By Roni A. Neff, Rebecca Kanter, and Stefanie Vandevijvere

Reducing Food Loss And Waste While Improving The Public's Health

DOI: 10.1377/hlthaff.2015.0647
HEALTH AFFAIRS 34,
NO. 11 (2015): 1821–1829

ABSTRACT An estimated 30 percent of the global food supply is lost or wasted, as is about 40 percent of the US food supply. There are valuable synergies between efforts to reduce food loss and waste and those promoting public health. To demonstrate the potential impact of building upon these synergies, we present an analysis of policies and interventions addressing food loss and waste, food security, food safety, and nutrition. We characterize as opportunities the policies and interventions that promote synergistic relationships between goals in the fields of food loss and waste and of public health. We characterize as challenges the policies and interventions that may reduce food loss and waste but compromise public health, or improve public health but increase food loss and waste. Some interventions are both opportunities and challenges. With deliberate planning and action, challenges can often be addressed and turned into opportunities. In other cases, it may be necessary to strike a balance between potential benefit in one area and risk of harm in the other. To help policy makers make the best use of the opportunities while tackling the challenges, it is essential to consider public health in efforts to reduce food loss and waste.

Roni A. Neff (rneff1@jhu.edu) is an assistant professor of environmental health sciences at the Johns Hopkins Bloomberg School of Public Health and program director for food system sustainability and public health at the Johns Hopkins Center for a Livable Future, both in Baltimore, Maryland.

Rebecca Kanter is a research fellow at the Institute of Nutrition and Food Technology (INTA), University of Chile, in Santiago, Chile.

Stefanie Vandevijvere is a senior research fellow in global health, food policy, obesity, and noncommunicable disease prevention in the Department of Epidemiology and Biostatistics, School of Population Health, University of Auckland, in New Zealand.

An estimated 30 percent of the global food supply—and up to 40 percent of the US food supply—is lost or wasted.[1,2] By 2030 the United Nations aims to "halve per capita global food waste at the retail and consumer levels and reduce food losses along production and supply chains, including post-harvest losses."[3] The UN Food and Agriculture Organization defines *food loss* as reductions in edible food mass occurring during agricultural production, post-harvest, and processing and *food waste* as reductions occurring at retail and consumer levels.[2] Both terms exclude inedible parts and items planned for nonfood use. *Food surplus* is defined as food exceeding needs, whether or not it is wasted.[4(p112)] Synergies exist between policies and interventions to reduce food loss and waste and those promoting public health.

The amounts and sources of food loss and waste vary globally (Exhibit 1). In low- and middle-income countries, loss predominates, given poor infrastructure and climate change vulnerability. In high-income countries, waste is particularly associated with consumers' behavior and food industry practices.[2]

Intersections Of Public Health And Food Loss And Waste

Food loss and waste and public health intersect primarily in the domains of food security, food safety, and nutrition. Food not eaten also has considerable unnecessary environmental,[5,6] occupational,[7] and social impacts,[8] but these are not discussed in this article.

Within the three public health domains, we present policies and interventions that we char-

EXHIBIT 1

Percentages Of Food Lost Or Wasted Across The Food Chain, By Geographical Region

	Agriculture		Postharvest handling and storage		Processing and packaging		Distribution		Consumption	
Region	Mean	Range	Mean	Range	Mean	Range	Mean	Range	Mean	Range
North America and Oceania	10%	2–20%	3%	0–10%	5%	1–15%	5%	1–12%	21%	4–33%
Europe, including Russia	10	2–20	3	1–9	5	1–15	5	1–10	13	4–25
Industrialized Asia	9	2–20	5	1–10	5	1–15	5	1–11	10	4–20
Sub-Saharan Africa	10	6–15	9	1–18	9	0–25	8	2–17	2	0–5
North Africa; West and Central Asia	9	4–17	7	0–10	8	2–20	7	2–15	7	2–12
Southeast Asia	7	4–15	8	0–19	9	2–25	8	2–15	3	1–7
Latin America	9	4–20	6	1–14	8	2–20	6	2–12	6	2–10

SOURCE Authors' summary of data from Gustavsson J, et al. Global food losses and food waste (Note 2 in text). **NOTE** Means and ranges are summarized across food categories.

acterize as either opportunities (which involve synergistic relationships between goals related to food loss and waste and those related to public health) or challenges (which may reduce food loss and waste but compromise public health, or reduce public health but increase food loss and waste; see Appendix Exhibit A1).[9] Some policies and interventions could be considered as both opportunities and challenges. Deliberate planning and action can, to varying extents, convert challenges into opportunities. Considering tensions between goals may lead to reprioritizing actions.

Strategies to address food loss and waste occupy a hierarchy of benefit, from reduce (food loss and waste prevention) through reuse (diverting food surplus for human needs, when appropriate, or for animal feed) and recycle (recovering some value via industrial use, composting, or anaerobic digestion) to landfilling.[4] Because of the strong synergies between efforts in the fields of public health and food loss and waste reduction, most of the interventions we discuss focus on the "reduce" and "reuse" parts of the hierarchy. In each domain we organize interventions loosely from "farm to fork." Exhibit 2 presents selected types of public policy that can address both goals related to food loss and waste and those related to public health.

Food Security

Globally, one in nine people lack sufficient food, and 5.6 percent of Americans suffer from very low food security (that is, disrupted eating patterns and reduced food intake).[10,11] The United Nations notes that while these figures in part reflect unequal food distribution, by 2050 the world will need 60 percent more food than it has now.[12] Halving food loss and waste would reduce this projected need by 20 percent.[13] Thus, the UN Food and Agriculture Organization has integrated the reduction of food loss and waste into its policy goals to "ensure food security and nutrition for all."[14] The discussion below is premised on the idea that reducing food loss and waste and diverting surplus food to people in need would increase food availability and security, although distribution would remain a concern in terms of both equity and logistics.

OPPORTUNITIES

▶ **FARMING METHODS:** Often the strategies needed to reduce agricultural loss are specific to the food item produced, but there are commonalities. For example, taking precautionary approaches to risk management, such as acting early based on uncertain information about weather, can reduce both catastrophic and minor losses.

Different farm types have different loss-reduction strengths. Farms oriented toward sustainability can reduce losses by strengthening resilience to threats, such as by using compost to build drought-tolerant soils. Smaller farms can more easily monitor threats directly, while larger and well-capitalized farms may use technology to detect threats and then protect crops—for example, through targeted pesticide use.

The approaches discussed above can be promoted with policies such as those that provide funds for training or technical assistance, financial incentive programs, investment in research, and making it difficult for famers to get insurance when planting on vulnerable land. Another approach is developing improved data, such as information about local weather, to improve farmers' ability to predict crop yields and plan purchasing. In our view, such data are particularly limited in many low- and middle-income countries and for farms that produce fruit and

EXHIBIT 2

Selected Policy Approaches For Jointly Advancing Goals Related To Food Loss And Waste And Public Health

	Potential benefits	
Policy type	**Food loss and waste (FLW)**	**Public health**
FLW reduction targets: Set ambitious national goals	Improves impetus for FLW activities	Multiple benefits[a]
Agricultural extension: Fund agricultural extension (farmer technical assistance and education) activities focused on FLW	Reduces food loss	Increases food supply and livelihoods
Food supply-chain infrastructure: Purchase, plan, and construct infrastructure	Reduces FLW	Improves food security, food safety, nutrition, or some combination
Access to loans and credit: particularly in low- and middle-income countries	Reduces food loss	Improves farm household and global food security
Date labeling: Create national date labeling standards, including encoded sell-by dates, consistent language, on-label food handling and freezing instructions, visual icons, and consumer education	Reduces unnecessary discarding of food	Improves food safety
Food recovery support: Provide resources to support food recovery efforts, support creation of secondary markets for "ugly" and older produce	Reduces FLW	Improves food security and (where relevant) produce consumption
Nutrition education: Incorporate food waste guidance into all government-funded nutrition programs, including signage, lesson plans, and staff training for school food programs	Improves consumers' knowledge and motivation	May improve household food security and nutrition
Research: Fund research and development related to FLW, including agricultural loss prevention; food packaging; online or cell phone applications to address food recovery program challenges; research on the psychology, sociology, and economics of FLW across the food chain; FLW surveillance; and program and policy evaluation	Reduces FLW, improves effectiveness of FLW programs and policies	Increases food security and nutrition via increased supply and improved food donation processes, improves food safety, increases use of interventions jointly benefiting public health

SOURCE Authors' analysis. [a]As the text explains, reducing food loss and waste has a range of public health benefits, including those related to food security, food safety, and nutrition; and other environmental health, occupational health, and social health benefits from reducing unnecessary food production. These are implied for every public health policy. For an expanded version of the table that lists additional policy opportunities, see Appendix Exhibit A2 (see Note 9 in text).

vegetables in high-income countries. While international policies vary, the US Farm Bill contains policy relevant to all of these approaches, though there is room to strengthen it.

▶ **SUPPLY CHAIN AND INFRASTRUCTURE:** In many low- and middle-income countries, improving storage, infrastructure, and mechanization are among the most important strategies for reducing postharvest food loss.[15] Storage containers that protect against moisture and pests are considered essential and are an area of much innovation.[15]

Mechanized systems for threshing and drying grains can increase the speed and volume of processing, thus reducing the time when grains are most vulnerable to spoilage. Mechanized devices can be simple and inexpensive; some use solar or pedal power. Refrigerated buildings and trucks and a stable electrical supply preserve the cold chain, which may save 25–50 percent of a harvest, depending on the crop.[16] Well-maintained roads are also essential for getting food to market before it spoils. International investment to support these priorities, in our view, should be an essential component of food assistance.

▶ **FOOD RECOVERY:** Food recovery programs gather and distribute surplus food to food-insecure people through food banks, food pantries, and other organizations. The food can be collected at any stage in the food chain, and donation sizes vary widely. Programs recovering fresh produce from farms in particular are proliferating in the United States. One example is the Society of St. Andrew, which engages volunteers across the United States in gathering unharvested produce for donation. Food recovery programs are seen as a multifunctional intervention with many benefits, including reducing food pantries' reliance on processed food and addressing the challenge of waste in the face of hunger.[17]

A key strategy to increase food recovery is providing tax breaks or other assistance to minimize the costs related to making donations—which can include harvesting, storage, packing, logis-

tics, and transportation costs. Another strategy is removing barriers to food redistribution. For example, in the United States the Bill Emerson Good Samaritan Food Donation Act of 1996 protects food donors from civil and criminal liability should donated products cause foodborne illness. Laws can also require donations. For example, a 2015 French policy proposal criminalizes supermarket food discards and requires retailers to reduce, reuse, or recycle food instead of discarding it.[18]

CHALLENGES

▶ **FOOD RECOVERY:** Food donors are seen as benefactors. However, they can gain significantly from the recipient's acceptance of food, which gives them the chance to offload unwanted products, improve their reputation, and sometimes receive tax or other financial advantages. One concern is that programs may cater more to the needs of donors than to those of recipients and may thus provide food in undesired amounts, types, or locations or at undesired times. New digital applications have been improving the real-time connections between donors and recipients to address issues of logistics and food preferences. However, significant challenges remain.

A related tension is that some donors may place the onus of culling and disposing of spoiled or expired food on recipients. Food distribution programs sometimes replicate these problems with their clients. Forty percent of retail donations to one program later went to landfills, including 10 percent of food received by consumers.[19] Some recipient sites have stopped accepting donations of unhealthy food.

Still another tension is that some efforts to encourage donations may reduce the disincentive to overproduce. For example, food donation tax incentives might shift the risk balance toward overproducing instead of increasing efforts to rightsize. Awareness of this concern may generate new ideas for incentive targeting.

In addition, food recovery programs may divert resources and political energy from the political work necessary to reduce the need for their services and from efforts targeted at the root causes of food insecurity.[20] The multifunctional appeal and, to many, the novelty of programs that recover surplus crops from farms could divert even more energy than do other charity emergency food programs. In response to these concerns, we note that some emergency food programs, especially larger ones, do also engage in advocacy for deeper change, directly or in partnership with other organizations.

Food safety is the top reason US consumers report for discarding food.

Food Safety

An estimated 582 million people globally were sickened by the twenty-two major foodborne enteric illnesses in 2010, and 351,000 people died, primarily in Africa and Southeast Asia.[21] In the United States, which has more robust food safety protections than many other countries do, foodborne illness annually affects one in six people.[22]

Food safety is the top reason US consumers report for discarding food.[23] While potentially unsafe food should be discarded, the analysis below suggests that a meaningful portion of safety-related discards in high-income countries may be unnecessary. By contrast, in some low- and middle-income countries, possibly even more food should be discarded than is already the case, because of recognizable food safety threats. The primary goal everywhere, in our view, is preventing food from becoming unsafe.

OPPORTUNITIES

▶ **FOOD STORAGE AND PACKAGING:** Appropriate storage with protection from weather, microbes, and pests can keep food safe and reduce food loss and waste. Storage, including refrigeration and freezing, is a top-priority approach to reducing food loss and waste and foodborne illness in low- and middle-income countries.[24] Spoilage can also be reduced by the use of food packaging, from high-tech materials to basic physical protections that prevent drying or bruising.[25]

Research and development are needed to further reduce packaging's environmental impacts. Some studies find, however, that packaging commonly has a lower environmental footprint than the food it holds. To the extent that packaging prevents food damage and decay, therefore, the benefits often outweigh the harms.[26]

▶ **FOOD RECALLS AND OTHER LARGE-SCALE DISCARDING:** Discarding large batches of potentially contaminated food can protect public health, whether before sale or afterward as voluntary food recalls. But these discards also create considerable unnecessary food loss and waste. Consumers often avoid products long after a recall concludes, and they may also avoid similar

One in four US consumers say they always discard food after the "sell by" date because of safety concerns.

products (for example, avoiding both romaine and iceberg lettuce after a recall of romaine lettuce).[27] Mass discards may be reduced through the use of skilled communication about such unnecessary precautions; enforcement of food safety regulations; tracking products through the supply chain so that food items of concern may be traced; and addressing the root causes of food contamination.

Poor working conditions, including the lack of workplace rights, represent one type of root cause that can increase the risk of food contamination and errors that lead to discarding large quantities of food.[28] Poor working conditions can also create negative health and social outcomes for workers.[7] One example of a policy with dual benefit for food safety and waste reduction is paid sick days. One survey found that over half of all workers in the food supply chain (from agriculture to restaurant workers) reported working while sick because they lacked paid sick days.[29] The result may be worsened health outcomes and the spread of contagion, including via food handling.

▶ **ASSESSING FOOD SAFETY:** To improve decision making about food safety, consumers need information about a food's shelf life and its storage history (for example, whether it was left unrefrigerated). Tools such as the US Department of Agriculture's Foodkeeper app provide guidance on shelf life.[30] Many consumers also lack broader knowledge of what information to use in making decisions about food safety and could benefit from education, though they may consider themselves already knowledgeable.[23] Educators may thus need to tread carefully to hold their audience's interest.

Many foods have date labels that suggest when quality is projected to decline. Consumers frequently misunderstand these labels, leading to excess discards and risk of foodborne illness from eating nonexpired foods while ignoring other evidence about safety.[31]

The "sell by" dates intended to guide retailers in shelf display are particularly problematic.[31,32] These dates precede the date when freshness is expected to begin declining and are not intended to address food safety. Yet one in four US consumers say they always discard food after the "sell by" date because of safety concerns, and 91 percent do so at least occasionally.[33]

Technological tools such as on-label food sensors that indicate time spent at elevated temperatures[25] can further assist consumer decision making. These tools are still costly and inconsistently available, however. And regardless, consumers benefit from having the skills to make their own assessments.

CHALLENGES IN CULTURE Cultures vary in promoting precautionary approaches to discarding food, versus stigmatizing the overly wasteful.[34] Decisions to discard food based on quality are also often irrational; not fully considered; and based on factors such as disgust, cultural perceptions of "when it stops being food," and habit.[34,35]

Research funding is needed to identify strategies to move consumers toward a "sweet spot" between food safety and the reduction of food loss and waste. This includes research on how safety messages are communicated by industry and understood by and among consumers; how messages influence behavior, shame, hesitancy, or discomfort related to food discards; and how to influence consumers' responses.

Nutrition

Dietary risk factors are currently the top contributor to the global burden of disease.[36] Since 1971 obesity and diet-related chronic diseases have surged in parallel with the globalization of the food supply,[37] and US food waste has increased by approximately 50 percent.[1]

The oversupply[37] and low valuation of food and the benefit to industry from encouraging excess consumer purchasing are likely shared risk factors for overconsumption and waste.[38] Other shared risk factors and opportunities and challenges related to food loss and waste and public health are embedded in how households obtain, store, plan, prepare, and eat meals and in family relationships.[35,39]

OPPORTUNITIES

▶ **OVERPRODUCTION:** Overproduction is an important agricultural contributor to food loss and waste. Moderate surpluses, such as production that is 30 percent above a population's caloric needs, are considered valuable for resilience and food security in the face of threats.[4] However, the US food supply, for example, contains roughly double the number of calories needed to meet the energy requirements of the country's

population.[40]

Excess food supply is associated with excess food consumption, which contributes to diet-related diseases.[37] The surplus may also contribute to reduced food prices and a conscious or subconscious view of food as a relatively low-value item.[38] Notwithstanding the very real financial struggles of many consumers and businesses, relatively low food prices—compared to other expenses—may make waste reduction activities seem economically unjustified, anywhere along the food chain from growers to consumers.

In the United States and other countries where agriculture is not centrally planned, overproduction reflects millions of individual decisions by farmers and food purchasers who are hedging their bets and responding to their own interests.[38] Policy changes, such as those described above in the section on "Farming Methods," may shift their interests.

▶ **WASTE OF PRODUCE:** Fruit and vegetables are among the healthiest but most wasted foods globally.[2] National produce supplies are commonly below what is needed for population nutritional requirements, especially in low- and middle-income countries, and waste increases the gap: The deficit is as high as 63 percent in the median low-income country.[41]

A central reason for produce discards is consumers' aesthetic expectations—both actual and as perceived by industry.[39] In many countries and retail chains, strict aesthetic and functional standards require discarding or repurposing noncompliant produce, such as apples with bruises or unusual shapes. Loosening these standards could add more produce to the food supply while reducing waste and protecting farmers' livelihoods.

Companies are also working to increase opportunities for repurposing food items into products such as soup and to create discounted sales strategies. The French chain Intermarché, for example, successfully marketed "ugly" fruit and vegetables with a clever campaign and reduced prices.[42] It is unknown how much such programs lead to consumers' increasing their fruit and vegetable consumption overall, versus just substituting "ugly" produce for items that are more costly. The answer may affect whether the programs ultimately benefit health and are accepted by businesses. Promoting frozen or canned produce, developing storage guides, and using innovative packaging for longer freshness also reduce waste of produce.[2]

▶ **HOUSEHOLD FOOD DECISIONS:** Many decisions that affect how much food is wasted, such as those related to food purchasing[43] or cooking, are made well before and conceptually distant from the point when food is discarded.[36] Planning meals and avoiding impulse purchases by using shopping lists and preordering can help avoid overconsumption and waste (although, realistically, meal plans often change as a result of unplanned events).[43,44] Also beneficial are efforts to increase consumers' awareness, which include encouraging consumers to track food discards so they can recognize patterns and identify ways to reduce their waste. In the United Kingdom, households used about half of the money saved by waste reduction to purchase higher-quality foods than those they might otherwise choose.[45]

Overproduction is an important agricultural contributor to food loss and waste.

Improving cooking skills and providing recipes for leftovers and guidance on portions are other ways to enhance nutritional health[46,47] while reducing food waste. Training can help improve home cooks' efficiency in using food scraps, which may be lower than that of processing plants or professional food preparers.

Some supermarkets have transformed the "buy one, get one free" model, which tempts cost-conscious consumers, into models such as "buy one, get one free later." The effects on waste reduction, however, remain to be evaluated. Retailer enthusiasm may decline if overall purchases fall.

▶ **PORTION SIZES:** Portion sizes have increased since the 1970s.[48] With larger portions, people eat and waste more,[49,50] so reducing portion size is a key waste-reduction strategy. Some all-you-can-eat buffet restaurants weigh customers' uneaten food and charge them for the waste, while many US campus cafeterias have removed trays, which encourages students to carry less food than they would otherwise. In packaged goods, smaller portion sizes may reduce food intake and are important for reducing waste of perishable products—especially for single-person households, which often discard more per capita than others.[49]

CHALLENGES

▶ **FOOD PROCESSING:** Highly processed foods often have long shelf lives, which reduces waste, but they are generally high in salt, saturated fat, and sugar, which contributes to diet-related chronic diseases.[51] We have not observed these

Improved understanding of the root causes of food loss and waste globally would advance the implementation of interventions.

foods being touted as antidotes to waste. There is some evidence, however, that consumers—particularly those with lower incomes—may purchase less produce than they prefer, because of concerns about perishability and the subsequent investment loss.[38,52] For consumers focused on shelf life, this challenge might be addressed with interventions that include promoting frozen and canned products as healthy substitutes for fresh produce and encouraging the food industry to reduce added sodium and sugar to minimum levels needed for safety and preservation.

▶ **EXPORTING AND SELLING UNHEALTHY PRODUCTS:** With increasing trade liberalization, high-income countries are exporting growing quantities of unwanted and mainly unhealthy surplus foods to low- and middle-income countries. One example is turkey tails exported from the United States.[53] To improve public health, Samoa banned such imports in 2007, but the ban violated World Trade Organization (WTO) rules and was later lifted.[54] Ghana succeeded in challenging similar imports through the WTO.[55]

Promoting health while reducing waste in such cases may require loosening WTO rules to favor domestic food policy or finding alternative economically beneficial uses for products, such as for animal feed. Some food surplus exports provide a mutually beneficial opportunity. For example, a healthy item such as salmon heads can be valued as a foodstuff in some places but considered waste in others.[54]

Discussion

Across the food chain, we have described strong synergies between interventions to reduce food loss and waste and those promoting public health. Highlighting these shared benefits and opportunities is helpful in prioritizing strategies for action, identifying new political allies, and coordinating civil-society advocacy efforts. We also identified challenges, in which interventions help solve the problem of food loss and waste but harm public health, or improve public health but increase food loss and waste. In many cases, careful and well-targeted approaches may address the tensions between these two priorities, as we have described. Given the synergy between interventions related to food loss and waste and those related to public health, a careful consideration of the nuances and relative impacts of an activity related to one of the two areas could lead to altering or curtailing some actions to avoid causing harm in the other area.

Through this analysis we have identified policy priorities that together may make a meaningful difference in reducing food loss and waste while advancing the public's health (Exhibit 2).

Significant research gaps remain. Most broadly, evaluations of policy and intervention effectiveness are needed to enable prioritizing and improving approaches for both public health advancement and food loss and waste reduction. Case studies and economic analyses could provide justification and guidance for policy makers and other actors across the food supply chain to take action. Improved understanding of the root causes of food loss and waste globally, both along the food chain and across sociocultural contexts, would advance the implementation of all interventions. Monitoring food loss and waste by food type along the food chain and across actors and countries is needed to increase accountability and measure program and policy impacts.

Conclusion

Efforts are increasing to prevent and reduce food loss and waste. It is essential to include voices advocating for public health at the table during discussions of food loss and waste prevention. The two fields together can help policy makers make the best use of opportunities while tackling the challenges. ■

Roni Neff's time was funded by the Johns Hopkins Center for a Livable Future with a gift from the GRACE Communications Foundation, which had no role in the study design, data collection and analysis, decision to publish, or preparation of the manuscript. Stefanie Vandevijvere's time was supported by a New Zealand National Heart Foundation Fellowship. Rebecca Kanter's time was financed by a postdoctoral fellowship from the Comisión Nacional de Investigación Científica y Tecnológica—Fondo Nacional de Desarrollo Científico y Tecnológico (No. 3150183) in Chile. The authors thank Boyd Swinburn of the University of Auckland and Shawn McKenzie and Marie Spiker of the Center for a Livable Future for reviewing and providing input on earlier drafts of this article.

NOTES

1 Hall KD, Guo J, Dore M, Chow CC. The progressive increase of food waste in America and its environmental impact. PLoS One. 2009; 4(11):e7940.

2 Gustavsson J, Cederberg C, Sonesson U, van Otterdijk R, Meybeck A. Global food losses and food waste: extent, causes and prevention [Internet]. Rome: Food and Agriculture Organization of the United Nations; 2011 [cited 2015 Sep 9]. Available from: http://www.fao.org/docrep/014/mb060e/mb060e.pdf

3 United Nations. Sustainable Development Goals, Goal 12.3 [Internet]. New York (NY): UN; 2014 [cited 2015 Oct 15]. Available from: https://sustainabledevelopment.un.org/?menu=1300

4 Papargyropoulou E, Lozano R, Steinberger JK, Wright N, bin Ujang Z. The food waste hierarchy as a framework for the management of food surplus and food waste. J Clean Prod. 2014;76(1):106–15.

5 Eshel G, Shepon A, Makov T, Milo R. Land, irrigation water, greenhouse gas, and reactive nitrogen burdens of meat, eggs, and dairy production in the United States. Proc Natl Acad Sci U S A. 2014;111(33):11996–2001.

6 Kummu M, de Moel H, Porkka M, Siebert S, Varis O, Ward PJ. Lost food, wasted resources: global food supply chain losses and their impacts on freshwater, cropland, and fertiliser use. Sci Total Environ. 2012;438:477–89.

7 Lo J, Jacobson A. Human rights from field to fork: improving labor conditions for food-sector workers by organizing across boundaries. Race/Ethnicity. 2011;5(1):61–82.

8 Casey JA, Kim BF, Larsen J, Price LB, Nachman KE. Industrial food animal production and community health. Curr Environ Health Rep. 2015;2(3): 259–71.

9 To access the Appendix, click on the Appendix link in the box to the right of the article online.

10 Department of Agriculture. Food security in the U.S.: key statistics & graphics [Internet]. Washington (DC): USDA; [last updated 2015 Sep 8; cited 2015 Sep 18]. Available from: http://www.ers.usda.gov/topics/food-nutrition-assistance/food-security-in-the-us/key-statistics-graphics.aspx

11 World Food Programme. Hunger statistics [Internet]. Rome: The Programme; c 2015 [cited 2015 Sep 18]. Available from: http://www.wfp.org/hunger/stats

12 Alexandratos N, Bruinsma J. World agriculture towards 2030/2050: the 2012 revision [Internet]. Rome: Food and Agriculture Organization of the United Nations; 2012 Jun [cited 2015 Sep 9]. (ESA Working Paper No. 12-03). Available from: http://www.fao.org/docrep/016/ap106e/ap106e.pdf

13 Searchinger T, Hanson C, Ranganathan J, Lipinski B, Waite R, Winterbottom R, et al. Creating a sustainable food future: interim findings [Internet]. Washington (DC): World Resources Institute; 2013 Dec [cited 2015 Sep 9]. Available from: http://www.wri.org/publication/creating-sustainable-food-future-interim-findings

14 Food and Agriculture Organization of the United Nations. Committee on World Food Security: about CFS [Internet]. Rome: FAO; [cited 2015 Sep 9]. Available from: http://www.fao.org/cfs/cfs-home/cfs-about/en/

15 Food and Agriculture Organization of the United Nations. Toolkit: reducing the food wastage footprint [Internet]. Rome: FAO; 2013 [cited 2015 Sep 9]. Available from: http://www.fao.org/3/a-i3342e.pdf

16 Institution of Mechanical Engineers. A tank of cold: cleantech leapfrog to a more food secure world [Internet]. London: The Institution; 2014 Jun [cited 2015 Sep 9]. Available from: http://www.imeche.org/docs/default-source/reports/a-tank-of-cold-cleantech-leapfrog-to-a-more-food-secure-world.pdf

17 Finn SM, O'Donnell T, Walls M. The time is ripe for food recovery. BioCycle [serial on the Internet]. 2014 Sep [cited 2015 Sep 9]. Available from: http://www.biocycle.net/2014/09/19/the-time-is-ripe-for-food-recovery/

18 Mourad M (Center for the Sociology of Organizations—Science Po, Paris). France moves toward a national policy against food waste [Internet]. Washington (DC): Natural Resources Defense Council; 2015 Sep [cited 2015 Sep 18]. Available from: http://www.nrdc.org/food/files/france-food-waste-policy-report.pdf

19 Alexander C, Smaje C. Surplus retail food redistribution: an analysis of a third sector model. Resources, Conservation and Recycling. 2008; 52(11):1290–8.

20 Poppendieck J. Sweet charity? Emergency food and the end of entitlement. New York (NY): Penguin; 1999.

21 World Health Organization [Internet]. Geneva: WHO. News release, World Health Day 2015: from farm to plate, make food safe. 2015 Apr 2 [cited 2015 Sep 9]. Available from: http://www.who.int/mediacentre/news/releases/2015/food-safety/en/

22 Centers for Disease Control and Prevention. Estimates of foodborne illness in the United States [Internet]. Atlanta (GA): CDC; [last updated 2014 Jan 8; cited 2015 Sep 9]. Available from: http://www.cdc.gov/foodborneburden/

23 Neff RA, Spiker M, Truant PL. Wasted food: U.S. consumers' reported awareness, attitudes, and behaviors. PLoS One. 2015;10(6): e0127881.

24 Parfitt J, Barthel M, Macnaughton S. Food waste within food supply chains: quantification and potential for change to 2050. Philos Trans R Soc Lond B Biol Sci. 2010;365(1554): 3065–81.

25 Biji KB, Ravishankar CN, Mohan CO, Srinivasa Gopal TK. Smart packaging systems for food applications: a review. J Food Sci Technol. 2015 Feb 17. [Epub ahead of print].

26 Parry A, James K, LeRoux S. Strategies to achieve economic and environmental gains by reducing food waste. Banbury (UK): Waste & Resources Action Programme; 2015 Feb [cited 2015 Sep 9]. Available from: http://newclimateeconomy.report/wp-content/uploads/2015/02/WRAP-NCE_Economic-environmental-gains-food-waste.pdf

27 Peake WO, Detre JD, Carlson CC. One bad apple spoils the bunch? An exploration of broad consumption changes in response to food recalls. Food Policy. 2014;49(1):13–22.

28 Clayton ML, Clegg Smith K, Neff RA, Pollack KM, Ensminger M. Listening to food workers: factors that impact proper health and hygiene practice in food service. Int J Occup Med

Environ Health. 2015. [Epub ahead of print].
29 Food Chain Workers Alliance. The hands that feed us: challenges and opportunities for workers along the food chain [Internet]. Los Angeles (CA): The Alliance; 2012 Jun 6 [cited 2015 Sep 9]. Available from: http://foodchainworkers.org/wp-content/uploads/2012/06/Hands-That-Feed-Us-Report.pdf
30 US Department of Agriculture [Internet]. Washington (DC): USDA. News release, USDA announces "FoodKeeper" application in advance of World Health Day; 2015 Apr 2 [cited 2015 Sep 9]. Available from: http://www.usda.gov/wps/portal/usda/usdamobile?contentid=2015/04/0086.xml&contentidonly=true
31 Newsome R, Balestrini CG, Baum MD, Corby J, Fisher W, Goodburn K, et al. Applications and perceptions of date labeling of food. Comprehensive Reviews in Food Science and Food Safety. 2014;13(4):745–69.
32 Broad Leib E, Gunders D, Ferro J, Nielsen A, Nosek G, Qu J. The dating game: how confusing food date labels lead to food waste in America [Internet]. New York (NY): Natural Resources Defense Council; 2013 Sep [cited 2015 Sep 9]. Available from: http://www.nrdc.org/food/files/dating-game-report.pdf
33 Food Marketing Institute. U.S. grocery shopper trends: 2011 [Internet]. Arlington (VA): FMI; c 2011 [cited 2015 Oct 15]. p. 144. Available from: https://sju.edu/int/academics/hsb/foodmarketing/academy/board/files/2011_06_Trends_2011.pdf
34 Blichfeldt BS, Mikkelsen M, Gram M. When it stops being food: the edibility, ideology, procrastination, objectification, and internalization of household food waste. Food Cult Soc. 2015;18(1):89–105.
35 Evans D. Beyond the throwaway society: ordinary domestic practice and a sociological approach to household food waste. Sociology. 2012;46(1):41–56.
36 Lim SS, Vos T, Flaxman AD, Danaei G, Shibuya K, Adair-Rohani H, et al. A comparative risk assessment of burden of disease and injury attributable to 67 risk factors and risk factor clusters in 21 regions, 1990–2010: a systematic analysis for the Global Burden of Disease Study 2010. Lancet. 2012;380(9859):2224–60.
37 Vandevijvere S, Chow CC, Hall KD, Umali E, Swinburn BA. Increased food energy supply as a major driver of the obesity epidemic: a global analysis. Bull World Health Organ. 2015;93(7):446–56.
38 Segrè A, Falasconi L, Politano A, Vittuari M (University of Bologna, Italy). Background paper on the economics of food loss and waste [Internet]. Rome: Food and Agriculture Organization of the United Nations; 2014 [cited 2015 Sep 9]. (Working Paper). Available from: http://www.fao.org/fileadmin/user_upload/save-food/PDF/WorkingPaper/Background_Paper_2014.pdf
39 Aschemann-Witzel J, de Hooge I, Amani P, Bech-Larsen T, Oostindjer M. Consumer-related food waste: causes and potential for action. Sustainability. 2015;7(6):6457–77.
40 Department of Agriculture. Food availability (per capita) data system: nutrients (food energy, nutrients, and dietary components) [Internet]. Washington (DC): USDA; 2015 Feb 1 [cited 2015 Sep 18]. Available for download from: http://www.ers.usda.gov/data-products/food-availability-(per-capita)-data-system/.aspx#26715
41 Siegel KR, Ali MK, Srinivasiah A, Nugent RA, Narayan KM. Do we produce enough fruits and vegetables to meet global health need? PLoS One. 2014;9(8):e104059.
42 Markham J. Intermarché—"inglorious fruits and vegetables." Vimeo [serial on the Internet]. 2014 Jul 16 [cited 2015 Sep 9]. Available from: https://vimeo.com/98441820
43 Quested TE, Marsh E, Stunell D, Parry AD. Spaghetti soup: the complex world of food waste behaviours. Resources, Conservation and Recycling. 2013;79:43–51.
44 Wing RR, Jeffery RW, Burton LR, Thorson C, Nissinoff KS, Baxter JE. Food provision vs structured meal plans in the behavioral treatment of obesity. Int J Obes Relat Metab Disord. 1996;20(1):56–62.
45 Britton E, Brigdon A, Parry A, LeRoux S. Econometric modelling and household food waste: final report [Internet]. Banbury (UK): Waste & Resources Action Programme; 2014 Jan [cited 2015 Sep 9]. Available from: http://www.wrap.org.uk/sites/files/wrap/Econometrics%20Report.pdf
46 Flego A, Herbert J, Waters E, Gibbs L, Swinburn B, Reynolds J, et al. Jamie's Ministry of Food: quasi-experimental evaluation of immediate and sustained impacts of a cooking skills program in Australia. PloS One. 2014;9(12):e114673.
47 Hersch D, Perdue L, Ambroz T, Boucher JL. The impact of cooking classes on food-related preferences, attitudes, and behaviors of school-aged children: a systematic review of the evidence, 2003–2014. Prev Chronic Dis. 2014;11:140267.
48 Nielsen SJ, Popkin BM. Patterns and trends in food portion sizes, 1977–1998. JAMA. 2003;289(4):450–3.
49 Wansink B, van Ittersum K. Portion size me: plate-size induced consumption norms and win-win solutions for reducing food intake and waste. J Exp Psychol Appl. 2013;19(4):320–32.
50 Freedman MR, Brochado C. Reducing portion size reduces food intake and plate waste. Obesity (Silver Spring). 2010;18(9):1864–6.
51 Monteiro CA, Levy RB, Claro RM, de Castro IR, Cannon G. Increasing consumption of ultra-processed foods and likely impact on human health: evidence from Brazil. Public Health Nutr. 2011;14(1):5–13.
52 Zachary DA, Palmer AM, Beckham SW, Surkan PJ. A framework for understanding grocery purchasing in a low-income urban environment. Qual Health Res. 2013;23(5):665–78.
53 Thow AM, Heywood P, Schultz J, Quested C, Jan S, Colagiuri S. Trade and the nutrition transition: strengthening policy for health in the Pacific. Ecol Food Nutr. 2011;50(1):18–42.
54 Snowdon W, Thow AM. Trade policy and obesity prevention: challenges and innovation in the Pacific Islands. Obes Rev. 2013;14(Suppl 2):150–8.
55 Thow AM, Annan R, Mensah L, Chowdhury SN. Development, implementation, and outcome of standards to restrict fatty meat in the food supply and prevent NCDs: learning from an innovative trade/food policy in Ghana. BMC Public Health. 2014;14:249.