validity (only weakly associated with measures of trait  
223 overeating and appetite). Our aim in Study 2 was to examine whether food waste concerns  
224 are predictive of a behaviour that may promote excess energy consumption in the current  
225 food environment (the tendency to clear one's plate when eating) and body weight. We also  
226 conducted a confirmatory factor analysis of the food waste concerns measure in Study 2.

227

#### 228 **3.1 Method**

229 We included the 5-item food waste concerns measure at the end of a series of laboratory  
230 studies conducted at the University of Liverpool during 2016-2018. Studies were approved  
231 by the University of Liverpool Research Ethics Committee and participants were drawn from  
232 University students and the local community. Studies typically involved participants  
233 consuming a lunchtime meal or snack, in addition to completing standard psychological and  
234 eating behaviour questionnaires. See online supplementary materials for detailed information  
235 on the included studies. For Study 2, we made use of data from 14 studies, all of which had a  
236 researcher taken measurement of weight and height and included the food waste concerns  
237 measure. In 4 of these 14 studies, self-reported plate-clearing tendencies were also collected.  
238 As used in previous research, the plate-clearing measure consisted of 5 questions ("I always  
239 tend to clear my plate when eating."; "I normally finish eating when my plate is empty.";

240 “Before I start eating, I normally plan to finish the serving I am about to eat.”; “I rarely leave  
241 food on my plate.”; “It is normal for me to have very little food left or an empty plate at the  
242 end of a meal.”) with a 5-point Likert measure response format (‘Strongly disagree’ to  
243 ‘Strongly agree’). Scores were summed, with a higher score indicating stronger plate-clearing  
244 tendencies ( $\alpha = .89$ ) (Robinson, Aveyard, & Jebb, 2015).

245

### 246 *3.1.1 Analysis strategy*

247 The hypotheses and analytic strategy were specified before the data were collected, and any  
248 data-driven analyses are clearly identified and discussed appropriately. Using SPSS AMOS  
249 24, a confirmatory factor analysis was performed on the single-factor solution observed in  
250 Study 1 (Section 2.). For full information on the analysis strategy for the confirmatory factor  
251 analysis see the online supplementary materials. A linear regression was used to test whether  
252 food waste concerns scores predicted plate-clearing tendencies scores while controlling for  
253 age, BMI and gender. We used linear regression analysis to also test whether food waste  
254 concerns scores were positively associated with BMI ( $\text{kg/m}^2$ ), while controlling for age and  
255 gender. Finally, a logistic regression was conducted to investigate whether food waste  
256 concerns score predicted the likelihood of having overweight ( $\text{BMI} < 25.0$  vs.  $\text{BMI} \geq 25.0$ ).  
257 Results were considered significant at a  $p < .05$ .

258

## 259 **3.2 Results**

260 We included 996 participants in our main analyses (739 females and 227 males), with a mean  
261 age of 25.4 ( $\pm 11.0$ ) years, and a mean BMI of 24.8 ( $\pm 5.3$ )  $\text{kg/m}^2$ . The sample had a mean  
262 food waste concerns score of 4.45 ( $\pm 1.26$ ). Of these 966 participants, 212 also completed the  
263 plate-clearing scale. The sample had a mean plate-clearing tendency score of 4.01 ( $\pm 0.85$ ) out  
264 of 5.

265

266 *3.2.1 Confirmatory factor analysis*

267 Five items loaded onto the latent factor (food waste concerns score). The Cronbach's alpha of  
268 the 5-item food waste concerns measure was acceptable ( $\alpha = .80$ ). The confirmatory factor  
269 analysis confirmed the single-factor structure yielded by the exploratory factor analysis in  
270 Study 1 (Section 2.). Following the addition of covariance pathways based on modification  
271 indices, the single-factor model provided a good fit to the data (normed  $\chi^2$  ( $\chi^2/df$ ) = 3.52, CFI  
272 =.995, TLI=.984, RMSEA (90% CI) =.051 (.02-.09), SRMR =.02). See online  
273 supplementary materials for an explanation and schematic of this model.

274

275 *3.2.2 Food waste concerns and plate-clearing tendencies*

276 A regression analysis was conducted to examine whether food waste concerns  
277 predicted plate-clearing tendencies score while controlling for gender, age, and BMI. The full  
278 model predicted approximately 22% of variance in plate-clearing tendencies score,  $R^2 = .22$ ,  
279  $F(4, 205) = 14.06$ ,  $p < .001$ . Gender was negatively associated with plate-clearing tendencies,  
280 with higher plate-clearing scores in males than females ( $\beta = -.23$ ,  $p < .001$ ). Food waste  
281 concerns score was positively associated with plate-clearing tendencies, with greater food  
282 was concerns being associated with greater plate-clearing tendencies ( $\beta = .37$ ,  $p < .001$ ). Age  
283 ( $\beta = .07$ ,  $p = .294$ ) and BMI ( $\beta = -.05$ ,  $p = .491$ ) did not significantly predict plate-clearing  
284 tendencies.

285

286 *3.2.3 Food waste concerns and weight*

287 A regression analysis was conducted to examine whether food waste concerns were  
288 associated with BMI, while controlling for age and gender. The full model predicted

289 approximately 21% of variance in BMI,  $R^2 = .21$ ,  $F(3, 960) = 86.65$ ,  $p < .001$ . Age was  
290 positively associated with BMI ( $\beta = .46$ ,  $p < .001$ ). However, gender ( $\beta = -.03$ ,  $p = .242$ ) and  
291 food waste concerns ( $\beta = -.04$ ,  $p = .174$ ) did not significantly predict BMI. A logistic  
292 regression analysis was conducted to investigate whether food waste concerns predicted  
293 likelihood of having overweight/obese, while controlling for age and gender. The regression  
294 model significantly predicted weight status, correctly identifying 70.6% of cases, Cox &  
295 Snell  $R^2 = .13$ , Nagelkerke  $R^2 = .17$ ,  $p < .001$ . Age was associated with an increased likelihood  
296 of having overweight/obese,  $B = .07$  ( $SE = .01$ ),  $Wald = 98.27$ ,  $p < .001$ ;  $OR = 1.08$ , 95% CIs  
297  $= 1.06-1.09$ . Neither gender,  $B = .18$  ( $SE = .17$ ),  $Wald = 1.14$ ,  $p = .286$ ;  $OR = 1.19$ , 95% CIs  
298  $= 0.86-1.66$ , nor food waste concerns,  $B < .01$  ( $SE = .01$ ),  $Wald < .01$ ,  $p = .984$ ;  $OR = 1.00$ , 95%  
299 CIs  $= 0.90-1.12$ , were associated with the likelihood of having overweight/obese.

300

### 301 **4. Study 3**

302 In Study 2 (Section 3.), we found that although concerns about food waste were associated  
303 with an increased likelihood of self-reported plate-clearing, there was no significant  
304 association between food waste concerns and body weight. In Study 3, we aimed to explore  
305 the relationship between food waste concerns and energy intake when served a large portion  
306 of food. We tested whether food waste concerns are associated with increased energy intake  
307 when served a large portion of food because concerns about wasting increase a person's  
308 likelihood of wanting to clear their plate when eating, which in turn has been shown to be  
309 predictive of increased energy intake (Sheen, Hardman, & Robinson, 2018) (i.e. an indirect  
310 effect of food waste concerns on energy intake via plate-clearing tendencies).

311

### 312 **4.1 Method**

#### 313 4.1.1 Participant recruitment and eligibility

314 Based on Fritz and MacKinnon (2010), we aimed to recruit a minimum sample size of at least  
315 126 participants in order to detect a mediation effect that was moderate to small in size. In  
316 total, 128 participants (85 females, 43 males) were recruited from staff/students at the  
317 University of Liverpool and the surrounding area. Most participants took part in exchange for  
318 course credit (1<sup>st</sup> year psychology students, 68.8%) whilst other participants were reimbursed  
319 financially for their participation. Eligibility criteria were aged 18 or over, no history of food  
320 allergies, and had not participated in any recent similar studies (i.e. laboratory studies of food  
321 intake).

322

#### 323 4.1.2 Overview

324 Participants completed questions on their plate-clearing tendencies and food waste concerns  
325 in an online pre-session questionnaire at least 1 day before the study session. To disguise the  
326 aims of the study, participants were informed in advance that the study was about ‘Eating and  
327 Memory’. Participants completed word memory tasks before and after consuming *ad libitum*  
328 from a large lunch time meal in the laboratory.

329

#### 330 4.1.3 Test food

331 Participants were served pasta in tomato sauce at a 1:1 ratio (Tesco Conchiglie pasta and  
332 Dolmio Bolognese ‘Smooth Tomato’ sauce, see online supplementary materials for  
333 nutritional information) in a 500g portion on a standard white dinner plate, with a 500ml  
334 glass of water. This portion size was chosen as participants in a recent laboratory study  
335 identified this portion as being ‘larger than normal’ and only a minority of participants (15%)  
336 consumed it in its entirety (Sheen et al., 2018). Pilot testing indicated that participants found

337 the meal to be palatable, which was confirmed by an item measuring liking of the meal in the  
338 current study.

339

#### 340 *4.1.4 Measures*

341 Participants completed the food waste concerns measure ( $\alpha = .80$ ) described in Study 1  
342 (Section 2.1.2), and the plate-clearing scale ( $\alpha = .89$ ) (Robinson et al., 2015) described in  
343 Study 2 (Section 3.1).

344 *Appetite:* A mood and appetite measures questionnaire was administered, including 3 appetite  
345 items: hunger, fullness, and desire-to-eat. These were presented as 99mm visual analogue  
346 scale questions (e.g. “How FULL do you feel right now?”) with the anchors of ‘Not at all’ to  
347 ‘Extremely’.

348 *Perceptions of portion size:* Participants completed the question (“In my opinion, the portion  
349 I was given in this study was...”) with a 7-point Likert scale response format (‘Too small’ to  
350 ‘Too large’).

351 *Liking:* Participants completed a question on liking of the lunchtime meal (“Overall, I liked  
352 the taste of the meal that was served to me”) on a 5-point Likert scale response format  
353 (‘Strongly disagree’ to ‘Strongly agree’).

354 *TFEQ:* The TFEQ (Stunkard & Messick, 1985) was used to measure uncontrolled eating (e.g.  
355 “When I have eaten my quota of calories, I am usually good about not eating any more.”),  
356 disinhibition (e.g. “I usually eat too much at social occasions, like parties and picnics.”), and  
357 restraint (e.g. “I am usually so hungry that I eat more than three times a day.”).



358 *Awareness of study aims:* Participants completed a free-text response question regarding what  
359 they believed the aim of the study to be (“What do you think the aim of the study was?”), in  
360 addition to another question (see online supplementary materials).

361

#### 362 *4.1.5 Procedure*

363 Ethical approval was gained from the University of Liverpool’s IPHS Research Ethics  
364 Committee (reference number: IPHS-1617-LB-284 - Generic RETH000955). Before  
365 attending a single weekday lunchtime session, participants completed an online pre-session  
366 questionnaire that included the food waste concerns measure and plate-clearing scale. To  
367 standardize appetite, participants were asked not to eat in the 2 hours prior to the study or  
368 drink in the hour prior. On arrival the experimenter obtained informed consent, verbally  
369 confirmed that the participant had no known food allergies and had not eaten in the 2 hours  
370 prior to the study session, and asked participants to complete a short medical history  
371 questionnaire in compliance with laboratory health and safety procedures. Participants then  
372 completed a word memory task (included as part of the cover story). Participants were  
373 presented with 25 words on a laptop. Each word was shown for 5 seconds and participants  
374 then were asked to write down as many words as they could remember. This was followed by  
375 a mock feedback questionnaire, which included filler questions about the difficulty of the task  
376 and any distractions they experienced whilst completing the task. Participants then completed  
377 the mood and appetite questionnaire, before being served the lunchtime meal. Participants  
378 were told that they could eat and drink (500ml water) as much as they desired and to press a  
379 buzzer located in the cubicle to alert the experimenter when they had finished. Upon  
380 completion, the experimenter removed the lunchtime meal. Participants then completed the  
381 mood and appetite measures questionnaire for a second time, and were given a similar word

382 memory task and mock feedback questionnaire. Participants then completed the questions on  
383 portion size, lunchtime meal liking, the TFEQ, and questions regarding awareness of the  
384 study aims, before having their height and weight measured. Finally, the experimenter  
385 debriefed the participant and reimbursed them for their time. Each experimental session took  
386 approximately 50 minutes.

387

#### 388 *4.1.6 Analysis strategy*

389 The hypotheses and analytic strategy were specified before the data were collected, and any  
390 data-driven analyses are clearly identified and discussed appropriately. We planned to  
391 examine the indirect effect of food waste concerns on food intake via plate-clearing  
392 tendencies using a mediation analysis, which was run using PROCESS version 3 (Hayes,  
393 2017). Food waste concerns (continuous score derived from total score) was the independent  
394 variable (X), food intake (measured as weight of food eaten in grams) was the outcome  
395 variable (Y) and plate-clearing tendency (continuous score derived from total scale score)  
396 was the mediator (M). All variables for the mediation analysis were log-transformed. Results  
397 were considered significant at a  $p < .05$ .

398

#### 399 *4.1.7 Sensitivity analyses*

400 We conducted Pearson's correlations between plate-clearing tendency score, food waste  
401 concerns score, food intake and the following variables: gender, age, BMI, appetite ratings  
402 (desire-to-eat, hunger, fullness), meal enjoyment, restraint, disinhibition and hunger  
403 (measured using the TFEQ). If any of these variables were significantly correlated with plate-  
404 clearing tendency score, food waste concerns score and/or food intake we included them as

405 covariates in an additional mediation analysis. All variables for the mediation analysis were  
406 log-transformed (except for gender). We also planned to examine the effect of removing  
407 participants that were aware of the study aims on our main planned analysis. Participants  
408 were characterised as being aware of the study aims if they mentioned the influence of plate-  
409 clearing tendencies, food waste concerns or eating from large portions. Two researchers  
410 independently coded participant responses to this question and identified 8 participants with  
411 some awareness of the study aims. One participant requested and consumed a second serving  
412 of food, and therefore was served a total of 1000g of pasta in tomato sauce (2 portions), and 2  
413 participants completed the screening questionnaire retrospectively (i.e. after the study  
414 session). We examined the effect of removing these participants in a sensitivity analysis and  
415 the results remained the same (see online supplementary materials).

416

## 417 **4.2 Results**

### 418 *4.2.1 Main analyses*

419 One hundred and twenty-eight participants (85 females, 43 males) were included in our  
420 sample. See Table 1 for sample characteristics, and see online supplementary materials for  
421 correlations between food waste concerns, plate-clearing tendencies, food intake and other  
422 study variables. In the mediation analysis there was no direct effect of food waste concerns  
423 on food intake,  $B = .12$ ,  $SE = .12$ , 95% CIs = -0.13-0.36,  $p = .340$ . Food waste concerns were  
424 positively associated with plate-clearing tendencies,  $B = .16$ ,  $SE = .06$ , 95% CIs = 0.05-0.28,  $p$   
425  $= .005$  and greater plate-clearing tendencies were associated with greater food intake, but not  
426 significantly so,  $B = .29$ ,  $SE = .18$ , 95% CIs = -0.08-0.65,  $p = .124$ . Contrary to predictions,  
427 there was no significant indirect effect of food waste concerns on food intake via plate-  
428 clearing tendencies ( $b(SE) = .05(.06)$ , 95% CI = -0.01, 0.22) (see Figure 1).

429 *Table 1. Participant characteristics, meal liking, perception of portion size of meal, average*  
 430 *food waste concerns score and average plate-clearing score*

431

	Mean ( $\pm$ SD)
Time between screening questionnaire and study session (days) <sup>a</sup>	11 ( $\pm$ 9)
Age (years) <sup>b</sup>	22.7 ( $\pm$ 9.1)
BMI (kg/m <sup>2</sup> )	23.9 ( $\pm$ 4.5)
Food waste concerns score <sup>c</sup>	4.25 ( $\pm$ 1.19)
Plate-clearing score <sup>d</sup>	3.94 ( $\pm$ 0.65)
Weight of food eaten (grams)	399.20 ( $\pm$ 109.86)
Liking <sup>e</sup>	4 ( $\pm$ 1)
Perception of portion size <sup>f</sup>	5 ( $\pm$ 1)

432 Table 1 displays averages for the number of days between completing the screening questionnaire and attending  
 433 the study session, participants characteristics (age, BMI), food waste concerns score, plate-clearing tendency  
 434 score, weight of food eaten (g), liking and perception of portion size.

435 <sup>a</sup> Two participants did not complete the screening questionnaire before the study session due to error, and  
 436 instead completed the measures shortly after the laboratory session.

437 <sup>b</sup> Age (years) contains data from 127 participants, as there are missing data.

438 <sup>c</sup> Food waste concerns score is on a 1 to 7 scale, with higher values denoting greater food waste concerns.

439 <sup>d</sup> Plate-clearing score is on a 1 to 5 scale, with higher values denoting greater plate-clearing tendencies.

440 <sup>e</sup> Liking is on a 1 to 5 scale, with higher values denoting greater liking.

441 <sup>f</sup> Perception of portion size is on a 1 to 5 scale, with higher values denoting that the participant perceived the  
 442 lunchtime meal to be larger in size.

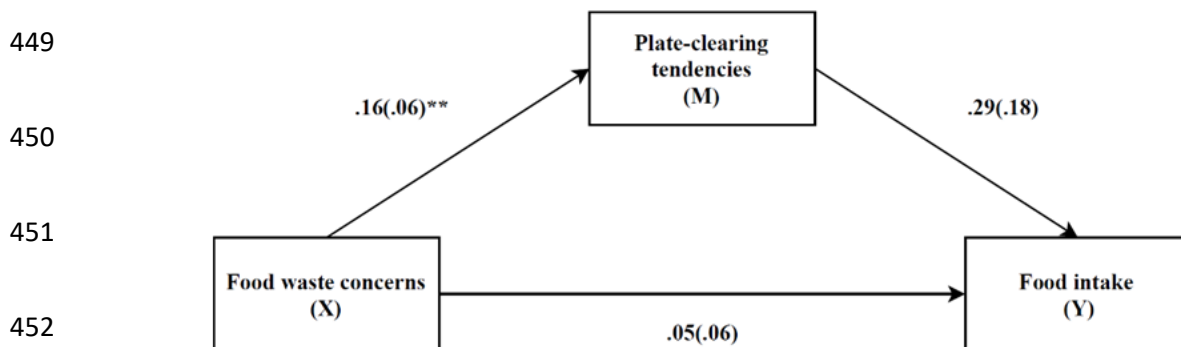
443

444

445

446

447 *Figure 1. Model displaying the indirect effect of food waste concerns on food intake via*  
 448 *plate-clearing tendencies*



453 Figure 1 shows a conceptual model of our expected mediation model, with food waste concerns (X) on food  
 454 intake (Y) mediated by plate-clearing tendencies (M). Contrary to predictions, there was no significant indirect  
 455 effect of food waste concerns on food intake via plate-clearing tendencies. Values are B(SE). \*\* $p < .01$

456

#### 457 4.2.2 Sensitivity analyses

458 For the sensitivity analysis, 6 variables were correlated with either food waste concerns,  
 459 plate-clearing tendencies and/or food intake and were therefore included in the mediation  
 460 analysis as covariates: gender, desire-to-eat pre-lunch, hunger pre-lunch, fullness pre-lunch,  
 461 meal enjoyment (liking) and hunger (measured by the TFEQ). The results of the model with  
 462 covariates included were the same as in the unadjusted model. Food waste concerns  
 463 significantly predicted plate-clearing tendencies, but were not directly or indirectly associated  
 464 with food intake (see online supplementary materials for full results). Two participants  
 465 completed the screening questionnaire retrospectively (i.e. after the study session), and 8  
 466 participants reported some awareness of study aims. Re-running the main analyses with these  
 467 participants removed did not change the patterns of significance observed.

468

## 469 5. Discussion

470 The aim of the present research was to examine the relationships between food waste  
471 concerns, eating behaviour and body weight. We developed and validated a short measure to  
472 quantify concerns about wasting food when eating. In Study 1 (Section 2.), the measure was  
473 shown to have a single factor structure, in addition to good internal consistency, excellent  
474 test-retest reliability, as well as both convergent (i.e. predictive of emotional responses to  
475 food waste) and divergent validity (i.e. only weakly associated with measures of trait  
476 overeating and appetite). In Study 2 (Section 3.), the single factor structure of the measure  
477 was confirmed. Because concerns about food waste may promote excess energy consumption  
478 through encouraging the behaviour of plate-clearing, we made a number of predictions. We  
479 predicted that greater concerns about wasting food would be associated with greater  
480 intentions to behave in ways that minimize food waste, such as eating leftovers (Study 1,  
481 Section 2.)), greater self-reported plate-clearing tendencies and/or heavier body weight  
482 (Study 2, Section 3.) and objectively measured energy intake when served a large portion of  
483 food (Study 3, Section 4.). Although we found that greater food waste concerns were  
484 associated with self-reported intentions to minimize food waste and plate-clearing tendencies,  
485 we did not find evidence that food waste concerns were associated with body weight or  
486 laboratory-measured energy intake when served a large meal.

487 A strength of this research is the development and validation of a short measure to  
488 quantify food waste concerns when eating. This improves upon the measurement of personal  
489 food waste concerns using a single non-validated question: “I don’t like to see food going to  
490 waste”, as in Robinson and Hardman (2016). Furthermore, although there are some scales  
491 created to measure attitudes towards food waste, these focus on engaging in specific food  
492 waste behaviours (e.g. reducing the amount of fruit and vegetables that gets thrown away in  
493 the home) (Graham-Rowe et al., 2015; Russell et al., 2017) or do not always directly measure  
494 food waste concerns in relation to eating behaviour (Aktas et al., 2018; Stancu et al., 2016).

495 Also, we found that scores on our food waste concerns measure predicted intentions to waste  
496 less food, which is supportive of previous research (Aktas et al., 2018; Graham-Rowe et al.,  
497 2015; Stancu et al., 2016; Stefan et al., 2013) and suggests the measure has some validity.  
498 Why we observed no evidence linking food waste concerns to increased energy intake  
499 warrants consideration. Previous research highlights a disconnect between attitudes,  
500 intentions and behaviours, often referred to as the attitude-behaviour gap (Ajzen, 2001;  
501 Sheeran, 2002). Alternatively, previous research has suggested that guilt regarding wasting  
502 food can stem from a variety of sources. For example, personal responsibility, ethical, moral,  
503 environmental, financial concerns (Benson, 2009; Schanes, Dobernig, & Gözet, 2018; Setti,  
504 Falasconi, Segrè, Cusano, & Vittuari, 2016), or perceived value of food itself (Ganglbauer,  
505 Fitzpatrick, & Comber, 2013). It may therefore be important to consider the origin of a  
506 person's concerns about wasting food in order to understand the effect these concerns may  
507 have on eating behaviour. For example, participants were provided with a free meal in Study  
508 3 in a laboratory context. However, in a restaurant setting in which a person has had to pay  
509 for a meal and/or perceives the meal as being more valuable, food waste concerns may be  
510 more influential and promote overconsumption.

511         Likewise, in Study 3 food was prepared by a researcher and participants may not have  
512 felt personally responsible for any wasted food and therefore not acted on their concerns  
513 about wasting food in this context. We also found no evidence linking food waste concerns to  
514 heavier body weight. This may be because food waste concerns do not cause overeating or it  
515 may be because there are other factors associated with food waste concerns that mitigate any  
516 association with overeating. It is also possible that some people may be concerned about  
517 food waste, but still choose to eat only what they need in the interest of other motivations,  
518 such as weight management . Alternatively, some people may be concerned about food  
519 waste, but primarily reduce the amount of food they waste through other ways than

520 overconsumption at one eating occasion (e.g. adjusting their purchasing behaviour, or  
521 utilising leftovers in a future meal (Cappellini & Parsons, 2013; Evans, 2012)). Furthermore,  
522 although we measured food intake and it may be the case that food waste concerns instead  
523 predict whether people eat more than they would otherwise intend to when served larger  
524 portions.

525         We did find that food waste concerns were predictive of self-reported plate-clearing  
526 tendencies (Study 2 and 3). This is consistent with a previous finding that disliking wasting  
527 food was associated with plate-clearing tendencies (Robinson & Hardman, 2016), and that  
528 avoiding food waste was a common reason for plate-clearing beyond the point of fullness  
529 (Fay et al., 2011). Food waste concerns may therefore be a determinant of plate-clearing  
530 tendencies. However, plate-clearing tendencies were self-reported in the present studies.  
531 These data were also cross-sectional and given that the food waste concerns measure was  
532 found to have excellent test-retest reliability, it would now be useful to investigate how food  
533 waste concerns impact on eating behaviour or weight gain over time.

534         There are a number of factors that limit the generalisability of the present research. As  
535 discussed, we measured energy intake in a laboratory context and it may be the case that food  
536 waste concerns are more likely to impact on energy intake under different circumstances,  
537 such as when food is perceived as being more valuable and/or when personal responsibility,  
538 moral or environment concerns for wasted food are more salient. In particular, these factors  
539 may be more or less important in a familial or household context (Cappellini & Parsons,  
540 2013; Evans, 2012). For example, Lazell (2016) suggests that when eating outside of the  
541 home, individuals feel less involved with the food and so less responsible for it, which may  
542 cause a diffusion of responsibility regarding leftovers. Perceived behavioural control may  
543 also be relevant to consider in future research as people may feel less control in laboratory



544 situations compared to the home, and perceived behavioural control may predict self-reported  
545 intended and actual food waste behaviours.

546 As we sampled U.K. participants and relied on predominantly white educated  
547 participants (university samples used in Study 2 and 3), examining food waste concerns in  
548 samples that are more diverse may yield different results. In addition, monetary concerns  
549 have been cited as a reason to avoid food waste (Lazell, 2016; Watson & Meah, 2012), but  
550 our measure did not consider factors that motivate food waste concerns. Therefore, our short  
551 measure does not consider the potential causes of concerns about wasting food when eating  
552 and future research may benefit from addressing the causes of food waste concerns. Finally,  
553 although we found evidence that food waste concerns were associated with intentions to  
554 avoid wasting food when eating, these findings are cross-sectional and therefore causality  
555 cannot be inferred.

556

## 557 **6. Conclusions**

558 Across 3 studies, we provide evidence that concerns about food waste are related to self-  
559 reported intentions to minimize food waste and plate-clearing tendencies, but no evidence  
560 that food waste concerns are related to objectively measured energy intake in the laboratory  
561 or body weight.

562

563

## 564 **List of additional files**

565 Additional file 1

566 Format: Microsoft word document (.docx)

567 Title: Table 1. Participant characteristics, meal liking, perception of portion size of meal,  
568 average food waste concerns score and average plate-clearing score

569 Additional file 2

570 Format: Microsoft word document (.docx)

571 Title: Figure 1. Model displaying the indirect effect of food waste concerns on food intake via  
572 plate-clearing tendencies

573

#### 574 **Declarations**

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578 their respective studies and providing us with the data for Study 2.

579

##### 580 *Authors' contributions*

581 FS designed the three studies, was the primary writer of the manuscript, recruited  
582 participants, and collected, analyzed and interpreted the data. ER and CAH contributed to the  
583 conceptualization, design and interpretation of the experiments. All authors contributed to the  
584 manuscript writing.

585

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591 American Beverage Association and Unilever.

592

##### 593 *Declaration of interest*

594 None.

595

596 *Competing interests*

597 The author(s) declare that they have no competing interests.

598

599 *Ethics approval and consent to participate*

600 Ethical approval was gained from the University of Liverpool's IPHS Research Ethics

601 Committee for Study 1 (reference number: 5332) and Study 3 (reference number: IPHS-

602 1617-LB-284 - Generic RETH000955). Participants provided written consent prior to

603 participation. The data sets included in Study 2 also gained ethical approval from University

604 of Liverpool's IPHS Research Ethics Committee.

605

606 *Consent for publication*

607 Not applicable.

608

609 *Availability of data and material*

610 The datasets generated and analysed during Study 1, Study 2 and Study 3 are available on the

611 Open Science Framework repository (<https://osf.io/aef75/>).

612

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