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Practical guidelines for evaluation of biological agents in occupational settings for occupational hygienists: identifying, monitoring, managing and documenting biological hazards at the workplace

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Abstract

Biological agents are often neglected. The aim of this study was to develop general guidelines for evaluation of biological agents in occupational settings for occupational hygienists. The hazard analysis and critical control points (HACCP) was investigated and adjusted to become a method for evaluation of biological agents at different workplaces / sectors / occupations. Two examples (veterinary clinics and animal farms) were worked using the adjusted HACCP method. Literature research was done to gather information on the exposure to biological agents, critical limits (cut-off values) for biological agents, monitoring / testing methods for biological agents and risk management measures. Additionally, four experts were interviewed in order to get more insight into the topic.

The adjusted HACCP method proved to be a helpful tool in evaluating biological agents at workplaces / sectors / occupations. Description of the work process was an essential part of the adjusted HACCP as it helped determining the ways employees come into contact with biological agents. The biological agents could be grouped based on for example indicators for the presence of biological agents, type of agent or associated physical hazards. This allowed a structured literature research and helped creating risk management methods. In addition, according to experts the best way to tackle biological agents at a workplace is the precautionary principle. By creating and following protocols the exposure to biological agents can be minimised. This study gives general guidelines on evaluating biological agents at workplaces / sectors / occupations. The adjusted HACCP method can be a tool in evaluating biological agents for a risk analysis and evaluation (RIE).

Samenvatting

Met biologische agentia wordt vaak nonchalant omgegaan. Het doel van het onderzoek was om praktische handvatten voor arbeidshygiënist te creëren, om biologische agentia te kunnen evalueren. De hazard analysis and critical control points (HACCP) was aangepast voor arbeidsomstandigheden. Twee hoog-risico werkplekken (dierenartsenpraktijken en dierboerderijen) waren uitgewerkt met behulp van de aangepaste HACCP methode. Middels literatuuronderzoek zijn blootstelling, afkapwaarden, monitoring / test methoden en risico management methoden betreffende biologische agentia onderzocht. Daarnaast waren er gesprekken gevoerd met vier experts om meer inzicht te krijgen in het onderwerp.

De aangepaste HACCP methode bleek een handige hulpmiddel te zijn in het evalueren van biologische agentia op werkplekken / sectoren / beroepen. Het beschrijven van het werkproces was een essentieel onderdeel van de aangepaste HACCP. Hiermee konden de manieren waarop een werknemer in contact komt met biologische agentia bepaald worden. De biologische agentia konden gegroepeerd worden op basis van bijvoorbeeld indicatoren voor aanwezigheid van biologische agentia, het type agens of geassocieerde fysieke gevaren. Dit had als doel een gestructureerd literatuuronderzoek en het creëren van risico management methoden. Daarnaast hebben de experts aangegeven dat het voorzorgsprincipe de beste methode is om biologische agentia op werkplekken aan te pakken. Middels het maken en volgen van protocollen kan de blootstelling aan biologische agentia geminimaliseerd worden.

Dit onderzoek geeft algemene richtlijnen voor het evalueren van biologische agentia op werkplekken / sectoren / beroepen. De aangepaste HACCP methode kan gebruikt worden als hulpmiddel in het evalueren van biologische agentia voor een Risico-inventarisatie en -evaluatie (RIE).

Contents

1	Introduction.....	5
2	Method	7
2.1	HACCP method	7
2.1.1	Description of the HAPPC method	7
2.2	Literature research.....	11
2.3	Interviews with experts	12
3	Results	13
3.1	Applying the HACCP method for evaluation of risks due to biological agents at the workplace.....	13
3.2	Worked example Veterinary clinics	14
3.2.1	Hazard analysis (Principle 1).....	14
3.2.2	Critical Control Points (Principle 2).....	15
3.2.3	Critical Limits (Principle 3)	21
3.2.4	Monitoring and measurement procedures (Principle 4)	23
3.2.5	Risk management measures (Principle 5).....	27
3.2.6	Documentation procedures (Principle 7)	29
3.3	Worked example Animal farming.....	30
3.3.1	Hazard analysis (Principle 1).....	30
3.3.2	Critical Control Points (Principle 2).....	30
3.3.3	Critical Limits (Principle 3)	33
3.3.4	Monitoring and measurement procedures (Principle 4)	34
3.3.5	Risk management measures (Principle 5).....	35
3.3.6	Documentation procedures (Principle 7)	37
4	Discussion and conclusions	38
5	Signatures	40
6	References	41
	Appendix A: Testing procedures	50
	Testing procedure MRSA & MRSP	50
	Testing procedure hygiene (TVC and Enterobacteriaceae)	50
	Appendix B: Literature research - used search terms combinations	52
	Appendix C: Interview reports	54
	Drs. Yvette de Geus.....	54
	Dr. Remko Houba	55
	Dr. Boyd R. Berends	56
	Dr. ir. Inge M. Wouters	56

1 Introduction

According to the Dutch law every company needs to have a risk assessment and evaluation (RIE) in the Netherlands (SZW, 2022b). Occupational hygienists are trained to manage health risks at workplaces. The health risks may be caused by ergonomic, chemical, physical or biological risk factors. However, biological agents often seem to be neglected. For instance, it is difficult to measure biological agents for different reasons. And if biological agents are measured, the issue that remains is how to interpret the results of these tests. Even in the European Directive 2000/54/EC there are no clear guidelines as how to handle biological agents at the workplace (Meima et al., 2020).

Biological agents differentiate into two groups: the living or infectious agents and structures originating from the previous ones. In occupational settings exposure to these biological agents can possibly cause either an infectious disease or an allergic/ toxin response reaction in the employees. The exposure to these agents can either occur when working intentionally with specific biological agents (for example in laboratories) or when being occupationally exposed to biological agents via different transmission routes (Kastelein & Spaan, 2014). For most occupations there are no surveillance or monitoring programmes for exposure to biological agents, and data on occupational exposure to biological agents are often lacking.

For the European Agency for Safety and Health at Work (EU-OSHA), Netherlands Organisation for Applied Scientific Research (TNO) in cooperation with other European research institutes conducted research on identification of biological agents potentially playing a role in different sectors and/or for different occupations. Some occupations turned out to be associated either with biological agents that have more impact or are associated with a higher exposure to biological agents than other occupations. When using the risk formula hazard x exposure x impact, it means that those occupations are at higher risk of health issues due to biological agents (Jedynska et al., 2019; Lipman & Ruiter, 2004). The following sectors were identified as being at high-risk: veterinary clinics, hospital workers, animal related occupations (zoo employees, farmers, pet shop workers, laboratory workers, slaughterhouses), arable farming, waste and wastewater sector, and occupations involving traveling. Forestry workers, sex workers, workers maintaining air-conditioning systems and childcare employees were at higher health risks as well.

In food safety various methods for minimising the risk of infection or contamination with biological agents are applied. One of these methods is the hazard analysis and critical control points (HACCP) that is used for instance in slaughterhouses to assure the quality of the food. The system involves identifying hazards at different production levels and gives guidelines to control the biological agents through controlling different production steps (critical control points (CCP)). All information with regard to the CCPs are documented. In case there is a risk, through the documentation it can be traced back to the source (United States Food & Drug Administration (FDA), 2022).

The goal of this study was to develop general guidelines for evaluation of health risks due to exposure to biological agents at the workplace. Firstly, it was investigated whether the HACCP method could be translated into a more general tool used in occupational settings. The steps of the generic HACCP were adjusted

for this purpose. Two examples, veterinary clinics and animal farms, were worked using the adjusted HACCP method. Considering the limited time of this study and the expertise of the author, only infectious biological agents were used in the examples.

Working the examples served a number of purposes. The applicability of the adjusted HACCP method could be determined. Additionally, the literature research done working the examples lead to identification of references/ sources containing general information on evaluation of biological agents. Using a One Health approach, evaluating the adjusted HACCP system, doing literature research and interviewing experts lead to the development of general guidelines on evaluating biological agents at workplaces.

2 Method

2.1 HACCP method

2.1.1 *Description of the HAPPC method*

The generic Hazard Analysis Critical Control Points (HACCP) method is applied to ensure product safety. This method involves identifying hazards and critical control points (CCPs), measuring and documenting the CCPs and describing controlling methods.

The HACCP method is applied in different sectors as well. Its use was suggested for animal health related issues, for example lameness control programme (Bell et al., 2009), calf rearing (Boersma et al., 2008) and animal health & welfare in organic egg production (Hegelund & Sorensen, 2007). Moreover, there were HACCP-based programmes described for premise plumbing (McCoy & Rosenblatt, 2015), the cosmetics industry (Goolsby & Schubert, 2006) and the pharmaceutical industry (Dahiya et al., 2009).

Within the food sector the HACCP method plays an important role in controlling chemical, physical and biological hazards. And that the HACCP method is applied in many other sectors apart from the food sector shows its broad potential. Therefore, in this study the possibilities of implementing the HACCP approach to evaluate health risks due to biological agents at the workplace were investigated.

As the HACCP method is used in the food industry to ensure product safety, for the purpose of this study the different steps are adjusted in order to develop a HACCP method in which biological agents at workplaces/ occupations can be evaluated. Steps 2, 3, 4 and 5 and sub-steps 10b, 12b, 12c and 12d are very food-processing oriented steps. Therefore, in the two worked examples these steps are not described.

The generic HAPPC method consists of seven principles and 12 steps (FDA, 2022; McCoy & Rosenblatt, 2015). The terms describing the seven principles were adjusted for the purpose of this study.

1. Assemble a HACCP team
2. Describe the food and its distribution
3. Describe the intended use and consumers of the food
4. Develop a flow diagram which describes the process
5. Verify the flow diagram in step 4
6. Conduct a hazard analysis (Principle 1)
7. Determine critical control points (CCPs) (Principle 2)
8. Establish critical limits (Principle 3)
9. Establish monitoring and measurement procedures for the CCPs (Principle 4)
10. Establish risk management measures (Principle 5)
 - a. Cause and correction of the non-compliance
 - b. Determine the disposition of non-compliant product
 - c. Record the corrective actions that have been taken
11. Establish verification procedures (Principle 6)
12. Establish record-keeping and documentation procedures (Principle 7)
 - a. Summary of the hazard analysis
 - b. HACCP team listing with the belonging responsibilities
 - c. Description of the food, its distribution, intended use and consumer

- d. Verified flow diagram
- e. HACCP summary table including:
 - i. Hazards of concern
 - ii. Critical limits
 - iii. Monitoring
 - iv. Corrective actions
 - v. Verification procedures and schedule
 - vi. Record-keeping procedures
- f. Support documentation such as validation records
- g. Records that are generated during the operation of the plan

Underneath the seven principles are described based on the adjustments made in order to make the plan feasible for evaluation of biological agents at different workplaces / sectors.

Initial screening to evaluate the need of a HACCP analysis for a workplace / sector

There are certain indicators for the presence of biological agents. Those are for example: organic material (plant, animal, human or microbiological) or an environment promoting growth of biological agents (water, nutrients, temperature, time, light, oxygen, acidity, presence of transmission pathways (recirculating process water, air currents, dust, aerosols) (Kastelein & Spaan, 2014).

An initial screening of the workplace / sector / occupation can involve screening on the presence of the mentioned indicators. When indicators are present, it still should be determined how and when workers come into contact with biological agents (describing the work process). This involves considering for example during which work activities the employees are exposed to organic dust or when they come into contact with animals. Afterwards, the biological agents can be evaluated using the following principles of the HACCP method.

Principle 1: Conduct a hazard analysis

In order to conduct a hazard analysis, all the relevant biological agents need to be identified. This can be achieved through a thorough literature research and consulting experts. The indicators for the presence of biological agents will give an idea for example what search terms to use. One of the studies describing biological agents for some occupations is the EU-OSHA research 'Biological agents and work-related diseases' (Jedynska et al., 2019).

In addition, grouping biological agents can possibly help with creating relevant search terms needed for literature research. The biological agents can be grouped based on the indicators for the presence of biological agents, the type of agent or the associated physical hazard. This is meant to help with a structured literature research on exposure, establishing critical limits, preventive measures and risk management procedures.

Principle 2: Establish the critical control points (CCPs)

In this step, the health risk(s) of employees is determined. The assessment whether the biological agent forms a risk for employees is based on the formula $\text{risk} = \text{hazard} \times \text{exposure} \times \text{impact}$ (Lipman & Ruiter, 2007). In order to assess whether the (grouped) biological agents form a health risk and therefore must be considered a CCP, the exposure to and severity (impact) of the (grouped) biological agents

needs to be determined. This can be done based on literature research and experts' opinion. A CCP is a risk that needs to be managed.

Exposure to biological agents means in this study the environmental prevalence of the biological agents, the number of times an employee is exposed to a biological agents or an indicator, number/ percentage of incidents, infections or seropositive individuals. The first step in obtaining this information is to consult the websites of for example Netherlands Central Bureau for Statistics (CBS) (2023), National Institute for Public Health and the Environment (RIVM) (2023a; 2023b, 2023c), Wageningen University & Research (WUR) (2023), Centre for Disease Control and Prevention (CDC) (2023), European Centre for Disease Control and Prevention (ECDC) (2023), World Health Organisation (WHO) (2023), Nederlands Centrum voor Beroepsziekten (NCvB) (2022), to determine whether there is a surveillance system for the relevant (groupings of) biological agents on a national, international, sector or workplace level. The surveillance systems can be based for example on the prevalence of a disease, incidence, prevalence of a vector in a given area. For instance, the tekenradar (RIVM, 2022c) gives information about the presence of the vector in a given area. This information can give an indication on the possible exposure to the vector at a workplace in that given area. Additionally, there should be literature research done to determine the level of exposure to the biological agents. To get an impression of how many workers had been exposed to the (grouping of) biological agent(s), data on seroprevalence (the level of a pathogen in a given population, measured in blood serum) can be used.

Absence of the exposure data does not mean that biological agents are not present. It could mean that there are no tests available for determining the presence of biological agents. One can use the precautionary principle and assume there are biological agents based on the indicators for the presence of biological agents. The exposure is considered low if there were no indicators for the presence of biological agents, and high - if an employee has contact with a biological agent(s) on a regular basis (daily, weekly, monthly).

The impact means the severity of the disease, which can be determined by literature research. For example the EU-OSHA research (Jedynska et al., 2019), WHO and RIVM (for example RIVM, 2023a or RIVM, 2023b) websites and other scientific literature can be consulted to determine the severity of biological agents. Low impact means possibility of development of disease is low and usually no medical intervention is needed. High impact means a disease causing severe symptoms and can possibly result in death (Klein, & Rijksinstituut voor Volksgezondheid en Milieu (RIVM), 2012).

The evaluation of the exposure to or severity of the grouped biological agents help determine whether the (grouped) biological agents are a risk and should be addressed/ considered a CCP. A high exposure or high impact can result in a high risk. In general, it can be assumed if there is some exposure and the impact is high or if the exposure is high but the impact is low that the risk is high and needs to be managed. A CCP is a (grouping of) biological agent(s) that needs to be managed.

Principle 3: Establish critical limits

Critical limits are values or changes meant to be warning signs that show that exposure possibly needs to be decreased/ minimised. It can eventually lead to applying risk management measures (RMM). There are three sorts of critical limits:

- critical limit being a certain level / number (of a pathogen; relating for example to hygiene),
- critical limit needing to be zero based on measuring the pathogen,
- critical limit based on registration of for example incidents (for example a change in the number of incidents over a given time period based on grouping of biological agents).

Critical limits can be for example: (a change in) the number of incidents, (a change in) the prevalence of an illness, number of times the employees did not act according to protocols or the number of colony forming units (CFU).

The different critical limits will require a different interpretation and a different approach. For the critical limits being values, the interpretation will be easier. A certain value should generally not be exceeded, and if so RMM are needed. A change in for example incidence over a certain time period will at first need to be thoroughly evaluated. The evaluation will involve for example: looking at the situation at the workplace - a different number of employees, new employees, other circumstances in the building. The evaluation will help determine whether RMM are needed. The critical limits can be established for example based on scientific literature, experts' opinion or registration.

In addition, the precautionary principle should be applied at all times, especially in the presence of indicators for the presence of biological agents. Preventive measures should be applied where possible. Creating and following protocols will ensure that employees are optimally protected against biological agents.

Nevertheless, in order to be able to establish a critical limit, there needs to be a monitoring or measuring procedure established first (see principle 4).

Principle 4: Establish monitoring and / or measurement procedures

Monitoring and measurement procedures are meant to monitor and / or measure the CCPs. These procedures can be established based on literature research and experts' opinion. These procedures can be based either on measuring a level of biological agent or on for example registration of (grouping of) biological agents.

The measuring / testing methods can be for example air sampling, surface or product sampling (using for example swabs, dipslides (a plastic carrier with a bacterial culture medium) or electrostatic dust collectors) and samples taken from the body. The monitoring of biological agents can be: documentation of the (grouping of) biological agents, inspection of hygiene and observation of the behaviour of employees (for example around following preventive / protective protocols). Monitoring and measurement procedures are needed in order to determine whether a critical limit is exceeded (see principle 3).

Principle 5: Establish risk management measures

Risk management measures (RMM) aim to decrease the exposure to (a grouping of) biological agents. RMM should be applied:

- possibly during an initial evaluation of biological agents at the workplace, and
- if a critical limit (a certain value) is exceeded, and
- if an evaluation of the increase in registration (of for example incidents) leads to a need for RMM.

Throughout for example the initial evaluation of biological agents at the workplace, the need for protocols can be established. In certain situations protocols can have added value, for example protocols on prevention of tick bites, working in a dusty environment, working with animals, protocols on washing hands. At first it should be evaluated whether protocols exist for the work situation / procedure. This can be done by for example consulting the Ministry of Social Affairs and Employment website with the listed 'Arbocatalogues' (Ministerie van Sociale Zaken en Werkgelegenheid (SZW), 2022c). If protocols are present at a workplace, there should be an evaluation done on whether the protocols are (properly) followed. That way a possible cause for not following protocols can be established, for example employees not knowing of the existence of protocols, protocols not being practical, no awareness on the consequences of not following protocols.

The website of the Ministry of Social Affairs and Employment (SZW, 2022a) can be consulted for determining possible RMM. For specific RMM scientific literature and experts can be consulted as well. RMM in general are for example: education or cleaning procedures.

Principle 6: Establish verification procedures

The verification procedures involve evaluating the RIE, preventive / protective protocols, monitoring and measurement methods. Generally, the verification procedures do not differ from the verification procedures needed for the RIE. An expert on the topic can be advised.

Principle 7: Establish documentation procedures

In this step the summary of the previous steps is described. The results of the evaluation of biological agents are documented and feedback on these results is given to the client (the company or the sector for whom the evaluation of biological agents is done).

2.2 Literature research

The aim of the literature research was to: gather information about the method, find general sources / references needed for evaluation of biological agents, develop the different steps of the adjusted HACCP method for the two workplaces and eventually develop general guidelines needed to evaluate biological agents at workplaces. In order to work the two examples literature research was also done on exposure to, the monitoring methods of and risk management measures for the biological agents.

The literature research revolved around answering the following questions:

- What is the HACCP and how is it used?
- Can the risk of microbiological agents at the workplace be evaluated using the HACCP method?
- What are the health risks of working in a veterinary clinic or on an animal farm?
 - o What are the hazards and what is the exposure to these hazards at a veterinary clinic or on an animal farm?

- What can be measured at veterinary clinics and animal farms to determine the exposure to or impact of microbiological agents?
- What risk management measures are needed in order to control the biological agents at veterinary clinics and on animal farms?
- What role does general hygiene play in evaluating biological agents at different workplaces?

The following scientific search engines were used: PubMed and Google Scholar. The websites of Netherlands Central Bureau for Statistics (CBS), National Institute for Public Health and the Environment (RIVM), Wageningen University & Research (WUR), Centre for Disease Control and Prevention (CDC), European Centre for Disease Control and Prevention (ECDC), World Health Organisation (WHO) were consulted for potential data on exposure to the identified hazards.

PubMed was the main search engine used. When no or irrelevant articles were found in PubMed, a search in Google Scholar was done. The search criteria were as follows:

- Literature from 2002 onwards
- Research performed in European
 - o Exception: if data in Europe were scarce, sporadically there was a non-European source used as an example of a high exposure when the hazard is endemic
- Articles written in English, Dutch or Polish

The used search term combination per search engine are to be found in [Appendix B](#).

2.3 Interviews with experts

Additionally to the literature research, there were four experts on the topic interviewed. The experts' opinions served as practical tips how to evaluate biological hazards. The following questions were asked during the conversation:

- What is your experience with the topic (evaluating health risks due to biological agents at different occupations)?
- What is in your opinion the best method to tackle the problem (exposure to and evaluation of health risks due to biological agents)?
- Are you familiar with relevant data on exposure to biological agents at different occupations?
- In your opinion, which (biological agents) tests are relevant to this topic / could be used for evaluation of the health risks due to biological agents at different occupations?
- Which points of interest do you find important and why?
- Do you have/ know where to find the most reliable data on exposure of vets or other employees that work with animals to animal bites?
- Do you know where to find any data on exposure of vets, employees that work with animals to zoonoses (for example ringworm)?
- Do you think overall hygiene can be assessed at different occupations?
 - o If so, can the overall hygiene assessment be based on a quantitative assessment of biological agents?
 - o Do you think that the overall hygiene tests (as used for example in slaughterhouses) can be translated onto different occupations?

During the interviews all questioned were asked directly or were answered indirectly throughout the conversation. The reports of the interviews can be found in [Appendix C](#).

3 Results

3.1 Applying the HACCP method for evaluation of risks due to biological agents at the workplace

The hazard and risk analysis was conducted for the two sectors using the following 7 principles of HACCP.

The European Agency for Safety and Health at Work (EU-OSHA) research and other scientific literature were used. The EU-OSHA project 'Biological agents and work-related diseases' was based on a structured, extensive literature research and general surveys of experts. Based on this research, certain occupations were established to be high-risk: veterinary clinics, hospital workers, animal related occupations (zoo employees, farmers, pet shop workers, laboratory workers, slaughterhouses), arable farming, waste and wastewater sector, and occupations involving traveling. For this study two of these high risk occupations, veterinary clinics and animal related occupations, were chosen as worked HACCP examples. The animal related occupations were narrowed down to animal farming. These choices were based on the expertise of the author.

There was also a distinction made between the living micro-organisms (subdivided into viruses, parasites, fungi, bacteria, oomycote, prions and other organisms) and resulting infectious diseases, and substances or structures that originate from living or dead micro-organisms (e.g. exotoxins, endotoxins, glucans, mycotoxins and allergens) (Jedynska et al., 2019; European Agency for Safety and Health at Work (EU-OSHA), 2019). Based on the expertise of the author the focus of this study were the following biological (infectious) agents: bacteria, viruses, fungi and parasites.

Principle 1: Conduct a hazard analysis

For the hazard analysis all relevant biological agents need to be identified. As the relevant biological agents for the two examples were already identified in the research performed for EU-OSHA (Jedynska et al., 2019; EU-OSHA, 2019), this step was not repeated in this document. In the EU-OSHA research the biological agents were already grouped for the high risk occupations. For example, for veterinary clinics it was stated that animal bites, vector bites and zoonoses formed the most risk for an employee. According to scientific literature needlestick injuries were considered a high risk grouping of biological agents as well as animal bites or scratches and zoonoses (but not vector bites). Based on the EU-OSHA research and other recent scientific literature biological agents were grouped. The grouping in this study referred to the indicators for the presence of biological agents (zoonoses) and the physical hazards (bites and injuries).

Principle 2: Establish the critical control points (CCPs)

Scientific literature was used in order to determine the exposure. Seroprevalence studies were means to show that employees had been exposed to a (grouping of) biological agents. The impact caused by the biological agents was based on scientific literature including the 'classification of biological agents' commissioned by the Dutch National Institute for Public Health and the Environment (RIVM). This document classifies different biological agents into four different risk groups based on the associated health impact (Klein & RIVM, 2012). Biological agents listed in

class one were considered of low impact, in class two – moderate impact and classes three or four in the document were considered high impact.

Principle 3: Establish critical limits

For establishing critical limits, scientific literature was used. The literature research resolved around establishing a critical limit in air samples, critical limit from environmental surface sampling and critical limit based on registration.

Principle 4: Establish monitoring and / or measurement procedures

Monitoring procedures were identified based on literature research and the interviews with experts. The measurement procedures consisted of measuring biological agents associated with antimicrobial resistance and biological agents associated with general hygiene (*Enterobacteriaceae* and Total viable colonies (TVCs)). Antimicrobial resistance organisms are of higher impact to human health, which underlined the need to measure and monitor these biological agents. Measuring general hygiene was meant to help determine the infectious pressure at the workplace and was therefore of importance to occupational health. The monitoring procedures were registration of incidence and prevalence.

Principle 5: Establish risk management measures

Specific RMM were based on literature research and conversations with experts.

Principle 6: Establish verification procedures

This step was not specified in this study, as the verification procedures will not differ per occupation in the two worked examples.

Principle 7: Establish documentation procedures

The summary/ the results of the evaluation of the biological agents at veterinary clinics and animal farms were presented in tables.

3.2 Worked example Veterinary clinics

3.2.1 Hazard analysis (Principle 1)

Based on the overview of the European Agency for Safety and Health at Work EU-OSHA project, the following infectious biological hazards have been identified for workers in veterinary clinics (Jedynska et al., 2019; EU-OSHA, 2019). Additional literature research (Weese & Jack, 2008; Buswell et al., 2016) and information received from the experts that were interviewed contributed to establishing the list of relevant biological agents.

Table 1: Grouping of biological agents for hazard analysis

Grouping of biological agents	Specific biological agent
Animal bite/ scratch	Rabies, wound infection, <i>Bartonella henslae</i> , <i>Capnocytophaga canimorsus</i>
Vector bite	<i>Borrelia burgdorferi</i> , Tick borne encephalitis, Russian spring-summer encephalitis virus, Louping ill virus, dengue virus, Crimean-Congo haemorrhagic fever virus

Grouping of biological agents	Specific biological agent
Zoonoses	MRSA, MRSP, <i>Chlamydia psittaci</i>, avian influenza virus <i>Microsporum</i> spp., <i>Trichophyton</i> spp. Flees, <i>Sarcoptes scabiei</i> <i>Cryptosporidium</i> spp., <i>Giardia lamblia</i>, <i>Dilofilaria repens</i>, <i>Echinococcus</i> spp., <i>Taenia</i> spp., <i>Toxocara canis</i>, <i>Trichinella</i> spp., <i>Trypanosoma</i> spp., <i>Toxoplasma gondii</i> <i>Brucella</i> spp., <i>Clostridium tetani</i>, <i>Coxiella brunetti</i>, <i>Leptospira</i> spp., <i>Bacillus anthracis</i>, <i>Mycobacterium bovis/ tuberculosis</i>, <i>Francisella tularensis</i>, <i>Erythropelothri rhusiopathiae</i>, <i>Escherichia coli</i>, <i>Streptococcus</i> spp., <i>Staphylococcus</i> spp., <i>Legionella</i> spp., <i>Yersinia</i> spp., <i>Corynebacterium pseudotuberculosis</i>, <i>Campylobacter</i> spp., <i>Pasteurella</i> spp., <i>Listeria monocytogenes</i>, <i>Salmonella</i> spp. Cowpox virus, Hanta virus, Monkeypox virus, Measles virus, Papillomavirus, Parapoxvirus, Newcastle disease virus, Orf virus Rift valley fever, yellow fever (flavivirus), chikungunya, <i>Leishmania infantis</i>, Hepatitis E, SARS coronavirus, West Nile virus, Lymphocytic choriomeningitis virus.
Needlestick injuries	Secondary wound infections, inflammatory reactions

3.2.2 Critical Control Points (Principle 2)

Animal bites and scratches

To the author's knowledge there were no national or veterinary clinic specific surveillance programs that documented dog/ cat bites or scratches. There were some studies done on occurrence of dog bites in certain countries. Most of the mentioned articles stated that bite incidents were most likely underreported.

A study by Sarenbo and Svensson (2020) showed a significantly increasing trend of fatalities due to dog bites in humans over the years 1997 - 2016. This study was based on a European database, there was a search done for the Code W54: 'bitten or struck by dog' as the official cause of death. The cause of increased fatalities was not researched in the study (Sarenbo & Svensson, 2020). This underlined that the severity can be extremely high in case of dog bites.

Commissioned by the Dutch Ministry of Agriculture, Nature and Food Quality in 2008 a general survey was performed, which showed that around 150 000 Dutch people were bitten by a dog annually. 66% of these bite incidents did not require medical help and therefore were considered to be mild. This corresponds with the data from the health care facilities in the Netherlands (Ministry of Agriculture, Nature and Food Quality, 2008). Additionally, Cornelissen and Hopster (2009) described that the majority of bite incidents occurred in men. 60% of the respondents stated that the bite incident occurred after interaction with the dog, like petting/playing with the animal, interfering with the animal while it was eating or stepping on the dog's tail (Cornelissen & Hopster, 2009).

Research carried out in the UK stated that out of 1812 dog bite incidents, 89 incidents (4,91%) were related to veterinary activities. Here, also mostly (61%) male victims were bitten. 30.3% of the total number of victims reported some kind of remedial action. In veterinary care 18 out of 151 cases undertook counter-measures before the incident, 37 out of 151 cases during the incident and 96 out of 151 cases after the incident (Owczarczak-Garstecka et al., 2019).

Epp and Waldner (2012) studied occupational health hazards in veterinary medicine in Canada. 63% of the study participants (507 out of 809) experienced at least one bite incident, 64% at least one scratch incident, and 20% at least one post-scratch/bite infection. Infections were mainly reported after cat bite or scratch incidents. Companion animal veterinarians and mixed veterinarians experienced respectively 4.4 times and 3.1 more bite incidents than equine veterinarians. Antibiotics were used by 41% of the individuals for a work-related infection. In this study bite incidents were described as the most frequent biological hazard for the Canadian veterinarians (Epp & Waldner, 2012).

Damborg et al. (2016) stated that bites were one of the most common biological hazards in companion animals. The most frequent bites were caused by dogs, but cat bites were the ones most frequently causing an infection. The mortality caused by *Capnocytophaga canimorsus*, found in the saliva of dogs, was 30%. However, it was rarely present in the saliva. It has only been reported in 200 cases worldwide, although probably underreported. 20 to 80% of cat bite wounds got infected. Additionally, cat scratch disease (*Bartonella henselae*) had an estimated incidence of 11.9% in the Netherlands and 7.6% in France. *Bartonella spp.* seemed to be associated with 3% of human endocarditis cases in Europe (Damborg et al., 2016).

An university in Pennsylvania did a case-control study on animal caregivers with a history of animal bites compared with randomly selected animal caregivers. The bitten caregivers were significantly more often handling scared, aggressive or wounded animals as compared to the control individuals. Animals with a warning sign on their cage as well as older animals were more likely to bite. The incidents occurred most often on extremities (mainly hands or fingers). The study stated that bite incidents were possibly underreported by caregivers (Drobatz & Smith, 2003).

European data on bite or scratch incidents at high risk occupations is lacking. Studies performed in North America show that there is quite a high exposure of veterinarians to animal bites and scratches and that the severity of these bites ranges from mild to severe. Moreover, most studies state that the number of scratch and bite incidents is probably being underreported (Drobatz & Smith, 2003; Epp & Waldner, 2012; Cornelissen & Hopster, 2009). This might mean that the true number of incidents is even higher. The risk of being bitten or scratched by an animal as a veterinary care employee is relatively high as the exposure (having daily contact with cats and dogs) is considered to be high. That is why animal bites and scratches are considered a CCP.

Vector bite

Lyme borreliosis caused by *Borrelia burgdorferi* was the most common vector-borne disease in Europe. De Keukeleire et al. (2016) conducted a study on individual and environmental factors associated with seroprevalence (the level of pathogen measured in blood serum of the population) of *B. burgdorferi* amongst Belgian

veterinarians and farmers. Out of 96 veterinarians 4 tested seropositive for *B. burgdorferi*. A tick-favourable environment increased the potential exposure to ticks and therefore to the possible tick-borne diseases (de Keukeleire et al., 2016).

A systematic review estimated that until 2010 employees in high risk occupations (farmers, veterinarians, outdoor activities, animal breeders, soldiers) were 3.03 more likely to be exposed to ticks than low risk occupations. After the year 2010 no significant difference was observed (Magnavita et al., 2022).

Rift valley fever, endemic in South Africa, has caused several outbreaks there in the past. The seroprevalence amongst veterinary care professionals was 8% (samples were collected from 138 veterinary professionals). The pooled seroprevalence was 9.1%. Compared to this, people who experience more outbreaks of Rift Valley Fever showed a higher seroprevalence of 14.5% (Msimang et al., 2019). This underlines the importance of ticks in South Africa.

Recent data on exposure of veterinarian to vector bites and vector-borne diseases in Europe is scarce. Both de Keukeleire et al. (2016) and Magnavita et al. (2022) stated that veterinary care professionals were more exposed to vectors of diseases through contact with animals, and thus at higher risk for vector-borne diseases. However, the seroprevalence in veterinary care personnel described in these studies was either low or outdated (Magnavita et al., 2022; de Keukeleire et al., 2016). The study conducted in South Africa proved that in endemic areas, in which outbreaks of a vector-borne disease occur, the exposure of veterinary professionals to the particular disease was higher than an average person (Msimang et al., 2019). Although the data on exposure to vectors or vector bites are lacking, the chance of being bitten by a vector is considered low. The vectors would need to be transmitted from the animal onto the veterinary care employee. This vector on the animal would most likely be directly seen by the employee, which gives a chance to the employee to remove the vector and prevent the vector bite. That is why, the health risk due to a vector bite in a veterinary clinic seems low and will therefore not be considered a CCP.

Zoonoses

The relevance of companion animals in transmission of zoonotic diseases has been neglected in the past. Recently more research on zoonoses amongst veterinarians was performed, as they are a widely recognized occupational hazard. Some zoonotic diseases were more common than others. Between the years 2001 and 2007 there were 400 cases psittacosis, caused by *Chlamydia psittaci*, reported. Its flu-like symptoms were a probable cause of the estimated underdiagnosing of the disease. The same was true for leptospirosis, with rather a-specific symptoms in humans. Then, 8% of *Campylobacter spp.* infections in humans were estimated to be of pet origin. Reptile salmonellosis in humans in the UK was estimated to be 0.95%. Apart from specific zoonotic diseases, there was a growing concern for antimicrobial resistant organisms. Exposure to companion animals was recognized as a risk factor for extended spectrum beta-lactamase producing bacteria (ESBLs). Also, a carriage of methicillin resistant *Staphylococcus pseudointermedius* (MRSP) with an incidence of 8% was found amongst owners, infected dogs and veterinary personnel (Damborg et al., 2016).

Guardabassi et al. (2013) stated that methicillin resistant *Staphylococcus aureus* (MRSA) and MRSP were associated with health care, livestock and/or veterinary clinics. In this study MRSP was present in 4-5% in nasal swabs of veterinary clinic personnel (Guardabassi et al., 2013). At the same time, the prevalence of MRSA in the nasal swabs of attendees of a veterinary farm animal conference in the United Kingdom was 2.6%. The general population was estimated to have a prevalence of 0.8-1.3%, and the highest prevalence was found in health care workers – 4.6% (Paterson et al., 2013). Prevalence of livestock-associated MRSA (LA-MRSA) was around 3.9%, except for five countries (Belgium, the Netherlands, Slovenia, Denmark and Spain) where the prevalence was around 10%. It was suspected that veterinarians formed a possible route of transmission. In Europe LA-MRSA in veterinary personnel ranged from 0 to 50% and was on average 8%. A larger prevalence in given countries was tied to more intensive pig farming (Crespo-Piazuelo, & Lawlor, 2021). Livestock veterinarians seemed to be at higher risk of carrying MRSA (Garcia-Graells et al., 2012).

Another study conducted in Denmark showed a prevalence of 3.9% for MRSP in nasal swabs taken from veterinarians (5 out of 128 veterinarians) and the prevalence of MRSA was 1.6% (2 out of 128 veterinarians) (Paul et al., 2011).

Although the transmission of MRSA and MRSP probably occurs via direct contact, some studies showed that MRSA and MRSP can also be present in the work environment of the clinic. Paul (2015) described that transmission of MRSP in veterinary practices possibly also occurred via contaminated floors or benches, not only via contact with animals. The contaminated person can transmit pathogens to sensitive individuals. This means that if a veterinary clinic employee visits a place young, old, pregnant or immunocompromised people (YOPs) (for example in a hospital or at the employee's home) transmission of the pathogens onto susceptible people is possible. This will have great human (and animal) health implications as the disease is difficult to treat (Julian et al., 2012; Paul, 2015).

In 2007/2008 there were 20 veterinary patients at the Utrecht University veterinary hospital in the Netherlands who tested positive for MRSP. Afterwards the transmission between infected pets, humans and the environment was studied. In this study MRSP was found in 31 out of 200 environmental samples taken in a veterinary teaching hospital. One out of 101 environmental samples at 3 out of 6 clinics were MRSP-positive after disinfection (van Duijkeren et al., 2011).

In Canada samples were taken from cellular phones from veterinary personnel at a veterinary hospital. Two out of 123 phones were positive for MRSP and one out of 123 phones positive for MRSA. Around 22% of the participants cleaned their phones. The authors state that although the true risk for a MRSP or MRSA infection is unknown, veterinary staff should be educated on cleaning and disinfecting their phones and avoiding using their phones when their hands might be contaminated with these microbials, as cellular phones should not be contaminated with MRSA and MRSP (Julian et al., 2012).

A study conducted in Glasgow in a university veterinary clinic looked at the prevalence of MRSA in the work environment (14 different rooms) and in nasal swabs taken from the employees. The prevalence of MRSA in the work environment was 1.4% (two sites out of 140) (Heller et al., 2009). In the United

Kingdom there was a long-term study carried out (between 2011 and 2016) during which environmental sampling for MRSA took place in an equine veterinary hospital. The samples were taken from high risk areas such as surgical units, intensive care units, treatment areas, recovery boxes, equipment (for example used for anaesthetics) and other areas like keyboards, door handles and phones. MRSA was present in 11.5% samples (62 out of 540 samples) collected in a period of 5 years, which proved that the work environment can become contaminated. This study underlines the importance of (the implementation of) active surveillance as well as control policies (Bortolami et al., 2017).

According to Epp & Waldner (2012) 16.7% (136/812) of the studied veterinarians were diagnosed with a zoonotic disease over the previous five years. Rabies post-exposure prophylaxis was administered to nine of these veterinarians. The most common zoonosis, with an incidence of 7.6% (59 veterinarians), was ringworm. 47% of these ringworm cases occurred in veterinarians working with only companion animals, 39% in veterinarians working with large and small animals and the rest in veterinarians working with food, horses or other animals. In general, the most common zoonoses were ringworm, rabies, MRSA, *Campylobacter*, WNV (Epp & Waldner, 2012).

During a veterinary congress in Finland there was a survey conducted amongst the participants. As high as 90.9% of the participating veterinarians were exposed to a zoonotic pathogen during their working time, 15% of the participants reported a zoonotic infection, 78.8% a needlestick injury, 85% an animal bite, and 24.2% skin lesions (Kinnunen et al., 2022).

Another study conducted amongst veterinary students showed that 13 out of 965 them were diagnosed with a zoonotic disease throughout their study. The most frequent zoonosis was similar as in the previously mentioned studies – ringworm (8.5%) and other fungal infections (5.5%). 20% of the students self-reported a zoonosis. The focus of the study was the prevalence of *Coxiella burnetii* amongst students and it turned out that 18.7% of the students were seropositive for *C. burnetii*. The seroprevalence was higher in students who were in a more advanced year of the study and in students working with farm animals. Comparatively, the seroprevalence of the total Dutch population for *C. burnetii* was 2.4% (de Rooij et al., 2012). The seroprevalence of *C. burnetii* amongst Belgian veterinarians was much higher than in veterinary students, namely 45.5%, with the highest seroprevalence in farm animal veterinarians (Dal Pozzo et al., 2017).

YOPIs are generally at higher risk of disease. High risk pathogens for pregnant employees are the previously mentioned Q fever, brucellosis, leptospirosis, listeriosis, lymphocytic choriomeningitis virus infection, gestational psittacosis, toxoplasmosis and general infections for example due to bites or scratches (Scheftel et al., 2017).

Another commonly described zoonotic disease in veterinary professionals was Hepatitis E (HEV). During a Finnish veterinary conference the seroprevalence of Hepatitis E was 10.2% amongst veterinarians and 5.8% amongst other veterinary personnel. It seemed that the prevalence was significantly higher in companion animal practices than in other practices. Not only swine should be considered while tracing back the source of HEV infection but also other HEV reservoirs and

traveling. The conclusion was that whether veterinary professional is at higher risk for gaining hepatitis E needs to be further evaluated (Kantala et al., 2017). In Estonia 2.6% of the veterinarians (three out of 115) tested positive for immunoglobulin G antibodies against the Hepatitis E virus, which was lower than in other countries (Lassen et al., 2017).

Lastly, seroprevalence of *Toxoplasma gondii* was studied in Finnish veterinarians. The seroprevalence was 14.6% and was most frequently associated with tasting uncooked beef and not their veterinary profession (Siponen et al., 2019).

Summarizing, the majority of the veterinary care professionals are exposed to zoonotic agents through daily contact with animals. A high percentage of the veterinary employees contracts one or more zoonotic diseases during their working life. Some of the zoonotic diseases are more frequently contracted than others. The prevalence of different pathogens differs per country. The exposure to zoonotic agents of people doing veterinary related activities is high through the daily contact with animals. The severity differs per person and disease. Therefore, the risk for contracting a zoonotic disease working in a veterinary clinic is considered to be high and thus a CCP.

Needlestick injuries

Information on needlestick injuries in veterinary clinic personnel is scarce. There was a lot of effort done to decrease the number of needlestick injuries amongst human health care personnel, but not amongst veterinary medicine personnel. It was commonly accepted that up to 82% of the needlestick injuries are underreported, based on Elder & Paterson (2006) and Wicker et al. (2008). Although the possibility of transmission of zoonotic pathogens via a needlestick injury is considered to be low, needlestick injuries could cause inflammatory reactions and are prone to secondary wound infections (Elder & Paterson, 2006; Wicker et al., 2008). The data on the severity of the consequences following a needlestick injury is lacking. According to Weese and Jack (2008) most of the needlestick injuries cause minor symptoms. There were previously described in one study severe effects, including abscess formation at the injection site, local nerve damage, brucellosis, miscarriage after injection with prostaglandin, joint infection, necrosis.

During a veterinary congress in Portugal in 2011 veterinary personnel filled in a questionnaire on needlestick injuries. Out of 373 participants, 293 (78.5%) reported a needlestick injury throughout their career. Working with dogs was considered a risk factor. The number of annual needlestick injuries decreased with worktime experience (Mesquita et al., 2015).

More data on needlestick injuries in veterinary personnel was found in non-European articles. In New Zealand needle recapping is common in veterinary medicine. Students and veterinarians were more likely than nurses to put used needles in their clothing. Mouth uncapping, resulting in a higher biosecurity risk and a higher risk of injury to the face and eyes, was done by 13% of veterinarians, 5% of the nurses and 3% other employees (Riley et al., 2016).

Weese and Faires (2009) observed needlestick handling practices amongst veterinary technicians. Most of the veterinary technicians (81%) reported that they

had received proper training in needlestick handling practices. However, throughout the study it was clear that the way the technicians were handling needles was putting them at higher risk of having a needlestick injury. Recapping (putting the cap back onto the already used needle) was the most common cause of needlestick injuries. Storing needles in clothing led to needlestick injuries during doing laundry. Reporting the injuries was uncommon (Weese & Faires, 2009).

The high percentage of underreporting indicates that the true frequency of needlestick injuries is most probably much higher. The exposure seems already high as veterinary care professionals use needlesticks on a daily basis. The impact of the needlestick injuries is most often low, however the seldomly occurring severe consequences (for example miscarriage, local nerve damage, etc.) should not be neglected. Due to the high exposure, the high frequency (up to 81%) of needlestick injuries stated in the articles and the assumption that needlestick handling practices are often not safe (due to recapping and storing needles in clothing) needlestick injuries are considered a CCP.

3.2.3 **Critical Limits (Principle 3)**

Animal bites and scratches

Having frequent contact with animals, for instance on a daily basis, increases the risk of getting bitten or scratched (Drobatz & Smith, 2003). However, most of the incidents do not lead to serious injury. The circumstances in which the bite or scratch incidents occur are also of importance. It matters whether a dog has a history of biting, whether the personnel knows this dog, and whether the owner informs the personnel about the character of this dog (Epp & Waldner, 2012; Owczarek-Garstecka et al., 2019; LNV, 2008). The availability of such information influences how the personnel approaches a specific animal (for example taking extra precautions), and therefore most likely influences the occurrence of this type of incidents in clinics.

Currently a critical limit for animal bites and scratches cannot be established based on literature research. Additionally, the frequency of the bite and scratch incidents will differ per clinic, depending on for instance the number of employees, type of clinic, and area where it is located. The incidence should be as low as possible. Preferably, a veterinary clinic should register their bite and scratch incidence. Possible changes in the situation, for example an increase or decrease in incidence, can be observed through evaluation of the registered data. This will help determine whether risk management measures are needed.

Zoonoses

In case of infectious diseases, here zoonoses, according to the experts the prevalence should be as low as possible. This can be achieved by following preventive measures, like wearing masks, wearing gloves, hand washing protocols, strict quarantine protocols, and thoroughly cleaning and disinfection of the clinic every day. The protocols and behaviour of employees should be monitored, for example checking if employees are wearing masks while handling birds, how employees wash their hands, and if the level of general hygiene in the clinic is appropriate. The general hygiene consist of the following aspects: cleanliness of the clinic ('visible' dirt) and the level of contamination of different areas with *Enterobacteriaceae* and Total viable colonies (TVCs). Use of protocols and hygiene

practices are essential in the prevention of infectious diseases. Additionally, cases of infectious diseases amongst employees, including the possible sources of the diseases, should be registered. Based on this registration the effectivity of the protocols and practices (e.g. if protocols are correctly followed) can be evaluated.

In order to prevent any kind of infectious disease good hygiene practices are needed. The level of general hygiene can be quantitatively assessed. In some sectors testing protocols are already applied after cleaning and disinfection. The limit values as used in these protocols could be more widely applicable. One of the experts gave an example of hygiene testing after cleaning in broiler farms as a possible reference method for veterinary clinics. On broilers farms cleaning, disinfection and sampling (for total viable count (TVC) and *Enterobacteriaceae*, usually) before cleaning, after cleaning and after disinfection are obliged. Sampling usually is done at ten to 12 different sites and is used as means of determining whether the hygiene improved after cleaning and after disinfection. The goal on broiler farms is to reduce infection pressure and eventually prevent food-borne diseases (Luyckx et al., 2015).

Most bacteria are able to grow in aerobic conditions. The higher the number of bacteria present the more contaminated the area is. That is why determining the total viable count (TVC) by means of sampling (for instance using dipslides) at ten different surfaces can be used as an indication of the level of contamination of a given area or surface. Testing for *Enterobacteriaceae* indicates the presence of *E.coli*, *Salmonella spp.*, ESBLs and *Proteus spp.*, and can be used as an indication of the level of contamination of an area or surface with the mentioned bacteria (Lipman & Ruiter, 2007).

In neither veterinary clinics nor broiler farms a sterile environment can be achieved after cleaning, especially not when animals are present. However, the *Enterobacteriaceae* and aerobic colonies should be kept as low as possible in order to prevent spread of diseases. A recent study evaluated hygiene on dairy farms in calf housing by taking environmental samples. In this study a cut-off value of **4.4 log₁₀ cfu/mL** bacteria (TVC) after cleaning and disinfection was derived based on literature research. For the total coliform count (TCC) a cut-off value of **2.0 log₁₀ cfu/mL** was derived (Heinemann et al., 2021). It is assumed that these values can be used as a critical limit in veterinary clinics as well, due to the presence of animals. However, according to one of the experts, one should also keep in mind the type of surface that is tested, as for instance floors do not need to be as clean as desks or kitchen counters. The mentioned TVC and TCC values can be critical limits for floors, ceilings, walls and other 'dirty' surfaces. Some surfaces, for example cellular phones, handles, kitchens should therefore be **free of *Enterobacteriaceae***.

Beforehand should be defined which surface need to be *Enterobacteriaceae* free and low in TVCs (**<13 colonies**), for example cellular phones, handles, veterinary equipment, kitchens and stethoscopes but also surgery tables, treatment tables, recovery kennels, etc. The TVC classification for cellular phones, kitchens, handles surfaces is based on the classification system of the Institute of Risk Assessment Sciences in Utrecht. This classification assumes that (Institute for Risk Assessment Sciences (IRAS), 2018):

- <3 aerobic colonies is an indication of excellent hygiene

- 3 to 12 colonies – an indication of good hygiene
- 13 – 37 colonies – moderate hygiene
- 38-112 colonies - inadequate hygiene
- >113 colonies - bad hygiene

These values can therefore be critical limits for the mentioned surfaces (using dipslides for sampling).

MRSA and MRSP

MRSA and MRSP, being a part of the upcoming antimicrobial resistance (AMR) issue, are of importance to society. It is estimated that by 2050 ten million people will die annually as result of AMR (Hillock et al., 2022). As indicated previously the carriage of MRSA in veterinarians is higher than in rest of the population, and there is a substantial presence of MRSP in veterinary staff.

Lutz et al. (2013) studied the prevalence of Methicillin Susceptible *Staphylococcus* spp. (MSS) in air samples collected in a veterinary hospital. More than half (52%, 25 out of 48 air samples) were positive for *Staphylococcus* spp., out of which six were positive for MRS. The prevalence for both MSS and MRS varied insignificantly between different months (November, December and January). The study shows that *Staphylococcus* spp. is present in air samples in veterinary hospitals and shows a possible method for MRSA surveillance (Lutz et al., 2013).

The monitoring procedures of MRSA and MRSP are based on environmental sampling. The prevalence of MRSA and MRSP in environmental samples differs per country and clinic. Through registration of the prevalence MRSA and MRSP in environmental samples per clinic possible changes in the prevalence (increase / decrease) can be observed. These changes can then be evaluated on whether risk management measures are needed.

The critical limit of 0% prevalence of MRSA and MRSP on cellular phones (Julian et al., 2012) could be applied more widely, for example for kitchen counters and surfaces that are regularly touched by employees (like handles, stethoscopes, thermometers and other veterinary equipment), but also with regard to patient health all treatment and surgery tables should be MRSA and MRSP free.

Needlestick injuries

Although most likely unavoidable in veterinary practice, needlestick injuries should occur as least frequently as possible. Certain factors, for example the number of patient per day or the number of unexperienced employees will have influence on the trend in the incidence. Registration of incidence per clinic will help observe possible changes in the incidence, for example a decrease or an increase. These changes can be evaluated on whether risk management measures are needed. Through proper education on behaviour around needlestick injections, the incidence should decrease (Buswell et al., 2016; Mesquita et al., 2015).

3.2.4 Monitoring and measurement procedures (Principle 4)

Animal bites and scratches

Registration of bites and scratches is considered to be the most important monitoring procedure. The incidents should preferably be documented on a regular basis by the clinic itself. If this is not the case, this could be surveyed by an external

health and safety professional (e.g. an occupational hygienist), for instance once a year, in order to get an impression of the incidence of bites and scratches. Based on the method used by Owczarek-Garstecka et al. (2019) the following information should be documented for each incident:

- Who is bitten/ scratched
- Circumstances surrounding the incident
 - o Behaviour history of the animal
 - o Relevant clinical history
 - o Information on the character of the animal received from the owner
 - o Procedure
- Severity of injury (mild, moderate, severe)
 - o Mild: no medical care needed
 - o Moderate: medical care needed
 - o Severe: Hospitalisation or post-exposure rabies prophylaxis needed
- Complications
- Based on the registration of the bite and scratch incidents at least the following should be evaluated: Number of incidents a year in the clinic
- Number of incidents per employee per year
- Number of incidents requiring medical care
- Percentage of personnel having an incident (in case of a large company)
- Percentage of incidents requiring medical care (in case of a large company)

Bites and scratches are inevitable, however the goal is to keep them as low as possible. If the incidence increases, it should be evaluated whether risk management measures are needed. It is possible that a higher incidence is related to not following protocols or lacking knowledge on certain topics.

Zoonoses

Occurrence of zoonoses should be registered as well. Information on who has contracted a zoonosis, what type of zoonosis, and the possible source of the zoonosis should be documented on a regular basis.

According to experts the best way to approach zoonoses in an occupational setting is by applying the precautionary principle, and thus the prevalence should be as low as possible. There should also be clear and easily accessible protocols to minimising the risk of getting a zoonotic disease, for example wearing masks while handling certain animals (suspected of an airborne zoonosis, for example birds), wearing gloves, washing hands after every patient and following quarantine unit protocols. The accessibility, clarity, content of and following the protocols should be evaluated. Through observation and evaluation of employees' behaviour, the prevention of zoonoses can be optimised. In addition the hygiene in the workplace should be tested by means of sampling (for instance using dip slides) for *Enterobacteriaceae* and TVCs at 10 different sites. This will give an indication whether protocols concerning hygiene are properly applied and thus whether the infectious pressure is kept as low as possible. In case of an increase in prevalence of zoonoses the causes should be evaluated and addressed accordingly (see below: *principle 5*).

Good general hygiene in the clinic contributes to a low infectious pressure. Veterinary clinics should have protocols regarding general hygiene. These protocols, as well as visibly established cleanliness, should be evaluated on a regular basis. Measuring aerobic total viable counts (TVC) and *Enterobacteriaceae*

colonies counts is considered sufficient to determine the level of general hygiene in a veterinary practice. Non-selective agar plates can be used for determining TVC and Chromocult coliform agars plates can be used for *Enterobacteriaceae*. The easiest measuring method is to take samples from ten different surfaces in the clinic. For the sampling for instance dipslides (a test for the presence of microbiological agents, a plastic stick with bacterial growth media on them) with the mentioned media can be used. After taking the samples, the dipslides should be put in a stove either in the veterinary practice self or in another laboratory. This needs to be done in order for the colonies to grow on the dipslides and to count them. This process can be carried out by the occupational hygienist or an external lab.

For more details on the sampling methods see [Appendix A](#).

In case of the critical limits (see principle 3) are exceeded, risk management measures are needed.

MRSA and MRSP

Extra attention should be paid to MRSA and MRSP, and eventually also to other antimicrobial resistance related biological agents, because of the limited treatment possibilities. Both MRSA and MRSP are found in the work environment. The monitoring procedure should involve environmental sampling for MRSA and MRSP on surfaces, on skin and/or and in the air.

There is more than one method of sampling and culturing MRSA and MRSP. Van Duijkeren et al. (2011), Julian et al. (2012), Agersø et al. (2014) and Veenemans et al. (2013) all describe MRSA and / or MRSP sampling and detection methods.

Veneemans et al. (2013) evaluated the brilliance MRSA 2 agar plate. The sensitivity for detection of MRSA was 98% and the specificity 99.1%, which indicates that this agar plate is a good plate for detecting MRSA (Veenemans et al., 2013). Van Duijkeren et al. (2011) described a method in which MRSA was sampled by means of dust collection, nose swabs and using sterile cloth wipes with Ringer's solution on surfaces. After collection, the samples underwent microbiological analysis (van Duijkeren et al., 2011).

According to Agersø et al. (2014) the most cost-efficient method for environmental sampling of MRSA is air sampling using air samplers (AirPort MD8) and culturing of the collected air samples. The sensitivity of air sampling was compared in this study to sensitivity of sampling by means of taking dust swabs and skins swabs on animal farms. Air sampling with direct selective agar plating had a sensitivity of 78%. In comparison, use of ear swabs had the highest sensitivity (90%). However, the conclusion is that all the methods (air sampling, dust swabs and skin swabs) can be used for detection of MRSA (Agersø et al., 2014).

The method described by Julian et al. (2012) for cellular phones, electrostatic cloth wiping and culturing, is an easy method and it is assumed that this method can also be applied on (other) surfaces in the workplace. This method could be feasible for monitoring both MRSA and MRSP.

The methods used by Agersø et al. (2014) and Julian et al. (2012) were the most thoroughly described and were considered to be the easiest to apply at different workplaces. That are the reasons why these methods are recommended to use in a veterinary clinic or other workplaces.

The monitoring should be carried out on a regular basis, for instance annually. This allows observation of possible changes in the occurrence, an increase for example. Evaluation of the results will help determine whether risk management measures are needed. Other surfaces (for example ten non 'dirty' surfaces: handles, veterinary equipment, kitchen) should also be sampled using the method described by Julian et al (2012). Some surfaces should be MRSA free, like kitchen counters, handles, veterinary equipment as well as surgery tables, treatment tables.

In general, the results of surface or skin samples by using cloths or swabs are more easy to interpret than the results of air samples. There could be a critical limit established for surfaces, based on which surfaces should be MRSA free. This could however not be done for the air samples. Air sampling as described by Agersø et al. (2014) can however be a helpful method for detecting MRSA. By using both surface sampling and air sampling, all of the environmental transmission routes are covered. This will help evaluate the environmental burden in the veterinary clinic most optimally. The airborne MRSA prevalence will most likely differ per clinic. The air sampling allows establishing a reference point for the air prevalence of MRSA in the clinic and observing possible changes (for example an increase) in MRSA prevalence in the air samples. These possible changes will help determine whether risk management measures are needed.

For more details on the sampling methods see [Appendix A](#).

In case the previously established critical limit is exceeded or an increase in the air prevalence of MRSA, risk management measures are needed.

Needlestick injuries

Needlestick injuries should be registered in the clinic to determine the prevalence and incidence of these injuries. In addition, through observation it can be determined whether needlestick handling practices are safe in the clinic. The following information should be documented concerning an incident:

- Injured person
- Circumstances of needlestick injury
 - o Information about the situation, e.g. Injection, doing laundry, recapping
 - o Information about the animal, if applicable
 - o Procedure
- Severity of injury (mild, moderate, severe)
 - o Mild: no medical care needed
 - o Moderate: medical care needed
 - o Severe: Hospitalisation or post-exposure rabies prophylaxis needed

Based on the registration of needlestick injuries at least the following should be evaluated:

- Number of incidents per year in the clinic
- Number of incidents per employee per year
- Number of incidents requiring medical care
- Percentage of personnel having an incident (in case of a large company)
- Percentage of incidents requiring medical care (in case of a large company)

In case of an increase of the incidence of needlestick injuries risk management measures are needed.

3.2.5 **Risk management measures (Principle 5)**

Animal bites and scratches

During the first evaluation, for instance evaluation of protocols preventing bites and scratches, it should be determined whether RMM are needed. In case there are no protocols or the protocols are not clear or practical RMM should be taken. During the following evaluations of the workplace RMM will be needed for instance in case of an increase of the incidence of animal bites and scratches.

According to the interviewed experts awareness is needed in order for people to follow preventive / protective protocols. The experts also said that awareness is often lacking. Therefore, possible preventive measures could be a refreshing course on bite countermeasures or modification of the clinic (e.g. an extension of their bite-prevention equipment reservoir (Owczarek-Garstecka, 2019). In the Netherlands a book on hygiene and biosecurity for veterinary clinics is available, in which also prevention of bite and scratch incidents is described (Koninklijke Nederlandse Maatschappij voor Diergeneeskunde (KNMvD) & de Stichting Diergeneeskundig Memorandum (DM), 2019). In case of a high incidence of animal bites and scratches it is advised to consult this book.

Counter measures for bite and scratch incidents include for instance (Owczarek-Garstecka, 2019; Epp & Waldener, 2012):

- Letting an aggressive dog wait outside of the clinic until it is his turn;
- Muzzling;
- Using a "cat-bag" or protective gloves;
- Sedating the animal for certain procedures;
- Discussing with the owner the possibilities of therapy, re-homing, in extreme cases euthanasia.

Zoonoses

During the first evaluation, for instance evaluation of protocols on preventing zoonoses and inspecting the hygiene, it should be determined whether RMM are needed. In case of there are no protocols, if the protocols are not practical or the kitchen is visibly dirty RMM should be taken. During the following evaluations of the workplace RMM will be needed for instance in case of an increase of the prevalence of the zoonotic diseases.

Possible preventive measures could be a (refreshing) course on zoonoses and associated risks. In the Netherlands a book on hygiene and biosecurity for veterinary clinics is available, in which prevention of zoonoses and hygiene measures are described (Koninklijke Nederlandse Maatschappij voor Diergeneeskunde (KNMvD) & de Stichting Diergeneeskundig Memorandum (DM), 2019). In case of a high incidence of zoonoses, failure to follow the clinic's protocols or poor hygiene it is advised to consult this book.

If the critical limits for TVCs and *Enterobacteriaceae* are exceeded, it is advisable to first repeat the cleaning procedure and test again. If the values are still above the critical limits, the cleaning and disinfection procedure should be evaluated. For cleaning procedures the 'Diergeneeskundig memorandum: Hygiëne en biosecurity in dierenartsenpraktijken' (KNMvD & DM 2019) can be consulted. These methods

involve removing the dirt with a detergent and water, letting the area dry and eventually applying a disinfectant on the surfaces. An overview and description of the disinfectants is to be found on pages 95-101 in the document (KNMvD & DM 2019).

MRSA and MRSP

Norway's MRSA control strategy includes surveillance and screening of personnel who have contact with MRSA-contaminated areas (Crespo-Piazuelo, & Lawlor, 2021). This could be applied in a veterinary clinic. Furthermore, thorough cleaning and disinfection of the workplace is important. The cleaning methods involve scrubbing off organic material using an alkaline detergent and warm water, pressure washing or steaming, allowing the area to dry and spraying with a 1-2% disinfectant solution or 0.25% bleach solution (Bortolami et al., 2017; Frosini et al., 2022; Grönthal et al., 2014). Another way to decrease the contamination with aerobic colonies and *Enterobacteriaceae* and increase the hygiene is thorough cleaning and disinfection according to the described methods in "Diergeneeskundig memorandum: hygiëne en biosecurity in dierenartsenpraktijken". These methods involve removing the dirt with a detergent and water, letting the area dry and eventually applying a disinfectant on the surfaces. An overview and description of the disinfectants is to be found on pages 95-101 in the document (KNMvD & DM, 2019).

In addition, If there is MRSA or MRSP found on cellular phones, handles, veterinary equipment and kitchen, education/ a course on cleaning phones or other equipment (and using for instance disinfecting alcohol wipes) and the risks associated with MRSA and MRSP should be considered. The focus should be on avoiding handling the phone when hands might be contaminated and routine disinfection of the phones with for example alcohol wipes (Julian et al., 2012) .

During the initial evaluation, involving for instance sampling of surfaces that should be MRSA and MRSP free and evaluating the results, it should be determined whether RMM are needed. In case the surfaces are contaminated, RMM should be taken. This should be evaluated on a regular basis for instance once a year.

Needlestick injuries

For human health care general needlestick prevention recommendations are available. Buswell et al. adjusted these recommendations for agricultural workers. These recommendations involve proper training of the employees, restraining animals, providing feedback to the employees on their handling practices, no uncapping by mouth, not carrying syringes in pockets, encouraging injury reporting, etc. (Buswell et al., 2016). These recommendation can be used in veterinary practices.

During the initial evaluation, for instance evaluation of protocols preventing needlestick injuries and / or observation of employees using needlesticks, it should be determined whether RMM are needed. In case of there are no protocols or the observed behaviour is a risk factor (uncapping by mouth, recapping / reusing needlesticks, putting needlesticks in clothing) should be taken. If the incidence is high, or if it is observed that the needlestick handling practices are unsafe, a training by for example an experienced employees on handling practices and or education on risks should be considered.

3.2.6 Documentation procedures (Principle 7)

HACCP Plan Summary Table (see Table 2).

Table 2: Summary of the HACCP

CCPs	Critical limit(s)	Monitoring and measuring	Risk management measures
Animal bites and scratches	Incidence as low as possible	Registration and evaluation of incidents to determine whether RMM are needed	Follow additional courses on animal handling practices and zoonoses and / or suggesting consulting for instance 'Diergeneeskundig Memorandum' for more information on prevention of animal bites
Zoonoses	Zoonoses: Prevalence as low as possible MRSA: 0% for kitchens, veterinary equipment, handles for electrostatic cloth samples MRSP: 0% for kitchens, veterinary equipment, handles for electrostatic cloth samples Enterobacteriaceae: 0 for kitchens, veterinary equipment, handles and maximum of 2.0 log ₁₀ cfu·mL ⁻¹ for floors, ceiling and walls TVC: 4.4 log ₁₀ cfu·mL ⁻¹ for floors, ceiling and walls	Registration, workplace observation, air sampling, dipslide tests (zoonoses) or electrostatic cloth wiping (MRSA and MRSP)	Following additional courses on zoonoses and protective practices and / or suggesting consulting for instance 'Diergeneeskundig Memorandum' for more information on prevention of zoonoses Proper cleaning and disinfection of the work environment
Needlestick injuries	Incidence as low as possible	Registration and evaluation of incidents to determine whether RMM are needed, workplace observation	Recommending a training by for example an experienced employee on needlestick handling practices Education on associated health risks

3.3 Worked example Animal farming

3.3.1 Hazard analysis (Principle 1)

Based on the overview of the European Agency for Safety and Health at Work EU-OSHA project, the following hazards have been identified for workers on animal farms (Jedynska et al., 2019; EU-OSHA, 2019). Additional literature research (Jennissen, 2010) contributed to the establishing the list of relevant biological hazards.

Table 3: Grouping of biological agents for hazard analysis

Grouping of biological agents	Specific biological agent
Zoonoses	MRSA, MRSP, <i>Chlamydia psittaci</i>, avian influenza virus, coronavirus A <i>Microsporum</i> spp., <i>Trichophyton</i> spp. Flees, <i>Sarcoptes scabiei</i> <i>Cryptosporidium</i> spp., <i>Giardia</i> spp., <i>Echinococcus</i> spp., <i>Taenia</i> spp., <i>Toxocara canis</i>, <i>Trichinella</i> spp., <i>Toxoplasma gondii</i> <i>Brucella</i> spp., <i>Clostridium tetani</i>, <i>Coxiella burnetii</i>, <i>Leptospira</i> spp., <i>Bacillus anthracis</i>, <i>Mycobacterium bovis/tuberculosis</i>, <i>Francisella tularensis</i>, <i>Erythrepelothrix rhusiopathiae</i>, <i>Escherichia coli</i>, <i>Streptococcus</i> spp., <i>Staphylococcus</i> spp., <i>Legionella</i> spp., <i>Yersinia</i> spp., <i>Corynebacterium pseudotuberculosis</i>, <i>Campylobacter</i> spp., <i>Pasteurella</i> spp., <i>Listeria monocytogenes</i>, <i>Salmonella</i> spp., <i>Listeria monocytogenes</i> Newcastle disease virus, orf virus, yellow fever (flavivirus), Hepatitis E, West Nile virus
Vector bites	<i>Borrelia burgdorferi</i> , tick borne encephalitis virus
Needlestick injury	Secondary infection of the wound related to bacterial contamination from the environment, animal, employees' skin

3.3.2 Critical Control Points (Principle 2)

Zoonoses

Zoonoses in farmers are considered to be an occupational risk. A systematic review by Klous et al. (2016) describes *Coxiella burnetii*, hepatitis E and avian influenza as zoonotic pathogens of importance in animal farming. For Hepatitis E and avian influenza however, the data on the seroprevalence in farmers was scarce (Klous et al., 2016). No current cases of avian influenza in humans in Europe were reported according to the European Centre for Disease Prevention and Control (ECDC) (2022).

There are several European studies describing the seroprevalence of *Coxiella burnetii* amongst animal farmers. In a Dutch study the seroprevalence of *Coxiella burnetii* amongst farmers on sheep farms was tested. Out of 27 participants (15 farmers and 12 household members), 18 (66.7%) were seropositive for *Coxiella burnetii*. The general population seroprevalence in the Netherlands was 2.4%. The prevalence amongst farmers was higher than in the household members. The

following risk factors were identified in the study: contact with livestock, contaminated aerosols breathed in during lambing inside stables, exposure to Q-fever at a young age, and having sheep breeds on a farm that had lower resistance to the pathogen (de Lange et al., 2014). Another Dutch study described the seroprevalence amongst humans on dairy cattle farms in the years 2010 – 2011. The overall seroprevalence among farmers, spouses and their children was 72.1%. In farmers the seroprevalence was the highest (87.2%). The risk factors described in this study were a larger herd size and contact with farm animals (Schimmer et al., 2014). On Dutch goat farms the seroprevalence amongst farmers and their families was high between 2007 and 2009 (73.5% farmers, 66.7% spouses and 57.1% children). The identified risk factors for testing seropositive were three or more tasks on the farm a day, farm location, proximity to *C. brunetti* positive bulk milk, presence of cats and multiple goat breeds and wearing regular use shoes instead of the ones that are meant to be worn only on the farm (Schimmer et al., 2012). In Estonia the seroprevalence for *C. brunetti* was significantly higher amongst veterinary personnel and farmers (9.62% and 7.73% respectively) than in the general population (3.9%). Again, the identified risk factor for being seropositive was having contact with farm animals, especially small ruminants (Naere et al., 2019). In France the seroprevalence for *C. brunetti* amongst farmers (56.3%) was significantly higher than amongst the control group consisting of blood donors (12.7%). Out of 374 blood donors, 22 worked with farm animals and nine of them tested positive. Having contact with ruminants and wearing shoes instead of the ones that are meant to be worn only on the farm were associated with a higher risk. The severity of the disease varied from mild to severe symptoms (Beaudeau et al., 2021). In Denmark in the years 2006-2007 around 11% of people tested for *C. brunetti* at one health institute were seropositive for *C. brunetti*. 84% of the people that tested positive had had contact with cattle in an occupational setting, 31% were tested because of symptoms consistent with Q-fever. Most cases were found amongst farmers, veterinarians and jobs related to farm work (90%). Most of the cases (64%) were asymptomatic. Nonetheless, the most frequently reported symptoms were weakness, muscle ache, fever and headache. The severe symptoms caused by Q-fever, like pneumonia and hepatitis, were reported seldomly (Bacci et al., 2012).

For Hepatitis E contact with pigs in occupational setting is a known risk factor (Lapa, Capobianchi & Garbuglia, 2015). For example, in an Italian study the seroprevalence for Hepatitis E amongst farmers was 3.5%, and in a German study 26.1%. The used serological assay used can have an influence on the results, which might be an explanation for the differences in seroprevalence of Hepatitis E in farmers (Caruso et al., 2017; Krumbholz et al., 2012; Mrzljak et al., 2021).

Prevalence of MRSA in the general population worldwide varied from 0.8% to 1.3%, while in farmers the average prevalence was around 14.4% (Paterson et al., 2013; Li et al., 2015). In a Dutch study the prevalence of MRSA in household members of 49 pig farms was determined. Nasal and oropharyngeal swabs, environmental wet wipe samples and electrostatic dust collector cloths (EDCs) (from house and stables) were taken and analysed. Farmers from 22 out of 49 pig farms were tested positive for MRSA and 26% of the household members tested at least once positive for MRSA throughout the study. The presence of MRSA was detected in 82% of the environmental wet wipes and 98% of the EDCs samples. Household members who wore face-masks were less likely to become a MRSA carrier. Conclusion of the

study was that transmission of MRSA to humans occurred via pigs and environment (van Cleef et al., 2015). MRSA was not only found in people working and/or living on pig, but also on farms with other animals. In a Belgian study the prevalence of MRSA on different farms was studied: veal, beef, pig and poultry. In total 26% (36/138) of the farmers and 9% (5 out of 53) of the household members of farmers included in the study tested positive. The highest MRSA prevalence in farmers was found on veal farms (72%) and the lowest on dairy farms (0%) (Vandendriessche et al., 2013). In Italy there was one buffalo farmer (1/22 farms) who tested positive for MRSA (Giovanni et al., 2020). In Germany the prevalence of MRSA and ESBLs was studied in dust samples and faecal animal samples as well as in nasal and stool samples from farmers in 51 farms. Presence of MRSA and ESBL was detected on 49 (96%) and 31 (61%) farms, respectively. 85% of the farmers carried MRSA and 6% of the farmers carried ESBL (Fischer et al., 2017). Dahms et al. (2015) found that ESBLs (amongst which *Klebsiella pneumonia* and *E.coli* most frequently found) were potential biological hazards for farmers as they were highly prevalent on farms and could cause difficultly treatable urinary tract infections, pneumonia and sepsis. The transmission occurred mainly via direct contact with animals or their faeces (Dahms et al., 2015). Dohment et al. (2017) also suggested the possibility of airborne ESBL transmission. In a Dutch study the ESBL-producing *E.coli* seroprevalence in human faeces samples was found to be 19.9% (27/141) in all participants, and more specifically 25.5% in farmers, 37.5% in employees, and 11.4% in farmers' partners. Contact with broilers was considered a risk factor (Huijbers et al., 2014). Dierikx et al. (2013) found ESBLs in six broiler farmers out of the 18 participating. The prevalence of ESBLs genes in pig farmers was 6% (out of 142 participants). Daily exposure to pigs was associated with human ESBL carriage (Dohmen et al., 2015). Research involving genome sequencing on broiler farms confirmed that there was strain transmission between broilers, farmers and household members (van Hoek et al., 2020). In Estonia the prevalence of ESBLs was low, only 14 pig farmers (6.8%) tested positive with ESBLs. Working as a pig farmer was considered a risk factor (Telling et al., 2020). Dahms et al. found a ESBL-producing *E.coli* prevalence of 6.8% (5/73) in farmers' faecal samples. Pig, poultry and cattle farms were included in the study and in all of the different types of farms a prevalence of at least 50% up to 88% in animals was found. Due to the high prevalence in animals it was concluded that transmission to humans was possible (Dahms et al., 2015).

Due to the unavoidable frequent contact with animals (exposure) and the varying severity of the different described diseases (based on the classification of biological agents described by Klein & RIVM (2012) report), zoonoses are considered a critical control point.

Vector bites

Zajac et al. (2017) evaluated the exposure of Polish farmers to ticks by means of investigating the seroprevalence of *Borrelia burgdorferi* in farmers. The seroprevalence varied between 18.2% and 50.7%, which was explained by regional environmental differences. There were significant correlations found between having a positive test result and living more than 10 years in Poland, and living close to and spending more than six hours per day in the forest (Zajac et al., 2017). In a Hungarian study 21% (44 out of 219) of the farmers reported an average of approximately four tick bites per year. Almost 60% of the farmers said to use tick prevention measures. No correlation between preventive measures and number of

tick bites was found. The majority of farmers participating in the study worked in an arable habitat. Farmers in Hungary were thus exposed to ticks and tick-borne diseases (Li et al., 2018).

Both studies state that all farmers are at higher risk of contracting tick bites and therefore contracting related tick-borne diseases. A lot of farmers work outside (exposure), in green areas where ticks are prevalent. Lyme disease caused by *Borrelia burgdorferi* can cause mild (erythema migrans) to severe (neurological) symptoms (Zajac et al., 2017). Therefore vector bites are considered a CCP.

Needlestick injuries

In a review by Jennissen et al. (2010) nine case reports of animal farm workers who experienced an unintentional needlestick injury were presented. All of the farm workers had to be medically treated with antibiotics and were hospitalized. Five out of the nine case reports were soft tissue infections due to secondary bacterial infections. The incidence in farmers was similar to the one reported in veterinary personnel. As needles were often reused in livestock farming, the needles became inoculated with pathogens and could definitely cause secondary infections upon injection. In Australia 80% of farmers who vaccinated animals reported an unintentional needlestick injury in one year (Jennissen et al., 2010).

Data on occurrence of needlestick injuries and related health effects in animal farmers are lacking. Farmers will probably give an injection to an animal (exposure) up to a couple of times a week. In the worst case scenario the needle will be reused a number of times during one day. The severity of the incident will differ from mild to severe. That is why needlestick injuries should be considered a CCP.

3.3.3 Critical Limits (Principle 3)

Zoonoses

It is difficult to establish critical limits for zoonoses in animal farms. The daily exposure to different zoonotic pathogens makes animal farms a high-risk workplace. The occurrence of zoonoses and the prevalence of zoonotic diseases should be kept as low as possible. For that monitoring can be helpful in order to determine whether RMM are needed. Not all zoonotic pathogens are easy to monitor or measure. However, some of the pathogens are easier or more important to monitor than others, for example drug resistant organisms. The occurrence of MRSA by means of air sampling and/or surface sampling should be measured. Some surfaces, for example kitchen counters, handles or phones, should be MRSA free. Livestock seems to be a reservoir for MRSA, which is why 'dirty' surfaces, like floors, walls, ceilings might be difficult to keep MRSA free. Occurrence of MRSA in air samples should be as low as possible. Evaluation on a regular basis of the air samples will help observe any changes in the occurrence of MRSA. This way it can be determined whether RMM is needed.

The cut-off values established based on the previously described study by Heinemann et al., (2021) can be translated onto animal farms. The critical limits would be **4.4 log₁₀ cfu/mL** bacteria (TVC) after cleaning and disinfection and for the total coliform count (TCC) – **2.0 log₁₀ cfu/mL** (Heinemann et al., 2021). These limits will only apply at times that the stables are kept animal free. When there are animals present the values can be higher and a limit is difficult to establish. Some

surfaces will need to be kept *Enterobacteriaceae* **free** and low in TVCs at all times, for example kitchens, desks or cellular phones. For the TVCs again the **classification** made by IRAS (described previously) can be used for these surfaces as well.

Vector bites

Vector bites will not always lead to disease. According to literature the frequency of tick bites is higher in farmers than in the general population. In order to assess the true risk and variation of this risk over time, per farm the number of bites per person should be registered. The incidence should be as low as possible. Registration of the vector bite incidents will help establish a reference value for the particular animal farm and observe possible changes (an increase or decrease). These possible changes can be evaluated and it can be determined whether RMM are needed.

Needlestick injuries

The evidence on the risk of needlestick injuries is scarce. In view of the possible health issues following an incident, needlestick injuries should occur as little as possible. Registration will help observe and evaluate possible changes in the incidence. The evaluation of the changes will help determine whether RMM are needed.

3.3.4 Monitoring and measurement procedures (Principle 4)

Zoonoses

Prevention of zoonoses is essential. This can be achieved by creating and following protocols to prevent transmission of zoonotic pathogens and applying proper hygiene measures (like having a hygiene zone with a changing room and (possibly) a shower; washing hands, wearing clothing meant for use on the specific animal farm). Observation of the use of protective clothing and/or face-masks in high-exposure situations, and presence and proper use of the hygiene zone (possibly with a boot disinfection bath / area, changing room and / or shower) at the workplace can help with deciding whether RMM are needed. The observation of the behaviour of employees will however not always be possible considering the relatively small amount of employees at an animal farm.

For certain pathogens it is possible to test and interpret the test results. It is important to keep certain pathogens under surveillance, for example drug-resistant antimicrobials. On animal farms there are surfaces that should be kept MRSA free, think of phones and homes of farmers. The method described in the article of Julian et al. (2012) can be used to test for MRSA on different surfaces: phones and at different sites in the farmers' homes. In addition, MRSA can be tested in air samples as described by Agersø et al. (2014) on a regular basis, for instance once a year. This way a reference point / value can be established and possible changes (for example an increase or a decrease) can be observed. Evaluation of these results can help determine whether RMM are needed.

General hygiene is also important in prevention of infectious diseases. Similarly to veterinary clinics not all surfaces can be sterile on an animal farm. Some surfaces should be *Enterobacteriaceae* **free**, for example phones and kitchens. An *Enterobacteriaceae* free surface, means a surface free of for example ESBL

producing bacteria, *Salmonella spp.*, *Giardia spp.*, etc. The quantitative assessment of *Enterobacteriaceae* can be assessed using the method by Heinemann et al. (2021). Additionally, testing for TVC will help evaluate the hygiene (for more information see principle 3).

For testing procedures consult [Appendix A](#).

Vector bites

Documentation of the vector bites can be considered monitoring. At increase in incidence the possible cause should be evaluated. The following should be documented:

- Number of vector bites on the farm per year
- Number of vector bites per employee
- Use of preventive measures (anti-mosquito/tick/insect sprays, protective clothing)
- Severity of injury (mild, moderate, severe)
 - o Mild: no symptoms or medical care needed
 - o Moderate: mild symptoms (for example erythema migrans) and/or medical care needed
 - o Severe: severe symptoms and/or hospitalisation

Prevention of the occurrence of vector bites is essential. Occupations in which vector bites are considered a substantial risk should have good protocols on taking protective measures, like use of anti-insect sprays, wearing protective clothing and regular tick self-checks. Additionally, evaluation of the protocols and observation of the employees' behaviour around prevention of vector bites can be useful in determining whether RMM are needed.

Needlestick injuries

Registration of incidents and related consequences should be considered to determine the prevalence and incidence of these injuries. In addition, through observation at the workplace it can be determined whether needles are handled safely. The following aspects of the incident should be documented:

- Number of incidents on the farm per year
- Number of incidents per employee
- Circumstances surrounding the incident
 - o Situation
 - o Whether needle recapping took place
- Severity of injury (mild, moderate, severe)
 - o Mild: no medical care needed
 - o Moderate: medical care needed
 - o Severe: Hospitalisation or post-exposure rabies prophylaxis needed

Registration of the incidents will allow creating a reference point and observation of possible changes (increase or decrease) in the incidence. Evaluation of the changes will help determine whether RMM are needed.

3.3.5 Risk management measures (Principle 5)

Zoonoses

During the initial evaluation, for instance evaluation of (the need for) protocols on preventing zoonoses, it should be determined whether RMM are needed. In case of

there are no protocols or protective equipment RMM should be taken. During the following evaluations of the workplace RMM will be needed for instance in case of an increase of the prevalence of the zoonotic diseases.

According to the interviewed experts awareness of biological agents and the health effect, especially long term effects, is lacking. Increased awareness of the risk of biological agents may change the way how employees perform their work, for instance with regard to following protocols that aim at reducing the risk of (exposure to) biological agents. In case protocols are neglected, education on zoonoses could be helpful. Consulting a website containing relevant information on specific zoonoses can be suggested, for example 'kennisbank' by Stigas (2023a).

When the areas that should be clean and/or free of *Enterobacteriaceae* and MRSA are dirty/contaminated, cleaning and disinfecting procedures should be evaluated and perhaps optimized. For proper cleaning and disinfection guidelines for example the Dutch 'Arbocatalogue' for animal farms (Stigas, 2023a) can be consulted.

Vector bites

During the initial evaluation of biological agents at the workplace, evaluation of whether protocols are needed can be useful. In case of there are no protocols RMM should be taken. During the following evaluations of the workplace RMM will be needed for instance in case of an increase of the prevalence of vector bites. For improvement of the protocols, consulting for example the Dutch 'Arbocatalogue' for animal farms (Stigas, 2023a) can be suggested. Observation of the behaviour of the employees can around prevention of vector bites can prove to be useful as well. Possible advice on improvement of the preventive methods can be given. If the number of vector bites shows an increasing trend, it should be evaluated whether preventive measures are clear, accessible and followed by the employees. Education on vector bites and vector-borne diseases is an important part of making people aware of these risks and what they can do themselves to minimise these risks. Consulting a website containing relevant information on specific zoonoses can be suggested, for example 'Teken en de ziekte van Lyme' or 'kennisbank' by Stigas (Stigas, 2023b; Stigas, 2023a).

Needlestick injuries

During the initial evaluation, for instance evaluation of protocols / information on preventing needlestick injuries, it should be determined whether RMM are needed. In case of there are no protocols / information on prevention of needlestick injuries RMM should be taken. During the following evaluations of the workplace RMM will be needed for instance in case of an increase of the incidence. Possible interventions could be education on the health risks of needlestick injuries due to recapping, uncapping by mouth, putting needlestick in clothing or a training/ instruction (given by for example the veterinarian of the farm) on needlestick handling practices (Buswell et al., 2016).

3.3.6 Documentation procedures (Principle 7)

HACCP Plan Summary Table (see Table 4).

Table 4: Summary of the HACCP

Hazard(s)	Critical limit(s)	Monitoring	Control and/ or risk management measures
Zoonoses	Zoonoses: prevalence as low as possible MRSA: 0% for homes, cellular phones for electrostatic cloth samples Enterobacteriaceae: 0 for homes, cellular phones and maximum of $2.0 \log_{10} \text{cfu} \cdot \text{mL}^{-1}$ for floors, ceiling and walls TVC: $4.4 \log_{10} \text{cfu} \cdot \text{mL}^{-1}$ for floors, ceiling and walls in case no animals are present $>13 \text{ CFU}$ for cellular phones and homes	Registration, (possibly) observation of employees at the workplace, air sampling, dipslide tests (zoonoses) or electrostatic cloth wiping (MRSA)	Consulting the arbocatalogue for animal farms or 'kennisbank (zoonoses, infecties en allergieën)' website (Stigas, 2023a)
Vector bites	Incidence as low as possible	Registration and evaluation of incidents to determine whether RMM are needed, workplace observation	Consulting the arbocatalogue for animal farms or 'Teken en de ziekte van Lyme' and 'kennisbank (zoonoses, infecties en allergieën)' websites (Stigas, 2023a; Stigas, 2023b)
Needlestick injuries	Incidence as low as possible	Registration and evaluation of incidents to determine whether RMM are needed, workplace observation	Creating and / or improving protocols Suggesting training on needlestick handling practices

4 Discussion and conclusions

Based on the two worked examples the adjusted HACCP method proved to be useful in evaluating biological agents at the workplace. Working the examples was possible, although there was much more scientific literature available for the worked example veterinary clinics than animal farms. That means that for certain workplaces / sectors / occupations it is possibly easier to find information about relevant biological agents than for other workplaces / sectors / occupations. A structured literature research and consultation of the websites suggested in this study might help with the evaluation of biological agents. Nonetheless, the adjusted HACCP method can be a helpful tool in evaluating the biological agents part of an RIE.

The assumption in the generic HACCP method aiming at product safety is that by controlling physical hazards (for example temperature or acidity) biological hazards are controlled as well (FDA, 2022). There are two aspects that are important in using the adjusted HACCP method: determining when the method should be used and a description of the work process. The method can be used when indicators for the presence of biological agents are found at a workplace. Description of the work process starts with determining how and when employees come into contact with biological agents. For example employees come into contact with biological agents while working with animals. In addition, for instance the way employees with and the presence of for example a quarantine unit will have influence on how and when people come into contact with biological agents. This description would be called the work process. Describing the work process is similar to the description of the production process in the generic HACCP. Description of the work process is needed to proceed with development of the next steps of the HACCP method.

The grouping of biological agents done in principle one allowed a structured literature research and was eventually a method that helped creating risk management methods. Grouping of biological agents can be based on for example the work process, indicators of the presence of biological agents or the associated physical hazard or the common preventive. The indicators for biological agents might be conditions promoting growth of biological agents: water, optimal temperature (between 7°C and 65°C), water activity, acidity, amount of oxygen, light, presence of nutrients. Every employee who works with organic material: plants, animals, humans, microbiological material is at certain health risk (Kastelein & Spaan, 2014). Grouping based on the indicators can help with the approach to minimise the health risk. For example, if an employee is exposed to process water, then the possible intervention should be around process water.

Not all biological agents will cause harm to the employees. Many of the biological agents will either give a-specific symptoms and / or be underdiagnosed. Especially in the presence of an indicator (for the presence of biological agents) it is important to apply the precautionary principle and thus apply where possible preventive measures. This is needed to keep the exposure as low as possible.

All the experts stated during the interviews that awareness about the health risks due to biological agents is lacking. They think this is the main reason why, if in place, protocols aiming at prevention of health risks due to biological agents, are not followed. The experts think that applying the precautionary principle is the best

way to control health risks due to biological agents. Creating and following protocols is a way of taking a preventive approach. This is needed in order to prevent or minimise exposure. In order to be able to follow protocols training of employees might be needed.

These protocols and documentation apply not only to infectious biological agents, but to biological agents in general and even other types of hazards. According to experts protocols around prevention of exposure to biological hazards lack for many occupations. An example given by one of the experts is arable farming, in which there is no protocol on for example wearing face-masks while working in dusty environments. This shows that a protocol can be short and easy to carry out. For many different sectors various protocols are described in for example the 'Arbocatalogues' (SZW, 2022c).

Furthermore, protocols on improving general hygiene are important in managing biological agents as well. General hygiene plays an important role in prevention of infectious diseases as it leads to a lower infectious pressure. Therefore, good hygiene measures play an important role in controlling health risks due to biological agents at the workplace. For example, clean workplaces or clean hands can help prevent (feco-)oral transmission of microorganisms.

It is difficult to assess the health risk due to biological agents quantitatively. Due to the lack of attention to biological agents, data, knowledge and research needed for the evaluation of biological agents is lacking. In order to assess the real risk for different biological agents there needs to be further research done on dose-response relationships, prevalence and/or exposure to biological agents.

In this study only two (related) examples were worked. In addition, only infectious biological agents were used for working the examples. There is a possibility that by working either two unrelated examples, more than two examples or including all the biological agents the conclusion of the study would be different.

In conclusion, the adjusted HACCP method can be a useful tool in evaluating the biological agents part of an RIE. Research on the topic is lacking and therefore it might be a challenge to find data on for example exposure to biological agents. Nonetheless, indicators for the presence of biological agents are a reason to assume the precautionary principle. The aim of the precautionary principle is to prevent or minimise the exposure to biological agents. Protocols and preventive measures, for instance aiming at general hygiene, play an essential role in controlling biological agents in occupational settings.

5 Signatures

Utrecht, 2 mei 2023

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Appendix A: Testing procedures

Testing procedure MRSA & MRSP

Before taking samples, contact a laboratory where the samples can be sent, cultured and read.

MRSA

Surfaces

Use one electrostatic cloth per surface to take a wipe samples with a gloved hand. Take 10 samples from ten different surfaces. Change gloves between each sample taken. After sampling put the cloth in a sterile bag and eventually add enrichment broth, incubate for 24h at 35 °C. Inoculate 10 µL of the solution onto an MRSA Chromogenic agar and incubate for another 24 – 48h before quantifying the colonies.

Air sampling

Use three air samplers (for example AirPort MD8, Sartorius Stedim Biotech, Denmark). Change gloves between each sample taken. Place a sterile filter cartridge in the sampler and hang it somewhere in the clinic. Let 750l (air flow 50l/min = 15 min period) flow through the sampler. Cover the filter with protective lid and put it in a plastic bag. Send the air filter to the laboratory, where the filters will be directly transferred onto the selective Brilliance MRSA 2 agar plate and incubated at 37°C for 18-24 hours. Afterwards, the colonies will be counted.

MRSP

Surfaces

Use one electrostatic cloth per surface to take a wipe samples with a gloved hand. Take 10 samples from ten different surfaces.. Change gloves between each sampling. After sampling put the cloth in a sterile bag and eventually add enrichment broth, incubate for 24h at 35 °C. Inoculate 10 µL of the solution onto an Mannitol Salt agar with 2g/mL oxacillin and incubate for another 24 – 48h before quantifying the colonies.

Testing procedure hygiene (TVC and Enterobacteriaceae)

These samples should be taken after cleaning.

TVC

Use dip slides with non-selective agar plates for aerobic Total Viable Count. Use ten dip slides to take samples by holding the agar plate surface against the sampled surface for five seconds. Do that for 10 different surfaces, for example: door handles, sink handles, kitchen counter, waiting room (chairs), sink handles, laboratory counter, etc. Incubate the dip slides at the veterinary clinic if possible or incubate them at the another laboratory. Count the number of CFU and / or log-transform them to compare them with the critical limit value.

Enterobacteriaceae

Use dip slides with Chromocult coliform agars for *Enterobacteriaceae*. Use 10 dip slides to take 10 samples by holding the agar plate surface against the sampled surface for five seconds. Do that for ten different surfaces, for example: door handles, sink handles, kitchen counter, waiting room (chairs), sink handles, lab

counter, etc. Use the dip slides to incubate at the veterinary clinic if possible or incubate them at the occupational hygienists laboratory if present. Count the number of CFU and / or log-transform them to compare them with the critical limit value.

Appendix B: Literature research - used search terms combinations

Table B.1: Search terms used in the literature research

Search engine	Search term	Number of outcomes	Remarks
PubMed	(needlestick) AND (injuries) AND (epidemiology) AND (health care) AND (europe)	143	
	(leptospirosis) AND (epidemiology) AND (netherlands)	88	
	(mrsa) AND (farm) AND (netherlands) AND (epidemiology)	45	
	(mrsa) AND (farm) AND (netherlands) AND (epidemiology)	2	Articles from 2019
	(mrsa) AND (agar plate) AND (testing) AND (environment)	36	
	(mrsa) AND (air) AND (sampling)	109	
	(Brilliance 2) AND (mrsa)	16	
	(Aerobic bacteria) AND (hygiene) AND (sample) AND (europe)	26	
	(haccp) AND (pharma)	4	
	(haccp) AND (cosmetics)	2	
	(HACCP)	5	Filter: systematic review
	(HACCP)	14	Filter randomized controlled trial
	(haccp) AND (veterinary clinic)	4	
	(haccp) AND (veterinary clinic)	1	Filter: systematic review
	(cat scratch) OR (cat bite) AND (veterinarian)	22	Articles from 2015
	(cat scratch) OR (cat bite) AND (veterinarian)	69	
	(dog bite) AND (veterinarian) AND (incident)	61	
	(lyme disease) AND (occupational risk) AND (veterinarian)	4	
	(vector-borne disease) AND (occupational risk) AND (veterinarian)	25	
	(Veterinarian) AND (tick) AND (risk)	86	Articles from 2010
	(vector) AND (bite) AND (veterinarian)		
	(veterinarian) AND (tick) AND (risk)	108	
	(borrelia burgdorferi) AND (veterinarian) AND (europe)	21	

Search engine	Search term	Number of outcomes	Remarks
	(zoonoses) AND (veterinarian) AND (occupational risk)	140	
	(mrsp) AND (veterinary practice) OR (veterinary clinic) AND (mrsa) AND (prevalence)	197	
	(mrsp) AND (veterinary clinic) AND (environment prevalence)	19	
	(vets) AND (mrsa)	4	
	(no of deaths) AND (amr) AND (2050)	6	Articles from 2022
	(mrsp) AND (environmental cleaning)	9	
	(mrsp) AND (environmental cleaning) AND (veterinary clinic)	5	
	(decreasing bite incidence) AND (veterinarian) AND (veterinary)	4	
	(hygiene testing) AND (Enterobacteriaceae count) AND (surface)	62	
	(testing after cleaning) AND (hygiene) AND (farm)	26	
	(testing after cleaning) AND (hygiene) AND (broiler)	5	
	(broiler) AND (hygiene) AND (testing)	161	
	(ESBL) AND (farmer)	54	
	(needlestick injuries) AND (farmer)	6	
	(farmer) AND (avian influenza)	13	Filter: review
	(farmer) AND (hepatitis E)	56	
	(farmer) AND (q-fever)	133	
	(farmer) AND (ecthyma)	29	
	(farmer) AND (ringworm)	52	
	(needlestick injuries) AND (veterinary)	49	
Google scholar	Bijtincidenten Nederland	77	
	haccp pharmaceutical industry	2	All in title
	haccp cosmetic	8	All in title

Appendix C: Interview reports

Drs. Yvette de Geus

Drs. Yvette de Geus worked in a veterinary practice as a veterinarian and works currently as PhD candidate and lecturer at Institute for Risk Assessment Sciences (IRAS), faculty of veterinary medicine, Utrecht University, Utrecht, the Netherlands. Her husband has his own company (Plant research), for which Yvette de Geus has made a risk assessment and evaluation (RIE) in the past. What she found most surprising during this process was the fact that there were clear risks and guidelines described for both physical and chemical agents, but not for biological agents specifically.

She finds it always surprising how nonchalant veterinarians are when it comes to biological agents. She says that she was the one who established the hygiene protocols for quarantine units in the veterinary clinic where she worked. Lots of veterinary clinics do not use the right hygiene protocols. The same is true for protocols as what to do after an employee is bitten. There should be clear protocols on wound hygiene for example. When there are no standard protocols how to deal with biological agents, experts should make them based on research and their own knowledge and experience.

Every veterinary care clinic in the Netherlands is by law obliged to make a risk assessment and evaluation (RIE) based on working conditions legislation (Arbeidsomstandighedenwet or Arbo-wet). Yvette de Geus claims that it would help to point out to the veterinary clinics the fact that making a RIE is legally required and that it helps managing the risk. As there are more and more chain companies in the Netherlands owning veterinary practices, it could be helpful for an occupational hygienist to evaluate the RIE together with the person responsible for the RIE. There is development on this topic in the Netherlands. Now there are clear guidelines for health care workers how to treat an animal-originated wound. Yvette de Geus is not familiar with the relevant data on exposure. She says that for that one would need to get an impression of the number of patients visiting a clinic and using a triage method put them in different risk categories. What Yvette de Geus finds important is the fact that the antimicrobial resistance is increasing and she sees this as one of the most important biological agents, for some of which it is easy to test.

For the prevention of infectious agents in general there need to be good hygiene measures taken. This is also simple to test with dipslides as a proxy for fecal contamination with possibly zoonotic pathogens as *E.coli* O157H7, *Salmonella* spp., *Campylobacter* spp. And *Giardia* Spp. Ideally, there would need to be done baseline / reference research first, for example testing certain surfaces with dipslides or leptostatic dust collectors in different clinics on the amounts of *Enterobacteriaceae* and aerobic colonies. Veterinary clinics will not be as clean as slaughterhouses, that is not feasible, but maybe as clean as stables. For broilers there are also hygiene measures taken when the stables are empty and are tested for the cleanliness. Yvette de Geus suggests this as a possible reference for veterinary practices.

Yvette de Geus underlines the fact that the clinics themselves need to have good protocols as to quarantine measures, hand hygiene and general hygiene. This could be a baseline / reference point to which occupational hygienists can refer

when monitoring or evaluating the biological health risks. Yvette de Geus gives a specific example of a separate waiting area for possibly infectious animals.

Dr. Remko Houba

Remko Houba is an occupational hygienist, who works at the Dutch Expertise Centre for Occupational Respiratory Disorders (NECORD/NKAL) and Institute for Risk Assessment Sciences (IRAS). He does research on biological agents, mainly on allergens. In the past he did research on endotoxins and infectious diseases in occupational setting. Remko Houba is also a part of the Dutch Health Council of the Netherlands, for which he advises on vaccinations for workers at different occupations. In order to give advice the Dutch Health Council considers both occupational risks for employees and the risks of spreading the disease by the employees. Remko Houba has also experience with extrinsic allergic alveolitis within NKAL. As part of a ZONMW research project, patients with extrinsic allergic alveolitis are investigated with the aim to identify the likely causative agents – fungi. He referred to and shared the publication.

Remko Houba indicated that the knowledge of occupational hygienists on (health risks due to) biological agents is often lacking and detailed expert knowledge is needed. In order to help occupational hygienists evaluate risks in occupational settings he and his colleagues created around 10 years ago an excel tool meant for risk analysis called "blueprint biological agents". Occupational hygienists would have to fill out the excel sheets based on literature research and expert judgement, in order to evaluate the risk.

Remko Houba thinks that for risk management there are several steps needed, some of which are performing a risk analysis, use of protective equipment and eventually optimal behaviour of employees (for example following protocols). For following protocols by employees, awareness of the hazards and risks is needed. He says though that people get used to their occupation, how they work and the circumstances under which they work, and as a result won't be able to see the risks they face on a daily basis anymore. Remko Houba gives an example of slaughterhouse employees walking into the kitchen still wearing their aprons covered with blood.

Biological agents vary in time and per occupation. What is lacking for a proper risk assessment in the field by occupational hygienists, is a list with biological agents per occupation, which is now only known for high-risk occupations.

What Remko Houba underlines is the fact that probably most of the infectious zoonotic diseases are not occupational. RIVM brings out monthly a document with cases of different zoonotic diseases. Remko Houba screens the document every month looking for abnormalities and occupationally related items.

Occupational hygienists can assess different risks for an occupation. Health risks due to biological agents are difficult to assess in comparison with other occupational risks, as data on dose-response and exposure for these risks are scarce. This is the reason why biological agents are usually omitted by occupational hygienists in general occupational health care. Occupational hygienists have to be asked for help dealing with this type of risks by the company itself. The surveillance of hazards at workplaces is done by labour inspectors. In the Netherlands the probability that a

company will get an inspection is which biological agents at the workplace are evaluated is estimated to be once in 25 years.

Dr. Boyd R. Berends

Boyd Berends works as a university professor at the Institute for Risk Assessment Sciences (IRAS), faculty of veterinary medicine, Utrecht University, Utrecht, the Netherlands. He has been working on biological agents at veterinary workplaces since the 1990's. Boyd Berends has developed risk assessments and evaluations (RIE) for veterinary clinics and petting zoos and teaches occupational safety and health at the faculty of veterinary medicine.

Boyd Berends suggests many articles as possible references and made them available for this article. In these articles the preventive measures at veterinary clinics are thoroughly evaluated. According to scientific literature a substantial fraction of the veterinarians do not follow hygiene and biosecurity protocols. Over the years veterinary clinics do not seem to improve their RIE as well. This could be a base for practical guidelines.

Boyd Berends believes that preventive medicine or applying the precautionary principle is of importance when it comes to biological agents at different workplaces. It would decrease the risk to follow protocols. Every veterinary clinic should have good biosecurity and hygiene protocols at their facilities and these protocols should always be followed by personnel.

When it comes to general hygiene, using dipslides to test for TVC and *Enterobacteriaceae* is advised by Boyd Berends. He says that the cut-off value should be different for each sampled area. On the operation and treatment tables, the recovery kennels should no *Enterobacteriaceae* be present. If there are *Enterobacteriaceae* at a treatment table for example, it means that there are extended spectrum beta-lactamase producing bacteria (ESBLs), *Salmonella*'s and many other pathogens which can be dangerous especially to YOPIs (think of puppies or sick animals needing treatment). All the samples should be taken after cleaning of the work area, because the number of pathogens will most probably increase throughout the day. Using cleaning and disinfection protocols, like cleaning the treatment table after each patient, helps to keep the number of pathogens low.

Dr. ir. Inge M. Wouters

Inge Wouters is assistant professor environmental epidemiology at Institute for Risk Assessment Sciences (IRAS), faculty of veterinary medicine at Utrecht University, Utrecht, the Netherlands. She is involved in research concerning exposure to biological agents (endotoxins, fungi, cell wall products, allergens), the health impact of biological agents and microbial diversity.

Inge Wouters says that regularly monitoring of biological agents is indeed sparse at workplaces as there are no formal regulations and knowledge on e.g. dose-response relationship is scarce. She knows that there are publications in which evaluation of transfer of biological agents in hospital environment have been evaluated, there are Danish publications on presence of biological agents in the work environment and an article on hygiene/ biological agents in a truck cabin.

The expert says that the goal is to create awareness both with employers and employees on biological agents. This is quite problematic as health effects are mostly not acute, thus a direct association between exposure and health is not observed. Regarding veterinarians, a recent student survey showed that veterinarians do not follow strict hygiene protocols and in some sectors there are no working protocols concerning prevention of health issues due to biological agents. Also in the agricultural sector, there is a need for increased awareness. Arable farmers for example do have high dust exposures and apply little prevention measures, whereas exposure to inhaled dust most probably results in long-term health effects.

Inge Wouters says that in veterinary settings general hygiene measures are applicable if it comes to prevention of health issues due to biological agents. Using dipslides in veterinary clinics can be an easy method to raise attention and awareness at the site, because a lot of clinics already have an incubator in house. She recommends searching for experimental (animal) studies for the agents of interest on dosis-response relationships and articles on prevention of infection in hospitals. She says that if there is a survey done amongst employees, the goal of the survey need to be clear, and the survey adapted to this. What is it you would like to achieve with the survey.

Concluding, Inge Wouters finds that awareness is missing amongst both employers and employees. This is why risk communication on biological agents is very important. The main question is to find ways to bring the message across to people which can convince them that biological agents at different occupations need attention.