LACORS/Health Protection Agency Co-ordinated Food Liaison Group Studies:

Microbiological Examination of Sandwiches from Hospitals and Residential/Care Homes with a focus on *Listeria monocytogenes* and other *Listeria* spp.

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On behalf of the Local Authorities Co-ordinators of Regulatory Services and the Health Protection Agency

Summary

In the UK there have been four recent outbreaks of *Listeria monocytogenes* associated with sandwiches purchased from or provided in hospitals. However, there is a scarcity of information on the prevalence of *L. monocytogenes* in sandwiches purchased or provided within hospitals and residential/care homes. Elderly people, or those that have impaired immunity due to disease or treatment, are particularly vulnerable to infection, and hence the focus of this study on sandwiches served in hospitals and residential/care homes. Of 3249 sandwich samples collected between April 2005 and March 2006, 3.3% were of unsatisfactory microbiological quality due to high levels of Enterobacteriaceae (2.0%, $\geq 10^4$ cfu/g for sandwiches not containing salad), *E. coli* (0.8%, $\geq 10^2$ cfu/g), *S. aureus* (0.6%, $\geq 10^2$ cfu/g), and/or *Listeria* spp. (0.1%, *L. welshimeri*: 1.8×10^2, 7.4×10^3 cfu/g; *L. seeligeri*:1.8×10^3 cfu/g). Overall contamination of *Listeria* spp. in sandwiches was 7.6%. *L. monocytogenes* was detected in 2.7% (88) of samples, 87 at <10 cfu/g and one at 20 cfu/g. Sandwiches were contaminated with *Listeria* spp. and *L. monocytogenes* more frequently when: from premises without a hazard analysis system in place; collected from cafeterias, shops or wards within hospitals; stored or displayed above 8°C. The presence of *Listeria* spp. and *L. monocytogenes* were also associated with sandwiches that were: supplied; prepacked; with a main sandwich filling of poultrymeat; or where the sandwich contained salad ingredients, soft cheese, and/or mayonnaise. This study demonstrates that control of *L. monocytogenes* in sandwich manufacturing and storage and handling in hospitals and residential/care homes is critical in order to diminish the potential for this bacterium to be present and multiply in sandwiches at levels hazardous to health. The findings from this study support the view that manufacturers supplying sandwiches to healthcare establishments should operate to the British Sandwich Association recommended target level of an absence of *L. monocytogenes* in sandwiches at the point of production.

Introduction

Listeria monocytogenes is a foodborne pathogen that causes severe disease, particularly in pregnant women, the unborn, newborns, the elderly, and the immunocompromised[1,2]. Although listeriosis is rare in the UK, four outbreaks of *L. monocytogenes* have occurred in England and Wales associated with the consumption of sandwiches acquired in hospitals between 1999 to 2004[3-5]. Sandwiches have also been linked to *Salmonella* spp.[6-8] and *Escherichia coli* O157[9] outbreaks of infection in the UK. Concern has, therefore, arisen over the safe production and adequate safe storage of sandwiches within hospitals, residential or care homes for the elderly population or where many of those on the premises purchasing or consuming sandwiches will have reduced immunity. For this reason, in 2007 the Health Protection Agency and Food Standards Agency alerted consumers about certain sandwiches contaminated with *L. monocytogenes* that were supplied to healthcare establishments in London and the South East of England that were subject to a recall[10]. A single case of *Listeria* infection was identified as a probable link with this incident[11].

Food hygiene in hospitals and residential/care homes is especially important since they contain populations who have less resistance to infection from contaminated food. Good hygiene and food safety practices, and trained staff are vital in the preparation, storage, distribution and service of food within healthcare establishments, and also for businesses supplying food to such establishments. The EC Regulation on the hygiene of foodstuffs (Regulation (EC) No. 852/2004)[12] provides a risk-based approach to controlling food hygiene and requires businesses to implement HACCP procedures (including documentation) to manage food safety, and for food handlers to be trained or instructed in good hygiene practices. Healthcare establishments must develop robust monitoring systems that cover all aspects of food service. The key food safety aspects include for example: obtaining food products from assured sources; provision of an adequate refrigerated food chain and checking and documenting food temperatures at key stages such as delivery, storage, transport to the kitchen or ward, storage within kitchens and wards; good standards of cleanliness of equipment; and personal hygiene of staff[13]. Thus the Department of Health through the implementation of Standards for Better Health requires food arrangements to be appropriately managed and controlled (Standard C15a), and this forms part of the performance assessment by the Healthcare Commission of all health care establishments[14]. However, food hygiene enforcement of food business operators and healthcare establishments is the responsibility of local authorities.

A sandwich is defined as any form of bread with a filling, generally assembled cold, and includes traditional wedge sandwiches, as well as filled rolls, baguettes, pitta, bloomers,

wraps, bagels etc.[15], and is complex as various ingredients are used. The NHS has a national framework agreement for the supply of sandwiches, sandwich fillings and related products which also covers the public sector and the Women's Royal Voluntary Service (WRVS)[16]. This is worth approximately £13m a year and equates to around 16 million sandwiches. Suppliers are only awarded a framework agreement if they have achieved an approved audit status against the NHS Code of Practice for Food Safety[17]. The Support, Training & Services plc (STS) is contracted by the NHS Purchasing & Supplies Agency to undertake food supplier assessment on behalf of NHS Trusts and hospitals utilising these national or framework contracts. However, at the local level, NHS Trusts may source food from suppliers through the framework contracts or negotiate their own contracts with suppliers. WRVS cafes and shops in hospitals generally serve the needs of the visitors to patients, but may also serve ambulatory patients. Therefore cafes and shops in hospitals supply consumers who could include vulnerable hospital patients or outpatients.

L. monocytogenes is widely distributed in the environment and is therefore present in a variety of raw food materials. *L. monocytogenes* is resistant to diverse environmental conditions and able to grow at refrigeration temperatures. Its ability to colonise food processing environments is also well recognized[18]. The EC Scientific Committee on Veterinary Measures relating to Public Health (SCVPH) recommended in 2000 that it should be an objective to keep the concentration of *L. monocytogenes* in food at the time of consumption below 100 cfu/g in order to ensure the safety of ready-to-eat foods[19]. However, this Committee emphasized that although levels below 100 cfu/g are usually not considered significant for human disease, vulnerable population groups may be more susceptible. Consequently, in 2006, the EC Regulation on microbiological criteria for foodstuffs[20] provides that *L. monocytogenes* should be below 100 cfu/g during the shelf-life of ready-to-eat foods, and that processing areas and equipment used in the manufacture of ready-to-eat foods must also be monitored for *L. monocytogenes*. Sandwiches have a high potential for contamination from *L. monocytogenes* due to extensive handling during preparation of the filling and sandwich assembly, or from cross-contamination from the environment. As sandwiches are ready-to-eat foods, this places the emphasis on high quality ingredients, hygienic manufacture, appropriate shelf-life, and correct storage for maintaining product safety. The British Sandwich Association Code of Practice for sandwich manufacturers recommends a target level of absence of the bacterium in sandwiches at the point of production[21].

Previous studies have shown that sandwiches frequently have high levels of microorganisms and, less frequently, potential pathogens[22-25]. However, there is a scarcity of published

information on the prevalence, levels and types of *L. monocytogenes* in sandwiches purchased or provided within hospitals and residential/care homes. Elderly people, or those that have impaired immunity due to disease or treatment, are particularly vulnerable to infection hence the focus of this study on sandwiches served in hospitals and residential/care homes.

Materials and Methods

Sample Collection

A total of 3,249 sandwiches collected from hospitals and residential/care homes were examined by 31 Official Food Control Laboratories in the UK between 1 April 2005 and 31 March 2006. Samples (≥100g) were collected and transported to laboratories by staff from 304 local Environmental Health Departments, involving 49 Local Authority Food Liaison Groups, in accordance with the Food Standards Agency Food Law Code of Practice[26] and the Local Authorities Co-ordinators of Regulatory Services (LACORS) guidance on microbiological food sampling[27]. Information on samples and premises was obtained by observation and enquiry and recorded on a standard proforma. This included information on the premises and practices with regard to type of sandwiches, place of manufacture, packaging, temperature and length of storage or display.

Sample Examination

Total *Listeria* spp. (including *L. monocytogenes*)*, Staphylococcus aureus, Escherichia coli*, and Enterobacteriaceae (sandwiches without salad ingredients) were enumerated or their presence sought in accordance with HPA Standard Microbiological Methods[28-31]. All isolates of *L. monocytogenes,* and other species of *Listeria* at high levels (≥100 cfu/g) were sent to the Food Safety Microbiology Laboratory (FSML), HPA Centre for Infections, for further characterisation. For *L. monocytogenes* this included sero-typing and Amplified Fragment Length Polymorphism (AFLP) as described previously[32,33]. Microbiological results were compared to the EC Regulation on microbiological criteria for foodstuffs[20] and Guidelines for the microbiological quality of some ready-to-eat foods sampled at the point of sale (Table 1)[34].

Statistical Analysis

Descriptive and statistical analysis of the data was undertaken using Microsoft Excel and Epi Info version 6.04d. Relative proportions were compared using the Chi squared test (χ^2) and Fisher's exact test. A probability value of less than 5% was defined as significant.

Table 1. Microbiological criteria / guidelines for *Listeria monocytogenes* and other *Listeria* spp. in ready-to-eat foods: Key to classification[20,34]

Criterion	Guidelines: Microbiological quality (cfu per gram)[34]				Regulation (EC) No. 2073/2005[20]
	Satisfactory	Acceptable	Unsatisfactory	Unacceptable	Food Safety Criteria (cfu/g)
Enterobacteriaceae[a]	<100	100 - $<10^4$	$\geq 10^4$	N/A	N/A[b]
Escherichia coli	<20	20 - <100	≥100	N/A	N/A
Staphylococcus aureus	<20	20 - <100	100 - $<10^4$	$\geq 10^4$	N/A
Listeria spp. (Total)	<20	20 - <100	≥100	N/A	N/A
Listeria monocytogenes	N/A	N/A	N/A	N/A	≥100[c]

a, Not applicable to sandwiches containing salad ingredients
b, N/A, Not applicable
c, a *L. monocytogenes* count of 100 cfu/g or more exceeds food safety criteria for ready-to-eat foods placed on the market during their shelf-life and is thus deemed to be legally unsatisfactory (Regulation (EC) No. 2073/2005).

Results

Microbiological quality of sandwiches

Overall 86.1% of sandwiches were satisfactory, 10.6% were acceptable, and 3.3% were of unsatisfactory microbiological quality. Unsatisfactory results were due to high Enterobacteriaceae (2.0%, 66 samples $\geq 10^4$ cfu/g for sandwiches not containing salad); *E. coli* (0.8% (25), $\geq 10^2$ cfu/g); *S. aureus* (0.6% (20), $\geq 10^2$ cfu/g); and/or *Listeria* spp. (0.1% (3), *L. welshimeri*: 180, 7.4 x 10^3 cfu/g; *L. seeligeri*:1.8 x 10^3 cfu/g) (Table 2). The overall contamination rate of *Listeria* spp. in sandwiches from hospital and residential / care homes was 7.6%. *L. monocytogenes* was detected in 2.7% (88) of samples, 87 at <10 cfu/g and one at 20 cfu/g (Table 2).

Sixty of the 88 *L. monocytogenes* isolates were referred for typing and 32 (53.3%) were serogroup 1/2a, 18 (30.0%) 4b, 8 (13.3%) 1/2c and 2 (3.3%) 1/2b. Seventeen different *L. monocytogenes* subtypes were obtained with the 1/2a/IX, 1/2a/VII, 4b/I, 4b/XVIII, and 1/2c/VII subtypes recovered from 71.7% of these (Table 3).

Table 2. Microbiological results of 3249 sandwiches by main filling

Main sandwich filling	ND* in 25g	D† in 25g	<10/ <20§	10/20 -<10^2	10^2 - <10^3	10^3 - <10^4	10^4 - <10^5	10^5 - <10^6	10^6 - <10^7	NE‡
Meat (n=1141)										
Enterobacteriaceae			561	135	83	37	19	9		297
E. coli			1115	19	6	1				
Staph. aureus			1110	22	8	1				
Listeria spp. (total)	1052	84[a]		2	1	2				
- *L. monocytogenes*		33[a]		2						
Poultry (n=376)										
Enterobacteriaceae			126	45	21	21	12	5	1	145
E. coli			368	4	3		1			
Staph. aureus			373	2	1					
Listeria spp. (total)	330	45[a]		1						
- *L. monocytogenes*		22[a]								
Cheese (n=708)										
Enterobacteriaceae			349	60	27	14	4	1		253
E. coli			695	10	3					
Staph. aureus			696	9	2	1				
Listeria spp. (total)	667	41[a]								
- *L. monocytogenes*		11[a]								
Egg (n=394)										
Enterobacteriaceae			182	44	21	14	3	4	1	125
E. coli			386	4	2	2				
Staph. aureus			387	3	2	2				
Listeria spp. (total)	356	37[a]		1						
- *L. monocytogenes*		10[a]								
Fish/seafood (n=509)										
Enterobacteriaceae			249	57	23	17	4	2		154
E. coli			495	10	3	1				
Staph. aureus			501	6	2					
Listeria spp. (total)	487	21[a]		1						
- *L. monocytogenes*		8[a]								
Salad only (n=35)										
E. coli			34	1						
Staph. aureus			35							
Listeria spp. (total)	32	3[a]								
- *L. monocytogenes*		1[a]								
Others (Banana, jam, sandwich spreads, n=86)										
Enterobacteriaceae			44	7	10	5		1		19
E. coli			80	3	1	2				
Staph. aureus			84	1		1				
Listeria spp. (total)	77	9[a]								
- *L. monocytogenes*		1[a]								

*ND, Not detected; †D, Detected; ‡NE, Not examined as samples contained salad ingredients
§, cfu/g
a, Detected in 25g and present at <20 cfu/g

Table 3. Subtypes of *L. monocytogenes* isolated from sandwiches by main filling type

Typing character (Serotype/AFLP*)	No. Samples n=60 (%)	Main sandwich filling
1/2a / II	3 (5.0%)	Corned beef (1), turkey (1), turkey & salad (1)
1/2a / III	1 (1.7%	Beef (1)
1/2a / VI	1 (1.7%)	Egg (1)
1/2a / VII	8 (13.3%)	Bacon (1), beef (1), cheese (1), chicken (1), egg (2), prawns (1), turkey (1)
1/2a / IX	16 (26.7%)	Cheese (1), chicken (2), chicken & salad (3), corned beef (1), egg (1), egg & salad (1), ham & salad (3), pork (1), smoked salmon (1), tuna & salad (1), turkey (1)
1/2a / XI	1 (1.7%)	Chicken & salad (1)
1/2a / XIV	1 (1.7%)	Cheese & salad (1)
1/2a / XV	1 (1.7%)	Ham (1)
1/2b / II	1 (1.7%)	Beef (1)
1/2b / IV	1 (1.7%)	Beef (1)
1/2c / VII	6 (10.0%)	Cheese & salad (1), chicken (1), egg (1), egg & salad (1), ham (1), tuna (1),
1/2c / IX	2 (3.3%)	Cheese (1), egg (1)
4b / I	7 (11.7%)	Beef (1), ham (3), ham & salad (1), ham & cheese salad (1), tuna (1)
4b / II	1 (1.7%)	Ham (1)
4b / IV	2 (3.3%)	Chicken & salad (1), ham & salad (1)
4b / VII	2 (3.3%)	Egg & salad (2)
4b / XVIII	6 (10.0%)	Cheese & salad (1), chicken (1), pork (1), tuna & salad (1), turkey (1), turkey & salad (1)

*, Amplified fragment length polymorphism

Microbiological quality of sandwiches in relation to bread type and fillings

Of the sandwich types collected most consisted of traditional sandwiches (93.3%), followed by rolls (2.7%), baguettes (1.4%), and baps (1.2%) (Table 4). The proportion of bap and other sandwich types (bagel, naan, pitta, wrap, etc.) of unsatisfactory microbiological quality was higher, 12.5% and 10.5% respectively, when compared to other types (2.2% - 3.4%) (Table 4). This finding was significant when comparing bap with traditional sandwich samples (p=0.0092). *Listeria* spp. was detected in more samples of bap (17.5%), baguette (10.8%) and other types (26.3%) compared with traditional sandwiches (7.5%) and rolls (4.5%) (p=0.0047). Similarly more samples of bap (7.5%) and other types (15.8%) had *L. monocytogenes* present compared with traditional sandwiches (7.5%), rolls (4.5%) and baguette (4.3%) (p=0.0071) (Table 4).

Seventy five percent of samples collected contained spreadable fat (Table 4). There was no significant difference in the microbiological quality of sandwiches in relation to the spread used (Table 4) (p=0.4885). However significantly more sandwiches with mayonnaise used as a spread had *Listeria* spp. (17.5%) and *L. monocytogenes* (6.7%) present compared with those that had used butter (8.1% *Listeria* spp., 3.5% *L. monocytogenes*) or spreadable fat (6.6% *Listeria* spp., 2.1% *L. monocytogenes*) (p<0.0001, p=0.0036, respectively).

Sixty percent of sandwiches collected had a single filling ingredient (Table 4). There was no significant difference in the microbiological quality of sandwiches in relation to single or mixed filling ingredients used (Table 4) (p=0.2333). Significantly, more sandwiches with mixed filling ingredients contained *Listeria* spp. (10.3%) and *L. monocytogenes* (4.2%) present compared with those that a single filling ingredient (5.9% *Listeria* spp., 1.7% *L. monocytogenes*) (p<0.0001).

Over a third (35.1%) of sandwiches contained meat as the main sandwich filling, 21.8% had cheese, 15.7% fish/seafood, 12.1% egg, 11.6% poultrymeat, and 3.7% contained either salad or other fillings (Table 4, Fig. 1). The proportion of poultrymeat sandwiches of unsatisfactory quality was higher (5.6%) when compared to other filling types (1.6 – 4.7%) (Table 4). This finding was only significant when comparing poultrymeat sandwiches with cheese (p=0.0004) and fish/seafood sandwiches (p=0.0183). Both *Listeria* spp. and *L. monocytogenes* was detected in more poultrymeat sandwiches (12.2% and 5.9%, respectively) compared to other filling types (4.7–9.7% *Listeria* spp.; 1.1–3.2% *L. monocytogenes*) (Table 4). This finding was significant when comparing poultrymeat sandwiches with cheese, fish/seafood, and meat sandwich samples for presence of *Listeria* spp. (p=0.0002) and for *L. monocytogenes*, poultrymeat sandwiches with cheese, fish/seafood, egg, and meat sandwich samples (p=0.0005).

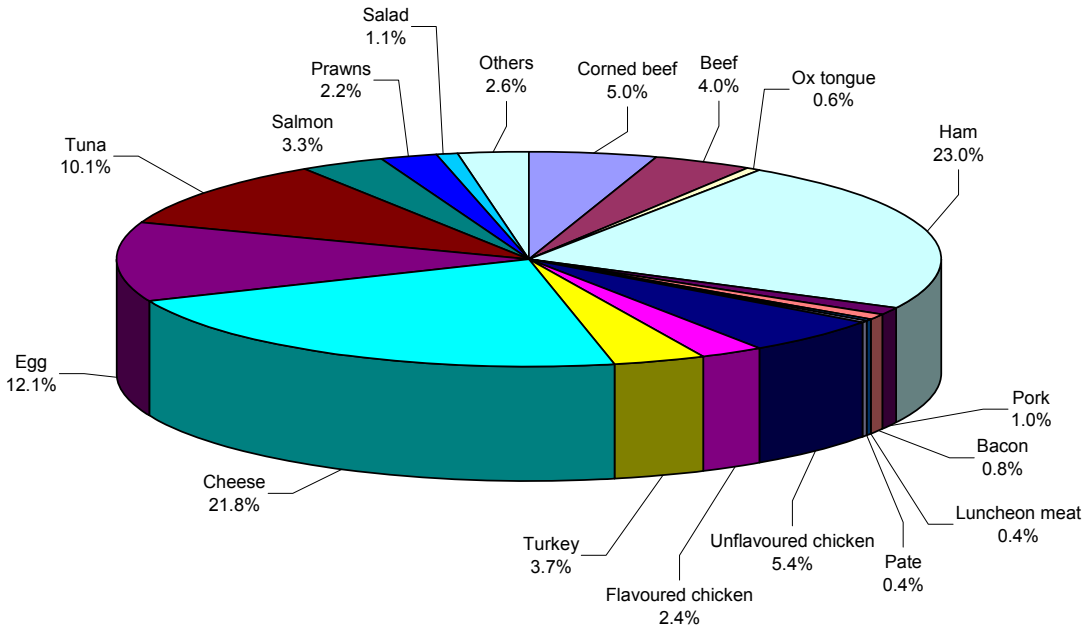
Two-thirds (65.5%) of the sandwiches containing meat filling examined were ham, followed by corned beef (14.3%), beef (11.3%), pork (2.8%), bacon (2.3%), ox tongue (1.6%), luncheon meat (1.1%) and pate (1.1%) (Table 4). The proportion of sandwiches with pork or beef fillings that were of unsatisfactory microbiological quality was higher (9.4% and 6.2%, respectively) when compared to other meat fillings (0-3.8%), however this finding was not statistically significant (p>0.05). Similarly, a greater proportion of sandwiches containing pork or beef contained *Listeria* spp. (15.6% and 16.3%, respectively) and *L. monocytogenes* (9.4% and 5.4%) compared with other meat fillings (Table 4). This finding was significant when comparing beef sandwiches with corned beef or ham sandwich samples for presence of *Listeria* spp. (p=0.0006) and for *L. monocytogenes*, pork sandwiches with ham sandwich samples (p=0.0140).

Of the sandwiches containing poultrymeat 67.8% were chicken. Amongst those containing fish/seafood, 64.6% were tuna (Table 4). There was no significant difference in the microbiological quality of sandwiches, nor to the presence of *Listeria* spp. and *L. monocytogenes*, in relation to the different types of poultrymeat of fish/seafood used as fillings (Table 4) (p>0.05).

Table 4. Microbiological quality of different sandwich types and ingredients

Sandwich details	Total No. Samples n=3249 (%)		No. Samples Unsatisfactory (%)		Samples with all *Listeria* spp. n= 248 (%)		Samples with *L. monocytogenes* n=88 (%)	
Bread Type								
Traditional sandwich	3032	(93.3)	96	(3.2)	226	(7.5)	78	(2.6)
Roll	89	(2.7)	3	(3.4)	4	(4.5)	1	(1.1)
Bap	40	(1.2)	5	(12.5)	7	(17.5)	3	(7.5)
Baguette	46	(1.4)	1	(2.2)	5	(10.8)	2	(4.3)
Other (Bagel, baton, ciabatta, naan, pitta, wrap)	19	(0.6)	2	(10.5)	5	(26.3)	3	(15.8)
Not recorded	23	(0.8)	2	(8.7)	1	(4.4)	1	(4.4)
Spread used								
Butter	491	(15.1)	17	(3.5)	40	(8.1)	17	(3.5)
Spreadable fat	2467	(75.9)	76	(3.1)	163	(6.6)	51	(2.1)
Mayonnaise	149	(4.6)	7	(4.7)	26	(17.5)	10	(6.7)
Not recorded	142	(4.4)	9	(6.3)	19	(13.4)	10	(7.0)
Filling ingredient(s)								
Single	1963	(60.4)	72	(3.7)	115	(5.9)	34	(1.7)
Mixed	1286	(39.6)	37	(2.9)	133	(10.3)	54	(4.2)
Main filling								
Meats	1141	(35.1)	45	(3.9)	89	(8.0)	35	(3.2)
Bacon	*26*	*(2.3)*	*1*	*(3.8)*	*2*	*(7.7)*	*1*	*(3.8)*
Beef	*129*	*(11.3)*	*8*	*(6.2)*	*21*	*(16.3)*	*7*	*(5.4)*
Corned beef	*163*	*(14.3)*	*5*	*(3.1)*	*4*	*(2.5)*	*3*	*(1.8)*
Ham	*747*	*(65.5)*	*28*	*(3.8)*	*56*	*(7.5)*	*21*	*(2.8)*
Luncheon meat	*13*	*(1.1)*	*0*		*1*	*(7.7)*	*0*	
Ox tongue	*18*	*(1.6)*	*0*		*0*		*0*	
Pate	*13*	*(1.1)*	*0*		*0*		*0*	
Pork	*32*	*(2.8)*	*3*	*(9.4)*	*5*	*(15.6)*	*3*	*(9.4)*
Poultry	376	(11.6)	21	(5.6)	46	(12.2)	22	(5.9)
Chicken	*255*	*(67.8)*	*12*	*(4.7)*	*32*	*(12.6)*	*14*	*(5.5)*
Turkey	*121*	*(32.2)*	*9*	*(7.4)*	*14*	*(11.6)*	*8*	*(6.6)*
Fish/seafood	509	(15.7)	12	(2.4)	22	(4.3)	8	(1.6)
Prawns	*62*	*(12.2)*	*1*	*(1.6)*	*4*	*(6.5)*	*3*	*(4.8)*
Salmon	*105*	*(20.6)*	*3*	*(2.9)*	*1*	*(1.0)*	*1*	*(1.0)*
Tuna	*329*	*(64.6)*	*8*	*(2.4)*	*16*	*(4.9)*	*4*	*(1.2)*
Other (crayfish, sardines, pilchards)	*13*	*(2.6)*	*0*		*1*	*(7.7)*	*0*	
Cheese	708	(21.8)	11	(1.6)	41	(5.8)	11	(1.6)
Egg	394	(12.1)	16	(4.1)	38	(9.7)	10	(2.5)
Salad only	35	(1.1)	0		3	(8.6)	1	(2.9)
Others	86	(2.6)	4	(4.7)	9	(10.5)	1	(1.1)
- Banana, jam	*14*	*(16.3)*	*1*	*(7.1)*	*1*	*(7.1)*	*0*	
- Sandwich spreads	*72*	*(83.7)*	*3*	*(4.2)*	*8*	*(11.1)*	*1*	*(1.4)*
Filling contained salad								
Yes	1087	(33.5)	26	(2.4)	108	(9.9)	42	(3.9)
No	2162	(66.5)	83	(3.8)	140	(6.5)	46	(2.1)
Filling contained cheese								
Soft cheese	89	(2.7)	2	(2.2)	12	(13.5)	6	(6.7)
Other cheese	722	(22.2)	13	(1.8)	42	(5.8)	10	(1.4)
No cheese	2438	(75.1)	94	(3.9)	194	(7.9)	72	(2.9)

Fig. 1 Main sandwich filling ingredient in sandwiches (n=3249)



Two-thirds (66.5%) of sandwiches collected did not contain salad ingredients (Table 4). The proportion of samples of unsatisfactory microbiological quality that contained salad was lower (2.4%) than those that did not (3.8%) (p=0.0303). However, significantly more sandwiches with salad ingredients contained *Listeria* spp. (9.9%) and *L. monocytogenes* (3.9%) compared with those without salad ingredients (6.5%, *Listeria* spp. (p=0.0006); 2.1% *L. monocytogenes* (p=0.0057)) (Table 4).

Three-quarters of sandwiches collected did not contain cheese as a filling ingredient (Table 4). The proportion of samples of unsatisfactory microbiological quality that did not contain cheese was higher (3.9%) when compared to those that did (1.9%) (p=0.0067) (Table 4). However, more sandwiches containing soft cheese contained *Listeria* spp. (13.5%) and *L. monocytogenes* (6.7%) compared with those with other cheese types (5.8%, *Listeria* spp. (p=0.0116); 1.4% *L. monocytogenes* (p=0.0048) or those without (7.9%, *Listeria* spp. (p>0.05); 2.1% *L. monocytogenes* (p=0.0183)) (Table 4).

Microbiological quality of sandwiches in relation to place of preparation and packaging

Seventy eight percent of sandwiches collected were made at hospitals and residential / care homes (Table 5). There was no difference in the proportion of sandwiches of unsatisfactory microbiological quality that were supplied to (3.9%) or made on the premises (3.3%)

(p=0.5339). However, a higher proportion of samples that were supplied contained *Listeria* spp. and *L. monocytogenes* (16.2% and 7.5%, respectively) compared to those made on the premises (5.7% and 1.7%, respectively) (p<0.0001) (Table 5). Samples from hospitals were significantly more likely to have been supplied (43.9%; 591/1347) compared to residential (0.1%;1/1191) and care homes (1.0%; 7/711) (p<0.0001).

Thirty eight percent of sandwiches collected were pre-packed, 37.9% were open/unwrapped (37.9%), and 18.9% from covered serving platters (Table 5). There was no significant difference in the proportion of sandwiches of unsatisfactory microbiological quality and the various forms of packaging used (2.1% - 3.9%, p>0.05). However, a higher proportion of samples that were pre-packed contained *Listeria* spp. and *L. monocytogenes* (11.9% and 4.7%, respectively) compared to those that were covered (5.1% and 2.1%, respectively) or open/wrapped (5.4% and 1.3%, respectively) (p<0.0001) (Table 5).

Of the 1245 pre-packed sandwiches collected, the packaging type used was mainly of plastic mould containers with snap on lids (36.4%), plastic mould containers with heat sealed lids (33.0%), or cellophane bags (16.5%) (Table 5). There was no significant difference in the proportion of sandwiches of unsatisfactory microbiological quality and the various forms of packaging types used (3.1% - 9.1%, p>0.05). However, a higher proportion of samples that were pre-packed using plastic mould containers with heat sealed lids contained *Listeria* spp. and *L. monocytogenes* (16.3% and 5.6%, respectively) compared to those packed in other formats (*Listeria* spp. 9.1-11.7%, *L. monocytogenes* 3.9-5.1%) (Table 5). This finding was significant when comparing sandwiches packed in plastic mould containers with heat sealed lids with those packed in plastic mould containers with snap on lids for presence of *Listeria* spp. (p=0.0014).

Of the 613 sandwiches collected from covered serving platters, 87.9% were covered using plastic cling film and of these a higher proportion of sandwiches were of unsatisfactory microbiological quality (Table 5). However, a higher proportion of samples that were covered using foil contained *Listeria* spp. and *L. monocytogenes* (7.8% and 5.9%, respectively) compared to those covered using other materials (*Listeria* spp. 4.6-4.8%, *L. monocytogenes* 0-1.9%) (Table 5), although this finding was not statistically significant.

Table 5. Microbiological quality of sandwiches in relation to place of preparation and packaging

Sandwich details	Total No. Samples n=3249 (%)		No. Samples Unsatisfactory (%)		Samples with all *Listeria* spp. n= 248 (%)		Samples with *L. monocytogenes* n=88 (%)	
Sandwich made:								
On premises	2544	(78.3)	85	(3.3)	145	(5.7)	42	(1.7)
Supplied	599	(18.4)	23	(3.9)	97	(16.2)	45	(7.5)
Not recorded	106	(3.3)	1	(0.9)	6	(5.7)	1	(0.9)
Packaging format:								
Pre-packed & intact	1200	(36.9)	44	(3.7)	144	(12.0)	56	(4.7)
Pre-packed & not intact	45	(1.4)	2	(4.4)	4	(8.9)	3	(6.7)
Covered & on serving platter	613	(18.9)	13	(2.1)	31	(5.1)	13	(2.1)
Open/unwrapped	1231	(37.9)	48	(3.9)	66	(5.4)	16	(1.3)
Not recorded	160	(4.9)	2	(1.3)	3	(1.9)	0	
Packaging of prepacked sandwiches (n=1245):								
Plastic mould & heat sealed	411	(33.0)	14	(3.4)	67	(16.3)	23	(5.6)
Plastic mould & snap on lid	453	(36.4)	14	(3.1)	41	(9.1)	23	(5.1)
Cellophane bag	205	(16.5)	11	(5.4)	24	(11.7)	8	(3.9)
Other (Cardboard & cellophane)	11	(0.9)	1	(9.1)	1	(9.1)	0	
Not recorded	165	(13.2)	6	(3.6)	15	(9.1)	5	(3.0)
Covering of sandwiches placed on serving platters, etc (n=613):								
Cling film wrap	539	(87.9)	13	(2.4)	26	(4.8)	10	(1.9)
Foil	51	(8.3)	0		4	(7.8)	3	(5.9)
Cellophane wrap	22	(3.6)	0		1	(4.6)	0	
Greaseproof paper	1	(0.2)	0		0		0	

Microbiological quality of sandwiches in relation to storage and display

Most sandwiches were collected from the kitchen (74.7%) or hospital cafeteria (11.6%) (Table 6). There was no significant difference in the proportion of sandwiches of unsatisfactory microbiological quality and areas within hospitals and residential / care homes where sandwiches were taken (2.1-4.8%, $p>0.05$). A higher proportion of samples that were collected from hospital cafeterias, shops and wards contained *Listeria* spp. and *L. monocytogenes* (*Listeria* spp. 13-15.9%, *L. monocytogenes* 6.1-8.7%) compared to those collected from other areas within the premises (*Listeria* spp. 5.8-10.3%, *L. monocytogenes* 1.8-4.6%) (Table 6). This finding was significant when comparing sandwiches collected from hospital cafeterias, shops and wards with those from kitchens for presence of *Listeria* spp. and *L. monocytogenes* ($p<0.0001$).

The British Sandwich Association recommends that sandwiches should be delivered and stored or retailed at 5°C and never higher than 8°C[21]. Seventy seven percent of sandwiches were stored or displayed at ≤8°C (Table 6), of which 63.3% were at or below 5°C. A slighter higher proportion of sandwiches of unsatisfactory microbiological quality, or containing

Listeria spp. and *L. monocytogenes* were from those stored >8°C, however this was not statistically significant (p>0.05) (Table 6).

Sixty six percent of sandwiches had been on display or storage for four hours or less (Table 6). A slighter higher proportion of sandwiches of unsatisfactory microbiological quality, or containing *L. monocytogenes* were from those stored or displayed for over four hours, however this was not statistically significant (p>0.05) (Table 6).

Ninety-four percent of sandwiches were collected from visually clean preparation or display/storage areas. A higher proportion of sandwiches of unsatisfactory microbiological quality, or containing *Listeria* spp. were from those sampled from unclean areas. However, it should be noted that the proportion of samples from unclean areas was only four and no statistical conclusions should be drawn from these results.

Table 6. Microbiological quality of sandwiches in relation to storage and display

Sandwich details	Total No. Samples n=3249 (%)		No. Samples Unsatisfactory (%)		Samples with all *Listeria* spp. n= 248 (%)		Samples with *L. monocytogenes* n=88 (%)	
Sandwich collected from:								
Kitchen	2427	(74.7)	81	(3.3)	141	(5.8)	44	(1.8)
Staff canteen	108	(3.4)	4	(3.7)	10	(9.3)	5	(4.6)
Hospital cafeteria	377	(11.6)	18	(4.8)	55	(14.6)	23	(6.1)
Ward	23	(0.7)	0		3	(13.0)	2	(8.7)
Hospital shop	189	(5.8)	4	(2.1)	30	(15.9)	13	(6.9)
Hospital vending machine	33	(1.0)	1	(3.0)	2	(6.1)	0	
Hospital chilled storage room	29	(0.9)	1	(3.5)	3	(10.3)	1	(3.4)
Other (Dining room, restaurant, hospital trolley)	26	(0.8)	0		4	(7.2)	0	
Not recorded	37	(1.1)	0		0		0	
Sandwiches stored/kept:								
≤ 8°C	2509	(77.2)	89	(3.6)	194	(7.7)	66	(2.6)
> 8°C (range: 9–28°C)	419	(12.9)	17	(4.1)	36	(8.6)	17	(4.1)
Not recorded	321	(9.9)	3	(0.9)	18	(5.6)	5	(1.6)
Length of time in display/ storage area:								
≤ 4 hours	2128	(65.5)	68	(3.2)	150	(7.1)	50	(2.4)
> 4 hours	337	(10.4)	12	(3.6)	21	(6.2)	9	(2.7)
Not known	784	(24.1)	29	(3.7)	77	(9.8)	29	(3.7)
Preparation/display/storage area visually clean:								
Yes	3052	(94.0)	106	(3.5)	241	(7.9)	86	(2.8)
No	4	(0.1)	1	(25.0)	1	(25.0)	0	
Not recorded	193	(5.9)	2	(1.0)	6	(3.1)	2	(1.0)

Microbiological quality of sandwiches in relation to premises details

Forty-one percent of sandwiches were sampled from hospitals, 36.7% from residential homes, and 21.9% from care homes (Table 7). There was no difference in the proportion of sandwiches of unsatisfactory microbiological quality that were sampled from hospitals (3.5%), residential homes (3.3%) or care homes (3.4%) ($p>0.05$). However, a higher proportion of samples that were collected from hospitals contained *Listeria* spp. and *L. monocytogenes* (11.2% and 4.5%, respectively) compared to those from residential (4.4% and 0.9%, respectively) and care homes (6.3% and 2.4%, respectively) ($p<0.0001$) (Table 7).

Eighty two percent of samples were collected from premises categorised as Inspection Rating Category B (41.0%, inspected every 12 months) or C (40.7%, inspected at least every 18 months) (Table 7). There was no significant difference in the proportion of sandwiches of unsatisfactory microbiological quality and the inspection rating category of the premises (2.7-6.1%, $p>0.05$). Similarly there was no significant difference in the proportion of sandwiches containing *Listeria* spp. and inspection rating category of the premises (7.1-8.6%, $p>0.05$). A higher proportion of sandwiches containing *L. monocytogenes* were found from those that had an inspection category D (4.3%) compared with those collected from premises in other categories (1.2-2.9%), however this was not statistically significant ($p>0.05$) (Table 7).

Seventy six percent of samples were obtained from premises categorised in consumer at risk score 5 (62.8%, few at risk) or 10 (12.7%, intermediate numbers at risk) (Table 7). A greater proportion of samples collected from premises with a consumer at risk score of 15 (9.9%, substantial number of customers) were of unsatisfactory microbiological quality compared to those from premises with lower consumer at risk scores (3.4%, very few to intermediate numbers) ($p=0.0029$) (Table 7). A higher proportion of samples contained *Listeria* spp. and *L. monocytogenes* from premises with a consumer at risk score of 10 (14.7% and 5.6%, respectively) compared to those with scores of 0 - 5 (6.1% and 1.9%, respectively) ($p<0.0001$) (Table 7).

Seventy two percent of samples were collected from premises that had a confidence in management score 5 (43.0%, moderate confidence in management/control systems) and 10 (29.2%, some confidence in management/control systems) (Table 7). The proportion of unsatisfactory samples was higher from premises where there was little confidence (7.2%) compared to premises where there was some, moderate or high confidence in management (3.4%) although this finding was not significant ($p=0.0683$) (Table 7). A higher proportion of

Table 7. Comparison of microbiological quality of sandwich samples collected from hospitals, residential home and care home settings

Premises details	Total No. Samples n=3249 (%)		No. Samples Unsatisfactory (%)		Samples with all *Listeria* spp. n= 248 (%)		Samples with *L. monocytogenes* n=88 (%)	
Premises Type								
Hospital	1347	(41.4)	46	(3.5)	151	(11.2)	60	(4.5)
Residential home	1191	(36.7)	39	(3.3)	52	(4.4)	11	(0.9)
Care home	711	(21.9)	24	(3.4)	45	(6.3)	17	(2.4)
Inspection Rating Category								
Category Minimum Frequency of Inspection								
A At least every 6 months	164	(5.1)	10	(6.1)	14	(8.5)	2	(1.2)
B At least every 12 months	1333	(41.0)	52	(3.9)	94	(7.1)	37	(2.8)
C At least every 18 months	1322	(40.7)	36	(2.7)	97	(7.3)	29	(2.2)
D At least every 2 years	70	(2.2)	4	(5.7)	6	(8.6)	3	(4.3)
E Alternative enforcement strategy	35	(1.0)	1	(2.9)	3	(8.6)	1	(2.9)
Not recorded	325	(10.0)	6	(1.9)	34	(10.5)	16	(4.9)
Consumers at Risk Score								
0 (Very few)	165	(5.1)	3	(1.8)	6	(3.6)	2	(1.2)
5 (Few)	2039	(62.8)	68	(3.3)	128	(6.3)	41	(2.0)
10 (Intermediate)	414	(12.7)	17	(4.1)	61	(14.7)	23	(5.6)
15 (Substantial)	101	(3.1)	10	(9.9)	4	(4.0)	1	(1.0)
27*	5	(0.1)	0		0		0	
Not recorded	525	(16.2)	11	(2.1)	49	(9.3)	21	(4.0)
Confidence in Management Score								
0 (High)	281	(8.7)	5	(1.8)	20	(7.1)	3	(1.1)
5 (Moderate)	1397	(43.0)	56	(4.0)	107	(7.7)	37	(2.7)
10 (Some)	951	(29.2)	28	(2.9)	65	(6.8)	25	(2.6)
20 (Little)	83	(2.6)	6	(7.2)	7	(8.4)	1	(1.2)
30 (None)	24	(0.7)	0		3	(12.5)	0	
Not recorded	513	(15.8)	14	(2.7)	46	(9.0)	22	(4.3)
Hazard Analysis Systems								
Until 01/01/06 **(n=2575)**								
In place & documented	1946	(75.5)	80	(4.1)	144	(7.4)	48	(2.5)
In place & undocumented	195	(7.6)	8	(4.1)	12	(6.1)	3	(1.5)
In place; document status not rec	136	(5.3)	4	(2.9)	8	(5.9)	1	(0.7)
Not in place	108	(4.2)	6	(5.6)	10	(9.3)	4	(3.7)
Not recorded	190	(7.4)	3	(1.6)	29	(15.3)	11	(5.6)
From 01/01/06 EC No. 852/2004, Art. 5 **(n=674)**								
HACCP† in place	407	(60.4)	1	(0.2)	26	(6.3)	10	(2.5)
HACCP not in place	78	(11.6)	1	(1.3)	0		0	
Not recorded	189	(28.0)	6	(3.2)	19	(10.1)	11	(5.8)
Manager Food Hygiene Training								
Received training & attended	2984	(91.9)	101	(3.4)	227	(7.6)	78	(2.6)
- Basic 6 hour	1533	(51.4)	45	(2.9)	106	(6.9)	31	(2.0)
- Intermediate	748	(25.1)	29	(3.9)	53	(7.1)	21	(2.8)
- Advanced	496	(16.6)	21	(4.2)	51	(10.3)	21	(4.2)
- Other course	55	(1.8)	1	(1.8)	4	(7.3)	2	(3.6)
- Not recorded	152	(5.1)	5	(3.3)	13	(8.6)	3	(1.9)
No training	72	(2.2)	3	(4.2)	2	(2.8)	1	(1.4)
Not recorded	193	(5.9)	5	(2.6)	19	(9.9)	9	(4.7)

*, An additional score of 22 should be included for hospitals and care/residential homes serving high risk foods and where there are more than 20 persons in a vulnerable group at risk[25].
†, Hazard Analysis and Critical Control Points

samples from premises where there was little or no confidence contained *Listeria* spp. (9.3%) compared to premises where there was some, moderate or high confidence in management (7.3%) (Table 7), although this finding was not statistically significant (p=0.3468). There was no significant difference in the proportion of sandwiches containing *L. monocytogenes* and premises with different confidence in management scores (1.1-2.7%, p>0.05).

Of the samples collected before 1 January 2006, 88.4% of samples were from premises that had a hazard analysis system in place (75.5% documented, 7.6% undocumented; 5.3% documentation status not recorded) (Table 7). Samples collected from premises without a hazard analysis system in place were more likely to be of unsatisfactory microbiological quality (5.6%) compared to those collected from premises where hazard analysis was in place (4.0%) (Table 7) (p=0.3205). Samples collected from premises without a hazard analysis system in place were more likely to contain *Listeria* spp. and *L. monocytogenes* (9.3% and 3.7%, respectively) compared to those that had a hazard analysis system in place (7.2% and 2.2%, respectively) (Table 7), although this finding was not statistically significant (p=0.1789).

Of the samples collected after 1 January 2006, 60.4% complied with HACCP requirements as provided in Article 5 of Regulation (EC) No. 852/2004[12] (Table 7). Samples collected from premises that did not comply with this requirement were more likely to be of unsatisfactory microbiological quality (1.3%) compared to those collected from premises that did (0.2%) (Table 7) (p>0.05). No *Listeria* spp. was detected in samples from premises which did not comply with Article 5. However *Listeria* spp. and *L. monocytogenes* were detected in samples (6.3% and 2.5%, respectively) from premises that did comply with Article 5 (Table 7).

Ninety-two percent of samples were collected from premises whose managers had received food hygiene training (Table 7). Samples collected from premises with managers that had not received food hygiene training were more likely to be of unsatisfactory microbiological quality (4.2%) compared to those with managers who had received training in food hygiene (3.4%) (Table 7) (p>0.05). Conversely, samples collected from premises with managers that had received food hygiene training were more likely to contain *Listeria* spp. and *L. monocytogenes* (7.6% and 2.6%, respectively) compared to those with managers without training in food hygiene (2.8% and 1.4%, respectively) (Table 7), although this finding was not statistically significant (p>0.05).

Discussion

This study has shown that the majority of sandwiches (96.5%) collected from hospitals and residential or care homes in the UK were of satisfactory or acceptable microbiological quality. 3.3% of sandwich samples were of unsatisfactory microbiological quality due to high levels of Enterobacteriaceae (≥10^4 cfu/g for sandwiches not containing salad), *E. coli* (≥10^2 cfu/g), *S. aureus* (≥10^2 cfu/g), and/or *Listeria* spp. (≥10^2 cfu/g; *L. welshimeri*, *L. seeligeri*). The incidence of *S. aureus* at unsatisfactory levels (0.6%) in this study was similar to that of an Irish retail sandwich study in 2002 (0.6%)[23] but lower than that previously reported in a 2001 UK retail study (2.2%)[22]. Similarly, the incidence of *E. coli,* an indicator of faecal contamination, at unsatisfactory levels (0.8%) was lower than that reported in the 2001 UK retail study (3.3%)[22]. High Enterobacteriaceae, *E. coli*, *S. aureus* and *Listeria* levels may indicate that contamination occurred during production and/or preparation of the filling, sandwich assembly, packaging, and/or the temperature of sandwiches in storage or on display was inadequate to prevent bacterial growth.

Overall contamination of *Listeria* spp. in sandwiches was 7.6%. *L. monocytogenes* was detected in 2.7% (88) of samples, 87 at <10 cfu/g and one at 20 cfu/g. In Wales, a similar study was carried out during October 2005 and March 2006 which reported an overall contamination rate of *Listeria* spp. and *L. monocytogenes* in 949 hospital sandwiches of 5.6% and 3.1%, respectively[35], with *L. monocytogenes* exceeding 100 cfu/g in 0.1% of samples. Five hundred and eighty eight sandwiches were also taken from retail premises in the Welsh study to provide a comparison, and were found to have a slightly higher prevalence of *Listeria* spp. (9.5%) and *L. monocytogenes* (5.2%); *L. monocytogenes* exceeded 100 cfu/g in 0.3% of retail samples. Previously in 1996 Wilson[24] reported *L. monocytogenes* present at over 100 cfu/g in 0.7% of 725 retail samples in Northern Ireland whereas in Ireland in 2002, 11% of 475 retail sandwiches contained *L. monocytogenes,* and 0.3% at over 100 cfu/g[23]. Sandwiches supplied to hospitals and residential or care homes were found to have a significantly higher rate of contamination of *Listeria* spp. (16.2%) including *L. monocytogenes* (7.5%) compared to those prepared on-site (5.7% and 1.7%, respectively). This also concurs with the findings from the study in Wales also carried out during 2005-6[35]. Food manufacturers and distributors play an integral role, and have a legal responsibility, in ensuring the microbiological safety of food available to the consumer[12]. The BSA recommends a target level of absence of *L. monocytogenes* in sandwiches at production, and the presence of any *Listeria* spp. in product must be investigated as it could indicate a failure in procurement, preparation and/or storage of food materials[21]. Attention should be paid to adherence to critical control points identified in Hazard Analysis and Critical Control Point (HACCP) plans as well as to good manufacturing practice (GMP),

effective hygiene standards, effective vegetable washing and decontamination systems, environmental swabbing, effective raw material testing regimes and personal hygiene[21]. The implementation of a HACCP system and associated relevant supervision and instruction and/or food hygiene training for all employees is a legal requirement[12].

This study has also highlighted contributory factors likely to cause problems with sandwiches served or retailed at healthcare establishments. While *L. monocytogenes* is the species of concern, the presence of any *Listeria* spp. in food is an indication of poor hygiene conditions hazardous for *L. monocytogenes* contamination. Sandwiches were contaminated with both *Listeria* spp. and *L. monocytogenes* more frequently when they were from premises without a hazard analysis system in place, from hospital cafeterias, shops and wards, and stored or displayed above 8°C. Storage of chilled foods such as sandwiches must comply with Regulation (EC) No 852/2004 on the hygiene of foodstuffs[12], i.e. should not be kept at temperatures that might result in a risk to health. Other significant risk factors identified with the presence of *Listeria* spp. and *L. monocytogenes* in sandwiches were if: supplied; pre-packed; contained poultrymeat as the main sandwich filling; and/or contained salad ingredients, soft cheese, or mayonnaise. World-wide a range of food types have been associated with transmission of listeriosis and these include products which are based on meats (sliced meats and pates), dairy (including soft cheese and butter) and salad vegetables[18]. The microbiological quality of ingredients incorporated in to sandwiches is, therefore, of importance for a product that is consumed without further treatment, such as cooking.

The particular characteristics of *L. monocytogenes* need to be taken into account in any HACCP system, in particular the low temperature survival and growth of the organism. It may be these points account for the more frequent detection shown in this study for sandwiches bought in rather than made on the premises (i.e. where there might be a longer delay between manufacture and use). The study also showed that whilst implementation of HACCP (which became a legal requirement in 2006) appeared to be linked to better overall microbiological quality, it also (and surprisingly) appeared to be linked to an increased detection of *Listeria* spp. and *L. monocytogenes* from those premises visited in 2006. This highlights the point that food safety management systems put in place to satisfy legislation will only properly meet legal obligations if they take account of all relevant hazards and risks. Clearly *L. monocytogenes* and the associated storage issues which are different from other bacteria need to be carefully considered in every sandwich making operation; particularly where sandwiches are served to vulnerable groups. The presence of properly considered and correctly implemented hazard analysis systems in food premises can undoubtedly

contribute to marked improvements in the microbiological quality of ready-to-eat foods[36] and is consistent with this study. Implementation of a hazard analysis system or similar food safety plan in healthcare establishments, whether in the kitchen, ward or shop, provides a pragmatic framework for good hygiene practice.

A rise in listeriosis has been observed in the UK and a number of other European countries between 2000 and 2006[3,37]. The serogroups most often causing infection in the UK are serogroups 4b, 1/2a, and 1/2b[38], with the subtype 4b AFLP I being most common, whereas the predominant serogroup recovered from food isolates in the UK during 2005 to March 2007 was serogroup 1/2a, of which half were AFLP VII or IX (J McLauchlin and K Grant, HPA pers comm*).* The predominant serogroup of *L. monocytogenes* recovered from the referred sandwich isolates was serotype 1/2a (53%), with subtypes AFLP IX and VII prevalent. However, 30% of sandwich isolates were serotype 4b, with subtypes AFLP I and XVIII prevalent. Contaminated sandwiches with various fillings and produced by different manufacturers have been associated with four outbreaks of listeriosis in England and Wales from 1999 to 2004 and were also the subject of a recent recall in 2007. *L. monocytogenes* types found in these outbreaks included 4b AFLP I, 1/2a AFLP III, 1/2a AFLP XI and 1/2c AFLP VII[3] (J McLauchlin and K Grant, HPA pers comm).

Food hygiene in healthcare establishments requires attention to rigorous preventative measures to minimise the hazard of foodborne disease. Providers of food to places with higher than average concentrations of people with lowered immunity, such as hospitals, including retail outlets, should be made aware of the need for the highest possible standards of food hygiene. *L. monocytogenes* is widely prevalent in the environment and to prevent contamination a number of prerequisite programs have to be followed during commercial preparation of food. Levels of *L. monocytogenes* at below 100 cfu/g are usually not considered significant for human disease except in vulnerable population groups[19,38,39]. Current EC microbiological criteria however indicate that levels of *L. monocytogenes* of up to 100 cfu/g in ready-to-eat foods within shelf-life are legally satisfactory[20]. This study highlights questions about whether this is appropriate for ready-to-eat foods made for and consumed by vulnerable groups and whether the target level should be absence of the bacterium in such foods, including sandwiches. The development of microbiological criteria for *L. monocytogenes* in ready-to-eat foods is currently being discussed at the international level by the Codex Committee on Food Hygiene[40]. As part of this the European Food Safety Authority is reviewing scientific data on *L. monocytogenes* risk related to ready-to-eat foods, and is to provide scientific advice on the appropriateness for establishing criteria for this pathogen at the global level.

Significant progress has been made in recognising foods which are at risk from *L. monocytogenes* and in developing strategies and processes that can minimise these risks. Dietary recommendations about when to avoid certain foods and patient education about food preparation are also important. Following the introduction of such advice by the Department of Health in 1989 to pregnant women and the immunocompromised to avoid eating pate following an outbreak of listeriosis, the incidence of disease dramatically declined[3]. In the UK, the advice to these susceptible groups to avoid the consumption of pate, camembert, brie and blue veined cheeses, and to cook poultry-based and other ready meals until they are hot throughout is still maintained[18]. Since 2001, an upsurge in the number of reported cases of listeriosis has been observed in England and Wales predominantly in patients over 60 years old[3]. Given that the elderly population will rise significantly during the next decades dietary advice on the avoidance of high-risk foods should also be provided routinely to this susceptible group. To this effect, an ACMSF Group has been set up to consider and advise the Food Standards Agency on whether advice targeted to different vulnerable groups needs to be re-emphasised, updated and/or expanded[41].

Although sandwiches are relatively simple products they have a complex microbiological make up due to the mixture of ingredients used. This study underlines the fact that high standards of hygiene must be observed in the preparation and supply of sandwiches. The BSA Code of Practice for sandwich manufacturers[21] advises that food ingredients must be of acceptable microbiological quality; storage and display temperatures must be correct (ideally $\leq$5°C but always <8°C); there should be separation of low/high risk areas; direct handling of high risk foods and fillings must be minimised; frequent hand washing by food handlers must be encouraged to minimise contamination risks; and there should be effective cleaning procedures. Priority must also be given in the reduction of *L. monocytogenes* in sandwiches and other high-risk foods that are consumed without any further treatment. Additionally manufacturers supplying sandwiches to healthcare establishments should operate to the BSA recommended target level of absence of *L. monocytogenes* in sandwiches.

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Annex 1: Participating Laboratories and Local Authority Food Liaison Groups and number of samples

Table 1a. Participating HPA and HPA Collaborating Laboratories and number of samples

HPA Region	HPA/HPA Collaborating Laboratory	Number of samples
East	Chelmsford	217
	Norwich	194
East Midlands	Leicester	28
	Lincoln	197
London	London FWEM[1]	179
South East	Ashford	91
	Brighton	234
	WEMS[2]	203
North East and	Leeds	98
Yorkshire and the	Newcastle	91
Humber	Hull	84
	Sheffield	98
North West	Carlisle	62
	Chester	135
	Preston	375
South West	Bristol	62
	Exeter	116
	Gloucester	34
	Truro	77
West Midlands	Birmingham	45
	Coventry	125
	Shrewsbury	78
	Stoke on Trent	90
	Hereford	39
Total		**2952**

1, London Food, Water & Environmental Microbiology Services Laboratory
2, Wessex Environmental Microbiology Services

Table 1b. Other participating Official Food Control Laboratories in Wales, Scotland, Northern Ireland & England and number of samples examined.

Country	Laboratory	Number of samples
Wales	NPHS-W Microbiology Rhyl	11
Ireland	Belfast City Hospital	99
Scotland	Aberdeen City Council Public Analysts	28
	Dundee City Council Scientific Services	79
	Edinburgh Analytical and Scientific Services	20
	Glasgow Scientific Services	39
England	Kings Lynn & West Norfolk	21
	Total	**297**

Table III: Participating Food Safety Liaison Groups and number of samples

Local Authority Food Liaison Group	Number of Samples
Berkshire	32
Buckinghamshire	23
Cambridgeshire	72
Cheshire	64
Cornwall	77
Cumbria	93
Derbyshire	149
Devon	73
Dorset	46
Durham	13
East Sussex	96
Essex	141
Gloucester	34
LFCG[1] Greater London NE Sector	31
LFCG Greater London NW Sector	28
LFCG Greater London SE Sector	25
LFCG Greater London SW Sector	27
Greater Manchester	147
Hampshire & Isle Of Wight	79
Hereford & Worcester	49
Hertfordshire & Bedfordshire	51
Humberside	84
Kent	91
Lancashire	196
Leicestershire	28
Lincolnshire	64
Merseyside	64
North Yorkshire	34
Northamptonshire	38
Northern Ireland Food Group[2]	99
Norfolk	153
Nottinghamshire	44
Northumberland	8
Oxfordshire	36
Scottish Food Enforcement Liaison Committee[3]	166
Shropshire	32
Somerset	43
South West Yorkshire	117
Staffordshire	92
Suffolk	56
Surrey	80
Tees Valley	28
Tyne & Wear	28
Wales North Group	18
Warwickshire	86
West Midlands	89
West of England	40
West Sussex	58
Wiltshire	27
Total	**3249**

1, London Food Co-ordinating Group; 2, Northern Ireland Food Group consists of Eastern, Northern, Southern & Western Groups; 3, SFELG consists of Central Scotland, Fife & Tayside, Lothian & Scottish Borders, North Scotland, and West of Scotland