



Cost distribution of bluetongue surveillance and vaccination programmes in Austria and Switzerland (2007–2016)

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Bluetongue virus (BTV) is an emerging transboundary disease in Europe, which can cause significant production losses among ruminants. The analysis presented here assessed the costs of BTV surveillance and vaccination programmes in Austria and Switzerland between 2007 and 2016. Costs were compared with respect to time, type of programme, geographical area and who was responsible for payment. The total costs of the BTV vaccination and surveillance programmes in Austria amounted to €23.6 million, whereas total costs in Switzerland were €18.3 million. Our analysis demonstrates that the costs differed between years and geographical areas, both within and between the two countries. Average surveillance costs per animal amounted to approximately €3.20 in Austria compared with €1.30 in Switzerland, whereas the average vaccination costs per animal were €6.20 in Austria and €7.40 in Switzerland. The comparability of the surveillance costs is somewhat limited, however, due to differences in each nation's surveillance (and sampling) strategy. Given the importance of the export market for cattle production, investments in such programmes are more justified for Austria than for Switzerland. The aim of the retrospective assessment presented here is to assist veterinary authorities in planning and implementing cost-effective and efficient control strategies for emerging livestock diseases.

Introduction

The economic assessment of animal health surveillance and intervention programmes is an area of veterinary research that is becoming increasingly relevant. However, analyses focusing on the costs of surveillance and intervention programmes with respect to animal epidemics are generally limited.¹

Bluetongue virus is an arbovirus transmitted by *Culicoides* midges, whose distribution is known to be influenced by climatic factors.^{2–4} Bluetongue virus (BTV)

serotypes, such as 1, 2, 4, 6, 11 and 16, have been spreading throughout Europe since 1998.⁵ However, bluetongue virus serotype 8 (BTV-8) was first reported in more northern regions of Europe in 2006.^{6,7} The initial case of BTV-8 was confirmed by the Dutch Central Institute for Animal Disease Control, and the virus soon spread to Belgium, Germany, Luxembourg and northern France.^{8–10} The first case in Switzerland was reported in the canton of Basel City in October 2007,¹¹ and in Austria in the federal state of Upper Austria in October 2008.¹² Both of these initial outbreaks were in regions bordering with Germany, with the canton of Basel City also sharing a border with France.

In accordance with the EU regulation 1266/2007,¹³ BTV surveillance and intervention programmes (ie, movement restrictions and/or vaccination) were subsequently initiated in 23 EU countries (including Austria) to reduce the spread of this disease.¹⁴ A variety of active BTV surveillance programmes were initially implemented in the EU, such as risk-based and/or sentinel surveillanceⁱ. In ad-

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ⁱ Sentinel surveillance aimed to detect BTV-8 by observation of a specific and limited number of animals at a specific location and over a predetermined period of time.^{38,39}

dition to these active surveillanceⁱⁱ programmes, passive surveillanceⁱⁱⁱ was applied, as well as routine sampling for animals that were exported, imported or traded within the EU. As agreed in the bilateral veterinary agreement originally signed in 2002, Switzerland (although not a member of the EU) has agreed to follow the EU regulations regarding animal health and disease control and therefore also set up a surveillance and intervention programme at this time.¹⁵

In the study presented here, a retrospective assessment of the implemented BTV surveillance and vaccination programme costs in Austria and Switzerland between 2007 and 2016 was carried out. The objective was to calculate the costs of surveillance and intervention programmes in both countries and to compare these costs with respect to time, type of programme, geographical area and payers. This comparison should allow recommendations for cost-effective approaches to be made in the future. In order to analyse whether costs could be predicted using information readily available in the public domain (eg, livestock population), linear regression models were applied. Additionally, we conducted a scenario analysis for the Austrian cattle export market and also compared the costs of hypothetically reduced export prices of cattle and calves and the programme costs in Austria and Switzerland in order to determine the level where the costs of the BTV programmes would still be covered. Simultaneously, we determined the number of exported cattle and calves needed in Austria and Switzerland in order to offset BTV programme costs.

Materials and methods

Description of the surveillance and intervention programmes in Austria and Switzerland

In 2007, at the beginning of the surveillance programme in both countries, bulk milk samples from milk tankers were analysed for the presence of BTV antibodies.^{12 16} Bulk milk testing continued until BTV vaccination began in both countries in 2008 and was then reduced due to the difficulties in reliably distinguishing between infected and vaccinated animals in this medium. Besides milk, blood and organ samples were also used for virus detection by PCR.

In Switzerland, 21 out of 76 BTV-8 infected herds were detected by the passive surveillance programme, with the remaining cases identified by active surveillance.¹⁷ A total of 160 infected animals were detected on 76 Swiss farms up to May 2010. In Austria, a total of 28 BTV-8 positive cattle were identified on 14 farms

between 2008 and 2009¹² during the active surveillance period.

A nationwide mandatory BTV vaccination campaign for cattle, sheep and goats was initiated in both countries in 2008. The mandatory vaccination programme ended in mid-2009 in Austria and spring 2010 in Switzerland. Voluntary vaccination then began in both countries. The main differences between the surveillance and vaccination programmes in Austria and Switzerland between 2007 and 2016 are summarised in [Table 1](#).

The EU granted freedom from disease status with respect to BTV in March 2011 in Austria and in 2012 in Switzerland. Austria lost its BTV-free status in November 2015 after BTV-4-infected cattle were detected in the eastern regions of the country. In total, 10 BTV-4-infected cattle on seven different farms were identified (as of January 2017). To date, BTV-4 or other BTV serotypes have not been reported in Switzerland. To maintain its BTV-free status, surveillance continues today (2017) in Switzerland and blood samples are routinely taken at slaughterhouses.¹⁸ Serological (2015 and 2016) and virological (2017) surveillance in Switzerland mainly focuses on animals born after completion of the mandatory vaccination campaign in 2011. In Austria, active surveillance is currently based on a sampling plan for different risk areas. Unvaccinated animals are tested on farms with testing intervals between one and three months, depending on perceived level of risk.¹⁹ In both countries, 60 samples per geographical unit are necessary in order to fulfil the requirement of the EU regulation.¹³

Calculation of the surveillance and vaccination programme costs in Austria and Switzerland

A retrospective assessment of the surveillance and vaccination programmes for the years 2007–2016 was performed for Austria and Switzerland. The costs were analysed for each of the programmes and years to demonstrate how resource allocation differed between both programmes and countries. Furthermore, these costs were analysed according to national costs (public and private sector) and EU funding. All invoices and data received with regard to the surveillance and vaccination programmes (see online supplementary table S1) were analysed according to their respective geographical locations and were normalised related to the number of animals and farms (in 2009).

The total costs of surveillance and vaccination programmes included costs of the programme implementation and diagnostics. Each of these cost components was divided into labour (eg, farm visit charges of veterinarians per farm, taking samples, laboratory tests, injection of vaccine, database creation and maintenance), material costs (eg, ear tags, vaccination doses, cool boxes for transportation of vaccine, information materials) and other costs (eg, travel costs, purchase of

ⁱⁱ In active surveillance, an investigator initiates the data collection by using a predefined action plan.⁴⁰

ⁱⁱⁱ The term passive surveillance means that an observer provides animal health data, for example, a farmer or a veterinarian reports symptomatic animals to the authorities and diagnostic testing is subsequently conducted.

Criteria for comparison	Austria	Switzerland
Demographic data		
No. of cattle (holdings)	2 006 000 (73 272)	1 597 000 (41 095)
No. of sheep (holdings)	425 000 (17 363)	431 000 (10 035)
No. of goats (holdings)	92 000 (12 336)	85 000 (7 212)
BTV situation		
First/last confirmed BTV-8 case	November 2008/July 2009	October 2007/March 2010
No. of infected animals/holdings (BTV-8)	28/14	160/76
Freedom from disease status	March 2011 (lost status: 2015)	March 2012 (ongoing)
First/last confirmed BTV-4 case	November 2015/December 2016	Not applicable (as of March 2017)
No. of infected animals/holdings	9/7	Not applicable
Surveillance programme		
Duration of surveillance	2007–2016	July 2007–2011, 2014–2016
Estimated design prevalence	3.28% (95 probability)	2.63% (95 probability)
Number of BTV surveillance units	28 units until 2010, 4 units (2011–2015), 28 units thereafter	16 units
Sample size/holdings in sentinel surveillance	150 tests/month/unit; 15 holdings/unit	14–30 tests/month/unit; 14 holdings/unit
Sample size in risk-based surveillance	91 tests/unit until 2011; approximately 300 tests/unit thereafter	2200 tests/220 holdings (whole CH in 2009); 1652 tests/432 holdings (whole CH in 2010)
Sampling duration	Entire year until 2011, September to December since 2011	January–May (2007–2016)
Tests of holdings in Liechtenstein	No	Yes (n=2)
Vaccination programme (BTV-8)		
Duration and area of vaccination	July 2008–March 2009 (entire country)	July 2008–May 2010 (entire country)
Voluntary vaccination	Yes (since March 2009)	Yes (since May 2010)
Vaccine used	BTVPUR Alsap 8	BTVPUR Alsap 8; Bovilis BTV-8; Zulvac 8 bovis
Number of vaccine doses ordered	4.75 million	4.00 million
Species	All goats and sheep from the age of 4 weeks and all cattle from 3 months old, with the exception of, for example, sentinel or male breeding cattle to be vaccinated.	Vaccination of all cattle, goats and sheep older than 3 months. It was not compulsory to vaccinate goats in Switzerland in 2009.
Interval	Primary immunisation for cattle consisted of two vaccinations at an interval of 4 weeks, whereas only a single vaccination was necessary for sheep and goats.	Primary immunisation for cattle consisted of two vaccinations at an interval of 4 weeks, whereas only a single vaccination was necessary for sheep and goats.
Farmers who refused BTV-8 vaccination	Paid a fine	Farmers in Switzerland could pay in advance to avoid the 'mandatory' vaccination campaign: 14% opted out of the scheme. ²⁰

animals for sentinel surveillance, administration costs as well as dispatching samples from the farm to the laboratory). Details of the prices can be found in the online supplementary table S1. Deterministic spreadsheet models for the cost calculation were developed using Microsoft Excel. All monetary values were expressed in EUR (1 CHF=0.66 EUR, according to estimates of the Swiss exchange rate by Häsler *et al.*²⁰ We used the linear model approach previously published by Pinior *et al.*²¹ to analyse whether the total costs per political district or canton were influenced by readily available data, such as ruminant (cattle, sheep and goat) population and average ruminant herd size. We compared both applied regression models and the corresponding root mean square error (RMSE) after application of the Akaike information criterion²² in order to assess the predictive goodness-of-fit of the model.

Additionally, we compared the costs of hypothetically reduced export prices of cattle and calves and the programme costs in Austria and Switzerland in order to determine the threshold level of export price change where the costs of the BTV programmes would still be covered. In this context, we assumed that if no BTV programme had been implemented in either Austria

or Switzerland, the trading behaviour of foreign countries would have changed due to the increased risk of purchasing possibly infected animals compared with countries with intervention programmes or with BTV-free status. Simultaneously, the required number of cattle and calves exported abroad in order to offset programme costs were examined for both countries for the period 2008–2016.

Besides the preceding market analysis, we conducted an export analysis for the Austrian cattle sector comprising three scenarios. For all three scenarios, we assumed that, as specified by Häsler *et al.*,²⁰ the number of animals not being exported was instead sold on the domestic market at a 15 per cent loss in market prices compared with export market prices. In the first scenario, we assumed that export of live animals (breeding and productive cattle and calves) decreased by 100 per cent in the year of the initial BTV-8 outbreak (2008) and the subsequent year 2009. The second and third scenario examined Austria's cattle export countries in the EU and non-EU countries. Neighbouring Italy is one of Austria's most important trading partners within the EU and with respect to all export countries accounting for up to 53.1 per cent of all breeding and

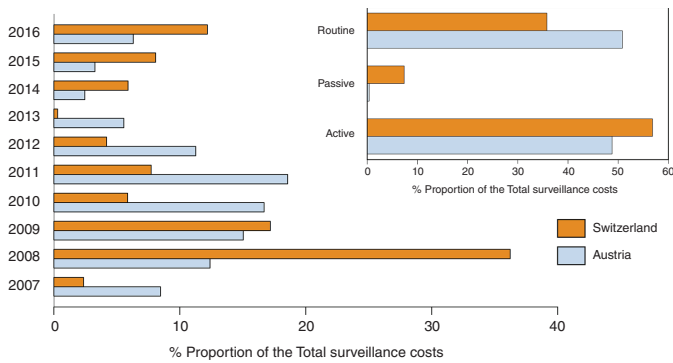


FIG 1: Distribution of the surveillance costs in Austria and Switzerland stratified by year and type of surveillance programme.

productive cattle and calf exports in 2009.²³ In our theoretical model, we assumed that Italy discontinued importing Austrian breeding and productive cattle and calves from the BTV-8 outbreak in 2008 until 2009. With respect to non-EU countries, Russia is one of Austria's most important cattle trading partners. The third theoretical scenario considered the implications of Russian import restrictions beginning in 2008 with respect to the BTV-8 outbreak until 2009.

Results

The total costs of the vaccination and surveillance programmes over this 10-year period in Austria amounted to €23.6 million, of which 34.0 per cent (€8.0 million) were allocated to the surveillance programme, and 66.0 per cent (€15.6 million) were incurred by the vaccination campaign. By contrast, the Swiss programmes amounted to €18.3 million, of which 14.7 per cent (€2.7 million) were allocated to the surveillance programme, and 85.3 per cent (€15.6 million) to the vaccination programme. Public costs in Switzerland made up 45.5 per cent (€8.3 million) and private costs 54.5 per cent (€10.0 million) of the total costs. In Austria, the EU bore 20.8 per cent (€4.9 million; without 2016) of the total costs, and the remaining costs were financed from national resources, divided into public costs with 61.9 per cent (€14.6 million) and private costs 17.3 per cent (€4.1 million). Switzerland did not receive any financial support from the EU.

The number of laboratory tests per year differed, both within and between the two countries (see supplementary figure 1). In Austria, 11 times more BTV laboratory tests were carried out than in Switzerland. Consequently, the distribution of the surveillance costs varied considerably during the study period. The highest surveillance costs were incurred in Austria in 2011 and in Switzerland in 2008 (Fig 1). In both countries, the surveillance costs increased in the period 2014–2016. Active sampling costs were two and half times higher in Austria than in Switzerland. In contrast, the costs of passive surveillance were approximately six times higher in Switzerland compared with Austria. If the total surveillance costs were divided by the total ruminant population (cattle, sheep and goats), the

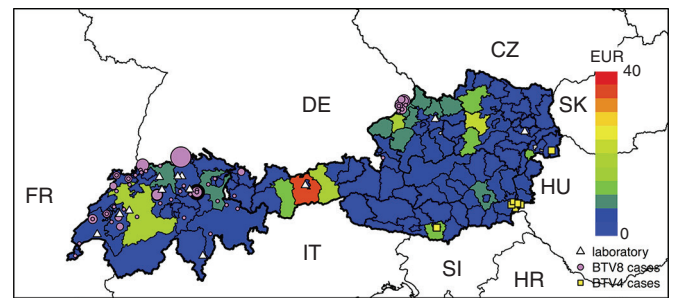


FIG 2: Total normalised surveillance costs in each political district in Austria (right) or canton in Switzerland (left) (€000 s). No data on the serological costs per political district in Austria were available for the years 2007–2010; these data were extrapolated from the data 2011 to 2016. The comparison between both countries is limited due to the different number of geographical units. BTV-8, bluetongue virus serotype 8; BTV-4, bluetongue virus serotype 4.

average costs per animal would be approximately €3.20 in Austria and €1.30 in Switzerland. The spatial allocation of the normalised surveillance costs with respect to the number of ruminants and farms per political district/canton can be found in Fig 2. However, the surveillance costs in Switzerland can be better predicted ($R^2=0.72$) by readily available data, such as ruminant population than in Austria ($R^2=0.45$), although the percentage error predicted by the model was high in both countries (Table 2).

The allocation of the vaccination costs per species was similar (cattle: around 85 per cent, sheep: 13 per cent, goat: 2 per cent of the total vaccination costs) in Austria and Switzerland. The highest vaccination costs (77 per cent of the total vaccination costs) were incurred in 2009 in Austria, whereas similar costs were caused in 2008 and 2009 combined (37 per cent and 41 per cent of the total vaccination costs, respectively) in Switzerland. If the total vaccination costs were divided across the total ruminant population, the average costs per vaccinated animal would be approximately €6.20 in Austria and €7.40 in Switzerland. The highest proportion of vaccination costs were incurred by labour costs, followed by material and other costs. In Austria, the highest labour costs were caused by the injection costs per vaccination which amounted to 46.3 per cent (€7.2 million) of the total vaccination costs, followed by the farm visit fees of veterinarians with 35.2 per cent (€5.5 million). In Switzerland, approximately 48.3 per cent (€7.6 million) of the total vaccination costs were spent on vaccination administration and 6.2 per cent (€970 000) for farm visit fees. The normalised vaccination costs in Austria and Switzerland are shown in Fig 3. The EU financed 27.8 per cent (€4.3 million) of the total costs of the vaccination campaign in Austria. Approximately 55 per cent of the vaccination costs were borne by the private sector in Switzerland, whereas the public sector in Austria financed almost all national vaccination costs of approximately €11 million.

The export value of the cattle market in Austria between 2008 and 2016 amounted to over €1 billion with an annual cattle export share ranging between

TABLE 2: Summary of the estimated final model parameters influencing the surveillance and vaccination costs				
	Estimate coefficient (β)	Standard error (se)	t value	P value
Austria surveillance				
Intercept	9.02E+00	1.84E-01	48.98	<0.0001***
Cattle population	4.60E-05	7.39E-06	6.23	<0.0001***
Goat population	2.44E-04	1.49E-04	1.63	0.106
Switzerland surveillance				
Intercept	9.69E+00	1.98E-01	48.85	<0.0001***
Cattle population	2.39E-05	5.65E-06	4.23	0.0004***
Sheep population	2.92E-05	1.08E-05	2.68	0.0139*
Cattle herd size	-1.87E-03	7.86E-04	-2.38	0.0267*
Austria vaccination†				
Intercept	4.42E+04	7.62E+03	5.80	<0.0001***
Cattle population	5.77E+00	1.36E-01	42.38	<0.0001***
Sheep population	5.95E+00	6.11E-01	9.73	<0.0001***
Cattle herd size	-1.26E+03	2.30E+02	-5.45	<0.0001***
Goat herd size	-3.41E+02	2.04E+02	-1.66	0.0987
Switzerland vaccination				
Intercept	1.85E+05	5.52E+04	3.36	0.0028**
Cattle population	3.61E+00	1.64E+00	2.20	0.0389***
Cattle herd size	4.03E+02	1.99E+02	2.02	0.0556‡
Prediction per geographical unit and goodness-of-fit (R²)				
	RMSE (EUR)	RMSE (%)	R ²	Reference
Surveillance costs Austria	136 174	167.93	0.45	
Surveillance costs Switzerland	130 446	125.94	0.72	
Vaccination costs Austria	20 521	14.30	0.97	Pinior <i>et al</i> ²¹
Vaccination costs Switzerland	189 645	30.41	0.84	

*P=0.05; **P=0.01; ***P=0.001.
†The linear model for the vaccination costs in Austria was previously published by Pinior *et al*.²¹
‡P=0.1.

5.7 per cent and 8.0 per cent, whereas the Swiss export market over the same period was worth just €19 million and annual cattle export shares varying between 0.0 per cent and 0.4 per cent. A real price reduction of export market prices of more than 2.2 per cent regarding breeding, productive and slaughter cattle and calves in Austria (see online supplementary table S2) would cause higher economic costs than the implemented BTV programme itself. Conversely, in Switzerland a reduction of export market prices of more than 95 per cent with respect to breeding, productive and slaughter cattle and calves would be necessary to cause higher economic costs in comparison to the implemented BTV programme itself (see online supplementary table S3). In Austria, a total of 26 082 productive, breeding and slaughter cattle and calves would have had to be exported between 2008 and 2016 to compensate for the

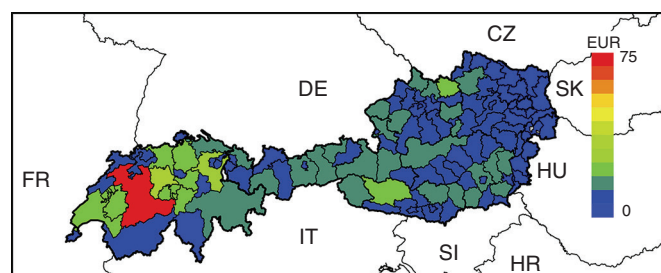


FIG 3: Total normalised vaccination costs in each federal state (right) or canton in Switzerland (left) (€000s). The comparison between both countries is limited due to the different number of geographical units.

incurred BTV programme costs of €23.6 million (see online supplementary table S2). In Switzerland, overall 12 078 exported cattle and calves would offset the programme costs of €18.3 million (see online supplementary table S3). Export scenario analysis revealed that a 100 per cent reduction in the export of breeding and productive cattle and calves in the years 2008 and 2009, and a 15 per cent price reduction for live animals on the domestic market for the number of animals sold instead at the domestic cattle market would have caused €29.0 million of lost sales revenues in Austria (approximately 123 per cent of overall BTV programme costs). Simultaneously, the hypothetical trade restriction in the period 2008–2009 of Austria's most important cattle export country, Italy, would cause significant economic losses amounting to €12.1 million (approximately 51 per cent of overall BTV programme costs). Considering trade relations with the non-EU country of Russia in the third export scenario, a theoretical trade barrier between 2008 and 2009 for Austrian breeding and productive cattle and calves would have incurred losses in sales revenues amounting to €6.3 million (approximately 27 per cent of overall BTV programme costs).

Discussion

A cost analysis is the first step to assess how much the government has spent on implementing disease control

and eradication activities. In contrast to the study by Piniør *et al*²¹ in which the costs of the Austrian BTV-8 control programme were calculated from 2005 to 2013, the present study considers the costs incurred in Austria during the EU regulation period (2007–2016) and compares these expenses with those of the surveillance and vaccination programmes incurred in the non-EU country of Switzerland. The results of the analysis presented here show that BTV surveillance and vaccination programmes incurred considerable costs in both Austria (€23.6 million) and Switzerland (€18.3 million), compared with the relatively small number of BTV-positive animals reported in these two countries between 2007 and 2016. If the previously published costs of vector monitoring²⁴ were included in this analysis, the total costs of BTV programmes carried out in accordance with the EU regulation would have amounted to €25.0 million in Austria and €18.4 million in Switzerland.

Despite the similarities in topography and agricultural production systems, it is important to note that a direct comparison of the programme costs between both countries is difficult. For instance, the low surveillance costs in Switzerland were caused by an 11 times smaller number of animals being tested compared with Austria, due to differences in sampling periods (Switzerland: from January to May; Austria: entire year until 2011), numbers of exported animals (and thus tested animals) and a different number of geographical sampling areas (Switzerland 16 units; Austria 28 units). Austria was initially divided into 28 geographical units and 91 animals per unit were tested between 2009 and 2011 in order to confirm no virus circulation. From 2011, these divisions were reduced from 28 geographical units to just four units covering the entire country, and from each of these units, approximately 300 animals were tested (Table 1). As part of the Swiss risk-based plan, Switzerland was divided into 16 geographical units, which remain in place today. Furthermore, Switzerland did not implement active surveillance in 2012 and 2013 (Table 1), but instead used data from the routine surveillance programme to make conclusions about the disease situation and, as such, to comply with the requirements of the EU regulation. Additionally, Switzerland had previous experience (2003/2004) with BTV surveillance programmes²⁵ in contrast to Austria. One limitation of the present study is that the power of the surveillance system to detect an outbreak or cases, often referred as the sensitivity of surveillance programmes,^{26 27} was not taken into account. Such effectiveness analyses should be carried out before implementation of the relevant surveillance programme.²⁸ The power of BTV surveillance programmes combined with a cost estimation approach was calculated in Switzerland before implementation; however, the Austrian authorities did not carry out this measure. Thus, a number of cost-effective surveillance options were communicated to the Swiss

authorities and were considered in their decision-making process,²⁸ whereas this step was not included in the Austrian procedure. Consequently, we assume that the implemented surveillance programmes were performed at different effectiveness levels in Austria and Switzerland. These variations in sampling strategy and geographical units initially represented the main difference between the Austrian and Swiss surveillance programmes and are likely to, at least partially, explain why surveillance costs in Switzerland were three times lower than in Austria. Compared with the total costs of surveillance and intervention, the surveillance costs make up only a small proportion, a result which is comparable with analyses published by other countries, such as the Netherlands.²⁹ In both countries, an increase of the surveillance costs can be observed in 2014–2016 due to the higher risk of new BTV infections from neighbouring countries. At the time of writing (April 2017), BTV-4 is still present in Austria, northern Italy, Slovenia, Croatia, Cyprus, Hungary, Slovakia, Romania, Bulgaria, Greece and Spain. BTV-8 re-occurred in France in 2015^{iv} and is present today^v (17 May 2017).

The costs to the private sector may have been underestimated as the costs of disease treatment and the production losses as a result of BTV infection were not included. Production losses are notoriously difficult to calculate as they are subject to both biological and financial variation.³⁰ Other authors have estimated the production losses incurred by BTV to range between €197.00 per head of cattle in Germany³¹ and €0–€26.00 per cow in the Netherlands.³² Benefits of control and intervention programmes (primarily measured as avoided production losses) were not quantified in the present study. In contrast to Germany where more than 24 000 animals (2006–2008) or in France where 37 000 herds (2007–2008) were infected,^{33 34} the production losses due to BTV infection can be assumed to be relatively small in Austria and Switzerland due to the low number of herds affected (21 infected herds in Austria and 76 infected herds in Switzerland; 2007–2016). Rushton and Lyons³⁵ pointed out that the authorities' reaction to BTV (ie, intervention measures) may have a greater economic impact than the direct losses themselves.

Further benefits of disease control programmes include continued livestock trade. These factors justify that the private sector bears a major proportion of the BTV surveillance costs. Due to the importance of the cattle export market, a reduction of just 2.2 per cent in cattle export prices in Austria would cause higher costs than the implemented programme itself. Thus, the investments in such programmes are justified due

^{iv}https://ec.europa.eu/food/sites/food/files/animals/docs/ad_control-measures_bt_outbreaks_video_en.mp4 (accessed on 29 July 2017).

^vhttps://ec.europa.eu/food/animals/animal-diseases/control-measures/bluetongue_en (accessed on 29 July 2017).

to reduced spread of BTV infection and to prevent negative market change (especially for Austria).

Austria and Switzerland were both declared to be a single restriction zone at an early stage of the BTV-8 outbreak and thus no²⁰ or very few²¹ costs were incurred with respect to movement restrictions within a country during this period, in stark contrast to France³⁶ and Germany³¹ where numerous restriction zones were established. It has been estimated that the total costs of the BTV-8 epidemic in Germany amounted to approximately €253.5 million (2006–2010), of which trade restrictions and the corresponding diagnostic testing made up 29.5 per cent (€74.8 million) and surveillance cost €3.2 million for the year 2006 only (the costs of the surveillance programmes for the other years were not calculated due to a lack of data).³¹ Häslér *et al.*²⁰ also estimated the costs of the BTV-8 surveillance and intervention programmes between 2008 and 2009 in Switzerland. In that study, the results indicated that the mean cost of surveillance and vaccination activities amounted to approximately €100 000 (per year) and €19 million (2008 and 2009), meaning that the present analysis determined higher costs for surveillance in Switzerland. By contrast, the costs of vaccination in our analysis are approximately €4 million lower than those estimated by Häslér *et al.*²⁰ It is important to note, however, that these studies are not directly comparable, due to a variety of data sources (eg, Häslér *et al.*²⁰ used census data of livestock in order to estimate the vaccination costs in contrast to the present study, where official data originating from veterinary authorities were used). In this context, as is frequently reported in animal health economics studies, the comparability of data is highly dependent on the quality of documentation for costs incurred.³⁷ The linear model indicated that the vaccination costs can better be predicted by ruminant population and herd size than surveillance costs (Table 2), whereas the prediction error of vaccination costs was higher in Switzerland (30 per cent) than in Austria (14 per cent). This could be explained by the different distribution of the costs between Austria and Switzerland. In Austria, 82 per cent of the vaccination costs can be assigned to labour costs such as operation fees for inspection and injection of vaccine, which correlate with the ruminant population size. In Switzerland, approximately half of the vaccination costs were assigned to material and other costs such as cool box packaging, information material and scientific projects.

The comparison of surveillance and intervention programmes presented here allows authorities to assess recommendations for a more cost-effective approach to disease monitoring in advance, such as focusing sampling on the risk period, in risk areas, passive surveillance or sampling at slaughterhouses. Furthermore, the EU regulation provides scope for surveillance implementation, for example, defining an accurate design prevalence (Table 1), which can be used to reduce costs

of surveillance, without loss of detection accuracy. The involvement and awareness of farmers is also indispensable for passive disease surveillance. This was shown in Switzerland where one-third of all BTV-8 cases were detected via this surveillance form, leading to much lower costs of the overall surveillance programme in Switzerland compared with Austria. Thus, clinical veterinary surveillance, previous experience and the participation of farmers is vital for early detection and to reduce the surveillance costs. It is known that BTV samples in Switzerland were often taken from a farm and the veterinarian subsequently vaccinated livestock on the same farm, effectively halving the necessary farm visits. This could be one reason why the operation fees for inspection during the vaccination programme were five times lower in Switzerland than in Austria. Such differences between comparable countries demonstrate the importance of calculating costs of surveillance and vaccination programmes in advance, as such actions can save veterinary authorities substantial amounts of financial resources while preventing the spread of transboundary diseases and ensuring the health and wellbeing of livestock.

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