UK-wide Survey of *Salmonella* and *Campylobacter* Contamination of Fresh and Frozen Chicken on Retail Sale

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EXECUTIVE SUMMARY

The Agency announced the preliminary findings on the level of *Salmonella* and *Campylobacter* contamination in August 2001. The present report provides the finalised overall figures for the survey which, apart from a very small change to the *Salmonella* figure, have not changed since the preliminary results were announced. The report also provides information on further characterisation of the *Salmonella* and *Campylobacter* isolates and a detailed analysis of the survey data. The findings reinforce the importance of thorough cooking of chicken and good hygiene to avoid cross contamination.

The Agency will continue to monitor trends in *Salmonella* and *Campylobacter* contamination of chicken.

Background

In 2000 the Food Standards Agency set a target of reducing *Salmonella* contamination of retail UK- produced chicken by 50% in 5 years. To set a baseline against which a reduction could be measured, a national survey was undertaken between April and June 2001 and involved testing 4866 samples of fresh, frozen, whole and portioned chicken purchased from over 1500 retail outlets throughout the UK. Chicken samples were purchased from a representative cross section of retail outlets, including major retailers, butchers, grocers, market and farm stalls according to market share. Samplers were only permitted to take a maximum of 5 samples from any one store, and the samples were required to be different types of chicken.

Chicken samples were sent to one of three laboratories and tested for the presence or absence of *Salmonella*, and the presence or absence and numbers of *Campylobacter*. Samples from England and Wales were sent to a single, dedicated laboratory at ADAS, Wolverhampton and the Scottish and Northern Ireland samples were sent to the Scottish Agricultural College (SAC) laboratories at Aberdeen and Auchincruive respectively. All *Salmonella* isolates and a proportion of the *Campylobacter* isolates were sent to reference laboratories for serotyping, phage typing, screening for antimicrobial resistance and archiving.

Overall levels of contamination

The overall frequency of *Salmonella* contamination in retail chicken in the UK was 5.7%. This is only slightly different from the preliminary figure (5.8%) announced in August 2001 and is much lower than in previous national surveys undertaken for whole chicken (ACMSF 1996). Although the frequency of contamination was low, there were significant differences between the four countries in the UK. Samples from Wales had the lowest frequency of *Salmonella* contamination (3.4%), with England and Northern Ireland both having a contamination rate of 5.5%. Scotland had the highest frequency of contamination (8.8%). *Salmonella* contamination of fresh chicken (4.0%) was lower compared to frozen chicken (10.4%) but there was no difference in the frequency of contamination between whole (5.7%) and portioned chicken (5.7%). There was no significant difference in contamination frequency between wrapped and unwrapped chickens or between birds with or without giblets.

The overall frequency of *Campylobacter* contamination was 50%, which is the same as the preliminary figure announced in August 2001. However, there was a significant difference in the contamination rate when England and Wales were compared to Scotland and Northern Ireland. The latter two countries had a much higher frequency of contamination (76% average compared with a 44% average for England and Wales). This was recognised when the preliminary results were announced in August 2001. Further work has failed to identify a definitive explanation for these differences, although variation between laboratories is likely to be a factor. In addition, there was a trend over time in *Campylobacter* contamination rates for samples from England and Wales ranging from 30-40% in the first 5 weeks rising to 60-70% in the last 3 weeks of the survey. The frequency of *Campylobacter* contamination of fresh chicken (56%) was higher than for frozen chicken (31%). Whole chickens were more likely to be contaminated (57%) than portions (46%). There was no significant difference in contamination frequency between wrapped and unwrapped chickens or between birds with or without giblets.

Non-UK Chicken

The frequency of *Salmonella* contamination was lower in UK-produced chicken than in non-UK chicken and this difference was statistically significant for frozen samples (8.3% UK compared to 13.6% non-UK). The figures were not significant for fresh chicken due to the small number of fresh, non-UK samples. *Salmonella* contamination varied according to country of origin although this was not statistically significant in all cases and the number of samples was often small.

In contrast to *Salmonella*, the frequency of *Campylobacter* contamination was higher in UK-produced chicken than in non-UK chicken. This difference was largely accounted for by whole chicken, as there was little difference in terms of fresh or frozen chicken portions.

Chicken Production Types

The samples purchased in the survey were based on market share and therefore the number of free-range, organic and corn-fed chicken samples was small in comparison to those from intensive production. Because of the limited numbers of samples of free-range, organic and corn-fed chicken, the differences in *Salmonella* and *Campylobacter* contamination that were seen between production types were small and not statistically significant.

***Salmonella* and *Campylobacter* strains**

Salmonella Typhimurium was the most frequent of the 30 serotypes isolated, accounting for 14% of the total number of *Salmonella* isolates. All but one of the *S.* Typhimurium isolates were from UK-produced chicken and the majority of isolates were of phage type DT104 or DT104b. *Salmonella* Enteritidis accounted for only 7% of the isolates and was mostly associated with frozen, non-UK chicken portions. This finding is markedly different from previous national surveys of whole chickens, where *S.* Enteritidis has consistently been the most frequent serotype isolated. The other main serotypes isolated in the survey were *S.* Heidelberg, *S.* Infantis, *S.* Ohio and *S.* Thompson.

Campylobacter jejuni comprised 75% and *Campylobacter coli* 24% of the isolates characterised by the reference laboratory. Chicken purchased in Scotland was found to have a significantly higher proportion of *C. jejuni* than the other UK countries (83%). The most frequent of the 37 Heat Stable (HS) serotypes of *C. jejuni* was HS31 (15% of isolates), whilst for 16 HS serotypes of *C. coli*, it was HS56 (38% of isolates). Among the 47 phage types

(PT) of *C. jejuni*, PT1 predominated (32% of total isolates), whereas among the 15 phage types of *C. coli* it was PT44 (32% of isolates).

Antimicrobial Resistance

Of the 279 *Salmonella* isolates tested, 54% were resistant to at least one antimicrobial drug. Multiple resistance, that is resistance to four or more unrelated drugs, was found in 23% of the isolates, 75% of which were obtained from UK-produced chicken. The observed frequency of multi-resistance was largely due to the higher proportion of *S.* Typhimurium found in UK chicken, where 36 out of 38 strains (95%) were multi-resistant.

Fifty percent of the *C. jejuni* and 43% of the *C. coli* isolates were resistant to at least one antimicrobial drug. Multiple resistance was found in 0.6% of *C. jejuni* and 2% of *C. coli* isolates. Resistance to ampicillin was most frequent in *C. jejuni* (36% of isolates), and tetracycline resistance most frequent in *C. coli* (25% of isolates). Resistance to ciprofloxacin was seen in 13% of *C. jejuni* and 15% of *C. coli* isolates.

There was a significantly higher frequency of resistant *Campylobacter* isolates from frozen chicken (59% of samples) than from fresh chicken (46% of samples). Chicken sampled in Northern Ireland had a significantly lower frequency of antimicrobial resistant *Campylobacter* isolates (35% of samples) compared to other parts of the UK (54-55% of samples).

INTRODUCTION

BACKGROUND

1. In its 1996 report on poultry meat, the Advisory Committee on the Microbiological Safety of Food (ACMSF) recommended "*that the Government considers conducting such further microbiological surveillance of finished raw poultry meat at an appropriate time in the future as is necessary to map progress towards the reduction and ultimate elimination of pathogens*" (ACMSF 1996).

2. Surveys to assess the extent of *Salmonella* contamination of UK raw, whole chicken have been undertaken at regular intervals over at least 25 years. During this time, the frequency of contamination has fallen from 54% of fresh and 64% of frozen chicken in 1987 to 33% and 41% respectively in 1993/4 when the last national survey was conducted (ACMSF 1996). Based on the findings in 1993/4, the ACMSF also "*saw no reason in principle why the prevalence of Salmonella contamination in the finished raw product should not within the next few years be reduced to a single figure percentage, on the basis of existing technology*" (ACMSF 1996).

3. At its launch in April 2000 the Food Standards Agency set itself a target of reducing *Salmonella* contamination of retail UK chicken by 50% over the following 5 years. Also in 2000, the Agency set a target of reducing the incidence of foodborne disease by 20% by 2006. Laboratory-confirmed isolations of *Salmonella* from humans, excluding those acquired outside the UK, form part of the baseline for the latter target. It is expected that a 50% reduction in *Salmonella* contamination of UK-produced chicken would contribute towards reducing human *Salmonella* infections from this source in the UK.

4. Work undertaken between 1998 and 2000 to develop microbiological methodology for future poultry surveys suggested that that there may have been a further reduction in *Salmonella* contamination of fresh and frozen retail chicken since the 1993/4 survey. However, the work was not based on a fully representative cross-section of the retail chicken market, as sampling was restricted to predominantly major retail outlets in only two areas of the country. Nevertheless, the work did indicate that *Salmonella* contamination of whole chickens could be in the range 13-27% depending on the method used (Jørgensen *et al*., 2002). Studies undertaken elsewhere, including other countries indicate that contamination rates are variable and in some cases higher than the figures reported by Jørgensen *et al.,* (2002). (Anon 1994; ACMSF 1996; Uyttendaele *et al.,* 1999; Dufrenne *et al.,* 2001; Harrison *et al.,* 2001; Zhao *et al.,* 2001; Dominguez *et al.,* 2002).

5. The overall aim of the survey was to establish the prevalence of *Salmonella* in retail chicken and to provide a baseline for the Agency's chicken target. *Campylobacter* was also included in the survey because it is an important cause of foodborne disease and the organism is a significant part of the baseline figure for the foodborne disease target. In addition, there are currently no comprehensive data on *Campylobacter* contamination of retail chicken on a UK-wide basis. Studies conducted in the UK and elsewhere indicate that the frequency of contamination is variable and wide-ranging (40-95%) (Hood *et al.,* 1988; Anon, 1994; Flynn *et al*., 1994; ACMSF 1996; Atanassova and Ring 1999; Ono and Yamamoto 1999; Uyttendaele *et al*., 1999; Kramer *et al*., 2000; Dufrenne *et al*., 2001; Harrison *et al*., 2001; Zhao *et al*., 2001; Dominguez *et al*., 2002; Jørgensen *et al*., 2002;

Moore *et al*., 2002). A number of factors will influence these data including methodology, seasonality, chicken production and processing methods and whether fresh or frozen chicken was tested. There is even less information on numbers of *Campylobacter* organisms on chicken, although the few studies that have been undertaken indicate that high numbers (>10^5 per carcass) do occur, particularly on fresh chicken (Hood *et al.,* 1988; Pearson *et al.,* 1993; Jørgensen *et al*., 2002).

6. The main objectives of the survey were to:

a) establish the prevalence of *Salmonella* on UK-produced and non-UK, fresh and frozen, whole and portioned chicken at retail in the UK

b) identify the *Salmonella* serotypes and phage types present and determine susceptibility of isolates to antimicrobial agents

In addition, the survey also provided an opportunity to:

c) establish the prevalence and numbers of Campylobacters on UK-produced and non-UK fresh and frozen, whole and portioned chicken at retail in the UK

d) identify the *Campylobacter* species, serotypes and phage types present and determine susceptibility of isolates to antimicrobial agents

SURVEY DESIGN

7. When planning the survey, it was recognised that a representative cross-section of the retail chicken market would need to be sampled across the UK. Agency statisticians calculated that testing 3,000 chicken samples would be sufficient to provide an overall UK baseline figure. Based on the data for the proportion of chicken consumed in different parts of the UK (National Food Survey, Defra 1999, *formerly* MAFF statistics), it was initially planned that 2,481 chicken samples would be purchased in England, and 283, 165 and 71 samples in Scotland, Wales and Northern Ireland respectively. However, this sampling framework would result in relatively few samples from Scotland, Wales and Northern Ireland, and there was a desire for data that would be representative of different parts of the UK. Therefore, the sample sizes for Scotland, Wales and Northern Ireland were increased to 800 each, bringing the total projected sample size for the survey to 4,881. Apart from England, the actual number of samples tested for each country departed from the market share, due to the boosting applied to samples from Wales, Scotland and Northern Ireland. This required re-weighting of the data when calculating contamination frequencies that were representative of the UK as a whole.

8. The survey was designed to cover fresh and frozen, whole and portioned raw chicken on retail sale, according to data on market share, provided by the British Poultry Council, *formerly* the British Poultry Meat Federation. The overall sampling framework is shown in Annex 1, and gives a breakdown for major retailers. No cooked, processed or added value (e.g. seasoned, marinaded) chicken was included in the survey. In previous national surveys only whole raw chickens were sampled, but market information indicated that there has been a marked shift in retail sales from whole chickens to portions during the 1990s. At the time the protocol for the survey was being prepared, portions comprised around 70% of the chicken sold at retail, and it was essential to reflect this in the survey design. Similarly, there has been a shift away from frozen chicken to fresh chicken, both whole and portions and this was also reflected in the design. The retailers that were sampled included supermarkets, freezer centres, butchers and grocers, as well as farm shops and market stalls. A small number of free-range and organic chickens were purchased, to reflect the small market share that these products currently have, although it was recognised that the numbers would be too small for meaningful comparisons to be made between production types.

9. Although the *Salmonella* target concerns UK-produced chicken it was intended from the outset that chicken of UK and non-UK origin would be sampled. However, it was not possible to plan a defined number of samples of non-UK chicken as in many cases, information on origin could only be clarified after follow-up of labelling and packaging codes with the retailers. This was particularly the case with chicken portions.

PURCHASE OF SAMPLES

10. Restrictions were placed on the types of chicken that could be purchased for inclusion in the survey. Whole chickens and portions had to be raw, and with no additional ingredients such as basting fat, stuffing, herbs or glaze/marinade. The types of portions that could be sampled were breast, leg, wing, thigh, quarter and drumstick. Boneless and skinless types of these portions were also permitted. Diced, minced and stir-fry strips/goujons of chicken were not purchased for the survey, as these products were considered to be examples of further prepared products.

11. Retail sampling of chicken was undertaken throughout the UK over 8 weeks from 9 April to 1 June 2001. The work was contracted to ADAS laboratories at Wolverhampton, with National Milk Records (NMR) and the Scottish Agricultural College (SAC) as sub-contractors. NMR purchased all chicken samples in England and Wales, and microbiological testing was undertaken by ADAS laboratories, Wolverhampton. SAC used their staff to purchase samples in Scotland and Northern Ireland and two SAC laboratories, Aberdeen and Auchincruive, examined and tested samples from Scotland and Northern Ireland respectively.

12. Chicken samples were purchased from retailers as specified in the Agency's sampling plan according to their market share (Annex 1). This resulted in approximately 70% of the chicken being taken from major supermarkets, with the remaining samples being purchased from smaller retailers, butchers, grocers market stalls and farm shops. The retail outlets were selected from the Yellow Pages Internet site (www.yell.com), according to geographical area and supermarket name.

13. The countries were split into geographical areas in order to simplify the sampling plan. Each region/area consisted of one or more counties and only counties with mutual borders were grouped together. Overall, some areas were larger and some were considerably smaller but population size was broadly similar. London was treated as a single county due to its high population and relatively small land area. The total numbers of samples to be purchased was allocated to each geographical area based on population size, and then split based on market share with some adjustment where certain supermarket chains were not present. Northern Ireland and Scotland were dealt with in the same way but using data specific to each country. A full list of the geographical areas used in the survey is in Annex 2.

14. Due to changes in store locations or ownership, the details of some geographical areas were changed as the project progressed whilst maintaining geographical and retailer split as close as possible to the original plan.

15. To reduce clustering of samples, each retail outlet was visited only once and a maximum of five chicken samples purchased. Two criteria were used for selecting the different sample types. These were variety, so that a wide range of sample types within those permitted were included, i.e. the types of portions that were being sampled from any one store, and price, so that samples fell within the allocated funds for each day's sampling.

16. Wherever possible, samples were purchased at random. After purchase, each chicken sample was given a unique reference number, so that all monitoring and tests carried out could be traced back to an individual sample and sampling form. Fresh and frozen samples were transported separately in cool boxes to the testing laboratory. Standard polystyrene boxes were used for transport of samples within Scotland and Northern Ireland. Each box contained bubble wrap and had approximately 10-12 freezer packs. England and Wales samplers used Coleman 24 litre cool boxes with Sorbafreeze ice packs. There was no upper temperature limit for the chicken samples at the time of purchase. This approach was adopted to reflect the conditions that an average consumer might find when purchasing chicken.

17. Upon arrival at the laboratory, the temperature of each sample was measured using an infra red gun and hand written on the respective sample form. Each sample was given a consecutive laboratory number, which was written on the sample form as well as the chicken label/wrapper, using an indelible pen. The forms were then used to log information on the samples onto an Excel '97 spreadsheet, including the date of reception and date of testing by the laboratory. This was carried out on a daily basis as samples arrived. Frozen chicken samples were thoroughly defrosted before microbiological testing was carried out.

MICROBIOLOGICAL ANALYSES

18. Chicken samples were tested for the presence of *Salmonella* and presence and enumeration of *Campylobacter* (See Annex 3 for details of methods). Confirmed isolates of *Salmonella* were sent to the PHLS Laboratory of Enteric Pathogens (LEP), Central Public Health Laboratory, Colindale, London for serotyping, phage typing, antibiotic resistance screening and archiving. *Salmonella* isolates from chicken samples purchased in Scotland were also sent to the Scottish *Salmonella* Reference Laboratory (SSRL), Stobhill Hospital, Glasgow. Presumptive *Campylobacter* isolates were sent to the *Campylobacter* Reference Unit (CRU) at LEP for confirmation, speciation, HS serotyping, phage typing and antimicrobial resistance screening and archiving.

19. ADAS laboratories and SAC Auchincruive are accredited with the United Kingdom Accreditation Service (UKAS) to undertake microbiological tests of foodstuffs. In addition, SAC Auchincruive also holds a certificate of participation in the PHLS External Quality Assurance (EQA) scheme. SAC Aberdeen operates under the Campden Laboratory Accreditation Scheme and the MAFF (now Defra) Quality Assurance Scheme. All three laboratories participate in External Proficiency Testing Schemes. Each laboratory was accredited for the detection of *Salmonella* in foodstuffs. It was not possible for the laboratories to be accredited for detection and enumeration of *Campylobacter*, as the method employed in the survey was developed in a pilot study (Jørgensen *et al*., 2002). A series of training days for the samplers and laboratory staff was carried out prior to commencing the sampling and testing, and had input from the laboratory that developed the microbiological methods.

20. Two rounds of external quality assurance (EQA) were carried out, one during the sampling period and the other after sampling had been completed. The EQA focused on *Salmonella* and *Campylobacter* detection and *Campylobacter* enumeration. A full report of the results of the EQA exercise can be found in Annex 13.

DATA COLLECTED

21. The survey provided an opportunity to collect comprehensive information about each chicken sample including price, weight, country of origin and production type. Information about each sample was recorded by the sampler on a sheet (1 per sample), which was sent with the chicken sample to the testing laboratory (Annex 4). When samples arrived at the laboratory, all the information was checked and entered into an Excel '97 spreadsheet. For all countries, the data from the sample forms were entered into the spreadsheet on a daily basis as samples were received. Each week during the survey the spreadsheet was sent electronically by the two SAC laboratories to ADAS for merging after checking for alignment of columns and data. The data from the sample forms was cross-checked with the database by each laboratory and ADAS were informed of any corrections needed.

22. Digital photographs were taken of individual chicken labels in England and Wales, and stored on CD-ROM. This enabled the Agency to cross check a proportion of the sample information in the final spreadsheet. Photographs were not taken for samples purchased in Scotland and Northern Ireland because of the smaller sample sizes involved.

STATISTICAL ANALYSIS

23. The Agency's statisticians performed comprehensive statistical analysis on the data and the detailed methodology relating to the main variables, including the models involved is presented in Annex 5. Because of the large number of comparisons made in the data, significance was only recognised at the 1% level rather than the usual 5% level. Throughout the report, comparisons stated as being significant are at the 1% level ($p<0.01$) unless otherwise indicated.

24. The characterisation and distribution of the main variables in the survey can be found in Annex 6. A glossary of statistical terms used is presented in Annex 7.

SURVEY RESULTS

OVERALL FREQUENCY OF CONTAMINATION

25. The survey was intended to provide a "snapshot" of *Salmonella* and *Campylobacter* contamination of retail chicken sampled across the UK over an 8-week period in April-June 2001. Table 1 shows the frequency of *Salmonella* and *Campylobacter* contamination of retail chicken according to the country where the chicken was sampled. Although the sampling plan specified 4881 samples, 15 of these (0.3%) were removed from the data set, due to non-compliance with the sample requirements. This may have been due to incorrect product specification (e.g. marinated chicken), the sample not falling in the specified weight range, or an error occurring during testing the sample at the laboratory. This means that the total number of samples that were included in the survey analysis was 4866.

26. Overall, 5.7% of the 4866 samples tested had *Salmonella* present, 55.4% had *Campylobacter*, and 2.7% had both organisms present. However, the data were re-weighted to take into account the oversampling of Wales, Scotland and Northern Ireland. This gave revised figures of 5.7% *Salmonella*, and 50% *Campylobacter* contamination. Relatively few chicken samples (3%) had both *Salmonella* and *Campylobacter* present. There was variation in the frequency of *Salmonella* and *Campylobacter* contaminated samples within the UK, being consistently lower in England and Wales than in Scotland or Northern Ireland. The reasons for these differences are explored later in the report. The following sections provide a detailed breakdown of the survey results and their significance.

Table 1 - Number of *Salmonella* and *Campylobacter* positive raw retail chicken samples in the survey. Figures in brackets are the percentage contamination.

Country	No. of samples tested	No. positive samples (%)		
		Salmonella	*Campylobacter*	Both organisms
England	2475	135 (5.4)	1148 (46.3)	52 (2)
Wales	800	27 (3.3)	339 (42.3)	9 (1)
Scotland	794	70 (8.8)	599 (75.4)	46 (5.7)
N. Ireland	797	44 (5.5)	611 (76.6)	25 (3)
Total	4866	276 (5.7)	2697 (55.4)	132 (2.7)
UK*	**4866**	**276 (5.7)**	**2697 (50)**	**132 (3)**

* After re-weighting of the data

Salmonella

27. The overall frequency of *Salmonella* contamination rate was 5.7% (Table 1). When the data were re-weighted for oversampling in Wales, Scotland and Northern Ireland, the overall figure remained at 5.7%. There was a highly significant difference ($p<0.001$) in the contamination rate between countries, which was lowest for samples purchased in Wales (3.3%) and highest for those purchased in Scotland (8.8%). Trend analysis did not reveal any significant change in the frequency of *Salmonella* contamination over the 8 weeks of the survey, irrespective of the country where the chicken was sampled.

28. Table 2 shows the breakdown of *Salmonella* contamination rates for fresh and frozen chicken by country of sampling. The overall contamination rate for fresh chicken was significantly lower (4.0%) than for frozen chicken (10.4%) and the higher frequency of contamination for frozen chicken was reflected across all parts of the UK. Contamination rates for frozen chicken were higher in Scotland and Northern Ireland than in England or Wales. Northern Ireland had the lowest contamination rate for fresh chicken (1.9%), which appears to be consistent with findings in previous surveys (ACMSF 1996). There was no difference between *Salmonella* contamination of whole chickens and portions (Table 3). However results presented later in this report show that there are differences when the data for whole chickens and portions are broken down according to *Salmonella* serotype. There was no significant difference in contamination frequency between wrapped and unwrapped chickens or between birds with or without giblets and there was no evidence of any significant trend between the *Salmonella* contamination rate and the weight of the chicken sample.

Table 2 - Percentage of *Salmonella* contaminated raw fresh and frozen chicken purchased at retail in different parts of the UK. Figures in brackets are standard errors.

Category of chicken	Country				
	England	**Wales**	**Scotland**	**Northern Ireland**	**UK**
Fresh	4.0 (0.5)	2.2 (0.6)	6.1 (1.0)	1.9 (0.6)	**4.0** (0.4) *n=133*
Frozen	9.8 (1.2)	6.6 (1.7)	16.7 (2.6)	16.2 (2.6)	**10.4** (1.0) *n=143*
All	**5.5** (0.5) *n=135*	**3.4** (0.6) *n=27*	**8.8** (1.0) *n=70*	**5.5** (0.8) *n=44*	**5.7** (0.4) *n=276*

n = number of positive samples

Table 3 - Percentage of *Salmonella* contaminated raw whole and portioned chicken purchased at retail in the UK. Figures in brackets are standard errors.

Whole chicken	Chicken portions
5.7 (0.7) *n=81*	5.7 (0.5) *n=195*

n = number of positive samples

Campylobacter

29. The overall frequency of *Campylobacter* contamination was 55.4% - 2697 positives from 4866 samples (Table 1). However, when the data were re-weighted for over-sampling in Wales, Scotland and Northern Ireland, the overall figure was reduced to 50%. Table 4 shows the frequency of *Campylobacter* contamination found in the survey, split into fresh and frozen, and based on country of purchase. There was a highly significant ($p<0.001$) difference in the overall contamination rate between countries. It was lowest for samples purchased in Wales (42%) and highest for those samples purchased in Northern Ireland (77%). The overall frequency of contamination for fresh chicken was significantly higher (56%) than for frozen chicken (31%). The higher rate of contamination of fresh chicken was also reflected in the different parts of the UK, but it was more pronounced for samples purchased in Scotland and Northern Ireland. Although the contamination rates fall broadly within the range seen in previous studies in the UK and elsewhere, the wide range in the rates seen for fresh chicken purchased in different parts of the UK was unexpected. In addition, trend analysis revealed a significant change in the frequency of *Campylobacter* contamination over the 8 weeks of the survey, particularly for samples purchased in England and Wales. These findings are explored in more detail in the discussion.

Table 4 - Percentage of *Campylobacter* contaminated raw fresh and frozen chicken purchased at retail in different parts of the UK. Figures in brackets are standard errors.

Category of chicken	Country				
	England	**Wales**	**Scotland**	**Northern Ireland**	**UK**
Fresh	52 (1.1)	47 (2.1)	89 (1.3)	89 (1.3)	**56** (1.0) *n=2289*
Frozen	30 (1.8)	29 (3.1)	35 (3.3)	40 (3.4)	**31** (1.0) *n=408*
All	**46** (1.0) *n=1148*	**42** (1.7) *n=339*	**75** (1.5) *n=599*	**77** (1.5) *n=611*	**50** (0.8) *n=2697*

n = number of positive samples

30. Table 5 shows that overall the frequency of *Campylobacter* contaminated chicken portions was lower than for whole birds, and this difference was significant. The exception to this pattern was in samples purchased in Northern Ireland where there was a similar contamination rate on whole chickens and portions. There was no significant difference in contamination frequency between wrapped and unwrapped chickens or between birds with or without giblets. There was no evidence of any significant trend between *Campylobacter* contamination rate and the weight of the chicken sample.

Table 5 - Percentage of *Campylobacter* contaminated raw whole and portioned chicken purchased at retail in different parts of the UK. Figures in brackets are standard errors.

Category of chicken	Country				
	England	**Wales**	**Scotland**	**Northern Ireland**	**UK**
Whole	54 (1.8)	51 (3.2)	84 (2.4)	76 (2.8)	**57** (1.5) *n=909*
Portions	43 (1.2)	38 (2.1)	72 (1.9)	77 (1.8)	**46** (1.0) *n=1788*
All	**46** (1.0) *n=1148*	**42** (1.7) *n=339*	**75** (1.5) *n=599*	**77** (1.5) *n=611*	**50** (0.8) *n=2697*

n = number of positive samples

COMPARISON OF UK AND NON-UK CHICKEN

31. Non-UK chicken was defined as being any chicken that did not originate from the UK (England, Wales, Scotland and Northern Ireland). Chicken from the Republic of Ireland (ROI) was classed as being non-UK.

32. It was not possible to determine the exact proportion of non-UK chicken on retail sale prior to the survey being undertaken and hence samples could not be purchased according to market share. Much of the chicken on sale that was labelled as non-UK consisted of frozen portions, and there was only limited availability of other types falling within the sampling specification, particularly whole fresh chicken. Follow-up of tracer codes and other packaging information with the retailers helped to clarify the origin for a significant number of the chicken samples particularly portions, where we had no clear information about the origin. Nevertheless, we have not been able to identify the origin in all cases, and these data have been left out of the comparison between UK-produced and non-UK chicken. Particular care is needed in interpreting the data as for many categories the numbers are small.

Salmonella

33. In total, 94 (13.6%) of 691 non-UK chicken samples were *Salmonella* positive. Table 6 shows the overall *Salmonella* contamination rates where information enabled non-UK and UK-produced chicken to be identified. Although the number of samples for non-UK chicken was much smaller than for UK-produced chicken, statistical analysis indicates that the frequency of *Salmonella* contamination was significantly higher in frozen, non-UK chicken. However, caution is advised when interpreting this finding. There was considerable heterogeneity in non-UK chicken, with only certain countries (France and Germany) being associated with a significantly higher prevalence of *Salmonella*. In addition, the survey was only conducted over 8 weeks and therefore may not fully reflect the pattern of non-UK chicken that might be seen over a larger sampling period.

Table 6 - Frequency of *Salmonella* contaminated raw fresh and frozen chicken purchased at retail in the UK cross classified by whether the chicken is UK-produced or non-UK in origin. Figures in brackets are standard errors.

Origin	Category	
	Fresh	**Frozen***
UK	3.9 (0.4) *n=120*	8.3 (1.2) *n=60*
non-UK	6.1 (2.1) *n=12*	13.6 (1.8) *n=82*

* Only the figures shown for frozen chicken are statistically significant

n = number of positive samples

34. Table 7 gives a breakdown of *Salmonella* contamination by country of origin for non-UK chicken. Although the frequency of contamination was highest for chicken from France and Germany (17%), the number of samples examined was relatively small and the chicken tested may not be truly representative of chicken exported from those countries. In addition, frozen chicken tends to have a higher frequency of *Salmonella* contamination and is likely to comprise a larger proportion of the samples for the non-UK countries.

Table 7 - Number and frequency (%) of non-UK *Salmonella* positive samples by country of origin.

Country	Number of Samples	Number positive (%)
Brazil	49	3 (6)
Denmark	42	4 (10)
France	259	45 (17)
Germany	109	18 (17)
Netherlands	151	18 (12)
Republic of Ireland	56	5 (9)
Thailand	23	1 (4)

Campylobacter

35. In total, 252 from 691 samples of non-UK origin were *Campylobacter* positive (36%). *Campylobacter* contamination was significantly lower in non-UK whole chicken, than in UK whole chicken, although this is mostly attributable to differences in contamination of frozen whole chicken as whole fresh non-UK chicken was rare. Because of the lower frequency of *Campylobacter* contamination in portions (see Table 5) it was necessary to partition the data between fresh and frozen and between whole and portioned chicken separately. Table 8 shows the contamination rates for different categories of UK and non-UK chicken.

Table 8 - Percentage of *Campylobacter* contaminated UK-produced, non-UK and unspecified raw chicken purchased at retail in the UK. The table is structured according to whether the chicken is fresh/frozen, whole/portions and the country of purchase. Figures in brackets are standard errors.

Fresh Whole chicken				
	UK	**Non-UK**	**Not Specified***	**All**
England	57 (2.2)	52 (10.4)	45 (15.1)	**57** (2.1)
Wales	54 (3.8)	- (-)**	- (-)	**53** (3.7)
Scotland	90 (2.3)	- (-)**	- (-)	**90** (2.2)
N. Ireland	82 (3.1)	90 (6.4)	- (-)	**83** (2.8)
UK	**61** (1.8)	**55** (9.0)	**55** (12.9)	**60** (1.8)
Frozen Whole chicken				
	UK	**Non-UK**	**Not Specified**	**All**
England	51 (4.3)	32 (6.2)	- (-)	**46** (3.6)
Wales	50 (7.9)	41 (10.5)	- (-)	**47** (6.3)
Scotland	79 (5.9)	24 (10.3)	- (-)	**65** (5.9)
N. Ireland	69 (8.2)	37 (9.3)	- (-)	**54** (6.5)
UK	**54** (3.7)	**31** (5.2)	- (-)	**48** (3.1)
Fresh Portions				
	UK	**Non-UK**	**Not Specified**	**All**
England	50 (1.4)	53 (5.8)	48 (10.0)	**50** (1.4)
Wales	45 (2.6)	38 (10.6)	45 (15.0)	**44** (2.5)
Scotland	90 (1.5)	60 (12.6)	86 (13.2)	**89** (1.5)
N. Ireland	92 (1.5)	96 (3.6)	90 (6.7)	**92** (1.4)
UK	**54** (1.2)	**54** (5.0)	**52** (8.4)	**54** (1.2)
Frozen Portions				
	UK	**Non-UK**	**Not Specified**	**All**
England	23 (2.7)	24 (3.1)	33 (15.7)	**24** (2.0)
Wales	24 (4.7)	21 (5.1)	- (-)	**22** (3.4)
Scotland	27 (5.2)	13 (4.2)	- (-)	**21** (3.5)
N. Ireland	27 (4.9)	45 (6.4)	- (-)	**34** (3.9)
UK	**24** (2.3)	**23** (2.6)	**37** (14.0)	**24** (1.7)

* Not specified refers to samples from individual butcher's shops where the country of origin could not be determined at either the point of sale or from subsequent follow-up by the Agency

** No samples were taken, due to non-availability

36. Data relating to contamination rates for chicken samples from different non-UK countries is shown in Table 9. The numbers of samples involved are too small to make meaningful comparisons between the contamination rates of different countries, but do give an indication of the range of data. It should be noted that the high frequency of *Campylobacter* contamination for chicken originating in the Republic of Ireland probably reflects the fact that these samples were only analysed by the laboratory testing Northern Ireland samples.

Table 9 - Number and frequency (%) of non-UK *Campylobacter* positive samples by country of origin

Country	Number of samples	Number positive (%)
Brazil	49	9 (18)
Denmark	42	8 (19)
France	259	96 (37)
Germany	109	32 (29)
Netherlands	151	54 (36)
Republic of Ireland	56	48 (86)
Thailand	23	5 (23)

RESULTS BY RETAILER

Salmonella

37. Table A8.1 in Annex 8 shows the number of fresh and frozen samples purchased from each of the major retailers. The overall frequency of *Salmonella* contamination in samples from 12 major retailers ranged from 2.2% to 10.1%, and the 5 major retailers with the lowest contamination rate had levels below the overall average of 5.7%. Results were also affected by the proportions of fresh and frozen chicken that were sampled. Retailers with a high number of frozen samples tended to have a higher level of *Salmonella* than those retailers where a large number of fresh samples were purchased.

Campylobacter

38. As for *Salmonella*, the *Campylobacter* contamination rates for various retailers were influenced by the distribution of fresh and frozen samples. Frozen chicken was associated with a much lower prevalence than fresh chicken, and this is reflected in the results for different retailers. One major retailer did not have any frozen chicken samples taken, and therefore had a higher *Campylobacter* prevalence than other retailers.

PRODUCTION TYPE

39. Sample sizes for chicken reared using alternative production methods (e.g. free-range, organic, corn-fed) were small. This means that the power for making comparisons is limited and there may be some worthwhile differences that have not been identified or which cannot be confirmed as statistically significant. Any differences such as they are, work in opposite directions for *Salmonella* and *Campylobacter*. Table 10 shows the frequency of contamination on chicken of different production types.

Table 10 - Frequency of contamination of *Salmonella* and *Campylobacter* on chicken of different production types.*

Production type	No. Samples	% *Salmonella*	% *Campylobacter*
Corn-fed	85	1.6	63
Free Range	181	3.5	61
Intensive	3286	4.2	55
Organic	62	0	63

* Only fresh chicken was available for alternative production types.

Salmonella

40. Although the 62 organic chicken samples were all *Salmonella* negative, the small number of samples tested means that the result is not statistically significant and cannot therefore, be taken as conclusive evidence that organic chicken has a lower level of contamination than conventional chicken. Other production types - free-range and corn-fed were also associated with a lower level of *Salmonella* contamination than conventionally produced chicken but again, this difference was not statistically significant (Table 10).

Campylobacter

41. Analysis of contamination rates for different production types indicated that alternative production types were likely to have a slightly higher frequency of *Campylobacter* contamination than conventionally produced chicken (Table 10). However, this was not statistically significant.

CAMPYLOBACTER ENUMERATION

42. One of the objectives of the survey was to enumerate *Campylobacter* organisms on chicken samples. Although this work was undertaken, the findings from the EQA exercise (See Annex 13) indicated that actual numbers are likely to be subject to significant variability and may be unreliable for detailed analysis. We have therefore restricted presentation of the data to the distribution of *Campylobacter* counts on fresh and frozen chicken samples. Graph 3 in Annex 12 shows the distribution of *Campylobacter* counts for fresh and frozen chicken.

SAMPLES WITH BOTH ORGANISMS PRESENT

43. Only 132 samples (3%) were found to have both *Salmonella* and *Campylobacter* present. Of the total number of *Salmonella* positive samples, 48% of these were also *Campylobacter* positive. However, in the case of *Salmonella* Typhimurium, 65% of positive samples were also positive for *Campylobacter*.

EXTERNAL QUALITY ASSURANCE

44. As part of an exercise to check the efficiency and quality of the testing laboratories, samples containing *Salmonella* and *Campylobacter* were sent to all the labs involved in the survey, to ensure that all microbiological methods were being carried out correctly. Although this exercise showed that, under pressure of the large volume of samples being tested, laboratories made errors, it did not reveal any systematic error that might affect the overall results of the survey. There is no reason to consider that other laboratories would return different results. The results and discussion of the findings of the External Quality Assurance (EQA) exercise are presented in Annex 13 of this report.

TYPING RESULTS

SALMONELLA SEROTYPES AND PHAGE TYPES

45. Table 11 shows the 29 named *Salmonella* serotypes isolated during the survey. The different phage types found in the survey for each of the *Salmonella* serotypes are shown in Table 12. *Salmonella* Typhimurium and *S.* Heidelberg were the most frequent serotypes, accounting for 26% of the 279 isolates. The top five serotypes accounted for 47% of the isolates, the top ten accounted for 70% and the top twenty accounted for 91%. *Salmonella* Enteritidis was only the fourth most frequent serotype, accounting for 7% of the isolates. Of the 38 *S.* Typhimurium isolates, 33 (87%) were phage typed as either DT 104 or DT 104b (Table 12). Half of the 20 *Salmonella* Enteritidis isolates were PT4 although PT21, 6 and 6A were also found. In contrast to previous surveys there were very few isolates of *S.* Hadar and *S.* Virchow.

46. Table 13 shows the breakdown of the main *Salmonella* serotypes by type of chicken and whether the chicken was of UK or non-UK origin. The majority of *S.* Enteritidis isolates were associated with non-UK frozen chicken portions. Only 5 of the 20 *S.* Enteritidis isolates were known to be from UK-produced chicken with 2 being PT4, 1 PT6, 1 PT6A and 1 untypeable. Isolates of *S.* Enteritidis from UK-produced chicken came from four different packers/producers.

47. Thirty-seven of the 38 *S.* Typhimurium isolates were known to be from UK-produced chicken all but five of which were phage typed as DT104 or DT104b. A substantial proportion of the *S.* Typhimurium isolates (55%) were associated with fresh portions. UK-produced chicken with *S.* Typhimurium contamination came from at least 7 packers/producers.

48. *Salmonella* Heidelberg was the second most frequent *Salmonella* serotype isolated although only 13 of the 34 isolates (38%) were from non-UK chicken, mostly frozen portions. For *S.* Infantis only 5 of the 21 isolates (24%) were from non-UK chicken, again mostly portions. All of the *S.* Java isolates were from chicken portions, all but 2 of which were from chicken of non-UK origin. By contrast, most of the *S.* Ohio isolates (90%) were from UK-produced chicken (Table 13).

Table 11 - Number (%) of isolates of *Salmonella* serotypes isolated from raw fresh and frozen chicken purchased at retail in the UK, April-June 2001.

***SALMONELLA* SEROTYPE**	**NUMBER OF ISOLATES (% of total)**
S. Typhimurium	38 (13.6)
S. Heidelberg	34 (12.1)
S. Infantis	21 (7.5)
S. Enteritidis	20 (7.1)
S. Ohio	20 (7.1)
S. Thompson	18 (6.4)
S. Bovis-morbificans	16 (5.7)
S. Java	11 (3.9)
S. Agona	10 (3.5)
S. Indiana	8 (2.8)
S. Kentucky	8 (2.8)
S. Montevideo	8 (2.8)
S. Virchow	8 (2.8)
S. Livingstone	7 (2.5)
S. Mbandaka	7 (2.5)
S. Brandenburg	6 (2.1)
S. Bredeney	6 (2.1)
S. Hadar	5 (1.7)
S. Derby	4 (1.4)
S. Senftenberg	3 (1.0)
S. Tennessee	3 (1.0)
S. Kottbus	2 (0.7)
S. Liverpool	2 (0.7)
S. Saint-paul	2 (0.7)
S. Binza	1 (0.3)
S. Cerro	1 (0.3)
S. Manhattan	1 (0.3)
S. Schwarzengrund	1 (0.3)
S. Wagenia	1 (0.3)
Unnamed	7 (2.5)
Total isolates	**279***

* Number is higher than 276 as 3 chicken samples had two different serotypes of *Salmonella*

Table 12 - Phage types for *Salmonella* serotypes isolated from raw fresh and frozen chicken purchased at retail in the UK (April-June 2001).

Serotype	Phage Type	No. isolates
S. Typhimurium	DT104	28
	DT104b	5
	Untypeable	2
	RDNC*	3
S. Enteritidis	4	10
	6	2
	6a	1
	21	3
	Untypeable	4
S. Thompson	1	9
	1a	2
	2	1
	6	3
	RDNC*	3
S. Java	Dundee Variant 1	10
	3aI Variant 1	1
S. Agona	1	1
	7	1
	37	3
	38	3
	Untypeable	1
	RDNC*	1
S. Virchow	8	6
	8a	1
	2	1
S. Hadar	1	1
	2	1
	11	1
	14	1
	RDNC*	1

*Reacts with typing phages but does not conform to a recognised pattern

Table 13 - Numbers of isolates of selected *Salmonella* serotypes from raw fresh and frozen whole and portioned chicken purchased at retail in the UK. Figures in brackets are the number of these isolates that were known to be from non-UK chicken.

Chicken type	No. of isolates (No. from non-UK samples)					
	Typhimurium	Heidelberg	Infantis	Enteritidis	Ohio	Java
Fresh Whole	4 (0)	2 (0)	-	2 (0)	3 (0)	-
Fresh Portions	21 (0)	14 (0)	8 (1)	-	13 (0)	6 (4)
Frozen Whole	8 (0)	6 (4)	2 (0)	1 (0)	1 (1)	-
Frozen Portions	5 (1)	12 (9)	11 (4)	17 (14)	3 (1)	5 (5)
All Types	38 (1)	34 (13)	21 (5)	20 (14)	20 (2)	11 (9)

49. The pattern of *Salmonella* serotypes found in the survey is very different to the last national survey of retail chicken in 1993/94 in England and Wales (ACMSF 1996). The 1993/1994 survey used different isolation methods for *Salmonella,* was restricted to whole UK chicken of one size category and examined equal numbers of fresh and frozen chicken. However, it should be noted that, in the earlier survey, 5 serotypes accounted for 83% and ten serotypes 92% of the isolates compared to 47% and 70% of isolates in the present survey respectively. The frequency of specific serotypes found also differed. In the 1993/4 survey, *Salmonella* Enteritidis accounted for 48% of the 260 isolates using method one whereas it only accounted for 7% of the 279 isolates in the present survey. *Salmonella* Typhimurium accounted for 2% of isolates in 1993/94 but 14% in the current survey. In the case of the other main serotypes, *S.* Heidelberg, *S.* Thompson, *S.* Bovis-morbificans and S. Java were not found in the 1993/94 survey.

50. Samples purchased in different parts of the UK had varying numbers of different *Salmonella* serotypes. Samples from England and Scotland had 26 and 24 different serotypes of *Salmonella* respectively, whilst samples from Wales and Northern Ireland had fewer serotypes (13 and 14 respectively).

51. Analysis of the data revealed that certain serotypes appear to be associated with particular non-UK countries. France had 45 positives from 259 chicken samples, and of these, 15 (33%) were *S.* Bovis-morbificans. Positive samples from German chicken tended to be *S.* Enteritidis (12 isolates from 18 *Salmonella* positives). The Netherlands had 8 isolates of *S.* Java from 18 *Salmonella* positive samples.

CAMPYLOBACTER SUBTYPES

52. All presumptive *Campylobacter* isolates from the survey were sent to the *Campylobacter* Reference Unit at the Laboratory of Enteric Pathogens (LEP), Public Health Laboratory Service, Colindale, London. Initially, the isolates were archived, pending confirmation, speciation and typing. Following checks for viability and purity, the reference laboratory reported that 2891 isolates were deposited in the archive for typing. A proportion of the isolates were subsequently typed at a later date.

53. A complete list of the *Campylobacter* serotypes and phage types found in the survey is shown in Annex 9.

SPECIATION

54. Overall, *C. jejuni* comprised 74% of the *Campylobacter* isolates from the survey, with *C. coli* making up 25%. The remaining 1% of isolates comprised *C. lari* together with unidentified *Campylobacter* species.

55. Differences were seen in the numbers of *C. jejuni* and *C. coli* isolates for each country (Table 14). Scottish samples comprised the greatest proportion of *C. jejuni* (83%) while samples from Northern Ireland comprised the greatest proportion of *C. coli* (32%). These differences were statistically significant compared to the other UK countries. The reason for these differences is not known. Moore *et al*. (2002) reported a similar figure for *C. coli* from retail chicken samples in Northern Ireland.

Table 14 - Numbers of *C. jejuni* and *C. coli* isolates from raw chicken at retail by country of purchase.

Country	Total isolates	No. Isolates (% of total)	
		C. jejuni	*C. coli*
England	566	417 (74)	147 (26)
Wales	188	133 (71)	54 (29)
Scotland	368	304 (83)	63 (17)
Northern Ireland	514	356 (69)	157 (31)
UK	1636*	1210 (74%)	421(25%)

* 5 isolates were other *Campylobacter* species

56. The data collected also provides evidence that the frequency of *C. jejuni* and *C. coli* isolation from chicken varied during the course of the survey. Table 15 shows that although the frequency of *C. jejuni* was consistently higher than for *C. coli* throughout the 8-week sampling period, it was found to be significantly higher ($p<0.001$) during the earlier weeks of sampling (April). A greater number of *C. coli* isolates were obtained during the latter weeks of the survey (May). The reason for this shift in the proportion of the two species is unclear, although seasonal changes in the prevalence of *Campylobacter* contamination of poultry and human infections are reported in the literature.

Table 15 - Number of isolates of *C. jejuni* and *C. coli* from raw retail chicken samples by week of sampling. The table also shows *C. jejuni* isolates as a percentage of all *Campylobacter* positive samples.

Species	Survey week Number							
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**
C. jejuni	164	151	165	163	150	176	165	77
C. coli	25	23	38	66	55	105	67	40
Percent *C. jejuni*	**87**	**87**	**81**	**71**	**73**	**63**	**71**	**66**

SEROTYPES

57. Table 16 shows the frequency of the most common of the 37 Heat Stable (HS) serotypes of *C. jejuni* found in the survey. The most frequent serotypes of *C. jejuni* were HS31 and HS13, which accounted for 183 (15%) and 154 (13%) of the 1210 *C. jejuni* isolates respectively. The top 5 HS serotypes accounted for 42% and the top 10 accounted for 51% of the *C. jejuni* isolates examined in the survey. There were 404 *C. jejuni* isolates (33%) which were not typable using the HS serotyping scheme. Kramer *et al.,* (2000) used HS serotyping to characterise 194 *C. jejuni* isolates from retail chicken portions sampled in North West England in February-March 1998. In contrast to the present study, none of the isolates were HS31 and only 1.6% were HS13, whilst HS50, HS44 and HS11 were more frequent than in the present study.

58. Table 17 shows the frequency of the most common of the 16 HS serotypes of *C. coli* found in the survey. The most frequent serotypes of *C. coli* were HS56 and HS61, which accounted for 161 (38%) and 44 (11%) of the 421 *C. coli* isolates respectively. In contrast to *C. jejuni*, the top 5 serotypes of *Campylobacter coli* accounted for 71% of the isolates examined. There were 68 *C. coli* isolates (16%) which were not typable using the HS serotyping scheme.

Table 16 - Number of isolates and relative frequency of HS serotypes of *C. jejuni* that were found in the survey. Types comprising less than 1% of the isolates are not included but are included in the full listing in Annex 9.

HS Type	No. Isolates	% of Total Isolates
31	183	15.1
13	154	12.7
50	84	6.9
37	48	4.0
18	35	2.9
4	26	2.2
2	25	2.1
9	22	1.8
12	22	1.8
27	22	1.8
1	18	1.5
6	18	1.5
21	16	1.3
60	15	1.2
5	13	1.1
8	12	1.0
Other types	92	7.8
Untypeable	404	33.4

Table 17 - Number of isolates and relative frequency of HS serotypes of *C. coli* that were found in the survey. Types comprising less than 1% of the isolates are not included but are listed in Annex 9.

HS Type	No. Isolates	% of Total Isolates
56	161	38.2
61	44	10.5
28	41	9.7
14	30	7.1
66	24	5.7
59	14	3.3
48	9	2.1
49	6	1.4
26	5	1.2
51	5	1.2
Other types	14	3.3
Untypeable	68	16.2

PHAGE TYPES

59. Tables 18 and 19 provide frequencies for the most common of the 47 *C. jejuni* and 15 *C. coli* phage types found in the survey respectively. Phage Types 1 and 2 were most frequent in *C. jejuni* isolates and PTs 44 and 2 in *C. coli*. The top 5 phage types of *C.jejuni* and *C.coli* comprised 63% and 87% of the isolates respectively. The top 5 *C. jejuni* phage types are the same types as those reported from a study of *Campylobacter* in retail chicken in North West England (Kramer *et al.,* 2000). As in the present study, a similar proportion of the *C. jejuni* isolates (58%) were accounted for by the top 5 phage types. However, several of the phage types in Table 18 (8, 21 and 39) were not found by Kramer *et al.,* (2000).

Table 18 - Number of isolates and relative frequency of phage types of *C. jejuni* that were found in the survey. Types comprising less than 1% of the isolates are not included but are listed in Annex 9.

Phage type	No. Isolates	% of Total Isolates
1	385	31.8
2	181	14.9
44	103	8.5
5	57	4.7
33	40	3.3
8	32	2.6
39	27	2.2
21	25	2.0
35	25	2.0
34	22	1.8
Other types	160	13.2
RDNC	104	8.6
Untypeable	48	3.9

RDNC - reacts with phages but does not conform to a recognised phage type

TABLE 19 - Number of isolates and relative frequency of phage types of *C. coli* that were found in the survey. Types comprising less than 1% of the isolates are not included but are listed in Annex 9.

Phage type	No. Isolates	% of Total Isolates
44	134	31.8
2	134	31.8
7	51	12.1
1	41	9.7
17	5	1.1
Other types	15	3.5
RDNC	28	6.6
Untypeable	13	3.0

RDNC - reacts with phages but does not conform to a recognised phage type

ANTIMICROBIAL RESISTANCE

Salmonella

60. *Salmonella* isolates were tested for sensitivity to antimicrobial drugs using a breakpoint method (Threlfall *et al.,* 1999). Details of the concentrations of the antimicrobial drugs used are summarised in Annex 10. Of the 279 isolates tested, 129 (46%) were sensitive to all of the drugs tested. The proportion of sensitive strains varied between serotypes and between phage types within a serotype. Results for individual serotypes and antimicrobials are shown in Annex 11, Table A11.1.

61. Multiple resistance, that is resistance to four or more unrelated drugs, was found in 64 (23%) of the isolates of which 36 (56%) were *S.* Typhimurium DT104/104b, 11 (17%) were *S.* Java and 5 (8%) were *S.* Heidelberg. There were 48 (27%) multiresistant isolates where the chicken was of UK origin and 15 (16%) where the chicken was non-UK. The difference in numbers of multiresistant isolates between UK-produced and non-UK chicken is accounted for by the higher frequency of *S.* Typhimurium DT104/104b and the lower frequency of multiresistant non Typhimurium in UK-produced chicken. None of the differences in multiple resistance between UK-produced and non-UK chicken were significant.

62. For individual antimicrobial drugs, the most frequent resistance was to sulphonamides, present in 39% of *Salmonella* isolates, followed by streptomycin (29%), ampicillin (27%), trimethoprim (25%) and tetracyclines (23%). Ciprofloxacin and nalidixic acid resistance was found in 7% of isolates, none of which were *S.* Typhimurium.

Campylobacter

63. *Campylobacter* isolates were tested for sensitivity to antimicrobials using a breakpoint method (Thwaites and Frost, 1999). Details of the concentrations of the antimicrobials used are summarised in Annex 10. Of the 1631 isolates tested, 840 (52%) were sensitive to all of the drugs tested. Multiple resistance, that is resistance to four or more unrelated drugs, was found in 14 (2%) of the isolates tested.

64. Full details of the numbers of *Campylobacter* isolates resistant to specific antimicrobial drugs are shown in Appendix 11, Table A11.2.

65. When the susceptibility data was broken down according to species, 50% of *C. jejuni* isolates were resistant to at least one antimicrobial, compared to 43% of *C. coli* isolates. Multiple resistance was seen in 0.6% of *C. jejuni* and 2% of *C. coli* isolates.

66. For individual antimicrobial drugs, *C. jejuni* was most likely to be resistant to ampicillin (36% of strains), whilst *C. coli* was more likely to be resistant to tetracycline (25% of strains). *C. coli* isolates also showed more resistance to erythromycin (6%) than *C. jejuni* (0.02%).

Antimicrobial resistance by country

67. Table 20 shows that for isolates of *Campylobacter* from chicken purchased in Northern Ireland, there was a significantly lower frequency of resistance to antimicrobial drugs ($p<0.001$) after correction for overall prevalence. The reasons for this are not known, but may reflect differences in production methods from other parts of the UK and the more localised production of chicken in Northern Ireland.

Table 20 - Numbers and frequency of *Campylobacter* isolates from chicken purchased in different parts of the UK that were sensitive or resistant to one or more antimicrobials.

	Sensitive	**Resistant**	Percent
England	259	307	54
Wales	84	104	55
Scotland	168	199	54
N. Ireland	334	180	35
UK	845	790	54

68. Table 21 shows the numbers and frequency of sensitive and resistant *Campylobacter* isolates from fresh and frozen chicken samples. *Campylobacter* isolates from frozen chicken were significantly more likely ($p<0.001$) to exhibit antimicrobial resistance than those found in fresh chicken. The reasons for this are not known.

Table 21 - Numbers and frequency of *Campylobacter* isolates from fresh and frozen chicken that were sensitive or resistant to one or more antimicrobial drugs.

	Sensitive	**Resistant**	Percent
Fresh	741	642	46
Frozen	104	148	59

Quinolone resistance

69. Sixteen percent of *C. jejuni* and 17% of *C. coli* were resistant to the quinolone nalidixic acid. Resistance to ciprofloxacin was seen in 13% of *C. jejuni* and 15% of *C. coli* isolates. Fresh chicken was significantly less likely to harbour *Campylobacter* that were resistant to quinolones (15% for fresh and 23% for frozen). The reason for this is not clear.

DISCUSSION ON THE MAIN FINDINGS OF THE SURVEY

70. The overall level of *Salmonella* contamination was much lower than results from previous surveys. Table 22 shows the results of previous surveys of *Salmonella* on retail whole chicken in the UK. The work carried out between 1998 and 2000 formed the basis of the Agency's target to reduce *Salmonella* contamination on UK retail chicken by 50% over 5 years. When the target was announced, it was estimated that the prevalence of *Salmonella* on chicken was between 20-30%.

Table 22 - Prevalence of *Salmonella* in whole, raw chicken: 1979 - 1994

Survey*	Source and Type	No. of chickens	No (%) with *Salmonella* spp.
1979 / 1980	UK, Frozen	100	79 (79)
1987	UK, Frozen	101	65 (64)
1990	UK, Frozen	143	77 (54)
1994	UK, Frozen	281	114 (41)
1987	UK, Fresh	103	56 (54)
1990	UK, Fresh	143	58 (41)
1994	UK, Fresh	281	93 (33)
1998 /1999**	UK and non-UK, Fresh	101	31 (31)
1999 /2000**	UK and non-UK, Fresh	140	30 (21)

* Data for 1979-1994 from ACMSF, 1994

**1998-2000 data used a range of methods and was not a national survey (Jørgensen *et al.,* 2002)

COMPARISONS WITH PREVIOUS SURVEYS

Salmonella

71. This is the largest survey of retail chicken carried out to date, and is also the first extensive study to include chicken portions, which currently make up approximately 70% of the raw chicken on retail sale. Whilst direct comparisons between the current and previous surveys are complicated by differences in survey design, sampling and methodology, it is clear that the frequency of *Salmonella* contamination in retail chicken has been falling over the last 20 years, and this is likely to be largely due to the measures taken by the industry to tackle the problem.

72. The 1993/4 survey only included whole chickens and was largely restricted to England and Wales. The overall *Salmonella* contamination rate was 33% for fresh chicken (Method 1, ACMSF 1996), whereas in the current survey it was only 3% for fresh whole chickens purchased in England and Wales. This represents a substantial reduction from the 1993/4 figure and suggests a further reduction on the contamination levels found in the more recent work (1998-2000) to develop methods for use in the survey (Jørgensen *et al.,* 2002).

73. Linked to the reduction in overall contamination levels are the differences in the serotypes that were found. In the 1993/4 survey, 17 different serotypes were identified, of which *Salmonella* Enteritidis was the most frequent, accounting for 43% of the isolates. In the current survey which was much larger, a total of 30 serotypes were found, with *Salmonella* Typhimurium being the most frequent serotype, making up 13% of isolates. The reduction *S.* Enteritidis is not unexpected given the marked fall seen in laboratory confirmed human cases since the late 1990s coupled with the efforts made by the broiler and layer sectors of the poultry industry to tackle the problem.

74. *Salmonella* is more prevalent in frozen chicken, which is consistent with previous surveys (Table 22). The amount of frozen chicken sold at retail is declining (Graph 2, Annex 12), and therefore, overall contamination rates are likely to fall further if the trend towards using fresh chicken continues.

Campylobacter

75. Poultry is recognised as a significant source of *Campylobacter* (see Introduction), although this is the first UK-wide survey to look at the extent of contamination of chicken on retail sale. The survey also provided an opportunity to look at the types of *Campylobacter* present on chicken, and enabled us to identify trends and patterns of contamination.

ANALYSIS OF UNEXPECTED RESULTS WITHIN THE SURVEY

76. Analysis of the results from the survey revealed differences in the frequency of contamination in samples purchased in different parts of the UK. These differences were particularly marked in the case of *Campylobacter*.

77. There was also evidence of an increase in the number of *Campylobacter* positive samples purchased in England and Wales in the last 3 weeks of the 8-week sampling period.

78. The overall prevalence figures for *Campylobacter* were based on the country where the chicken was purchased. However, because chicken production occurs UK-wide, the UK country where the chicken was purchased is not necessarily the same as the country of origin/production. To explore this issue further, Table 23 shows the number of chicken samples purchased in each of the four countries, together with their known UK country of origin/production, where this information was available. Overall figures for non-UK chicken are also shown.

Table 23 - Numbers of raw retail chicken samples examined according to where the chicken was produced and where it was purchased in the UK.*

Chicken purchased in	Chicken produced in (% of Total Samples purchased)						No. samples purchased
	England	Wales	Scotland	Northern Ireland	UK not specified	Non-UK	
England	**1400 (57)**	117 (5)	154 (6)	132 (5)	45 (2)	345 (14)	**2475**
Wales	461 (58)	**35 (4)**	47 (6)	35 (4)	16 (2)	112 (14)	**800**
Scotland	212 (27)	30 (4)	**310 (39)**	17 (2)	11 (1)	99 (12)	**794**
Northern Ireland	101 (13	6 (0.7)	48 (6)	**431 (54)**	28 (4)	135 (17)	**797**

Only those samples where a producer code was obtained are included in the table. Results not included are those from butchers and smaller, individual retailers.

*For example: Of the 2475 samples purchased in England, 1400 were produced in England, 117 were produced in Wales, 154 in Scotland and 132 in Northern Ireland. A further 45 were UK-unspecified and 345 were of non-UK origin

79. The data in Table 23 indicates that the majority of samples were produced in England and 13%, 11% and 4% were produced in Northern Ireland, Scotland and Wales respectively. For each country apart from Wales, the largest proportion of samples taken originated in that country. Once the figures for country of purchase vs. country of production had been established, it was possible to look at the contamination rate using the country of production as the variable.

80. Table 24 shows the *Campylobacter* contamination rate for each country if the number of positives is determined by country of origin/production, rather than country of purchase/testing. When prevalence is presented by country of production, the same broad differences are seen between the findings for the different countries (see Table 1). The differences seen in *Campylobacter* contamination, whether expressed in terms of country of purchase or origin of the chicken, appear to reflect broad differences between the frequency of contamination found by the laboratories testing samples purchased in England and Wales (ADAS, Wolverhampton), Scotland (SAC Aberdeen) and Northern Ireland (SAC Auchincruive). The frequency of isolation by ADAS, Wolverhampton ranged from 37-60% compared to 75-93% for SAC Aberdeen and 50-100% for SAC Auchincruive (Table 24). The reason why chicken samples originating in England and tested in Scotland and Northern Ireland tended to have a lower contamination rate than chicken produced in those countries is unclear but may relate to the nature of the chicken samples tested. The findings from Tables 23 and 24 would support the hypothesis that the differences between the UK countries are primarily a reflection of laboratory variation.

Table 24 - Comparison of the *Campylobacter* contamination of raw retail chicken according to where the chicken was produced and where it was purchased in the UK.

Purchased in	No. of *Campylobacter* positive (%) chicken samples produced in			
	England	**Wales**	**Scotland**	**N. Ireland**
England	**659 (47)**	62 (53)	79 (51)	76 (58)
Wales	199 (43)	**13 (37)**	28 (60)	20 (57)
Scotland	159 (75)	28 (93)	**275 (89)**	14 (82)
N. Ireland	50 (50)	6 (100)	39 (81)	**376 (87)**

81. Agency statisticians also identified a time trend in the *Campylobacter* prevalence figures for England and Wales during the survey (Table 25). In the first five weeks of the survey, the *Campylobacter* positivity for England and Wales samples tested by ADAS, ranged from 30-40%. However, during the last 3 weeks of sampling, this figure increased dramatically to 60-70%. This is much closer to the prevalence found in the SAC laboratories testing Scottish and Northern Ireland samples, where in both cases the laboratories showed similar high rates of positivity throughout the sampling period.

Table 25 - Prevalence (%) of *Campylobacter* in retail raw chicken in the UK (April-June 2001) by week of sampling and country of purchase. Figures in brackets are standard errors.

	Week1	**Week2**	**Week3**	**Week4**	**Week5**	**Week6**	**Week7**	**Week8**	**All**
England	**33**	**32**	**27**	**39**	**44**	**69**	**64**	**64**	**46**
	(2.6)	(2.8)	(2.5)	(2.7)	(2.8)	(2.7)	(2.7)	(2.7)	(1.0)
Wales	**27**	**39**	**21**	**19**	**44**	**74**	**63**	**56**	**42**
	(4.3)	(5.3)	(3.8)	(3.9)	(4.9)	(4.4)	(4.8)	(5.0)	(1.7)
Scotland	**79**	**82**	**83**	**82**	**72**	**68**	**71**	**67**	**75**
	(4.1)	(4.1)	(3.7)	(3.8)	(4.5)	(4.7)	(4.6)	(4.6)	(1.5)
N. Ireland	**66**	**68**	**92**	**78**	**77**	**72**	**74**	**81**	**77**
	(6.1)	(7.5)	(2.7)	(4.0)	(4.0)	(3.7)	(3.7)	(4.3)	(1.5)
UK	**38**	**38**	**33**	**43**	**47**	**69**	**65**	**65**	**50**
	(2.2)	(2.3)	(2.1)	(2.3)	(2.4)	(2.3)	(2.3)	(2.3)	(0.8)

82. With the data available, there did not seem to be an obvious explanation for the sudden increase in *Campylobacter* positivity in samples tested by ADAS, towards the end of the survey. The Agency informed the laboratory of the results, and collaborated with them to try and explain the reason(s) why the shift in positivity might have occurred. From the information that ADAS provided, a series of experiments were conducted to look at any effect of laboratory procedures on isolation rates of *Campylobacter*. The experiments yielded useful information, but did not explain the trend that was seen.

83. It is possible that the sudden change reflected changes in *Campylobacter* prevalence in flocks, which have been documented to increase in late May and early June. If this is the explanation, the increase would be expected to occur later in Scotland and Northern Ireland. However, whilst this explains the absence of a time trend in Scotland and Northern Ireland, it does not explain the differences between the countries. In addition, when the results for frozen chicken and for non-frozen chicken were looked at, a similar

pattern was seen towards the end of the survey. This would suggest that the results are more likely to reflect laboratory differences than seasonal or geographical differences in contamination.

OTHER FACTORS THAT MAY HAVE HAD AN INFLUENCE ON THE SURVEY

84. Sampling for the survey commenced at the beginning of April, amidst the Foot and Mouth Disease (FMD) outbreak in the UK when all movements of livestock were suspended throughout the country. FMD only infects hoofed mammals and poultry were not directly affected by the outbreak. However, because of restrictions on the movements and slaughter of livestock there may have been an increase in the demand for and purchase of poultry meat because of the shortage of pork and red meat. We do not have any data to show whether this actually occurred, but it should be recognised that the survey was undertaken at a time when the chicken meat available at retail may not have been representative of the poultry market as a whole.

85. An EU ban on the chlorination of poultry carcasses was introduced at the beginning of May, about half way through the sampling period of the survey. This practice was used as a control mechanism for the surface contamination of carcasses, but was outlawed because of concerns about the potential risks of chlorine to the consumer. However, the level of *Salmonella* contamination remained fairly constant throughout the sampling period as a whole.

FUTURE SURVEILLANCE WORK

86. The results of the survey have revealed that *Salmonella* contamination of UK retail chicken is now at its lowest level for at least 20 years. However, the Agency will continue to work with the industry to ensure that the current control measures are maintained and we hope to see a further reduction in the level of *Salmonella* in subsequent surveys.

87. The overall level of *Campylobacter* contamination of UK retail chicken was shown to be 50% over the months during which the survey was carried out. Since *Campylobacter* is seasonal, contamination rates may be higher than this at certain times of the year. Unlike *Salmonella*, we do not have comprehensive surveys undertaken over many years with which to compare the *Campylobacter* findings. However, a figure of 50% is within the wide range of figures for chicken reported from various studies conducted in the UK and elsewhere. Nevertheless, the discussion in the preceding sections indicates a degree of uncertainty around the overall figure and this will need to be taken into account when planning future UK surveys of *Campylobacter* contamination of chicken.

88. The Agency feels that future work should be directed towards reducing the level of *Campylobacter* contamination in retail chicken. However, we recognise that the epidemiology and spread of *Campylobacter* in flocks is different to *Salmonella*. Most importantly, vertical transmission is thought to play little or no part in the spread of *Campylobacter* and hence control in the breeding flock. This is a major component of *Salmonella* control, but does not have a role in the control of *Campylobacter* at the production level.

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