

Institution: University of Liverpool		
Unit of Assessment: UOA6 - Agriculture, Veterinary and Food Science		
Title of case study: Simultaneous administration of multiple live respiratory vaccine viruses in day-old broiler chicks for better production worldwide		
Period when the underpinning research was undertaken: 2002-2020		
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:
Kannan Ganapathy Anne Forrester Chris Ball	Senior Lecturer Technician Postdoctoral Researcher	2002-present 2009-2018 2014-Present
Period when the claimed impact occurred: 2013-2020		
Is this case study continued from a case study submitted in 2014? N		
<p>1. Summary of the impact (indicative maximum 100 words)</p> <p>With more than 66,000,000,000 broiler chickens globally produced each year, vaccination against production losses caused by Infectious bronchitis (IB) and Newcastle disease (ND) is essential. The traditional practice of staggering live IB and ND virus vaccinations required expensive labour and caused stress to the birds. Our research showed that a simplified simultaneous vaccination of a strain of IB and ND vaccine virus in day old broiler chicks is safe and induces the same disease protection as when the vaccines were given separately. Producers have adopted this vaccination practice globally and have identified production and welfare benefits. Benefits include reduced mortality, increased body weight, and decreased feed intake, which are reflected in improved economic performance of the co-vaccinated flocks.</p>		
<p>2. Underpinning research (indicative maximum 500 words)</p> <p>The two most significant and common diseases in chickens are Newcastle disease (ND) and infectious bronchitis (IB). Both diseases are caused by viruses; ND virus (NDV, a <i>paramyxovirus</i>) and IB virus (IBV, a <i>Gammacoronavirus</i>). Infections with NDV or IBV can cause 80-100% or 25-80% mortality respectively. These diseases can have significant impact on health, welfare and global chicken production. These impacts can be minimised through use of live attenuated vaccines. Poultry producers and veterinarians were traditionally wary of concurrent administration of these live vaccines in day-old chicks.</p> <p>From the 1990's, in addition to NDV, 'IBV Mass (Massachusetts)' and another strain of live 'IBV Variant 793B' vaccines were administered. However, usage of IBV vaccines was staggered, with IBV Mass and IBV Variant given at the ages of 1 and 7-14 days old respectively. Since 2002, Ganapathy and others at the University of Liverpool have been studying the compatibility of concurrent co-administration of live attenuated virus vaccines in day-old chicks. Initial research on the co-administration of NDV, IBV (Mass strain) and/or avian metapneumovirus (aMPV) showed no adverse effects on the host's immune induction and provided excellent protection against virulent NDV, IBV or aMPV challenges. In order to provide greater and wider protection against emerging virulent variant IBV strains, Ganapathy followed this fundamental work by further investigating the effects of co-vaccination of two different strains of IBV in day-old chicks. Following the protocols of <i>European Pharmacopoeia</i> and <i>World Organisation for Animal Health</i> (OIE), research carried out at the University of Liverpool have showed that co-administration of two IBV strains (Mass and a variant strain, 793B) gave higher protection against virulent Mass and 793B strains, <u>as well as wider protection against other virulent variant strains of IBVs, such as QX, Q1, IS/1404/06 and IS/885/00 (3.4; 3.5).</u> We were the first to use molecular virology and immunology, immunohistochemistry and pathology to establish the underlying immune mechanisms for this wider and greater protection. We demonstrated that the levels of mucosal immunity (IgA in lachrymal fluid) and tracheal CD8+ were associated with the protection (3.6).</p> <p>Globally, we were the only research group to demonstrate that co-vaccination of IBMass+IBVariant+ND in <u>day-old broiler chicks had no adverse effects on immune induction or health of chicks.</u> Furthermore, the protection conferred was comparable to giving the vaccines separately. This provided firm evidence for producers to <u>change their vaccination practices from</u></p>		

ND alone or IBMass+ND to IBMass+IBVariant+ND (3.1), globally. Giving IBV (Mass and Variant) and NDV vaccines simultaneously in day-old broiler chicks ensures disease protection from an early age, which leads to better health and welfare and improved production (3.2; 3.3).

3. References to the research (indicative maximum of six references)

3.1. GANAPATHY, K. & BALL, C. Global change in day-old broiler chick vaccination practices. 2020. World Poultry. <https://www.poultryworld.net/Health/Articles/2020/12/Global-change-in-day-old-broiler-chick-vaccination-practices-686415E/>

3.2 BALL, C., FORRESTER, A., HERRMANN, A., LEMIERE, L. & GANAPATHY, K. Comparative protective immunity provided by live vaccines of Newcastle disease or avian metapneumoviruses when co-administered alongside classical and variant strains of infectious bronchitis virus in day-old broiler chicks. 2019. *Vaccine*, 37(52). 7566-7575. doi: [10.1016/j.vaccine.2019.09.081](https://doi.org/10.1016/j.vaccine.2019.09.081)

3.3 GANAPATHY, K, BALL, C., FORRESTER, A. & S. LEMIERE. Simultaneous vaccination of a live Newcastle disease and two live infectious bronchitis vaccines in commercial broiler chicks. 2016. 9th International symposium on avian corona-and pneumovirus infections & 4th annual meeting of the COST ACTION FA1207, Leiden/Utrecht, The Netherlands. 21-24 June 2016, p. 39-45. https://avcov2016.org/wp-content/uploads/sites/21/2016/12/GDOV0941_Proceedings-symposiumboek_PRINT.pdf

3.4 AWAD, F., FORRESTER, A., BAYLIS, M., LEMIERE, S. & GANAPATHY, K. Protection conferred by live infectious bronchitis vaccine viruses against variant Middle East IS/885/00-like and IS/1494/06-like isolates in commercial broiler chicks. 2015. *Veterinary Record Open*, doi: 10.1136/vetreco-2014-000111. eCollection 2015

3.5 AWAD, F., FORRESTER, A., BAYLIS, M., LEMIERE, S. & GANAPATHY, K. Immune responses and interactions following simultaneous application of live Newcastle disease, infectious bronchitis and avian metapneumovirus vaccines in specific pathogen free chicks. 2015. *Research in Veterinary Science*, 98, 127-133. doi: 10.1016/j.rvsc.2014.11.004

3.6 CHHABRA, R., FORRESTER, A., LEMIERE, S., AWAD, F., CHANTREY, J. & GANAPATHY, K. Mucosal, cellular and humoral immune responses induced by different live infectious bronchitis virus vaccination regimes and the protection conferred against infectious bronchitis virus Q1 strain. 2015. *Clinical Vaccine Immunology*, 9, 1050-1059. doi: 10.1128/CVI.00368-15

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

Research on 'interactions between live viral chicken vaccines started in 2002 and has *transformed the practice of day-old chicks vaccination worldwide*. We have provided an evidence-based vaccination strategy—initially against IB, then against both IB and ND. Through a series of experiments, we demonstrated compatibility between the IBMass and IBVariant (793B) strains of vaccines in day-old chicks to confer greater and wider protection against classical (Mass) and variant IBV strains. Thereafter, we showed that it is advantageous to use both IBMass and IBVariant live vaccines simultaneously in day-old chicks, and in tandem with a live ND vaccine. This has resulted in a major shift in vaccination practice of day-old chicks: *from vaccinating with IBMass+ND to vaccinating with IBMass+IBVariant+ND*.

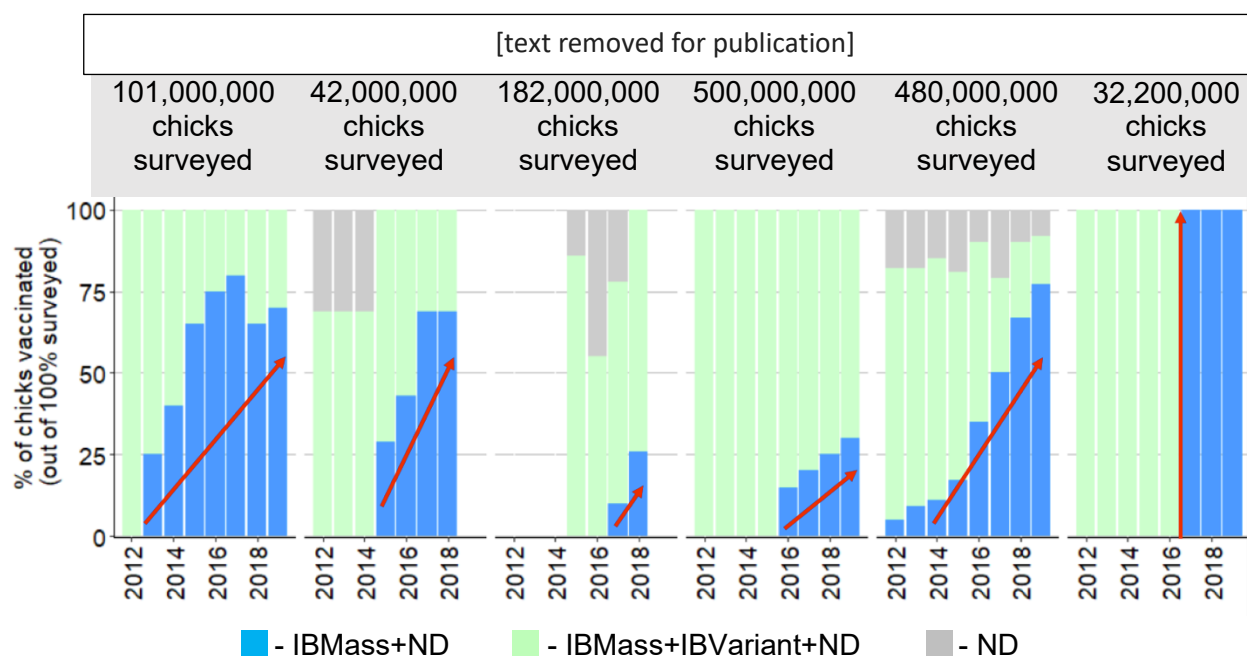
Being able to administer multiple live vaccines at the same time in hatchery ensures efficient vaccination in a clean environment. This vaccination approach promotes early immunity in young chicks. In most cases, this innovative strategy has avoided further ND or IB vaccination in farms, thus avoiding unnecessary stress due to bird handling. Labour costs have been reduced and potential biosecurity breakdowns due to vaccination team movement are avoided.

Shifted vaccination practice: Our research findings have given new impetus to the global broiler poultry industry, which had an estimated annual production of more than 66,000,000,000 birds in 2018. We are the only institution to have provided peer-review published scientific

evidence (3.2) regarding the efficacy of IBMass+IBVariant+ND vaccine coadministration on which this shift is based. Being an invited speaker at several international conferences, seminars, internal meetings of poultry commercial pharmaceutical/biological companies, and major poultry producers (5.1), Ganapathy's research has been disseminated to many in the poultry industry. Commercial companies have disseminated findings from Ganapathy's research through vaccination concept notes/brochures. An example is through [text removed for publication] (5.1;5.2). The dissemination has encouraged higher usage of the IBMass+IBVariant and IBMass+IBVariant+ND vaccination at day-old in hatcheries worldwide.

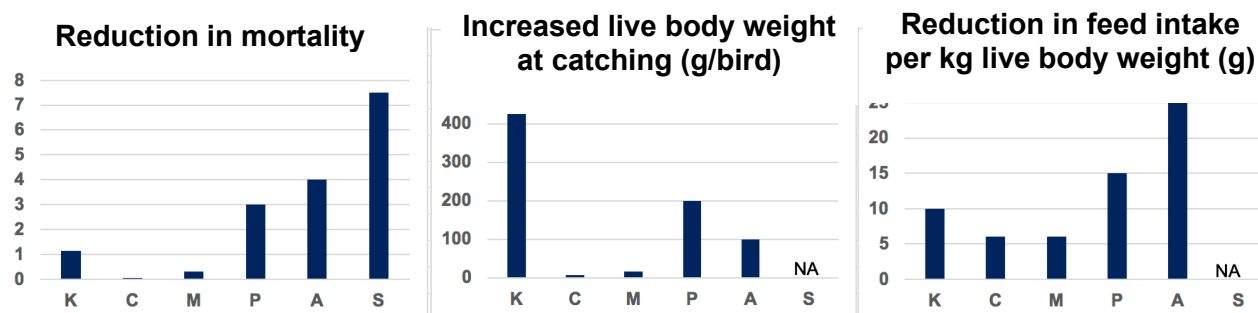
Dissemination of our research outputs has directly influenced the vaccination protocol of day-old chicks by individual producers/veterinary practices in a number of countries; [text removed for publication] (5.3), [text removed for publication] (5.4), [text removed for publication] (5.5), [text removed for publication] (5.6), [text removed for publication] (5.7) and [text removed for publication] (5.8). These are summarised in Figure 1.

Figure 1: Increasing percentages of broiler chicks receiving concurrent administration of live IBMass+IBVariant+ND vaccines compared to the traditional IBMass+ND programme. Red arrow shows marked change in the vaccination practice.



Two other major poultry producing countries, [text removed for publication] (5.9) and [text removed for publication] (5.10), have also benefited substantially from this shift in vaccination practice with Ganapathy repeatedly invited for seminars and technical discussions in both countries (5.1). [text removed for publication] (5.9): Ganapathy has presented data on the IBMass+IBVariant+ND vaccination in meetings attended by [text removed for publication] veterinarians and farmers. As a result, this new vaccination strategy is widely practiced. For example, for the last 4 years, 50% of 30,000,000 chicks serviced by [text removed for publication] Veterinary Practice used the triple vaccination at day-old (5.9), which reflects confidence on this programme. [text removed for publication] (5.10): In 2018, Ganapathy met with major [text removed for publication] producers [text removed for publication], presenting data on IBMass+IBVariant+ND, and all participants have adopted this simultaneous vaccination with a notable improvement in production (5.1). [text removed for publication] (5.10), producer of 1,500,000,000 chicks per year, cross-compared the vaccination programmes (IBMass+IBVariant+ND versus IBMass+ND). The economic data supplied by this producer was analysed and provided (Figure 2), showing reduction in mortality rate, increase in body weight gain and improvement of conversion of feed consumed to body weight.

Figure 2. The additional benefits of broiler chickens that received day-old IBMass+IBVariant+ND co-vaccination compared to the traditional IBMass+ND.



K-[text removed for publication]; C-[text removed for publication]; M-[text removed for publication]; P-[text removed for publication]; S-[text removed for publication]; NA – data not available

Increased economic revenue of poultry producers. The three main indicators of broiler profitability are i) mortality (including culling) rate, ii) live body weight at catching, iii) feed conversion ratio (FCR). These values may differ based on local agriculture resources and a country's socioeconomic status. Compared to IBMass+ND, the application of IBMass+IBVariant+ND in day-old chicks has led to global reduction in mortality, and improvement in body weight and FCR (5.3; 5.4; 5.5; 5.6; 5.8; 5.10) (Figure 2). Based on field control studies, comparison of the IBMass+IBVariant+ND *versus* IBMass+ND data from [text removed for publication](5.6) showed that for every 1,000 chicks, the new programme provided an extra 11.3 birds (equivalent to GBP17), an extra 425g per bird body weight (equivalent to GBP319) and 10kg less feed consumption (equivalent saving of GBP2.70). With the adoption of IBMass+IBVariant+ND vaccination for the [text removed for publication] per year production of 130,000,000 birds in 2019, the extrapolated additional benefits are 1,703,000 birds to market, 5,525t of extra body weight and 130t of less feed consumed. These impacts would have provided an additional revenue (or saving) of GBP4,400,000 in 2019 alone. In [text removed for publication](5.10), [text removed for publication], a poultry integrator cross-compared the performance of vaccination programmes IBMass+IBVariant+ND (21,000,000 birds) *versus* IBMass+ND (32,000,000 birds). The economic return was hugely beneficial, where for every 1,000 chicks, the new programme resulted in an extra 6 birds to market (equivalent to GBP9), 60kg extra body weight (equivalent to GBP45) and 6kg less feed consumed (equivalent saving of GBP1.62). This impact provides a total of GBP56 of additional income for every 1,000 chicks placed in the farm of this producer. When extrapolated to the [text removed for publication] birds produced in 2018 in [text removed for publication], the economic benefits and savings are considerable.

Decreased wastage of meat at the poultry abattoirs. In poultry meat production, the whole carcass and meat is inspected and those considered 'damaged' and unsuitable for human consumption are condemned. Co-vaccination of three live vaccines has reduced the rate of carcass condemnation in abattoirs and decreased wastage of valuable poultry meat. For example, a producer in [text removed for publication] (5.6) reported a reduction in carcass condemnation of 0.155% with the IBMass+IBVariant+ND compared to IBMass+ND vaccination. This resulted in a saving of GBP2.33 per 1,000 birds. For example, with [text removed for publication]'s 130,000,000 bird production in [text removed for publication] alone, extrapolation shows possible savings of an estimated GBP227,175. This is mainly due to IBMass+IBVariant+ND co-vaccination at day-old.

Increased family income through improved flock performances (5.8). Effective co-vaccination of IBMass+IBVariant+ND results in improved production and health of chickens, and also benefits smallholder poultry farmers in developing countries. For example, in [text removed for publication], a smallholder rearing 4,000 chicks (8-weeks cycle; 6.5 times/year) used day-old chicks that had received IBMass+IBVariant+ND co-vaccination instead of those given only IBMass+ND. Remarkable improvements were found, where the average mortality decreased from 15% to 7.5%, and the birds reached market body weight of 1.5kg at 39-40 instead of 40-41

days. Based on per cycle production, the smallholder's income was increased by 4,550 saleable birds. The smallholder makes a profit of GBP0.28 per bird, which means that with chicks vaccinated with IBMass+IBVariant+ND, the annual family income grew by 19%. In addition, by sending the birds to market 1-2 days earlier than before, the smallholder saved on feed and water, and started the subsequent cycle of production sooner.

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

- 5.1 Dissemination of research findings and global participation on co-vaccination of day-old broiler chicks with IBMass+BVariant+ND live vaccines. Also, copies of brochures/leaflets and presentations, in English and other languages, referring to our research output.
- 5.2 Letter from the Global Poultry Technical Director of [text removed for publication], outlining research collaboration and contribution of University of Liverpool on increasing the application of IBMass+IBVariant+ND live vaccination in day-old chicks. Substantial increases in sales of 793B and ND live vaccine was noted. Also, a letter from regional manager of [text removed for publication] in Asia, where ND is endemic.
- 5.3 Letter from a senior poultry veterinary expert lead in [text removed for publication], who is also a global consultant. Letter outlines the benefits of the IBMass+IBVariant+ND programme and how it has helped and still helps the [text removed for publication] poultry industry, changing vaccination practices, and providing higher economic benefits.
- 5.4 A senior veterinarian in [text removed for publication], which supplies chickens to [text removed for publication], has provided a letter on increasing usage and practical benefits of the co-vaccination with IB Mass, IB Variant and ND in day-old chicks in his farm operation.
- 5.5 Letter from coordinator of avian technical services in [text removed for publication], on increasing usage of IBMass+IBVariant+ND following Q1 IB variant emergence in South America. Change in the vaccination practices and production benefits are outlined. Our work was also used in obtaining registration of IB Variant ([text removed for publication]) in [text removed for publication].
- 5.6 Veterinarian and owner of [text removed for publication], which provides services to 42 million out of the 130 million (2019) broiler chickens produced in [text removed for publication], provided a statement and data. She outlined the benefits of the IBMass+IBVariant+ND vaccination programme, including boost in performances and reduction in carcass wastages in the abattoir.
- 5.7 A statement from the head of [text removed for publication]. He outlines the strong influence of our research in getting registration for the IB Variant vaccine in [text removed for publication], and subsequent increases in application of IBMass+IBVariant+ND vaccines at day-old, and its benefits to producers in [text removed for publication].
- 5.8 A senior veterinarian from [text removed for publication] provided a statement on how our vaccination (IBMass+IBVariant+ND) programme shifted the vaccination practices in [text removed for publication] commercial broiler farms. More importantly, she stated the extra income enjoyed by smallholder farmers when broiler chicks given the tree vaccine concurrently were supplied to smallholders.
- 5.9 Letter from current president of [text removed for publication] and owner [text removed for publication]. Poland is the largest broiler (1.3 billion birds) production country in Europe. He provides evidence on continuous usage of IBMass+IBVariant+ND among producers serviced by his company veterinarians.
- 5.10 Testimony and production data from the [text removed for publication] Technical Head Poultry & Veterinary Consultant. Testimony/statement from Chief Poultry Veterinarian of [text removed for publication]; Technical Director Poultry, [text removed for publication]. All focusing on increasing usage of IBMass+IBVariant+ND and its economic benefit to the [text removed for publication] poultry industry.