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Preventive Behaviour to Avoid **Animal-Transmitted Diseases**

Literature review for behavioural determinants and interventions in a leisure context

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R. Wuyts et al.

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Synopsis

Preventive Behaviour to Avoid Animal-Transmitted Diseases

Literature review for behavioural determinants and interventions in a leisure context

Infectious diseases that can be transmitted from animals to humans are a risk to public health. These diseases include Lyme disease, which is transmitted through ticks, and rabies, which is transmitted by infected animals through scratches or bites. People may get these infections during leisure activities, for example in the woods, at home or on outings.

People can do various things to avoid getting an infection, such as wearing protective clothing, using an insect repellent or getting vaccinated against rabies before they travel to certain countries. This is called ‘preventive behaviour’. To find out what can help people to engage in preventive behaviour, it is important to have an insight into what motivates or demotivates them. RIVM has conducted a review of the scientific literature to assess the current state of knowledge about this.

It appears that people who take preventive actions are generally more knowledgeable about infectious diseases than people who do so less often. They are more aware of what they can do to avoid infection. In addition, they experience a greater sense of risk: they believe the risk of infection is higher, or that an infection can lead to serious illness. Furthermore, they are more likely to expect that preventive actions are effective when it comes to avoiding infection and are more confident that they are capable of carrying out such actions successfully (feasibility). Lastly, it is notable that women are more likely to engage in preventive behaviour than men.

People can be helped to engage in preventive behaviour in a variety of ways. Providing them with more knowledge, for example through education or information leaflets, appears to be effective and is already common practice. However, other factors also appear to play an important role, such as the feasibility of behaviour. This can be increased by making actions easier to carry out. For instance, providing soap and water in areas where people are required to wash their hands will make people more likely to do so. It is also important to assess whether interventions work in practice.

The literature review shows that researchers have so far mainly focused on preventive behaviour to avoid diseases transmitted by ticks and mosquitos. Less attention has been paid to behaviour to avoid diseases transmitted through surface water, birds or mammals.

Keywords: zoonoses, infectious diseases, preventive behaviour, determinants, interventions, leisure

Publiekssamenvatting

Preventief Gedrag bij door Dieren Overdraagbare Infectieziekten

Literatuuronderzoek naar gedragsdeterminanten en interventies in de recreatiecontext

Infectieziekten die van dieren op mensen worden overgedragen zijn een risico voor de volksgezondheid. Denk aan de ziekte van Lyme, die via teken wordt overgedragen of aan hondsdolheid, dat wordt overgedragen als een besmet dier iemand bijt of krabt. Mensen kunnen dit soort infecties krijgen als ze aan het recreëren zijn, bijvoorbeeld in het bos, als ze thuis zijn of op reis.

Mensen kunnen verschillende dingen doen om een infectie te voorkomen. Voorbeelden zijn beschermende kleding dragen, een insectwerend middel gebruiken of zich tegen hondsdolheid laten vaccineren bij reizen naar bepaalde gebieden. Dat heet preventief gedrag. Om te weten wat mensen helpt om dit gedrag uit te voeren, is het belangrijk inzicht te hebben wat hen daartoe wel of niet motiveert. Het RIVM heeft onderzocht wat hierover bekend is in de wetenschappelijke literatuur.

Het blijkt dat mensen die preventieve acties nemen over het algemeen meer kennis hebben over infectieziekten dan mensen die dat minder vaak doen. Ze weten beter wat ze kunnen doen om een infectie te voorkomen. Ze verwachten vaker dat de acties goed werken om een infectie te voorkomen. Ook ervaren ze meer risico: ze denken dat de kans groter is om de ziekte te krijgen of dat ze er heel ziek van kunnen worden. Bovendien hebben ze vaker meer vertrouwen dat ze deze acties kunnen uitvoeren (haalbaarheid). Tot slot valt op dat vrouwen vaker preventief gedrag vertonen dan mannen.

Mensen kunnen op verschillende manieren worden geholpen om preventief gedrag uit te voeren. Zorgen voor meer kennis, bijvoorbeeld via onderwijs of informatiefolders, lijkt te werken en wordt al veel gedaan. Andere zaken blijken ook belangrijk te zijn, zoals de haalbaarheid van gedrag. Deze kan worden vergroot door acties makkelijker te maken. Door bijvoorbeeld water en zeep te plaatsen op plekken waar mensen hun handen moeten wassen, gaan mensen dat vaker doen. Verder is het belangrijk te evalueren of interventies in de praktijk werken.

De literatuurstudie laat zien dat er vooral onderzoek is gedaan naar preventief gedrag bij ziektes die door teken en muggen overdraagbaar zijn. Minder aandacht is er voor gedrag bij ziektes die worden overgedragen via oppervlaktewater, vogels of zoogdieren.

Kernwoorden: zoönosen, infectieziekten, preventief gedrag, determinanten, interventies, recreatie

Contents

Summary

Background and aim

This report covers zoonoses and other infectious diseases that can be transmitted by animals. Zoonoses are infectious diseases that vertebrate animals can transmit to humans, if those animals are carrying the disease. Examples include rabies, which is transmissible through a bite or scratch from an infected animal, or leptospirosis, which is transmissible through rat urine in surface water found in open bathing water. Ticks and mosquitoes can transmit various other infectious diseases, such as Lyme's disease, malaria and dengue fever. These diseases pose a major risk to human health, since an estimated 61% of all known infectious diseases originate from animals. Human behaviour plays a key role in preventing the transmission of infections. Examples include wearing protective clothing, vaccinating, seeking advice, or avoiding high-risk areas. Insight into factors associated with this behaviour is needed in order to design effective interventions. Knowledge about which interventions are effective offers direct tools for formulating policy.

In this report, we specifically focus on animal-transmitted infectious diseases that Dutch people could encounter during leisure activities in the Netherlands and abroad. We offer an answer to two questions: 1) Which factors are associated with behaviour that prevents transmission of these infectious diseases? 2) Which effective interventions that support these preventive behaviours are described in the literature? Based on the questions to these questions, we formulate a number of immediate policy considerations. This report also identifies knowledge gaps and opportunities for future research.

Method

Based on literature review, we offer an overview of what is currently known in behavioural science literature about preventive behaviour in relation to infectious diseases that can be transmitted by animals. We use a scoping review for that purpose. Included literature covers 1) preventive behaviour during leisure activities in the Netherlands and abroad, 2) by Dutch people or people with a comparable cultural background, and 3) regarding diseases that Dutch people could currently potentially encounter or that could form a potential threat in the future.

Key findings

There are a number of factors (determinants) that play a role in most preventive behaviours for the various infectious diseases in the context of leisure activities. People who display more preventive behaviour generally also know more about the infectious disease and possible preventive measures and have a higher risk perception. They expect the preventive behaviour to be effective. The feasibility of behaviour also plays a role: they have more confidence in their own ability to perform the behaviour. Moreover, preventive behaviours are often concurrent: people who are more inclined to adopt one precautionary measure are

also more inclined to adopt another. It is also notable that women are more likely to exhibit preventive behaviour than men.

Limited research is available so far on interventions to support this preventive behaviour. Interventions that use educational elements generally seem to work. This is in line with the finding that knowledge is a significant determinant of preventive behaviour.

Knowledge gaps and opportunities for future research

This literature review shows which behaviours from the official guidelines for prevention of animal-transmitted diseases in the context of leisure activities have been researched and where knowledge gaps exist. Much of the research on preventive behaviour has focused on infectious diseases that are transmitted by ticks or mosquitoes. It primarily covers tick checks, protective clothing and the use of insect or tick repellents. However, factors that influence correct tick removal or follow-up checks of a tick bite have hardly been investigated. For mosquitoes, there is a particular lack of studies on specific guidelines for Zika in the context of pregnancy.

There has been even less research on preventive behaviour for infectious diseases that can be transmitted by mammals or birds and infectious diseases that can be transmitted through surface water. Limited research on preventive behaviour is available for infectious diseases that can be transmitted by mammals, such as rabies and Q fever; the research that is available primarily covers travel advice and vaccination. Much less research has been done on behaviour after a possible infection. There is only one study on infectious diseases that can be transmitted by birds, but it covers a mixture of preventive measures, so concrete conclusions are not reached. The studies that were found about infectious diseases that are transmitted through surface water focus on staying out of the water if there is an alert about water quality, and not ingesting surface water. Other guidelines, such as specific hygiene measures, have not yet been investigated. More research is needed on under-researched and unstudied preventive behaviours.

Additionally, there are further opportunities for interventions. Most of the interventions found here focus on increasing knowledge; however, since they combine multiple educational elements, it is unclear exactly which elements are effective. We did not find much intervention research focusing on other important behavioural determinants that became apparent from the current literature review, such as feasibility of preventive behaviour.

Considerations for policy and future research

- **Increasing knowledge works:** People who know more about animal-transmitted diseases in a leisure context exhibit more preventive behaviour. It is therefore useful to focus on increasing knowledge. This goes beyond knowledge about the disease itself, such as how it is transmitted and what the risks are. It also helps if people know more about the preferred behaviour, e.g. how

effective that behaviour is in preventing diseases and how they should perform the behaviour.

- **Also make it easy to do:** To promote preventive behaviour in the entire target group, solely increasing knowledge will not suffice. Feasibility of behaviour also plays a role. People who have more confidence that they can perform the behaviour are also more likely to exhibit that behaviour. This aspect can be addressed by making it easier and more feasible to perform specific behaviours, e.g. by providing access to hand-washing facilities or lowering the price of vaccinations.
- **Take the context into account:** Which specific factors play a role vary according to the behaviour and context. Interventions should therefore be developed on the basis of the knowledge available about the context and the specific target group. If this knowledge is not available, it would be useful to conduct additional research.
- **Evaluate interventions:** Relatively few studies have investigated the effectiveness of behavioural interventions. Evaluating interventions is essential in order to gain insights into effectiveness in actual practice as well as which elements had an impact. That knowledge helps in adapting interventions and deploying new (and more effective) interventions.
- **Monitor actual behaviour:** Based on current data on compliance with recommended behaviours, interventions can be deployed in a more focused way in contexts and target groups where they will be most effective. It is therefore useful to conduct systematic monitoring of key behaviours and influencing factors among the population of the Netherlands. The infrastructure of the RIVM Pandemic Preparedness & Behaviour survey-based monitor offers options for this as needed.

1 Introduction

1.1 Background and aim

This report covers zoonoses and other infectious diseases that can be transmitted by animals. Zoonoses are infectious diseases that vertebrate animals can transmit to humans, if those animals are carrying the disease. Examples include rabies, which is transmissible through a bite or scratch from an infected animal, or leptospirosis, which is transmissible through rat urine in surface water found in open bathing water. Ticks and mosquitoes can transmit various other infectious diseases, such as Lyme's disease, malaria and dengue fever. These diseases pose a major risk to human health, since an estimated 61% of all known infectious diseases originate from animals.(1-4) To prevent transmission, and thus to prevent infectious diseases from spreading, it is essential for people to take preventive measures. In this report, we offer an overview of what is currently known in behavioural science literature about preventive behaviour in relation to zoonoses and other infectious diseases in which animals play a role. More specifically, we offer an overview of the factors associated with preventive behaviour and the interventions that support such behaviour.

Insight into factors associated with behaviour is needed in order to design effective policy interventions. This includes barriers to and motivators of behaviour, as well as demographic characteristics. These insights can be used to target interventions to specific groups. Knowledge about which interventions are effective offers direct tools for formulating policy. This report reinforces and expands the knowledge base in the field of behaviour and perception regarding infectious diseases, while simultaneously identifying knowledge gaps and opportunities for future research.

1.2 Scope and research questions

In this literature review, we specifically focus on animal-transmitted infectious diseases that Dutch people could encounter during leisure activities in the Netherlands and abroad. Infectious diseases that are not related to the context of leisure activities are outside the scope of this study. This means that we will not be looking at situations within the home, such as infectious diseases that could be transmitted by pets or are related to kitchen hygiene. Similarly, we will not be looking at work-related exposure to animal-transmitted infectious diseases, such as livestock farming or forestry. Finally, we will also not be looking at studies about COVID.

In this literature review, we will be focusing on infectious diseases that occur in the Netherlands, such as Lyme disease, Q fever and bird flu. However, we will also include infectious diseases that do not currently occur in the Netherlands, or are rare in this region, but could potentially pose a threat in the future, such as dengue fever and West Nile virus. We will also be looking at infectious diseases that Dutch travellers could encounter, such as malaria and rabies.

Within the scope as defined above, we formulated two research questions:

1) Which factors are associated with behaviour that prevents transmission of these infectious diseases? This question is about what characteristics are present in people who do or do not exhibit this preventive behaviour.
2) Which effective interventions that support these preventive behaviours are described in the literature? This question is about what can effectively be done to support people in exhibiting preventive behaviour.

1.3 Reading guide

The results have been structured into five sections based on the main sources of transmission: tick-borne infectious diseases (3.2), mosquito-borne infectious diseases (3.3), infectious diseases transmitted by mammals (3.4), infectious diseases transmitted by birds (3.5) and infectious diseases transmitted through surface water (3.6). Each section starts by presenting the key findings: an overview of the determinants found in at least two studies, the interventions that were found, and the knowledge gaps. Then a brief description is provided of the official guidelines for preventing the specific infectious diseases that are the main focus of that section. Finally, the results from the literature review regarding determinants and interventions are discussed in more detail.

2 Methods

For this literature review, we searched in three databases (Embase, PubMed and PsycINFO) between 29 and 31 July 2024 using search queries related to zoonoses, other infectious diseases that can be transmitted by animals, and behaviour (see Appendix 1 for the search queries). The search results from the different databases were compiled in EndNote and any redundancies were removed. ASReview, an open source AI tool that helps to identify relevant articles more quickly(5), was used to screen titles and abstracts. Two researchers assessed the relevance of the titles and abstracts, working independently from each other. In the event of discrepancy or doubts regarding the suitability of an article, they consulted to reach consensus. If they were unable to decide, they presented it to the other researchers. If it still remained unclear, they included the article in the next step and skimmed through the full text.

The following **inclusion criteria** were used:

- Language: English, Dutch;
- Type of study: published in peer-reviewed journals;
- Topic: determinants of behaviour and/or behavioural intervention in conjunction with zoonosis or other animal-transmitted infectious disease, contact with animals, water. No COVID studies, no prevalence studies, no pets (but including contact with street cats or dogs while travelling), no work-related contact;
- Participants: People from the Netherlands or from culturally comparable Western countries (Europe, USA, Canada, Australia, New Zealand). This could cover the general population and/or specific sub-groups, such as children, older people or travellers;
- Context: Zoonoses and other animal-transmitted infectious diseases
    - that Dutch people could encounter during leisure activities outside the home;
    - in a travel context, where Dutch travellers could encounter them;
    - that are currently absent or rare in the Netherlands, but pose a potential future threat, such as dengue fever and West Nile virus;
- Scope of outcome: Individual behaviour or behavioural intention.

Since a large number of articles remained after screening the titles and abstracts (N=294), we decided only to include articles from the last 20 years (N=252). A single researcher then skimmed the full text of each of these articles and assessed them for suitability according to the same criteria. If there were doubts, the researcher discussed the article with the team. Additional relevant articles that we came across while screening the articles were also skimmed. Two more articles were added in this way.(6, 7) Individual studies that had also already been included in a review were excluded to avoid overlap. In one case, the individual studies were included and the review was excluded due to quality

considerations. See the flowchart in Appendix 2 for detailed information about the selection process.

Since this is an exploratory literature review, we used a scoping review method. This means that we conducted a wide-ranging search for relevant studies and that the quality of the studies included here was not subjected to systematic assessment. Where relevant, we do discuss the quality of the studies in the context of the results.
In line with the exploratory nature of this review, we included research on behavioural intentions as well as actual behaviour. This made it possible for us to achieve a broader perspective on the factors that play a role in behavioural change. No strict differentiation is made in this report, unless explicitly stated.

3 Results

3.1 Characteristics of the articles

The initial search produced 2,989 articles. We ultimately included 59 of those articles (2%) that examined various infectious diseases, such as tick-borne encephalitis, Lyme disease, malaria, West Nile virus, dengue fever, rabies and Q fever. For studies that group different infectious diseases into categories (such as tick-borne or mosquito-borne infectious diseases or infectious diseases related to travel), we also maintain the same categories in this literature review.

52 of the included articles are about determinants of behaviour or intention of behaviour, of which 31 are about tick-borne infectious diseases, 13 about mosquito-borne infectious diseases (including three reviews), five about infectious diseases transmitted by mammals, one about infectious diseases transmitted by birds, and two about infectious diseases transmitted through surface water. Nine articles discuss interventions to promote preventive behaviour regarding infectious diseases, of which six are about tick-borne infectious diseases (three reviews), one about mosquito-borne infectious diseases, and two about infectious diseases transmitted by mammals (including one review). We did not find any intervention studies about infectious diseases transmitted by birds or infectious diseases transmitted through surface water. Two of the nine intervention studies also discuss determinants. See Appendix 2 for the flowchart of the selection process.

Participants from the included studies came from the USA (n=17), the Netherlands (n=9), Canada (n=2), Germany (n=1), Finland (n=2), France (n=2), Greece (n=1), Italy (n=2), Poland (n=2), the UK (n=1), Sweden (n=2), Switzerland (n=1) and various other countries combined (n=12). The studies that were included primarily focused on the general population, travellers or students.

3.2 Tick-borne infectious diseases

Ticks are found all over the country in green spaces such as forests, parks, heaths and dunes, but also in gardens, especially in tall grass and between dead leaves and near trees and shrubs. Most ticks are picked up while walking or working in the garden.(8) The main disease spread by ticks in the Netherlands is Lyme disease (1 in 5 ticks are infected). Tick-borne encephalitis is much less common here (1 in 1500 ticks are infected).(9, 10)

3.2.1 Key findings

Determinants

- People who **check for ticks** on their body more often after doing leisure activities in green spaces are more likely to be women and less well educated. They also generally have more knowledge about preventive behaviour or the infectious disease and a higher risk perception. They have more confidence in their own ability to perform the behaviour, are more likely to have had

previous experience with tick bites or Lyme disease, and are also more likely to take other preventive measures.
- People who take more **showers** or baths after spending time outside the home are more likely to be women.
- People who wear **protective clothing** to ward off ticks more often are generally older than 50–55 years, more likely to be women, have more knowledge, have a higher risk perception, and/or find this measure more effective.
- Conversely, people who **wear protective clothing less often** are more likely to have negative opinions or attitudes about this type of protection.
- **Tick repellent** is used more often by women, people who have a higher risk perception, and/or have more confidence in the effectiveness of this preventive measure.
- People with higher incomes are **less likely to use tick repellent**.

Interventions
- Educational interventions usually lead to more preventive behaviour in adults. Further research is needed to gain a better understanding of exactly which elements in these interventions are effective.
- Among Dutch children, an educational video game or information leaflet did not lead to more frequent tick checks, but an educational session in the classroom did.
- In the short term (but not in the long term), an app to track tick bites resulted in a higher intention to perform preventive behaviours.
- A vaccination consultation at the pharmacy led to an increase in vaccinations against tick-borne encephalitis.

Knowledge gaps
- We did not find any behavioural research about factors that influence correct removal of ticks, bite care, or monitoring the bite.

3.2.2 Official guidelines

Official guidelines are almost identical for Lyme disease and for tick-borne encephalitis, except that a preventive vaccination is available for tick-borne encephalitis before travelling to regions where these infected ticks are common.

Recommended measures include:
- Wear clothing with long sleeves and long trousers (and tuck trouser legs into socks), and wear closed shoes when visiting areas where ticks may be present.(11)
- The same day, after visiting these areas, check the whole body (but especially the groin, behind the knees, in the armpits, between the buttocks, at the edges of underwear, behind the ears, and along the hairline on the neck) and all clothing for ticks, possibly using a mirror or having a second person help you.(9, 11) The guidelines offer an extra tip: ticks are easier to spot on light-coloured clothing.

- Stay on the paths as much as possible and avoid contact with dense undergrowth, low vegetation, shrubs and the leaf litter on the soil in forests, dunes, heaths, parks and gardens.
- Use tick repellent containing something like DEET.(11) The guidelines emphasise that tick repellents do not offer full protection and that it is necessary to use them in combination with other anti-tick measures. Alternative recommendations for DEET are in place for children and during pregnancy and breastfeeding.

After a tick bite, it is important to remove the tick within 24 hours (and preferably as soon as possible) and treat the wound in the recommended way(11). The tick bite should then be monitored for three months after the bite to check for the emergence of an expanding red spot or ring, which is the most common presentation of Lyme disease. For that reason, it can be useful to note the date and location of the bite. In the event of symptoms that may be related to Lyme disease, the recommendation is to contact a doctor.

3.2.3 Determinants

31 studies investigated determinants of preventive behaviour for tick-borne infectious diseases. These studies focus on specific preventive measures that are also stated in the official guidelines, such as checking for ticks, wearing protective clothing, using tick repellent, and vaccinating, but also measures that are not in the official guidelines, such as showering and avoiding places where ticks are found. The studies show that various determinants are associated with these preventive behaviours: demographic characteristics, access to information and knowledge, risk perception, response efficacy, attitudes, opinions and beliefs, self-efficacy, social norms, previous experiences, and other preventive behaviour. In the following section, we look at each preventive measure and explain how these determinants are associated with behaviour.

Checking for ticks

Twenty studies investigated which factors are associated with checking the body for ticks, after spending leisure time in green areas. In terms of **demographic characteristics**, women are more likely than men to check for ticks.(12, 13) People with a lower education level(14, 15) and office staff (compared to independent contractors or workers) are also more likely to check for ticks.(15) Most studies show that people over 50 or over 65 are less likely to check for ticks.(12, 16, 17) A dissenting study, in contrast, shows that people over 44 are in fact more likely to check for ticks.(13) One possible explanation for the difference may be the different ways in which age groups are bracketed.

There is no clear correlation between living environment and checking for ticks. Most studies show that people who live in an area where ticks are common(15, 17, 18) or who state that it is very likely to find ticks around their home(19) are more likely to check for ticks. People living in rural areas(18) are also more likely to check their children for ticks after leisure activities in green areas, and Dutch children from heavily forested areas (within 10 km around the school) are also more likely to be checked for ticks by their parents.(20) At the same time, some

studies show that people living in urban areas (compared to rural areas) are in fact more likely to check for ticks(15, 21), while other studies do not show any correlation (checking children for ticks).(22)

Having sufficient **knowledge** about ticks, tick-borne diseases and prevention methods turns out to be a key factor in checking for ticks. In general, it is apparent that people who check for ticks more often are also more likely to know about tick-borne diseases(14, 17, 23-26) and prevention methods to ward off ticks(27). Dutch children who have more knowledge about ticks also state that their parents check them for ticks more often.(20) Moreover, people who check for ticks more often are also more likely to feel that they are well informed about ticks or Lyme disease(15, 26). Conversely, Dutch people who feel that they do not have enough information and do not know how to recognise and remove ticks are less likely to check for ticks(24). Dutch people who expect a tick bite to itch, or think that their child would notice a tick bite themselves, are also less likely to check for ticks(28).

The correlation between checking for ticks and knowing about where ticks are present is still unclear. In one of the studies we found, this type of knowledge was not correlated with checking for ticks more often(27), but in two studies it was(26), (28). Two studies do not show any correlation between knowledge and checking their own body(29) (Dutch study) or their child(22) for ticks.

Risk perception is often seen in the literature as a determinant of checking for ticks. People with a higher risk perception are more likely to check for ticks. Specifically, people are more likely to check if they are more concerned or see risks related to: the prevalence of ticks or tick-borne diseases, the chance that they or their child will have a tick bite(12, 14, 19, 26, 27), the severity of transmissible diseases(15, 22-24, 30) (such as Lyme disease)(14, 19, 26), and how susceptible they or their children are to infections(14). Two studies, including one in the Netherlands, do not show any correlation between risk perception (considering Lyme as a severe health risk(29), believing that a tick bite would have serious consequences in their life(26)) and checking for ticks. Dutch people are less likely to check for ticks if they believe that the risk of a tick bite is low for their children(28) or themselves(24) or if they see it as overly cautious to check for ticks after spending time outside(24).

Three studies show a positive correlation between checking for ticks and viewing the measure as effective (**response efficacy**)(17, 23, 25), while one Dutch study does not show any correlation(29).

The **attitude** people have towards ticks and checking for ticks also plays a role. People who are more likely to check for ticks find ticks less disgusting.(26) Dutch children who find it important to be checked for ticks are in fact more likely to be checked for ticks.(20) Dutch people who are less likely to check for ticks believe that tick checks are too time-consuming(26) or simply do not care(28).
People who are more likely to check for ticks also hold the characteristic belief that **their own behaviour influences** whether they will encounter ticks(26) and feel good about themselves if they check for

ticks (Dutch study)(29). People who have more confidence in their own ability to perform the behaviour (**self-efficacy**) are more likely to check for ticks(26, 29). However, the same correlation was not found in checking their child for ticks.(22) Finally, a Dutch study found a positive correlation between checking and the **descriptive social norm**, but a negative correlation with the **injunctive norm**.(29) Injunctive norms are about what people think you should do, such as checking for ticks. Descriptive norms are about what people observe that others actually do.

Finally, **previous experiences** also play a role. People who have had a tick bite before are more likely to check themselves for ticks.(15-17, 24, 29) People are also more likely to check for ticks if they themselves or someone they know (within the family) has a confirmed or suspected diagnosis of Lyme disease(19, 31), or has been treated for Lyme disease(25). However, there may be a difference in checking children for ticks: one study shows no correlation between finding a tick on yourself in the past 6 months and checking your child for ticks.(22)

Showering

Although showering is not included in the official guidelines in the Netherlands, showering or bathing after spending time outside the home can help people to find ticks on the body. This behaviour was investigated in five studies. People who are more likely to shower or bathe after spending time outside are more likely to be **women**(12, 13, 18), are more likely to consider showering effective (**response efficacy**)(25), and are more likely to **believe** that Lyme disease is endemic and that the disease is severe(14). People in the USA who have an **Afro-American background** are also more likely to report that they exhibited this behaviour.(13) Conversely, older people (>65 years) are less likely to shower after spending time outside.(12) **Knowledge** about Lyme disease or previous treatment for a tick-borne disease do not play a role in showering or bathing after spending time outside.(25)

Protective clothing

Thirteen studies[a] looked at determinants of wearing protective clothing, such as clothing in light colours and clothing with long sleeves and/or long trousers (with trouser legs tucked into the socks). Various **demographic factors** were investigated. People who are more likely to wear protective clothing are generally a bit older than 50–55 years.(15-17, 23, 24) Studies on the influence of living environment do not show conclusive evidence of correlation between living in an area where ticks are common or the urbanisation level of an area and wearing protective clothing.(15, 17, 21, 30) Most studies show that women are more likely to wear protective clothing.(13, 15, 31) One study shows no difference between men and women.(21) The studies we found do not offer conclusive evidence of the correlation between educational level or employment status and wearing protective clothing.(15, 24, 31) One study looked at having pets. People with pets are generally more likely to wear long sleeves and tuck their trouser legs into their socks, but are just as likely to wear long trousers as people without pets.(32)

[a] In the study by Septfons et al. (2021), wearing protective clothing was often (also) investigated in combination with checking for and removing ticks. For more details, please see the full text of the article.

Five studies investigated the role of **knowledge**. All except one show a positive correlation between wearing protective clothing more often and having more knowledge: about ticks (NL)(24), about preventive measures(24, 31), about Lyme disease(23, 24, 31), and about tick-borne diseases(17). One study does not show any correlation between more knowledge about Lyme disease and wearing protective clothing.(25) **Feeling well-informed** about Lyme disease also shows a positive correlation with wearing protective clothing.(15)

Five studies looked at **risk perception**. In general, people with a higher risk perception (e.g. very worried about Lyme disease, a possible infection or health consequences) are more likely to wear protective clothing themselves(15, 23, 24, 30) and have their child wear it(22). Dutch people with a low risk perception for tick bites are less likely to wear protective clothing(24). Moreover, people are more likely to wear protective clothing if they view the measure as effective (**response efficacy**).(17, 23-25)

The literature also shows several **opinions or attitudes** that are associated with less frequent use of protective clothing among Dutch people: they consider it over-cautious, feel that wearing protective clothing is too warm in summer(24), or consider it impractical for their child in warm weather(28). Having children wear a hat is also less common among Dutch parents, who expect that their child will take the hat off.(28) One Dutch study compared the practice of wearing protective clothing among outdoor people (people who frequently spend leisure time outside) who check for ticks and outdoor people who do not check for ticks. Outdoor people in the Netherlands who do not check for ticks are less likely to wear protective clothing if they feel that such clothing is uncomfortable or looks stupid.(28) Outdoor people in the Netherlands who do already check for ticks are less likely to wear protective clothing if they do not enjoy wearing it in warm weather, and are more comfortable checking for ticks later rather than wearing protective clothing.(28)

People who have **previous experience** with a tick bite are more likely to wear protective clothing.(15) Previous treatment for a tick-borne infectious disease does not appear to play a role.(25)

Tick repellent

The use of tick repellent was investigated in 15 studies. It is associated with **demographic factors**. Eight studies show a difference between men and women. Women are more likely (12-15, 18, 24, 31)than men(33) to use tick repellent. One study shows no difference.(21) Four studies show a difference in age, but the results are not conclusive. Two studies show that people who are more likely to use tick repellent are also more likely to be over 35 (35–54 years(23); >45 years(13)). Two other studies show that people over 50 are less likely to use tick repellent (>50 years(19); >65 years(12)). People over 45 are less likely to treat their outdoor clothing with tick repellent.(13) People who use tick repellent more often are more likely to have completed a higher education level(31) and are more likely to be Caucasian (compared to people from an Afro-American background in the USA(13)). People with higher incomes are less likely to use tick repellent on themselves(14,

15) or in the garden (natural or chemical pesticide(14)). The literature also shows that tick repellent is used more often by people who live in an urban (compared to rural) setting(21), also on their child(22).

Three studies investigated the role of **knowledge and information**. Knowledge is not conclusively correlated with the use of tick repellent to ward off ticks. Knowing more about ticks and tick-borne diseases is correlated with parents being more likely to use tick repellent on their child.(22) However, another study shows no correlation between knowing more about Lyme disease and using tick repellent on oneself.(25) One Dutch study shows that people who believe that insufficient information is provided about using tick repellents to prevent tick bites are less likely to use them.(24)

Six studies looked at **risk perception**. People are more likely to use tick repellent if they consider the disease more severe, view themselves as more susceptible, are more concerned about the disease and becoming infected themselves(15, 19, 23, 30), and see a higher observed prevalence of the disease(14). People who are more concerned about their health due to tick risks are also more likely to use tick repellent on their child's outdoor clothing.(22)

People who have more confidence in the effectiveness of the measure (**response efficacy**) are also more likely to use tick repellent.(23, 25) Conversely, people who have less confidence in the effectiveness of tick repellent are less likely to use it (NL).(24)

Two Dutch studies looked at the role of **attitude**. They show that people who do not like rubbing tick repellent on their skin are less likely to use it.(24) Similarly, parents who do not want to apply it to their child or their clothing every day because it contains DEET are also less likely to use it.(28) On the other hand, outdoor people who check for tick bites are more likely to use tick repellent if they believe that they would be able to wear shorts as a result.(28)

Previous experiences with ticks sometimes play a role in using tick repellent. People are more likely to use tick repellent on their child if they found a tick on their own body in the past six months.(22) They are more likely to use tick repellent on themselves if they have had one or more tick bites in their life, compared to people who have never had that experience.(15) However, finding a tick in the garden was not correlated to treating their child's outdoor clothing.(22) Similarly, no correlation was found between ever having been treated for a tick-borne disease and the use of tick repellent.(25)

Vaccination

At this time, a vaccine is only available for tick-borne encephalitis. A study on vaccinating against tick-borne encephalitis shows that having accurate **knowledge** about what the vaccine protects against is correlated with being vaccinated.(34) For example, people who correctly believe that the vaccine protects against tick-borne encephalitis, but not against Lyme disease, are more likely to be vaccinated. People who think that erythema migrans (the red spot that can appear on the skin

around a tick bite in a Lyme infection) is a symptom of tick-borne encephalitis are less likely to be vaccinated.(34)

Although there is no human vaccine against Lyme disease, two studies were found that looked at determinants of the intention to be vaccinated against Lyme disease if a vaccine did exist. These studies investigated many determinants. **Demographic characteristics:** Students who intend to get the vaccine are often younger and come from an Asian, Asian-American or South Asia background (compared to Caucasian people or people from Afro-American or Latino backgrounds in the USA).(35)

Regarding the role of **knowledge**, various results were found in different target groups: People from areas where ticks are present, and who assess their own knowledge about Lyme disease as higher, are more likely to intend to be vaccinated against Lyme disease, if a vaccine were available.(14) However, a study among students shows no correlation with knowledge.(35)

The group that would be willing to vaccinate against Lyme disease also has a higher **risk perception** (prevalence, severity, concern, feeling vulnerable) of the disease.(14, 35) They are more likely to believe that the vaccine will ensure they no longer have to worry about an infection, and that their friends and/or family would no longer have to worry about it either.(35)

Students who intend to be vaccinated see lower **response costs for vaccination** (the difficulty involved in getting vaccinated) and have more confidence in its effectiveness (**response efficacy**).(35) Students who hold the **opinion** that vaccines are usually unsafe have a lower intention to be vaccinated if a vaccine against Lyme disease became available.(35)

Students who intend to get the vaccine also have more confidence in their own ability to perform the behaviour (**self-efficacy**).(35) **Previous experiences** also play a role: Although students who have ever had a tick bite have a lower intention to get the vaccine(35), students who have ever had a tick-borne disease have a higher intention.(14)

Avoidance
Avoiding areas where ticks are present or common was investigated in six studies, which show that it is positively correlated with (**demographic characteristics**) being a woman(18), having a pet(32), living in an urban area(18), going to the park several times a week(30), and visiting parks in suburban areas, compared to parks in peripheral areas around cities or in rural areas(30).

Others opt to visit outdoor areas less often. This is more likely to be the case among (**demographic characteristics**) men, people with higher incomes, (**risk perception**) people who believe that the risk of tick bites is higher, (**previous experiences**) saw a tick last summer, and people who have already had a tick-borne disease, or had a household member who did.(32) People who are simultaneously aware of the

exposure risk (**knowledge**) and are also already taking **other preventive measures** are also more likely to visit outdoor areas somewhat less often.(36) Dutch people who hold the **opinion** that children should be able to roam freely outdoors are less likely to avoid areas where ticks are present.(28) No difference was found between people who are or are not vaccinated, or between people from high-risk or emergent-risk areas.(17)

Measures in the garden

Demographic characteristics are correlated with being more likely to use tick prevention measures in the garden, such as keeping grass trimmed short and clearing away dead leaves. People with pets are more likely to take measures in the garden. People who are older than 18–24 years and rent a home (compared to owning a home) are less likely to take tick prevention measures in the garden.(32) Finally, people who have someone in their household who had a tick-borne disease (**previous experience**) are more likely to take tick prevention measures in the garden.(32)

Preventive measures (general)

Sixteen studies did not investigate one specific measure, but looked at measures in general (e.g. “How often do you take preventive measures?”) or looked at measures in combination (e.g. at least one of the three measures). This made it impossible to identify which specific measure was involved. For that reason, we will discuss these studies under the heading of “preventive measures”.

Most studies on **demographic characteristics** show that people who take preventive measures more often are more likely to be women.(16, 17, 36, 37) However, two studies do not show any difference between men and women.(18, 33) No clear correlation with age was identified. While one study shows that people over 55 are more likely to take measures to prevent tick exposure than people aged 18–24 years(15), another study shows that older people are more likely to take preventive measures, but only if they have never had Lyme disease.(38) Two studies show no correlation with age.(33, 36) One study that looked at ethnicity shows that Caucasian people are less likely to take measures to prevent tick exposure than people from an Asian background (in the USA).(32) One study compared areas where ticks are common with areas where they are rare. It showed that unmarried people from areas where ticks are rare are more likely to take preventive measures. This correlation is not found in regions where ticks are common.(39) People living in a rural area (compared to an urban area) are more likely to take measures to prevent ticks around their home (such as mowing grass(18)). One study looked at the role of pets. It only shows a positive correlation between having pets and taking measures to prevent tick exposure in areas where ticks are rare (compared to areas where ticks are common).(39) Whether or not a person is vaccinated against tick-borne encephalitis does not play any role in taking preventive measures.(40)

Four studies looked at the role of **knowledge**. They show that people who are more likely to take measures to prevent tick exposure also know more about Lyme disease(23, 32) and feel better informed about

Lyme disease(15). The fourth study compared people from an area where ticks are common with people from an area where ticks are rare.(39) The results show that people from an area where ticks are common are more likely to take steps to prevent tick exposure if they know how a person can get Lyme disease. This correlation was not found among people from an area where ticks are rare. People from an area where ticks are rare are also more likely to take preventive measures if they regularly read the newspaper (four or more days a week) or know whether a tick repellent contains DEET. These correlations were not found among people from an area where ticks are common.

Eight studies investigated the role of **risk perception**. People who are more likely to take measures to prevent tick exposure generally have a higher risk perception.(17, 23) More specifically, they perceive a perceived risk of tick bites(24, 41), are more likely to be concern about being bitten by ticks(39) and being infected with Lyme disease(15), perceive themselves as more susceptible to a tick bite(32), view the bite or Lyme disease as more severe(24, 41), and perceive a higher risk of getting Lyme disease if they are bitten by a tick(41). Conversely, people who are less likely to take measures to prevent tick exposure are more likely to believe that they have a low risk of infection with Lyme disease, or do not know if they are at risk.(42) Despite this, a study was also found that did not show any correlation with the perceived risk of contracting Lyme disease at some point.(39) One study also shows that people from an area where ticks are rare are more likely to take measures to prevent tick exposure if they view Lyme disease as more severe.(39) This correlation was not found among people from an area where ticks are common. Studies that looked at tick-borne encephalitis separately do not show any correlation with the perceive risk of contracting tick-borne encephalitis from a tick bite, nor with the perceived severity of tick-borne encephalitis.(41)

People are more likely to take preventive measures if they have a greater **sense of responsibility** for their health(24) and if they view the measures as effective (**response efficacy**)(24, 41). Conversely, people are less like to take preventive measures if they are less convinced that the measure is effective.(41)

Six studies investigated the correlation between **previous experiences** and taking preventive measures. People are more likely to take preventive measures if they have had a tick bite before(15, 16, 33, 36) or have recently seen a tick(32). Another study shows this latter correlation in people from areas where ticks are rare, but not in people from areas where ticks are common.(39) Five studies looked at the influence of a person’s history of illness. People who were more likely to take measures to prevent tick exposure were also more likely to have been previously diagnosed with or treated for a tick-borne disease(32, 36), such as Lyme disease(38, 42), and are more likely to have a close friend or family member with a history of tick-borne disease(32, 38). Again, one study confirms this latter correlation in people from areas where ticks are rare, but not in people from areas where ticks are common.(39)

Other preventive behaviour
Adopting one preventive measure is also correlated with adopting another preventive measure. People who are vaccinated against tick-borne encephalitis, for example, are also more likely to check their body for ticks and to use tick repellent.(17)

3.2.4 Interventions

Six of the articles we included describe interventions for promoting preventive behaviour in relation to ticks. Three reviews looked at **educational interventions**, covering a wide range of educational tools. They generally show a positive impact on preventive behaviour in various target groups in the USA, Europe and the UK.(26, 43) Educational methods that were used included videos, video games, information leaflets and packets, interactive workbooks, presentations, one-on-one education, face-to-face sessions in a classroom setting, letters, educational campaigns, and advertising on traditional and social media. There was also a 15-minute live show with public interaction, workshops (e.g. for learning to remove ticks) and free gadgets (e.g. that contain information, offer reminders, or give discounts on tweezers and tick repellent) on a ferry boat. Since so many different elements were grouped together under the heading of ‘educational interventions’ and often used in combination, it is difficult to differentiate which specific elements are effective and to what extent.

A general impression gathered from the reviews is that these educational interventions usually lead to more preventive behaviour in adults. Further research is needed to gain a better understanding of exactly which are effective. There were a few intervention studies that were only conducted among children. The results show that, among Dutch children, an educational video game or informative leaflet did not lead to more frequent tick checks than in the control group.(43, 44) However, an educational session in the classroom did lead children to do a tick check and wear long trousers more often.(43, 44)

Besides the reviews, we also found three separate intervention studies. In France, public information campaigns were launched or intensified to inform the general public about Lyme disease and other tick-borne diseases.(15) This happened as part of a national plan. Regional and national health authorities and patient organisations worked together to raise public awareness of the disease and the importance of effective preventive measures. These campaigns comprise running short ads on radio, distributing leaflets, placing information signs at the entrances to nature reserves, and providing educational materials to care providers about diagnosis, treatment and prevention of the disease. An increase was observed in applying preventive measures, particularly wearing protective clothing, regular tick checks, and removing ticks quickly after exposure.

In the Netherlands, a mobile app called ‘Tekenbeet’ (Tick Bite) was developed that offer information about ticks and Lyme disease, how to check yourself for ticks, and how to correctly remove a tick.(45) The app also offers current data on tick activity in the Netherlands (‘tick radar’) and sends an alert when a specific level of tick activity has been reached. It also has an option to keep records about tick bites and set

reminders to keep checking the skin until several weeks after a bite. In the short term (but not in the long term), the app led to a higher intention to perform preventive behaviours among the group that downloaded the app, compared to the group that did not download the app.(45) However, one advantage of mobile technology is that it is always within easy reach and can be used when needed, which reduces the necessity of a long-term effect, according to the authors.(46)

A study was conducted in Germany to investigate how vaccination consultations at the pharmacy affected vaccination coverage among patients.(47) This included vaccination coverage for tick-borne encephalitis. To promote the consultation, flyers, posters and newspaper advertisements were used and the people working at the pharmacy actively offered it to visitors when they came in. Patients received a detailed consultation in which they were informed about the benefits and possible risks of vaccination. They also were given an overview of their personal vaccination status and a personal advisory report for getting any missing vaccinations from their doctor. At least five weeks after the vaccination consultation, they were asked to re-submit their vaccination details to the pharmacy, or were contacted by phone to review their vaccination status. An increase was observed in vaccination coverage for tick-borne encephalitis (as well as vaccination coverage for diphtheria, tetanus, influenza and pneumococcal disease). However, it could not be confirmed with certainty that the intervention had caused this increase, since the results were not compared with a group of patients who had not had the intervention (control group).

3.3 Mosquito-borne infectious diseases

There are a number of mosquito-borne infectious diseases. Mosquitoes that can transmit diseases can also be found in the Netherlands. However, it is very unlikely. In rare cases, the common mosquito found in the Netherlands can transmit the West Nile virus, and exotic mosquito species such as the Asian tiger mosquito or yellow fever mosquito are occasionally transported to the Netherlands via international transport or travellers. However, the highest risk of mosquito-borne infectious diseases is seen among people who travel to endemic regions where malaria, West Nile virus, dengue fever, Zika, chikungunya, yellow fever, La Crosse encephalitis or Japanese encephalitis are common.

3.3.1 Key findings

Determinants

- Women are more likely than men to **seek advice** about possible infectious diseases at their destination before leaving on a trip.
- People who are more likely to wear **protective clothing** against mosquitoes also know more about mosquito-borne diseases and/or have a higher risk perception.
- **Insect repellent** against mosquitoes is used more often by people younger than 50 years, who know more about mosquito-borne diseases and/or have a higher risk perception.
- People who have a higher risk perception are more likely to **avoid mosquitoes**.

Interventions

- One intervention study shows that an educational programme in a children's classroom did lead to removal of mosquito breeding spots and wearing protective clothing, but not to the use of insect repellent.

Knowledge gaps

- We did not find any behavioural research on specific guidelines for Zika in the context of pregnancy.

3.3.2 Official guidelines

The official guidelines regarding mosquito-borne diseases state that the primary goal is to prevent mosquito bites, e.g. by taking measures to prevent mosquito exposure in regions and at times when the mosquito is active.(48) They also recommend seeking advice from a travel vaccination clinic before a trip.

Recommended anti-mosquito measures include protective clothing (long sleeves, long trousers, socks, closed shoes and a hat or cap, a mosquito net (preferably treated with insect repellent), and rubbing any uncovered skin with insect repellent containing DEET or icaridin (which can also be used to treat clothing, mosquito nets and sleeping bags). Alternative recommendations for DEET and icaridin are in place for children and during pregnancy and breastfeeding. In high-risk areas for malaria, travellers are advised to take prophylactic malaria medication.(49)

There are a few disease-specific guidelines. In the context of Zika, women who are currently pregnant or trying to conceive are advised to avoid endemic areas. In addition, men returning from endemic areas are advised to use a condom during sexual contact with a partner who is currently pregnant or trying to conceive for up to two months after their return, or during any sexual contact if they test positive for the virus. Dengue fever is the only mosquito-borne disease for which a preventive vaccination is available. Whether this vaccine is recommended depends on the destination, trip duration, whether the traveller has had dengue fever before, and other personal characteristics of the traveller. For that reason, it is recommended to seek personalised advice from a travel vaccination clinic before a trip.(50)

3.3.3 Determinants

Thirteen studies investigated determinants of preventive behaviour for mosquito-borne diseases. They focus on specific preventive measures that are also stated in the official guidelines, such as seeking advice (including travel advisories), wearing protective clothing, using a mosquito net, using insect repellent, and vaccinating, but also measures that are not in the official guidelines, such as avoiding places where mosquitoes are found. The studies show that various determinants are associated with these preventive behaviours: demographic characteristics, access to knowledge, awareness of the infectious disease, risk perception, response efficacy, attitudes, self-efficacy, social norms, financial or other barriers, previous experiences and other

preventive behaviour. In the following section, we look at each preventive measure and explain how these determinants are associated with behaviour.

Seeking advice
Two studies show that whether travellers seek advice about any infectious disease risks at their destination before their trip is associated with **demographic characteristics**. Women are more likely to seek advice (students(51)) and men are less likely(52). Among students, a European background (compared to an Asian or Oceanic background) is also associated with seeking advice more often.(51) Travellers with a higher level of education were more likely to seek advice(51), while travellers with a lower education level were less likely to seek advice. Finally, a shorter trip duration, travelling to visit friends or family, and unemployment are correlated with being less likely to seek advice (travellers).(52)

Protective clothing
Two studies about the West Nile virus looked at determinants of wearing protective clothing as a way of warding off mosquitoes. They show no correlation between **demographic characteristics** (gender, income, age, education) and protective clothing.(53) However, one study shows that people who have more **knowledge** about the West Nile virus or the disease are more likely to wear protective clothing.(54) A study about the chikungunya virus also shows that people who are **aware** of this virus are more likely to wear protective clothing.(55) **Risk perception** also plays a role: people who are concerned about the West Nile virus are more likely to wear protective clothing.(53)

Mosquito net
A study among Dutch people who take long trips (for 13 weeks or longer) shows that these travellers are more likely to use a mosquito net when travelling to Africa than when travelling to Asia or Latin America.(56)

Measures around the house
Two studies looked at taking specific measures around the house. Both studies highlight the role of **knowledge**, correlated with removing mosquito breeding spots(7), draining away standing water, and spreading pesticides in Italy (West Nile virus(54)). The removal of mosquito breeding spots around the house is also correlated with believing in **personal responsibility** for this and having more confidence in the ability to perform the behaviour (**self-efficacy**).(7)

Insect repellent
The use of insect repellent was investigated in six studies. A few looked at **demographic characteristics**. People under 50 are more likely to use insect repellent against mosquitoes (West Nile virus).(53) Dutch travellers who are travelling for 24 weeks or longer, or visiting low-endemic countries where malaria is not very common, are less likely to use insect repellent to prevent malaria.(56) The use of insect repellent is positively correlated with **awareness** of the chikungunya virus(55), have **knowledge** about mosquitoes and mosquito-borne viruses(7) and about the West Nile virus and West Nile fever(54). **Risk perception**

also plays a role: people who are concerned about the West Nile virus are more likely to use insect repellent, while concerns about the safety of the repellent itself are correlated with lower use.(53) Moreover, people who have more faith in the effectiveness (**response efficacy**) and **benefits** of preventive measures(7) are more likely to use insect repellent.

Medication
Three studies looked at taking malaria medication (and continuing to do so over time), including such factors as the role of **demographic characteristics**. A study among Dutch travellers shows poor regime compliance in taking malaria medication as prescribed among travellers who are younger and have achieved a higher level of education.(57) A study of people who had a hospital consultation to seek medical travel advice shows no correlation with gender, the purpose of travel, whether malaria is prevalent in the traveller's country of origin, and whether the medication had to be taken once a day or once a week.(58) No conclusive results were found for trip duration and destination.(56-58)

The literature on **risk perception** shows poor regime compliance in taking malaria as prescribed among Dutch travellers who believe that malaria is a low-severity disease. Conversely, side effects (and related anxiety) and self-assessment as less susceptible to malaria are not correlated with taking malaria medication.(57)

Among Dutch travellers, a negative (cognitive) **attitude** or negative thoughts about taking malaria medication is correlated with poor compliance, but no correlation was found with affective attitude, dislike of swallowing pills.(57) Similarly, there is no correlation with perceiving a stronger **social norm** among local peers not to take the medication, or other **barriers**, such as financial barriers or perceived fatigue during the trip.(57)

Vaccination
One study looked at determinants (**demographic characteristics**) of vaccination. The results of this study show that, in an area where the West Nile virus is endemic, people living in a household with family members aged 14 years or younger show lower acceptance of a potential vaccine against West Nile virus.(54)

Avoidance
Two studies about the West Nile virus described determinants of avoidance behaviour (trying to avoid mosquitoes). The literature does not show any correlation between avoidance behaviour and **demographics** (gender, income or age).(53, 54) However, people with more **knowledge** about the virus and the disease are more likely to avoid going outside at dawn and dusk.(54) Avoidance behaviour is also correlated with **risk perception**: people who are concerned about the West Nile virus, believe that there is a probable risk of contracting the West Nile virus, and consider the disease severe are more likely to avoid visiting areas where mosquitoes are found or going outside at times when mosquitoes are active.(53)

Preventive measures (general)
Six studies did not investigate one specific measure, but looked at measures in general (e.g. “How often do you take preventive measures?”) or looked at measures in combination (e.g. at least one of the three measures). This made it impossible to identify which specific measure was involved. For that reason, we will discuss these studies under the heading of “preventive measures”.

Three studies investigated the role of **demographic characteristics**. The results show that women are more likely than men to take preventive measures. This was found in studies about the West Nile virus(53), about dengue fever among travellers(59), and about mosquito-borne diseases among travellers(60). The literature does not offer conclusive evidence about the role played by age (West Nile virus, review).(53)

People who are more likely to take measures to prevent mosquito exposure also **know** more about mosquito-borne diseases(7, 61, 62) and are more likely to be **aware** of the role that mosquitoes play in mosquito-borne diseases(62).

Four studies looked at the role of **risk perception**. People who are more likely to take measures to prevent mosquito exposure are also more likely to be concerned about becoming ill from mosquitoes(7), or about the virus (West Nile virus(53)). They see a higher risk of infection (West Nile virus(53)), see the disease as more severe, and feel more susceptible to it, and have a higher affective reaction (such as fear or anxiety) to their perceived risk (dengue(61)).

Other aspects associated with being more likely to take preventive measures are considering the measures effective (**response efficacy**) and seeing the benefits(61), feeling **responsible** for removing mosquito breeding spots (such as standing water in the garden)(7), higher confidence in personal ability to perform the behaviour (**self-efficacy**) and perceived **support from family** for taking preventive measures(61). Envisioning more **barriers** (unfavourable expected outcomes of preventive behaviour), on the other hand, is correlated with being less likely to take measures to prevent mosquito exposure.(61)

Other preventive behaviour
Adopting one preventive measure is also correlated with adopting another preventive measure. Travellers who exhibit low compliance with preventive measures, such as using malaria medication or a mosquito net, are also less likely to use insect repellent to prevent malaria.(56) Conversely, students who are more likely to seek travel advice (including professional advice) are also more likely to use insect repellent to prevent malaria.(51)

3.3.4 Interventions
One intervention study was found about preventive behaviour related to mosquito-borne diseases. This intervention was implemented at schools in the USA, among children aged 9–11 years, with a pre- and post-intervention measurement and follow-up after four months.(63) The intervention programme consisted of a presentation and a 10-minute

interactive project, based on biology and the CDC programme[b] for mosquito bite prevention. The intervention was effective in promoting removal of standing water (mosquito breeding spot) and wearing protective clothing. The intervention had no effect on the use of insect repellent. It should be noted that 70% of the respondents were already using insect repellent before the intervention.

3.4 Infectious diseases transmitted by mammals

While mosquitoes and ticks can indirectly transmit infectious diseases from mammals to humans, there are also some infectious diseases, such as Q fever, rabies and Ebola, that are transmitted through direct contact with a mammal. Q fever is a bacterial infection that is primarily transmitted by goats and sheep. Ebola is an extremely rare disease with occasional local outbreaks in Africa. A rabies infection is caused by a virus and can be transmitted to humans by a bite, scratch or lick from an infected animal.(64) Without treatment, a rabies infection is fatal. Rabies infections are extremely rare in the Netherlands, and usually involve patients who contracted the virus in another country.

3.4.1 Key findings

Determinants

- Financial considerations play a role in **vaccination** against rabies: more expensive vaccines are correlated with lower vaccination uptake.
- Travellers who are more likely to **seek travel advice** from specialists are more likely to get vaccinations against travel-related infectious diseases.

Interventions

- Interventions that encourage hand hygiene at petting zoos lead to better compliance with hygiene recommendations.
- An intervention that used communication in which a broader range of animals were mentioned as possibly susceptible to Ebola resulted in higher intentions to report all animal bites, compared to communication covering a more limited range of animals.

Knowledge gaps

- It is clear that significantly less behavioural research has been done on infectious diseases transmitted by mammals than on those transmitted by mosquitoes and ticks.
- We found hardly any behavioural research on factors that influence the recommended behaviour in the event of a possible infection, or on avoiding contact with animals in regions where rabies is prevalent.

3.4.2 Official guidelines

Official guidelines for rabies advise seeking advice before travelling and considering preventive vaccination against rabies when travelling to a region where rabies is prevalent. They also advise avoiding all contact with animals (living and dead) in areas where rabies is prevalent, and

[b] The Centers for Disease Control and Prevention (CDC): the national institute for healthcare and public health in the United States of America.

not to feed animals. Even with these precautions, in the event of an animal scratch or bite, the wound should be thoroughly cleaned immediately with soap and water for at least 15 minutes, and then disinfected with iodine or alcohol. After this, the recommendation is to see a doctor as soon as possible, but in any case within 24 hours, for assessment to see if further treatment is needed, and if so, which form.(64)

Ebola is an extremely rare disease with occasional local outbreaks in Africa. For people travelling to high-risk areas, a number of precautionary measures are important to mitigate the risk of an Ebola infection(65): seek information before leaving on your trip; avoid contact with Ebola patients, people who have died from Ebola, or any material from patients that may be infected; avoid contact with animals (living and dead); do not eat any raw meat (bushmeat); avoid unprotected sexual contact with a person who has recovered from Ebola within six months after full recovery; wash hands regularly with soap or other disinfectants; avoid bat habitats; if you develop flu-like symptoms within 21 days after returning home, contact your doctor (GP) and mention the location of your trip.

There are no guidelines for Q fever for use outside a professional context. Official guidelines for Q fever mainly apply to people who could encounter the disease in the course of their work.

3.4.3 Determinants

Five studies investigated determinants of preventive behaviour for infectious diseases transmitted by mammals. These studies focus on specific preventive measures that are also stated in the official guidelines, such as seeking advice and looking up travel advisories, vaccinating, and reporting an animal bite, but also measures that are not in the official guidelines, such as measures to prevent Q fever. The studies show that various determinants are associated with these preventive behaviours: demographic characteristics, access to information and knowledge, risk perception, response efficacy, attitudes, opinions and beliefs, self-efficacy, social norms, previous experiences, and other preventive behaviour. In the following section, we look at each preventive measure and explain how these determinants are associated with behaviour.

Seeking advice

Seeking travel advice before leaving on a trip was found in two studies about rabies. Various **demographic characteristics** play a role: a study among students shows that travellers who have achieved a higher level of education are more likely to seek travel advice.(51) Another study shows that younger people or people travelling for leisure activities are also more likely to seek travel advice.(66) (However, this study compares one group with an average age of 28 years to another group with an average age of 31.) The nationality of travellers also plays a role. Where one study among students shows a positive correlation with European origin (compared to Asian or Oceanic origin)(51), another study shows that British and Irish travellers are more likely to seek advice than travellers from Germany, Austria, France or Oceania(66). No

clear differences were found between men and women: one study among students shows that women are more likely to seek travel advice than men(51), while a study among the general population does not show any significant difference(66). Trip duration does not appear to play a role.(66)

Vaccination
Three studies investigated determinants of rabies vaccination. One **demographic characteristic** plays a role here: nationality. A study among international travellers in Thailand shows that British and Irish travellers are more likely to be vaccinated than travellers from Germany, Austria, France or Oceania.(66) As we saw above, they are also more likely to seek advice, and seeking advice is associated with preventive vaccination against rabies. Gender, age, trip duration or purpose of the trip do not play any significant role here.(66)

Risk perception plays a role in vaccination: people who see a lower risk of rabies and lower benefit of vaccination, and are more anxious about side effects of the vaccine, are less likely to be vaccinated.(67)

Financial considerations also play a role. A study among travellers shows that more expensive vaccines are associated with lower vaccination uptake.(67) Another study shows that travellers from countries where the vaccine is cheaper are more likely to be vaccinated against rabies. However, this correlation was not found for all countries where the price is low. According to the authors, this suggests that cultural influences may also play a role here.(66)

Reporting an animal bite
One international study shows that people who consider it more plausible that diseases can be transmitted between different animal species (e.g. from birds to mammals) are more likely to report an animal bite.(68) According to the authors, these people may be more inclined to generalise the risk and extend it to humans, and thus perceive higher risks associated with animal bites (**risk perception**).

Preventive measures (general)
One study was found about Q fever. This Dutch study looked at determinants of exhibiting one or more of the following eight behaviours: adopting hygiene measures, avoiding regions with Q fever, avoiding contact with goats and sheep, not using raw milk products, wearing a face mask, relocating to a town or city without Q fever, consulting a doctor in the event of symptoms, and taking antibiotics. The study shows that people who exhibit one or more of these behaviours are more likely to be **women**, often **over 50**, have more **knowledge** about Q fever, experience more **anxiety**, perceive the disease as more **severe**, consider the measures to be more effective (**response efficacy**), have more confidence in their own ability to perform the behaviour (**self-efficacy**), have **had Q fever themselves** or have someone in their household who had Q fever.(6)

Other preventive behaviour
Adopting one preventive measure is also correlated with adopting another preventive measure. Travellers who are more likely to seek

travel advice about travel-related diseases from specialists at the travel clinic or from friends are more likely to be vaccinated against rabies.(51)(66) Interestingly, the group of travellers who are more likely to rely on books for information about vaccines are also less likely to be vaccinated.(66)

3.4.4 Interventions

Two studies were found on behaviour in the context of infectious diseases transmitted by animals. Petting zoos are a location where humans have contact with animals, and where multiple infectious diseases could be transmitted. A review on encouraging hand hygiene at petting zoos in the USA and Canada found three effective elements that led to increased compliance: strategic placement of hand hygiene units with clear instructions at the exit; having employees actively hand out disinfectant gel at the exit; the visible presence of employees at the units who gave verbal reminders to visitors.(69)

One intervention study investigated two different public communication updates and how they affected the intention to report an animal bite. Participants from the USA, Australia, Canada, the UK, Ireland, New Zealand and the Bahamas received a communication update about Ebola, based on the factsheet provided by the World Health Organization (WHO) or based on the factsheet provided by the US Centers for Disease Control and Prevention (CDC). A communication update stating that a broader range of animals is susceptible to the virus (WHO) led to stronger generalisation to other animals that were not mentioned in the update and therefore did not transmit Ebola, and an increase in the intention to report (all) animal bites.(68)

3.5 Infectious diseases transmitted by birds

The best-known infectious disease transmitted by birds is bird flu, also known as avian flu or avian influenza. Bird flu is seen as a potentially serious disease, but is rare in humans.(70) Some variants, such as H5N1, can be fatal. The disease can also lead to mass fatalities among wild and domesticated fowl. Moreover, the virus has the capacity to mutate, resulting in a higher pandemic risk.

3.5.1 Key findings

Determinants

- *Too few studies were found to formulate key findings.*

Interventions

- *No intervention studies were found on behaviour in the context of infectious diseases transmitted by birds.*

Knowledge gaps

- Only one study was found on behaviour in the context of infectious diseases transmitted by birds (bird flu). Since it combines a mixture of effective and non-effective measures, it is uncertain whether the determinants from this study are associated with recommended behaviour.
- We did not find any behavioural research on individual measures.

3.5.2 Official guidelines

The only guideline for private citizens on preventing bird flu to avoid touching dead birds, including advice on safe reporting or removal.(71) Beyond that, official guidelines are only in place for people who have contact with birds in the context of their work, such as people working at poultry farms or in nature.

3.5.3 Determinants

Only one study investigated determinants of preventive behaviour for infectious diseases transmitted by birds.(70) This study takes a combined look at three types of measures: measures that are stated in the official guidelines, such as avoiding contact; measures that are not in the official guidelines but may have some preventive effect; and **non-effective** measures. As a result, it is uncertain whether the determinants from this study are associated with recommended behaviour.

3.5.4 Interventions

No intervention studies were found on behaviour in the context of infectious diseases transmitted by birds.

3.6 Infectious diseases transmitted through surface water

Outdoor water sports and leisure activities are popular in the Netherlands. However, since natural water can be contaminated, water-based leisure activities come with certain risks. Animal faeces can cause viruses, bacteria and parasites to end up in the water. When people do leisure activities in that same water, they can ingest these pathogens and become ill. Examples of these types of infectious diseases include leptospirosis, Weil's disease and *E.coli*.(72, 73)

3.6.1 Key findings

Determinants

- *Too few studies were found to formulate key findings.*

Interventions

- *No intervention studies were found on behaviour in the context of infectious diseases transmitted through surface water.*

Knowledge gaps

- Only two studies were found on behaviour in the context of infectious diseases transmitted through surface water. These studies investigated the occurrence of human ingestion of surface water and staying away from the beach in the event of a water quality alert.
- We did not find any behavioural research about looking up water quality alerts (online), only swimming at locations where the water quality is monitored, showering and thoroughly drying off after swimming, not swimming in ditches and canals after heavy rainfall, avoiding sea foam, or contacting the doctor (GP) in the event of health problems after swimming in natural water outdoors.

3.6.2 *Official guidelines*

Official guidelines for leisure activities in natural water outdoors recommend looking up swimming advisories and complying with them. In the swimming season, water quality is tested regularly and the results are posted on the official website (zwemwater.nl), in the associated mobile app, or on official information signs at the designated outdoor bathing locations. This makes it possible for everyone to check water quality and following swimming advisories. However, water quality is only tested at designated outdoor bathing locations.(73) Another measure therefore involves only swimming at these locations. [74]

Beyond that, the guidelines advise always showering or rinsing off with clean tap water after swimming, and drying off thoroughly. If that is not possible, then it is in any case important to at least wash hands before eating. It is also important to avoid ingesting surface water, not to swim in ditches and canals after heavy rainfall (when sewers are likely to be flooded), not to swim in lukewarm standing water or near dead animals, and to avoid sea foam (since micro-organisms can accumulate there). In the event of health problems after swimming in natural water outdoors, the doctor (GP) should always be contacted.(74, 75)

3.6.3 *Determinants*

Only two studies investigated determinants of preventive behaviour in the context of infectious diseases transmitted through surface water. One study focuses on a preventive measure that is also mentioned in the official guidelines: preventing ingestion of surface water. The other study looks at behaviour in line with the directive to comply with swimming advisories: avoiding the beach in the event of a water quality alert. The studies show that various determinants are associated with these preventive behaviours, particularly the type of diving equipment that people wear and the way in which they use the beach. In the following section, we look at each preventive measure and explain how these determinants are associated with behaviour.

Preventing ingestion of surface water

One Dutch study looked at preventive behaviour associated with preventing ingestion of surface water when diving in various types of surface water (e.g. open sea, freshwater).(76) The results show that the **type of diving equipment** that people wear is correlated with the amount of surface water that they ingest while diving. For example, wearing a full face mask is more strongly associated with ingesting less surface water than wearing an ordinarily diving mask, and wearing a diving helmet is even more strongly associated with ingesting less surface water.

Avoiding the beach in the event of a water quality alert

The other study showed that most people would stay out of the water in the event of an alert about unsafe levels of bacteria in the seawater.(77) However, the study did not look at determinants of this behaviour, but at determinants of avoiding the beach. The **way in which people use the beach** plays a role here: people who want to use the beach to go swimming or walk their dog are more likely to avoid the beach (and

therefore stay out of the water) after a water quality alert. People who only go to the beach for picnics are less likely to avoid the beach at such times. There is also a difference between local residents and visitors. Visitors are more likely than local residents to avoid the beach covered by the alert. Local residents who keep using the beach do generally state that they stay out of the water in such situations.

3.6.4 Interventions

No intervention studies were found on behaviour in the context of infectious diseases transmitted through surface water.

4 Conclusion and discussion

This report offers an overview of the available literature on factors associated with behaviour to prevent the transmission of zoonoses and other animal-transmitted diseases that people could encounter in a leisure context in the Netherlands and abroad. It also offers an overview of which effective interventions are known to support these preventive behaviours and identifies knowledge gaps and opportunities for further research. Insight into barriers to and motivators of preventive behaviour is needed in order to design effective policy interventions. In that context, insight into differences between groups can also be used to tailor interventions to specific target groups. Knowledge about which interventions are effective offers direct tools for formulating policy.

4.1 Factors that influence preventive behaviour

The vast majority of the studies we found are about preventive behaviour in the context of infectious diseases transmitted by ticks or mosquitoes. Far less research has been done on preventive behaviour for infectious diseases transmitted by mammals or birds and infectious diseases transmitted through surface water.

There are a number of psychosocial determinants that play a role in most preventive behaviours, regardless of the type of infectious disease. For example, people who take more preventive measures generally have more knowledge about e.g. the disease, how they might contract an infection, and/or the possible preventive measures. They also have a higher risk perception. For example, a person who perceives a higher risk of being bitten or infected, who is more worried about this risk, and/or believes that the consequences would be more severe, is more likely to take preventive measures. Moreover, people who exhibit more preventive behaviour expect that behaviour to be effective (response efficacy) and have more confidence in their own ability to perform the behaviour (self-efficacy).

Discomfort associated with the desired behaviour also plays a role. People who feel that covering up with clothing is too warm or impractical are less likely to wear protective clothing. People who do not like to use insect or tick repellent, or prefer not to use DEET-based repellent on their child too often, are less likely to use this measure. Previous experiences also play a role in exhibiting preventive behaviour. People who have previously been bitten by a tick or found a tick on their body are more likely to take preventive measures. Moreover, preventive behaviours are often concurrent: people who are more inclined to adopt one recommendation are also more inclined to adopt another.

Finally, certain demographic factors are also relevant. Most studies show that women are more likely than men to take preventive measures. Age, education and income are inconclusive: studies show both positive and negative correlations, and sometimes do not show any correlation at all.

A significantly smaller quantity of literature was found about infectious diseases transmitted by mammals or birds and infectious diseases transmitted through surface water, compared to infectious diseases transmitted by ticks or mosquitoes. As a result, the findings about those diseases have less substantiation and are less useful for drawing general conclusions.

4.2 Effective interventions

Limited research is currently available on interventions to support preventive behaviour related to animal-transmitted diseases. We only found nine intervention studies (which includes two reviews): six about ticks, one about mosquitoes, and two about mammals. Interventions that use educational elements, focusing on increasing knowledge, generally seem to be effective. This is in line with the finding that knowledge is a significant determinant of preventive behaviour. However, since such wide-ranging elements were combined under the heading of 'educational interventions', from information leaflets to face-to-face education, it is difficult to differentiate which specific elements are effective and to what extent. Further research is needed to gain a better understanding of exactly which are effective.

Although knowledge is associated with preventive behaviour, the current literature review shows that multiple determinants can be targeted by interventions. For example, feasibility of behaviour also plays a role. People who have more confidence that they can perform the behaviour are also more likely to exhibit that behaviour. This aspect can be addressed by making it easier and more feasible to perform specific behaviours, e.g. by providing access to hand-washing facilities or lowering the price of vaccinations. Previous research on vaccination also shows that interventions may be more effective if they focus on multiple determinants at the same time, such as giving information tailored to the target group, providing timely reminders of the behaviour, and eliminating barriers in order to facilitate the behaviour.(78) In addition, most intervention studies only looked at short-term effects, so it is unclear how long the effects will persist. Only one intervention study also looked at long-term effects, regarding the tick bite app used in the Netherlands, and only found a short-term effect.(45) However, if this app is consistently used at the right times, and the short-term effect occurs each time, then the necessity of achieving a long-term effect is reduced. In this respect, there are opportunities to be explored in interventions that offer a repeat option. This is in line with research on other preventive behaviour which suggests that recurring interventions are essential to retaining effects in the long term.(79-81)

4.3 Limitations

This literature review has a number of limitations that should be mentioned. First, this report only offers an impression of how often various behavioural determinants were found in relevant literature. It does not focus on underlying explanations as to why the determinants are associated with the behaviours. Moreover, how often a determinant is found in the literature does not necessarily offer any direct indication of the strength of the correlation. For example, it is possible to repeatedly find a weak statistical correlation between a determinant and

an outcome. On the other hand, the more often a determinant is found and the more conclusive the results of various studies are, the more we know about it – and the less likely it is that findings will change as new insights emerge. Furthermore, this report did not investigate the extent of actual compliance with the desired behaviours. As a result, there is no insight into current implementation of the behaviour in actual practice. Insight into the degree of compliance is important in order to determine where the biggest behavioural changes are needed.

Another limitation regards the difference between intended behaviour and actual behaviour. This report looked at intentions and behaviour in combination, which may limit conclusions about actual behaviour. After all, we know that these two are not always correlated.(82) Most studies did look at actual behaviour, but it must be noted that they often involved self-reported behaviour. A major drawback of self-reported behaviour is that it depends on what respondents recall and perceive, which can lead to inaccuracies. Social acceptability, differences in interpretation and memory bias can result in a partial discrepancy between self-reported behaviour and reality.

Although we found hardly any studies that specifically focus on desired preventive behaviour after a bite, this topic is regularly investigated as an aspect of knowledge level. This means that there is research available on whether people know how to correctly remove a tick, for example, but not on whether they actually use that method in practice and what the determinants of that behaviour are. Our review focused solely on behaviour and intention, not on other outcome factors, such as knowledge. A more comprehensive overview of which knowledge people have could be valuable for developing more targeted educational interventions..

Finally, we selected countries with culturally comparable target populations; however, differences in the prevalence of infectious diseases remain between these countries, which may affect the generalisability of the findings.

4.4 Knowledge gaps and opportunities for future research

By taking stock of what is known in current literature on behavioural science and comparing it to the official guidelines for preventive behaviour in the context of these infectious diseases, we see several opportunities for future research. Although we found the highest number of guidelines in the literature about tick-borne and mosquito-borne diseases, several measures have still not been fully addressed. In the context of tick-borne diseases, extensive research has been done on checking for ticks, wearing protective clothing and using tick repellent. However, we did not find any research about factors that influence correct removal of ticks, bite care, or monitoring the bite. Most of the measures mentioned in the guidelines for preventing mosquito-borne diseases were also found in the literature, such as seeking advice and looking up travel advisories, wearing protective clothing, using a mosquito net, using insect repellent, vaccinating and prophylactic medication use. The only topic for which no behavioural research was found was specific guidelines for Zika in the context of pregnancy.

Limited research has been done on determinants of preventive behaviour for infectious diseases transmitted by mammals. This primarily covers preventive behaviour in the context of rabies, such as seeking travel advice and preventive vaccination. Recommended behaviour after a possible infection still offers opportunities. There is also a knowledge gap regarding avoiding contact with animals in regions where rabies is present. Although no guidelines for Q fever are available for private citizens, research has been done on the determinants of preventive behaviour in this context. It covers adopting hygiene measures, avoiding regions where Q fever is present, avoiding contact with sheep and goats, wearing a face mask, consulting a doctor in the event of symptoms, and taking antibiotics.

Hardly any research has been done on preventive behaviour for infectious diseases transmitted by birds and infectious diseases transmitted through surface water. More research is needed, both on the guidelines that have only been subjected to minimal research and those that have not yet been researched at all. We found only one study about infectious diseases transmitted by birds. However, the study looked at a mixture of preventive measures, so it is impossible to reach any clear conclusions. We found two studies on infectious diseases that are transmitted through surface water. Both investigated official guidelines (not ingesting surface water) or behaviour in line with the official guidelines (avoiding the beach during a water quality alert).

Very limited literature is available about the effectiveness of interventions to promote behaviour. Most of the interventions described in the literature focus on increasing knowledge, but since they focus on a wide range of methods, it is unclear exactly what is effective and to what extent. Further research is needed to gain a better understanding of exactly which elements are effective. There are also opportunities for more interventions focusing on determinants other than knowledge that are covered in this literature review, such as feasibility of preventive behaviour.

Opportunities also exist for addressing other infectious diseases that could be transmitted by animals in a leisure context, for which no studies have been found, such as hantavirus. However, it is important to keep assessing the current and emergent risks of specific infectious diseases. For example, there are no more than a few dozen Hantavirus infections annually(83), while the 2021 reference level indicated 25,600 confirmed cases of Lyme infection. Accordingly, an important consideration in future research is to focus on the gaps in research that could help to offer insights for addressing current and future challenges.

4.5 Considerations for policy and future research

- **Increasing knowledge works:** People who know more about animal-transmitted diseases in a leisure context exhibit more preventive behaviour. It is therefore useful to focus on increasing knowledge. This goes beyond knowledge about the disease itself, such as how it is transmitted and what the risks are. It also helps if people know more about the preferred behaviour, e.g. how

effective that behaviour is in preventing diseases and how they should perform the behaviour.

- **Also make it easy to do:** To promote preventive behaviour in the entire target group, solely increasing knowledge will not suffice. Feasibility of behaviour also plays a role. People who have more confidence that they can perform the behaviour are also more likely to exhibit that behaviour. This aspect can be addressed by making it easier and more feasible to perform specific behaviours, e.g. by providing access to hand-washing facilities or lowering the price of vaccinations.
- **Take the context into account:** Which specific factors play a role vary according to the behaviour and context. Interventions should therefore be developed on the basis of the knowledge available about the context and the specific target group. If this knowledge is not available, it would be useful to conduct additional research.
- **Evaluate interventions:** Relatively few studies have investigated the effectiveness of behavioural interventions. Evaluating interventions is essential in order to gain insights into effectiveness in actual practice as well as which elements had an impact. That knowledge helps in adapting interventions and deploying new (and more effective) interventions.
- **Monitor actual behaviour:** Based on current data on compliance with recommended behaviours, interventions can be deployed in a more focused way in contexts and target groups where they will be most effective. It is therefore useful to conduct systematic monitoring of key behaviours and influencing factors among the population of the Netherlands. The infrastructure of the RIVM Pandemic Preparedness & Behaviour survey-based monitor offers options for this as needed.

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Appendix 1

Table 1 Search queries for infectious diseases transmitted by ticks and mosquitoes

Search queries Embase (29 July 2024)	TiAb: (tick* OR mosquito*) AND TiAb: (health behavior* OR health behaviour* OR health measure* OR protective behavior* OR protective behaviour* OR protective measure* OR preventive behavior* OR preventive behaviour* OR preventive measure* OR preventative behavior* OR preventative behaviour* OR preventative measure* OR health guidelines OR protective guidelines OR preventive guidelines OR preventative guidelines OR treatment seeking OR zoonotic literacy OR health literacy OR behavioural psychology OR behavioral psychology OR social psychology OR behavioral science OR behavioural science) NOT Ti: (covid OR corona OR sars)
Search queries PubMed (31 July 2024)	TiAb: (tick* OR mosquito*) AND TiAb: (health behavior* OR health behaviour* OR health measure* OR protective behavior* OR protective behaviour* OR protective measure* OR preventive behavior* OR preventive behaviour* OR preventive measure* OR preventative behavior* OR preventative behaviour* OR preventative measure* OR health guidelines OR protective guidelines OR preventive guidelines OR preventative guidelines OR treatment seeking OR zoonotic literacy OR health literacy OR behavioural psychology OR behavioral psychology OR social psychology OR behavioral science OR behavioural science) NOT Ti: (covid OR corona OR sars)
Search queries PsycINFO (29 July 2024)	TiAb: (tick* OR mosquito*) AND TiAb: (health behavior* OR health behaviour* OR health measure* OR protective behavior* OR protective behaviour* OR protective measure* OR preventive behavior* OR preventive behaviour* OR preventive measure* OR preventative behavior* OR preventative behaviour* OR preventative measure* OR health guidelines OR protective guidelines OR preventive guidelines OR preventative guidelines OR treatment seeking OR zoonotic literacy OR health literacy OR behavioural psychology OR behavioral psychology OR social psychology OR behavioral science OR behavioural science) NOT Ti: (covid OR corona OR sars)

Table 2 Search queries for infectious diseases transmitted by mammals and birds

Search queries Embase (29 July 2024)	('zoonosis'/exp) AND TiAb: ('health behavior*' OR 'health behaviour*' OR 'health measure*' OR 'protective behavior*' OR 'protective behaviour*' OR 'protective measure*' OR 'preventive behavior*' OR 'preventive behaviour*' OR 'preventive measure*' OR 'preventative behavior*' OR 'preventative behaviour*' OR 'preventative measure*' OR 'health guidelines' OR 'protective guidelines' OR 'preventive guidelines' OR 'preventative guidelines' OR 'treatment seeking' OR 'zoonotic literacy' OR 'health literacy' OR ((check* NEAR/2 quality)) OR ((asses* NEAR/2 quality)) OR ((water NEAR/2 monitoring)) OR (((reading OR searching OR informing OR seeking) NEAR/2 (information OR risk* OR zoono* OR 'travel health' OR 'health advice'))) OR 'behavioural psychology' OR 'behavioral psychology' OR 'social psychology' OR 'behavioral science' OR 'behavioural science') AND TiAb: ((animal NEAR/3 wound*) OR ((animal NEAR/3 injury)) OR ((animal NEAR/3 mauling*)) OR ((animal NEAR/3 bite*)) OR 'bite wound*' OR bite OR scratch OR ((animal NEAR/3 scratch*)) OR ((animal NEAR/3 claw*)) OR ((animal NEAR/3 petting)) OR ((animal NEAR/3 caress*)) OR ((animal NEAR/3 lick*)) OR 'scratch wound*' OR 'claw wound*' OR 'petting injury' OR dog OR dogs OR cat OR cats OR rodent OR rodents OR bat OR bats OR rabbit OR rabbits OR hare OR hares OR bird OR birds OR mammal OR mammals OR rabies OR tetanus) NOT Ti: (covid OR sars OR corona)
Search queries PubMed (31 July 2024)	("zoonoses"[MeSH Terms]) AND TiAb: ("mauling*" OR "bite*" OR "scratch*" OR "petting" OR "caress*" OR "lick*" OR "claw*" OR "bite wound*" OR "scratch wound*" OR "claw wound*" OR (("petted" OR "petting") AND "injury") OR "dog" OR "dogs" OR "cat" OR "cats" OR "rodent" OR "rodents" OR "bat" OR "bats" OR "rabbit" OR "rabbits" OR "hare" OR "hares" OR "bird" OR "birds" OR "mammal" OR "mammals" OR "rabies" OR "tetanus") AND TiAb: ("health behavior*" OR "health behaviour*" OR "health measure*" OR "protective behavior*" OR "protective behaviour*" OR "protective measure*" OR "preventive behavior*" OR "preventive behaviour*" OR "preventive measure*" OR "preventative behavior*" OR "preventative behaviour*" OR "preventative measure*" OR "health guidelines" OR "protective guidelines" OR "preventive guidelines" OR "preventative guidelines" OR "treatment seeking" OR "zoonotic literacy" OR "health

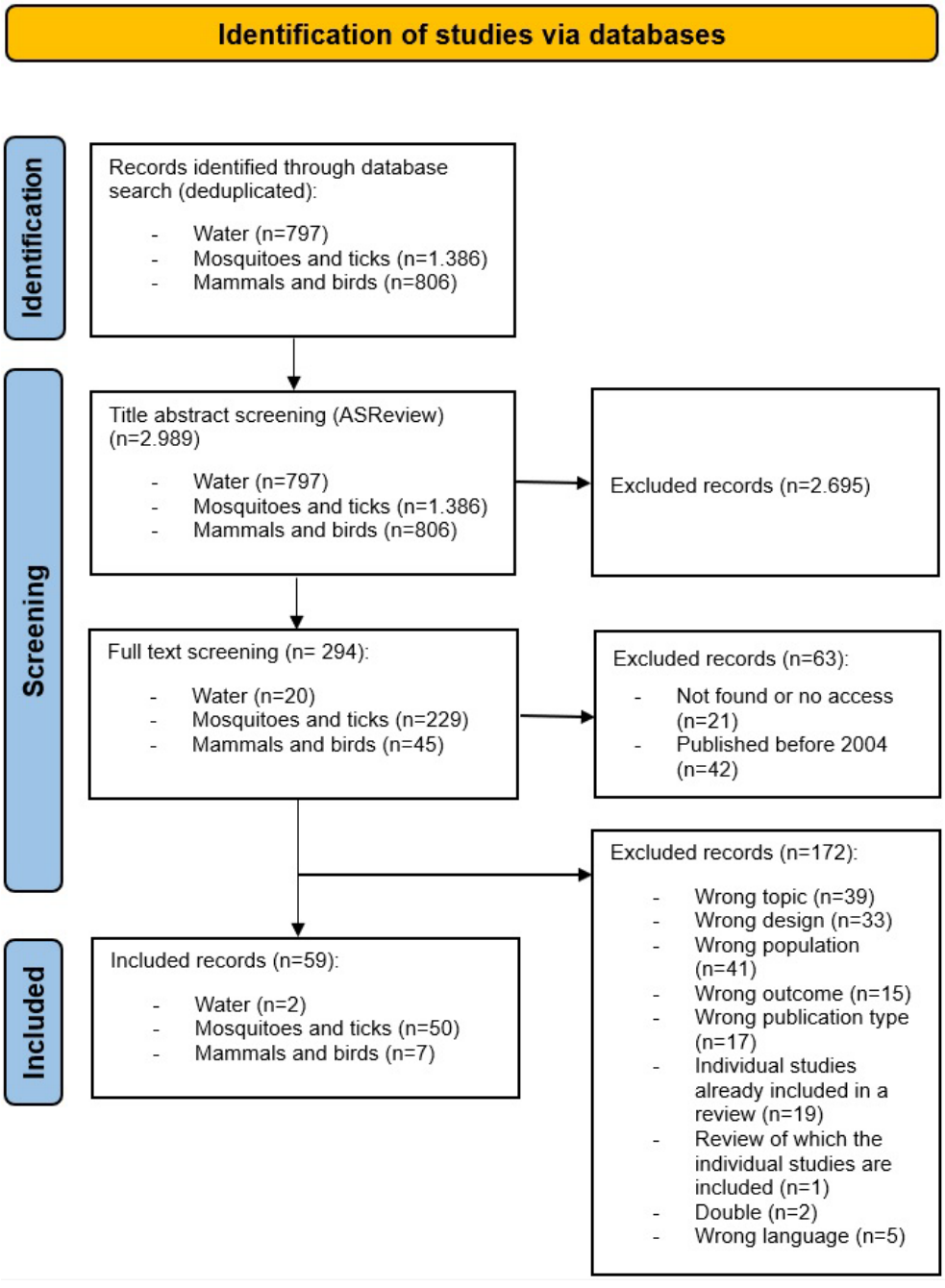
	literacy" OR "behavioural psychology" OR "behavioral psychology" OR "social psychology" OR "behavioral science" OR "behavioural science") NOT Ti: ("covid" OR "corona" OR "sars")
Search queries PsycINFO (29 July 2024)	TiAb: ("zoono*") AND TiAb: ("mauling*" OR "bite*" OR "scratch*" OR "petting" OR "caress*" OR "lick*" OR "claw*" OR "bite wound*" OR "scratch wound*" OR "claw wound*" OR (("petted" OR "petting") AND "injury") OR "dog" OR "dogs" OR "cat" OR "cats" OR "rodent" OR "rodents" OR "bat" OR "bats" OR "rabbit" OR "rabbits" OR "hare" OR "hares" OR "bird" OR "birds" OR "mammal" OR "mammals" OR "rabies" OR "tetanus") AND TiAb: ("health behavior*" OR "health behaviour*" OR "health measure*" OR "protective behavior*" OR "protective behaviour*" OR "protective measure*" OR "preventive behavior*" OR "preventive behaviour*" OR "preventive measure*" OR "preventative behavior*" OR "preventative behaviour*" OR "preventative measure*" OR "health guidelines" OR "protective guidelines" OR "preventive guidelines" OR "preventative guidelines" OR "treatment seeking" OR "zoonotic literacy" OR "health literacy" OR "behavioural psychology" OR "behavioral psychology" OR "social psychology" OR "behavioral science" OR "behavioural science") NOT Ti: ("covid" OR "corona" OR "sars")

Table 3 Search queries for infectious diseases transmitted through surface water

Search queries Embase (31 July 2024)	('water sport'/exp OR TiAb: 'water recreation' OR 'freshwater recreation') AND TiAb: ('health behavior*' OR 'health behaviour*' OR 'health measure*' OR 'protective behavior*' OR 'protective behaviour*' OR 'protective measure*' OR 'preventive behavior*' OR 'preventive behaviour*' OR 'preventive measure*' OR 'preventative behavior*' OR 'preventative behaviour*' OR 'preventative measure*' OR 'health guidelines' OR 'protective guidelines' OR 'preventive guidelines' OR 'preventative guidelines' OR 'treatment seeking' OR 'zoonotic literacy' OR 'health literacy' OR ((check* NEAR/2 quality)) OR ((asses* NEAR/2 quality)) OR ((water NEAR/2 monitoring)) OR (((reading OR searching OR informing OR seeking) NEAR/2 (information OR risk* OR zoono* OR 'travel health' OR 'health advice'))) OR 'behavioural psychology' OR 'behavioral psychology' OR 'social psychology' OR 'behavioral science' OR 'behavioural science'))) NOT Ti: (covid OR sars OR corona OR drinking)

Search queries PubMed (31 July 2024)	TiAb: ('water sport' OR 'water recreation' OR 'freshwater recreation') AND TiAb: (health behavior* OR health behaviour* OR health measure* OR protective behavior* OR protective behaviour* OR protective measure* OR preventive behavior* OR preventive behaviour* OR preventive measure* OR preventative behavior* OR preventative behaviour* OR preventative measure* OR health guidelines OR protective guidelines OR preventive guidelines OR preventative guidelines OR treatment seeking OR zoonotic literacy OR health literacy OR behavioural psychology OR behavioral psychology OR social psychology OR behavioral science OR behavioural science OR (check* AND quality) OR (asses* AND quality) OR (water AND monitoring) OR ((reading OR searching OR informing OR seeking) AND (information OR risk* OR zoono* OR travel health OR health advice))) NOT Ti: (covid OR sars OR corona OR drinking)
Search queries PsycINFO (31 July 2024)	TiAb: ('water sport' OR 'water recreation' OR 'freshwater recreation') AND TiAb: (health behavior* OR health behaviour* OR health measure* OR protective behavior* OR protective behaviour* OR protective measure* OR preventive behavior* OR preventive behaviour* OR preventive measure* OR preventative behavior* OR preventative behaviour* OR preventative measure* OR health guidelines OR protective guidelines OR preventive guidelines OR preventative guidelines OR treatment seeking OR zoonotic literacy OR health literacy OR behavioural psychology OR behavioral psychology OR social psychology OR behavioral science OR behavioural science OR (check* AND quality) OR (asses* AND quality) OR (water AND monitoring) OR ((reading OR searching OR informing OR seeking) AND (information OR risk* OR zoono* OR travel health OR health advice))) NOT Ti: (covid OR sars OR corona OR drinking)

Appendix 2


Identification of studies via databases
Identification
Records identified through database search (deduplicated):
- Water (n=797)
- Mosquitoes and ticks (n=1.386)
- Mammals and birds (n=806)
Screening
Title abstract screening (ASReview) (n=2.989)
- Water (n=797)
- Mosquitoes and ticks (n=1.386)
- Mammals and birds (n=806)
Excluded records (n=2.695)
Full text screening (n= 294):
- Water (n=20)
- Mosquitoes and ticks (n=229)
- Mammals and birds (n=45)
Excluded records (n=63):
- Not found or no access (n=21)
- Published before 2004 (n=42)
Excluded records (n=172):
- Wrong topic (n=39)
- Wrong design (n=33)
- Wrong population (n=41)
- Wrong outcome (n=15)
- Wrong publication type (n=17)
- Individual studies already included in a review (n=19)
- Review of which the individual studies are included (n=1)
- Double (n=2)
- Wrong language (n=5)
Included
Included records (n=59):
- Water (n=2)
- Mosquitoes and ticks (n=50)
- Mammals and birds (n=7)

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