

Institution: The University of Nottingham		
Unit of Assessment: UoA6		
Title of case study: Reducing clinical and subclinical mastitis in UK dairy herds		
Period when the underpinning research was undertaken: 2006-2018		
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:
Professor Martin Green	Professor of Cattle Health and Epidemiology	Jan 2006-present
Professor Andrew Bradley	Professor of Dairy Herd Health and Production	Aug 2009-present
Dr Peter Down	Clinical Assistant Professor in Farm Animal Population Health	Feb 2016-present
Dr James Breen	Clinical Associate Professor in Cattle Health and Production	Sept 2009-present
Dr Chris Hudson	Clinical Associate Professor in Dairy Health and Production	Sept 2009-present
Period when the claimed impact occurred: 2013-2020		
Is this case study continued from a case study submitted in 2014? No		
1. Summary of the impact		
<p>Mastitis is one of the most significant diseases affecting the dairy industry in the UK and worldwide. In the UK, implementation of the AHDB Dairy Mastitis Control Plan (DMCP), a nationwide control programme based and developed entirely on University of Nottingham research, has resulted in a dramatic reduction in mastitis across approximately 40% of the UK dairy herd and impressive on-farm cost savings. The DMCP is highlighted as the gold standard in UK mastitis control. There has been a decrease of 38-40% in the national incidence of clinical mastitis, leading to cost savings of approximately GBP95,000,000 – GBP125,000,000 within the UK dairy industry, and substantially improved dairy cow welfare. Concomitant reductions in subclinical mastitis means the UK now has milk somatic cell counts at their lowest level in 17 years, with a decrease of 6% between August 2013 to July 2020. The DMCP has received European recognition and has been successfully piloted in Denmark.</p>		
2. Underpinning research		
<p>Mastitis is a major and complex endemic disease affecting the UK dairy industry. Mastitis affects dairy cow welfare, reduces milk production and quality, involves treatment costs (averaging GBP250 - GBP350 per case) and leads to the culling of persistently infected cows. A body of research undertaken solely by the University of Nottingham (UoN) Dairy Herd Health Group, led by Professor Martin Green, led to the creation of the Agriculture and Horticulture Development Board (AHDB) 'DairyCo Mastitis Control Plan' (DMCP) in 2009 (https://www.mastitiscontrolplan.co.uk/). Since its launch, UoN research has driven continued improvements to the DMCP.</p> <p>AHDB Dairy is the UK statutory dairy levy board and the DMCP is part of AHDB Dairy Technical Services. The DMCP is a 'paid for' service, provided to farmers by specially trained vets and consultants (Plan Deliverers). The DMCP is an evidence-based approach to mastitis control and prevention. Plan Deliverers analyse farm data and mastitis infection patterns and create a bespoke solution consisting of farm specific interventions.</p>		
Research underpinning the launch of the DMCP		
<p>Drawing on their considerable knowledge and expertise, the UoN group designed and tested a novel, structured method for mastitis control. This two-part method first involved evaluating and identifying individual farm infection patterns (such as environmental or contagious). Then software-enhanced decision making was used to select from a range of over 350 interventions; those most beneficial to control mastitis on that farm.</p>		

In 2007, the results of implementing this method in a randomised controlled trial across 52 farms in England and Wales were published (1). The trial found **the new two-part control method resulted in a reduction in clinical and subclinical mastitis of 20% in a one-year period. It also found increased compliance with interventions resulted in increased mastitis reduction.**

Further research was undertaken to optimise the selection of farm interventions and the UoN group assessed how the combinations of cow, farm and management factors after calving influenced mastitis rates on 52 farms across England and Wales (2). The study identified certain combinations of factors were associated with increased and decreased risk of mastitis, which informed refinement of the new mastitis control method. The mastitis control method formally became the DMCP and was launched by AHDB in 2009.

Research underpinning continued improvements to the DMCP

Disease control on farms is challenging; numerous options are available to veterinarians and farmers, and uncertainty and personal belief over how effective each option may be on a specific farm will impact the motivation to implement any given option. Bayesian analysis is particularly well suited to modelling such uncertainty. UoN undertook research in 2009 to identify the role personal belief plays in influencing veterinary surgeons when implementing the DMCP. This showed that scepticism of veterinary surgeons can influence the financial benefit they perceive a farmer would gain from implementing the control plan (3). Further research in 2010 (4) indicated that for some herd management practices, high levels of uncertainty in efficacy existed and these could be mitigated by using an iterative process of updating mastitis control strategies. These additional research studies were used to improve implementation of the DMCP by training of plan deliverers who incorporated strategies to overcome the influence of personal bias and uncertainty in intervention efficacy. Such strategies included more frequent monitoring and updating the control plan on-farm and increased use of farm tools to illustrate benefits (<https://www.mastitiscontrolplan.co.uk/>).

The research underpinning the launch and initial development of the DMCP was reported in the previous REF (*British Dairy Herd National Mastitis Control Scheme. The "DairyCo Mastitis Control Plan"*, <https://impact.ref.ac.uk/casestudies/CaseStudy.aspx?Id=28729>).

Since then, new research by UoN has continued to drive improvements to the DMCP and impact has increased. The DairyCo Mastitis Control Plan is now referred to as the AHDB Dairy Mastitis Control Plan.

In a study published in 2017 (5) the UoN group investigated the cost effectiveness of new approaches to diagnosis and treatment of mastitis to incorporate into the DMCP. It was found that delays in treatment associated with new cow-side diagnostics, particularly for Gram-positive bacteria, resulted in reduced treatment efficacy and poorer financial returns, and this procedure should not be advocated for implementation on farm. Indeed, delays in treatment and transmission of pathogens between clinically infected and uninfected cows had already been shown by the UoN group to be the major reason for the high costs of mastitis (6) and methods to mitigate this transmission (such as careful isolation of infected cows) are now incorporated into the DMCP. Further developments arising from diagnostic research in 2018 using mass spectrometry and novel machine learning protocols (7) enabled improved discrimination of bacteria from environmental and contagious routes. Those data are now collated on a herd basis to further refine and improve the DMCP.

From its initial conception to the current day, UoN research has driven continuous improvements to the DMCP. This research has been supported by high profile funders such as the AHDB, Wellcome Trust and BBSRC (G1-6).

3. References to the research. University of Nottingham UoA6 staff are **bold** **Underpinning references:**

1. **Green MJ**, Leach KA, **Breen JE**, Green LE, **Bradley AJ**. 2007. National intervention study of mastitis control on dairy herds in England and Wales. *The Veterinary Record* 160(9), 287-93. DOI: 10.1136/vr.160.9.287
2. **Green MJ**, **Bradley AJ**, Medley GF, Browne WJ. 2007. Cow, farm, and management factors during the dry period that determine the rate of clinical mastitis after calving. *Journal of Dairy Science* 90(8), 3764-3776. DOI: 10.3168/jds.2007-0107

3. **Green MJ**, Browne WJ, Green LE, **Bradley AJ**, Leach KA, **Breen JE**, Medley GF. 2009. Bayesian analysis of a mastitis control plan to investigate the influence of veterinary prior beliefs on clinical interpretation. *Preventive Veterinary Medicine* 91(2-4), 209-217. DOI: 10.1016/j.prevetmed.2009.05.029
4. **Green MJ**, Medley GF, **Bradley AJ**, Browne WJ. 2010. Management interventions in dairy herds: Exploring within herd uncertainty using an integrated Bayesian model. *Veterinary Research* 41:22. DOI: 10.1051/vetres/2009070
5. **Down PM**, **Bradley AJ**, **Breen JE**, **Green MJ**. 2017. Factors affecting the cost-effectiveness of on-farm culture prior to the treatment of clinical mastitis in dairy cows. *Preventive Veterinary Medicine* 145, 91-99. DOI: 10.1016/j.prevetmed.2017.07.006
6. **Down PM**, **Hudson CD**, **Green MJ**. 2013. Rate of transmission: a major determinant of the cost of clinical mastitis. *Journal of Dairy Science* 96, 6301-14. DOI: 10.3168/jds.2012-6470
7. Esener N, **Green MJ**, **Emes RD**, Jowett B, **Davies PL**, **Bradley AJ**, **Dottorini T**. 2018. Discrimination of contagious and environmental strains of *Streptococcus uberis* in dairy herds by means of mass spectrometry and machine-learning. *Scientific Reports* 8, 17517. DOI: 10.1038/s41598-018-35867-6

Underpinning grants:

G1 Use of Bayesian statistical methods to investigate farm management strategies, cow traits and decision-making in the prevention of clinical and sub-clinical mastitis in dairy cows. Sponsor: Wellcome Trust, 2006 – 2010. GBP406,615. PI: Professor Martin Green.

G2 The DairyCo Mastitis Control Plan. Sponsor: AHDB Dairy, 2008 – 2012. GBP310,000. Co-PIs: Professors Martin Green, Dr Andrew Bradley (Co-Is: Dr James Breen and Dr Chris Hudson), Jointly held with industrial partner Quality Milk Management Services Ltd.

G3 A quantitative (Bayesian) assessment of veterinary surgeons clinical beliefs in order to improve preventive healthcare for dairy cattle. Sponsor: Wellcome Trust, 2009 – 2013, GBP313,498. PI: Professor Martin Green.

G4 Continuation of the DairyCo Mastitis Control Plan. Sponsor: AHDB Dairy, 2012 – 2017. GBP281,000. Co-PIs: Professor Martin Green, Dr Andrew Bradley (Co-Is: Dr James Breen and Dr Chris Hudson).

G5 Continued optimisation of farm strategies for control: A Bayesian decision theoretic framework to evaluate and optimize decision making for mastitis control in the UK Mastitis Control Scheme. Sponsor: BBSRC, 2012 – 2016. GBP91,932. PI: Professor Martin Green.

G6 Maintenance of the AHDB Mastitis Control Plan. Sponsor: AHDB Dairy, 2016 – 2021. GBP156,429. PI: Professor Martin Green (Co-Is: Professor Andrew Bradley, Dr James Breen, Dr Chris Hudson and Dr Peter Down).

4. Details of the impact

Mastitis is a significant endemic disease in the UK dairy industry affecting animal welfare, milk production and treatment costs. The AHDB Dairy Mastitis Control Plan (DMCP, formerly DairyCo Mastitis Control Plan) has dramatically reduced mastitis rates and improved finances on farms implementing interventions across approximately 40% of the UK dairy herd. This has led to a national reduction in clinical mastitis (CM) and subclinical mastitis (SCM) levels. The DMCP is regarded as the gold standard for mastitis control within the UK dairy industry, has received European acclaim and has been implemented in Denmark through a successful pilot.

Benefits and uptake of the DMCP in the UK

The DMCP, a 'paid for' service sitting in AHDB Technical Services, is delivered across the UK by specially trained vets and consultants (Plan Deliverers). As the DMCP website explains '*University of Nottingham continues to contribute to and lead the technical information within the AHDB Dairy Mastitis Control Plan*' (a). Of the approximately 12,000 UK dairy farms, '*a survey of Plan Deliverers in 2018 suggested that the **Mastitis Control Plan has been used widely in practices/ businesses that work with approximately 40% of the national dairy herd***' (b, pg. 7).

The DMCP can benefit dairy farms of all types and sizes by offering farm-specific interventions to control and reduce mastitis. This results in **a marked beneficial effect on**

farm finances. Data from a sample of DMCP farms between 2013 to 2016 (exact data before and after 1st August 2013 unavailable due to the way data was recorded by DairyCo) showed an **average decrease of 20% in clinical mastitis rate**, from 44 to 35 cases per 100 cows per year **over the three-year period (c, pg. 27-8)**. This equated to an estimated average net cost saving of GBP138.31 per cow over the 3 years between 2013 and 2016, even after accounting for DMCP fees and implementation costs **(c, pg. 28)**. Based on the number of DMCP plans in place between 2013 and 2016 (1,044) and the number of cows known to be on these DMCP plans, between 2013 and 2016 there was an **estimated total net cost saving of approximately GBP11,000,000 - GBP12,000,000 per year across the farms using the DMCP (c, pg. 28)**.

Experiences of DMCP in the UK; a farm example

One 800-cow herd in Oswestry, Shropshire **(d)**, was experiencing CM rates of close to 70 cows per 100 cows per year, at a cost of approximately GBP120,000 per year. Following implementation of the key actions identified in the DMCP, between 2014 and 2016 there was a **CM decrease of approximately 30 cases per 100 cows, more than halving the original CM rate (d, pg. 1-2)**. The total cost for CM was almost halved, a cost saving of GBP57,000. As the farm explains: *"We were using less and less mastitis tubes, so I knew cases were coming down. Even so, I was staggered when I saw that we'd cut our costs in half. It shows that if you put the Mastitis Control Plan in place and follow it through, you'll see the benefit"* **(d, pg. 1-2)**.

Influence on mastitis control in the UK

The DMCP is highly regarded and influential in mastitis control in the UK dairy industry. At the 30th annual British Mastitis Conference in November 2018, it was noted the DMCP **'is accepted in the UK as a gold standard in mastitis control' (e(a), pg. 166)**. Similarly, the Cattle Health & Welfare Group (CHAWG) 4th Report 2018 highlighted that **'the DMCP was perceived as a 'gold standard' approach to mastitis control'** as it **'is an effective, evidence-based, nationwide plan for mastitis control that has been shown to have excellent clinical efficacy' (e(b), pg. 31)**. CHAWG is an independent group of key industries and farming bodies that meets to collaboratively address relevant cattle health and welfare issues. In 2019 two key UK veterinary organisations, the Royal College of Veterinary Surgeons and British Cattle Veterinary Association, produced a report including **'14 landmark stories' (e(c), pg. 3)** on evidence-based veterinary medicine. The DMCP was included as 1 of these landmark stories **(e(c), pg. 10)**. The DMCP principles are an integral component of the Mastitis element of the GB Dairy Cattle Welfare Strategy 2018-2020 **(e(d), pg. 4)**, a national strategy of priority areas for cow welfare developed by CHAWG. The DMCP is also highlighted by the Red Tractor, the UK national farm assurance provider, as a key mastitis control measure **(e(e), pg. 37)**. The DMCP has been continuously funded by AHDB since 2009 and is the longest running non-government funded endemic disease control scheme in the UK; a clear indication of its success and contribution to UK mastitis control. As the AHDB Lead Veterinary Science Expert comments **'AHDB recognises the global-leading expertise in bovine mastitis control at the University of Nottingham' (e(f), pg. 2)**.

Reductions in mastitis (clinical and subclinical) in the UK

The DMCP has been used in approaching half (40%) of all dairy herds in the UK **(b, pg. 7)**, with an average decrease of 20% in mastitis on farms using the DMCP **(c, pg. 28)** and a decrease of greater than 50% also reported **(d, pg. 1-2)**.

At a national level, the CHAWG reported in 2020 that there had been **a decrease of 40% in the incidence rate of CM between the end of December 2013 and the end of March 2020, from 43 to 26 cases per 100 cows (f(a), pg. 36)**, as reported by Kite Consulting, a consulting firm highly regarded in the dairy industry. A decrease of 38% from 58 to 36 cases per 100 cows between the end of March 2013 and the end of March 2020 was reported by Kingshay Dairy, Independent Dairy Specialists **(f(a), pg. 36)** (exact data between the end of March 2013 and 1st August 2013 unavailable). This substantial reduction in CM rate represents an **important improvement to dairy cow welfare**. Since there are approximately 1,900,000 dairy cows in the UK (ahdb.org.uk/dairy/uk-and-eu-cow-numbers)

and based on an average cost of clinical mastitis of GBP300, the national decrease of between 17 (Kite) and 22 (Kingshay) cases per 100 cows represents a cost saving of approximately **GBP95,000,000-GBP125,000,000 to the UK dairy industry as a whole between the end of March 2013 and the end of March 2020** (figures between the end of March 2013 and 1st August 2013 unavailable).

Since 2009, when the DMCP was implemented, there has been a **decrease in SCM as measured by somatic cell counts (SCC)**, an indicator of infection. There was an average decrease of 15% in SSC between 2009 and 2019, **of which a decrease of 6% occurred between August 2013 and July 2020 (177,000 to 166,000 per ml) (f(b)). SCC are currently at their lowest level in 17 years** (SCC records began in 2003) averaging 161,000 per ml between 1st January and 31st July 2020. These peaked at an average of 197,000 per ml in 2008 (f(b)).

European recognition and adoption

The DMCP is highlighted as the key national approach to mastitis control in a **European Commission Report in 2016 evaluating measures to ensure the welfare of cattle on dairy farms (g(a), pg. 5-6)**. The DMCP has been piloted in Denmark for a national initiative to improve CM and SSC. As a Senior Specialist in Livestock Innovation at the Danish Agricultural and Food Council explained in November 2019: *“The outcome of the Danish initiative was considered a success and models for the roll out of the initiative on a national basis are now being considered”* (g(b)).

5. Sources to corroborate the impact

- a [AHDB DairyCo Mastitis Control Plan](#) (weblink, last accessed 6th January 2021)
- b AHDB Dairy Mastitis Control Plan Progress Report December 2019
- c [2016 British Mastitis Conference](#) (weblink, last accessed 5th January 2021)
- d [Farm antibiotics article: New approach to mastitis ‘almost halves’ farmer’s costs](#) (weblink, last accessed 5th January 2021)

Influence on mastitis control in the UK:

e(a) 2018 British Mastitis Conference summary, DOI: 10.1111/1471-0307.12577, e(b) [Cattle Health and Welfare Group GB Fourth Report 2018](#) (weblink, last accessed 6th January 2021), e(c) [Royal College of Veterinary Surgeons Evidence-Based Veterinary Medicine Matters: Our Commitment to the Future](#) (weblink, last accessed 5th January 2021), e(d) [Cattle Health and Welfare Group GB Dairy Cattle Welfare Strategy 2018 - 2020](#) (weblink, last accessed 5th January 2021), e(e) [Red Tractor Dairy Standards 2017](#) (weblink, last accessed 6th January 2021), e(f) Letter of support from AHDB

Reductions in mastitis (clinical and subclinical) in the UK:

f(a) [Cattle Health and Welfare Group GB Fifth Report 2020](#) (weblink, last accessed 6th January 2021), f(b) [National somatic cell count records](#) (weblink, last accessed 24th November 2020), ‘GB milk hygiene’ downloaded Excel dataset, SCC tab, downloaded on 24th November 2020 and available on request

European recognition and adoption:

- g(a) [European Commission Final report 2017](#) (weblink, last accessed 6th January 2021)
- g(b) Letter of support from Danish Agriculture & Food Council