Food hygiene challenges in replacing single use food service ware with reusable food service items

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EXECUTIVE SUMMARY

The context

Single use materials are widely used, especially within the retail, self-service, convenience, food service and consumer sectors of the human food chain, as key elements in preventing cross contamination of food products with pathogenic (disease causing) bacteria and viruses. The environmental profile of single use packaging and food service ware is of increasing interest to consumers, governments and industry (1-3). It has been suggested that reusables alternatives may have better environmental profiles, although little research has been carried out to confirm these suggestions (4). However, it is becoming clear that some reusables must be used a considerable number of times to achieve better environmental profiles than single use food service ware (5), and further life cycle studies could usefully be conducted (6).

This report reviews the risks of increased foodborne disease associated with the move to wider use of reusable food service ware and systems, in the absence of very necessary significant changes in consumer understanding and hygienic practices. These risks are inherent in the additional, more complex, multilocation cleaning, sanitation, storage and transport of reusable food service ware within the human food chain. In essence, this is because there are greater risks of cross contamination within "circular" reuse systems, than in the current "linear" single use systems. The inherent complexity of "circular" reuse systems may also make it more difficult to track and suppress outbreaks of food borne illness and/or carry out related food product recalls.

Cross contamination

Cross contamination of food is the unintended process by which bacteria, fungi, viruses or allergens, are unintentionally transferred from one substance or object to another, with harmful effects. Such transfer can occur at any stage of food production, processing and service, and can be direct, e.g. transfer from the hands of an operative into a ready to eat meal (7), or indirect, e.g. transfer of harmful organisms/material from a contaminated food contact surface onto food during processing, retail or service (8).

Cross contamination is the most frequent cause of most foodborne illness, causing 600 million cases of per year of which 350 million are caused by pathogenic bacteria such as *Campylobacter* sp., *Salmonella* sp., *Listeria* sp., or the Enterobacteriaceae family. EFSA/ECDC (European Food Safety Authority /European Centre for Disease Prevention and Control) have reported *Campylobacter* and *Salmonella* as the most common causes of foodborne zoonotic disease in the EU, affecting as many as 350,000 people per year (9, 10), with most sufferers having mild illness (very brief nausea and vomiting). However, a much smaller proportion of sufferers have long term illnesses such as temporary or persistent paralysis and nervous system damage, dysfunction of the nervous system and brain, or kidney or liver failure, which may be fatal (11).

Adequate means of mitigating the significant impacts of cross contamination are relatively easy to describe, in terms of what food handlers should know, and what they should do. They are, however, difficult to establish and maintain. Food handlers should have a clear understanding of how to avoid cross contamination, and how to consistently apply and maintain good hygienic practice. They should be trained, supported, and monitored in cleaning/ sanitising work surfaces, utensils and equipment. They should understand the importance of washing hands before/after touching /preparing food, safe cooking, separating raw and ready to eat foods, along with the correct use of fridges. Food handlers should be supplied with appropriate protective clothing, an adequate supply and use of cleaning materials e.g. cloths, sponges, mops etc, and should work in separate food preparation and storage areas, with surfaces, machinery and equipment, which are cleaning between working with raw and ready to eat foods. These key elements of food hygiene have been effectively presented in the 4Cs (Cleaning, Cross-contamination, Cooking and Chilling) (12), From Farm to Fork Safety of the Agri-food Chain (13) , and Five Keys to Safer Food (14)

Changes in food consumption patterns
People are increasingly consuming food away from home, on-the go, often in crowds, and frequently where and when the reuse, recovery and effective sanitisation of single service ware, packing and utensils is difficult, if not impossible. There are good reasons why, where appropriate, effort could be made to reduce the use of single use packaging and service ware. However, there are many circumstances in which the continued use of single use packaging and service ware provides the only feasible option for maintaining adequate food hygiene, public health and consumer safety.

The evidence is clear. The potential for the persistence/transfer of agents of foodborne disease (bacteria, fungi and viruses) on food service reusables, remains a clear and present hazard, especially at the retail/service/consumer interface.

The risks to human health posed by cross contamination within the food chain are well-known and long-established. It is a hundred years since Dr Samuel Crumbine, one of the founding fathers of modern public health, invented the first single use disposable cup with the express purpose of reducing cross contamination and the incidence of human foodborne disease. It is twenty years since J.G. Doser (15) concluded that “Individual pre-packaging of food is the only certain method of preventing contamination by customer handling”. The factors which led Crumbine and Doser to establish the crucial importance of breaking the chain of cross contamination to prevent foodborne illness have not changed. In essence, neither have the foodborne bacteria which cause foodborne illness, although many of them are becoming more resistance to antibiotics, increasing the dangers involved in foodborne illness (16-20).

It is unlikely that consumers can willingly and effectively change their views or practices to ensure adequate levels of safety in this area, in the absence of single use food contact materials in the presentation, transport, storage and serving of higher risk/ready to eat food items.

Banning or reducing the use of food service disposables, in the absence of radical significant and unprecedented changes in consumer practice, will lead to greater persistence and circulation of foodborne pathogens within the human food chain, and increased risks of human foodborne illness in our community. Those rushing to replace food service disposables with reusable food service ware may need to think long and hard about the unexpected consequences in relation to increased foodborne illness among consumers, and potential litigation damages sought from food businesses involved in the more complex processes around the use of reusable food service items.

The inherent problem
In the absence of food service disposables, consumers and food service providers will be restricted to using reusable cups, containers and other food service ware, which have been shown to harbour and disseminate harmful agents of food borne illness. These bacteria, fungi and viruses will subsequently cross-contaminate any food coming into contact with inadequately cleaned and disinfected reusable items, significantly increasing the risks of larger and more frequent outbreaks of food borne illness.

Such use of reusable containers poses particular problems at the retail/service/consumer interface, other unsuitable environments, and in domestic environments which are not protected by the food safety legislation and inspection systems which defend most of the human food production, processing, retail and service chain.

Increases in reusable food service ware and increased foodborne Illness
A number of studies have already reported increased risks of cross contamination foodborne illness when the use of single use items is reduced at the retail/service/ consumer interface (21-25). For example, Reep (26) identified a reusable grocery bag as the source of an outbreak of norovirus involving 9 members of a soccer team.
The introduction of reusable cups and other food service ware introduces a number of challenges which do not occur in single use systems. These include the importance of effective cleaning and sanitisation of reusable items, and the subsequent correct storing and reissuing of these items to consumers. The different criteria which apply across the range of materials and applications, are available from the European Committee for Standardization (27).

Dishwashers
Moving to reusable food service ware requires a significant step up in machine based cleaning and sanitising food service ware, Single use food service ware usually arrive in sealed packs, and do not need to be cleaned on site, but effective cleaning and sanitisation of reusable items, e.g. cups, cutlery, and other food service ware on a commercial scale can only be achieved using a specialist (large) dishwasher, or other large scale treatment system.

Fungal infections and allergies
Moving to reusable food service ware magnifies the risks associated with possible fungal infections and allergies. Single use food service ware is rendered commercially sterile during the production process, and subsequently protected in delivery packs until just before use. This means that single use items are unlikely to be cross-contaminated, and do not present an environment which will can support the growth of fungi or bacteria (i.e. no moisture or microbial nutrients). The very short period between pack opening and food service also limits the other thing that fungi and bacteria need, i.e. time to grow.

However, the circumstances around recovery, cleaning and open storage of reused food service ware are very different, and pose more significant risks. Unwashed cups are likely to contain residues of nutrients which are ideal (from the microbes' point of view) to support bacterial growth. Unwashed cups may be collected, stored, sorted and transported over of a relatively long period of time, at room temperature, giving any microbes cross-contaminating from the consumer and their environment, and/or during collection, sorting, and storage before or after cleaning plenty of time for bacteria to multiply and for fungal growth to produce fungal spores. Bacterial multiplication is clearly undesirable, but is likely to be cancelled by effective cleaning and sanitisation. However, fungal spores are significantly allergenic and very small concentrations (low ppm) can very rapidly trigger severe responses in sensitive consumers (28-30).

Reducing cross contamination to reduce foodborne illness
National and international food safety agencies and authorities have long recognised the very significant role of cross contamination as the most frequent cause of most foodborne illness. This is why they already invest considerable resources into campaigns to constantly remind all food producers, processers, retailers, food servers and consumers, of the importance of preventing cross contamination of food at all stages of the human food chain (31-40)

Some progress has been made in informing individuals and organisations along the food chain about the importance of consistently effective food hygiene procedures and practices(41), but food borne illness remains a significant public health challenge, with very undesirable economic, societal and clinical costs (9, 42, 43).

Symptoms of foodborne illness

Many cases of foodborne illness are transient and mild, being limited to malaise, nausea and vomiting. Unreported, these cases are usually resolved without reference to health authorities. However, a significant number of more severe cases of foodborne illness caused by cross contamination within the food chain, involve life-threatening kidney or liver failure, temporary or persistent paralysis, dysfunction of the nervous system and brain, and/or death, particularly among higher risk groups i.e. young, old, pregnant or immunocompromised (11).

Incidence of foodborne illness

In global terms, consumption of contaminated food is estimated to cause 600 million cases of (bacterial, viral and parasitic) food borne illness per year (44, 45). Of these, the World Health Organisation (WHO) has estimated almost 350 million cases of foodborne disease are caused by pathogenic bacteria such as *Campylobacter* sp., *Salmonella* sp., *Listeria* sp., or the Enterobacteriaceae family. EFSA/ECDC (European Food Safety Authority /European Centre for Disease Prevention and Control) reported *Campylobacter* and *Salmonella* as the most common causes of foodborne zoonotic disease in the EU, affecting as many as 350,000 people per year (9, 10).

The costs of foodborne illness

EU public health costs and lost productivity for just one foodborne pathogen (*Campylobacter*) has been estimated by EFSA at 2.4 billion EUR per year (42). In economic terms, the wider costs of foodborne illness include hospitalisation, work absence, and financial losses associated with public concerns of food quality, as well as legal costs which vary widely among jurisdictions (46, 47). The US spends 10 - 83 billion USD (8.5 - 72 billion EUR) per year. Australia spends 1 billion USD (870 million EUR) a year, and New Zealand, 86 million USD (74 million EUR)(48) on foodborne illness. Even a small outbreak can be expensive. Bartsch (49) estimated the overall costs of a single small (5 person) outbreak in a fast-food restaurant to range from 3,422 EUR to 1.6 million EUR excluding lost revenue, lawsuits, legal fees, or fines. Bartsch (49) noted that, apart from the number of ill people, the latter factors, especially law suits and legal fees, can be the biggest drivers of outbreak costs. The full costs in relation to larger outbreaks in, for example, a large hotel complex or a cruise liner are much larger.

Moving from single use food service ware to reusable food service ware will further increase foodborne illness

Bearing in mind the above clinical, societal and economic impacts of moving from single use to reusable food service ware, single use items should be exempt from restrictions until robust effective alternative materials and systems are in place. Failure to adequately protect the public health at the final stages of the human chain, i.e. food packaging, retail, service and consumption, will increase cross contamination within the food chain. Such increases will damage public confidence in the food chain, reduce the quality/safety of our food, threaten the economic survival of companies producing, retailing and serving foods, and increase foodborne illness, morbidity and the potential for mortalities among consumers.

A matter of balance

Consumers are unlikely to accept the personal, medical, industry and societal costs of increased risks of foodborne illness. Other measures must be identified and actioned to assess and improve the environmental impact of food service disposables and reusables without compromising food hygiene, public health and consumer safety.

REPORT STRUCTURE

This report:

- summarises and assesses the background, challenges and available scientific evidence in relation to the food safety, public health and consumer safety aspects in relation to replacing single use plastic food service ware with reusable food contact items, which today are increasingly plastic.

- outlines the significant dangers inherent in increased cross contamination with foodborne bacteria and viruses within the human food chain, and discusses the undesirable implications of the use of alternative reusable containers/packaging (i.e. increased persistence, spread, and recycling of foodborne pathogens within the retail/service/consumer stages of the human food chain);

- notes the likelihood of increases in human illness by increased contact with, and consumption of, such pathogens, and outlines the poor levels of consumer hygiene.

- highlights scenarios where the use of inadequately cleaned and sanitised reusable food service ware will break the food safety chain, facilitating the persistence and dissemination of pathogenic bacteria and viruses, and increasing the incidence and impact of foodborne illness.

- notes special/restricted circumstances where alternatives are limited.

BACKGROUND SCIENCE

The current situation in relation to foodborne disease in the EU

Despite considerable efforts at national and international levels, foodborne disease continues to impose a significant burden. WHO estimates 23 million cases of foodborne illness worldwide and up to 5000 deaths in Europe every year (50). Although significant, these figures are probably under estimations, as many infections are not recorded/reported, and many deaths are not correctly identified as caused by foodborne pathogens (51-54).

Wider costs of foodborne illness

As well as the above clinical and societal pressures, foodborne illness entails considerable commercial costs, including loss of sales and significant damage to brand image, although these are difficult to quantify. Estimates vary significantly, although the annual overall costs of such illness in these areas are likely to be in billions rather than millions. For example, within the UK, the headline human and societal costs are estimated as approximately £9bn per annum (55) .

The scale and severity of the clinical, societal and commercial implications of the consumption of contaminated or re-contaminated foods are such that considerable industrial and public health resources are engaged in reducing the presence of the agents of foodborne illness at each and every stage of the food production, processing and service chain. Despite all these efforts, cross-contamination or recontamination remain the most important routes by which the agents of human foodborne illness access and spread along the human food chain, and ultimately infect consumers (33, 56-61) .

Disease causing bacteria and viruses enter and persist in the human food chain
Studies have demonstrated the considerable abilities of significant foodborne pathogens such as *Salmonella*, Verocytotoxigenic *E. coli* (VTEC), *Listeria,* and *Campylobacter* and norovirus (62-69), to penetrate food production, processing and preparation environments, including food retail/service and domestic kitchens, and to persist for extended periods on a wide range of foods and food contact surfaces (70-87). Such persistence is enhanced by the ability of bacteria to produce biofilms which protect them from adverse conditions including desiccation, and the application of sanitizing agents (72, 73, 77, 83, 87-93). Similarly, more recent studies have established that food borne viruses, such as norovirus, rotavirus and human adenovirus, which cause acute gastroenteritis (66, 85, 87, 94, 95), can access, and persist for very extended periods on, food and food contact surfaces.

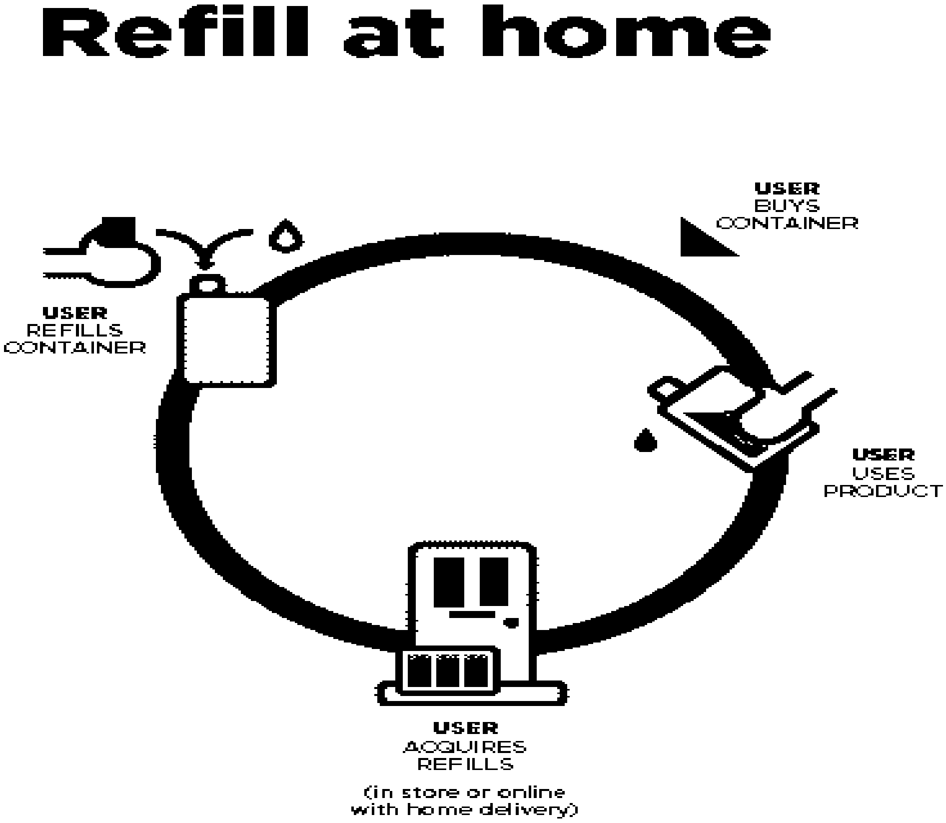
The above circumstances and characteristics mean that increased reuse of inadequately cleaned/sanitized food containers and food contact surfaces will significantly increase the risks that the agents of foodborne illness will survive to cross contaminate any individuals and foods coming into direct contact with such containers/surfaces. In overall terms, it is therefore important to take every opportunity to reduce, or ideally to prevent, cross contamination at every stage of the human food chain.

Currently, food service disposables and related items provide very effective means of breaking this undesirable cycle of bacterial/fungal/viral infections by reducing cross contamination, especially at the retail/service/consumer interface. At a time when growing numbers of people are eating and drinking out of home and on the move, the risks involved in reducing the availability of such single use products are increased by the fact that consumer hygiene at this interface is known to be one of the weakest links in the human food chain (87, 96-98).

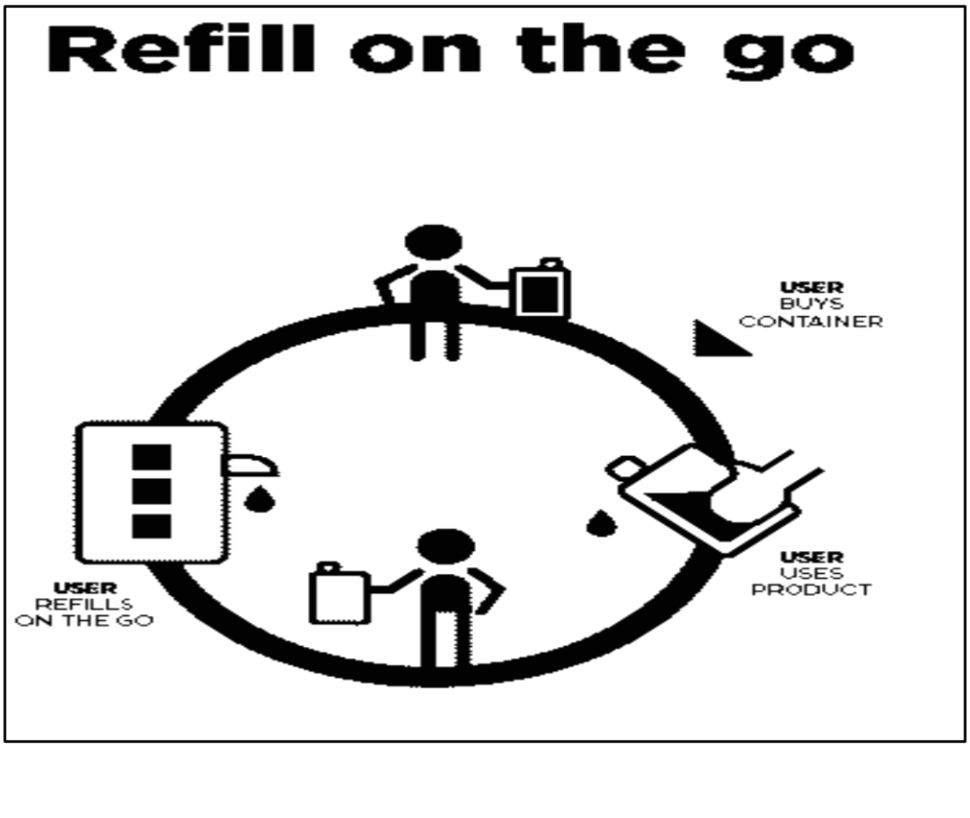
Consumers cross contamination at home and away from home
Until recently, there was comparatively little information on the scale of consumer related cross contamination during food handling at retail, and inside the home (99-103). As an aside, a number of studies have confirmed that a worryingly large proportion of consumers do not currently practice adequate food safety at home, or away from home (31, 57, 101, 102, 104-113), especially in less controlled circumstances involving consumer consumption of “ready to eat” or “take away” foods (114-117). In relation to out of home purchasing or consumption, it is important that appropriate single use food & beverage service packaging and related items, ideally with lower environmental impacts, e.g. paper/fibre rather than plastics, should be available at this later stage of the food chain (118).

Reuse model systems
A number of reuse models have been identified, some of which are already in use, although not all of them currently include food. Examples of these models, and their benefits and potential challenges are presented and discussed by Lendal and Wingstrand (119) including:

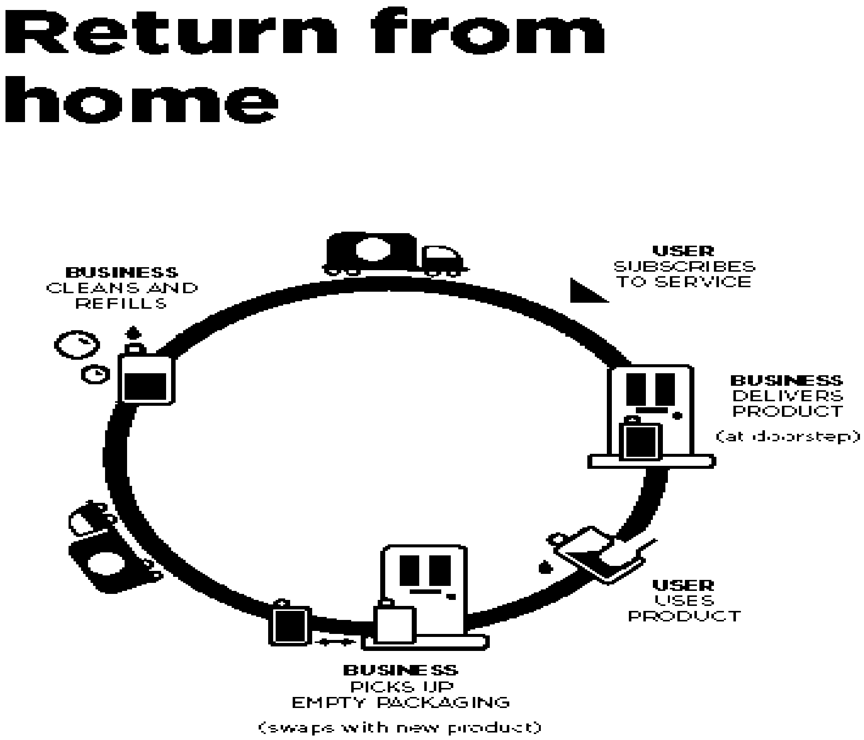
“Refill at home” – i.e. users refill their reusable container at home (e.g. with refills delivered through a subscription service). Suitable for traditional or online retail.



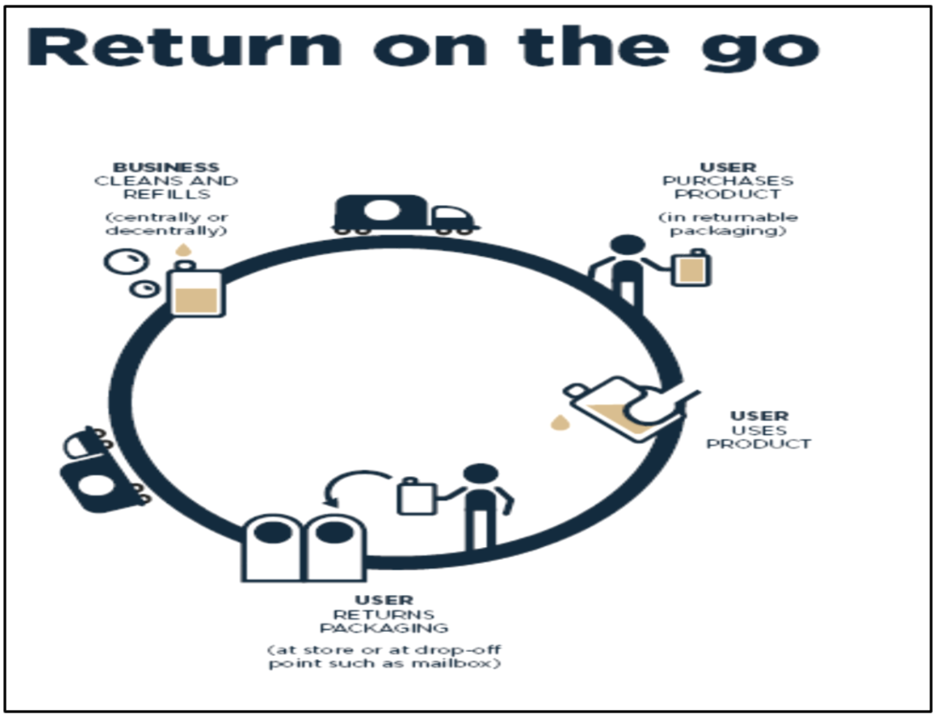
“Refill on the go”- i.e. users refill their reusable containers at a retail “physical” store or dispensing point. Suitable for traditional or online retail.



"Return from home" – pickup of empty packaging combined with the delivery of new products. Suitable for e-commerce.



"Return on the go" i.e. user purchases product (in returnable packaging) at retail or dispersed dispenser sites, uses/consumes the product and returns packaging to store or drop off point – to be collected by business, taken to central or dispersed cleaning/refilling sites and reissued to dispersed dispenser sites.



The food safety and public health issues involved in the commercial application of such models are dictated by a range of factors. These include the nature and stability of the particular packaged foods, the complexity, consistency and security of hygienic preparation, transport, storage, and recovery, along with achieving certainty of effective cleaning and sanitising of recovered packaging materials. However, as with current food chain safety, uncertainties at the consumer interface, for example, consumers bringing their own, inadequately washed, cups for refill are likely to remain the weakest links in terms of hygienic practice, and will therefore present the most significant opportunities for cross contamination or recontamination leading to increased food borne illness.

Risks of recontamination from food contact surfaces under domestic, retail or specialist conditions

Increasing concern for sustainability compels citizens, enterprises and governments to reduce waste and encourages reuse of food service ware by consumers. As discussed above, this can include bringing their own previously used cups and containers into sales outlets for refilling, or using them in free standing dispensing or vending machines accessible to large numbers of people. These containers will typically be brought to and stored in home kitchen areas (after use) or to left with retailers to be cleaned and sanitised by retail employees at the workplace, or professional specialist cleaning hubs, where the efficiency and consistency of cleaning processes and general quality control standards will be much higher. It is, therefore, relevant to consider the relative risks from these diverse environments and processes (113, 120-124).

Particular concerns remain in relation to ineffective cleaning and sanitising of domestic food contact surfaces and equipment, and failure to avoid cross contamination (31, 41, 99, 100, 125, 126), especially as consumer activities in this area are not protected by the food safety legislation and inspection systems which apply across the rest of the human food production, processing and service chain (127, 128). Given the greater complexity and diversity of the activities which occur in domestic kitchens (and workplace equivalents) in comparison with other parts of the food chain, and the diverse levels of knowledge and practice among consumers, it is likely that the risks of cross contamination in domestic food handling operations are considerably higher. Thus, the risks associated with increased consumer storage and reuse of contaminated packaging and related food service ware are of public health concern.

These risks are increased by the consumer’s typical “optimistic bias” where the domestic environment is seen as a safe place, causing consumers to underestimate the risks of cross contamination at home (103, 129, 130) and, by extension, at retail/foodservice environments (112, 131, 132). Such general conclusions are supported by a number of reviews which have identified private households and consumer/retail interfaces as frequent locations, if not the most frequent locations, of verified outbreaks of foodborne disease (53, 103, 113, 133-138) .

Consumers and unpackaged food

Poor consumer food safety handling practices have also been reported away from home, i.e. during food shopping and/or other self-service operations. Paulin et al. (112) observed unsafe handling practices including, touching/squeezing food, returning handled food, and tasting food, in addition to poor hygienic practices. Such practices are undesirable, as direct hand contact with foods is well recognised as a frequent risk factor in outbreak investigations (63, 106, 139-146) . A number of reports have highlighted the increased levels of risk of cross contamination and subsequent foodborne illness associated with customer contact with unprotected (i.e. unpackaged) ready to eat (RTE) foods in salad bars, buffets, etc. (15, 39, 147-151).

Overall, the amount of public health research in this area has declined in recent years, probably because nearly all retail food is currently effectively protected within single use plastic or paper packaging. It is, however, interesting to note growing concerns among food safety and public health agencies about the increasing number of significant outbreaks of foodborne illness related to unpackaged fruit and vegetables. For example, Fischer et al. (152) noted that these items caused more illnesses than any other food category, and had the largest number of outbreaks in the USA during the last 12 years. Similar concerns have been expressed in a number of countries worldwide (151, 153-155). This is relevant given the growing consumption of prepared salads or items including salad products. Replacing single use food service containers with reusable containers is likely to create a potential new route of pathogen recycling and cross-contamination, as single use food service items are important elements of food safety, significantly reducing the risks of persistence and transfer of contaminating bacteria or viruses(22, 156-158). Recognition of the importance of single use food service disposables has led the following advice /comments/requirements:

> "In situations where reusing multiuse items can cause food borne illness to consumers, single-use articles (disposable packaging) must be used" (US Food and Drug Administration), &
> "the use of paper placemats/tray covers provides a more sanitary eating surface than uncovered tabletops or trays" "18% of reusable food service items were unclear [failed the generally accepted standard of 100 colonies per item]" "only 8% of single use items exceeded that standard" (Food Service Packaging Institute)

Broader benefits of single use packaging and food service ware

In most highly developed countries around 98% of widely used products, especially food products, are sold in various types of packaging including paper, card, plastics, glass, metal and composite materials to ensure product safety, quality, shelf-life and authenticity (159-161). This means that currently, most foods, especially pre-prepared ready-to-eat (RTE) foods, are effectively protected within sealed single use packaging during the latter stages of the human food chain, i.e. prior to retail sale or food service. This packaging also protects foods from physical damage and dirt, contacts with undesirable chemicals, taints, etc.

In wider terms, single use packaging has a very important extended role in delivering product information, including product authenticity, regulatory compliance, the quantitative and qualitative composition of food, nutritional and allergen advice, appropriate usage, use-by dates, cooking instructions, producer/processor details, branding, and country of origin. Placing food in previously used containers increases packaging risks and significantly reduces the amount of information available to consumers. It also makes it easier for criminals to commit food fraud, in circumstances where it will be much more difficult for food safety and standards agencies to protect consumers from substandard, potentially dangerous, "fake" food.

Sealed single use packaging reduces dehydration during retail and domestic chill storage, and facilitates modified atmosphere packaging, which significantly extends product shelf life(162-164). "Smart" sealed single use packaging is now being increasingly recognised as enabling post packaging processing. It delivers further extension of shelf-life and safety using such technologies as: sous-vide processing; "in pack" microwave pasteurisation /reheating; radiofrequency and infrared heating of ready-to-eat (RTE) foods; and non- thermal treatments such as: high hydrostatic pressure (HHP); irradiation; pulsed light (PL); and active packaging(165, 166). Active packaging involves changing permeation properties or gas composition within the packaging, or releasing agents to suppress bacterial growth, and chemical, enzymatic and oxidative spoilage (160, 166-171).

Thus, a move towards reusable packaging which is less likely to be [a] adequately cleaned and sanitised and [b] capable of applying the above food safety properties, would have very negative impacts on the wider safety, stability and customer acceptability of such foods. Consumers may wish to see reductions in the use of single use packaging, especially plastic based packaging, but are unlikely to accept compromised food safety/food hygiene, significant reductions in food product shelf-life, or the removal of the qualitative, quantitative, assurance and advisory information currently provided on single use packaging.

The impact of moving from single use to reusable food service items

The above studies have begun to improve our understanding of, if not our confidence in, the extent to which consumers are consistently applying effective methods of preventing cross contamination of food. It would therefore seem unwise to expect consumers to ensure that reusable packaging and related items used in purchasing, transporting and storing food, are frequently and adequately cleaned and sanitised.

Consumers can be encouraged (i.e. forced) to use reusable packaging, bags, cups and other service items (172, 173), but there is considerable evidence that these materials will become contaminated with foodborne pathogens, and subsequently transfer these pathogens to and from retail and domestic environments. Studies of the microbial status of these reusable materials, once they are "released into the wild" confirm that they are not being frequently and adequately cleaned and sanitised, if ever (22, 25, 87, 158, 174). They are also frequently reused in a wide range of inappropriate non-food activities. For example, a number of studies report reusable grocery bags being wrongly used in diverse locations beyond the domestic kitchen for the transport/storage of school books, sports kits, shoes, soiled clothes, nappies and flowers (64, 175, 176)., Subsequent reuse of these bags within the food chain, e.g. bringing home groceries, carries very significant risks of cross contamination and subsequent infections caused by bacterial and viral agents.

Thus, a move away from food service disposables/single use packaging towards reusable alternatives puts at risk many of the significant advances in food safety, quality, shelf-life extension and product authenticity, gained over the last 50 years, and may well derail the safety of our current food processing, purchasing, storing and consumption patterns.

The consumer response to moving to reusable food service ware

We already have some evidence of what consumers will do when single use food related items are replaced with reusable alternatives. The UK single use bag taxes (2015), and the EU single-use plastics directive (2018), have significantly reduced the use of single use plastics and increased the use of reusable alternatives.

When these bans are in place, consumers will have to purchase, correctly sanitise and store alternative reusable containers, following the "circular models" described above. However, failure to carry out these different and more complex actions will increase consumer exposure to undesirable bacteria, fungi and viruses which persist on a wide range of fomites including foods and food contact materials, including contaminated (i.e. used) reusable ware (174, 176-

178). While most studies have focused on bacteria, recent studies of viruses, facilitated by the development of better detection methods (179), have confirmed the importance of cross contamination with viruses such as Norovirus, Hepatitis E virus, Sapovirus and Rotavirus within the food supply chain (178) Reusable packaging can become contaminated with foodborne viruses (e.g. Norovirus), which persist and are transferred to customer/service staff hands, packaged and unpackaged foods, and other surfaces in food retail (22, 180). The same levels of contamination are likely in food service, on the go and domestic activities using reusable food service ware or packaging.

For example, Summerbell (174) reported the impact of the introduction of reusable plastic bags (recovered from shoppers by offering a “new for old” swap), as fomites for faecal coliforms, *E. coli*, *Salmonella*, moulds, and yeasts.

As an aside, Gerba et al. (176) carried out a similar study of the incidence, persistence, and growth of faecal coliforms, *E. coli, Salmonella* and *Listeria* in stored used bags contaminated with meat juices. No bacteria were recovered from “new” unused bags, but significant numbers of undesirable bacteria were frequently recovered from reusable bags collected from consumers. As well as persisting in reusable bags, bacteria can grow in any food particles remaining in used bags, to large enough numbers to cause illness in humans subsequently reusing these bags.

Gerba also examined the effectiveness of washing reusable bags in water or bleach in reducing bacterial numbers, as well as how often the bags were washed/decontaminated, alternative use, and cleaning of bags. Machine or hand washing significantly reduced bacterial numbers. This finding is encouraging, but the potential hygienic impact of such processing is in reality limited, as the study also observed that only 3% of the consumers questioned ever washed their bags.

More recent studies (21, 25, 181) have reinforced the above findings, and established that the introduction of reusable containers (at any stage of the food chain) can disseminate pathogens between batches or portions of food with bacterial pathogens and transmit disease because of inadequate or absent cleaning/sanitisation steps (26, 158). It is likely that consumer responses to wider use of reusable food service ware will be similar to the responses noted for reusable bags, i.e. insufficient understanding of the risks, leading to inadequately hygienic practice, cross contamination and increased foodborne illness.

This is unfortunate, as a number of studies have suggested that consumer education on reducing the use of single use packaging, and safe switching to a wider range of reusable food service ware is difficult to deliver and expensive to implement and maintain (172, 182). In some cases, initial reductions in the use of single use food service ware were achieved, but suffered a “rebound” effect, increasing rather than decreasing use in the longer term (175). Other undesirable responses include, in the absence of single use packaging as easily visible evidence of purchase, some customers “simply walk out of stores with trollies full of unbagged items” (175).

Implications from the available evidence

The report summarises the capacities of foodborne pathogens to gain access to and persist on most animate and inanimate surfaces, and to subsequently [re]contaminate food, individuals and materials by direct and indirect contact with contaminated surfaces, leading to foodborne illness. It notes the frequency, and clinical, economic and societal impacts of foodborne illness. The available scientific evidence confirms the significantly increased risks of bacterial cross contamination in reducing access to single use food & beverage packaging. Such a reduction will increase use of reusable packaging, cups and other food service ware, which are unlikely to be consistently and effectively cleaned and sanitised by consumers, and potentially by retail outlets, which vary greatly in capacity and capability.

The example of removal of single use plastic bags has been shown to increase consumer use and wider recirculation of reusable plastic bags, but at least most purchased foods - even if placed in reusable bags - are currently protected in sealed single use primary packaging. Despite this primary protection of food products, the increase of use of contaminated reusable grocery bags is likely to increase foodborne illness and food related deaths. Removal of the primary protection provided by single use food & beverage packaging, and its replacement with reusable food service disposables is likely to have much greater impact, as the opportunities for cross contamination to and from unpackaged foods are much more direct, frequent and dangerous. This is a particular risk in relation to takeaway meals placed in reusable bags, especially when the food is consumed on the move and any residual food in the reusable/container is inoculated with bacteria on unwashed hands, to persist, grow, and contaminate any other foods subsequently placed in the reused bag/container. The situation is slightly different in the case of viruses, which can only replicate within a living host. Even so, viruses present risks as they can survive for long periods of time, especially if protected in biological materials (e.g. food) (183-186).

The identified risks apply equally to all forms of reusable food service packaging and service items. Consumer circumstances and responses remain the same, as do the dangers posed to the public health by foodborne pathogens (cross contamination leading to human illness).

Undesirable scenarios and problems with reusables

As discussed above, the correct use and rapid disposal of food service disposables prevents cross contamination between and among the food, the initial user of the materials, other individuals and their immediate environment. “Single use” supports the key elements of food safety, i.e. clean materials and good hygiene practices. If these key elements are in place, they prevent the transfer of bacteria or viruses to and from any individuals, food items, food contact surfaces, and other animate and inanimate fomites in the immediate environment.

Failure to adequately wash and sanitise reused contaminated food or beverage packaging and related service items and/or storage of contaminated materials under conditions that will allow pathogens to persist, and multiply, sets the scene for cross contamination. Such contamination may grow within food debris, soil, water, freezer drip, etc., on contaminated food utensils and surfaces etc, at ambient storage temperatures. This creates the scenario of increased numbers of bacteria spreading to anything and anybody by direct or indirect contact in a cycle of contamination, persistence, and re-cycling of bacteria within food processing, retail/domestic food shopping, storage and preparation environments. These environments involve domestic, commercial or institutional scenarios and some involve more than one of these groups.

New challenges in dealing with reusable food service ware

There are a number of additional challenges in wider use of reusable food service ware. Dealing with single use food service ware is fairly simple. These items are issued to customers, who take them away along with their food, or they are collected and rapidly disposed of, by food service staff. Dealing with reusable food service ware is a lot more complicated. In retail systems, all used reusable ware needs to be rapidly collected, sorted, cleaned and sanitised, and stored. In most cases, this process will include

[a] use of a specialised commercial on site or off-site dishwasher.

[b] specific steps to avoid build-up of bacteria, fungi, viruses, and allergens in cleaned food service ware, particularly cups and other items capable of supporting the persistence/growth of undesirable organisms and materials.

Dishwashers

Dishwashers aim to do two things, one of which we can see, and one of which we cannot see. The first step is to wash/clean food contact surfaces to remove food soil, scraps, grime, grease etc. (visible). The second step is to sanitise the cleaned surfaces by removing or killing foodborne bacteria and viruses remaining on the cleaned surfaces. (invisible)

A domestic dishwasher heats cold water heated to between 30°C to 60°C – much hotter that most people would use to wash by hand. This in the first reason why dishwashers are more hygienic (removing or killing more bacteria/viruses) than hand washing. Detergents, mixtures of cleaning chemicals and surfactants (surface active agents) which help remove grease and grime is usually included at this stage.

Domestic dishwashers wash for longer than washing by hand, the second reason why dishwashers are more hygienic, because the longer the washing cycle at the above temperatures, the more bacteria will be removed/killed.

The rates of bacterial deaths are dictated by the relationship between temperature AND time, so hotter water will achieve the same bacterial kill rate in a shorter time, as less hot water and a longer treatment time. This means that delicate items which might be damaged at higher temperatures can be safely washed and decontaminated at lower temperatures - IF the wash/ sanitisation period is longer. Thus, domestic dishwashers have a longer washing cycle of between 30 to 90 minutes.

Commercial dishwashers have the same objectives i.e. cleaning and sanitising dishes, cutlery etc, but aim to achieve these objectives within a much shorter cycle i.e. typically within 5-minutes.To achieve such a short cycle time, they use much more aggressive (highly alkaline) detergents, at higher concentrations and considerably higher water pressures and temperatures, as well as specialist rinsing agents to rinse off and dry sanitised items.

Unlike domestic dishwashers, which are very easy to use, it is more difficult to safely and effectively maintain staff and consumer safety in relation to commercial dishwashers. For this reason, public health agencies have developed detailed food safety advice, standards and requirements in relation the maintenance and use of commercial dishwashers. Examples in this area include the USDA Public Health Service Food Code (187) which sets safety standards, including details of the required temperatures of wash solutions in different types of commercial dishwashers, and reinforces the importance of adherence to the temperatures specified by the cleaning agent manufacturer label instructions. It is particularly important that commercial dishwashers are correctly selected, adjusted and operated under good hygienic conditions, as an inefficient, badly adjusted, or incorrectly used dishwasher is unlikely to achieve satisfactory cleaning and sanitation standards in reused food service ware.

The conditions and materials used in bars to clean and sanitise glass/cup washing machines are not as aggressive as commercial dishwashers, with longer cleaning/rinsing/sanitising cycles (less than 10 minutes) and specialised cleaning agents.

No single detergent is ideal for all materials and conditions in the food service, retail, and takeaway sectors, and it not possible to specify which detergent should be used in cleaning and decontaminating the range of reusable materials and items which might be used in these sectors. Statutory agencies such as USDA (187) and FSS (188) emphasise the importance of following the manufacturer's instructions in operating commercial dishwashers, and discussing the chemicals used with the relevant chemical's manufacturer to ensure the effective use of appropriate chemicals,

Additional benefits of using a domestic or commercial dishwasher include

-consistency of process, i.e. the correct amount of an appropriate detergent, and a standard temperature/time process is much more likely to deliver target reductions in bacterial/viral numbers.

-the final hot rinse. It is important not to open the dishwasher until the full cycle is complete, i.e. the final hot rinse heats all of the items to a point beyond the temperatures possible during hand washing. After the final hot rinse water is pumped out – the heat transferred to the washed items means that they are rapidly dried within the dishwasher.

As well as avoiding possible recontamination by manual drying, the final hot/dry state of the items inactivates remaining bacteria or viruses. Bacteria and viruses like it warm and wet, not hot and dry. Not opening the dishwasher until contents have dried and cooled also reduces the release of large amounts of warm water vapour, which would condense on surfaces providing the ideal warm/wet conditions in which bacteria thrive and viruses survive. In wider terms, such conditions also support the development of bacterial biofilms which accelerate bacterial growth, protect bacteria from sanitising agents, and can be very difficult to suppress in industrial environments (91, 189-191).

While much of the attention in relation to the survival of bugs in badly managed dishwashers relates to undesirable bacteria and viruses, it is becoming clearer that disease causing fungi including Candida, Cryptococcus and Rhodotorula, are frequent members of the mixed and complex bacterial and fungal biofilms in dishwashers (192-195)

It may not possible to make a blanket statement about the reductions or levels to achieve good hygiene in relation to reused food service items. Most of the bacteria on most surfaces do not present any dangers to human health. However, there are safety standards in relation to pathogenic bacteria and viruses on food contact surfaces (13, 196-198).

Paper used as food service disposables, should, as materials directly in contact with foods, meet the general requirements of the Framework Regulation (EC) No. 1935/2004 Article 3 (199). The relevant hygiene requirements indicate that materials and articles intended to come into contact with food should be manufactured in compliance with good manufacturing practice so that, under normal or foreseeable conditions of use, they do not transfer their constituents to food in quantities which could:

(a) endanger human health;

or (b) bring about an unacceptable change in the composition of the food;

or (c) bring about a deterioration in the organoleptic characteristics thereof.

Fungal infections and allergies
The challenges which exist in relation to drink residues left in inadequately cleaned reusable cups have been highlighted by a recent study carried out at Aston University (200). This study confirms the inherent risks of exposure to undesirable bacteria and fungi, growing in unwashed cups. Bacteria and fungi will grow rapidly under these conditions i.e. sufficient nutrients and a suitable (room) temperature. The dangers in relation to bacterial persistence and growth have been described earlier in this report.

However, it is equally important to recognise the additional risks associated with the growth of fungi identified above. Such fungi can, as well as causing disease in unsuspecting consumers, generate fungal allergens (spores) with significant allergic effects in sensitive individuals ranging from fatigue, through hives and itching, to anaphylactic shock (201). Such allergic responses can be triggered by relatively small amounts of fungal allergen(s), which poses challenges for those responsible for rendering reused food service items clean enough (i.e. low ppm of allergen), to avoid allergic responses among sensitive consumers. Cleaning and validation strategies in relation to allergen cross-contacts in food processing operations have been discussed by a number of authors, including Jackson et al., (202) and Soon et al.(30)

Quality controls and standards
Paper used as food service disposables, should, as materials directly in contact with foods, meet the general requirements of the Framework Regulation (EC) No. 1935/2004 Article 3 (199). The relevant hygiene requirements indicate that materials and articles intended to come into contact with food should be manufactured in compliance with good manufacturing practice so that, under normal or foreseeable conditions of use, they do not transfer their constituents to food in quantities which could:

(a) endanger human health; or

(b) bring about an unacceptable change in the composition of the food; or

(c) bring about a deterioration in the organoleptic characteristics thereof.

While there is some information on the hygienic standards of single use materials and items (27, 203) there is some variations in terminology and practice making comparisons difficult (204). It is important to recognise the significant differences between “general use” paper mill products e.g. newsprint, books, printer paper, poster paper menus labels, non-food wrapping paper, and the very different food contact paper products produced in board mills, which are designed to produce food contact materials.

Overall, there is comparatively little information on the microbiology, characteristics and standards (bacterial/viral /fungal counts) of (non-food contact) paper mill products. This is probably because the heat treatment processes used in paper milling are more than sufficient to reduce the numbers of viable bacteria, viruses and fungi in raw/recycled paper pulp, to acceptable (safe) levels, bearing in mind the non-food contact usage of these products. For example, a UK Health and Safety Executive study (205) reported high bacterial counts in pulp water of between 10^6 and 10^9 at the early stages of paper production, but heat treatments at later stages of the paper production process significantly reduce the bacterial counts from finished products (206). Bacteria which can cause human foodborne Illness e.g. Salmonella, Listeria and Staphylococcus, and many other pathogens, are very rapidly destroyed at temperatures well below the temperatures applied during dry rolling on paper mills (207, 208).

On the other hand, paper products which are intended to come into contact with food i.e. food service ware, must meet higher microbiological and chemical quality standards and comply with EU Commission regulation 1935/2004(209). Such items are produced in board mills, under Food Safety System Certification (FSSC 22000) (210), and endorsed by Global Food Safety Initiative (GFSI) which combines ISO 22000, sector specific elements and other relevant aspects, including purity, hazards and risk assessment (211).

A number of studies have noted that food packaging papers are not sterile (212), and some heat resistant bacterial spores, can best survive the temperatures involved the production of paper (> 140°C). Some spore formers e.g. Bacillus cereus (a potential human pathogen) can be of some concern (198). Thankfully, many of the bacterial spores which survive paper production temperatures remain immobilised within the fibre web of single use paper food service disposables (83, 212). Fibre-based packaging is not designed for reuse and academic research has raised concerns that such immobilised bacterial spores may be released from fibre by the repeated washing and sanitisation treatments applied to reusable items, and may increase the overall microbial loading of products (213).

There are also challenges in relation to the development and design of reusable items which can resist repeated washing, sanitisation and drying cycles It may be necessary to identify/modify methods of decontaminating paper and paper related reusable items, which may involve the application of emerging sanitisation methods, such as the use of various forms of cold plasma if these items are to be adequately decontaminated without suffering major damage (214-216).

Wider recontamination and pathogen dissemination at retail level

Customers bringing their own contaminated reusable bags and packaging into a retail environment will transfer “their” bacteria and viruses onto the hands of retail staff, and other retail food contact surfaces as the customer or server places purchased food into the customers bags.

Currently, food retail processes and premises have structural and operational safeguards in place to prevent raw materials, packaging etc. cross contaminating cooked products. However, it is not immediately clear how, under current retail environments and conditions, a retailer could prevent such cross contamination at the point of service involving potentially contaminated reusable food service ware. It should also be borne in mind that such contamination, once established at the point of service, is likely to be serially transferred to food and food service ware served to or collected by subsequent customers.

Recontamination of high risk (ready to eat) foods

Most retail foods arrive in the domestic environment packaged, or they will be subject to a final domestic (bacterial/fungal/viral kill) cooking process before consumption. As long as packaging is carefully removed and discarded, and/or raw contaminated foods are cooked – the risks associated with bringing contaminated foods/packaging into the domestic environment (217) are significantly reduced. However, the recontamination of safe, heat treated, RTE (e.g. “take away”) food by placing it in contaminated reused containers/bags is highly undesirable. Pathogens from reused bags will transfer to the RTE food, negating the very important final (bacterial kill) protection provided by cooking, leading to foodborne illness among consumers. Currently, the use of single use packaging has a vital role in preventing such recontamination of heat treated RTE food.

Take away foods
Take away foods are usually not presented in contamination proof containers. For example, burger or sandwich packs are not sealed, to allow hot food to "breathe". While there are no food safety problems with such items coming into contact with the inner surface of (effectively sterile) single use containers and service disposables, contact with the contaminated surface of a pre-used reusable container is likely to lead to the undesirable transfer of bacteria onto the cooling "ready to eat" product. The wider risks are even higher in the event that consumers are encouraged/required to bring their own reusable containers to food service outlets for such takeaway foods, thereby putting other customers at risk of cross-contamination.

Eating on the move
Similarly, the well-established consumer practice of directly eating "take away" foods by hand "from the pack"- when that pack is contaminated, especially when consumer's hands are very unlikely to be washed - will transfer contamination onto the fingers, onto the handled foods, and into the consumer mouth. The use of single use items, e.g. disposable forks/spoons help to reduce the risks in this area, but such risks will increase if these single use disposable forks/spoons are banned. Similar parallels can be drawn for beverages and beverage containers. It is noteworthy that the European Commission's proposal explicitly puts forward an exemption for disposable plastics/paper straws used for medical purposes, implicitly recognising the hygiene benefits of these products. Such hygiene benefits are equally valid for food service applications.

Unsuitable environments for reusable alternatives
There are a number of scenarios where the location or nature of food service operations make it difficult or impossible for food service outlets to recover and adequately decontaminate reusable food packaging and service ware, without very major, difficult and costly changes in their business models, ethos, facilities and operations. There are also scenarios where the resources, circumstances, and scale or nature of events make the recovery, sanitisation and reissue of reusable alternatives challenging, if not impossible. These include:

Commercial outlets
- independent food and beverage service outlets such as coffee shops, snack bars, fish and chip shops, take-aways, kebab shops, ice-cream vendors and food trucks.
- smaller scale food and beverage service chains
- major branded food and beverage service chains

Institutional outlets
- schools, universities and other educational establishments
- hospitals, dental surgeries and care homes
- prisons or similar detention centres where safety is a top priority (i.e. where metal cutlery and glass/ceramic crockery/containers cannot be used for safety reasons)
- in corporate and public service canteens

Unattended outlets
- vending machines supplying both hot and cold drinks
- water fountains/distributors
- public transport contexts such as air and rail travel

Domestic environments
- at home (for parties or for outdoor activities)

External events -

- indoor and outdoor gatherings, such as sports events, concerts, and music festivals,
- other cultural and tourist festivals
- crisis situations such as at the site of natural or other disaster zones (where organised recovery and effective sanitisation of used food service ware are not feasible, or where there is also a heightened risk of the spread of disease)

CONCLUSIONS

People are increasingly consuming food away from home (218-221), on-the go, often in crowds, and frequently where and when the recovery and effective sanitisation of packaging and utensils is difficult, if not impossible. There are good reasons why (where appropriate) every effort should be made to reduce the impact of single use packaging and food service ware. However, there are many circumstances in which the continued use of single use packaging and food service ware provide the only feasible option for maintaining adequate food hygiene, public health and consumer safety. In any comparison of reusable and single use food service items, it is important to consider the number of times that the reusable items are used, along with the overall costs of producing, using, recovering and (re)sanitising these items versus the overall costs of producing, using and disposing of single use items (222, 223).

The evidence is clear. The potential for the persistence/transfer of foodborne pathogens on reusable packaging and food service ware, (i.e. the current alternatives to disposable cups, glasses, forks, spoons, stirrers, trays, boxes and bags), remains a clear and present hazard, especially at the retail/service/consumer interface.

We should not be surprised by this hazard. The risks to human health posed by cross contamination within the food chain are well-known and long-established. It is a hundred years since Dr Samuel Crumbine, one of the founding fathers of modern public health, invented the first single use disposable cup with the express purpose of reducing cross contamination and the incidence of human foodborne disease. It is now twenty years since J.G. Doser (15) concluded that "Individually pre-packaging of food is the only certain method of preventing contamination by customer handling". The factors which led Crumbine and Doser to establish the crucial importance of breaking the chain of cross contamination to prevent foodborne illness have not changed, and the agents of such illness have, if anything become more dangerous with the relentless spread of antimicrobial resistance within the major foodborne pathogens (16-20).

It is unlikely that consumers can willingly and effectively change their views or practices to ensure adequate levels of safety in this area, in the absence of single use food contact materials in the presentation, transport, storage and serving of higher risk/ready to eat food items. However, there are various practical and legal obstacles to a widespread use of reusable containers (222, 224). These include the consumer inconvenience in carrying reusable food service ware and containers to the food outlet and having to clean and decontaminate these items after each use.

It has been suggested that only committed or incentivised (e.g. food discounts) consumers would achieve the number of reuses necessary to balance out the impacts of single-use containers (222). There are also the operational problems of different sizes of containers in relation to portion sizes, although these would be reduced if the reused containers are provided by and returned to, the food outlet.

Another issue is related to possible legal challenges, for example, due to food poisoning (225-227). It is well known that outbreaks of foodborne illness can be caused by food contamination at the outlet (7), but the additional complications associated with possible inadequate cleaning of returned reused containers may make even more difficult to prove who is responsible. It is frequently difficult to identify the breakdown point where food safety systems failed, leading to foodborne illness within a linear food chain. It will be considerably more difficult to identify the breakdown/cross contamination point in a food chain which had circular processes using reusable food service items and recycling pathogens.

Increases in the application of reusable food service ware, in the absence of radical significant and unprecedented changes in consumer practice, will lead to greater persistence and circulation of foodborne pathogens within the human food chain, and increased risks of human foodborne illness in our community.

Glossary/Abbreviations	
ambient temperature	domestic and retail room temperatures
biofilm	A thin but robust layer of mucilage adhering to a solid surface and containing a community of bacteria and other microorganisms.
Commercially sterile	Treated to destroy all pathogenic and spoilage organisms that can grow in food under normal storage and handling conditions.
(cross) contamination	Transfer of bacteria/viruses to people, foods & food contact surfaces
dehydration	loss of water content
EFSA	European Food Safety Authority
ECDC	European Centre
EU	European Union
Fomite	An inanimate object which can transfer a pathogen to a host
foodborne	Agents of infection capable of persisting in and/or growing on food
freezer drip	liquid exuding from defrosted foods
infection	Illness in an individual
HHP	sanitisation using high hydrostatic pressure
longer life bags	Fabric or heavier plastic grocery bags
morbidity	disease state and symptoms
mortality	death
pathogen	agent of disease (bacteria/virus)
PL	sanitisation using pulsed light
sanitised	Treated to remove/kill bacteria/viruses
outbreak	An episode of illness involving more than one person, usually with a common exposure and symptoms
RTE	(Ready to Eat) Prepared food which will be consumed without further (heat) treatment
WHO	World Health Organisation
zoonotic	a disease which can be transmitted to humans from animals

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