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Perspective—Evaluating the impact of food waste reduction policies

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1. Introduction

Food waste is increasingly recognized as a driving problem affecting high-income countries but is expected to be rapidly growing in emerging economies (van der Werf and Gilliland, 2017; Aschemann-Witzel et al., 2019). The identification and quantification of food waste generated throughout the supply chains, especially at the household level remain challenging and academic efforts are directed to address this gap. A shy but growing strand of empirical literature has proposed, tested and assessed methodologies to collect data on household food waste, quantify (Corrado et al., 2019; van Herpen et al., 2019), and model it (Gil, 2020). Several studies provide extensive coverage of primary data collection methodologies for quantifying household food waste. Self-reports via food waste diaries, kitchen caddies, coding of pictures, and food waste composition analysis are the most commonly applied methodologies (Leverenz et al., 2019; Quested, 2019; van Herpen et al., 2019). Besides, there is an interest to explore secondary data in addition to direct food waste measurements, either based on territorial or consumption-based approaches.

If the development of data collection methodologies and tools is a prerequisite to lay unbar the food waste problem, there is also an urgent need for more scientific reflection on the designs which can best help identify causal changes in consumers' behaviors and attitudes due to food waste prevention interventions. Indeed, there is a growing global policy- and grassroots-driven trend to develop policies and initiatives to reduce food waste and its impacts on the environment, driving for the more systematic use of evaluation and monitoring of food waste prevention initiatives. Although some studies took stock of existing interventions and their success factors, their actual food waste reduction impact remains unclear (Aschemann-Witzel et al., 2017). Several systematic reviews concluded on the lack of evidence about anti-food waste interventions along the supply chain (Stöckli et al., 2018), but also that there is little information available regarding what interventions have been evaluated, and how they have been evaluated (Goossens et al., 2019). Only isolated studies attended to quantify the effects of grassroots initiatives to reduce food waste but systematic impact assessment is lacking (Nikravech et al., 2020).

2. The necessity of determining causal inference to assess food waste prevention

There is an inherent difficulty in evaluating food waste reduction since it implies the measurement of something "*that is not there* [anymore]" (Zorpas and Lasaridi, 2013; p. 1055). In addition, measurement and quantification methods alone do not suffice to determine the causal inference to an intervention to bear an effect on food waste. We would

like to appeal to the research community and funding to direct further efforts and funds to the identification of the causal effect of food waste prevention interventions. This should be done with the application of robust research designs that can offer an objective assessment of the causal effect of food waste prevention interventions. More specifically, this is an appeal to the scientific community to reflect on the way to include an econometric impact attribution evaluation perspective in food waste research endeavors. Indeed, compared to observational contribution evaluation designs, such approaches allow identifying the causality of interventions leading to food waste reduction, disentangling and quantifying their effects. This paper provides food for thought about applying impact evaluation designs to food waste reduction interventions.

Existing food waste impact assessments were achieved mostly in the form of quantification (Schneider, 2013; Reynolds et al., 2015; Makov et al., 2020), whereby food and food waste inputs and outputs are measured up and downstream of the food waste prevention initiatives. Adding environmental economic and social dimensions to the assessment with the help of Life Cycle Assessment, social indicators such as the number of redistributed meals or jobs created were proposed to holistically evaluate interventions (Goossens et al., 2019). Such methodologies provide useful descriptive information about the flows of food and food waste policies and initiatives deal with or prevent, as well as about other social and economic outcomes. Yet, they do not allow *per se* a causal impact identification.

Another strand of food waste studies has sought to identify the impact of policies using multivariate regression frameworks on the food waste outcome, using a treatment status as an independent variable. This analytical framework allows exploratory analysis of the influence of individual, group, societal, and time factors on food waste amounts. Nonetheless, it does not account robustly for the impact of other factors that influence the change in food waste outcome nor can distinguish non-observable differences, for instance, motivations or personal goals (van Geffen et al., 2020). Before-after comparison designs with the same participants (longitudinal studies) (Lorenz-Walther et al., 2019; Wharton et al., 2021) or cross-section comparison designs (participant-nonparticipants) are also commonly used designs to identify the effects of anti-food waste interventions (Wharton et al., 2021).

3. Applying the golden standard of randomized control trials to food waste prevention

A deeper reflection should be conducted about a valid and feasible counterfactual condition against which the impact can be measured. This counterfactual seeks to mimic the hypothetical condition in which recipients of treatment did *not* receive the treatment. Ensuring its validity along the way is key to studying the causal impact of anti-food waste interventions. This reflection shall therefore consider the golden standards of impact evaluations to identify causal inference: randomized control trials. Popularized in the field of development economics, their use in the field of food waste policy has been so far marginal and reserved to small-size pilots and nudges in the gastronomy and hospitality sector (Kallbekken and Sælen, 2013). There is little research about the potential to use such experimental methodologies to assess more large-scale food waste prevention interventions. Randomized control trials imply the randomization of eligible units into treatment groups, to which the intervention is allocated, and control groups. Such endeavors are costly to achieve because they imply strict control over the treatment status of the units and the compliance to remain valid and provide robust inference. Moreover, they involve a large number of sample units.

When engaging in such assignments, it is important to consider the levels at which a food waste prevention intervention is expected to "work", possible spill-overs, and existing clustering, to decide on which level it makes more sense to randomize (Glennerster and Takavarasha, 2013). For example, food waste prevention taking the form of an "ugly fruits and vegetables" campaign (Hooge et al., 2017) is more appropriate to be randomized at the supermarket level while an intervention providing a kitchen food waste monitoring device may be randomized at the household level. Whether the randomization should be simple, pairwise, or stratified is also to be considered by food waste social scientists (Glennerster and Takavarasha, 2013).

Whenever random sampling and random treatment assignment are not feasible (because e.g., there are not enough eligible units or the treatment allocation was decided before the research started) or not desirable (taking the example of an extreme case: randomizing the access to food donation and preventing part of its eligible beneficiaries to access edible rescued food, even in a phase-in approach would be ethically inappropriate) other types of robust designs should be considered. Yet, before moving to quasi-experimental designs, one could consider the use of phase-in or rotation designs when everyone needs to receive the intervention, or encouragement designs, whenever the program is open to all and undersubscribed (Glennerster and Takavarasha, 2013) could find their application, when it comes to food redistribution.

4. Quasi-experimental designs as workable alternatives: opportunities and pitfalls

Quasi-experimental designs are more regularly employed to explore household food waste and can be a valid way to assess impact. Yet there is little methodological discussion existing about their opportunities, challenges, and how to use them when it comes to measuring the impact of food waste prevention interventions. In a natural experiment or an organized field experiment setting, the use of baseline measurements and of a sound control group to mimic the counterfactual bear the potential to identify an impact in a more robust way than simple difference designs. One path we suggest exploring is the use of difference-in-difference, propensity score matching, and matched difference-in-difference designs. By matching one unit from a non-random control group with one unit from a non-random treatment group based on their propensity to be exposed to the treatment conditional on covariates (Dehejia and Wahba, 2002), one could pair households and compare the food waste amount pairwise. Using propensity score matching

(PSM) is deemed appropriate in the case of small N to adjust for confounders which makes it a promising method for food waste social research. Moreover, PSM can be used in combination with the difference-in-difference in a matched difference-in-difference assignment (Abadie, 2005). So far, we found one study that explored the potential of a matched difference-in-difference to measure the impact of two local food waste disposal payment policies on food waste (Lee and Jung, 2017).

More generally, when assessing impacts in the field of food waste policy, it should be reflected how big the expected effects in terms of food waste reduction are, given the intervention type and its intensity, to consider the reasonable sample size, most importantly the number of clusters to integrate in order to detect the minimum effect. Holding such reflection is crucial since food waste measurements are highly likely to come along with high standard errors due to measurement imprecision, especially when they are based on self-report, and to their high variance, biasing the estimates. It is important to keep in mind what changes are expected and how to detect these changes, and therefore adapt the sampling strategy to the expected change. Studies on food waste have so far suggested diverging effect sizes in terms of food waste prevention depending on the interventions. Hence, they should be reviewed before engaging in evaluation endeavors to prevent disappointing false-negative. An experimental study showed a reduction in food waste of 15% due to the reduction of plate size (Kallbekken and Sælen, 2013). Reynolds et al. (2019) found in a review that nudge interventions in the hospitality sector could lead to up to 57% food waste reduction while information campaigns could reduce up to 28% of food waste.

Finally, as previous literature has highlighted, large-scale food waste data collection is challenging and often relies on low-cost participatory data collection methodologies which can endanger the validity of the results (attrition, tiredness, social desirability). Conducting impact assessments on food waste implies a consideration of how the measurements are carried out in control groups. Indeed, primary food waste data collection is often carried out based on self-report, be it with pictures, diaries, or kitchen caddies, and one should think about the best way to engage control groups in the study itself and the measurement activities. Avoiding differential attrition and receiving food waste information of the same quality both from control groups and the treatment groups is paramount to preserve the validity of the results. These questions, often raised in the field of impact evaluation have rarely found their place in the field of consumer studies and food waste. Researchers should monitor the quality of food waste measurements throughout the process to ensure balance.

5. Discussion and concluding remarks

This opinion piece highlighted the urgent need to gather robust evidence on the impact of food waste prevention interventions. It recalled that only few studies on the effectiveness of such interventions have questioned the causality identification methods. So far, most of the scientific literature in the field of food waste reduction used primarily non-experimental observational studies (e.g., pre-post, participant-nonparticipant designs), focused on quantification of food waste or explored the relationships between individual and collective factors and food waste. This opinion piece suggested that exploring more systematically the potential of experimental and quasi-experimental studies is the next step to providing robust empirical impact evidence. The potential and challenges of employing randomized control trials to assess food waste reduction interventions were discussed, and alternative paths presented. Experimental designs allow to distinguish whether the reduction of the measured food waste is indeed strictly attributable to the intervention and not to sources of bias, such as differentiated self-reported food waste measurements, as long as compliance to the treatment status is controlled. By contrast, in alternative quasi-experimental designs, the differential measurement errors induced by the control or treatment conditions need to be utterly monitored by researchers willing to engage in such an endeavor.

Evaluating food waste reduction interventions presents similar challenges to other fields of policy impact evaluation to ensure causality identification. However, it additionally implies the challenge of opening the black box of households' kitchens and trashcans, and often dealing with self-reported food waste data. While the specific challenges related to measuring food waste still require to be addressed, removing systematic sources of impact bias by employing causality inference designs is necessary. Overall, this opinion paper contributes to the food waste prevention literature by calling up attention on this. We hope that it helped to highlight the need for a research and policy agenda to test experimental and quasi-experimental research designs in the field of consumer studies and food waste.

Author contributions

MN: conceptualization, formal analysis, methodology, writing—original draft, and writing—review and editing.

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Conflict of interest

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