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The application of epidemiology in national veterinary services: Challenges and threats in Brazil

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ABSTRACT

The application of epidemiology in national veterinary services must take place at the interface between science and politics. Animal health policy development and implementation require attention to macro-epidemiology, the study of economic, social and policy inputs that affect the distribution and impact of animal or human disease at the national level. The world has changed fast over the last three decades including the delivery of veterinary services, their remit and the challenges addressed by public and animal health policies. Rethinking the role of public services and how to make public programs more efficient has been at the heart of the political discussion. The WTO through its SPS Agreement has changed the way in which national veterinary services operate and how trade decisions are made. Most low and middle income countries are still struggling to keep up with the new international scene. Some of these countries, such as Brazil, have very important livestock industries and are key to the global food systems. Over the last two decades, Brazil became a leading player in exports of livestock products, including poultry, and this created a strong pressure on the national veterinary services to respond to trade demands, leading to focus animal health policies on the export-driven sector. During the same period, Brazil has gone a long way in the direction of integrating epidemiology with veterinary services. Epidemiology groups grew at main universities and have been working with government to provide support to animal health policy. The scope and quality of the applied epidemiological work improved and focused on complex data analysis and development of technologies and tools to solve specific disease problems. Many public veterinary officers were trained in modern epidemiological methods. However, there are important institutional bottlenecks that limit the impact of epidemiology in evidence-based decision making. More complex challenges require high levels of expertise in veterinary epidemiology, as well as institutional models that provide an appropriate environment for building and sustaining capacity in national veterinary services. Integrating epidemiology with animal health policy is a great opportunity if epidemiologists can understand the real issues, including the socio-economic dimensions of disease management, and focus on innovation and production of knowledge. It may be a trap if epidemiologists are restricted to answering specific decision-making questions and policy makers perceive their role exclusively as data analysts or providers of technological solutions. Fostering solutions for complex issues is key to successful integration with policy making.

1. Veterinary epidemiology and national veterinary services in a fast changing world

The application of epidemiology in national veterinary services must take place at the interface between science and politics. Animal health policy development and implementation require attention to macroepidemiology, the study of economic, social and policy inputs that affect the distribution and impact of animal or human disease at the national level (Hueston and Walker, 1993). Therefore, veterinary epidemiology should apply scientific methods to deal with complex policy issues through approaches that consider the economic, legal, and cultural context, as well as the biological and medical issues (Hueston, 2003).

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The world has changed fast over the last three decades, including the delivery of veterinary services, their remit and the challenges addressed by public and animal health policies. The post-war expansion of the services provided by governments was over in the 1980s. New free market economics gained ground and have dominated the economic and political landscape since then, in advanced and developing economies alike. Rethinking the role of the state and how to make public programs more efficient in an era of small government, or rather smaller budgets, has been at the heart of the political discussion.

The Sanitary and Phytosanitary Agreement (WTO, 1995) has also changed the way in which national veterinary services operate and how trade decisions related to agriculture products are made. It requires World Trade Organization (WTO) members to base their sanitary measures on international standards, guidelines and recommendations, which should be defined by the World Organization for Animal Health (OIE), as regards animal health and zoonoses. Zepeda et al. (2005) recognized that national veterinary services worldwide, especially those in developing countries, are facing major challenges to adjust to this new international decision-making scenario. Being a member of the WTO and having signed regional or bilateral trade agreements demands greater responsibility and puts additional pressure upon existing infrastructure, whilst governments' budgets have decreased in many countries. Likewise, risk averse consumers in food producing and importing countries alike, with easy and ready access to information, add to such pressure and bring about the need for transparency and better risk communication. Zepeda et al. (2005) summarized the impact of the SPS Agreement on national veterinary services and identified areas where veterinary epidemiology can contribute to the development of cost-effective solutions: harmonization; equivalence; risk analysis and determination of the appropriate level of protection; regionalization and compartmentalization; transparency, including the need for comprehensive surveillance systems.

The use of risk analysis has been recognized as a tool for applying scientific knowledge to both domestic and international animal and public health issues (Hueston, 2003), especially in the context of international trade. Risk Assessment can also be used to inform risk management in national disease prevention and control programs and to plan risk-based surveillance systems. Risk analysis increased the demand for epidemiological methods within veterinary services and, most importantly, it brought about the need for sound epidemiological information. It is epidemiology applied to policy decisions at the interface of science and politics.

Regionalization opened up new possibilities for establishing disease free zones/compartments, as defined by the OIE, and using this as a strategic tool for disease control. It increased the demand for epidemiological studies to substantiate disease freedom and for methods to establish zones based on differential epidemiological risks.

Epidemiology also plays a key role in harmonization. The development of international standards and guidelines on animal health at the OIE requires the contribution of veterinary epidemiologists, e.g. providing disease models to inform sanitary measures, new surveillance guidelines and criteria for disease risk categorization of countries or zones, as well as methods for the use and evaluation of diagnostic tests. All countries participate in the process and the national veterinary services have to evaluate and approve changes to the OIE Code, further increasing the need for epidemiological skills at the national level.

Transparency involves the notification of disease status and of SPS measures (Zepeda et al., 2005). It requires well-structured independent veterinary services and depends on the existence of high quality comprehensive surveillance systems, which are now the backbone of national veterinary services with considerable expansion of active components. Epidemiological reasoning and epidemiological tools are key to implement effective surveillance systems. According to Willeberg (2012), animal health surveillance is an ever-evolving activity, since health- and risk-related policy and management decisions now and in the future need to be backed by the best available scientific evidence and methodology. In a world of shrinking government budgets, epidemiology can help reduce costs and improve efficacy of surveillance and this has led to newer methods of risk-based surveillance (Reist et al., 2012; FAO, 2014) or the emergence of strategies like syndromic surveillance (Dórea et al., 2011).

The OIE publishes guidelines on surveillance for terrestrial (OIE, 2015a) and aquatic animals (OIE, 2015b), as well as a guide to terrestrial animal health surveillance (OIE, 2015c). In addition, epidemiologists from around the world organize a new conference fully dedicated to surveillance – the International Conference on Animal Health Surveillance (ICAHS). Surveillance is, therefore, a key area for the application of veterinary epidemiology, and a major challenge for national veterinary services.

It goes without saying that the revolution in information technology and communications has had a profound impact upon the way we do research and the way we make decisions, including health policy decisions. Computer technology is increasingly making possible unlimited data storage and manipulation. The massive increase in captured data will present great opportunities for new scientific discoveries on an unprecedented scale (Weisberg, 2014). Hence, veterinary epidemiology is ever more focused on complex data analysis and development of technologies and tools to solve specific disease problems. Statistics, mathematics and information technology are increasingly at the heart of veterinary epidemiology.

In the process, veterinary epidemiologists must not forget that science progresses as much by providing answers as by refining our questions, because the answer is not separate from the problem (Weisberg, 2014). This is key if epidemiology is to be applied to policy decisions in animal health services. There is no point in providing a solution, using complex and sophisticated methods, if one does not get the question right.

New and more complex challenges require high levels of expertise, notably in veterinary epidemiology, as well as institutional models that provide an appropriate environment for building and sustaining capacity in national veterinary services. In many countries with advanced economies and stable institutions, veterinary epidemiology has been progressively incorporated into the planning and management of animal health policies, albeit with different models. The creation of the European Food Safety Authority (EFSA) stands out as a major development in the European Union. EFSA provides independent scientific advice to the decision makers who regulate food safety in Europe. However, low and middle income economies are still struggling to keep up with the new international challenges. Some of these countries have very important livestock industries and are key to the world food systems. So, let us now look at what has happened in Brazil over the last two decades, a country that is a major producer and exporter of livestock and livestock products.

2. The extraordinary growth of livestock production and exports in Brazil over the last 20 years

The size, structure and focus of national veterinary services should be commensurate with the dimension of a country's livestock and food industry and tuned to the challenges posed to the economy, as well as to animal and public health. When the livestock industry plays an important role in exports, eradication of animal diseases that have an impact on trade tends to be given the highest priority in public policies and investments. This is certainly the case of foot-and-mouth (FMD) disease in Brazil, as in other

South American countries like Argentina, Uruguay, and Paraguay (Urcelay, 2009).

The livestock sector grew markedly in Brazil over the last three decades, as a result of complex changes in the country's economy, notably the macroeconomic and currency stability, coupled with major investments in agriculture technology and modernization of the livestock value chains. Exports of livestock derived products increased to the extent that Brazil became a world leading player in beef and chicken exports (Figs. 1 and 2) and a major player in pork exports (Fig. 3). Milk production more than tripled over the last twenty years (Fig. 4). In all subsectors of the livestock industry, Brazil witnessed herd growth, productivity gains and increased participation in the world food system. Therefore, government veterinary services had to respond to enormous challenges.

3. Trends in animal health policy in Brazil and the role of veterinary epidemiology

Governments have to implement animal health policies, in other words, to make decisions and commit to particular courses of action, in a larger political context. The Brazilian veterinary services are under such pressure to cope with trade related issues that other problems tend to be sidelined. This has led to a two-tier system, whereby public animal health policies are focused on the export-driven sector of the livestock value chains. Animal health authorities, both at the federal and state levels, are mostly involved in programs driven by trade accreditation schemes. Moreover, they are progressively acting as planners and auditors of the system, with the private sector assuming an increasing role in the implementation of regulatory measures.

The success of efforts to control and eradicate diseases that potentially affect trade, notably foot-and-mouth disease (FMD), classical swine fever (CSF) and Newcastle disease is shifting the focus from control and vaccination to surveillance. When FMD was endemic in Brazil, epidemiological studies conducted under the aegis of the Pan-American Center for FMD (PANAFTOSA) focused on the understanding of the dynamics of livestock production chains as determinants of FMD ecosystems (Obiaga et al., 1979) and used this concept to propose regional strategies to tackle disease control and eradication (Astudillo et al., 1986), creating the basis for future regionalization and establishment of FMD free zones. Such studies attempted to gain insights into the epidemiology of FMD with a holistic approach that included the social and economic aspects, in addition to the biological dimension of the problem (Obiaga et al., 1979).

With progress towards FMD, CSF and Newcastle disease eradication over the last twenty years, government veterinary services have carried out countless surveys to demonstrate disease freedom. This demanded intense contribution of veterinary epidemiology, including network analysis to establish sampling regions where the disease agents could be present, sampling methods to deal with clustering, survey sensitivity and complementary investigations to make up for imperfect diagnostic specificity, information systems to process large amounts of data, validation of diagnostic tests, as well as methods for data analysis (Gonçalves et al., 2003; Moraes et al., 2015). Hopefully, there is a trend to move away from surveys to sustained surveillance efforts, which has triggered discussions on surveillance systems' attributes (e.g. sensitivity) and evaluation (Mota et al., 2015). Epidemiological methods have also been used to inform and devise risk-based active surveillance efforts.

Over the last two decades, programs to control endemic diseases, such as bovine brucellosis and tuberculosis, rabies in cattle, or glanders and infectious equine anemia in equids, gained ground. These require new approaches and a different mindset. Such diseases may prove very hard to eradicate, progress is slower compared to fast-moving diseases, and national veterinary services need to sustain long term policies. Trade impact is not the main driver for controlling these diseases, which makes it harder to secure public and private funding. Hence, there is a strong case for cost-effective strategies that ought to be based on epidemiological models and in-depth knowledge of determinants of disease spread. This is no small undertaking in a continent-sized country, with massive livestock populations and extremely varied socio-economic and ecological regions. As the FAO puts it in the guidelines for a Value Chain Approach to Diseases Risk Management (FAO, 2011), strategic planning must be based on knowledge in order to identify: the disease agent and the disease it causes; the risk factors of the diseases and the livestock populations in which it is active; possible interventions; and the people who manage and own these animals. This is epidemiology in its clearest sense.

The Brazilian national program for the control and eradication of bovine brucellosis and tuberculosis (PNCEBT), launched in 2001, stands out as an example of a new policy that triggered a high demand for epidemiological knowledge. From the outset of PNCEBT, the federal animal health authority (Ministry of Agriculture, Livestock and Food Supply—MAPA) has led a long-term on-going research program that includes studies on the epidemiological status and risk factors of brucellosis and tuberculosis in each state. This was carried out by the state animal health services and the scientific coordination was taken over by the veterinary epidemiology group at the University of São Paulo, with the collaboration of the University of Brasília (Poester et al., 2009; Mota et al., 2016; Borba et al., 2013). Also, there have been studies on the economics of herd accreditation from the dairy farmer's perspective and on the economics of brucellosis vaccination (Alves et al., 2014).

Another emerging area in the Brazilian government veterinary services is aquatic animal health. It started with the creation of a Coordination of Aquatic Health within the new Ministry of Fisheries and Aquaculture (MPA). From the very beginning, it was established that all sanitary measures applied to aquaculture would be based on risk analysis, following the OIE guidelines. The aquatic health authorities fostered links with veterinary epidemiologists in the academia and discussed ways of promoting the generation of epidemiological knowledge with a view to evidence-based planning and management decisions. In 2013, it was created an official collaborative network of aquatic epidemiology (AQUAEPI), coordinated by the University of São Paulo. However, MPA was later extinguished and merged with MAPA, and the aquatic health sector was integrated into the Animal Health Department, alongside the health programs for terrestrial animals. Although the efforts to develop the field of epidemiology applied to aquaculture are still in very early stages, there are now epidemiological contributions to surveillance (Marques et al., 2015), risk analysis for trade, as well as studies on the disease dynamics in fish production systems (Delphino et al. 2016). An important feature of this institutional arrangement is the very close operational link between the epidemiology network and the diagnostic laboratory network that was established by MPA, although both networks are based at public universities, not government-run institutes.

4. Challenges for integrating epidemiology into animal health policy

The scenario described above shows that Brazil has gone a long way in the direction of integrating epidemiology with veterinary services. It should be stressed that the examples given above are not an exhaustive list of all studies and contributions of veterinary epidemiology to animal health policy in the last two decades. There have been many more, including the whole array of modern

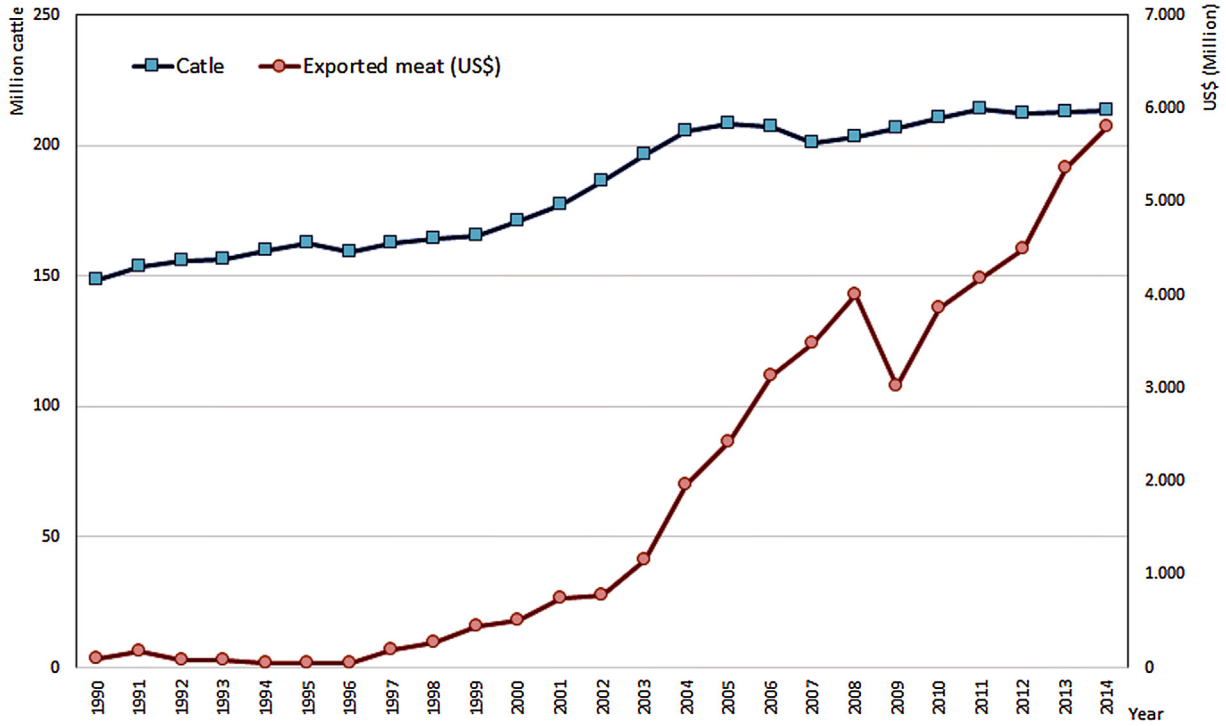

Fig. 1. Trend of the cattle herd and beef exports in Brazil, from 1990 to 2014* (AliceWeb, 2014).
*Sources: Instituto Brasileiro de Geografia e Estatística (IBGE) e Ministério do Desenvolvimento, Indústria e Comércio Exterior (sistema AliceWeb)

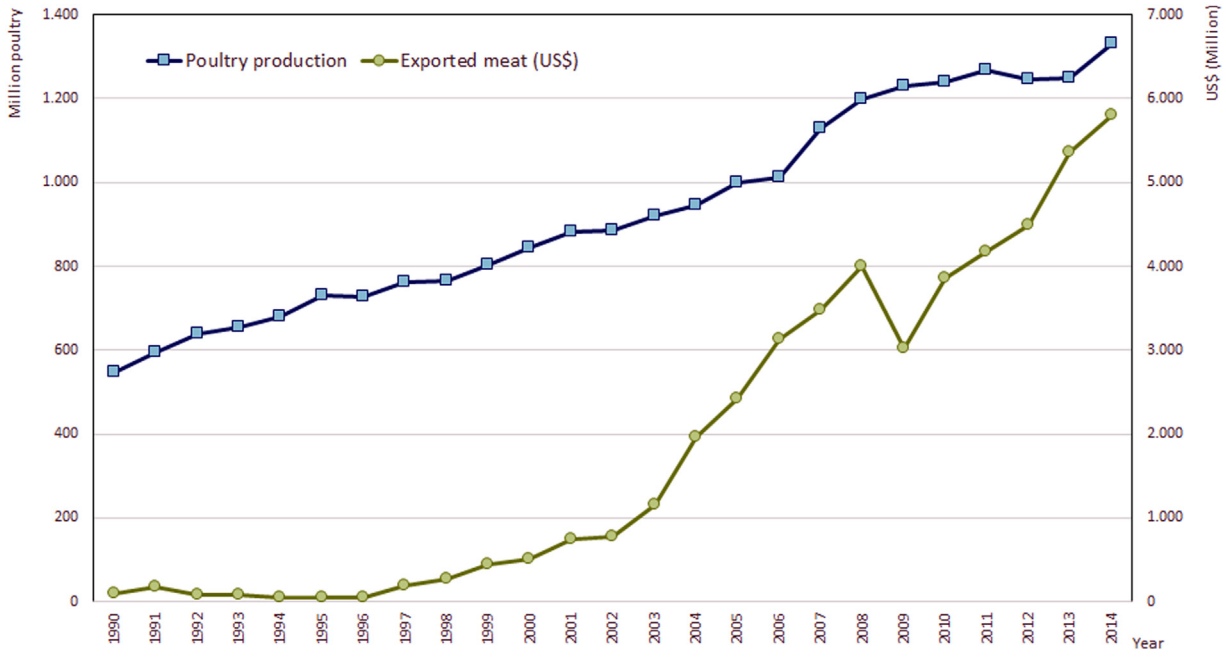

Fig. 2. Trend of the poultry flock and chicken exports in Brazil, from 1990 to 2014* (AliceWeb, 2014).
*Sources: Instituto Brasileiro de Geografia e Estatística (IBGE) e Ministério do Desenvolvimento, Indústria e Comércio Exterior (sistema AliceWeb)

methods and tools used in epidemiology, including network analysis (Amaku et al., 2015), GIS and spatial analysis (Carvalho et al., 2012; Polo et al., 2015), disease spread models, evaluation of diagnostic tests, observational studies (Borba et al., 2013; Belchior et al., 2016), risk assessment (Corbellini et al., 2012), to name a few. Most have brought about new knowledge and may have contributed to improved decision-making.

The increasing demand of collaborative projects with the animal health authorities led veterinary epidemiology groups at major universities to build capacity both in human resources and methodological expertise. The array of methods, tools and technologies that are now used in the application of epidemiology to animal health policy in Brazil is in line with current trends in modern epidemiology in advanced economies. However, the integration of epidemiology with national veterinary services is rather inefficient and progress is slower than it could be. The actual gains in the quality of animal health policies are falling short of expectations. There

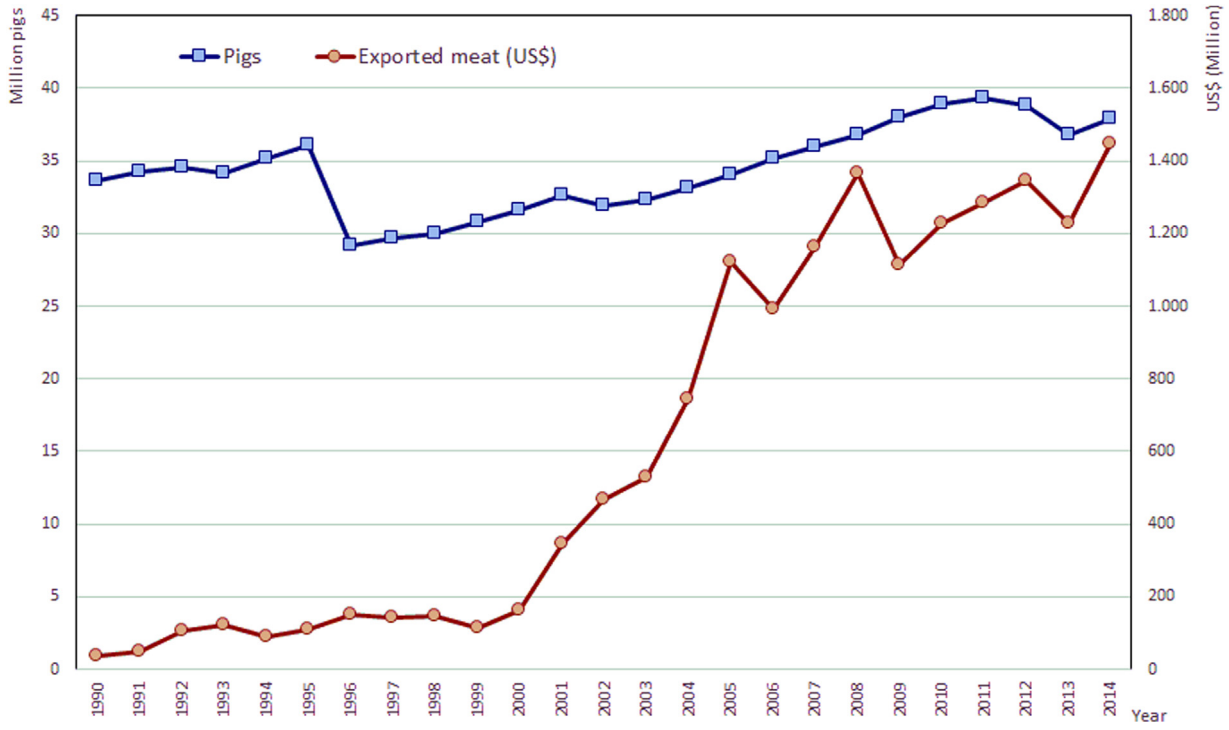

Fig. 3. Trend of the swine herd and pork exports in Brazil from 1996 to 2014* (AliceWeb, 2014).
*Sources: Instituto Brasileiro de Geografia e Estatística (IBGE) e Ministério do Desenvolvimento, Indústria e Comércio Exterior (sistema AliceWeb)

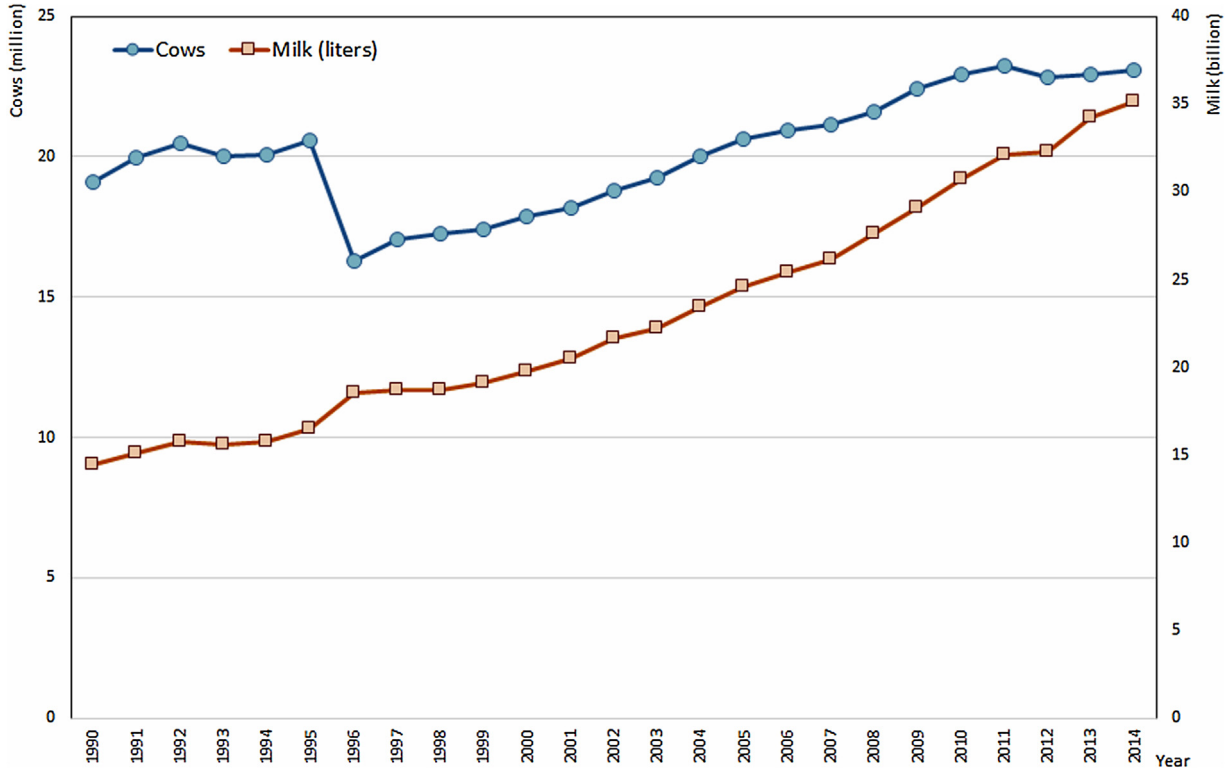

Fig. 4. Trend of the dairy herd and milk production in Brazil from 1996 to 2014* (AliceWeb, 2014).
*Sources: Instituto Brasileiro de Geografia e Estatística (IBGE) e Ministério do Desenvolvimento, Indústria e Comércio Exterior (sistema AliceWeb)

isn't an easy explanation but some issues may play a key role in the process.

First of all, most of the epidemiological work is demanded by specific disease control/eradication government programs and carried out by external academic groups, as described above. The in-depth methodological discussions and developments tend to stay confined to one single program or project. It is not unusual that important methodological issues (e.g. the limitations of cross-

sectional studies in low prevalence settings and for the purpose of studying risk factors) may be discussed and dealt with in one disease control program but be ignored a few years down the line in the context of another program, most likely with other epidemiologists involved. The solution to this problem depends on specific institutional arrangements but it requires a professional support in veterinary epidemiology that is sustained over time and that interacts with disease management.

Secondly, despite the considerable amount of epidemiological information made available to disease managers, these are usually inadequately prepared to make evidence-based decisions, by incorporating epidemiological knowledge to the process. They also tend to respond to short-term trade and industry pressures and give priority to practical operational concerns—this is not necessarily wrong; it comes with the job. Such scenario further limits the role of epidemiology as an effective intelligence service, at the interface between politics and science. Therefore, there is a case to engage disease managers in training aimed at recognizing and understanding the value of epidemiology to inform policy decisions.

Another way of looking at the issue is to ask ourselves if epidemiologists are using the right approach to make a real and positive impact in animal health policy. Although a science should not be defined by its methods, veterinary epidemiology is increasingly focused on methods, tools and technologies, in Brazil as elsewhere. Sometimes this leads to meaningful developments, but very often it drives epidemiologists away from formulating the right policy questions. Thus, veterinary epidemiologists may be seeking to provide answers to trivial problems, sometimes using rather complex methods. Epidemiology should be, instead, a key element of the understanding of animal health issues and epidemiologists should be involved in formulating the questions.

Lastly, what has been the role of epidemiology departments within the government veterinary services? The federal Department of Animal Health, at MAPA, features an epidemiology section that has historically functioned as an information unit. Likewise, for the animal health services at the 26 states and the Federal District. A recent survey showed that only 20% of those carry out any statistical and epidemiological analysis of data collected, although 40% of the personnel has done graduate studies in related areas of expertise (Teixeira et al., 2015). In Rio Grande do Sul, the state animal health service established an agreement with the epidemiology group at the university with a view to providing support and training in veterinary epidemiology applied to animal health policy. At the federal level, the establishment of AQUAEPI is also an attempt to secure continuous epidemiological support using external/academic expertise.

Although the value of veterinary epidemiology is appreciated in the national veterinary services, there isn't a clear idea with regard to the adequate institutional arrangement to integrate it into the system. Epidemiology units have to be strengthened within the animal health departments and equipped with well trained personnel. The veterinary epidemiologist has to be viewed as an expert, just as a virologist or a pathologist in diagnostic labs. However, should epidemiologists be simply perceived as "data analysts", epidemiology units, as well as external epidemiology experts, are doomed to fail in the objective of providing relevant knowledge to inform evidence-based disease management, because they won't be involved in formulating the questions.

5. Training should be fit for purpose

The scenario described above depends on education and training in veterinary epidemiology. In Brazil, epidemiology is part of the veterinary curriculum, including basics of quantitative veterinary epidemiology. Several universities offer graduate research-oriented programs (MSc; PhD) and an increasing number of veterinary officers are using this opportunity to specialize in veterinary epidemiology. The national veterinary services routinely contract short courses in epidemiology applications (e.g. sampling methods, data analysis; risk assessment; network analysis; GIS), usually offered by the university groups. Since 2012, it is held in Brazil a veterinary epidemiology conference (ENEPI), with a view to present and discuss methodological developments and applications. The first meeting was hosted by the University of São Paulo (USP), the second one was held in 2015 at the University of Brasília, and a third one will be hosted by the Federal University of Rio Grande do Sul (UFRGS), in 2018. The attendance has been good, between 150 and 200 people, both from academia and veterinary services, showing that veterinary epidemiology is a growing field in Brazil.

Nevertheless, given the number of people trained, the impact to the system is falling short of expectations, mostly due to institutional factors already described. Also, epidemiology units have a high turnover of personnel and many veterinarians trained in epidemiology end up doing other activities in the animal health departments, partly because the epidemiologist is not yet viewed as a specialist.

Training should not focus on data analysis and tools only. Epidemiological principles, data capture and management, as well as the socio-economic dimension of health problems are equally important. Epidemiologists must have a passion for the multidimensional problems they deal with in addition to pursuing refinement in the methods and tools they use. Those involved in training should not forget the law of the instrument. As Abraham Maslow said in 1966, "I suppose it is tempting, if the only tool you have is a hammer, to treat everything as if it were a nail.Ä key issue in training is that most epidemiological courses are not tuned to the needs of the attendees. Training in epidemiology should be targeted at different levels of the veterinary services: those that will be full-time epidemiologists and should make a career as such within the system; the disease managers; the field vets. The Ministry of Health runs a comprehensive 2-year graduate course in Epidemiology Applied to the Public Health Services (EpiSUS). Public health officers, a number of them veterinarians, don't see themselves as 'police', but as specialists in population health; it is epidemiology in practice. The animal health services would benefit from this kind of training and changing of mind set, albeit with different objectives and content to reflect the nature of the activity of animal health services.

However, it should be stressed that no matter how good training might be, epidemiology won't make an impact on the quality of animal health policy if the institutional bottlenecks are not solved, notably the integration of epidemiology with the disease management process and the maintenance of a professional epidemiology service over time.

6. Complex problems or complex solutions?

So, is epidemiology about complex problems or about complex solutions? Complex, multifactorial problems, may be framed to us simplistically as a policy decision issue. In science, resolving ambiguity by acquiring relevant evidence and refining hypotheses should precede the decision-making stage (Weisberg, 2014). Veterinary epidemiologists should deal with data capture, quality and verification, and use exploratory analysis to make sure the relevant questions are asked. This is key to ensure that epidemiological intelligence is effectively used to inform the planning and evaluation of animal health programs. Therefore, the veterinary epidemiologist might be acting as *The Honest Broker of Policy Alternatives*, as defined by Pilke (2007), by clarifying or seeking to expand the scope

of choice available to decision-makers, especially when the problems addressed have considerable uncertainty involved, which is the case in most animal health issues. Such role attempts to integrate scientific knowledge with stakeholders' concerns in the form of alternative courses of action (Pilke, 2007).

Integrating epidemiology into animal health policy is a great opportunity if epidemiologists can understand the real issues and focus on innovation and production of knowledge. It may be a trap if epidemiologists are restricted to answering specific decision-making questions and see their role exclusively as data analysts or providers of technological solutions. This is an example of what Pilke (2007) called *The Science Arbiter*, someone who acts as an expert and seeks to answer questions posed by policy-makers, but stays away from explicit considerations of policy and politics.

Epidemiology should be about creating knowledge which will assist, but not replace, decision-making in animal health policy. This has to be understood by disease managers and epidemiologists alike. These are dilemmas faced by modern veterinary epidemiology in Brazil at a time when the field is growing in response to the demands of a large livestock industry and of a government veterinary service that has to respond to great challenges posed by the public and by trade partners. It is up to the reader to judge whether it is relevant for other countries.

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