Institution: University of Aberdeen

Unit of Assessment: UoA1: Clinical Medicine

Title of case study: Test-Track-and-Tracing *Campylobacter* Food Poisoning in Retail Chickens from Farm to Fork

Period when the underpinning research was undertaken: 2009-2013

Details of staff conducting the underpinning research from the submitting unit:

Name(s):	Role(s) (e.g. job title):	Period(s) employed by submitting HEI:
Ken Forbes	Professor in the Department of Medical Microbiology, key research carried out 2001-2019	1989-2019
Norval Strachan	Professor of Physics, key research carried out 2001-2020	1998-present
Iain Ogden	Research Fellow, key research carried out 2001-2012	1996-2012

Period when the claimed impact occurred: Aug 2013 onwards

Is this case study continued from a case study submitted in 2014? No

1. Summary of the impact (indicative maximum 100 words)

In one of the world's largest molecular epidemiological studies of its kind, University of Aberdeen researchers identified retail chicken as the single largest source of *Campylobacter* food poisoning in Scotland. This underpinning evidence has been used by Food Standards Scotland and the Food Standards Agency to inform their Scottish and UK strategies for reducing food poisoning, and across the EU, by the European Food Standards Agency to drive the introduction of regulations that specify permissible levels of *Campylobacter* on chicken carcasses. This has led to radical industry interventions that has reduced *Campylobacter* in poultry meat improving food safety for 445 million EU people consuming over 15 million tonnes of poultry per year.

2. Underpinning research (indicative maximum 500 words)

Campylobacter is the most common cause of bacterial food poisoning in the world. Symptoms include diarrhoea, abdominal pain, fever and vomiting, and infection can prove fatal for very young children, the elderly and immunosuppressed individuals. The European Centre for Disease Control reported 250,161 cases in 2017[(i)], of which 63,304 were from the UK. A second study of infectious intestinal disease found 9-fold under-reporting of cases suggesting >500,000 cases in the UK[(ii)] annually, resulting in more than 3,500 hospitalisations and >30 deaths[(ii)]. The monetary value of this burden of disease has been estimated to be >GBP1.4 billion in the UK per year[(iii)].

Since 2001, researchers at the University of Aberdeen have investigated sources of human *Campylobacter* food poisoning from farm to fork. This work has been led by Ken Forbes, Professor in the Department of Medical Microbiology (1989-2019), Norval Strachan, Professor of Physics (1998-present) and Iain Ogden, Research Fellow (1996-2012). In conjunction with Food Standards Scotland and the Food Standards Agency, they have led a substantial research programme involving industry and supported by collaborators at Oxford and Glasgow Universities and SRUC.

Campylobacter bacteria live commensally in the gastrointestinal tracts of a wide range of animals and birds and so initial research focussed on identifying the sources of *Campylobacter* infection in humans (2001-2009). Using an interdisciplinary framework for infectious diseases [R3], the Aberdeen research integrated empirical epidemiology, case-case and case-control studies, time

series analysis, and microbial sub-typing (source attribution, diversity, genetic distance) to identify the main sources of human campylobacteriosis. The Aberdeen laboratories specifically used multi-locus sequence typing to characterise isolates recovered from samples allowing researchers to reliably type different *Campylobacter* strains. This interdisciplinary approach established that *Campylobacter* infection in humans was linked with *Campylobacter* contaminated poultry [**R1**; **R2**] and that *Campylobacter* can be considered as an emerging infectious disease [**R3**].

This research also showed that, especially in a rural environment, non-poultry sources of infection (i.e., from ruminants or wild birds) are also important [**R4**; **R5**]. Furthermore, molecular epidemiology was able to link trends in human *Campylobacter* infection with strains of *Campylobacter* typically found in retail chicken [**R4**]. Also, although virtually all campylobacteriosis cases are believed to be sporadic (not recognisably linked) this epidemiological research identified evidence of a common source of infection in one-sixth of cases, even across considerable distances. This suggests that the UK's extensive food distribution networks are likely to be playing an important role in the dissemination of contaminated chicken.

This research has continued during the current REF period focussing on the Grampian region of Scotland which has been established as being representative of Scotland due to its mix of urban, peri-urban and rural areas [**R6**]. These studies provide evidence that chicken continues to be the most important source of human infection. These later studies also employed whole genome sequencing to maximise strain resolution to the highest possible level. It was found that there was commonality of strains from chickens and human cases at this higher resolution providing robust evidence that humans are contracting campylobacteriosis from retail chickens.

External References

(i)ECDC, Campylobacteriosis. Annual Epidemiological Report for 2017. Available online at: https://www.ecdc.europa.eu/sites/default/files/documents/AER_for_2017-campylobacteriosis.pdf (accessed 6th December 2019).

(ii)Tam et al., (2015) The Second Study of Infectious Intestinal Disease in the Community (IID2 Study) Final Report https://www.food.gov.uk/sites/default/files/media/document/711-1-1393_IID2_FINAL_REPORT.pdf (accessed 6th December 2019).

(iii)eftec (2017) Estimating Quality Adjusted Life Years and Willingness to Pay Values for Microbiological Foodborne Disease (Phase 2). Available online at: https://www.food.gov.uk/sites/default/files/media/document/fs102087p2finrep.pdf (accessed 6th December 2019).

3. References to the research (indicative maximum of six references)
(Google Scholar **citations**)

[R1] Sheppard SK, **Dallas JF**, **Strachan NJC**, **Macrae M**, McCarthy ND, Falush D, **Ogden ID**, Maiden, MCJ, **Forbes KJ**. (2009). *Campylobacter* Genotyping to Determine the Source of Human Infection. Clinical Infectious Diseases, 48:1072-1078. doi:10.1086/597402 (**384**)

[R2] Strachan NJC, **Forbes KJ**. (2010). The growing UK epidemic of human campylobacteriosis. Lancet 376:665-667. doi:10.1016/S0140-6736(10)60708-8 (**32**)

[R3] Strachan NJC, **Rotariu O**, **MacRae M**, Sheppard SK, Smith-Palmer A, Cowden J, Maiden MCJ, **Forbes KJ** (2013). Operationalising factors that explain the emergence of infectious diseases: a case study of the human campylobacteriosis epidemic. PloS one 8 (11), e79331. https://doi.org/10.1371/journal.pone.0079331 (**20**)

[R4] Gormley FJ, **Macrae M**, **Forbes KJ**, **Ogden ID**, **Dallas JF**, **Strachan NJC**. (2008). Has retail chicken played a role in the decline of human campylobacteriosis? Applied and Environmental Microbiology 74:383-390. doi: 10.1128/AEM.01455-07 (**111**)

[R5] Strachan NJC, **Gormley FJ**, **Rotariu O**, **Ogden ID**, **Miller G**, **Dunn GM**, Sheppard SK, **Dallas JF**, Reid TMS, Howie H, Maiden MCJ, **Forbes KJ**. (2009). Attribution of *Campylobacter* infections in northeast Scotland to specific sources using multi-locus sequence typing. Journal of Infectious Diseases 199:1205-1208. doi: 10.1086/597417 (**139**)

[R6] Forbes KJ et al., (2017) i-CaMPS4 - Employing Source Attribution and Molecular Epidemiology to measure the impact of interventions on human campylobacteriosis in Scotland. An extension focused on the role of Scottish broiler production on human campylobacteriosis cases. Food Standards Scotland Contract FSS00017 Final report November 2015 - December 2016. Available at: https://www.foodstandards.gov.scot/publications-and-research/publications/campylobacter-attribution-extension

Key Research Grants

Forbes KJ, **Ogden, ID** and **Strachan NJC**. The Molecular Epidemiology of Scottish *Campylobacter* Isolates from Human Cases of Infection using Multilocus Sequence Typing (MLST), Food Standards Agency, GBP759,984.

Forbes KJ and **Strachan NJC**. Employing source attribution and molecular epidemiology to measure the impact of interventions on human Campylobacteriosis in Scotland. Food Standards Agency Scotland, 2010 – 2017, GBP945,759.

Forbes KJ and **Strachan NJC**. A systems wide approach for the control of *Campylobacter* in the food chain: Exploiting Genetic Variation; Rural & Environment Research & Analysis Directorate (RERAD); 2016-2018, GBP245,727.

Forbes KJ and **Strachan NJC**. Integrating Microbiology and Modelling to determine the Source of *Campylobacter* Infection in the Broiler House and Develop interventions, BBSRC; 2012 – 2014, GBP295,130.

Evidence of the Quality of the Research

All papers were published in peer reviewed scientific journals of international standing. The research grants were externally peer reviewed prior to funding being awarded. Final reports from the projects were also assessed by external peer review prior to publication.

The Food Standards Agency and Food Standards Scotland carried out peer review:

Project: FS421003 Employing source attribution and molecular epidemiology to measure the impact of interventions on human Campylobacteriosis in Scotland. Ken Forbes, Norval Strachan (2010-2016)

The reviewing panel evaluation

"This was a well written piece of work. It involved the setting up of an archive, and it was felt very important to have this resource....The project outcomes were considered highly beneficial. Overall, it has shown that the work was of high quality, yielding some very important data. The panel were confident that either referring to, or using, this data could be relied upon. This project was held up as an excellent example of funding by the FSA."

Science: 5 (out of 5), Value for money: 5 (out of 5).

4. Details of the impact (indicative maximum 750 words)

The Aberdeen work investigating the sources of human *Campylobacter* infection in Scotland was the first study in the world to do so on a national scale and this was reported in REF2014. Since then, the more recent Grampian-based studies have further refined and strengthened the evidence at a genome-wide resolution – detailing that retail poultry is the main reservoir of human campylobacteriosis. In the current REF period these data have driven the public health strategies of both Food Standards Scotland and Food Standards Agency in aiming to reduce *Campylobacter* from the 250 million[a] retail chickens produced in the UK each year. This has been achieved by industry interventions, listed by the British Poultry Council Chief Executive as including "*on farm biosecurity; catching practices; thinning practices; crates and modules; scalding practices; washing practices; heat treatments; cold treatments and novel packaging*" [**S1**] which have reduced the prevalence of birds with >1000 cfu/g (colony-forming units: a measure of viable bacteria per gram) from 18.4% to 5.8% between 2014 and 2019[b]. Our work has had international impact across the EU, with its 445 million citizens, and annual consumption of over 15 million tonnes of poultry per year. Our work has had international impact by providing underpinning data on which to base current EU regulations on the permissible levels of *Campylobacter* in retail chicken.

Our work underpins EU regulations on *Campylobacter* in retail chickens

Our previous impact case study for REF2014 reported that in 2009, the Aberdeen team had provided the European Food Safety Authority (EFSA) BIOHAZ panel with evidence of the extent to which meat derived from retail chickens contributes to human campylobacteriosis, following which EFSA published scientific opinion and issued guidance in 2010 [**S2i**]. EFSA, as a result of this and in combination with its risk assessment work issued advice on reduction of *Campylobacter* in retail meat production in 2011 [**S2ii**]. This led to publication on 23rd August 2017 of the EU commission regulation (EU) 2017/1495 [**S3**] which stipulates the levels at which *Campylobacter* may be present in chicken carcases. Para 5 of this document quotes the EFSA opinion [**S2i**] which as mentioned above is underpinned by the Aberdeen studies. The EU regulation came into force across the EU in January 2018. Hence, the Aberdeen studies have been central to the provision of underpinning evidence for food safety regulation across the 27 member states of the European Union, as evidenced in testimony from the EFSA Chief Scientist [**S2iii**].

Our research drives food safety policy impacts in England, Wales and Northern Ireland

The Food Standards Agency (FSA), which is an independent Government department working across England, Wales and Northern Ireland to protect public health and consumers' wider interests in food, published its strategic plan 2015-20 FSA in 2015 [**S4i**]. The plan's "Food is Safe" theme states that ***"Campylobacter is the most common cause of human bacterial food poisoning in the UK…. … up to 80% of cases can be attributed to raw poultry meat",*** a statistic arising directly from Aberdeen University's research [**S4v**]. The FSA plan used this evidence as a rationale for a campaign to significantly reduce levels of *Campylobacter* in retail chickens. Updates on the *Campylobacter* campaign were presented to the FSA board in July 2015 [**S4ii**] and March 2016 [**S4iii**] which detail results of surveys of *Campylobacter* in retail chickens as well as progress being made by the industry in reducing the prevalence of birds with >1000 cfu/g [**S4iv**]. Hence the Aberdeen studies have been directly used as underpinning evidence to inform the policy making decisions of the FSA, as confirmed by FSA Senior Scientific Officer, who said "*The expertise of Professor Strachan has been of immense help to the work of the FSA in relation to Campylobacter reduction and his knowledge and expertise have aided the FSA in policy development in this space*" [**S4v**].

Our work provides the platform for chicken food safety policy in Scotland

In 2016, Food Standards Scotland (FSS) developed its 3-year Corporate Plan that lays out its programme of work [**S5i**]. The plan states "***Reducing foodborne illness from Campylobacter is a priority for FSS. Current evidence suggests that between 55-75 percent of all reported cases of Campylobacter infection in Scotland are associated with a chicken source, and that a significant proportion of fresh chicken on retail sale in the UK is contaminated with the pathogen***." The evidence quoted is from the Aberdeen studies and is used here to directly underpin FSS policy. The FSS corporate plan then goes on to state "**What we'll (FSS) do….. ….generating programmes to reduce the risks of *Campylobacter* in Scottish-produced chicken….."** [**S5iv**].

This evidence, together with updated evidence from our more recent source attribution studies in Grampian [**S5ii**], was used in a recent (15th May 2019) FSS board paper [**S5iii**] on *Campylobacter* which states ***"chicken-related Campylobacter strains continue to be most commonly identified in human illness in Scotland (52-68%) followed by strains from ruminant (cattle and sheep) sources."*** This then informs the policy which was agreed by the FSS Board at the meeting ***"to drive further reductions in Campylobacter in UK produced chicken by promoting sustained action by the major retailers, and supporting farmers and smaller producers/retailers in Scotland and the rest of the UK in controlling the risks."*** Hence, the Aberdeen studies are being used as underpinning evidence to inform the policy-making decisions of FSS, the national food body of Scotland, as confirmed by the FSS Chief Executive, who said "*The policies of FSS and FSA, informed by the University of Aberdeen work, have been successful in reducing the levels of Campylobacter in retail chicken. This is evidenced by the implementation*

of industry interventions which have reduced the prevalence of birds with >1000 cfu/g from 18.4% to 5.8% between 2014 - 2019 and hence improving food safety" [**S5iv**].

Therefore, the claimed impacts include: public health and disease prevention has been enhanced by research; decisions by a health service or regulatory authority have been informed by research; public awareness of a health risk has been raised. Impacts on commerce have been that industry (including overseas industry) have had to develop practices and/or change existing production and processing practices, to ensure that they produce retail chickens that satisfy EU and national regulations. Impacts on public policy and services have been that policy debate has been stimulated and moved forward by research evidence; policy decisions have been informed by research evidence. Impacts on production have been that decisions by regulatory authorities have been influenced by research. International policy development has been influenced by research.

[a]DEFRA, Historical statistics notices on poultry and poultry meat production, 2018 https://www.gov.uk/government/statistics/historical-statistics-notices-on-poultry-and-poultry-meat-production-2018
[b]Food Standards Agency (2019) *Campylobacter* Data Gathering Survey https://www.food.gov.uk/sites/default/files/media/document/campylobacter-data-gathering-survey.pdf

5. Sources to corroborate the impact (indicative maximum of 10 references)

[**S1**]. BPC testimonial – Chief Executive
[**S2**]. EFSA documents
i. EFSA Panel on Biological Hazards
ii. EFSA articles (press release + scientific opinion piece) on advice on reduction of Campylobacter in chickens
iii. EFSA testimonial – EFSA Chief Scientist
[**S3**]. Commission Regulation (EU) 2017/1495
[**S4**]. Food Standards Agency documents
i. FSA Strategic Plan 2015-20
ii. FSA Board Paper 15th July 2015 (FSA 15/07/05
iii. FSA Board Paper 16th March 2016 (FSA 16/03/06)
iv. FSA (2019) *Campylobacter* Data Gathering Survey
v. FSA testimonial – FSA Senior Scientific Officer
[**S5**]. Food Standards Scotland documents
i. Shaping Scotland's Food Future: Our Strategy to 2021 and Corporate Plan
ii. i-CaMPS4 – Final Report Nov 205 to Dec 2016
iii. Board Meeting 15th May 2019
iv. FSS testimonial – FSS Chief Executive