Animal & Plant Health Agency

Risk to human health from consumption of VTEC O157 in beef burgers

Summary Report

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Introduction

A quantitative risk assessment has been developed previously to estimate the impact on human health from the consumption of VTEC O157 within a beef burger and other food products (Kosmider *et al*., 2010; Appendix 1). The beef model simulates the prevalence and amount of VTEC O157 through the production process starting at the abattoir through to human consumption. The model provides an estimate of the prevalence of contaminated beef burgers within 100,000 servings and the corresponding number of human illnesses given the estimated amount of VTEC O157 consumed within a contaminated burger in the domestic home setting.

The aforementioned model was developed in 2008 as part of an EU Camp-EC Net project and aimed to use the best available data including, where possible, data to reflect cooking preferences and consumption patterns in Great Britain. The assumptions, data used and methods are outlined in Appendixes 1 and 2. Over time, however, cooking preferences and consumption patterns can change as has been recently observed, for example, with an increasing trend in eating under-cooked beef burgers. As part of the iterative nature of risk assessment, the model can be updated to reflect these changes and provide revised, current estimates of the impact on human health from consumption of VTEC O157 in beef burgers. This report provides an overview of the parameter estimates that have been updated in view of these recent changes in behaviour, the scenarios considered in agreement with the FSA, and a summary of the updated results. All other parameters and assumptions remain as per the original model.

Parameter updates

The parameters considered influential in determining the impact to human health from the consumption of VTEC O157 within cooked or raw burgers were: 1) the size of the burger produced, 2) the amount of the burger consumed (consumption patterns), and 3) the style of cooking (e.g. rare, medium, well-done). Each parameter is considered in turn. All other parameters remain unchanged from the original model, as agreed with the FSA.

Size of burger produced

Within the original model, it was assumed that during further processing either a pack of 4 or 2 burgers were produced with each weighing 113 grams. This was based on a small retail survey of burgers sold in main supermarket chains. To ensure that this was still a reflective estimate, a further small retail survey was undertaken. From this study, it was observed that in addition to the 113 gram burgers, smaller burgers in packs of 8 were on retail sale with each burger weighing approximately 85 grams. The model, therefore, was updated to reflect the inclusion of these small burgers.

Amount of burger consumed

Within the original model, the amount of burger consumed was based on a study of food portion sizes in adults aged 19-64 years undertaken in 2004. This study, though used in the model, provided highly variable estimates with a median of 78 grams, 25th percentile of 52 grams and 75th percentile of 106 grams. More recent consumption data are available for 2008-2012 but was not specific to burgers stipulating consumption of red meat only. It also did not provide an estimate of the frequency of consumption. These consumption studies typically provide an average estimate over a short time period (e.g. 7 days) and do not consider the amount consumed per serving or frequency of consumption; both of these estimates are important inputs for the model. Therefore, in discussion with FSA, it was assumed that in a given serving, the whole burger (either 113g or 85g) is consumed.

Style of cooking

The cooking preferences incorporated within the original model were well done, medium and rare, with mean temperatures of 68.3, 62.7 and 54.4^{o}C respectively. The temperatures were modelled using a Normal distribution to allow for variation around this mean temperature of 2 ^{o}C. The corresponding log reduction after cooking is then calculated using the same methodology as Cassin *et al*., 1998. The current FSA recommendation is to cook a burger at 70 ^{o}C for 2 minutes. This temperature value is included within the range of possible temperatures for a well-done burger. The temperature ranges, therefore, were not changed from the original model.

Within the original model, it is assumed that the frequency in which these cooking styles are observed were 87% of the time (well done), 12% of the time (medium) and 1% of the time (rare). In discussions with the FSA, it was considered that this may not be reflective of the current situation. Updated data from a 2014 'Food and You' Survey (FSA, 2014) suggested that these preferences had changed to a slight increase in raw burgers (3.3% of time), with medium reducing to 8.8% of the time and well done remaining at approximately 87.9% of the time. Using these revised preferences provides an indication of the national level of human infection given 100,000 servings of burgers. However, as the FSA are also interested in understanding the risk at an individual level, the model was run with each cooking preference in isolation to provide a direct comparison of the relative risk between cooking burgers well done, medium and rare.

In addition to the revised estimates for the cooking styles, at the FSA's request, two additional log reductions were considered: a 4 log and 6 log reduction respectively.

Scenarios

In summary given the revision to the parameters as outlined above, several scenarios were considered namely,

- All burgers well done
- All burgers medium
- All burgers rare
- All burgers reduced by 6 logs during cooking
- All burgers reduced by 4 logs during cooking

For each scenario, three further scenarios were considered regarding burger size consumed namely, big burgers only (113g), small burgers only (85g) and both sizes (big and small 50:50). This yielded a total of 15 different scenarios.

In addition, a further scenario of consuming burgers (big and small) cooked using either of the preferences (well-done, medium and rare burgers) according to the revised frequencies outlined above was considered.

Results

The model was run for 1 million iterations in order to capture all variability/uncertainty contained within the model. As per the original model, the main output is given regarding the mean number of infections per 100,000 servings of burgers. A summary of the expected number of infections with VTEC O157 per 100,000 servings for the 6 scenarios is shown in Table 1. Investigation into the effect of burger size found very little difference in the expected number of cases (results not shown); as such, we only consider a combination of big and small burgers (half big, half small).

Table 1: Summary of the number of human infections per 100,000 servings for the 6 scenarios

	Mean
Well done	8
Medium	11.3
Rare	19
6 log	3.3
4 log	10
All cooking styles	9.3

As expected, the model predicts that consumption of rare burgers results in the highest number of human illness per 100,000 servings (average = 19) compared to medium (average = 11.3) and well done (average = 8) burgers. More specifically, on average, there is a 41.25% and 137.5% increase in the mean likelihood of infection for medium and rare burgers respectively, compared to a well-done burger. Furthermore, a burger that achieves only a 4 log reduction is 203% more likely to cause an infection compared to one that achieves a 6 log reduction (which is assumed to be the desired reduction).

A key consideration here is the difference between well done burgers and burgers achieving a 6 log reduction after cooking. Assuming that both are comparable (i.e. a well done burger should achieve a log reduction of a similar magnitude), the well done category highlights that, in practice in the home, cooking burgers to 'well-done' is unlikely to achieve the same log reduction. This is a result of the variability of cooking practices in the home with not all well done burgers reaching 70°C (only 19.8% of burgers reach the required temperature). Further, importantly, the model does not account for the duration of cooking.

Within the combined simulation, it was assumed 87.9% of burgers are well done, 8.8% medium and 3.3% are rare (FSA, 2014). The corresponding mean number of cases per 100,000 servings was 9.3.

This compares to 8 infections estimated in the original model (Kosmider *et al.,* 2010). This increase in the number of infections in the revised model is not unexpected given the increase in the frequency to eat rare burgers compared to the original model.

Model verification

An important part of producing models, particularly if using to base policy or other decisions, is to ensure that they are providing plausible and valid outputs and, thereby, simulating as accurately as possible the process under study. There are, however, limited points at which data are available for validation for this model. Ideally, it would be useful to validate the model output by comparing the predicted number of human infections with raw data on the number of human illness of VTEC O157 from consumption from food. However, to date, this is difficult to achieve as the source of human infection is not always identified and, further, does not differentiate between infections acquired in the domestic versus the catering setting. An alternative validation or verification step, however, is at retail comparing model outputs from this module to data from retail studies.

There are limited studies providing updated results on VTEC O157 at retail. A study by Cagney *et al*. 2004, found 4.46% of fresh burgers in Irish supermarkets to be positive for *E. coli* O157, with counts from <0.52 – 3.04 $\log_{10}$ cfu g^{-1}. This in addition to those studies considered for verifying the original model, suggests that the retail prevalence of VTEC O157 in beef products ranges from 0.36% to 4.46% (Kosmider *et al*., 2010). Within all simulations and model scenarios, the average proportion of contaminated burger packets at retail was found to be approximately 2.0%, with an average of 0.67 $\log_{10}$ cfu per contaminated burger. Broadly, the predicted prevalence levels are in-line with the ranges observed in retail studies. Though this is not proof that the model is valid, it provides an indication the model is producing plausible results.

Quality statement

The original model was developed in accordance with the APHA quality standards at that time (ISO9001). The final report was peer reviewed and commented upon by the FSA (Appendix 2). In updating the model, it has been internally verified and checked for accuracy (including linked cells, equations) including ensuring the model aligns with the written report and peer-reviewed scientific paper (Appendix 1).

Discussion

A model that was developed previously is used here with updated parameter values to assess the risk of human infection with VTEC O157 due to the consumption of beef burgers cooked to varying preferences. The model predicts an increased risk of infection for burgers that are consumed medium compared to a well-done burger. A higher risk is predicted for rare cooked burgers. Similarly, burgers that achieve a 4 log reduction, pose a higher risk than those that achieve a 6 log reduction.

Interestingly, there is a difference in the estimated risk of human infection between the model estimates for the individual cooking styles (well done, medium and rare), compared to the assumed 4 and 6 log reductions. This is believed to highlight the variability in obtaining the cooking temperatures in the home and actually achieving the recommended 6-log and 4-log reduction representative of well done and medium cooked burgers respectively. This will be investigated further through the application of a thermodynamic model developed by the RIVM within the APHA risk assessment. This work will be undertaken in early 2015.

References

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