

The role of epidemiology in public health

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Summary

Epidemiology is the study of disease in populations. Veterinarians and others involved in the preventive medicine and public health professions use epidemiological methods for disease surveillance, outbreak investigation, and observational studies to identify risk factors of zoonotic disease in both human and animal populations. Knowledge of these risk factors is used to direct further research investigation and to implement disease control measures. The use of hazard analysis critical control point (HACCP) systems depends greatly on information produced by epidemiological studies. Epidemiological methods are used for disease surveillance to identify which hazards are the most important. Epidemiological studies are also used to identify risk factors which may represent critical control points in the food production system.

Keywords

Epidemiology – Food hygiene – Public health – Risk factors – Zoonoses.

What is epidemiology?

The word 'epidemiology' comes from the Greek *epi* meaning 'upon' and *demos* meaning 'people or populace'. As such, it is the study of 'that which is upon the people'. It was infectious disease which was upon the people when the science of epidemiology began, and if one thinks that the importance of infectious disease is long past, one should read *The coming plague* by L. Garrett (3).

Although many different definitions of epidemiology are available in epidemiology texts, perhaps the simplest description is that it regards the 'mass phenomena of disease' (4, 5, 6). Epidemiologists examine disease in populations rather than in individual organisms (as the clinician would do), or in individual cells (the histologist or microbiologist), or in individual molecules (the geneticist or molecular biologist). Many veterinary specialities are reductionistic in that they learn about the world by focusing their attention on the details of restricted areas of interest. When viewing an unknown object through a microscope, some people will switch to a higher power to see the object in more detail. Most epidemiologists would probably switch to a lower power to see more of the object in relation to its surroundings. Epidemiologists are 'big picture people' (holistic) by nature, in

that they seek to understand disease by moving back from the individual molecule, cell, or host organism to see the disease in the population.

Veterinary epidemiology

For many years, epidemiologists at most veterinary schools were also the public health specialists, and thus the two specialities were inseparably linked. Although veterinary epidemiologists sometimes conducted studies on non-zoonotic animal diseases, most had their training firmly rooted in veterinary public health. Recently, a new breed of veterinary epidemiologist has been created. This breed has no public health background and uses epidemiological techniques to investigate food animal production. After experimenting with different labels such as herd health, production medicine, preventive medicine and population medicine, it has become widely recognised that it is the statistical, population-oriented approach which defines the discipline, not the species of host animal being studied. As such, veterinary epidemiology is one discipline, regardless of which host species or disease is being investigated.

Every few years, a debate is launched in the veterinary world regarding the use of the words 'epidemiology', epidemic and

endemic' as applied to diseases in animal populations. Although the historical origins of these words clearly relate to disease in human populations (*demos* meaning people), most veterinary epidemiologists believe that it is pointless to use different words (epizootiology, epizootic, enzootic) when referring to a disease in an animal population. The word 'blink' is used when a person, giraffe, snake, or any other animal briefly closes both eyes. Similarly, people and animals all have legs, livers, diabetes, and pneumonia: few would suggest that we need to separate words for such things in animals. Similarly, the creation of a separate set of words to describe disease in populations of animals is unnecessarily complex and serves no useful purpose. The words 'epidemiology, epidemic and endemic' should be used to describe disease occurrence in all host species.

Health experts of the production environment

R.K. Anderson has written a classic and comprehensive work on the role of veterinarians in public health (1). This book advances the argument that virtually all veterinarians of all specialities are involved in some aspect of public health service to the community. The food animal private practitioner, in particular, is regarded as the health expert of the food animal production environment, in which all diagnoses are seen as screening for zoonotic disease, and therapy, disease control, and disease prevention are actions taken to reduce exposure of humans to zoonotic disease. The veterinary practitioner is in a position to provide advanced warning of potential zoonotic or environmental human disease problems. Public practice veterinarians are often extremely dependent on the observations of private practice colleagues in the food production environment to give warning when something with potential human health impact is discovered. From this perspective, all food animal veterinarians are involved in public health and are the first line of defence in food safety. Trained in epidemiological principles, the practitioner uses these and other tools to monitor disease in the food animal population, diagnose population disease problems, reduce exposure of humans to zoonotic disease and provide for safe use of antibiotics and other substances (pesticides, hormones) with potential human health impact.

The tools of epidemiology are not restricted to veterinary epidemiologists alone; they can be used by all veterinarians. Unfortunately, many veterinarians forget that the tools of epidemiology are available. Until recently, food hygiene veterinarians used the tools of epidemiology to convince colleagues and the public that the current meat inspection system was not focusing on the appropriate health hazards, and that the system would need to be changed (2).

Types of epidemiological studies

'You can observe a lot just by watching', Yogi Bera once said. Observational epidemiologists like to watch. They are 'biological accountants' in that they keep track of what they see, and look for patterns and trends in the occurrence of disease which might suggest the cause(s) of particular diseases, and how these might be controlled.

Disease surveillance systems provide the data needed to determine the health status of populations. The population is the patient for the epidemiologist and disease surveillance resembles the physical examination. Each disease surveillance system has advantages and disadvantages. For example, in the United States of America (USA), human cases of zoonotic foodborne diseases such as salmonellosis and *Escherichia coli* O157:H7 infection are reported by clinical laboratories and physicians to local health departments, which then forward the reports to State health departments, which in turn centralise the data at the Centers for Disease Control and Prevention. At each level of this pathway, epidemiologists (including veterinary epidemiologists) are, or should be, watching for patterns in the data. Such patterns might include time clusters, geographical clusters, cycles and trends, which could lead to disease control efforts and/or epidemiological hypotheses which can then be tested with additional studies. A disadvantage of this system is that fewer than 10% of human culture-confirmed cases of *Salmonella*, for example, are reported through the system. Another disease surveillance system is maintained by slaughter inspection systems, although usually only rates of condemnation for very non-specific reasons are available from this system.

Some disease surveillance systems measure incidence, and others measure prevalence. Incidence is the occurrence of new cases over a period of time, and prevalence is the number of existing cases at one point in time. Epidemiologists have a strong interest in the differences between incidence and prevalence. In fact, many veterinarians probably think that, along with calculating sensitivity and specificity, this is all that epidemiology is about.

The case-control study is usually the first type of epidemiological study conducted to determine which agent, host, or environmental factors are associated with the occurrence of a disease. Factors found to be associated with disease are called risk factors. Identification of risk factors can lead to increased understanding of the disease process and possibly enactment of disease control measures long before more detailed information about the cause of the disease can be confirmed. For example, human cases of salmonellosis found to be associated with a particular food item may lead to the closure of a particular restaurant, or recall of the food item from the market. An observed high prevalence of *Listeria* contamination in hot dogs from plants using a particular processing method may lead to identification of this

processing step as a 'critical control point' which could become the basis for regulatory action.

Classic foodborne outbreak investigation

Foodborne disease outbreaks have been investigated so many times that a classic, recommended procedure has been established. Cases (people or animals who meet the working case definition of the disease) are summarised with regard to symptoms and time of onset. An epidemic curve (Fig. 1) and a tabulation of symptoms are made. If a hypothesised time of exposure exists (such as a suspect meal), the mean and range of incubation periods (time from exposure to disease onset) can be calculated. The investigators should obtain food histories (a list of food items eaten by each person) from all people at the suspect meal, not just from those who were ill. The most common mistake is to only obtain food histories from the people at the meal who were ill. The resulting data can then be tabulated as shown in Table I. An attack rate can be calculated for those who ate each food item (number of ill who ate a particular food divided by the total number who ate that food), and an attack rate for those who did not eat each food item (number of ill who did not eat a particular food divided by the total number who did not eat that food item). The most highly suspect food item will have a high attack rate for those people who ate the particular food item, and a low attack rate for those who did not eat the particular food item. Calculation of relative risk or attributable risk for each kind of food is a good way of finding the most highly suspected food. A relative risk for each food item can be obtained by dividing one attack rate by the other. An attributable risk for each food item can be obtained by subtracting one attack rate from the other. A chi-square test can be used to evaluate the possibility that the difference in measured attack rates might be due to chance alone. In the example given in Table I, turkey is the most highly suspect food item, as this meat has both the highest relative risk and the highest attributable risk.

Disease outbreak investigation is one of the most useful methods of learning about disease in populations. Disease outbreaks can be 'experiments of nature'. Due to ethical considerations, the infection of people (or sometimes animals) with a particular disease agent in order to learn about the disease is not possible. Therefore, the examination of a naturally-occurring 'experiment of nature' is often the only way investigators can study the epidemiology of a given disease.

The basic principles of the case control study can be applied equally well to risk factors other than food histories. For example, a food hygiene veterinarian may use the same technique to identify particular carcass characteristics associated with bacterial contamination, certain processing



Fig. 1
Onset of foodborne illness in people eating suspect meal

methods associated with contamination, or meat from particular herds associated with increased rates of disease among consumers. Veterinary clinicians – and others interested in pre-harvest food safety – can also look for associations using the methods described in Table I, except that the suspected risk factors would not be particular food items on the menu but might be factors such as gender, age, exposure to a group of infected cattle, exposure to a particular wildlife reservoir, etc. Delineation of important risk factors in the production environment may help determine the epidemiology of a particular disease agent on the farm. However, unless the relative risk of an on-farm factor is extremely high, control of this factor might reduce the level of contamination in the human food source but would probably never eliminate contamination to the extremely low safety levels required for human consumption. Therefore, pre-harvest control measures will need to be used in conjunction with control measures at other levels of the food-processing pathway.

'Cohort' or prospective studies are usually more expensive and take longer to conduct than do case-control studies. An example of a cohort study would be a comparison of the contamination rate in samples of meat produced during the warm day shifts to the contamination rate of meat produced during the cool evening shifts at a processing plant. In a cohort study, the two groups (cohorts) to be compared are identified before the beginning of the study, and the cohorts are then monitored for disease occurrence.

Controlling bias

Veterinarians also become involved in experimental studies, in which risk factors are randomly and blindly assigned to study participants before the monitoring period commences. Such assignment tends to balance the study groups with respect to all other factors which might otherwise affect (bias) the measurement of the study outcome. These other factors

Table I**Typical food history from a foodborne outbreak**

For each food item, attack rates are calculated for those who ate the item, and for those who did not eat the item. The most highly suspect food item will be the one with a high AR for those who ate the item, and a low AR for those who did not eat it. This is usually determined by dividing the two ARs to obtain a relative risk, or subtracting them to obtain an attributable risk

Food item	No. of people who ate a food item			No. of people who did not eat a food item			Relative risk	Attributable risk
	No. ill	Total	AR	No. ill	Total	AR		
Carrots	6	12	50	4	8	50	1.0	0
Turkey	9	11	82	1	9	11	7.45	71
Beans	9	19	47	1	1	100	0.47	-53
Bread	3	8	37	7	12	58	0.64	-21
Milk	9	18	50	1	2	50	1.0	0
Peas	1	3	33	9	17	53	0.62	-20
Fish	3	4	75	7	16	44	1.7	31
Gravy	8	11	73	2	9	22	3.3	51

AR: attack rate (%)

(confounders) can cause large problems in observational studies. In an observational study, selection bias occurs when the manner in which study participants are selected for membership in a study group (case versus control or risk cohort versus control cohort) predetermines the study outcome. Informational bias occurs when the way in which the study outcome is measured systematically affects the study results.

Confounding bias occurs when a third factor is associated with both the study factor and the study outcome. For example, suppose one is trying to study the relationship between cow size and the rate of pneumonia. Housing type (indoor versus outdoor) might be a confounding variable, since larger cows tend to be dairy cows housed inside where the rates of pneumonia are probably greater. A random sample of large cows in a particular country may therefore predominantly contain indoor cattle. A comparison group of small cows may contain predominantly beef cattle living outdoors. While investigators may think that they are comparing large cattle to small cattle, they are also simultaneously comparing indoor cattle to outdoor cattle, since housing and cattle size are associated. The comparison between cattle size and pneumonia is thus confounded by housing type. Much of what epidemiologists do is to use various techniques such as stratification, matching, restriction and multivariable statistics to un-confound the results of observational studies.

Clinical epidemiology

Clinical epidemiology is a subspeciality which emphasises those epidemiological tools used in support of clinical medicine (5). Much of clinical epidemiology relates to interpretation of diagnostic test results and evaluation of

treatment efficacy, although considerable overlap exists with subject areas long considered the core science of epidemiology.

Statistician or epidemiologist?

Epidemiologists should be experts in study design, data collection, and control of bias. Statistical analysis is only one of the duties of an epidemiologist, and frequently is not the most important duty. In obtaining the correct answer to the study question, quality of data is usually more important than the sophistication of the statistical analysis. Although analytical epidemiologists occasionally like to impress each other with new and complicated statistical approaches, the more mundane matters regarding accurate and precise data collection probably have a greater impact on whether or not the study results accurately represent reality.

Conclusion

Epidemiological methods are frequently used by food hygiene and public health veterinarians to determine relevant risk factors associated with disease occurrence. Knowledge of these risk factors is used to direct further research investigation and to implement disease control measures. The following papers in this issue give information about hazard analysis critical control points. Bear in mind that epidemiological tools are used for disease surveillance to identify which hazards are the most important, and epidemiological studies are used to identify risk factors which may represent critical control points in food production systems.

Rôle de l'épidémiologie en santé publique

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Résumé

L'épidémiologie est l'étude des maladies dans une population donnée. Les méthodes épidémiologiques sont utilisées par les vétérinaires ainsi que par les professionnels de la médecine préventive et de la santé publique lors des programmes de surveillance des maladies, des enquêtes sur les foyers et des études appliquées en vue d'identifier les facteurs de risque de zoonoses pour les populations humaine et animales. La connaissance de ces facteurs de risque permet d'orienter les enquêtes ultérieures et de mettre en œuvre des mesures de prévention. L'utilisation de la méthode de « l'analyse des risques, points critiques pour leur maîtrise » (*hazard analysis and critical control point*: HACCP) dépend dans une large mesure des données épidémiologiques disponibles. Les méthodes épidémiologiques permettent également de détecter les risques les plus importants lors des programmes de surveillance des maladies. Enfin, l'épidémiologie contribue à identifier les facteurs de risque pouvant représenter des points de contrôle critiques dans le système de production agro-alimentaire.

Mots-clés

Épidémiologie – Facteurs de risque – Hygiène alimentaire – Santé publique – Zoonoses.

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El papel de la epidemiología en la salud pública

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Resumen

La epidemiología es el estudio de una enfermedad en el seno de una población dada. Los veterinarios y otros profesionales de la medicina preventiva y la salud pública se sirven de métodos epidemiológicos para la vigilancia sanitaria, la investigación de brotes infecciosos y los estudios sobre los factores de riesgo de enfermedades zoonóticas en poblaciones tanto humanas como animales. El conocimiento de estos factores de riesgo sirve para orientar ulteriores investigaciones y para aplicar medidas de control de enfermedades. La utilización de sistemas de análisis de riesgos y control de puntos críticos (*hazard analysis and critical control point*: HACCP) depende en buena medida de la información que suministran los estudios epidemiológicos. También se emplean métodos epidemiológicos para llevar a cabo acciones de vigilancia sanitaria destinadas a identificar los riesgos más importantes y para determinar factores de riesgo que puedan constituir puntos críticos de control de los sistemas de producción agroalimentaria.

Palabras clave

Epidemiología – Factores de riesgo – Protección de alimentos – Salud pública – Zoonosis.

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