**Original article for Public Health**

**Title:** An assessment of food safety information provision for UK chemotherapy patients to reduce the risk of foodborne infection.

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**Highlights:**
- Patients are aware of immunosuppression but underestimate foodborne infection risk (84)
- Resources to reduce the risks associated with foodborne infection were lacking (81)
- Targeted resources to ensure patients/caregiver food safety practices are required (85)

**Abstract:**

**Objectives:** Given the increased risk of foodborne infection to cancer patients receiving chemotherapy treatment, and the risk of listeriosis reportedly five-times greater to this immunocompromised patient group, there is a need to ensure the implementation of domestic food safety practices among chemotherapy patients and their family caregivers. However, information regarding the adequacy of resources to inform and enable patients to implement domestic food safety practices to reduce the risk of foodborne infection are limited. Consequently, this study aimed to evaluate the provision of food safety information available to UK chemotherapy patients.
**Study Design:** In-depth semi-structured interviews and content-analysis of online patient information resources.

**Methods:** Interviews with patients and family caregivers \((n=15)\) were conducted to explore food-related experiences during chemotherapy treatment. Online food-related information resources for chemotherapy patients \((n=45)\) were obtained from 35 of 154 National Health Service (NHS) chemotherapy providers in England, Scotland and Wales, the Department of Health (DoH) and three of 184 identified UK cancer charities. Identified food-related information resources were reviewed using a content-analysis approach to assess the inclusion of food safety information for chemotherapy patients.

**Results:** In-depth interviews established that many patients indicated awareness of immunosuppression during treatment. Although patients reported practicing caution to reduce the risk of communicable diseases by avoiding crowded spaces/public transport, food safety was reported to be of minimal concern during treatment and the risk of foodborne infection was often underestimated. The review of online food-related patient information resources established that many resources failed to highlight the increased risk of foodborne infection and emphasize the importance of food safety for patients during chemotherapy treatment. Considerable information gaps exist, particularly in relation to listeriosis prevention practices. Cumulatively, information was inconsistent, insufficient and varied between resources.

**Conclusion:** The study has identified the need for an effective, standardized food safety resource specifically targeting chemotherapy patients and family caregivers. Such intervention is essential to assist efforts in reducing the risks associated with foodborne infection among chemotherapy patients.

**Keywords:** Behavior; Chemotherapy; Foodborne Infection, Food safety; Information; Patients;
Introduction.

Increased risk of foodborne infection.

The cytotoxic drugs utilized for chemotherapy reduce the numbers of lymphocytes,\(^1\) consequently, chemotherapy is described as an immunosuppressant.\(^2\) Subsequently, people receiving chemotherapy for the treatment of cancer are at an increased risk of infection, including foodborne infections. Given that patients have very little defenses against opportunistic pathogens, the mortality rate of such infections are elevated in cancer patients as infections can take longer and be more difficult to treat.\(^3\) Data suggest that cancer patients receiving chemotherapy treatment have an increased risk of foodborne infections relative to people not currently diagnosed with cancer.\(^3\) Therefore, a significant number of people receiving chemotherapy for the treatment of cancer, may suffer unnecessarily from foodborne infection each year.

A range of foodborne infections including campylobacteriosis, listeriosis and salmonellosis are reportedly more prevalent among patients with cancer.\(^4\)-\(^6\) Research from the USA indicates that cancer and immunosuppressive therapy were the most frequently recorded comorbid conditions in non-pregnancy-associated cases of listeriosis.\(^7\) Similarly in the UK, cancer was the most common underlying condition of reported listeriosis cases (26%) in 2014.\(^8\) Furthermore, data suggest that that an increase of listeriosis among cancer patients has occurred in the UK between 1999–2009, and has determined that cancer patients have a five-fold increased risk of listeriosis.\(^9\),\(^10\)

Neutropenic diet.

To reduce the risk of foodborne infection, there is a need to reduce the likelihood of consuming pathogens. Cancer patients that have been classed as having severe neutropenia (where absolute neutrophil counts are <500 cells/µL\(^11\)) are at an increased risk of foodborne infection, are
advised to follow the neutropenic diet,\textsuperscript{12} which has a strict limitation of foods to reduce the potential risk of infection by limiting microbial intake to prevent foodborne infection or bacteraemia.\textsuperscript{13} A low microbial diet for patients with neutropenia is intended to maintain the integrity of the bowel and microbial flora.\textsuperscript{14} However, research evaluating potential benefits of a neutropenic diet is limited and proof of its advantages is lacking.\textsuperscript{13} The argument for the development of consensus-based and evidence-based guidelines for neutropenic diet restrictions remains,\textsuperscript{15} with uncertainties relating to the food products to be included, the practices to improve compliance, the specific patients that would benefit and the timing of the intervention.\textsuperscript{16} However, to minimize microbial risk of foodborne infection, safe food handling and storage practices are essential, particularly as data suggest many patients fail to adhere to neutropenic diet restrictions, when receiving this form of intervention.\textsuperscript{12} It is suggested that the implementation of safe food handling and storage practices may allow for a more liberalized diet among cancer patients.\textsuperscript{13}

**Domestic food safety practices.**

The prevention of foodborne infection involves co-operation of all stages of the food supply chain,\textsuperscript{17,18} no one stage has sole blame or responsibility.\textsuperscript{19} Consumers are the important final link in the food chain to assure safe food consumption and to prevent foodborne infection.\textsuperscript{20,21}

It is widely accepted that many sporadic cases of foodborne infection occur as a result of improper food handling and storage practices by consumers in their own homes.\textsuperscript{22,23} However, the true incidence of foodborne infection that results from food prepared and consumed in the home is difficult to determine.\textsuperscript{24} It is suggested that up to 70\% of foodborne infection mortality is associated with food consumed at home.\textsuperscript{25} There is a lack of research that explores the differences between outbreak-associated foodborne infection and sporadic foodborne infection.\textsuperscript{26} The International Scientific Forum on Home Hygiene suggests that a significant proportion of foodborne infections are related to hygiene practices within the home.\textsuperscript{27}
Multiple food safety responsibilities are required by consumers because they not only purchase and receive products, but also process and provide foods for themselves and for others. This is particularly the case for family caregivers, providing food for relatives receiving chemotherapy for the treatment of cancer.

The domestic kitchen is reported to be a multi-factorial contributor to foodborne infection, additionally, microbiological risks require control during the stages of purchase, transportation to the home, domestic storage, preparation, cooking and consumption in the home to ensure food safety. The most common contributory factors associated with the transmission of foodborne infection reported by the UK Health Protection Agency (HPA), Public Health England (PHE) and the USA Food and Drug Administration (FDA) include cross-contamination, insufficient heat treatment of foods, inadequate food storage/chilling, inadequate hand washing and improper cleaning of food contact surfaces.

It is suggested, that to minimize the risk of foodborne infection to patients during chemotherapy treatment, it is important that patients consume foods prepared and/or stored at home according to food safety recommendations and avoid risk-associated food products. Food safety practices of importance for immunosuppressed cancer patients include avoiding cross-contamination of food during food handling and storage, safe temperature control during storage, adequate heat treatment during cooking, and avoiding risk-associated foods. Currently, data regarding the availability and adequacy of such information to patients in the UK is unknown. Clear food safety advice should be provided for vulnerable people within the community, alongside tailored risk-based educational food handling and storage recommendations.

Given the increased risk of listeriosis to chemotherapy patients, key behaviors required to reduce the risks associated with listeriosis in the domestic kitchen should particularly be communicated to chemotherapy patients. Such practices include adherence to ‘use-by’ dates
on unopened pre-packed ready-to-eat (RTE) food products, avoidance of prolonged storage of RTE food products and consumption within two days of opening, and insurance of safe operating temperatures (≤5.0°C) of domestic refrigerators, which are commonly included in consumer listeriosis risk-reduction food safety information from the UK, Europe and the USA.

**Food safety information provision.**

As listeriosis is said to be almost entirely preventable through safe food handling and appropriate food choices, it is important for vulnerable populations to have knowledge of safe food practices, this is particularly true for chemotherapy patients. There is a clear need for food safety education specifically intended for chemotherapy patients. The provision of targeted food safety advice to this group prior to, during, and after treatment may reduce the impact of subsequent infection. Indeed it is suggested that due to the lack of appropriate food safety advice that is tailored specifically for cancer patients in the UK, emphasis on this group might help to prevent further cases of foodborne infection.

It is suggested that if patients have an improved awareness of recommended practices and perceive that such practices are important and will not interfere with their lifestyles, they may be more likely of accepting food safety recommendations. Previous research suggests cancer patients have positive attitudes towards receiving food safety education and are reportedly willing to follow recommendations to ensure the safety of food, however patients need to receive informative and appropriate food safety information from sources perceived to be trustworthy and reliable.

To date, there has been no review, or evaluation of the availability and adequacy of UK food safety information accessible for chemotherapy patients and family caregivers. Given the elevated risk of foodborne infection during chemotherapy treatment, determination of current
information is needed to assess whether appropriate and informative information is available to this immunocompromised patient group along with exploring the food-related experiences of patients during treatment to ensure the chance of reducing foodborne infection is maximized.

Methods.

The purpose of this study is to explore the food-related experiences of patients and family caregivers during chemotherapy treatment, and review food-related information resources available to cancer patients in the UK for the inclusion of effective food safety messages. Ethical approval to conduct the study was granted by the Cardiff School of Health Sciences Research and Ethics Committee. Project reference number: 0001-SREC-2014(01). The study was funded by the Tenovus Cancer Care innovation research grant [TIG 2014-30].

In-depth interviews with chemotherapy patients and family caregivers.

A convenience sample of patients and family caregivers was recruited following a period of publicizing the research study, which included promoting the project online using Twitter and Facebook, sending emails to cancer support groups with information regarding the study. Study information posters were displayed on community notice boards in supermarkets, shops, community centers and libraries, and attendance of the researcher at cancer support groups and a charity funded cancer support community centre whereby project participation information was shared. The inclusion criteria for participation included being over 18 years of age, a patient currently receiving or having recently (within the last three years) received chemotherapy for the treatment of cancer, or a family caregiver (involved with the non-professional care) of a current/recent chemotherapy patient. No inclusion/exclusion criteria related to cancer type/site.

The development of the standardized semi-structured interview schedule was informed by an in-depth literature review, the schedule was devised to structure a discussion regarding food-
related experiences during chemotherapy treatment. The standardized semi-structured interview schedule was piloted with three people meeting the inclusion criteria (two patients and a carer) prior to commencing with data collection. As discussed by van Teijlingen and Hundley, the process of piloting research methods increases the likelihood of a successful study and can provide valuable insight regarding the appropriateness and adequacy of the research approach.\textsuperscript{43}

The pilot identified issues relating to the order of the schedule and allowed for the suitability of questions to be determined and whether questions gave adequate response range. The duration of interviews were recorded to indicate likely participation time and determine if length was reasonable and appropriate. Consequently, minor amendments to the interview schedule were made, including removal of repetitive, irrelevant, sensitive or ambiguous questions. Initial questions regarding background of patient treatment were added to allow participants to talk freely and give insight regarding treatment experience to the researcher prior to commencing with the food-related semi-structured interview schedule, thus improving the process of the interview.

The finalized semi-structured interview schedule discussion points included: factors influencing food-related problems experienced during chemotherapy treatment; changes in food shopping, preparation and/or consumption practices during chemotherapy treatment; the role of family caregivers in relation to food procurement during chemotherapy treatment; Awareness of infection susceptibility and infection control during chemotherapy treatment; perceptions of risk, control and responsibility for food safety during chemotherapy; recalled receipt of food safety information, information requirements and preferences for sources for food safety information.

Potential participants were provided with a participant information sheet detailing the study. Participants gave consent to participate in the study by means of completing a participant
consent form. Individual in-depth interviews with patients and family caregivers were conducted either at the university, in a charity funded local cancer support community center, or over the telephone (to the preference of the participant). Interviews were transcribed and thematic analysis was conducted using NVivo 10 to determine common trends. Following completion of the first twelve interviews, the researcher recognized that many responses and themes were very similar and identified that a theoretical saturation point may have been reached. As suggested by Guest et al., saturation of data often occurs within the first 12 interviews. A further three participants were interviewed to go beyond the point of saturation. It was determined that the additional participants were not providing any additional insights and ensured that ‘no new categories or relevant themes emerged’.

Consequently, it was decided that a sample of 15 participants would be sufficient for the aims of the interviews. Cumulatively, ten patients and five family caregivers participated in the study. Only one participating patient was related to a participating caregiver.

**Content-analysis of food-related information resources.**

To enable content-analysis of food-related information resources available to chemotherapy patients, there was a need to firstly identify all National Health Service (NHS) chemotherapy providers in England, Scotland and Wales. However, a comprehensive list detailing such information, was not publicly available. Consequently, all Teaching and University Health Boards and NHS Trusts in Wales (n=10), all NHS Health Boards in Scotland (n=14), and all NHS Authorities and Trusts in England (n=231) were identified. From which, mental health, ambulance services and community health NHS trusts were excluded, leaving only NHS Hospital Trusts, Foundation Trusts and Health Boards that provide secondary healthcare services (n=176). The website of each was accessed and searched to identify if a provider of chemotherapy services. Of the NHS Trusts and Health Boards in England, Scotland and Wales determined to be chemotherapy providers (n=154), online patient information resource
collections were accessed and searched to identify and obtain any food-related information resources available for patients.

The Charity Commission for England and Wales Central Register of Charities was utilized to identify cancer related charities that may provide information and support to people receiving chemotherapy treatment. A total of 184 charities operating throughout England and Wales classified as advancing health or saving or lives in relation to cancer ($n=164$), lymphoma and/or leukemia ($n=20$) were identified. Along with the DoH owned public facing website of the NHS ‘NHS Choices’, identified charity websites were accessed and searched to identify and obtain any food-related information resources available.

A Microsoft Access 2013 database (Microsoft, Redmond, WA USA) was designed and developed to store and analyses data obtained from each of the food-related information resources available from NHS and charity sources. Resources were evaluated using a content analysis approach. Findings were summarized according to key topics critical to food safety and listeriosis, (e.g. hand hygiene, adequate cooking, cross-contamination, refrigeration practices, listeriosis prevention, risk-associated food products and potentially ‘unsafe’ practices).

**Results.**

**Food-related experiences and recalled receipt of food safety information among chemotherapy patients and family caregivers.**

Throughout the interviews, patients and caregivers discussed that food provision was a very important role for the caregiver, it was often cited as one of the few areas the family can input during chemotherapy treatment. It often gave comfort as little could be done in relation to healthcare treatment. Although many patients and caregivers were aware of the increased risk of infection during chemotherapy treatment and the need for control measures to reduce related
risk, the association was often not made between the potential of foodborne infection and the need for implementation of food safety behaviors. Indeed, the most widespread awareness for infection control was preventing communicable diseases from contact with people. There was a distinct lack of awareness regarding the increased risk of food poisoning during chemotherapy, and many patients/caregivers did not make the link between the potential of infection from a foodborne pathogen, “I knew there was increased risk of picking up infections so I was especially careful about hand washing after being in public space, I didn’t think about a risk of food poisoning.” (Participant 01). “It was certainly drummed home to me that you can get quite ill on chemotherapy if you pick up an infection. It was more about, trying to avoid people and friends and family that may have some virus or some sickness, trying to avoid being hemmed in with too many people in a GP waiting room for example or on public transport.” (Participant 10). “I can remember it being made clear to us that we should avoid contact with anybody with any contagious or infectious illness” (Participant 05). A lack of emphasis was placed on the potential of food causing an infection.

Obtaining information from some respondents regarding receipt of food safety information during chemotherapy treatment was problematic, as participants did not want to put their healthcare providers in a bad light for not providing information as they were pleased with the quality of care that they had received. “I would hate for them (referring to healthcare provider) to have provided that (referring to food safety information) and then somebody (referring to self) say not. I wouldn’t want to be quoted as saying “I didn’t have any information on food safety from...”, but I can’t recall receiving it (referring to food safety information), other than being told to just keep fit and well and as healthy as you can” (Participant 06).

It was established that many patients reported that they did not recall receiving any food safety information during their chemotherapy treatment. A few participants suggested that if advice had been provided to them during the time of their chemotherapy treatment they may not have
paid attention to it due to ‘bigger concerns’, whilst others had not considered the risk of foodborne infection and perceived that their practices were already ‘safe’. One participant, when asked if food safety was of importance during his wife’s chemotherapy treatment responded “That would have just given you something else to worry about! Well knowing fully well that the food we were cooking was good healthy food, we didn’t specifically think about safety at that time.” (Participant 04), similarly a patient stated that “I had much bigger things to worry about. But I do equally from talking to you now understand the need for people to prepare food safely and things of this nature, but I had much bigger things to worry about.” (Participant 01).

Food safety was of minimal concern compared to being able to cook or eat as many reported factors that influence the food habits of patients during treatment. These included concerns for wanting to consume a nutritious diet, and commonly recognized eating problems associated with chemotherapy including appetite loss, dry or sore mouth, nausea, dysgeusia and cachexia. “I felt nausea all the time, I felt really ill and I couldn’t even bare the smell of cooking. I would be in the bedroom and I would say to my husband “please shut all the doors” it was nothing to do with his cooking, just the aroma that came from the cooking” (Participant 09). “I found it difficult to go in the kitchen, I found it very difficult to sit down and eat meals, I think that was psychological as much as anything else” (Participant 02).

Only three participants recalled receiving advice relating to food safety, generally the advice only focused on risk-associated food products to be avoided and not on domestic food safety practices such as hygiene, refrigeration and cooking. “Just the one leaflet, it was just focusing on the foods to avoid. There was no other information” (Participant 07). Although the majority did not recall receiving food safety information, during the course of the interviews, many participants recognized the need for food safety information in healthcare settings, “I didn’t receive that sort of thing, I think that would have been handy to know.” (Participant 08), “I
honestly can’t remember receiving any (food safety) information. But every patient would benefit from it. No, I would say it is something that ought to be.” (Participant 03). “Well it was a good start with the nurse because there were questions etcetera to answer, but perhaps a DVD or a booklet with more information would have been really helpful.” (Participant 07). During treatment, some patients sought as much information as possible, whilst others refrained to only consult the information received from healthcare providers. These factors can influence a patient’s interaction with healthcare professionals, engagement with received information and their adherence to recommendations. Consequently, the role of the healthcare professional was determined to be important in the delivery of information. However, a lack of communication regarding the importance of food safety from healthcare professionals was reported. When asked if they recalled receiving food safety information being communicated by healthcare professionals a participant stated “No, it was more the catering lady, it was a discussion with her saying ‘well we have got a list of food that we can and can’t give you’, and it was quite extensive, which really surprised me, so it was much more restrictive than I was. The catering staff knew more.” (Participant 11). “We saw a dietician about diet, although that wasn’t about food safety.” (Participant 04). Indeed, research suggests that patient knowledge, understanding and effective communication between healthcare professionals and the patient are critical in ensuring patient adherence, however an individual’s beliefs, attitudes, subjective norms, social support and both physical and emotional well-being can influence adherence.46, 47

The availability and adequacy of food safety information for chemotherapy patients and family caregivers in food-related information resources.

Overall, 45 food-related information resources for patients were obtained from 35 of the 154 NHS chemotherapy providers’ online patient information resource collections (n=41), the DoH
‘NHS Choices’ (n=1) and from three of the 184 cancer support/research charity websites (n=3). All resources were different, no duplicates were identified, thus suggesting that a standardized NHS food safety information resources is not available specifically for healthcare providers to provide to chemotherapy patients and family caregivers. Less than a third (29%) of resources were specifically food safety focused, the majority (71%) were food-related information sources that included some elements of food safety. Although 64% of sources explained why patients are at an increased risk of developing infection during treatment, few (20%) highlighted the importance of food safety to prevent infection, the majority of which (78%) referred to neutropenic restrictions. Overall, 67% of resources included one or more reference to a food safety practice, ranging from one (e.g. “Ensure eggs are thoroughly cooked”) up to 43 practices, however, the majority (70%) included only ten food safety practices or less. Thirteen percent of resources suggested that patients should allow ‘others’ to prepare food for them during chemotherapy treatment if energy is low, however only 4% incorporated the importance of food safety for ‘others’ when preparing food. The provision of food safety information for family caregivers who undoubtedly provide an essential role in the provision of food for many people undergoing chemotherapy treatment was considerably lacking.

**Inclusion of hand hygiene information.**

Although hand hygiene is recognized as essential to reduce the transmission of infection in healthcare settings, hand hygiene is also critical to ensure food safety in the home. The implementation of sufficient hand hygiene practices in the home have the potential to significantly reducing the incidence of foodborne infection, as hand washing is important in preventing cross-contamination in the domestic kitchen. Hand hygiene practices should include the use of soap or hand sanitizers and hot water to decrease microbial contamination by removal or destruction of microorganisms on hands. Hand washing needs to be followed by hand drying, as the
friction caused during the abrasive action of drying hands removes residual microorganisms from hands.\textsuperscript{56}

Implementation of hand hygiene was the most common food safety practice recommended in 22 of the 45 identified resources. The need for washing hands before preparing food was included in less than half (49\%) of the resources, the need for hand washing after handling raw meat/poultry (27\%) was lacking and no resource indicated the need for hand washing before handling RTE food (see Table 1). Although some resources indicated ‘when’ handwashing was required, recommendations for ‘how’ to implement hand hygiene practices were insufficient. Only 20\% recommended use of soap and warm water to wash hands and only 16\% recommended that hands should be dried using a clean hand towel or disposable kitchen paper.

Although information relating to hand hygiene was most frequently included, a lack of sufficient information detailing when and how hand hygiene practices should be implemented was identified. Failure to implement adequate hand decontamination has been proven to result in the hands being vectors for microbial cross-contamination, indeed, hand washing and drying are the most effective means of preventing the spread of foodborne infection.\textsuperscript{56-58}

**Inclusion of adequate cooking information.**

Correct cooking practices are a critical point during domestic food preparation to ensure food safety in the home.\textsuperscript{59} The consumption of undercooked meat, poultry, seafood, and eggs has commonly been implicated with incidence of foodborne infection.\textsuperscript{60} A significant number of foodborne infection occurs as a result of inadequate cooking.\textsuperscript{61} Advising consumers to achieve a core temperature of $75^\circ C$ or above by means of inserting a temperature probe into the center of the food, will determine that a sufficient temperature has been achieved to destroy harmful pathogen bacteria in food.\textsuperscript{62} Furthermore, it is advised that immunocompromised consumer groups should avoid the consumption of undercooked meat, shellfish and eggs.\textsuperscript{62}
Recommendations to ensure heating efficacy were included in less than half (47%) of the identified resources, the recommended practices to optimize cooking adequacy included in resources are listed in Table 2. Although 42% of resources recommended the avoidance of raw meat, poultry, and/or fish, and as indicated in Table 2, 33% stated to cook all food until piping hot, only 9% of resources recommended the use of a thermometer to achieve a core temperature of ≥75°C. Information about specific cooking methods was lacking and concernedly advice that may result in undercooked meat and fish products was also included; “Shellfish and steamed fish must be cooked for at least seven minutes. Meat should be too hot to touch” (Resource 029). Although such text has attempted to advise regarding the cooking efficacy of food products, the use of a temperature thermometer is regarded by food safety professionals as the best way to ensure cooking efficacy rather than consumer judgment. 63 Provision of a cooking time without method, portion size or cooking temperature is inadequate and this may be potentially misleading, assessment of the external temperature of food will not indicate core temperature and such recommendations cannot be classed as risk-reducing behaviors.

**Inclusion of cross-contamination information.**

Consumer food safety research suggests that cross-contamination events are common in the domestic kitchen by consumers,64-65 cross-contamination events can occur during food handling malpractices from raw food by hands and/or food contact surfaces/equipment.66-69 It is suggested that cross-contamination events are of greater importance than the risks associated with undercooking.70 Consequently the prevention of cross-contamination is a critical point to ensure domestic food safety,59 for which, there is a need for consumer awareness of effective hygiene practices.71

Generic recommendations to reduce the risks associated with microbial cross-contamination in the domestic kitchen were included in only 38% of the resources, this is insufficient. As illustrated in Table 3 the most frequently recommended practices included in only 29% of
identified resources were to store RTE foods above raw meat/poultry in the refrigerator, and to use separate chopping boards for preparing raw meat/poultry and RTE foods (27%). However, specific cross-contamination recommendations related to direct and indirect cross-contamination to sufficiently inform and reduce risks were not included.

**Inclusion of refrigeration information.**

Refrigeration is one of the most widely utilized methods to maintain the safety and quality of food products as temperature regulation is a critical factor in reducing the growth rate of microorganisms. Indeed, refrigeration practices in the domestic kitchen can have a significant impact on food safety. It is reported that failing to ensure adequate refrigeration temperatures is the greatest hazard with RTE food products, as temperature control is essential to maintain the safety of minimally processed RTE food products. UK food safety requirements for the domestic storage of refrigerated foods is ≤5.0°C. Refrigeration temperatures were included in only 22% of identified resources, additional practices to prevent unsafe operating temperatures were less frequently recommended, for example, 11% stated ‘do not overload refrigerator’ and 11% stated ‘do not refrigerate hot foods. Failure to communicate the importance of checking refrigerator operating temperature may result in unsafe refrigeration temperatures that will enable foodborne pathogens, particularly *L. monocytogenes*, to proliferate in foods, thus increasing the risk of foodborne infection.

**Inclusion of listeriosis preventative information.**

Foodborne listeriosis is reportedly more prevalent and is frequently associated with cancer patients and chemotherapy treatment. Due to the microbiological characteristics of the causative pathogen *Listeria monocytogenes*, listeriosis risk reducing food safety practices are defined as: following ‘use-by’ dates on unopened prepacked RTE food products, consuming RTE food products within two days of opening, and ensuring the safe operating temperatures
of domestic refrigerators (≤5°C). In addition to refrigeration as discussed above, the inclusion of information in resources regarding listeriosis risk reducing behaviors were particularly lacking (see Table 4).

‘Use-by’ dates of foods that will support the growth of *L. monocytogenes* are calculated to ensure that a critical limit of the pathogen will not be exceeded at any point between production and consumption. Therefore, adhering to the ‘use-by’ dates on RTE foods is essential to reduce the risks associated with listeriosis. Only a third of resources (33%) recommended following ‘use-by’ dates, however, 13% listed ‘use-by’ dates with ‘best before end’ dates (indicating food quality not food safety), this may cause confusion for consumers. Indeed, previous research suggests that many consumers do not know the meaning of different types of date labelling on food products.

The use of modified atmosphere packaging increases the shelf life of foods, particularly RTE foods, however the desirable properties that restrain microbial growth are lost after opening, therefore it is recommended that such food products are consumed within two days of opening to ensure food is safe to eat. It was determined that only 7% recommended that RTE foods should be consumed within two days of opening to ensure food safety and only 4% included information regarding dealing with leftover foods.

The lack of information to reduce the risks associated with listeriosis is of considerable concern given the elevated incidence rates among chemotherapy patients. Failure to adequately inform patients and family caregivers of these key practices may result in the prolonged storage of RTE food products at potentially unsafe temperatures, which may be contributory factors to listeriosis.

**Inclusion of risk-associated food products and safer alternatives.**
Food products that are minimally processed along with RTE food products pose a greater risk of foodborne infection,\textsuperscript{84, 85} consequently there is a need for chemotherapy patients to avoid the consumption of risk-associated food products including raw and undercooked seafood, eggs and meat, soft cheeses and unpasteurized dairy products.\textsuperscript{32, 86} Recommendations regarding risk-associated food products to be avoided were included in 44\% of resources. The food products most frequently recommended to be avoided were raw/undercooked eggs (42\%), raw/undercooked meat or poultry (42\%), and unpasteurized dairy products (38\%). However, only half of those that included risk-associated food products listed safer alternative food products (22\%). Research by Lund and O'Brien,\textsuperscript{36} discussed that clear advice detailing high-risk foods and suitable substitutions should be provided for vulnerable persons.

**Inclusion of potentially ‘unsafe’ messages.**

Recommendations or information deemed to be potentially ‘unsafe’ and may increase the risks associated with foodborne infection were included in 11\% of resources which included: “Food at room temperature may be more enjoyable than hot food, and can be as nutritious.” (Resource 035), “Eat room temperature foods.” (Resource 031) and “All food and drink should be lukewarm or at room temperature” (Resource 017). Both spoilage and pathogenic bacteria will grow at ambient temperatures,\textsuperscript{87} as the preferred growth temperature of many foodborne pathogens is 20°C to 40°C,\textsuperscript{88} food products out of refrigeration for prolonged periods should be disposed of to prevent microbial proliferation to potentially harmful numbers, consumers are advised to avoid the consumption of RTE food products out of the refrigerator for more than 3 hours.\textsuperscript{89} It is advised that consumers cool leftover food within two hours and store in the refrigerator.\textsuperscript{90} The communication of potentially unsafe food safety information may result in the implementation of food safety malpractices in the domestic kitchen that may increase the risk of foodborne infection.

**Discussion.**
Completion of the in-depth interviews have established that information on food safety was reportedly seldom received by patients and family caregivers prior to/during chemotherapy treatment. The perceived lack of importance regarding food safety was a point of discussion. Failing to communicate the importance of food safety to this vulnerable patient group in healthcare settings may result in patients and family caregivers perceiving that food safety is not of equal importance to other factors, such as control of communicable infections, and fail to prioritize food safety in the home. There is a need to adopt a ‘food safety culture’ in healthcare settings to inform patients and family caregivers of the increased risks and enable the implementation of adequate domestic food safety practices required to reduce the risks of foodborne infection.

The review of food-related information resources has determined that although some information detailing food safety recommendations and risk reducing behaviors are available, access to this information for patients is limited, considerable gaps exist and information provided varies greatly between sources, and in some cases the information that is provided promotes potentially unsafe practices. The most comprehensive sources of food safety information were tailored for neutropenic patients and these are unlikely to be provided to/accessed by all people undergoing chemotherapy. Advice relating to hand decontamination was most frequently included, practices to reduce the risk of listeriosis or safer alternatives to risk associated food products were lacking.

There is a need for research to establish if the information resources included in this study are received by patients receiving chemotherapy treatment and determine the potential impact of such resources upon food safety behavior and behavioral influences (including knowledge, attitudes, risk perceptions, intentions, and motivations) of cancer patients and/or their family caregivers during domestic food preparation.
Cumulatively, completion of this study has determined that currently, there is a lack of consistent, correct and credible information regarding the critical importance for the implementation of domestic food safety practices for patients receiving chemotherapy treatment. Failure to implement adequate food safety behaviors may not only increase the risk of foodborne infection among chemotherapy patients, but also result in additional health complications and delays in treatment and potentially increase patient mortality.

Failure to inform and enable patients to adequately implement food safety practices may result in potentially serious implications. Indeed, the provision of targeted food safety information to this group during treatment may reduce the risk of foodborne infection.\textsuperscript{9} Therefore, there is an urgent need for a standardized approach to overcome the variation of information between different NHS trusts, hospital departments and charities to ensure all patients are equally informed to enable the implementation of food safety/food hygiene risk reducing behaviors. Investment in efforts to reduce foodborne infection among chemotherapy patients may not only benefit patients but also may have cost-saving benefits for the NHS.

**Conclusions.**

Consequently, completion of the research has identified that chemotherapy patients and family caregivers are aware of immunosuppression but underestimate foodborne infection risk, furthermore, suitable resources to reduce the risks associated with foodborne infection were lacking. There is an identified need to design and develop a standardized and specifically targeted food safety intervention, using a patient-orientated approach for chemotherapy patients and family caregivers to reduce the risk of foodborne infection during chemotherapy treatment and safeguard patient wellbeing.

**Author statements.**
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Authorship: All authors have made substantial contributions to all of the following: (1) the conception and design of the study, or acquisition of data, or analysis and interpretation of data, (2) drafting the article or revising it critically for important intellectual content, (3) final approval of the version to be submitted.
References.


26. Tam CC, Larose T, O’Brien SJ. Costed extension to the Second Study of Infectious Intestinal Disease in the Community: Identifying the proportion of foodborne disease in the UK and attributing foodborne disease by food commodity. FSA Project B18021 (FS231043). 2014; Available from:


Tables.

Table 1 Inclusion of information on occasions requiring the implementation of hand hygiene practices in reviewed resources (n=45)

<table>
<thead>
<tr>
<th>Occasions requiring hand hygiene practices</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Before food preparation</td>
<td>49</td>
</tr>
<tr>
<td>After handling raw meat/poultry</td>
<td>27</td>
</tr>
<tr>
<td>After using toilet</td>
<td>27</td>
</tr>
<tr>
<td>After touching pets</td>
<td>20</td>
</tr>
<tr>
<td>Before eating</td>
<td>18</td>
</tr>
<tr>
<td>After sneezing</td>
<td>7</td>
</tr>
<tr>
<td>After handling dirty laundry</td>
<td>4</td>
</tr>
<tr>
<td>After handling rubbish</td>
<td>2</td>
</tr>
</tbody>
</table>
Table 2 Inclusion of recommendations to optimize cooking adequacy in reviewed resources (n = 45)

<table>
<thead>
<tr>
<th>Recommended practices</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cook all food thoroughly until piping hot</td>
<td>33%</td>
</tr>
<tr>
<td>Don't reheat food</td>
<td>20%</td>
</tr>
<tr>
<td>Cook until meat juices run clear</td>
<td>16%</td>
</tr>
<tr>
<td>Preheat oven</td>
<td>11%</td>
</tr>
<tr>
<td>Follow cooking instructions</td>
<td>11%</td>
</tr>
<tr>
<td>Cook eggs until firm</td>
<td>11%</td>
</tr>
<tr>
<td>Ensure core temperature $\geq$ 75°C</td>
<td>9%</td>
</tr>
</tbody>
</table>
Table 3 Inclusion of recommendations to reduce the risk of cross-contamination in the domestic kitchen in reviewed resources (n = 45)

<table>
<thead>
<tr>
<th>Practices required to reduce the risk of cross-contamination</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Store RTE food above raw meat/poultry in refrigerator</td>
<td>29</td>
</tr>
<tr>
<td>Use separate or adequately clean chopping boards and knives between use for raw meat/poultry and ready to eat food</td>
<td>27</td>
</tr>
<tr>
<td>Cover raw food in fridge</td>
<td>13</td>
</tr>
<tr>
<td>Avoid contact between raw and RTE food</td>
<td>13</td>
</tr>
<tr>
<td>Replace cloths or clean regularly</td>
<td>13</td>
</tr>
<tr>
<td>Disinfect worktops after raw meat/poultry</td>
<td>11</td>
</tr>
</tbody>
</table>
Table 4 Inclusion of listeriosis risk reducing practices in reviewed resources (n =45)

<table>
<thead>
<tr>
<th>Practices required to reduce the risk of listeriosis</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Check refrigerator operating temperature is 0 – 5°C</td>
<td>22%</td>
</tr>
<tr>
<td>Follow ‘use-by’ dates on food products</td>
<td>33%</td>
</tr>
<tr>
<td>Consume RTE foods within two days of opening</td>
<td>7%</td>
</tr>
</tbody>
</table>