In spite of all the preventative measures taken in recent years, Campylobacteriosis is still a considerable health risk for the Dutch population. Moreover, the industry has lacked a strong understanding of the measures aimed at reducing Campylobacteriosis. The CARMA project’s goal was to advise the Dutch government about the effectiveness and efficiency of measures aimed at reducing the infection in the Dutch population.

Campylobacteriosis

Campylobacter bacteria are a common cause of food-borne infection. It is estimated that each year in the Netherlands 80,000 cases of Campylobacter gastro-enteritis result in 18,000 patients visiting their GP. Also, more than 600 hospitalisations occur and about 30, mainly elderly, patients die.

The disease burden from Campylobacter infections is estimated at about 1,200 Disability Adjusted Life Years (DALYs) per year, which is comparable to that of tuberculosis and bacterial meningitis. Illness costs are estimated at about €21 million per year, of which three quarters is a result of sick leave due to gastro-enteritis.

CARMA’s questions

To meet its goal, CARMA investigated two key questions:

● What are the most common routes by which the Dutch population is exposed to Campylobacter, and can the contribution of these routes be quantified?

● What measures can be taken to reduce exposure to Campylobacter, and what is their expected effectiveness, efficiency, and societal support?

The multi-disciplinary project combined input from microbiologists, epidemiologists, mathematicians, economists and social scientists, all from various research institutes (RIVM National Institute for Public Health and the Environment, Animal Sciences Group of Wageningen UR, LEI Agricultural Economical Institute, the Dutch Food Safety Authority VWA and RIKILT Institute of Food Safety). The project cost (around €2 million) was financed by the Ministries of VWS and LNV and by the VWA.

Figure 1 – Evaluated interventions in the chicken meat production chain

Monospecies farms
Improved hygiene
No thinning
Phage therapy
Logistic slaughter
Channeling
Reduction of faecal leakage
Decontamination of scalding tank
Treatment of carcasses:
- decontamination,
- crust freezing,
- irradiation
Freezing of products
Channeling to meat processing
Freezing at home
Improved kitchen hygiene
Information campaign
In consultation with representatives of the Ministries of VWS and LNV, of the VWA and of the poultry industry, the project group studied a number of interventions in the chicken meat chain that could reduce health risks to the consumer (Figure 1).

Mathematical and economical modelling were used to estimate the costs and benefits of the various potential interventions.

Attention was also paid to the societal support for these preventive measures among consumers and the industry. This information aims to support the political decision-making process.

The results of the project can be summarised in four key messages:

- Campylobacter infection in humans is a multi-source problem, and chicken meat is one of the most common routes.
- Reducing Campylobacter contamination in chicken meat is effective for public health.
- Measures to reduce contamination of chicken meat may be cost-effective for society as a whole.
- Active communication with all stakeholders during governmental decision making and implementation of measures is paramount.

Infection routes
Different routes for Campylobacter infections can be identified, but it is very difficult to determine the quantitative contribution of each separate route to the total number of infections. According to epidemiological investigations, the most important route of infection is by the handling and consumption of poultry meat (estimated at 20-40% of all infections, corresponding to 16,000-32,000 Dutch cases of gastro-enteritis yearly).

Quantities
One of the most important insights gained from the CARMA-project was that it is not just presence or absence of pathogenic bacteria that is important, but also the amounts in which they are present. Figure 2 shows the results of our base-line model.

From this base-line model it was calculated that in 0.8% of all cases the consumer is exposed to one or more Colony Forming Units (CFU) of Campylobacter-bacteria due to cross-contamination from chicken fillet to salad. Dose-response modelling assumes the single-hit-principle: exposure to only one CFU may lead to infection and disease, even though the risk is very low.

Increasing the dose also increases the risk for infection and disease. Figure 2 also shows that a relatively large number of illnesses are caused by relatively few exposures of more than ten CFU.

So, poultry products with low-level contamination do not carry a major public health risk. Therefore, some interventions (such as discontinuing thinning and logistic slaughter) are not effective in risk reduction for the consumer, because they only prevent low level contaminations.

Effectiveness and efficiency
The effectiveness of the various interventions in risk reduction for consumers as calculated from the models is given in Figure 3.

A cost-benefit analysis of the interventions was also undertaken, to estimate the efficiency of these measures. The cost-benefit ratio (K-W)/Z per averted DALY was calculated from:

K: (direct) costs of an intervention, like investments and variable costs (in €)
W: reduced costs of human illness (in €)
Z: reduced human disease burden (in DALY)

Figure 4 summarises the efficiency of interventions.

Scheduling
Instead of applying intervention measures to all flocks, treating only Campylobacter-positive tested flocks might be a possibility. This is called scheduling. Figure 5 shows the cost-benefit ratio for some interventions, comparing scheduling and non-scheduling. In general, scheduling leads to better efficiency, but there are some additional drawbacks:

- highly sensitive protocols to detect infected flocks are a prerequisite but are not yet available
- for some interventions, there may be a shortage in fresh meat supply in summer
- Logistical problems may lead to product inefficiency.
- The economic consequences of product inefficiency and quality losses may be greater than the benefits due to scheduling.

These drawbacks become less problematic if flock prevalence at the farm is low.

Import of poultry meat
The Netherlands imports and exports both live poultry and poultry meat. The origin of the poultry meat consumed in the Netherlands is not very clear, which results in additional uncertainties. Also, the Dutch consumer will not be fully protected when measures are only taken within the Netherlands. On the other hand, taking into account all consumers of Dutch poultry meat (including the export market), overall health benefits will be higher.

From a public health point of view, measures should be taken on an European level, taking into account imported meat from countries outside Europe.
The intervention costs must primarily be paid by the industry, whereas the benefits generally would be for individual (European) citizens, employers and healthcare insurance companies.

Compensations and bonus payments might be considered when introducing implementation of intervention measures.

**Recommendations**

Based on the results of the CARMA project, the following recommendations have been given to the Dutch government and the industry:

- address multiple sources of Campylobacter (like chicken meat, direct contact with animals and foreign travel), and
- reduce exposure from chicken meat specifically by:
  - promoting a consistently high level of farm hygiene
  - implementing scheduling programmes
  - considering and optimising decontamination and reducing faecal leakage during slaughtering
  - maintaining hygiene education for consumers
  - developing compensation mechanisms to recover costs
  - increasing chain transparency
  - taking measures at the European level
  - aiming for risk-based food safety and performance objectives rather than zero-tolerance.

![Figure 5 – The relative frequencies of dose classes and the percentages of human cases of campylobacteriosis attributable to those classes.](image)