Food Safety in the Poultry Industry: An estimate of the health benefits

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Abstract

A food safety compliance programme applied to poultry primary processing since 2007 has reduced the burden of disease. By addressing the primary source of this foodborne disease campylobacteriosis notifications have dropped by 58% since 2007, and public health costs dropped proportionately. Mutually linked externalities generated great advantage for public health at some expense to the private industry profit margin.

A cost benefit analysis was undertaken comparing health benefits with the industry costs following the application of the *Campylobacter* compliance programme. A clear positive linkage between the industry and regulatory cost of compliance and the internal social benefit to the New Zealand economy is demonstrated.

General outline

Presently the monitoring of disease reduction is focussed on medical practices, costs of associated chronic complications, determining the sources of pathogenic microbes and emerging strains, alternative pathways and public health urban/rural analyses. There has been little or no focus on the direct health impact of primary industry compliance measures.

Attention is generally focussed on the costs of disease, including outbreaks, rather than the value of preventative measures to reduce disease. This paper considers the impact of a compliance programme at the primary processing stage to reduce the burden of disease. It is based on preliminary findings from my thesis.

The example I use is the cost of the application of the National Microbiological Database (NMD) sampling programme for poultry broilers (broilers are birds killed specifically for human consumption). This was first applied by the poultry industry in 2001 testing for generic *E. coli* and *Salmonella* to provide comparative data on hygienic slaughter and dressing. In April 2007, as a key component of the NZFSA *Campylobacter* Strategy, a *Campylobacter* sampling and testing programme for poultry broilers began under the NMD programme. By the end of 2007 *Campylobacter Performance Targets* (CPT) had been established from the data received. In April 2008 regulatory responses were required to be applied to premises upon breaching the *Campylobacter* Performance targets according to the level of the breach (Site 2008).

There were high initial capital costs in meeting the new NMD *Campylobacter* programme standards. It was unlikely industry would have found this a worthwhile investment in the absence of this compliance programme.

The National Microbiological Database (NMD)

In 2001 the poultry industry volunteered to participate in the NMD programme to assist the industry to meet the microbiological standards required gaining Risk Management Programmes (RMPs) as required for the Animal Products Act 1999. The NMD programme had been established for the meat industry from 1996 to meet market access requirements to the United States of America and the EU.

Despite the application of the NMD programme from 2001 no advance was being made on reduction in *Campylobacter*. In fact campylobacteriosis in New Zealand continued to increase. Early results in

2006 from attribution studies using cases from the Manawatu region (located in the lower North Island of New Zealand) indicated consumption of poultry meat was associated with 50% of campylobacteriosis cases (Sears, Baker et al. 2011). It was this study conducted by Massey University for NZFSA with initial findings published in January 2007 (final report published 2009) that motivated the poultry industry to begin investing to reduce the *Campylobacter* loading on product for sale for human consumption (Mullner, Carter et al. 2007),(Mullner and French 2009). Particular *Campylobacter* measures needed to be implemented over and above those that had been effective for *E. coli* and *Salmonella*.

Interventions

A key part of the poultry industry undertaking to improving industry practices was research into interventions including good hygienic practice (GHP) based control measures on the farm, and hazard analysis of critical control points (HACCP) and GHP in primary processing (CODEX 2010).

Intervention has a wider meaning than a "silver bullet" such as pasteurisation or single activity in the process such as the use of acidified sodium chlorite. Interventions are activities that reduce the pathogenic microbiological loading of the bird on the farm, or during the processing. Such practices include biosecurity on poultry broiler farms, improvements in crates used to carry the birds, equipment maintenance, upgrading process equipment, evisceration procedures, carcass washing procedures, chlorination levels in spin chill and other chemical decontamination steps. Chemical decontaminating steps include those chemicals used by organic processors; for example citrox. To ensure the effectiveness of any intervention steps oversight and control of risks must include smarter procedures, staff training, statistical analysis of data, good maintenance programmes and attention to the detail of good management practice. The set up of any intervention will incur a cost. The cost could be increased operating costs, research costs and /or capital investment.

Impact on industry

PIANZ claims that the poultry risk management programme has reduced its operating margins. -(Gadiel 2010), and personal communication with Michael Brooks, Chief Executive of the Poultry Industry Association of New Zealand (Inc) (PIANZ). The consequence of this has been withdrawal of some industry players and possible lack of confidence in future investment in the poultry industry.

Since the poultry *Campylobacter* NMD commenced in March 2007 there have been no product withdrawals, but some premises have been required to freeze product for consumer safety. Two premises reached response 5 level due to ongoing breaches of the *Campylobacter* Performance Target (CPT) and required inspection visits by the NZFSA/MAF *Campylobacter* Response Team. One premises reached response 5 level on two occasions and was ordered to freeze product while taking steps to address issues. It then became compliant, but closed its business soon after. The other premises, processing to organic standards, reached response 5 level on three occasions. This premises was ordered to freeze product each time, but made the necessary improvements. This premises has maintained compliance since November 2009 and remains in business.

Two premises reaching response 4 level requiring a *Campylobacter* Response Team visit. General hygiene issues and poor control of chemical decontamination steps were identified. Upon becoming compliant this premises voluntarily shutdown. Another premises reaching response 4 level had taken insufficient samples, had not ensured that sample testing was conducted according to the

NMD *Campylobacter* programme, in addition to process and chemical decontamination issues. This premises is now meeting sampling and processing requirements and remains in business (MAF 2011).

The above examples demonstrate the business impact of compliance with the NMD programme. Other premises have faced similar challenges to meet the CPT and remain in business.

Reduction in human cases from 2006 to 2008

To compare the costs of industry investment in NMD compliance in 2006/2007 and 2008/2009 with improvement in New Zealanders health I reviewed the Notifications of *Campylobacter* that peaked in the year 2006, against those for the 2008 year. In 2006 there were 383.5 Campylobacter cases per 100,000. By the end of 2008 this had reduced to 166.3 per 100,000 (ESR 2010). This was a 58% reduction in notifiable cases (calculated using total case figures).

The principal factor that contributed to the decline was the implementation of the *Campylobacter* Strategy which, as outlined in the previous section, required substantial investment by the poultry industry. Other enteric diseases, such as salmonellosis and cryptospiridosis, did not demonstrate any decline over this period. The fall in notifications followed a seasonal pattern with a higher proportion of notifications in the summer. Notifications fell across all population subgroups. This is consistent with a common standard applied at primary industry level affecting all consumers equally (Sears 2009). That common standard was the compliance programme applied by the poultry industry in partnership with the regulator.

Economic analysis

A comprehensive breakdown of the costs over the 12 months of the poultry broiler NMD sampling programme (April 2006 to March 2007), and after the inclusion of *Campylobacter* (April 2008 to March 2009) has been compiled. The estimated total cost to industry of implementing the original NMD *E. coli*/*Salmonella* compliance programme in the year April 2006 to March 2007 was $98,893 based on data supplied by PIANZ.

The poultry broiler *Campylobacter* NMD programme required: (1) greater complexity in coordinating the NMD programme including additional operator audits of farm, plant and samplers, (2) increased staff training, (3) review of results including grower education, production staff meetings dedicated to *Campylobacter* processing issues and generation of quality reports, (4) improved IT facilities to incorporate *Campylobacter* results and responses to results. Industry costs rose to $377,636 over 2008/2009. This represented a 282% increase from the original NMD compliance programme, pre-*Campylobacter*.

Capital upgrades to improve washing/chilling and/or post chill dip over 2007/2008 prior to the imposition of regulatory responses in April 2008 were $2,014,000. The on-going cost of the capital investment in intervention systems is the cost of chemicals; citric acid and sodium chlorite estimated at $500,000 per annum overall (personal communication with Roy Biggs). The total cost to industry to maintain the compliance programme (excluding initial capital investment) was now $877,636 per annum ($377,636 plus the $500,000 per annum chemical costs). The greater expense of the *Campylobacter* NMD compliance programme itself and the capital investments needed to be made to improve standards was of no direct commercial advantage to the poultry industry.

An estimate of the health costs of foodborne disease in 2005 was taken from Cressey and Lake(Cressey and Lake 2008) and converted to 2007 dollars. The estimated cost of campylobacteriosis from Cressey and Lake is the nearest to 2007, but will underestimate the cost of disease at the beginning of 2007 as the epidemic had peaked by then at 15,900 notified cases per annum corresponding to a total of approximately 159,000 community cases. To ascertain cost data for the start of 2007 (the health challenge for 2007) I needed to scale up the 2005 data appropriately. The number of community cases estimated by Cressey and Lake was 123,000 (Derived from Tables 8 and 9: ((Cressey and Lake 2008)). Thus the estimated *total cost* due to foodborne campylobacteriosis at the start of 2007 is $99m per annum (ie $77m*(159,000/123,000)).

Table 1 Estimation of health costs in 2007 ($m)

	2005 (a)	2005 data adjusted to 2007 dollars	Estimated health cost for 2007. Figures in 2007 dollars
Direct health costs	4.3		
Indirect health costs	0.3		
Total health	**4.6**	4.8	6.2
Lost productivity	69		
Loss of life	-		
Total Indirect	**69**	72	93
TOTAL	**74**	**77**	**99**

(a) From Cressey and Lake (2008)

Reduction in the disease burden

There was a 58% reduction in Campylobacter (15873 cases in 2006 compared to 6694 cases in 2008). Assuming a linear relationship between health costs and the number of cases this implies savings of $57.4m (ie 58% of $99m). Excluding the indirect costs, there is still an annual benefit of $3.6m (ie 58% of $6.2m) based on the total health costs (Table 1).

Industry costs

I used the capital investment cost ($2.014m) and estimated on-going annual costs ($0.88m per annum) from the figures supplied to me by industry.

Government costs

The government cost for the poultry *Campylobacter* strategy was $950,000 in 2009 equivalent to $885,000 in 2007 dollars (Gadiel 2010, page 14); $0.89m per annum.

Assumptions

My assumptions are:

(1) that the compliance programme will maintain this reduction in *Campylobacter* levels just as a vaccination programme would;

(2) the compliance programme is the principal vector affecting this change;

(3) the total community cases are 10 times the notifications (Professor Diane G. Newell (Casey 2011)); and

(4) that there is a linear relationship between notifications and health benefits.

The application of this common compliance standard would be expected to have an initial impact, level out and then possibly rise again as the focus shifts away from the original epidemic, loss of industry experience of factors related to contamination of broiler carcasses and development of maintenance problems with interventions or other occur. This type of pattern is described as the Bathtub curve (NIST). I have not made any estimation of a possible future rise in notifications.

NPV

To estimate the benefits from the investment in the compliance programme a Net Present Value (NPV) calculation was undertaken **using a discount rate of 10%**. While a rate of 3% has been used with industry compliance studies for *Salmonella enteriditis* in the USA(Roberts 2006-7-31) 10% is recommended by Treasury for CBA (The Treasury New Zealand Government 2005). The NPV calculations were based on a 10 year horizon.

Table 2 Comparing benefits to health from poultry industry investment in compliance.

						Benefits	
	Confirmed		Costs	Costs		undiscounted	
	notified		undiscounted	undiscounted		The 58% gained	
	cases		Industry	Government	Total costs	Income	Benefit
Year	per annum	Year	$m	$m	$m	$m	$m
2007	12778	0	$2.01	0.89	2.90		-2.90
2008	6694	1	$0.88	0.89	1.77	57.40	55.63
2009	7177	2	$0.88	0.89	1.77	57.40	55.63
2010	*7345*	3	$0.88	0.89	1.77	57.40	55.63
2011	*7000*	4	$0.88	0.89	1.77	57.40	55.63
2012	*7000*	5	$0.88	0.89	1.77	57.40	55.63
2013	*7000*	6	$0.88	0.89	1.77	57.40	55.63
2014	*7000*	7	$0.88	0.89	1.77	57.40	55.63
2015	*7000*	8	$0.88	0.89	1.77	57.40	55.63
2016	*7000*	9	$0.88	0.89	1.77	57.40	55.63
2017	*7000*	10	$0.88	0.89	1.77	57.40	55.63
					Total costs		
		Sum	$10.81	9.79	20.60	574.00	553.40
				Internal Rate of Return		IRR =	1918%

	Discounted	10%	
j	Total	Benefits	Benefits
year/power	Costs	discounted	
	$m	$m	$m
0	2.90	0.00	-2.90
-1	1.61	52.18	50.57
-2	1.46	47.44	45.98
-3	1.33	43.13	41.80
-4	1.21	39.20	38.00
-5	1.10	35.64	34.54
-6	1.00	32.40	31.40
-7	0.91	29.46	28.55
-8	0.83	26.78	25.95
-9	0.75	24.34	23.59
-10	0.68	22.13	21.45
PV	13.78	352.70	338.92
		B/C ratio	25.60

This is a very high benefit cost ratio. The highest proportion of the **total** benefit is due to indirect **non-health care** costs which have been estimated by the human capital method. A sensitivity analysis has been conducted removing all the indirect **non- health care** costs and basing the NPV

calculations using 58% savings of $6.2m Total health (from Table 1, excluding indirect costs) which is $3.6m.

Table 3 Comparing the benefits if only direct and non-direct health benefits are included

						Benefits	
		Confirmed	Costs	Costs		undiscounted	
		notified	undiscounted	undiscounted		The 58% gained	
		cases	Industry	Government	Total costs	Income	Benefit
Year	Year	per annum	$m	$m	$m	$m	$m
2007	0	12778	$2.01	0.89	2.90		-2.90
2008	1	6694	$0.88	0.89	1.77	3.60	1.83
2009	2	7177	$0.88	0.89	1.77	3.60	1.83
2010	3	7345	$0.88	0.89	1.77	3.60	1.83
2011	4	7000	$0.88	0.89	1.77	3.60	1.83
2012	5	7000	$0.88	0.89	1.77	3.60	1.83
2013	6	7000	$0.88	0.89	1.77	3.60	1.83
2014	7	7000	$0.88	0.89	1.77	3.60	1.83
2015	8	7000	$0.88	0.89	1.77	3.60	1.83
2016	9	7000	$0.88	0.89	1.77	3.60	1.83
2017	10	7000	$0.88	0.89	1.77	3.60	1.83
					Total costs		
		Sum	$10.81	9.79	20.60	36.00	15.40
				Internal Rate of Return		IRR =	63%

	Discounted	10%	
j	Total	Benefits	Benefits
year/power	Costs	discounted	
	$m	$m	$m
0	2.90	0.00	-2.90
-1	1.61	3.27	1.66
-2	1.46	2.98	1.51
-3	1.33	2.70	1.37
-4	1.21	2.46	1.25
-5	1.10	2.24	1.14
-6	1.00	2.03	1.03
-7	0.91	1.85	0.94
-8	0.83	1.68	0.85
-9	0.75	1.53	0.78
-10	0.68	1.39	0.71
PV	13.78	22.12	8.34
		B/C ratio	1.61

A benefit cost ratio > 1.0 still exists, and the IRR remains high.

Sensitivity analysis comparing indirect costs

There is cause to be concerned that the indirect non-health care costs have been over-estimated due to too great a weighting being placed upon the small proportion of fatalities associated with foodborne diseases, and small proportion of complications which lead to longer periods of time off

work. In fact the economic burden is a result of the large number of persons absent from work for short periods. In the case of *Campylobacter* a very small proportion of community illnesses lead to complications and of those most persons are able to continue working.

The Cressey and Lake study from which I derived my estimate of $99m for cost of illness used Human Capital (HC) approach. The indirect costs are derived from the lost production associated with the disease including the loss of productive life years induced by premature death due to foodborne disease in this case. The potential income lost by the individual is discounted. The individual is treated as a valuable economic resource whose removal from the workplace temporarily or permanently reduces the total contribution of human capital to the economy.

Analysis was undertaken using two alternative approaches to determine the indirect health care costs; Willingness to Pay (WTP) used by Gadiel (Gadiel 2010) and the friction cost method (Koopmanschap, Rutten et al. 1993). Willingness to Pay is based on an estimate of the amount individuals in society would be willing to pay in order to avoid the discomfort and reduction in quality of life (disability), or loss of life if afflicted by a disease or injury. From the Willingness to Pay approach used by Gadiel the Value of 'A Statistical Life' (VOSL) in June 2008 was $3.35m. This converts to $3.22m in April 2007 and applying a 3.5% discount is $144,000 (40 years) for VOSL; the WTP corresponding to $144,000 for a full year's disability, or $395 per day of disability.

Using the estimated 159,000 illnesses due to campylobacteriosis at the beginning of 2007, of which 15,900 were reported implies some 143,100 went unreported. From Gadiel (Table 9, p. 26) I used the GE (gastroenteritis) self care, 3 days of disability, weighted at 0.067, and GE GP care, 10 days weighted at 0.393. Weightings range from zero representing perfect health to 1.0 representing death. Thus the WTP cost per case is the days of disability times the weighting times $395. The results are summarised in Table 4.

Table 4 Estimation of indirect costs based on the Willingness to Pay (WTP): 2007

Campylobacteriosis care option	Days of disability	Disability weighting	Cost per case	Number of cases	Total cost
Self care	3	0.067	$79	143,100	$11,297,000
GP care	10	0.393	$1552	15,900	$24,676,800
TOTAL				159,000	$35,973,800

Total indirect costs using WTP are $36m; a much lower value than human capital method. Adding the $6.2m health costs generates $42.2m of which there is a 58% cost benefit in reduction of disease valued at $24.5m. This delivers a benefit cost ratio of 9.87 and IRR of 776 %.

The friction cost method is about the influence of the labour market on indirect costs; the impact of absence from work or labour productivity. There are macro-economic consequences of absence from work and disability. Sick leave has short term effects at the level of the firm and medium term effects because of changes in labour costs per unit of output, social insurance premiums and labour supply. All these influence national income plus other economic indicators such as (un)employment, inflation, balance of payments and government deficit. The aim for the national economy must be attainable reductions in absence from work and disability (Koopmanschap, Rutten et al. 1993).

If I examine a specific instance estimated by Koopmanschap *et al* in 1993 and apply the ratio between the Friction Cost and the Human Capital cost the indirect costs are further reduced. Table 5 is derived from Koopmanschap *et al* (Table 2, p. 182). The figures demonstrate the huge difference in the estimates of the health costs using different approaches.

Table 5 Comparison between friction costs and human capital cost estimations of health costs

	Guilders $ billion		
Cost category	Friction cost 1988	HC cost 1988	Friction cost 1990
Absence from work	9.2	23.8	11.6
disability	0.15	49.1	0.2
mortality	0.15	8.0	0.2
Total indirect costs	**9.5**	80.9	**12.0**
% GDP	2.1%	18%	2.6%

The total indirect costs for purposes of my thesis by friction cost method (FCM) would be (9.5 + 12.0)*0.5/80.9 = 13.3% of total indirect costs estimated by HC (see Table 1).

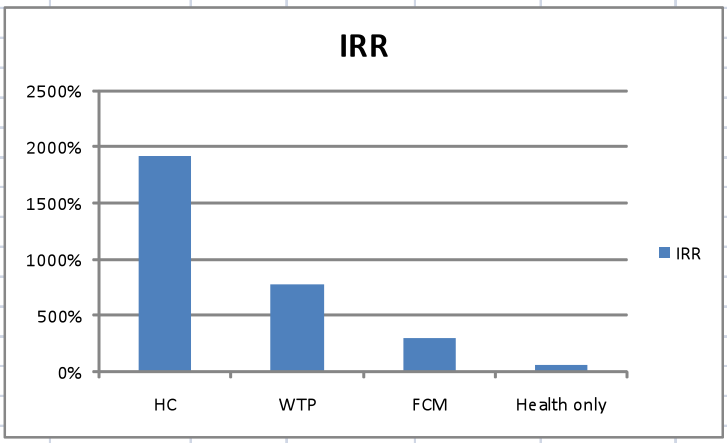
From $99m for 2007 estimated costs of illness from *Campylobacter*, of which $92.5m is indirect costs, times 0.133 gives $12.3m. Plus $6.2m health costs generates $18.5m of which there is a 58% cost benefit in reduction of disease valued at $10.7m. This gives a benefit cost ratio of 4.31 and IRR of 300%.

Summary of sensitivity analyses

One sensitivity analysis was undertaken using direct and non-indirect health benefits only (see Table 3). Further sensitivity analyses were undertaken comparing human capital method, WTP and friction cost methods to calculate indirect costs and derive the health benefits.

Table 6 Internal Rate of Return

Method	IRR
HC	1918%
WTP	776%
FCM	300%
Health only	63%



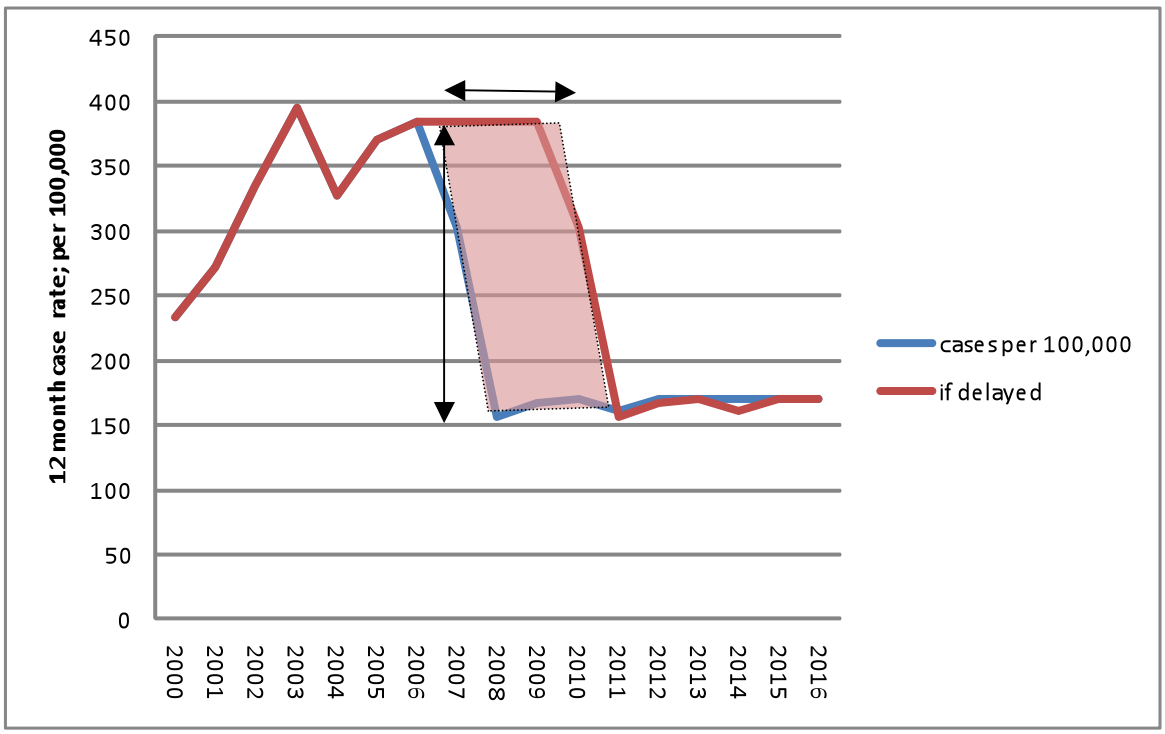
As can be seen from the results above a benefit cost ratio greater than 1.0 exists in all cases and the IRR remains high. This highlights the economic benefit of compliance investment by industry and

the regulator. For campylobacteriosis, where the majority of cases are short periods of illness, the cost of illness and health benefits appear to be best represented by the friction cost method.

Comparison in cost savings

If the NMD Specifications as per 2001 (without *Campylobacter* measurement and regulatory controls) had continued it can be assumed that the rates of campylobacteriosis in New Zealand would have remained high. The cost of this to the New Zealand economy can be demonstrated by calculating the area between the curves of actual reduction and anticipated continuation of campylobacteriosis at the average of yearly rate from 2000 to 2006 if the poultry *Campylobacter* NMD was delayed until 3 years later. The comparison in cost savings if *Campylobacter* NMD implementation was delayed is represented in the following graph.

Figure 1 Reduction in reported cases of campylobacteriosis following the introduction of the compliance programme



The area between curves, represented by the pink parallelogram, can be estimated by height of $57.4m benefit, the reduction of disease cost, times the base which is 3 years totalling $172.2m saved.

Future targets

Even though case numbers have been reduced a campylobacteriosis epidemic still exists in New Zealand. A further 50% reduction in *Campylobacter* would result in a further $20.8m saved per annum ($99m – $57.4m =$ 41.6m divided by 2). The cost benefit ratio would become correspondingly greater. The level of investment required by the poultry industry to effect or contribute to a further 50% reduction is the next hurdle.

Discussion: Private and public

I have examined the industry costs and public health benefits as two completely independent sets; one private and one public. There are no common drivers between the primary industry (in this case

the poultry industry) and the Department of Health. The industry drivers are profit, quality, market share and supply. The industry motivators to invest in compliance are willingness to pay to gain market share, and willingness to pay to protect public health to avoid consumer backlash. The desire to protect profit limits this willingness to pay. The public health drivers are expenditure, pathogen control and disease treatment to maintain population productivity.

There are mutually linked externalities which create a great advantage for public health at some expense to the private industry profit margin. The first externality is regulatory compliance to maintain a guarantee of food safety at industry expense. The second is pathogen control to reduce treatment costs which has cost savings benefits to public health and to New Zealand in general, in that more people are available for work. There is some tension between private and public to maintain compliance to in turn guarantee food safety and pathogen control; the main benefit to the economy being reduced absence from work and greater productivity.

Food stakeholders will be concerned about both costs recovered by government and the capital and ongoing costs required to develop, implement and maintain the compliance programmes (Gadiel 2010). However the importance of the health impact of such compliance programmes and the gains made to the economy by reducing campylobacteriosis must be the first consideration. In appreciating these gains both industry and total government spending need to be more properly assessed.

Conclusion

New Zealand's campylobacteriosis epidemic had been identified as a foodborne disease, with poultry as the problem. To fix the problem the level of *Campylobacter* contamination of poultry carcasses at end of slaughter and dressing needed to be measured. The NMD was useful in monitoring production every processing day with the data being submitted to the regulator. Industry then re-evaluated investment in interventions or upgrading of premises with the intention of improving hygienic standards. At the time their investments were made neither they nor the regulator could have anticipated that it would make such a considerable difference to the number of notifications.

A clear positive linkage between the industry and regulatory cost of compliance and the social benefit to the New Zealand economy has been demonstrated. By addressing the primary source of this foodborne disease, rather than focussing on measures to reduce costs of surveillance, outbreak responses and treating the disease, a more economically efficient outcome has been achieved.

From a policy perspective questions must be raised on margins industry profit is affected by compliance costs, and the concurrent health benefits of such primary industry investment. Any hesitation by industry and government to pursue further developments and improvements to reduce the campylobacteriosis disease burden is unjustified. There is still a *Campylobacter* epidemic in New Zealand resulting in a huge economic burden in lost work and lost productivity.

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